Section 4

Storm Drain Inlets

4.01 General

The primary purpose of storm drain inlets is to intercept excess surface runoff and deposit it in a drainage system, thereby reducing the possibility of surface flooding.

The most common location for inlets is in streets which collect and channelize surface flow making it convenient to intercept. Because the primary purpose of streets is to carry vehicular traffic, inlets must be designed so as not to conflict with that purpose.

The following guidelines shall be used in the design of inlets to be located in streets:

1. Minimum transition for depressed inlets shall be 10 feet.

2. The use of inlets with a 3" depression is discouraged on collector, industrial and arterial streets unless the inlet is recessed.

3. When recessed inlets are used, they shall not interfere with the intended use of the sidewalk.

4. Design and location of inlets shall take into consideration pedestrian and bicycle traffic.

5. Inlet design and location must be compatible with the criteria established in Section 3 of this manual.

4.02 Classification

Inlets are classified into three major groups, namely: inlets in sags, and inlets on grade without gutter depression and inlets on grade with gutter depression. Each of the three major classes includes several varieties. The following are presented herein and are likely to find reasonably wide use. (See Table 4-1).

Inlets in Sags

(1) Curb Opening
(2) Grate
(3) Combination (Grate and Curb Opening)
(4) Drop
(5) Drop (grate Covering)

Inlets on Grade without Gutter Depression

(1) Curb Opening
(2) Grate
(3) Combination (Grate and Curb Opening)

Inlets on Grade with Gutter Depression

(1) Curb Opening
(2) Grate
(3) Combination (Grate and Curb Opening)

Engineering Department review of proposed drainage plans shall include an examination of the supporting computations. Computations must be submitted as part of the plans convenient for review and permanent record.

4.03 Inlets in Sags

Inlets in sags are inlets in low points of surface drainage to relieve ponding. Inlets with a 5" depression located in streets of less than one percent (1.0%) grade, shall be considered inlets in sags. The capacity of inlets in sags must be known in order to determine the depth and width of ponding for a given discharge. The charts in this section may be used in the design of any inlet in a sag regardless of its depth of depression.

A. Curb Opening Inlets and Drop Inlets

General. Unsubmerged curb opening inlets and drop inlets in sag or low point are considered to function as rectangular weirs with a coefficient of discharge of 3.0. their capacity shall be based on the following equation:

$$Q = 3.0 y^{3/2} L$$

Q = Capacity in cfs of curb opening inlet or capacity in cfs of drop inlet

y = Head at the inlet in feet

L = Length of opening through which water enters the inlet

Where the depth of water is such that the curb inlet is completely submerged the proper orifice formula should be used in determining the discharge rather than the wier formula. Although this is a very rare condition, as the proportioning of inlets should be such as to preclude ponding in sufficient depth to submerge the inlet.

The capacity of a low point inlet shall be determined by use of figure 4-1.

B. Grate Inlets

General. The flow of water through grate openings may be treated in the same manner as flow of water through rectangular orifices. The formula in most general use for flow through orifices is stated as follows:

$$Q = C\,A\sqrt{(2gh)}$$

where

Q = the discharge in cubic feet per second

C = the coefficient of discharge (approximately 0.7)

A = the area of orifice (the net area of the openings in the grate) in square feet

g = acceleration due to gravity 32.2 feet per second^2

h = head on grate in feet

This formula gives the theoretical capacity of the grate inlet. Since grate inlets are subject to considerable clogging, it is recommended that for practical purposes, the capacity of the grate inlet be taken as 1/2 of the value given by this formula, or conversely that the net area of the grate be twice as large as the theoretical area required when calculated by the above formula.

C. Combination Inlets

The capacity of a combination inlet consisting of a grate and curb opening inlet in a sag shall be considered to be the sum of the capacities of a combination inlet shall be considered to be 50 percent of the sum of the capacities as determined for a curb openings inlet and a grate inlet without (allowing for reduction due to clogging). When the capacity of the gutter is not exceeded, the grate inlet accepts the major portion f the flow. Under severe flooding

conditions, however, the curb inlet will accept most of the flow since its capacity varies with $y^{3/2}$ whereas the capacity of the grate inlet varies as $y^{1/2}$.

