# SECTION 9
# STORM SEWER INLETS

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## 9.1 INTRODUCTION

There are three types of inlets: curb opening, grated, and combination inlets. Inlets are further classified as being "continuous grade" or “sump”. The term "continuous grade" refers to an inlet located such that the grade of the street has a continuous slope past the inlet and, therefore, ponding does not occur at the inlet. The “sump” condition exists whenever the inlet is located at a low point. A “sump” condition can occur at a change in grade of the street from positive to negative or at an intersection due to the crown slope of a cross street.

The criteria and methodology for the design and evaluation of storm sewer inlets in the CITY are presented in this section. Except as modified herein, all storm sewer inlet criteria shall be in accordance with the MANUAL.

## 9.2 STANDARD INLETS

The standard inlets permitted for use in the CITY are:

| INLET TYPE | PERMITTED USE |
|---|---|
| Curb Opening Inlet<br>Type R | All street types.<br>Minimum inlet length is 5 feet |
| Grated Inlet<br>Type C | All streets with a roadside median ditch.<br>Private areas where pedestrian use is limited. |
| Grated Inlet<br>Type 13 | Private areas with a valley gutter only.<br>Must use a “Bicycle Safe” grate. |
| Combination Inlet<br>Type 13 | Private areas only.<br>Must use a "Bicycle Safe" grate. |

## 9.3 INLET HYDRAULICS

The procedures and basic data used to define the capacities of the standard inlets under various flow conditions were obtained from the MANUAL and Reference 11 for curb opening inlets. The procedure consists of defining the amount and depth of flow in the street gutter and determining the theoretical flow interception by the inlet. To account for the effects which decrease the capacity of the inlets such as debris plugging, pavement overlaying, and variations in design assumptions, the theoretical capacity calculated is reduced to the allowable capacity.

Allowable inlet capacities for the standard inlets have been developed and are presented in Figures 901, 902, and 903 for the "continuous grade" condition and Figure 904 for the “sump” condition. These nomographs already include the capacity reduction factors. The allowable inlet capacity is compatible with the allowable street capacity discussed in Section 10. The values shown on the figures were calculated based on the maximum flow allowed in the street gutter or roadside ditch. For gutter flow amounts less than the maximum allowable street flow, the allowable inlet capacity must be proportionately reduced. Table 901 shall be included in the Phase II and Phase III drainage reports. The table is provided to assist in calculating the required inlet type, sizing, and carry-over flow.

### 9.3.1 Continuous Grade Condition

For the "continuous grade" condition, the capacity of the inlet is dependent upon many factors including gutter slope, depth of flow in the gutter, height and length of the curb opening, street cross-slope, and the amount of depression at the inlet. In the “continuous grade” condition, not all of the gutter flow will be intercepted by the inlet. A portion of the gutter flow will continue past the inlet area and is referred to as carryover flow. The amount of carryover flow must be included in the drainage facility evaluation as well as in the design of the inlet.

The use of Figures 902 and 904 is illustrated by the following example:

EXAMPLE 1: DESIGN OF TYPE R CURB OPENING INLETS

| | | |
|---|---|---|
| Given: | Arterial street | Type C |
| | Longitudinal slope | 1.0 percent |
| | Maximum flow depth | 0.5 feet (refer to Section 10) |
| | Maximum allowable gutter capacity | 11.0 cfs (refer to Section 10) |
| | Starting gutter flow ($Q_L$) | 8.0 cfs |
| | Minor storm design event | |

Find: Interception and carryover amounts for the inlets #1 and #2 illustrated on Figure 905.

Procedure:

As shown on Figure 905, inlets #1 and #2 are in a “continuous grade” condition and inlet #3 is in a “sump” condition. The size of the inlet required for the sump condition is discussed in Example 2.

Step 1:

From Figure 902 for an allowable flow depth of 0.50 feet and a 15-foot Type R inlet, the allowable inlet capacity is 8.6 cfs. Note that even though the actual gutter flow is less than maximum allowable gutter flow, the maximum allowable flow depth is used for Figure 902.

