6

STREET DRAINAGE

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Urban streets with curb and gutter serve an important and necessary drainage service, even though their primary function is for the movement of traffic. Traffic and drainage uses are compatible up to a point, beyond which drainage is, and must be, subservient to traffic needs.

Gutter flow in streets is necessary to transport runoff water to storm drain catch basins and to major drainage channels. Good street planning can substantially help in reducing the size of, and sometimes eliminate the need for, a storm drain system in newly urbanized areas.

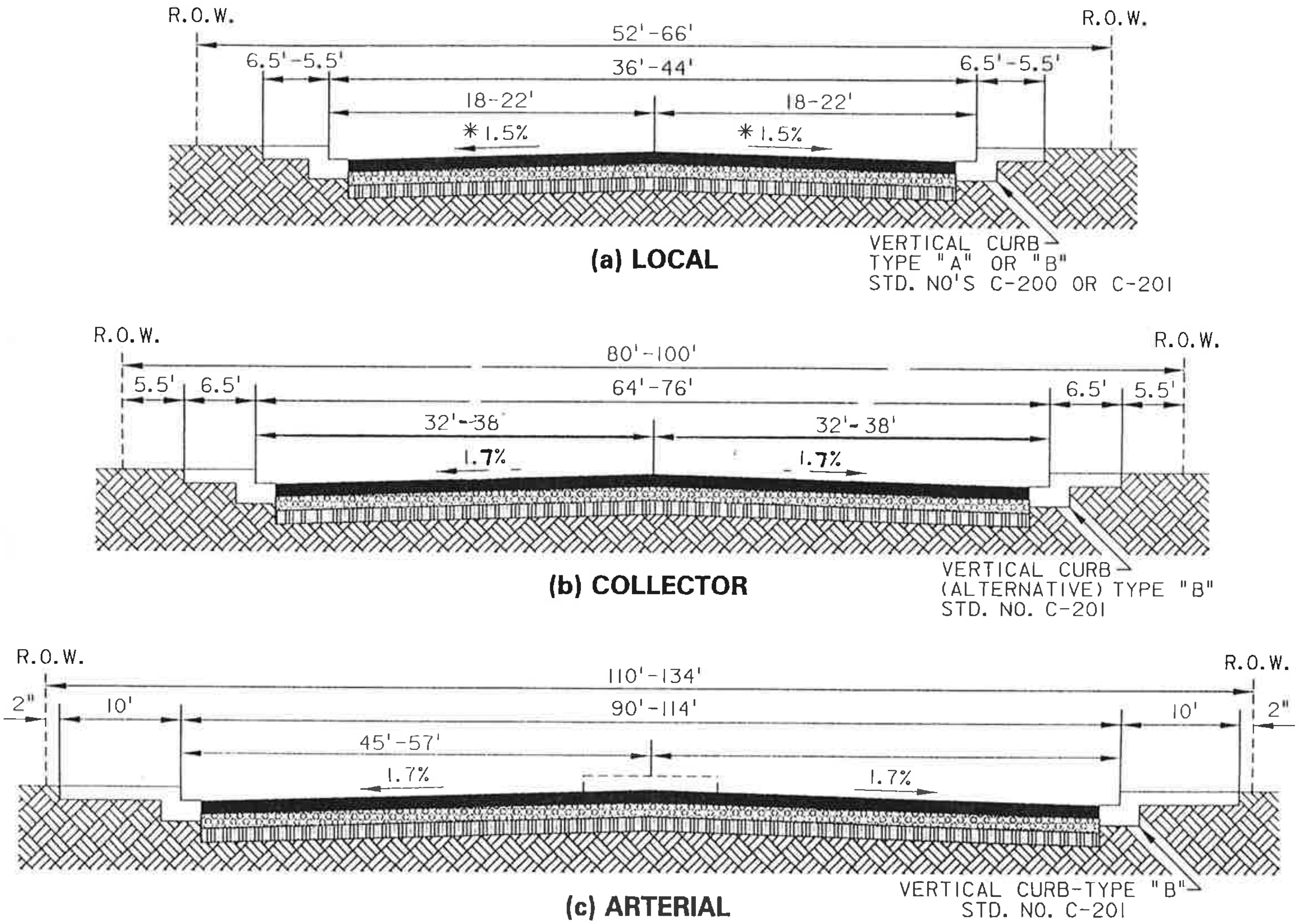
Drainage design for the collection and conveyance of storm water on public streets is based on a reasonable frequency and magnitude of traffic interference. That is, depending on the character of the street, certain traffic lanes can be fully inundated once during the design storm return period. However, during less intense storms, runoff will inundate traffic lanes but to a lesser degree. Therefore, one of the primary functions of streets is to convey nuisance flows quickly and efficiently to a storm drain or other drainage facility without obstructing traffic movement. During a major storm event, the function of streets is to provide an emergency escape for flood flows with minimal damage to urban environment.

6.1 STREET CLASSIFICATION

The streets in the City are classified for drainage purposes as Local, Collector or Arterial according to the average daily traffic (ADT) for which the street is designed. The larger the ADT, the more restrictive the allowable drainage encroachment into driving lanes. Traffic classifications and typical cross sections of the three drainage classifications are presented in Table 6.1 and Figure 6.1, respectively.

