

Section 900

Streets

901 INTRODUCTION

The criteria presented in this section shall be used in the evaluation of the allowable drainage encroachment within public streets. The review of all planning submittals (Section 200) which involve storm flow in streets will be based on the criteria herein.

902 FUNCTION OF STREETS IN THE DRAINAGE SYSTEM

Urban and rural streets in the Clark County area having curb and gutter facilities or roadside ditches are part of the Local Drainage System. The streets naturally carry runoff from both the minor and major storm events. For design purposes, the streets are allowed to carry runoff in excess of the minor storm (Section 304.2), subject to certain limitations (Section 304.4). When the storm flows in the street exceed allowable limits (Section 304.4), a storm sewer system (Section 800) or an open channel (Section 700) is required to convey the excess flows. The primary function of urban streets is for traffic movement and therefore the drainage functions are subservient and should not interfere significantly with the traffic function of the street.

Design criteria for the collection and conveyance of runoff water on public streets are 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 during the storms. During less intense storms, runoff will also inundate traffic lanes but to a lesser degree. The primary drainage function of the streets is to convey minor storm and nuisance flows quickly and efficiently to the storm sewer or open channel drainage with minimal interference of traffic movement. For the major storm event, the function of the streets is to provide an emergency passageway for the flood flows with minimal damage to the urban environment.

903 DRAINAGE IMPACTS ON STREETS

Storm runoff can influence the traffic movement function of a street in the following ways:

1. Sheet flow across the pavement resulting from precipitation runoff
2. Runoff in the gutter
3. Duration of the storm
4. Ponded water
5. Flow across traffic lanes
6. Physical damage to the street

To minimize the drainage impact on the streets, each of the above factors must be understood and controlled to within acceptable limits. The effects of the above factors is discussed in the following sections.

903.1 Sheet Flow

Rainfall on the paved surface of a street or road must flow overland in what is referred to as sheet flow until it reaches a channel. Streets, which have curbs and gutters become the channel, while on roads which have a drainage ditch, the ditch becomes the channel. The depth of sheet flow will be essentially zero at the crown of the street and will increase in the direction of the curb and gutter or drainage ditch.

Traffic interference due to sheet flow is by hydroplaning or by splash. Hydroplaning is the phenomenon of vehicle tires becoming supported by a film of water which acts as a lubricant between the pavement and the vehicle. This generally occurs at higher speeds associated with arterials and freeways and can result in loss of vehicle control. Drainage design can reduce the hydroplaning potential by increasing the street cross slope which drains the runoff more quickly.

Splashing of the sheet flows interferes with traffic movement by reducing visibility. The increase in cross slope of the street crown also reduces the splash potential. In general, a 2 percent cross slope is a desirable practical slope.

903.2 Gutter Flow

Water which enters a street as sheet flow from the pavement surface or as overland flow from adjacent land area will flow in the gutter and possibly a portion of the street section until reaching some outlet, such as a storm sewer inlet or a channel. As the flow progresses downstream and additional areas contribute to the runoff, the width of flow will increase and progressively infringe upon the traffic lane. If the roadway width allows vehicles parked adjacent to the curb, the flow width will have little influence on traffic capacity until it exceeds the width of the vehicle by several feet. However, on streets where parking is not permitted, the flow width significantly effects traffic movement after exceeding a few feet, since the flow encroaches on a moving lane rather than a normal parking lane. Field observations show that vehicles will crowd adjacent lanes to avoid curb flow. This creates a traffic hazard which contributes to the rash of small accidents that occur during rain storms.

As the flow width increases, the traffic must eventually move through the inundated lanes, progressively reducing traffic movement as the depth of flow increases. Although some reduction of traffic movement caused by runoff is acceptable, emergency vehicles (i.e., fire equipment, ambulances, police vehicles) must be able to travel the streets. Therefore, certain limitations on the depth of flow in the street are required.

903.3 Storm Duration

The storm duration also plays a role in the drainage impact on the streets. The high intensity, short duration thunderstorms typical of the Clark County area generally do not influence traffic for a long period of time (generally 30 minutes to 1 hour). Therefore, increased flow depths are tolerable for the shorter flood period.

These periods of inundation will continue after precipitation has stopped .

903.4 Temporary Ponding

Storm runoff temporary ponded on the street due to grade changes or intersection street crowns effects traffic movement by increasing flow depths and the duration of flow at the greater depths. This temporary ponding is localized and vehicles may enter the ponded area at high speeds unaware of the ponded water until the vehicle is out of control. Ponding will often cause traffic to halt to avoid vehicle stalling, resulting in reduced traffic movement. Therefore, depths of temporary ponding must be controlled in a similar manner to gutter flow and in some cases eliminated on high traffic volume streets.