The effect of the lower gutter flow depth on the inlet capacity will be accounted for in the following steps.

Step 2:

Compute the interception ratio R:

$$R = \frac{\text{Allowable Inlet Capacity}}{\text{Allowable Street Capacity}} = \frac{8.6 \text{ cfs}}{11\text{cfs}} = 0.78$$

Step 3:

Compute the interception amount $Q_I$:

$Q_I = R \times Q_{street} = 0.78 \times 8.0$ cfs
$Q_I = 6.2$ cfs amount intercepted by inlet

Step 4:

Compute the carryover amount $Q_{CO}$:

$Q_{CO} = Q$ street – $Q_I = 8.0$ cfs - 6.2 cfs
$Q_{CO} = 1.8$ cfs

Step 5:

Compute the total flow at inlet #2, which is the sum of the carryover flow (Qco) from inlet #1 plus the local runoff to inlet #2:

$Q_T$ (inlet #2) = $Q_{CO}$ (inlet #1) + $Q_L$ (inlet #2) = 1.8 cfs + 4 cfs
$Q_T$ (inlet #2) = 5.8 cfs

Step 6:

Compute the interception ratio, intercepted amount, and carryover flow for inlet #2 (10-foot Type R) using the procedure described in Steps 1 through 4:

Allowable inlet capacity = 7.2 cfs from Figure 902
R = (7.2 cfs) / (11.0 cfs) = 0.65
$Q_I$ (inlet #2) = (0.65)(5.8 cfs) = 3.8 cfs
$Q_{CO}$ (inlet #2) = 5.8 cfs - 3.8 cfs = 2.0 cfs

Step 7:

Compute the flow to inlet #3 using the procedure described in Step 5:

$$Q_T \text{ (inlet \#3)} = 8 \text{ cfs} + 2.0 \text{ cfs} = 10.0 \text{ cfs}$$

Step 8:

Size inlet #3, which is in a "sump" condition using the procedures described in the following example.

### 9.3.2 Sump Condition

The capacity of an inlet in a "sump" condition is dependent on the depth of ponding at the inlet. Typically, the inlet design consists of estimating the number of inlets or depth of flow required to intercept a given flow amount. The use of Figure 904 is illustrated by the following example:

EXAMPLE 2: ALLOWABLE CAPACITY FOR TYPE R INLET IN A SUMP

| | | | |
|---|---|---|---|
| Given: | Total street flow at inlet #3 | 10.0 cfs | from Example 1 |
| | Arterial street | Type C | |
| | Longitudinal slope | 1.0 % | |
| | Maximum allowable street depth | 0.50 feet | |
| | Type R inlet | double | |

Find: Depth of ponding at inlet #3

Procedure:

Step 1:

From Figure 904, the depth of ponding (D) for a double Type R inlet at a gutter flow of 10.0 cfs is 0.49 feet.

Step 2:

Compare the computed depth to the allowable flow depth. Since the computed depth is less than the allowable depth, the inlet is acceptable. Otherwise, the width of the inlet or the type of inlet would need to be changed and the depth of ponding procedure repeated.

## *9.4 INLET SPACING*

The optimum spacing of storm inlets is dependent upon several factors including traffic requirements, contributing land use, street slope and capacity, amount of flow bypassed at the upstream inlet, and distance to the nearest outfall system. The suggested sizing and spacing of the inlets is based upon the interception rate of 70% to 80%. This spacing has been found to be more efficient than a spacing using a 100% interception rate. Using the suggested spacing, only the most downstream inlet in a development would be designed to intercept 100% of the flow. Also, considerable improvements in the overall inlet system efficiency can be achieved if the inlets are located in the sumps created by street intersections.

A comparison of the inlet capacity with the allowable street capacity (refer to Section 10) will show that the percent of flow interception by the inlets varies from less than 50% to as much as 95% of the allowable street capacity. Therefore, the optimum inlet spacing cannot be achieved in all instances.