TABLE 6.1
TRAFFIC AND DRAINAGE CLASSIFICATION

TRAFFIC CLASSIFICATION	STANDARD DRAWING NO.	DRAINAGE CLASSIFICATION
Arterial Highway	ST-100	Arterial
Arterial Highway	ST-100A	Arterial
Major Highway	ST-101	Collector
Secondary Highway	ST-102	Collector
Local Street	ST-103	Local
General Local Street	ST-104	Local
Restricted Local Street	ST-106	Local



* FOR LOCAL STREETS WITH 52' RIGHT-OF-WAY, CROSS SLOPES SHALL BE 2%

Figure 6.1
Typical Street Cross Sections
(Source: FHWA, 1984)

6.2 DESIGN CRITERIA FOR STREETS

6.2.1 Design Frequency

Storm drainage within a street system serves two primary objectives:

1. Removes nuisance flows from pavement during frequent return period storms to maintain safe and efficient movement of traffic.

2. Protects adjacent properties from damage caused by large, infrequent storms.

The function of removing storm flows from pavement is based on providing storm drain catch basins at points where maximum depth or driving lane inundation criteria are reached.

Storm drain system design is generally based on the concept of a design storm. The design storm is the storm associated with the governing return period for longitudinal street flow from Table 6.2. In some locations, along Local and Collector streets, physical improvements may prohibit the water surface from spreading to the building setback line, such as a street lined with block walls constructed at the right-of-way line. In this situation, the depth of flow at the centerline of the street, assuming flood waters are spread between the building setback lines, will define the design storm. In the upper reaches of a system the 10-year criteria will govern. Farther downstream in the system, the storm drain system design for the 10-year event may not meet the street flow criteria stated for the 100-year storm. In this case, the storm drain will need to be upsized to meet the appropriate criteria. Both return periods need to be checked to determine which condition governs. In other words, the greatest storm condition governing design at any point is the design storm.

TABLE 6.2
DESIGN STORM FREQUENCIES FOR STREET DRAINAGE

<table>
<tr><th rowspan="2">DRAINAGE CLASSIFICATION</th><th colspan="2">LIMITS OF LONGITUDINAL STREET FLOW BY DESIGN STORM FREQUENCY</th></tr>
<tr><th>10-YEAR</th><th>100-YEAR</th></tr>
<tr><td>Local</td><td>Flow spread to crown of street, no curb overtopping.</td><td rowspan="2">Flow 6 inches deep at centerline</td></tr>
<tr><td>Collector</td><td>Flow spread to crown of street, no curb overtopping</td></tr>
<tr><td>Arterial</td><td>One 12-foot driving lane in each direction, no curb overtopping.</td><td>Flow contained between right-of-way lines.</td></tr>
</table>

6.2.2 Pavement Encroachment

The following sections present specific design requirements for storm drainage on urban streets for the design storm. Determination of street carrying capacity for the design storm shall be based upon the requirements outlined in Table 6.2:

The storm drain system should begin at or prior to the point where the maximum encroachment and/or depth is reached, and should be designed on the basis of the design storm. The final design must meet both the 10-year and 100-year criteria established in Table 6.2.

6.2.3 Theoretical Capacity

When the allowable pavement encroachment has been determined, the theoretical gutter capacity shall be computed using Manning's formula for flow in a uniform open channel.

$$Q = \frac{1.486}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}} \qquad \textbf{(6.1)}$$

Typical gutter cross sections used in the City may be found in the City of *Standard Specifications for Public Works Construction* dated September 1989. Additional information related to theoretical capacity of streets can be obtained from the *County of Los Angeles Road Department, Highway Design Manual of Instructions*, dated January, 1992.

An "n" value of 0.15 shall be used for street flow unless special considerations exists.

6.3 CATCH BASINS

Proper surface drainage of streets and highways may require intercepting excess flows with stormwater catch basins. The most upstream catch basin in the system should be placed as far downstream as possible, because as soon as the runoff enters the pipe system, it is carried rapidly downstream which tends to reduce the time of concentration. Locating catch basins is dictated by encroachment into the traveled way and flow depth criteria (see Table 1.1).

6.4 DESIGN CRITERIA

6.4.1 General

Catch basins shall be located within street rights of way unless otherwise approved by the City Engineer. All catch basins which must be located outside street right of way lines in order to intercept storm waters under existing conditions are acceptable only when other provisions can not be made to intercept these flows. Right of way for such catch basins, or inlets, will be offered for dedication on the tract or parcel map for the project or acquired prior to final approval of the storm drain system.

Catch basins to be constructed off the paved portion of the roadway but within the street right of way lines shall be made operable by grading the roadway to permit storm water to flow to the basin. Street remodeling of this nature shall be performed as soon as possible after construction of the drainage facilities.

Local depressions may be omitted for catch basins to be constructed off the paved portion of the roadway. It is expected that the local depressions will be constructed concurrently with the ultimate street improvements. Nevertheless, grading to make such catch basins operable must be done by the jurisdictional agency and signified by the above note on the project drawings.

If, during the design of the project, it is determined that storm water cannot be adequately collected by a catch basin to be constructed off the paved portion of the roadway, the designer should consider using alternate methods of collecting storm runoff. Alternatives and recommendations shall be reviewed and approved by the City Engineer prior to preparation of final construction drawings.