The capacity of a combination inlet shall be considered to be 50 percent of the sum of the capacities as determined for a curb opening inlet and a grate inlet (without allowing for reduction due to clogging).

4.04 Inlets On Grade Without Gutter Depression

A. Curb Opening Inlets (Undepressed)

General. The capacity of a curb inlet, like any weir, depends upon the head and length of overfall. In the case of an undepressed curb opening inlet, the head at the upstream end of the opening is the depth of flow in the gutter. In streets where grades are greater than 1 percent the velocities are high and the depths of flow are usually small as there is little time to develop cross flow into the curb openings; therefore, undepressed inlets are inefficient when used in streets of appreciable slope, but may be used satisfactorily where the grade is low and the crown slope high or the gutter channelized. Undepressed inlets do not interfere with traffic and usually are not susceptible to clogging.

The capacity of an undepressed inlet shall be determined by use of figures 4-2 and 4-3.

B. Grate Inlets on Grade (Undepressed)

General. Undepressed grate inlets on grade have a greater hydraulic capacity than curb inlets of the same length so long as they remain unclogged. Undepressed grate inlets on grade are inefficient in comparison to grate inlets in sags.

Grates with bars parallel to the curb should always be used for the above described installations because transverse framing bars create splash which causes the water to jump or ride over the grate. Grates used shall be certified by the manufacturer as bicycle-safe. For flows on streets with grades less than one percent, little or no splashing occurs regardless of the direction of bars.

Grate inlets in depression have a tendency to clog when gutter flows carry debris such as leaves and papers. For this reason the calculated inlet shall be reduced by 50 percent to allow for clogging.

All points of concentration from offsite drainage shall be picked up by inlet or headwall before flow enters the street or crosses the sidewalk.

C. Combination Inlets on Grade (Undepressed)

General. Undepressed combination (curb opening and grate) inlets on grade have greater hydraulic capacity than curb inlets or grate inlets of the same length. Generally speaking, combination inlets are the most efficient of the three types of undepressed inlets presented in this manual. Grates with bars parallel to the curb should always be used. The basic difference between a combination inlet and a grate inlet is that the curb opening receives the carry-over flow that falls between the curb and the grate.

The capacity of a combination inlet shall be considered to be 50 percent of the sum of the capacities as determined for a curb opening inlet and a grate inlet (without allowing for reduction due to clogging).

4.05 Inlets On Grade With Gutter Depression

A. Curb Opening Inlets on Grade (Depressed)

General. The depression of the gutter at a curb opening inlet below the normal level of the gutter increases the cross-flow toward the opening, thereby increasing the inlet capacity. Also, the downstream transition out of the depression causes backwater which further increases the amount of water captured. Depressed inlets should be used on continuous grades that exceed one percent except that their use in traffic lanes shall conform with requirements of Section 3 of this manual.

The depression depth, width, length and shape all have significant effects on the capacity of an inlet. References to Section 3 of this manual must be made for permissible gutter depressions.

The capacity of a depressed inlet shall be determined by use of figures 4-2 and 4-3.

B. Grate Inlets on Grade (Depressed)

General. The depression of the gutter at a grate inlet decreases the flow past the outside of a grate. The effect is the same as that when a curb inlet is depressed, namely the cross slope of the street directs the outer portion of flow toward the grate.

The bar arrangements for depressed grate inlets on streets with grades greater than one percent greatly effects the efficiency of the inlet. Grates with longitudinal bars eliminate splash which causes the water to jump and ride over the cross bar grates, and it is recommended that grates have a minimum of transverse or crossbars for strength and spacing only.

For low flows or for streets with grades less than one percent, little or no splashing occurs regardless of the direction of bars. However, as the flow or street grade increases, the grate with longitudinal bars becomes progressively more superior to the cross bar grate. A few small rounded cross bars, installed at the bottom of the longitudinal bars as stiffeners or a safety stop for bicycle wheels, do not materially affect the hydraulic capacity of longitudinal bar grates.

