
2M-3 Street Flow and Intake/Manhole Capacity

A. Introduction

Storm sewer intakes are the main access points by which urban runoff enters the storm sewer system. In fact, the storm sewer intake is an important element of the design in its own right. The hydraulics of flow into an inlet are based on principles of weir and orifice flow, modified by laboratory and field observation of entrance losses under controlled conditions.

Curb and gutter intakes are installed along street sections having curbs and gutters to intercept stormwater runoff and to allow its passage into a storm sewer. Inlets can be located at low points (sumps), directly upstream from street intersections and at intermediate locations as well. The spacing of these intermediate curb inlets depends on several criteria but is usually controlled by rate of flow and the permissible water spread toward the street crown. The type of road is also important since the greater the speed and volume of traffic, the greater the potential for hydroplaning. On the other hand, it is also considered acceptable practice to allow some periodic and temporary flooding of low volume streets (see Section 2A-4 for criteria).

B. Definitions

Frontal flow: The portion of the flow that passes over the upstream side of a grate.

Side-flow interception: Flow that is intercepted along the side of a grate inlet, as opposed to frontal interception.

Slotted drain inlet: A drainage inlet composed of a continuous slot built into the top of a pipe that serves to intercept, collect, and transport the flow.

Splash-over: Portion of the frontal flow at a grate that skips or splashes over the grate and is not intercepted.

Storm sewer intake: A storm sewer intake is an opening into a storm sewer system for the entrance of surface storm runoff. There are four basic types of intakes:

- Curb-grate opening (normal municipal street intake)
- Curb opening (normal Iowa DOT open throat street intake)
- Combination intakes (street intake with manhole)
- Grate intake only (parking lot, driveway, or ditch intake)

In addition, intakes may be further classified as being on a continuous grade or in a low point. The term "continuous grade" refers to an intake so located that the grade of the street has a continuous slope past the intake and therefore ponding does not occur at the intake. The sump or low point condition exists whenever water is restricted to the inlet area because the intake is located at a low point. A low point condition can occur at a change in grade of the street from positive to negative or due to the crown slope of a cross street when the intake is located at an intersection.

Storm sewer manhole: A storm sewer manhole is an access structure where storm sewers start, are joined together or change size. There are five basic types of manholes:

a. **Manhole types:**

Figure No. ¹	Type	Description
6020.12	M-A	48" minimum diameter short cone or flat top with cast-in-place or precast base
6020.13	M-B	Precast or cast-in-place box with precast or cast-in-place base
6020.14	M-C	Cast-in-place box with cast-in-place base
6020.15	M-D	Combination 48" diameter short cone with cast-in-place riser and cast-in-place base
6020.16	M-E	48" diameter short cone with T-section

b. **Casting types:**

Figure No. ²	Casting Type	Ring/Cover	Gasket	Bolted Cover (Floodable)	Typical Surface
6020.17	E	Standard	No	N/A	Non-paved/flexible ³
6020.18	F	Adjustable	No	N/A	PCC ⁴

1. **Design flow.** Design flow is defined as that quantity of water at a given point calculated from the design storm runoff. For gutter applications, design flow should include bypass flow from upstream intakes.
2. **Bypass flow.** Bypass flow is defined as the flow in the gutter that is not intercepted by a given intake. Bypass flow is calculated by subtracting the allowable capacity of the given intake from the design flow assigned to that intake. Bypass flow is added to the design storm runoff for the next downstream intake. As a minimum, intakes at a low point will have design capacity equal to the assigned storm discharge plus upstream bypass flows.

C. Intercepting flows

Storm sewer intakes should be designed to intercept design flow with the following allowable bypass from the system:

1. **Streets on continuous grade.** The downstream intake or intakes should be designed to intercept no less than 50% of the design flow.
2. **Temporary dead-end streets on down grade.** Unless otherwise approved by the Jurisdictional Engineer, intakes should be designed to intercept 100% of the design Flow, or according to Table 1.
3. **Permanent dead-end streets on down grade and low points.** Intakes should be designed to intercept 100% of the design flow, or according to Table 1. Depending on downstream conditions, the Jurisdictional Engineer may require oversizing intakes at low points.

¹ The figure numbers listed in this table refer to figures from the SUDAS Specifications.

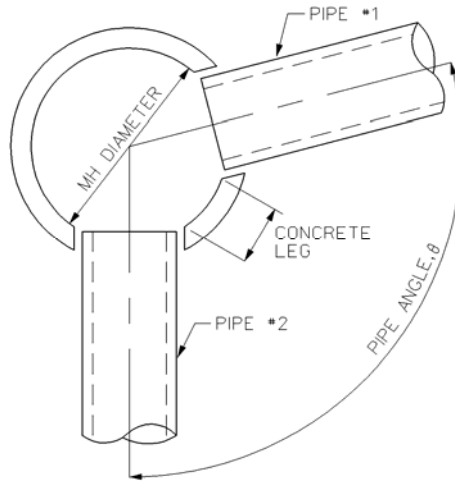
² The figure numbers listed in this table refer to figures from the SUDAS Specifications.

³ Includes HMA, seal coat, gravel, and brick.

⁴ Includes casting in concrete boxouts.

D. Storm sewer structure locations

1. **Access ports (manholes/intakes).** Manholes or other access ports (intakes) are required under the following conditions:
 - a. At the end of each sewer line
 - b. At all changes in pipe size, elevation and grade, or alignment, and at all bends
 - c. At all sewer pipe intersections, except where the size of the storm sewer conduit (54 inches diameter or greater pipe) eliminates the need for a maintenance access. Manholes are required for 54 inches or greater pipes when direct access is desired every 400 feet.
 - d. When feasible, at street intersections
 - e. Pipe T-section on 48 inches diameter pipe or larger may be used as manholes.
2. **Openings**
 - a. **Standard.** The minimum size for an access port (manhole) is 48 inches in diameter. Jurisdictions require concentric manholes, without built-in steps, with the manhole opening over the centerline of the pipe or on an offset not to exceed 12 inches. Some Jurisdictions may allow for eccentric manholes.
 - b. **Special.** For square or rectangular manholes, the manhole openings should be over the centerline of the pipes or on an offset not to exceed 12 inches. The distance from the centerline of the manhole opening to the face of the inside manhole wall should not exceed 30 inches to better facilitate video inspection and maintenance equipment. This may require more than one manhole opening.
 - c. **Determining diameters.** When utilizing circular precast manholes, it is necessary to determine the diameter required to maintain the structural integrity of the manhole. As a general rule, a minimum concrete leg of 6 inches should remain between the manhole blockouts for adjacent pipes. Determining the required manhole diameter to provide this minimum distance may be done as follows:
 - 1) Determine the diameters of, and the angle between, the two pipes in question. If more than two pipes connect at the manhole, the adjacent pipes with the critical configuration (i.e. smallest angle and largest pipes) should be selected. If the critical configuration is not apparent, calculations may be required for all adjacent pipes.