903.5 Cross Flow

Whenever storm runoff, other than sheet flow, moves across a traffic lane, traffic flow is affected. The cross flow may be caused by super-elevation of a curve, by the intersection of two streets, by exceeding the capacity of the higher gutter on a street with cross fall, or simply poor street design. The problem associated with this type of flow is the same as for ponding in that it is localized in nature and vehicles may be traveling at high speed when they reach the location. If the speed limits are slow and the traffic volume is light, then the influence of cross street flow may be within acceptable limits.

903.6 Parking Lots and Driveways

The maximum depth of flow through a parking lot is dependent upon a criterion that depth x velocity is less than 6. Hydraulic calculations should be limited to the area of the parking lot where cars are not parked. Parking stalls must not be included in the computation of conveyance areas.

Driveways are often graded to act as berms to protect commercial properties. In these cases, the freeboard shall be defined as one-half the velocity head, but not less than 6 inches. In other words, freeboard will be a minimum of 6 inches above the 100-year flow depth in the street.

904 DRAINAGE IMPACT ON STREET MAINTENANCE

The use of the roadway system for drainage of runoff during and immediately after storm events also has an impact on the structural integrity of the pavement system and the roadway maintenance required. If water penetrates the road surface and saturates the sub-grade material, the sub-grade may fail and cause failure of the pavement.

Additionally, runoff from rural and urban areas can carry large amounts of debris and sediment, which may reduce the performance of hydraulic structures or become a safety hazard and must be removed.

904.1 Pavement Deterioration

The efficient removal of a storm runoff from pavement surfaces has a positive effect on street maintenance and repair. Street maintenance and repair procedures can in turn affect the efficiency of a street as part of the runoff collection system. Research has indicated that pavement deterioration is accelerated by the presence of storm runoff.

Pavement surfaces are subject to numerous types of distress such as weathering, raveling, long cracks, alligator cracks, chuck holes, bleeding, depression, and edge breakup. Water is probably the greatest cause of distress in a pavement structure. Flow of water across a bituminous pavement surface has little effect on the pavement so long as the pavement retains its watertight condition. A number of types of pavement distress may cause the pavement to become permeable, allowing water to reach the sub-grade. Once the water reaches the sub-grade, the problems multiply as the sub-base and sub-grade weakens and increases the cracks through the surface.

A common practice to reduce the problem of bituminous surface deterioration is to seal-coat or overlay the surface. This reduces the problem of pavement deterioration, but indirectly creates a problem with the carrying capacity of the adjacent gutter. As the street section is resurfaced, the flow area of the section is decreased. Over a period of 20 to 30 years, a considerable portion of the runoff carrying capacity of the street may be lost. Scarifying the surface to remove the upper layer of asphalt prior to resurfacing reduces the problem, but is expensive. In any case, the street section flow capacity must be maintained.

904.2 Sedimentation and Debris

A common problem in Clark County is the deposition of sediment on the street surface during and after a storm event. During the flow event, this sedimentation can cause problems by reducing the flow carrying capacity of the street section and causing increased encroachment into the traffic lanes. This problem is most prevalent at major grade changes where the flow velocity in the street section is reduced. Reducing the flow velocity decreases its sediment transport ability and sediment is deposited.

Additionally, sediment and other debris carried by runoff can impair the operation of hydraulic structures such as curb inlets and grated drop inlet structures. The sediment and debris can block a portion of the flow area into these facilities and cause artificially increased water surface elevations.

Immediately after a storm event, identified problem areas should be reviewed and street sweeping initiated to remove accumulated sediment and debris. By regularly scheduled sweeping of upstream areas the source of some of the sediment can be eliminated. Also, runoff from construction sites may cause site-specific sedimentation problems and should be controlled as recommended in Section 1300.

904.3 Landscaped Areas

If flow is expected in landscaped areas behind the back-of-sidewalk (i.e., when flows are over the top-of-curb), such areas need to be protected from erosion to stabilize them. This is of particular concern where building pad elevations are below the top-of-curb elevations.

905 STREET CLASSIFICATION AND ALLOWABLE FLOW DEPTH

The streets in Clark County are classified according to traffic volume and ROW width. The standard street sections are provided in Drawings 202-210 of the STANDARD DRAWINGS. The street classifications, ROW requirements, and allowable storm flow depth criteria are provided in Policy Section 304.4.

A minimum street slope of 0.4 percent (0.004 ft/ft) or as identified in Section 1600 shall be used. The outside slope shall be used for “knuckles” in roadways. Where this slope cannot be achieved, mitigation shall be considered through underground storm drains at flatter slopes.