The following example illustrates how inlet sizing and interception capacity may be analyzed:

EXAMPLE 3: INLET SPACING

| | | |
|---|---|---|
| Given: | Maximum allowable street flow depth | 0.48 ft. |
| | Street slope | 1.0 % |
| | Maximum allowable gutter flow | 11.0 cfs |
| | Actual gutter flow | 11.0 cfs |
| | Minor design storm event | |

Find: Size and type of inlet for a 75% interception rate

Procedure:

Step 1:

Compute the desired interception capacity:

$$Q = (0.75)\ (11.0 \text{ cfs}) = 8.3 \text{ cfs}$$

Step 2:

Since the actual gutter flow equals the maximum allowable gutter flow, the inlet capacity is not reduced due to the depth of flow in the street. Using Figure 902, the allowable inlet capacities for various inlet lengths were obtained:

| Inlet type | Capacity | % interception |
|---|---|---|
| Double Type R | 6.5 cfs | 59 |
| Triple Type R | 7.7 cfs | 70 |

Thus, a 15-foot Type R inlet is required and will intercept 7.7 cfs. The carryover flow of 3.3 cfs will continue downstream and contribute to the next inlet.

## *9.5 CHECKLIST*

To aid the designer and reviewer, the following checklist has been prepared:

1. Place the inlets on the flattest street grades or in sump conditions to increase inlet interception capacity.

2. Space inlets based upon the interception rate of 70% to 80% of the actual gutter flow to optimize inlet capacity.

3. Reduce the inlet interception capacity due to the actual depth of flow in the gutter.

4. Check the actual inlet capacity to determine the carryover flow. Account for the carryover flow plus the local runoff in the sizing of the next downstream inlet.