- 2) Determine the blockout diameter. The blockout is the opening provided in the manhole for the pipe. Blockout dimensions are based on the outside diameter of the pipe, plus an additional distance to accommodate the integrally cast gasket for sanitary sewer pipe. For storm sewer, a circular or doghouse type opening is provided with additional clearance to allow for the insertion of the pipe and sufficient space to accommodate placement of concrete grout in the opening. Typical blockout dimensions for various pipe sizes and materials are given in Table 1 below.

Table 1: Manhole Blockout Sizes

Pipe Dia.	Manhole Blockout, in		
	RCP	PVC	DIP
8"	N/A		
10"	N/A		
12"	21"	16"	16"
14"	N/A	16"	18
15"	24"	19"	N/A
16"	N/A	N/A	20"
18"	18"	22"	23"
20"	N/A	N/A	24"
21"	31"	25"	N/A
24"	35"	28"	29"
27"	38"	31"	N/A
30"	42"	35"	36"
33"	47"	N/A	N/A
36"	48"	42"	41"
42"	57"	N/A	N/A
48"	64"	N/A	N/A
54"	71"	N/A	N/A
60"	78"	N/A	N/A

- 3) Determine the diameter of the manhole required to provide the minimum concrete leg dimension. This diameter may be calculated with the following equation:

$$MH_d = \frac{BO_1 + BO_2 + 2CL}{\theta \times \left(\frac{\pi}{180}\right)} \quad \text{Equation 1}$$

where:

MH_d = Manhole Diameter, inches

BO = Blockout Diameter, inches

CL = Minimum Concrete Leg Length, inches (6 inches)

θ = Angle between pipe centerlines, degrees

- 4) Round the minimum manhole diameter calculated, up to the next standard manhole size (48 inches, 60 inches, 72 inches, 84 inches, 96 inches, 108 inches, or 120 inches).
- 5) Verify that the manhole diameter calculated is sufficient for the largest pipe diameter (See Table 2).

Table 2: Minimum Manhole Diameter Required for Pipe Size

Pipe Dia.	Minimum Manhole Diameter Required for Pipe		
	RCP	PVC	DIP
8"	N/A	48"	48"
10"	N/A	48"	48"
12"	48"	48"	48"
14"	N/A	N/A	48"
15"	48"	48"	N/A
16"	N/A	N/A	48"
18"	48"	48"	48"
20"	N/A	N/A	48"
21"	48"	48"	N/A
24"	48"	48"	48"
27"	60"	48"	N/A
30"	60"	60"	60"
33"	60"	N/A	N/A
36"	60"	60"	60"
42"	72"		
48" ⁵	84"		
54" ^{13, 6}	96"		
60" ^{13, 14}	96"		

3. **Combination intakes.** Intakes with combined manholes will be used when the size of the connecting pipes so indicate or when horizontal clearance is necessary behind the back of curb. The Project Engineer is encouraged to place intakes combined with manholes for storm sewers that are parallel to the street. This will prevent storm sewers from being installed under pavement and thus improves future maintenance access without removing pavement. Approval will be required by the Jurisdictional Engineer when storm sewers or footing drains parallel to the street are placed under the pavement.

⁵ T-section may be allowed as manhole.

⁶ Manholes are not required for 54" pipes or larger unless direct access is desired every 400'.

4. **Cleanouts.** Lamp holes or clean-out structures are required at the beginning of footing drains and subdrains in street right-of-way. Cleanouts may be permitted in place of a manhole at the end of lines which are less than 150 feet in length.
5. **Access spacing.** Storm sewer structures (manholes, intakes, combination intakes, or cleanouts) in street right-of-way must be located in areas which allow direct access by maintenance vehicles. Areas outside the street right-of-way will be subject to the approval of the Jurisdictional Engineer.
 - a. **Manhole spacing**
 - 1) Manholes are to be spaced at intervals not exceeding 400 feet for sewers 24 inches or less at intervals not exceeding 500 feet when adequate cleaning equipment is available.
 - 2) Spacing of manholes over 500 feet may be permitted in sewers larger than 24 inches if the owner has adequate cleaning equipment.
 - b. **Intake spacing.** Locate street intakes upgrade from intersections, sidewalk ramps, and outside of intersection radius. At least one intake is to be installed at the low point of the street grade.
 - 1) **First intake.** An intake should be located no further than 500 feet from the street high point.
 - 2) **Remaining intakes.** To be spaced at a distance no greater than 400 feet regardless of gutter flow capacity.
1. **Invert drop.** When there is a change in pipe size at a structure, the invert of the smaller sewer must be raised to maintain the same energy gradient. An approximate method of doing this is to place the 0.8 depth point of both sewers at the same elevation. When there is a change in alignment between storm sewer of 45° or greater, the suggested minimum manhole drop is 0.10 foot.

E. Intake capacity

The capacity of an intake is decreased by such factors as debris plugging, pavement overlaying, etc. Therefore, the allowable capacity of an intake is determined by applying the applicable reduction factor from the following table to the theoretical capacity calculated from the design procedures outlined in this section. These reduction factors are based on vane grates, which are required on all curb grate intakes within the street. Other intake grates may be approved by the Jurisdictional Engineer outside of the street right-of-way. The Iowa DOT normally requires curb only intakes on primary roads.