Grate inlets in depression have a tendency to clog when gutter flows carry debris such as leaves and papers. For this reason the calculated inlet shall be reduced by 50 percent to allow for clogging.

C. Combination Inlets on Grade (Depressed)

General. Depressed combination inlets (curb opening plus grate) have greater hydraulic capacity than curb opening inlets or grate inlets of the same length. Generally speaking, combination inlets are the most efficient of the three types of depressed inlets presented in this manual. Grates with bars paralleled to the curb should always be used for maximum efficiency. The basic difference between a combination inlet and a grate inlet is that the curb opening receives the carry-over flow that passes between the curb and the grate.

The depression depth, width,length and shape all have significant effects on the capacity of any inlet. Reference to Section 3 of this manual must be made for permissible gutter depressions.

The capacity of a combination inlet shall be considered to be 50 percent of the sum of the capacities as determined for a curb opening inlet and a grate inlet (without allowing for reduction due to clogging).

TABLE 4–1

STORM DRAIN INLETS

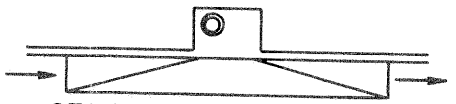
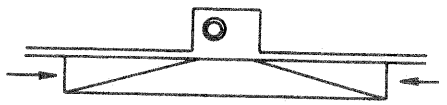
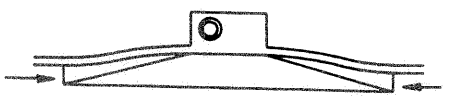
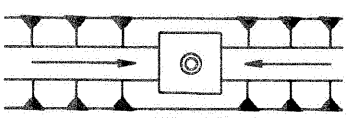
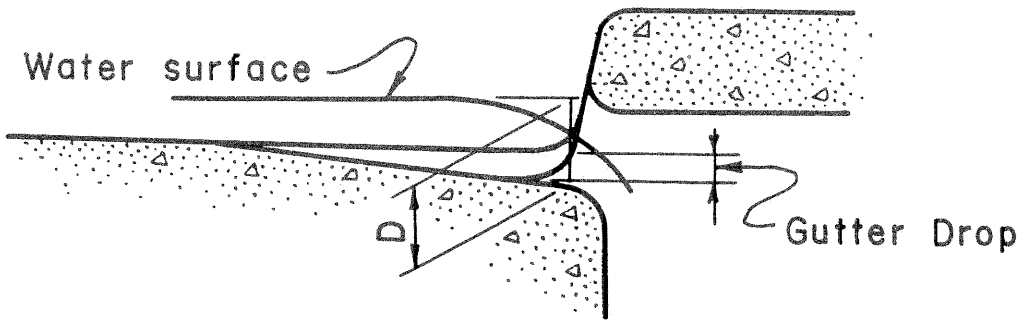
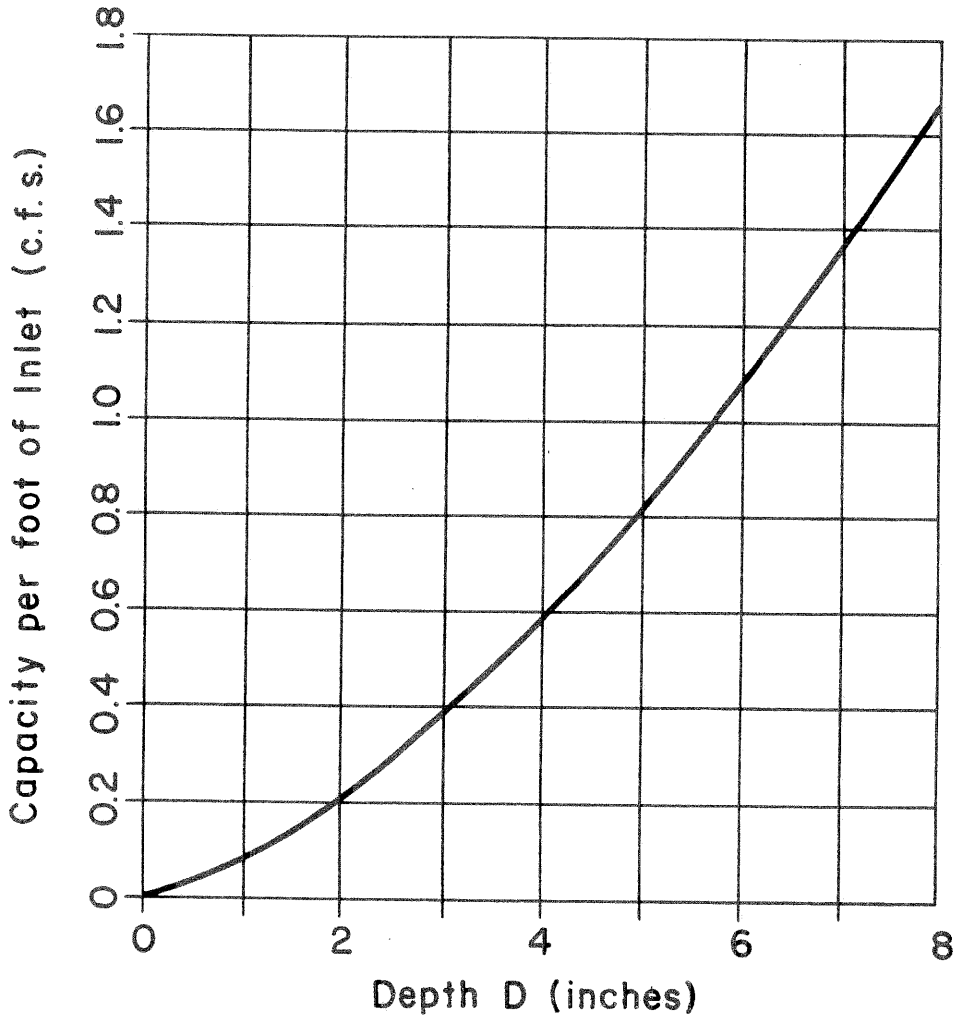
INLET DESCRIPTION	AVAIL. INLET SIZES	
 STANDARD CURB OPENING INLET ON GRADE	5' 10'	Residential Street
 STANDARD CURB OPENING INLET AT LOW POINT	5' 10'	Residential Street
 RECESSED CURB OPENING INLET ON GRADE	5' 10'	Collector Streets Minor Arterials Primary Arterials
 RECESSED CURB OPENING INLET AT LOW POINT	5' 10'	Collector Streets Minor Arterials Primary Arterials