6.4.2 Limitations

Grated catch basins shall be used where street slopes are five percent or greater, grated basins should generally not be used in sump conditions because of the possibility of debris clogging the grates. Additionally, due to the possibility of clogging grated catch are not recommended for sump conditions.

Side opening basins generally should be used where street slopes are less than 5 percent or where sump conditions exist.

6.4.3 Length Requirements

The construction of catch basins over 28 feet in length should be avoided. In lieu thereof, two shorter equivalent length basins should be designated. Figures 1.2 through 1.3, in Section 1.6 Design Aids, are provided to assist the designer with the determination of the required catch basin length or total number of grates required.

6.4.4 Series Catch Basins

The number of catch basins to be connected in a series should normally not exceed two. If the connection of more than two catch basins in a series is unavoidable, consideration should be given to designing a lateral drain. Additional criteria for the design of series catch basins is presented in Section 1.5.

6.4.5 Interior Dimensions

The inside front-to-back dimension of a catch basin may be reduced to avoid conflicts with structures or utilities. The necessary reduction in the internal dimension shall be determined by the designer, but in no case shall the dimension be less than 30 inches.

If reduction of the interior dimension to the minimum specified herein is not sufficient to avoid the conflict, refer to Los Angeles County Flood Control District Standard Drawing No. 2-D 461 for other possible solutions.

6.4.6 Local Depressions

The Local Depression usually has a drop of 4 inches and produces a curb face at the catch basin opening equal to the existing curb face plus 4 inches, unless otherwise shown on the general plan. This Local Depression shall be used on residential streets and on other streets with light vehicular traffic.

A Local Depression of 2 inches can be used with side inlet or combination catch basins. In general, a 2 inch Local Depression shall be used on major streets carrying arterial traffic, on any other heavily traveled street, and in any situation where vehicles may be traveling in traffic lanes adjacent to curbs at relatively high speeds.

If, at any time during design, a Local Depression is changed, the length of opening of the corresponding catch basin shall be checked in size and changed, if necessary.

6.4.7 Connector Pipe

- The minimum diameter of connector pipe shall be 18 inches.
- The horizontal alignment of connector pipes shall contain no angle points or bends, unless approved by the City Engineer.
- The minimum length of connector pipe to be installed between catch basins in a series shall be 12 feet, unless prevented by field conditions.
- Catch basin connector pipes shall outlet at the downstream end of the catch basins, unless prevented by field conditions. Downstream, in this paragraph, refers to the direction of the gutter slope at the catch basin in question.
- Where feasible, connector pipes should be located so as to avoid, as much as possible, cutting into existing cross gutters and spandrels.

6.5 DESIGN PROCEDURE FOR CONNECTOR PIPES AND "V" DEPTH

6.5.1 Single Catch Basins

Connector Pipe: Given the available head (H), where "H" is defined as the difference between the mainline hydraulic grade line and the free water surface in the catch basin, the required connector pipe size can be determined from culvert equations, such as those given in King & Brater, "Handbook of Hydraulics", Section Four, fifth edition. Figure No. 1.8 can be used for a nomographic solution of a culvert equation for culverts flowing full.

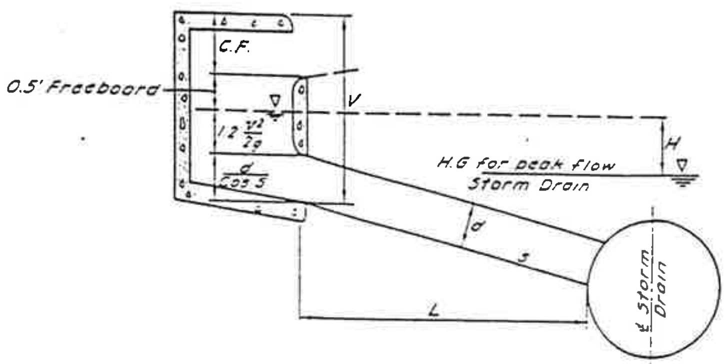
Depth: The minimum catch basin depth, V shall be determine by equation 1.2:

$$V = C.F. + 0.5 + 1.2\frac{V^2}{2g} + \frac{d}{Cos^s} \qquad \textbf{(1.2)}$$

Where

V = Depth of the catch basin, or "V" depth, measured in feet from the invert of the connector pipe to the top of the curb.

$C.F.$ = Vertical dimension of the curb face at the catch basin opening, in feet.



V = Average velocity of flow in the connector pipe, in feet per second, assuming a full pipe section.

d = Diameter of connector pipe, in feet.

S = Slope of connector pipe.