Table 3: Reduction Factors to Apply to Intakes

Intake Type	Location	Reduction Factor ⁷
M-A, M-B, & M-C	Continuous Grade Low Point	90% Vane Grates with Curb 80% Vane Grates with Curb
M-D & M-E	Continuous Grade Low Point	90% Vane Grates with Curb 80% Vane Grates with Curb
M-F & M-I	Continuous Grade Low Point	80% Curb Only (No Grate) 70% Curb Only (No Grate)
Driveway Grate	Continuous Grade Low Point ⁸	75% Grate Only (No Curb) 65% Grate Only (No Curb)

1. Abbreviations

- a = Intake Depression in Inches
- d = Depth of Flow in Gutter at Face of Curb
- h = Height of the Curb Opening
- H = Total Head in Feet = d + a in Feet
- K = Value Used in Equation $Q = Kd$ (See Figures 3 and 5)
- L = Length of Curb Opening in Feet
- n = Manning's Roughness Coefficient = 0.016
- Q = Discharge in cfs
- Q_{CO} = Flow Intercepted by the Curb Opening
- Q_G = Flow Intercepted by the Grate
- Q_I = Allowable Flow Intercepted by the Intake
- R_F = Reduction Factor
- S_L = Longitudinal Street Slope
- S_T = Transverse Street Slope or Crown
- T = Spread of Water in Gutter From Face of Curb
- Z = 1/S_T = Reciprocal of Transverse Slope

2. Equations

- a. **Capacity of gutter for straight crown.** Figure 1 is the nomograph used to determine the gutter capacity for a straight crown or segmented straight crown. Figure 1 can also be used to approximate the capacity of curved crowns.
- b. **Capacity of standards M-A, M-B, or M-C intake on a continuous grade.** The allowable capacity of a M-A, M-B, or M-C intake on a continuous grade is determined by the following equation:

$$Q_I = K \left(d^{5/3} \right) (R_F)$$

⁷ Minimum reduction factor is to be used to reduce intake capacity.

⁸ Use of driveway grates at low points is discouraged due to their tendency to become plugged with debris and flood the surrounding area. Obtain permission of the Jurisdictional Engineer prior to placing a driveway grate in a low point. If allowed, the Jurisdictional Engineer may also require installation of standard curb intake(s) immediately upstream of the driveway.

Figure 3 is used to determine "K" for a vane grate and includes the curb hood. Figure 4 gives "K" for a driveway condition where no curb hood can be used. The appropriate reduction factor from Table 1 must then be applied to obtain the actual flow intercepted by the intake.

- c. **Capacity of standard M-F or M-I intakes on a continuous grade.** Figure 2 is used to determine the interception ratio of the intake. This theoretical interception ratio (Q_i/Q) multiplied by the design flow in the gutter and the reduction factor equals the flow intercepted by the intake.
- d. **Capacity of M-A and M-F intakes at a low point.** Figure 5 is used to determine the capacity Q of a Standard Type M-A or M-F intake at a low point. The appropriate reduction factor must be applied to the results.

Figure 1: Nomograph for Capacity of the Gutter for Straight Crown

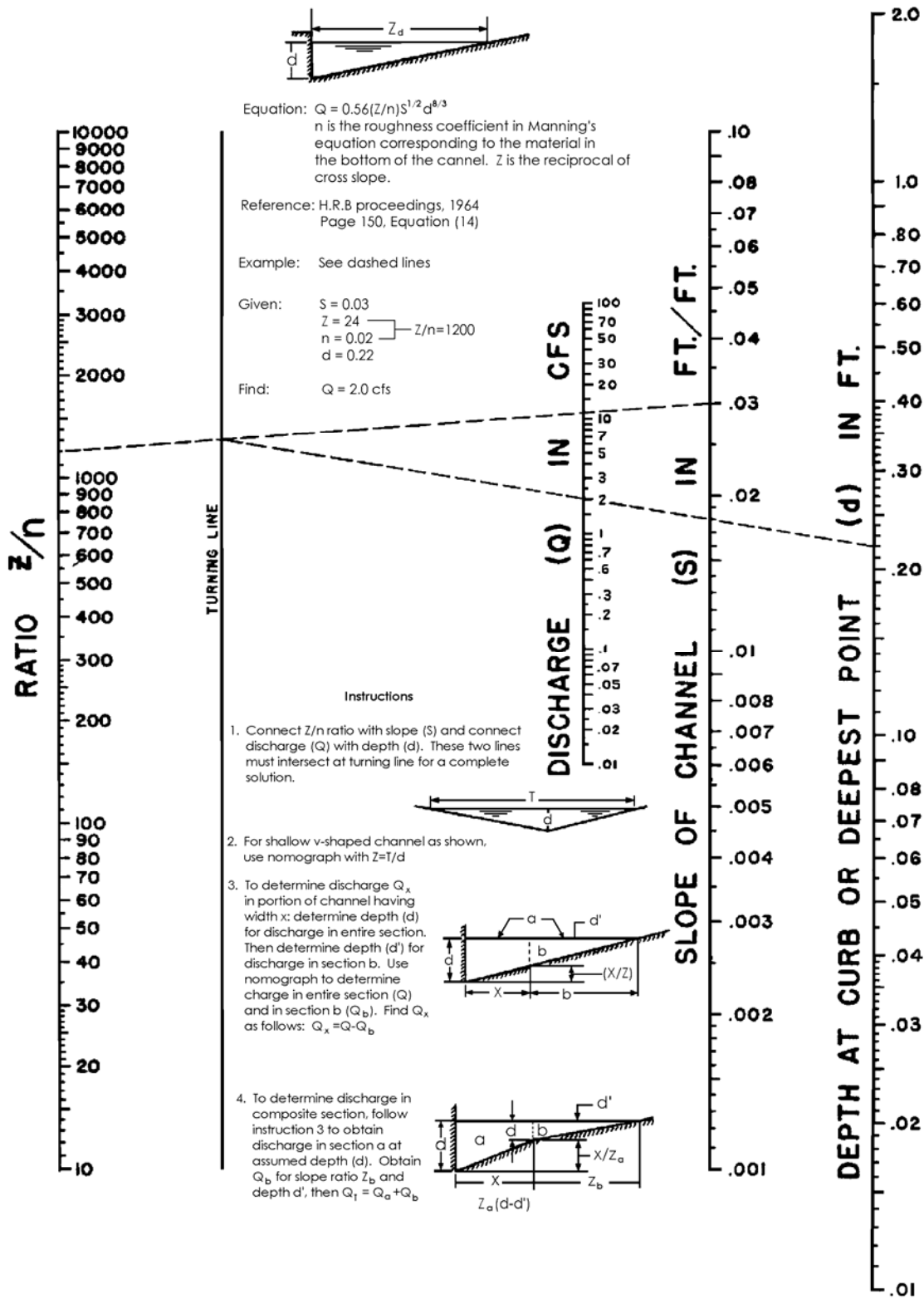


Figure 2: Interception Ratio for Standard Type M-F and M-I Intakes on Continuous Grade

STANDARD CURB - OPENING INLET CHART

EXAMPLE

W = 2 ft
 a = 2 in
 h = 6 in

Given: $S_T = 0.02$ ft/ft
 T = 10 ft
 $S_L = 0.03$ ft/ft
 Find: $L_i = 4$ ft $L_i = 8$ ft