5. Verify the storm inlets behavior during both the major and minor storm events.

6. Include Table 901 in the drainage report for both the major and minor storm.

# Table 901
# Inlet Design Information

Design Storm = ______________

| Inlet Designation | Contributing Design Pt or Subbasin Designation | Street Slope or Sump | Inlet Size and Type | Street Type (A, B, C) | Maximum Allowable Depth of Flow in Street | Maximum Allowable Inlet Capacity | Maximum Allowable Gutter Capacity | $Q_{CO}$ | $Q_{STREET}$ | $Q_{TOTAL}$ | Inlet Reduction Ratio | Actual Inlet Capacity $Q_{DESIGN}$ | Inlet Capture $Q_{INLET}$ | $Q_{CO}$ | Inlet receiving $Q_{co}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (ft) | (cfs) | (cfs) | (cfs) | (cfs) | (cfs) | | (cfs) | (cfs) | (cfs) | |
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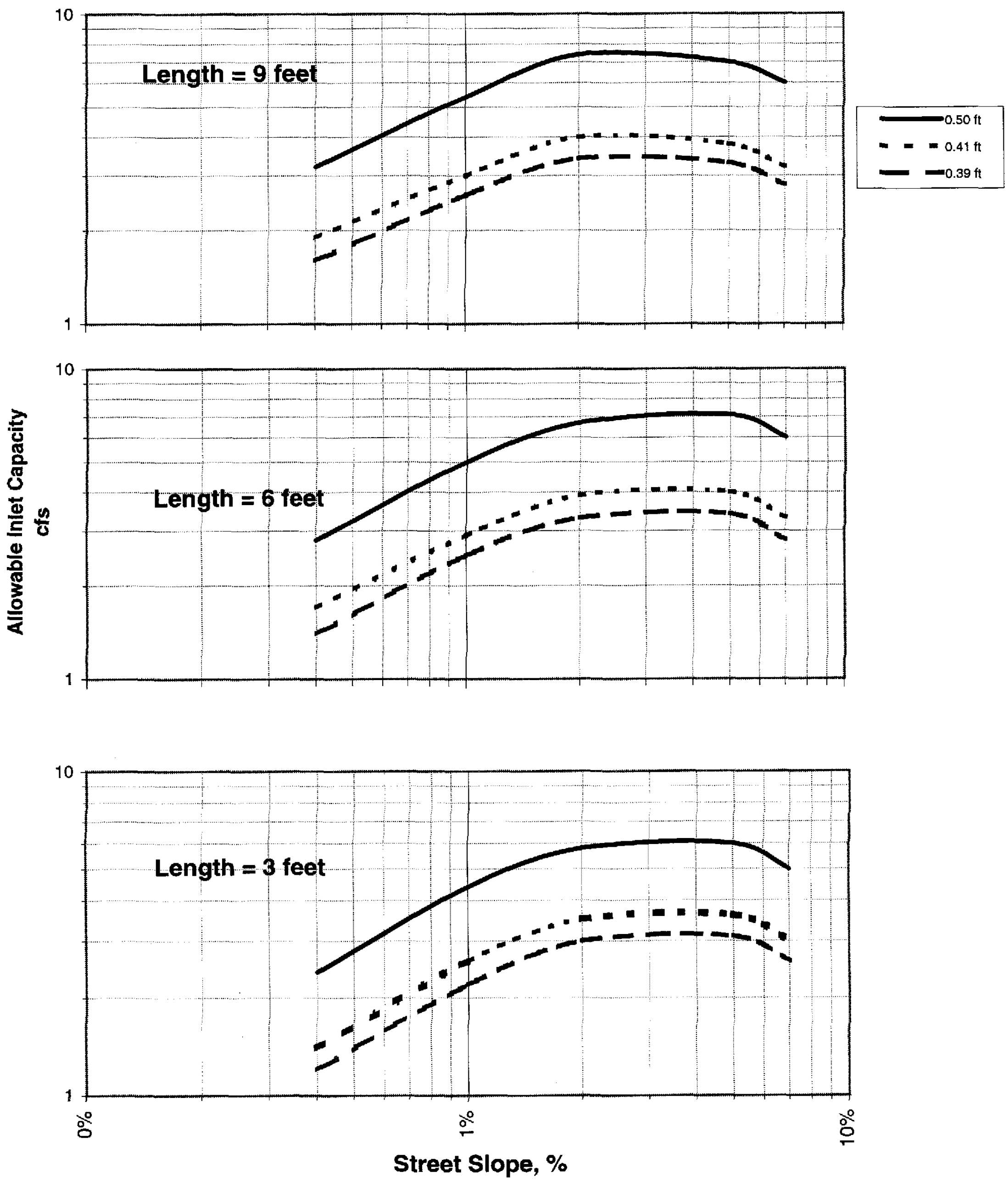
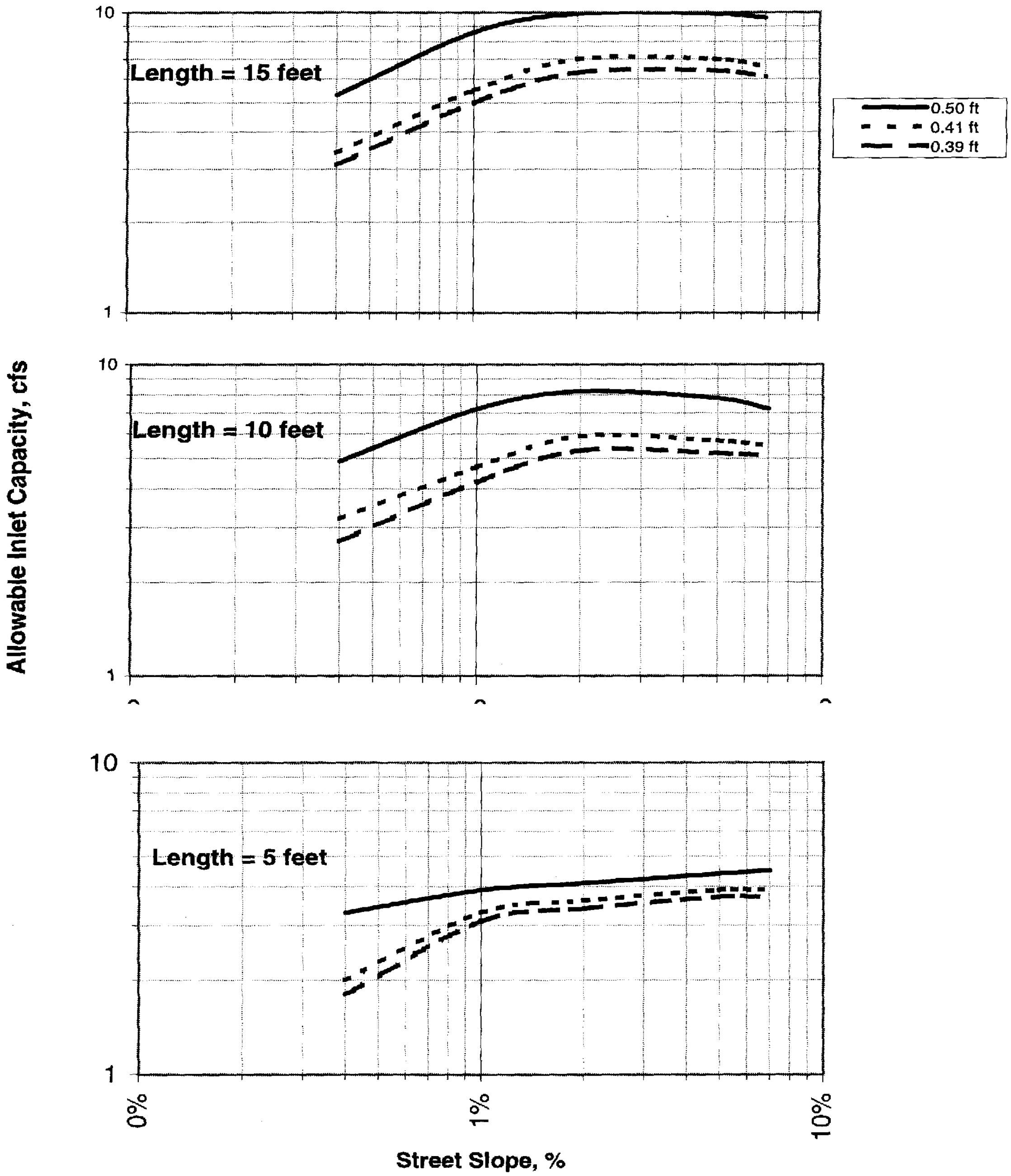
**Figure 901**
**Allowable Inlet Capacity**
**Type 13 Combination on Continuous Grade**