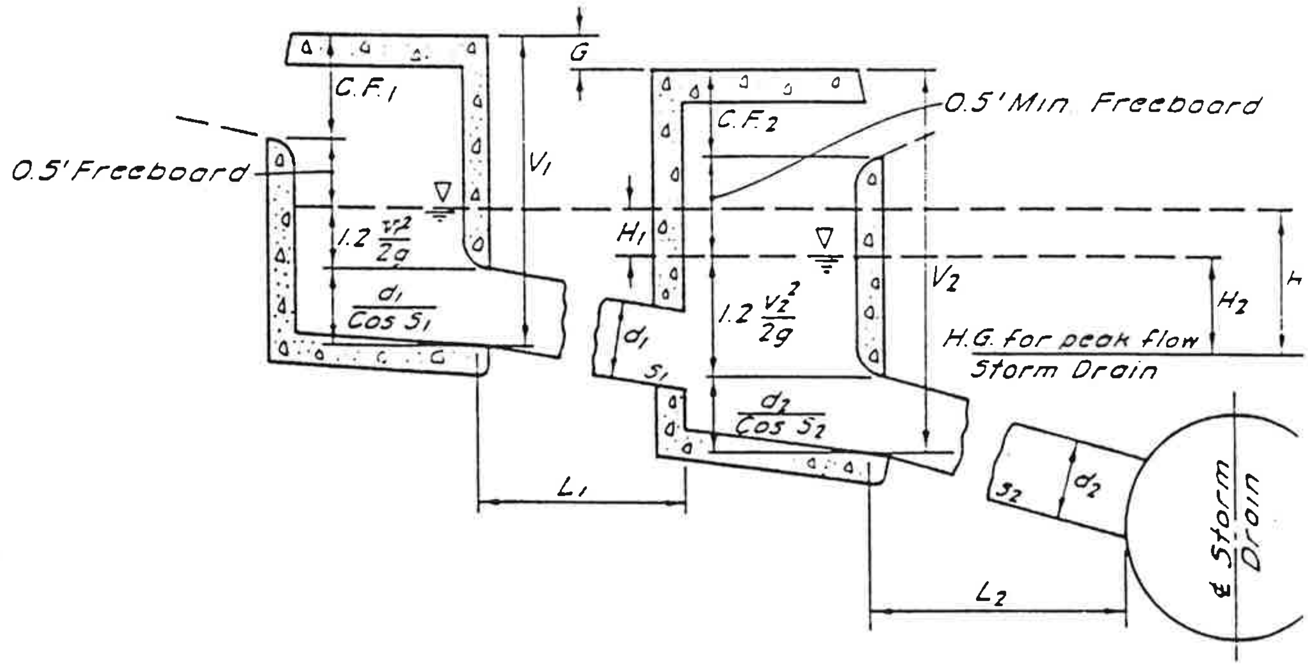
The term 1.2 $v^2/2g$ includes an entrance loss of .2 of the velocity head. In addition to the energy required to achieve the velocity in the outlet pipe.

Assuming a curb face at the catch basin opening of 10 inches, which is the value normally used by most agencies, and Cos S = 1, the above equation 1.3 may be simplified to the following:

Figure 1.9 provides a graphical solution to Equation 1.4 for curb faces of 10 inches.

$$V = 1.33 + 1.2\frac{V^2}{2g} + d \qquad \textbf{(1.3)}$$

6.5.2 Catch Basins in Series



Connector Pipe: Select a connector pipe size for each catch basin, and determine the related head loss (H_1, H_2) by means of a culvert equation, or by Figure 1.8. The sum of head losses in the series shall not exceed the available head as shown by the relationship:

$$H_1 + H_2 + \ldots\ldots + H_n < H. \qquad \textbf{(1.4)}$$

The minimum catch basin depths, V_1 and V_2, shall be determined in the following manner:

1. The first catch basin depth, V_1, shall be calculated as for a single catch basin using Equation 1.4.

2. The second catch basin depth V_2 shall be determined using Equation 1.6:

$$V_2 = C.F. + 0.5 + H_1 + 1.2\frac{V2^2}{2g} + \frac{d_2}{Cos\ S_2} - G \qquad \textbf{(1.5)}$$

Assuming again that C.F. = 0.83 and Cos S_2 = 1, then Equation 1.5 can be simplified to:

$$V_2 = 1.33 + H_1 + 1.2\frac{V2^2}{2g} + d_2 - G \qquad \textbf{(1.6)}$$

3. The freeboard provided for the second catch basin generally shall not be less than 0.5 feet and shall be checked by Equation 1.7:

$$FB_2 = V_2 - \frac{d_2}{\cos S_2} - 1.2\frac{V^2}{2g} - C.F._2 \qquad \textbf{(1.7)}$$

If $C.F._2 = 0.83$ and $\text{Cos } S_2 = 1$, then Equation 1.7 becomes:

$$FB_2 = V_2 - d_2 - 1.2\frac{V\frac{2}{2}}{2g} - 0.83 \qquad \textbf{(1.8)}$$

Where especially "tight" conditions prevail, the 0.5 feet freeboard requirement referred to above may be omitted. In such cases the difference between the gutter elevation and the hydraulic grade line elevation of the main line will be accepted as the available head.