$Q_i/Q = .22$ $Q_i/Q = 0.48$
 $d_w = S_T(T-2)$

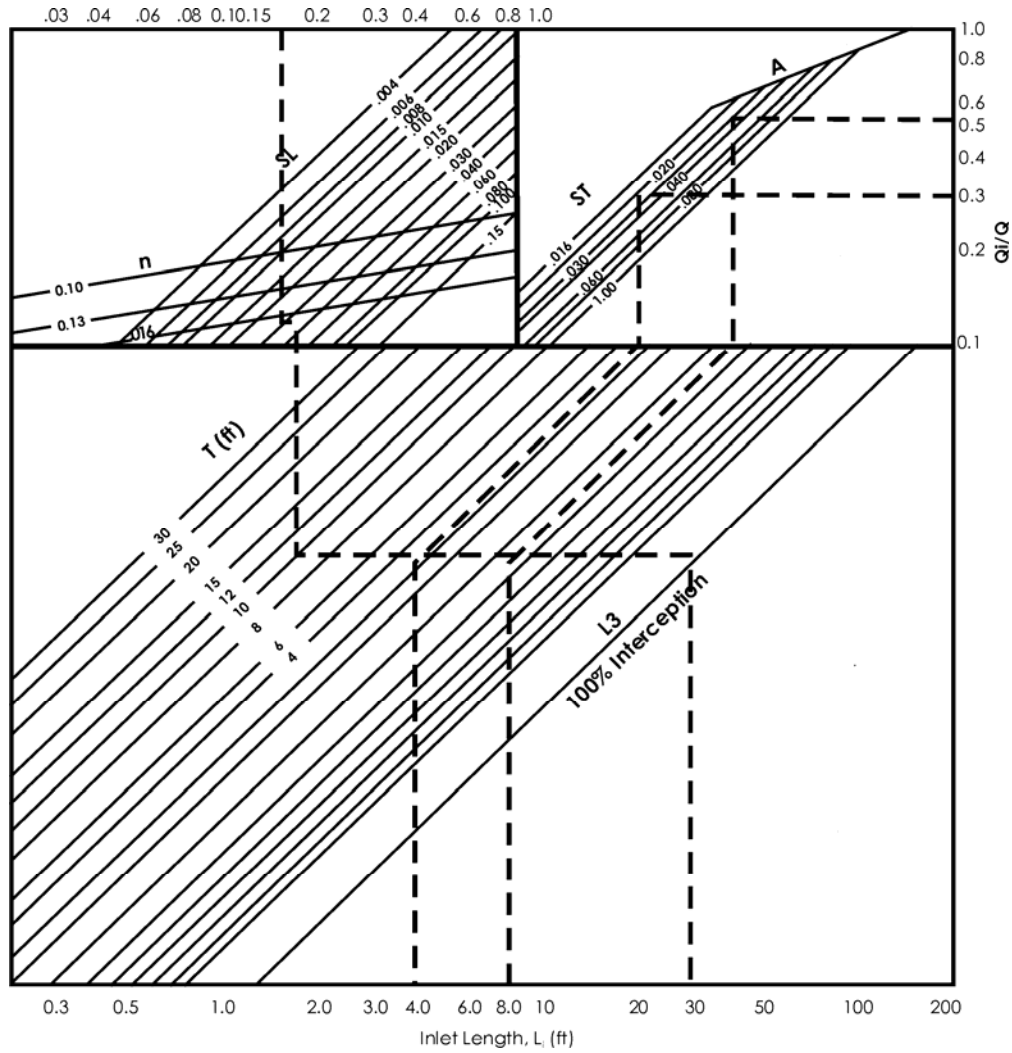


Figure 3: “K” Values for Standard Type M-A, M-B, M-C Intakes – Vane Grate & Curb Hood