1. Allowable capacity = 66% of theoretical capacity.
2. Maximum inlet capacity at maximum allowable street flow depth. Proportionally reduce capacity for other depths.
3. Residential, Major Collector, Major Arterial (6 lanes) – 0.50 ft; Major Arterial (4 lanes), Minor Arterial – 0.41 ft; Minor Collector – 0.37 ft

Reference: WRC Engineering, Inc., TM-1, February 1989

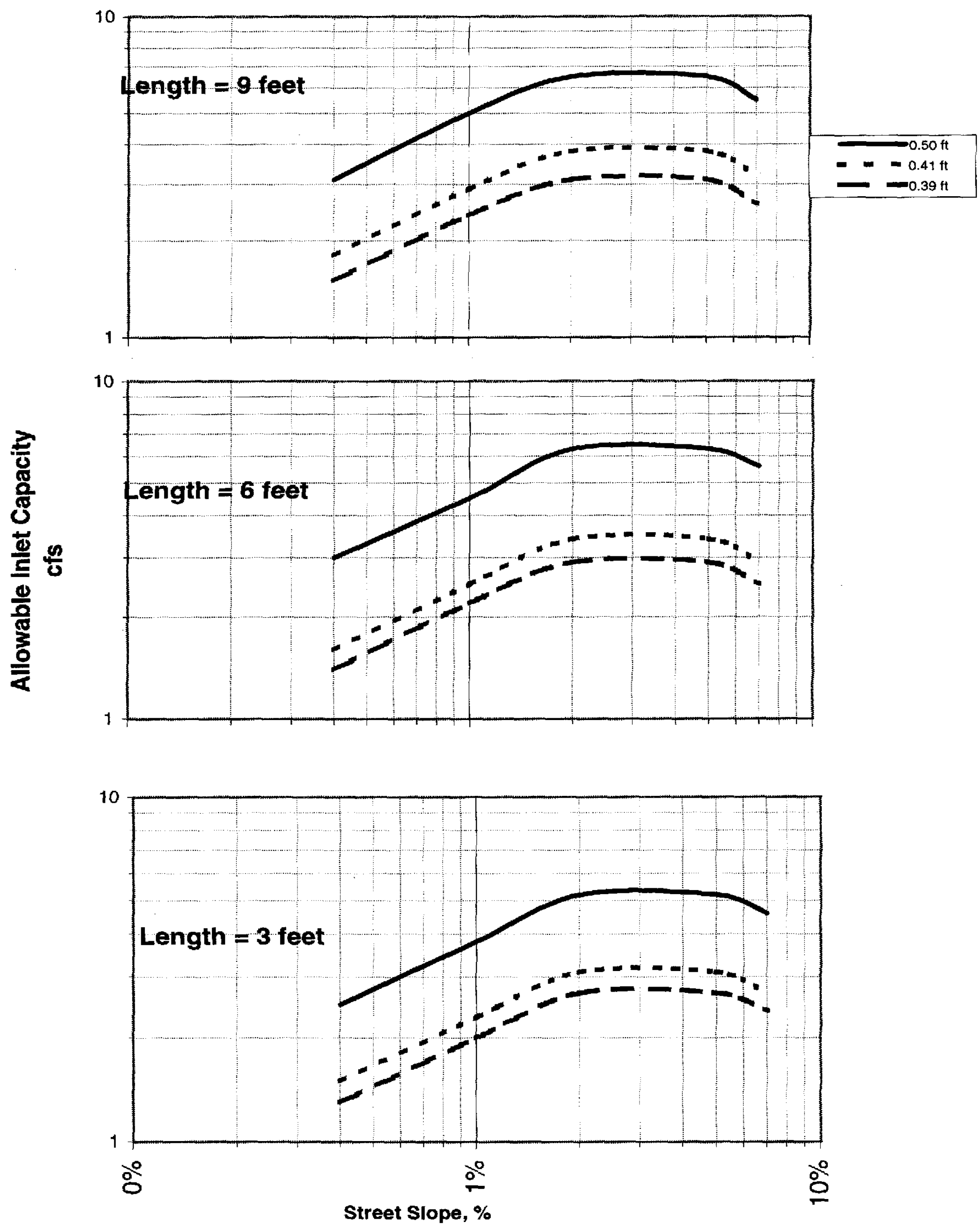
Figure 902
Allowable Inlet Capacity
Type R on a Continuous Grade




1. Maximum inlet capacity at maximum allowable flow depth in street. Proportionally reduce for other depths.
2. Allowable Capacity = 88% of theoretical capacity for L = 5 feet, 92% for L = 10 feet, and 95% for L = 15 feet
3. Interpolate for other inlet lengths
4. Residential, Major Collector, Major Arterial (6 lanes) – 0.50 ft; Major Arterial (4 lanes), Minor Arterial – 0.41 ft; Minor Collector – 0.37 ft