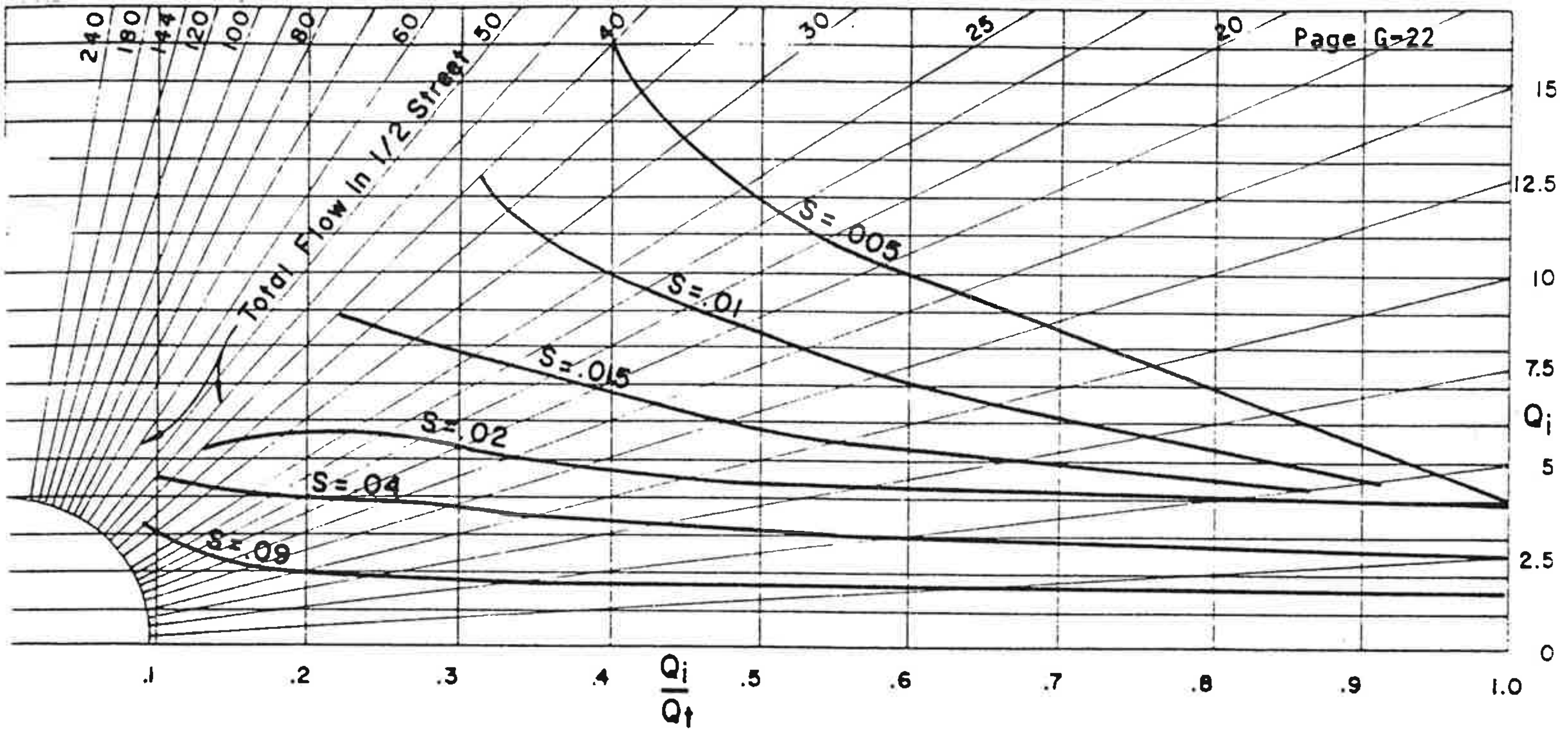
4. Connector pipes between catch basins in series shall be checked for adverse slope by the following relationship:

$$V_2 - 0.5 > V_1 - G \qquad \textbf{(1.9)}$$

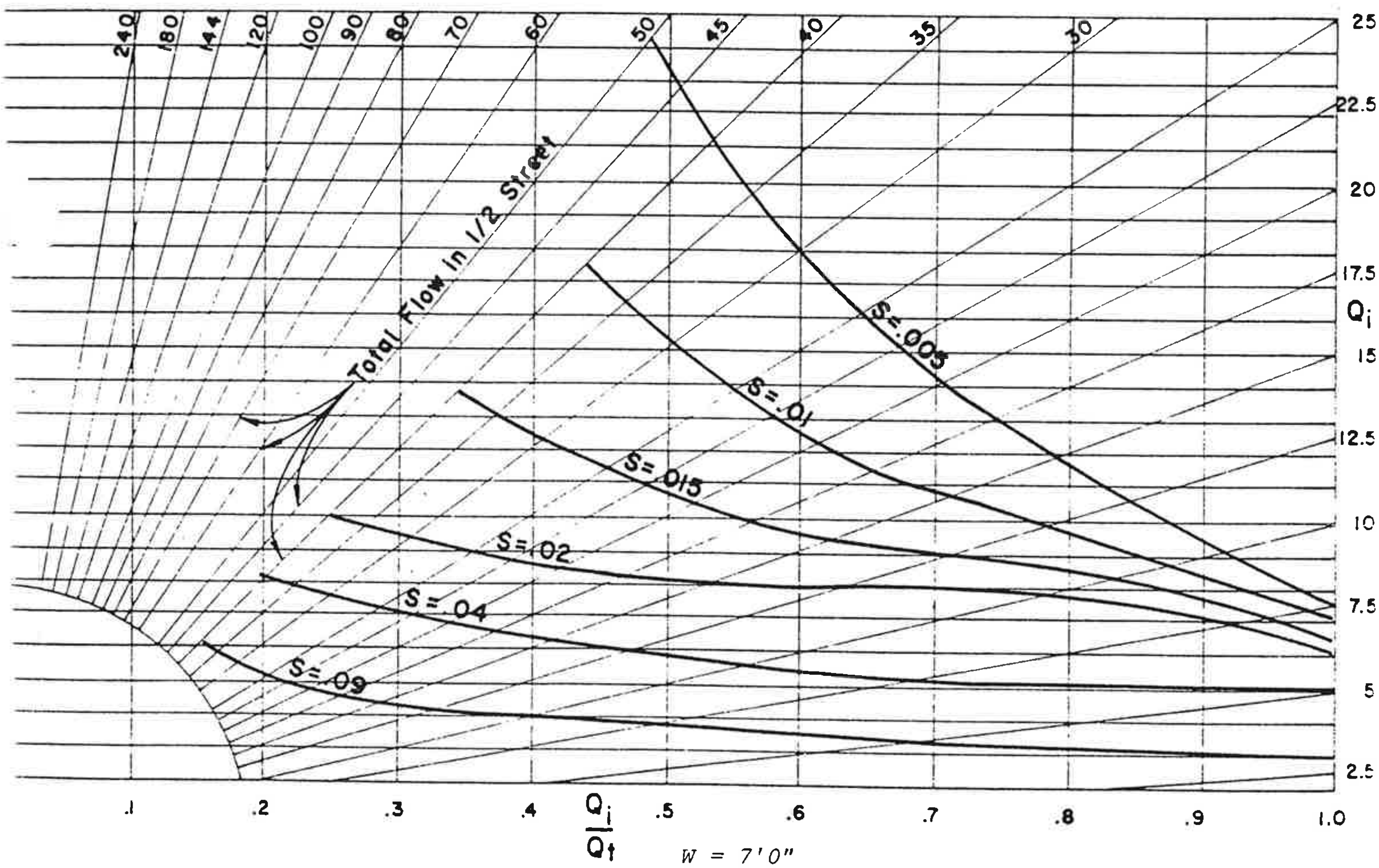
The figure of 0.5 shown above is the standard 6-inch cross slope of the catch basin floors.

6.6 DESIGN AIDS

Figures 6.2 through 6.5 are provided to assist the designer during the development of catch basin and connector pipe design.



W = 3'6"



W = 7'0"