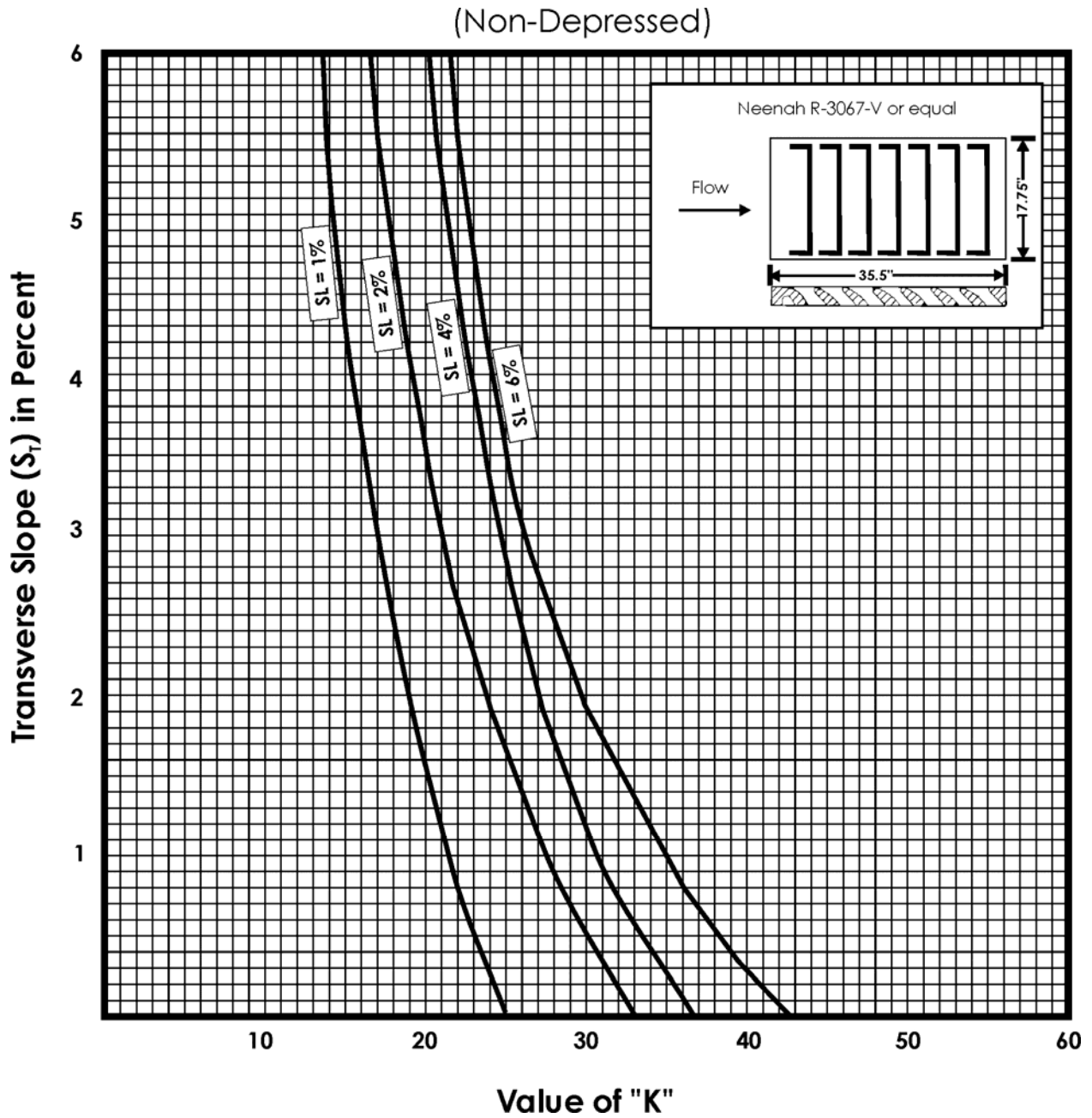


Figure 4: "K" Values for Driveway Grate Intake
(Non-Depressed)

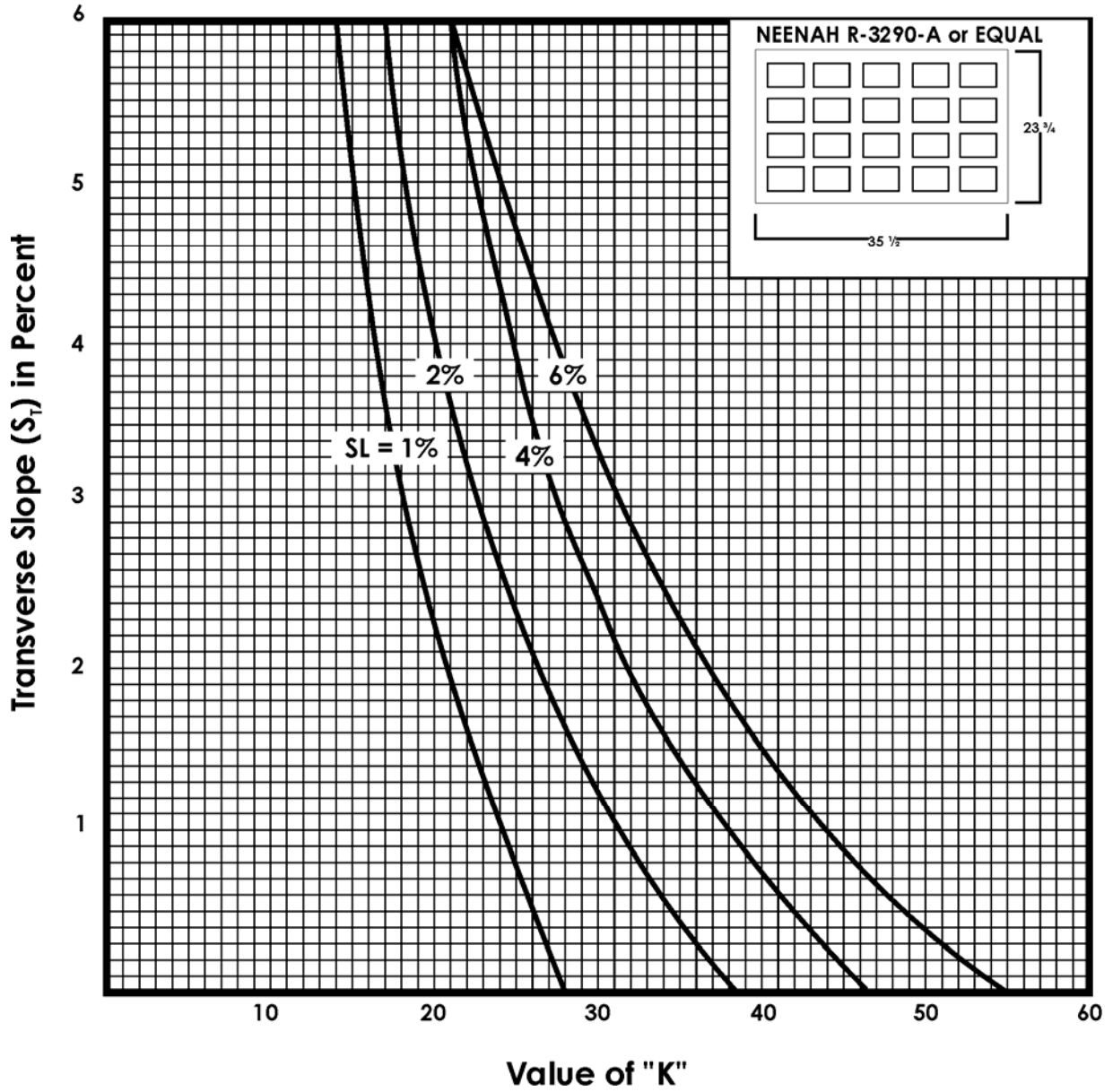
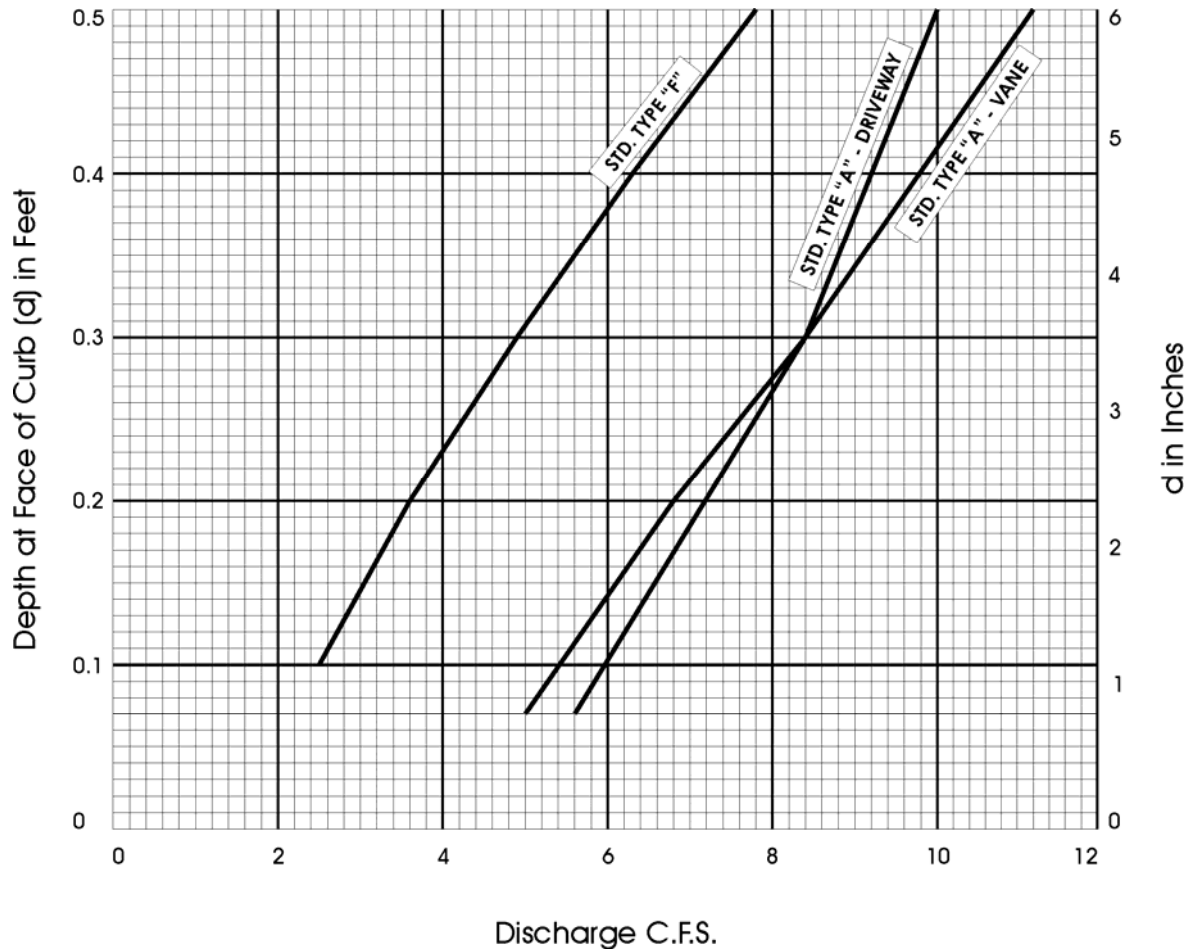