Reference:  WRC Engineering, Inc., TM-1, February 1989

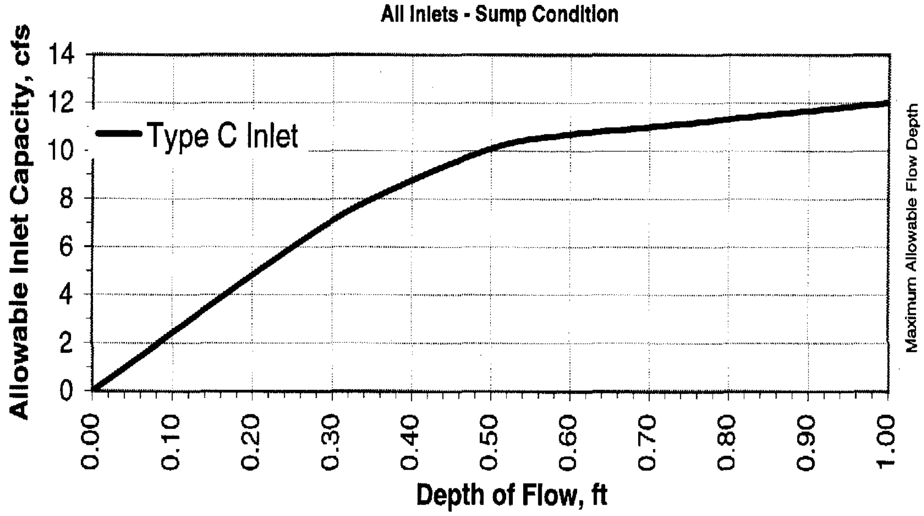
**Figure 903**
**Allowable Inlet Capacity**
**Type 13 Grated on a Continuous Grade**