Table 4–1 Continued

INLET DESCRIPTION	AVAIL. INLET SIZES	
 COMBINATION INLET ON GRADE	5' 10'	Combination Inlets to be Used Where Space Behind Curb Prohibits Other Inlets
 COMBINATION INLET AT LOW POINT	5' 10'	Combination Inlets to be Used Where Space Behind Curb Prohibits Other Inlets
 COMBINATION RECESSED INLET ON GRADE	5' 10'	Collector Streets Minor Arterials Primary Arterials
 COMBINATION RECESSED INLET AT LOW POINT	5' 10'	Collector Streets Minor Arterials Primary Arterials
 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.
 DROP INLET	2' x 2' 3' x 3' 4' x 4'	Open Channels



SECTION



INLET CAPACITY FOR LOW POINT INLETS

Figure 4-1

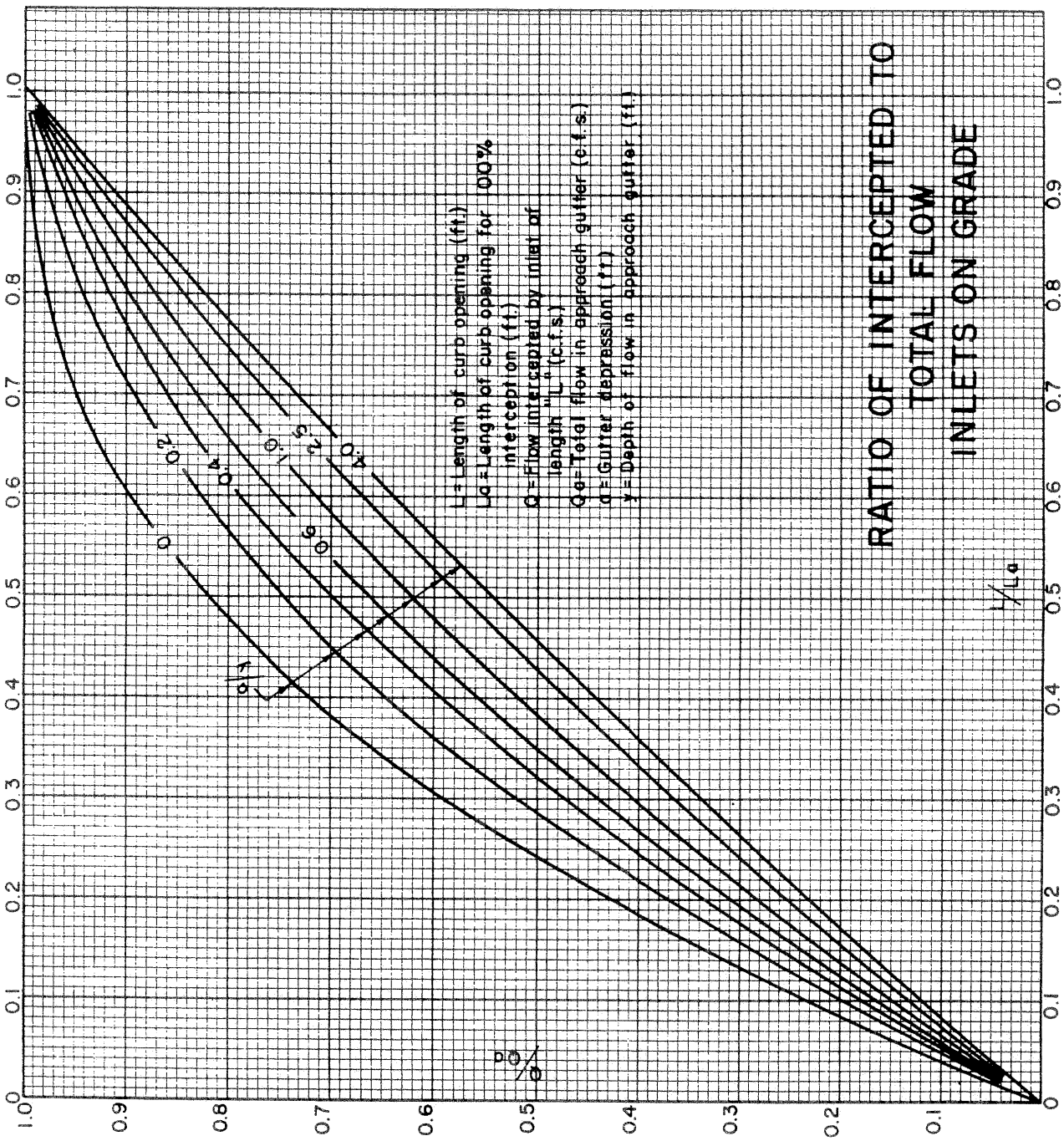

RATIO OF INTERCEPTED TO TOTAL FLOW
INLETS ON GRADE
L=Length of curb opening (ft.)
La=Length of curb opening for 100% interception (ft.)
Q=Flow intercepted by inlet of length "L" (c.f.s.)
Qa=Total flow in approach gutter (c.f.s.)
a=Gutter depression (ft.)
y=Depth of flow in approach gutter (ft.)
Q/Qa
L/La
a/y
0
0.2
0.4
0.6
0.8
1.0
1.5
2.0