Figure 5: Capacity of Standard Single Type Intakes at a Low Point



Equations for above Curves

Std. M-F
 Std. M-A, M-B, M-C - Vane
 Std. M-A, M-B, M-C - Driveway

$$Q = 12h^{3/2}$$

$$Q = 8.44h^{1/2} + 8.25h^{3/2}$$

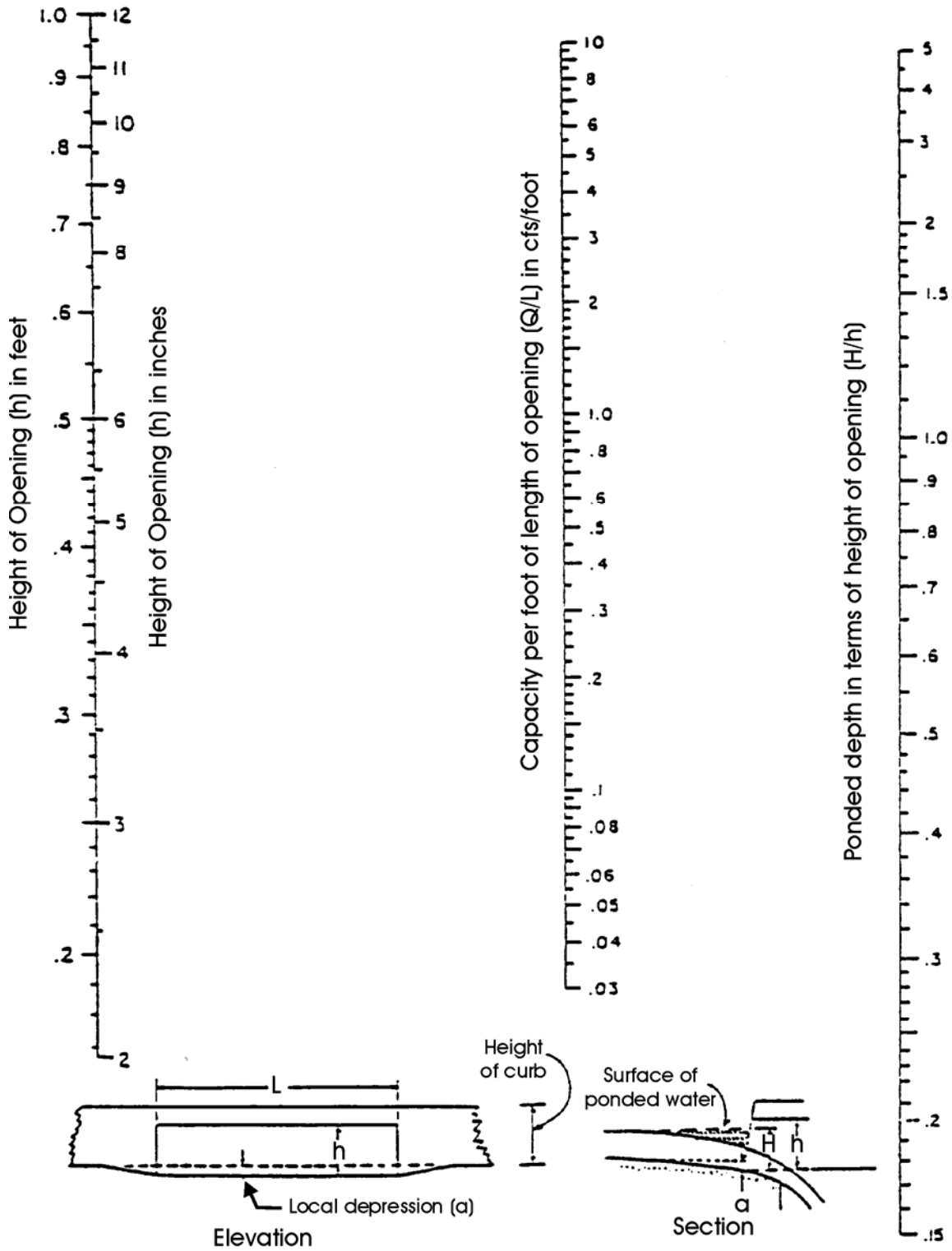
$$Q = 12.62h^{1/2}$$

where $H = D + A$ in feet

M-F $A = 3'' (0.25')$
 Vane $A = 2'' (0.167')$
 Driveway $A = 1.5'' (0.125')$

Note: For standard double intakes, take the values calculated for single intakes times two for "H" greater than 0.3 Foot.