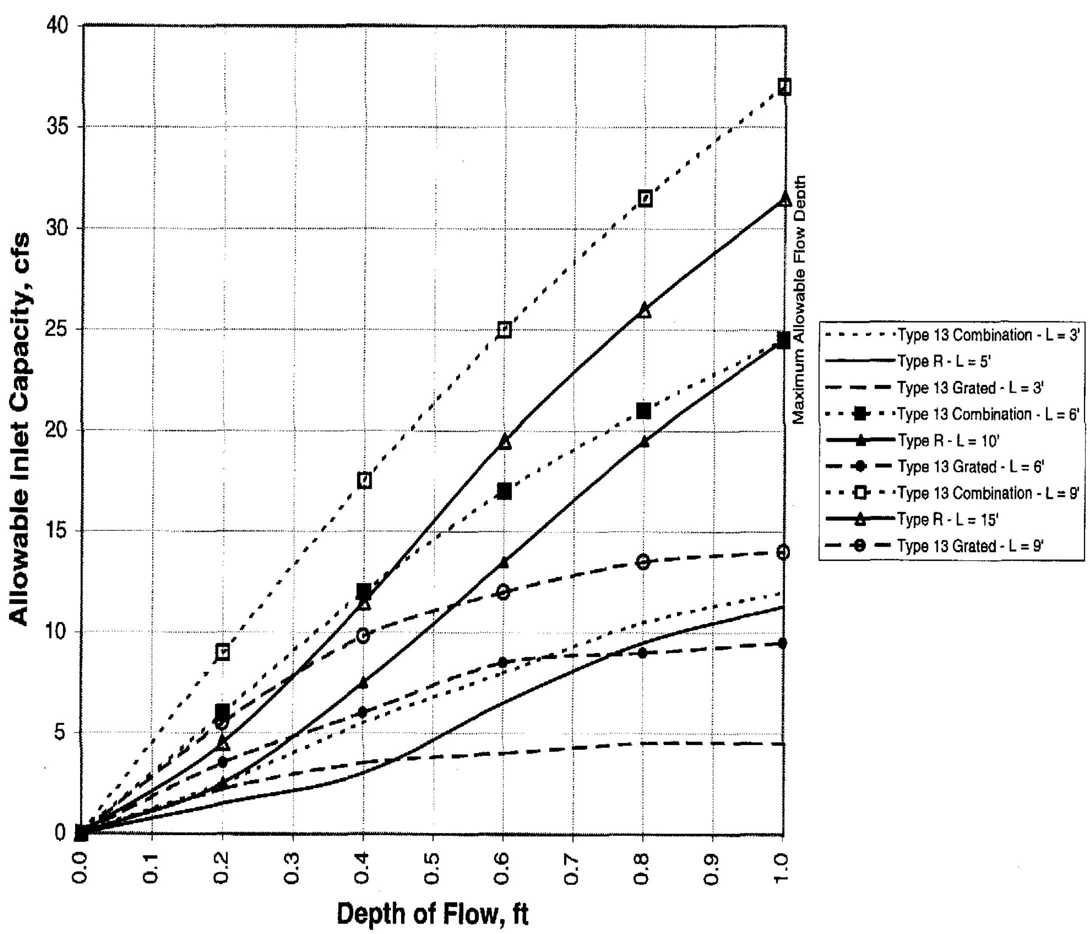



1. Allowable capacity = 60% of theoretical capacity
2. Maximum inlet capacity at maximum allowable street flow depth. Proportionally reduce capacity for other flow depths.
3. Residential, Major Collector, Major Arterial (6 lanes) – 0.50 ft; Major Arterial (4 lanes), Minor Arterial – 0.41 ft; Minor Collector – 0.37 ft

Reference: WRC Engineering, Inc., TM-1, February 1989

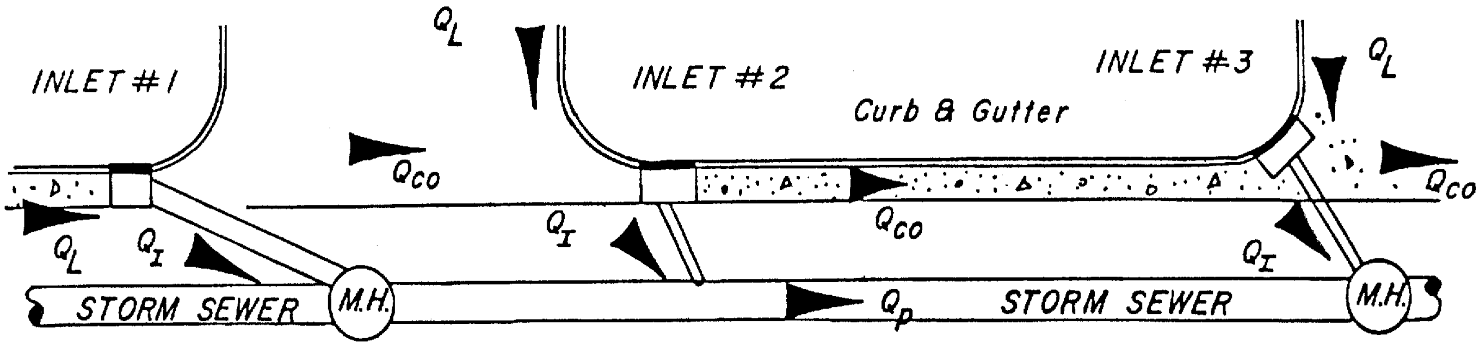
**Figure 904**
**Allowable Inlet Capacity**
**All Inlets - Sump Condition**




Reference: WRC Engineering, Inc., TM-1, February 1989

Figure 905
Design Example for Inlet




LEGEND

- $Q_L$ = Local runoff for design storm tributary to designated inlet (cfs)
- $Q_I$ = Runoff intercepted by inlet (cfs)
- $Q_{CO}$ = Carry over runoff past inlet (cfs)
- $Q_T$ = Total runoff at inlet = $Q_L + Q_{CO}$
- $Q_P$ = Runoff in Pipe

SUMMARY OF FLOWS
FOR DESIGN EXAMPLE

| INLET | $Q$ ALLOW | $Q_L$ | $Q_{CO}$ | $Q_T$ | $Q_I$ | $Q_{CO}$ | $Q_P$ SEWER | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| NO. 1, 15' TYPE R | 8.6 | 8 | 0 | 8 | 6.2 | 1.8 | 6.2 | Inlet on Grade |
| NO. 2, 10' TYPE R | 7.2 | 4 | 1.8 | 5.8 | 3.8 | 2.0 | 10.0 | Inlet on Grade |
| NO. 3, 10' TYPE R | 10.4 | 8 | 2.0 | 10.0 | 10.0 | 0 | 20.0 | Inlet in Sump Condition |

Reference: WRC Engineering, Inc.