Figure 4-2

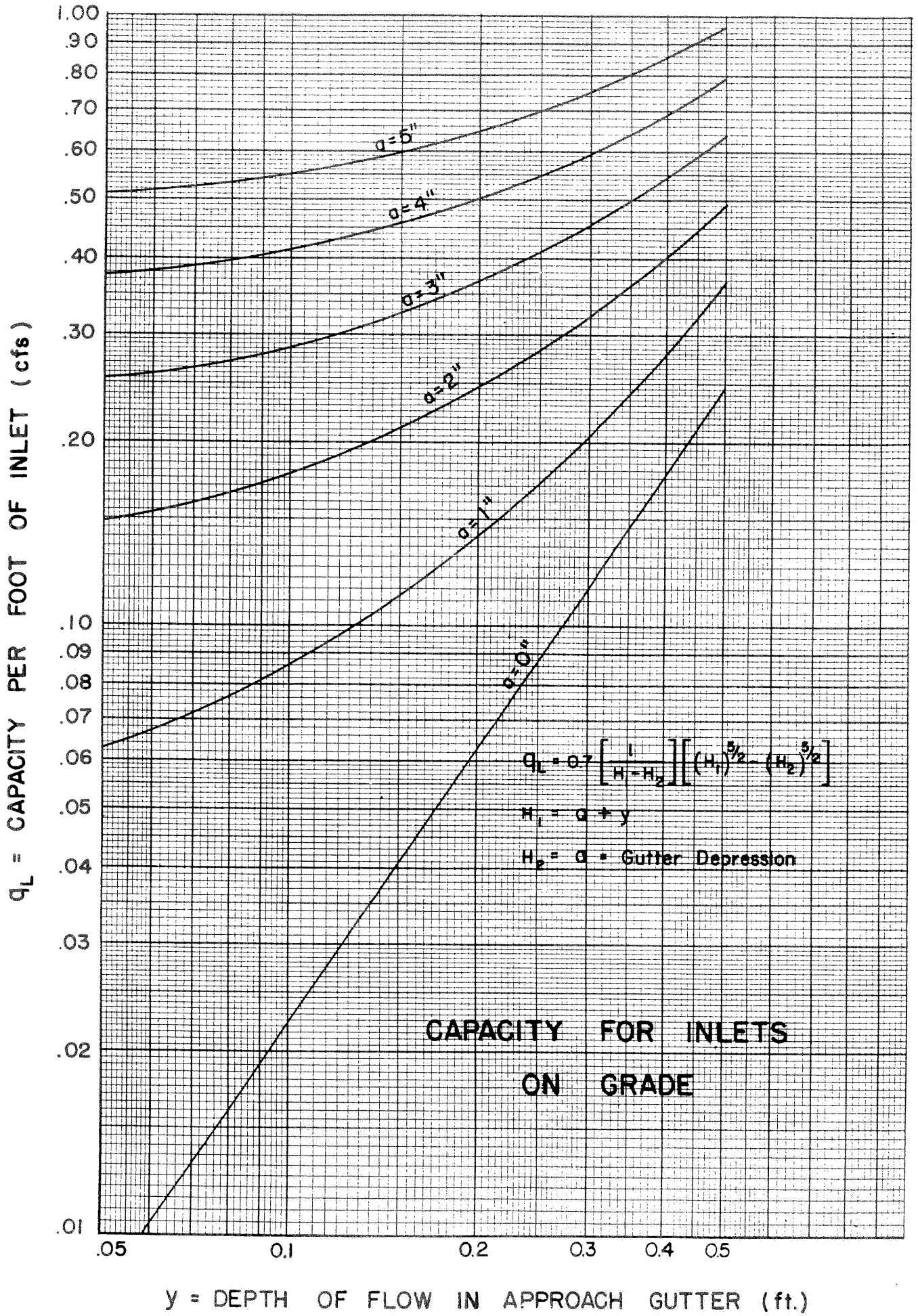

1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
q = 5"
q = 4"
q = 3"
q = 2"
q = 1"
q = 0"
$q_L = 0.7 \left[\frac{I}{H_1 - H_2}\right]\left[(H_1)^{5/2} - (H_2)^{5/2}\right]$
H_1 = q + y
H_2 = q + Gutter Depression
CAPACITY FOR INLETS ON GRADE
q_L = CAPACITY PER FOOT OF INLET (cfs)
.05
0.1
0.2
0.3
0.4
0.5
y = DEPTH OF FLOW IN APPROACH GUTTER (ft.)

Figure 4-3