Figure 6: Capacity of Curb Opening Intake at Low Point



F. Manhole and intake standards

1. Manhole standards to be utilized:

Type	Description	Use	
		Main Pipe Size	Typical Depth
M-A Fig. 6020.12	48" Min. Dia. Short Cone or Flat Top with Poured or Precast Base	See Table 1, Fig. 6020.12 for Max. Dia. Pipe	<7'
M-B Fig. 6020.13	Precast or Poured-in-Place Box with Precast or Poured-in-Place Base	24" or Greater	8' Max.
M-C Fig. 6020.14	Poured-in-Place Box with Poured-in-Place Base	12" Dia. or Greater	6' - 12'
M-D Fig. 6020.15	Combination 48" Dia. Short Cone with Poured-in-Place Barrel and Poured-in-Place Base	12" Dia. or Greater	12' - 22'
M-E Fig. 6020.16	48" Dia. Short Cone with T-Section	48" Dia. or Greater with eccentric reducer	8.5' Min.

2. Ring and cover standards to be utilized:

Type	Description	No. of Pieces	Bolted Frame	Bolt Cover	Gasketed
E ⁹ Fig. 6020.17	Standard	2	Yes	No	No
F ¹⁰ Fig. 6020.18	Adjustable	3	No	No	No
G ¹⁵ Fig. 6020.19	Machined Bearing Surfaces	2	No	No	No

⁹ Use when placed in earth fill, asphalt pavement, or HMA manhole boxout.

¹⁰ Use when placed in PCC pavement or PCC manhole boxout.

3. Intake standards to be utilized:

Intake Type	Standard	Conditions
Curb-Grate "M-A"	Single, poured 6" walls	Intake depth $\leq 7'$ (Pipe size: 18" max. on 2' side, 30" max. on 3' side)
Curb-Grate "M-B"	Single, precast walls	Intake depth $> 7'$ (Pipe size: 24" max.)
Curb-Grate (Combination) "M-C"	Single, poured 6" walls	Intake depth $\leq 7'$ (Pipe size: 30" max. on 3' side, 36" max. on 6' side)
Curb-Grate "M-D"	Double, poured 6" walls	Intake depth $\leq 7'$ (Pipe size: 18" max. on 2' side)
Curb-Grate (Combination) "M-E"	Double, poured 6" walls	Intake depth $\leq 7'$ (Pipe size: 30" max. on 3' side, 36" max on 6' side)
Curb Only "M-F"	Single open throat, poured 6" walls	Intake depth $\leq 10'$ (Pipe size: 30" max. on 3' side, 36" max. on 4' side) NOTE: Intake depth greater than 10' requires 8" poured wall.
Curb Only "M-F" (Modified)	Single open throat, poured 8" walls	Intake depth $> 10'$ (Pipe size: 36" max.)
Curb Only "M-I"	Double open throat, poured 6" reinforced walls	Intake depth $\leq 10'$ (Pipe size: 30" max. on 3' side) NOTE: Intake depth greater than 10' requires 8" poured wall.
Curb Only "M-I" (Modified)	Double open throat, poured 8" reinforced walls	Intake depth $> 10'$ (Pipe size: 36" max. on 4' side)
Ditch Intake "M-G"	Area Intake (side open intake) Poured 6" walls	Intake depth $\leq 7'$ (Pipe size varies on structure size)
Driveway or Alley Grate Intake "M-H"	Single (Surface Intake) Poured 6" walls	Intake depth $\leq 7'$

- Concrete poured walls are required for all other drainage structures. Cure time is required for poured wall intakes unless high early strength concrete is used, or concrete beams are taken. Upon approval of the Jurisdictional Engineer solid concrete block walls may be used on shallow structures when the depth from the gutter flowline to the pipe invert does not exceed 40 inches. Restrictions on the number of pipe connections and angle of entry may be imposed on solid concrete block intakes without combination manholes.
- Combination Intakes may be required if utility locations and/or pipe size show a need for the manhole. Intakes with combined manholes will be used when the size of the connecting pipes so indicate or when horizontal clearance is necessary behind the back of curb. The Design Engineer is encouraged to place intakes combined with manholes for storm sewers that are parallel to the street. This will prevent storm sewers from being installed under pavement and thus improves future maintenance access without removing pavement. Approval will be required by the Jurisdictional Engineer when storm sewers or footing drains parallel to the street are placed under the pavement.

G. Intake capacity design example

1. **Capacity of gutter for straight crown.** Figure 1 is the nomograph used to determine the gutter capacity for a straight crown or segmented straight crown. Figure 1 can also be used to approximate the capacity of curved crowns.

- a. **Given:**

- 1) 26' B/B Street
- 2) $S_L = 4.0\%$
- 3) $S_T = 2.0\%$
- 4) $n = 0.016$
- 5) $Q = 2.5$ cfs

- b. **Find:**

- 1) d = depth of flow
- 2) T = spread of water from face of curb

- c. **Steps:** (Use Figure 1)

- 1) Calculate the value of "Z" which is the reciprocal of the transverse slope (S_T). $Z = 1/S_T = 1/0.020 = 50$.
- 2) Calculate the ratio $Z/n = 50/0.016 = 3125$.
- 3) Connect the Z/n ratio (3125) and the channel slope ($S_L = 4.0\%$) with a straight line. This will give a point of intersection on the turning line.
- 4) Connect this point and the discharge (2.5 cfs) with a straight line and read the depth at the face of curb ($d = 0.158$) in feet.
- 5) Calculate the value of the spread using the equation:
 $T = Zd$
 $T = 50 (0.158) = 7.9$ feet

2. **Capacity of M-A, M-B, or M-C intake on a continuous grade.** The allowable capacity of a M-A, M-B, or M-C intake on a continuous grade will be determined by the following equation:

$$Q_I = K \left(d^{5/3} \right) (R_F)$$

Figure 3 is used to determine "K" for a vane grate and includes the curb hood. Figure 4 gives "K" for a driveway condition where no curb hood can be used. The appropriate reduction factor from Table 3 must then be applied to obtain the actual flow intercepted by the intake.

- a. **Given:** Street conditions as per “capacity of gutter for straight crown” example.

Design discharge	Q	= 145 cfs	[9]
Invert of pipe		= 94.50'	[2]
Starting water surface	W.S.	= 100'	[4]

Note: Number in brackets refers to the columns of Worksheet 2.

The pipe diameter needs to meet: 1) Low-flow cleaning velocity, 2) Slope for full flow, and 3) Surcharges in manhole or intake structures.