Q_t = flow in 1/2 of street Q_i = inlet flow S = street slope

Figure 6.2
Catch Basin Capacities
Los Angeles County Flood Control District

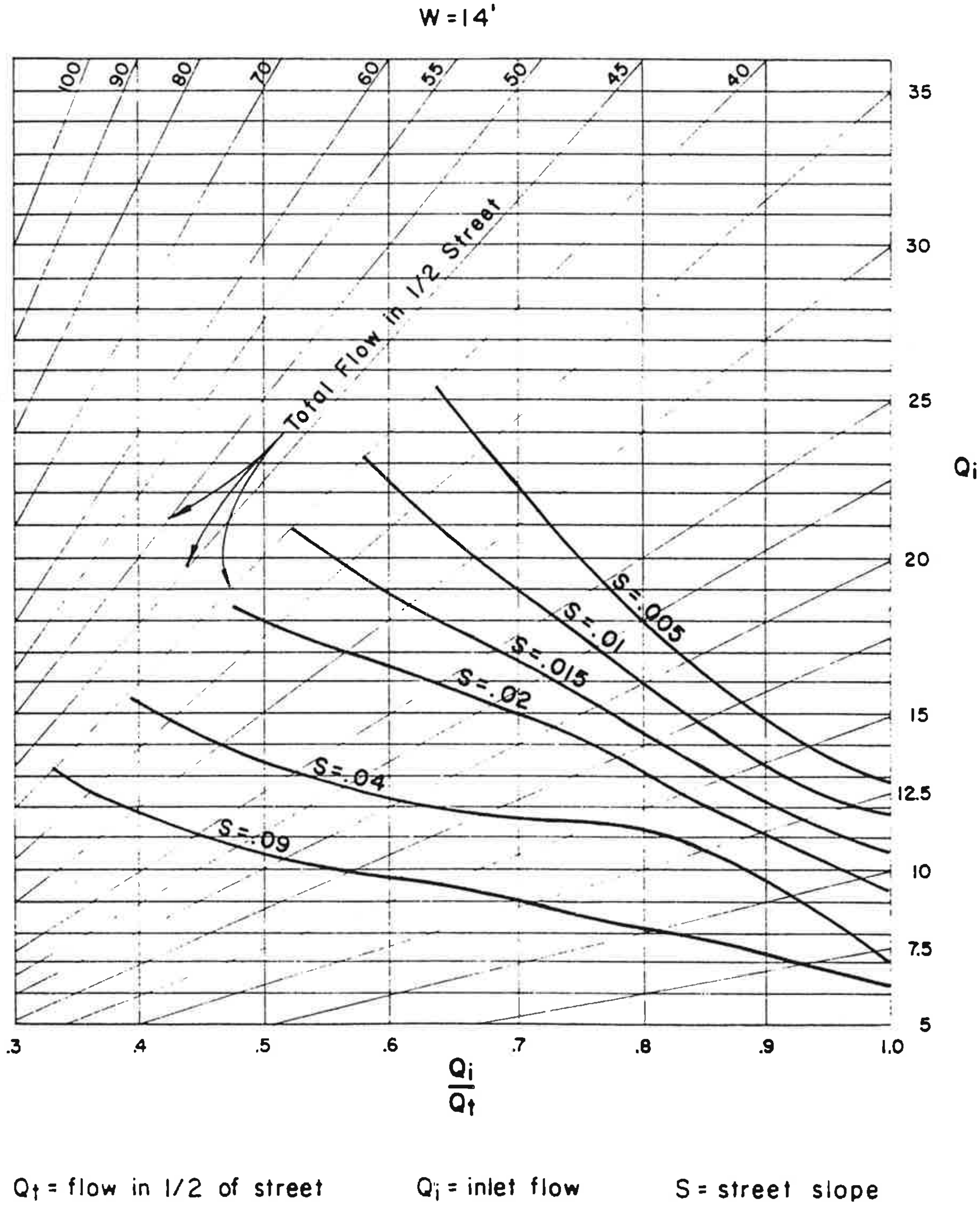


Figure 6.3
Catch Basin Capacity
Los Angeles County Flood Control District

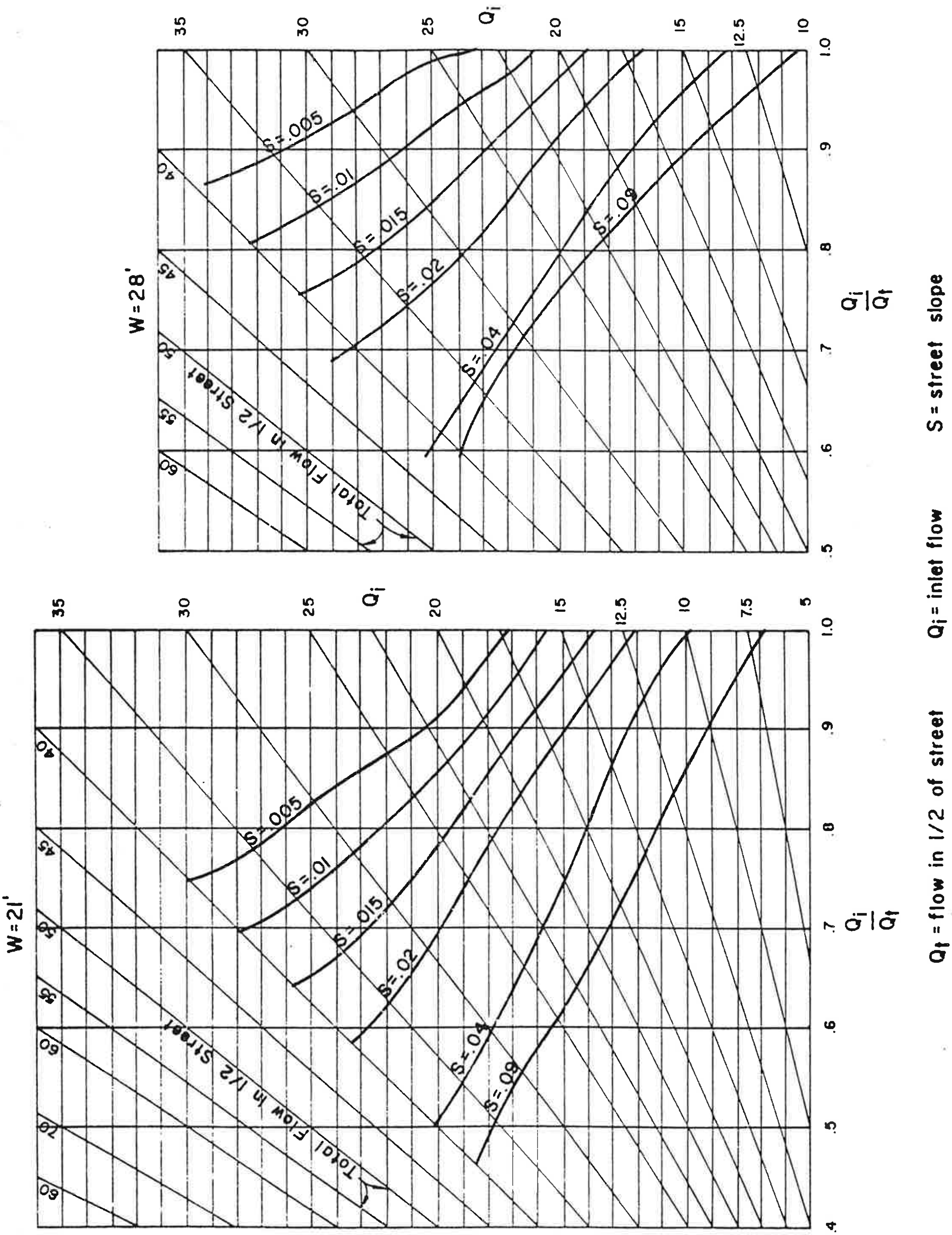


Figure 6.4
Catch Basin Capacities
Los Angeles County Flood Control District

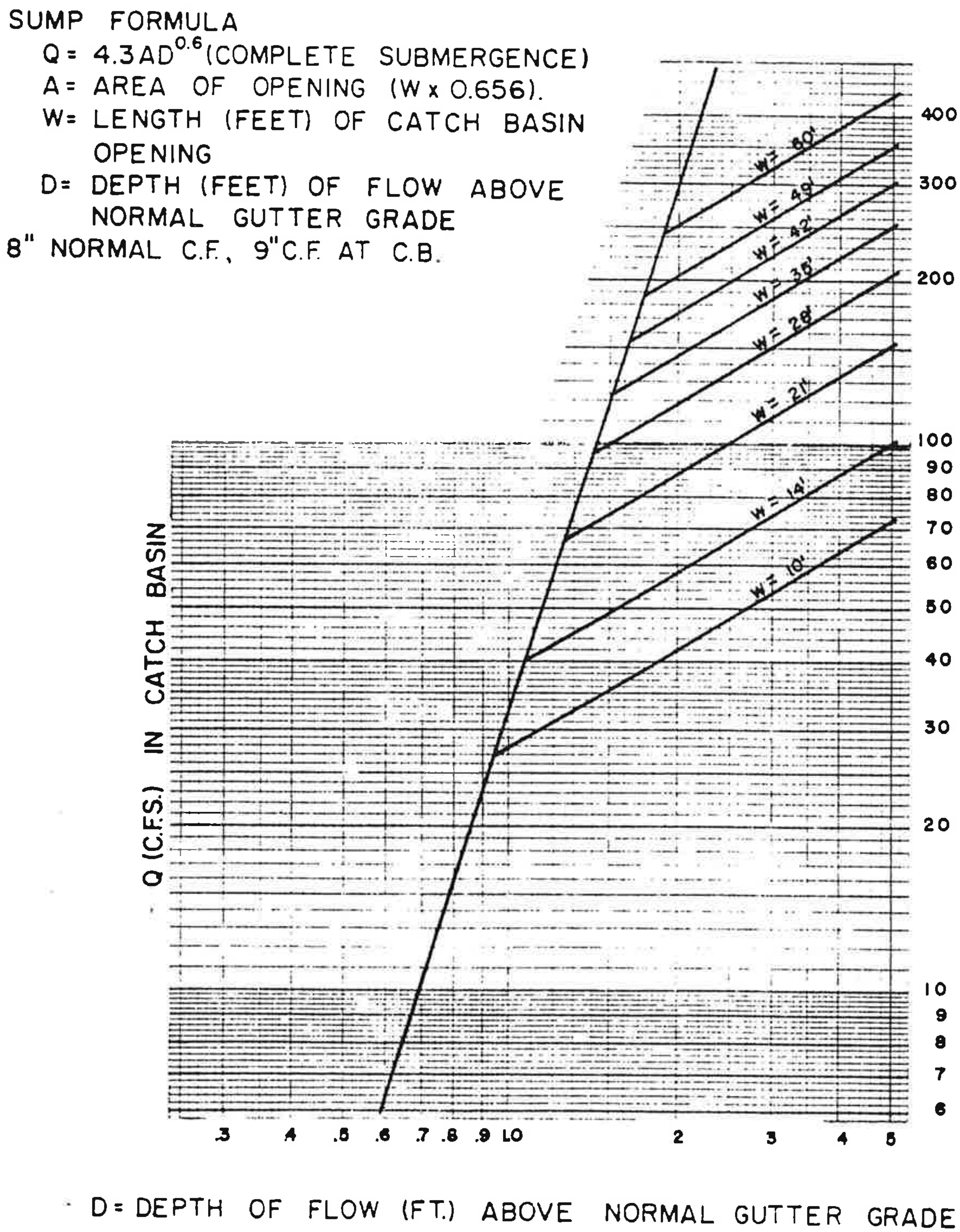


Figure 6.5
Catch Basin Capacities Sump Condition
Los Angeles County Flood Control District

6.7 CHECKLIST

To assist the engineer, designer or reviewer, the following checklist has been prepared. This list includes the minimum information that should be investigated when evaluating street drainage.

- ☐ Use the flattest street slope to calculate allowable gutter capacity.
- ☐ Determine street classification prior to calculation of flow depth and gutter capacity.
- ☐ Evaluate non-symmetrical street sections, with special emphasis on the effects of street flow on adjacent, existing dwellings.
- ☐ Storm drains are required when the gutter capacity or velocity criteria are exceeded.

6.8 LIST OF VARIABLES

E = Efficiency of catch basin

F_s = Reduction factor

L = Curb opening length for partial interception in feet

L_T = Curb opening length for total interception in feet

n = Manning's roughness coefficient

Q_c = Allowable capacity in cubic feet per second

Q_t = Theoretical capacity in cubic feet per second

S = Longitudinal street slope in feet per foot

S_x = Cross slope of roadway in feet per foot

T = Flooded width

Y = Depth of flow in feet

Z = Reciprocal of the pavement cross-slope in feet per foot

6.9 REFERENCES

U.S. Department of Transportation Federal Highway Administration, March 1984 Hydraulic Engineering Circular No. 12, Drainage of Highway Pavements

Los Angeles County Flood Control District, Hydraulic Design Manual