- b. **Find:** Flow intercepted by Standard Type "A" Intake (Q_I)

c. **Steps:**

- 1) Enter Figure 3 with the transverse slope ($S_T = 2.0\%$)
- 2) Extend horizontally to the appropriate curve for the longitudinal slope ($S_L = 4.0\%$); extend vertically downward and read the value of "K" equal to 23.9. The reduction factor for standard intake on continuous grade is 90% (from Table 3).

$$Q_I = K \left(d^{5/3} \right) (R_F)$$

$$Q_I = 23.9 \left(0.158^{5/3} \right) (0.90) = 0.99 \text{ cfs}$$

3. **Capacity of M-F or M-I intakes on a continuous grade.** Figure 2 is used to determine the interception ratio of the intake. This theoretical interception ratio (Q_I/Q) multiplied by the design flow in the gutter and the reduction factor equals the flow intercepted by the intake.

- a. **Given:** Street conditions as per “capacity of gutter for straight crown” example

- b. **Find:** Flow Intercepted by Standard Type “F” Intake (Q_I)

c. **Steps:**

- 1) Enter Figure 2 at the top left hand edge with the depth of flow d_w ($d_w = S_T(T-2)$) (0.118 feet).
- 2) Follow vertically down to the line representing Manning’s n (0.016). Move horizontally across until intersecting the line representing the longitudinal slope, S_L (0.04). Follow vertically down to the flow spread, T (7.9 feet). Construct a horizontal line from this point.
- 3) Next, enter the chart from the bottom with the length of the inlet opening (4 feet for a standard M-F intake). Extend a line vertically from this point to the horizontal line constructed at the intersection with the flow spread (T). Move diagonally to the line formed at $Q_I/Q=0.1$. Extend a line vertically to S_T (0.02), or line A, and then horizontally to Q_I/Q (0.29).

$$Q_I = \left(\frac{Q_I}{Q} \right) (Q) (R_F)$$

$$Q_I = (0.29)(2.5)(0.9) = 0.653 \text{ cfs}$$

4. **Capacity of M-A and M-F intakes at a low point.** Figure 5 is used to determine the capacity Q of a Standard Type M-A or M-F intake at a low point. The appropriate reduction factor must be applied to the results.

a. **Given:**

- 1) 26 feet B/B Street – Residential
- 2) S = 2% from East
- 3) S = 1% from West
- 4) Q = 4.5 cfs from East in each gutter
- 5) Q = 6 cfs from West in each gutter

b. **Find:** Q_I for Type M-A intake w/vane grate

c. **Steps:**

- 1) Enter Figure 5 with d-max for 26 feet B/B street (6 inches). Extend vertically downward from the Standard Type M-A vane grate curve and read the value of 11.4 cfs (or use equations provided).
 $Q_I = 11.4 (0.80) = 9.12 \text{ cfs} = Q_I \text{ maximum allowable.}$
- 2) Since Q_I is less than $Q_{\text{total}} = 4.5+6= 10.5 \text{ cfs}$, additional intakes must be constructed to intercept flow so that flooding beyond the allowable limit does not occur.

5. **Capacity of M-A intakes at a low point**

a. **Given:** $Q_{\text{total}} = 9 \text{ cfs}$

b. **Find:** d, if one Standard Type M-A intake is built.

c. **Steps:**

- 1) Calculate the actual flow in the gutter (if the intake is partially clogged) so that the intake will intercept 10 cfs.

$$Q = \frac{Q_I}{R_F} = \frac{9.0}{0.80} = 11.25 \text{ cfs}$$

- 2) Use equations shown in Figure 5 (or use curves)

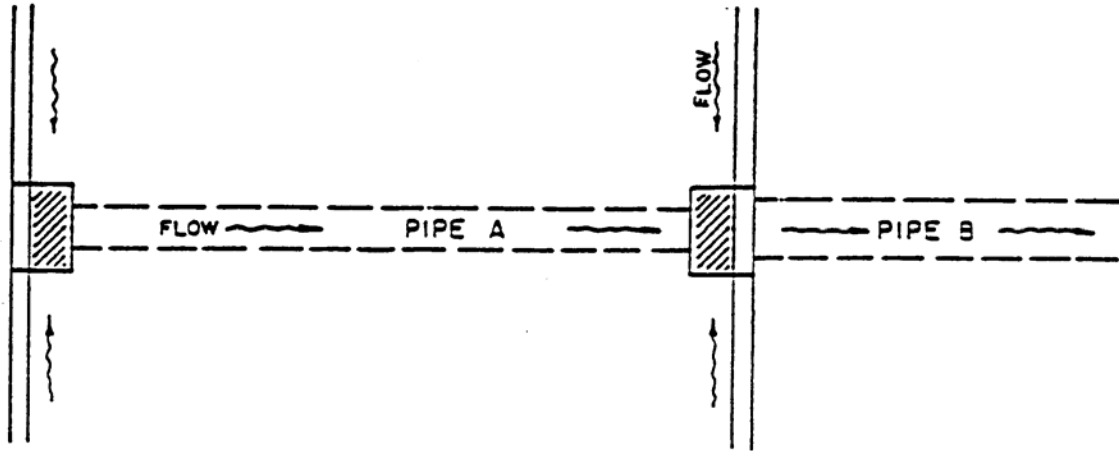
$$11.25 = 8.44 \left(H^{1/2} \right) + 8.25 \left(H^{3/2} \right) \text{ where } H = d + a$$

$$H = .66 \text{ ft.}$$

$$d = H - a = .66 - .17 = 0.49 \text{ ft.}$$

Figure 7: Pipe Standards at a Low Point for Standard Type “A” Intake

(Unless otherwise approved by the Jurisdictional Engineer, the following pipe sizes and grades will be the minimum allowable at low points. (Based on $n = 0.013$)



Minimum for Single Intakes

Pipe A	Pipe B
Q = 7.6 CFS	Q = 15.2 CFS
18" Pipe @ 1.0% (Minimum)	24" Pipe @ 0.46%
15" Pipe @ 1.5%	18" Pipe @ 2.23%
	15" Pipe @ 6.0%

Minimum Desirable for Single Intakes

Pipe A	Pipe B
Q = 11.8 CFS	Q = 23.6 CFS
18" Pipe @ 1.4%	24" @ 1.1%
15" Pipe @ 3.6%	18" @ 5.4%

Minimum for Double Intakes

Pipe A	Pipe B
Q = 15.2 CFS	Q = 30.4 CFS
24" Pipe @ 0.46%	30" Pipe @ 0.55%
18" Pipe @ 2.3%	24" Pipe @ 1.8%
15" Pipe @ 6.0%	18" Pipe @ 9.0%