The calculation of the water surface elevation and velocity must be based on limiting the flow to the width of the ROW. This implies that for calculation purposes only, an infinitely high vertical wall exists at the right of way boundary and any flow area outside of the ROW is not considered in the analysis.

906 HYDRAULIC EVALUATION

The hydraulic analysis of flow in street sections is similar to open channel flow analysis for larger flood control channels (Section 700). The basic governing equation, Manning’s equation, is as follows:

$$Q = (1.49 / n) AR^{2/3} S^{1/2} \quad (901)$$

where Q = Discharge in cfs
 n = Roughness Coefficient (0.016)
 A = Flow Area in sq ft
 R = Hydraulic Radius, A/P
 P = Wetted Perimeter, ft
 S = Slope of the EGL, Generally Assumed Equal to the Street Slope, ft/ft

Based upon the policy of Section 304.4, the allowable storm capacity of the minor storm of each street section is calculated using **Equation 901**.

The calculation of depth of flow for the major storm event is also based on **Equation 901**. The major difference is in the assumed flow area. For the calculation of flow depth and velocity, the area outside the limits of the right of way is not considered in the calculation of conveyance. Even though water will flow in the area outside of the ROW, the depth of flow allowed is based on containment of the flow within the ROW.

The maximum allowable capacity for standard Clark County area street cross-sections has been calculated and is presented in **Figures 901** through **906**. The calculations were performed for various allowable flow depths and street slopes. A Manning's "n" value of 0.016 was assumed for the gutter and street flow areas and a cross slope of 2 percent was used. If standard street sections are used, the maximum allowable street capacity shall be obtained from **Figures 901** through **906**. If non-standard sections are used, the standard Manning's equation with a Manning's "n" value of 0.016 shall be used to calculate allowable flows.

Streets with grades flatter than 0.4 percent must be given special consideration when calculating allowable flow depth. These streets are subject to ponding and are candidates for storm sewers. Storm sewers and their inlets are described in Section 800.

907 EXAMPLE APPLICATION

907.1 Introduction

The criteria and methods developed in Section 900 will be used to calculate the allowable flow in a standard street section.

907.2 Example: Allowable Flow In 100 Foot ROW Street

Problem: A major arterial roadway (100 foot ROW without median) is to be constructed with a longitudinal slope of 1.5 percent with the standard 6-inch curb height. A determination of the allowable street capacity is required to determine the need for storm inlets and storm sewers.

Solution:

Step 1: Enter **Figure 905** with a longitudinal street slope of 1.5 percent and record flows for $vd = 6$ and $vd = 8$ (See Policy Section 304.4)

For Minor Storm:

$$vd = 6; Q = 120 \text{ cfs}; d = 0.95 \text{ ft for } 1/2 \text{ street)}$$

For Major Storm:

$$vd = 8; Q = 190 \text{ cfs}; d = 1.1 \text{ ft (for } 1/2 \text{ street)}$$

Step 2: Calculate allowable flow depth to provide 12 foot dry lane in each direction (center turning lane cannot be used for dry lane).

Allowable Flow Width for Minor Storm =

$$45 \text{ ft} - 0.5 \text{ ft} - 6.0 \text{ ft} - 12.0 \text{ ft} = 26.5 \text{ ft}$$

Step 3: Check for adequate dry lane width by calculating flow width for minor storm based on allowable $vd = 6$.

$$\begin{aligned} W &= \text{Width of Gutter} + (\text{Flow Depth} - 2 \text{ in}) / 0.02 \\ &= 1.5 \text{ ft} + (0.95 - 2 / 12) / 0.02 \\ &= 1.5 \text{ ft} + 39.2 \text{ ft} \\ &= 40.7 \text{ ft} \end{aligned}$$

Therefore, the allowable depth of flow in street must be reduced.
Allowable Flow Depth for Minor Storm =

$$(26.5 \text{ ft} - 1.5) \times 0.02 + 2 \text{ in} / 12 = 0.67 \text{ ft}$$

Step 4: From **Figure 905** find flow for depth of 0.67 feet and a longitudinal slope of 1.5 percent.

Allowable Flow for Minor Storm =

$$35 \text{ cfs} / \text{gutter}$$

Step 5: Determine minimum required structures elevation above gutter flowline (H).

The maximum major storm flow depth of 1.1 feet must be checked against the allowable water surface criteria provided in Policy Section 304.4.

1. Special Flood Hazard Area and Areas of Interim Delineation:

Residential finished floor elevations

$$H = 1.1 \text{ ft} + 1.5 \text{ ft} = 2.6 \text{ ft above gutter flowline.}$$

2. Non-Special Flood Hazard Areas:

Finished floor elevation = 2 (1.1) or 1.5 feet above gutter flowline, whichever is greater.

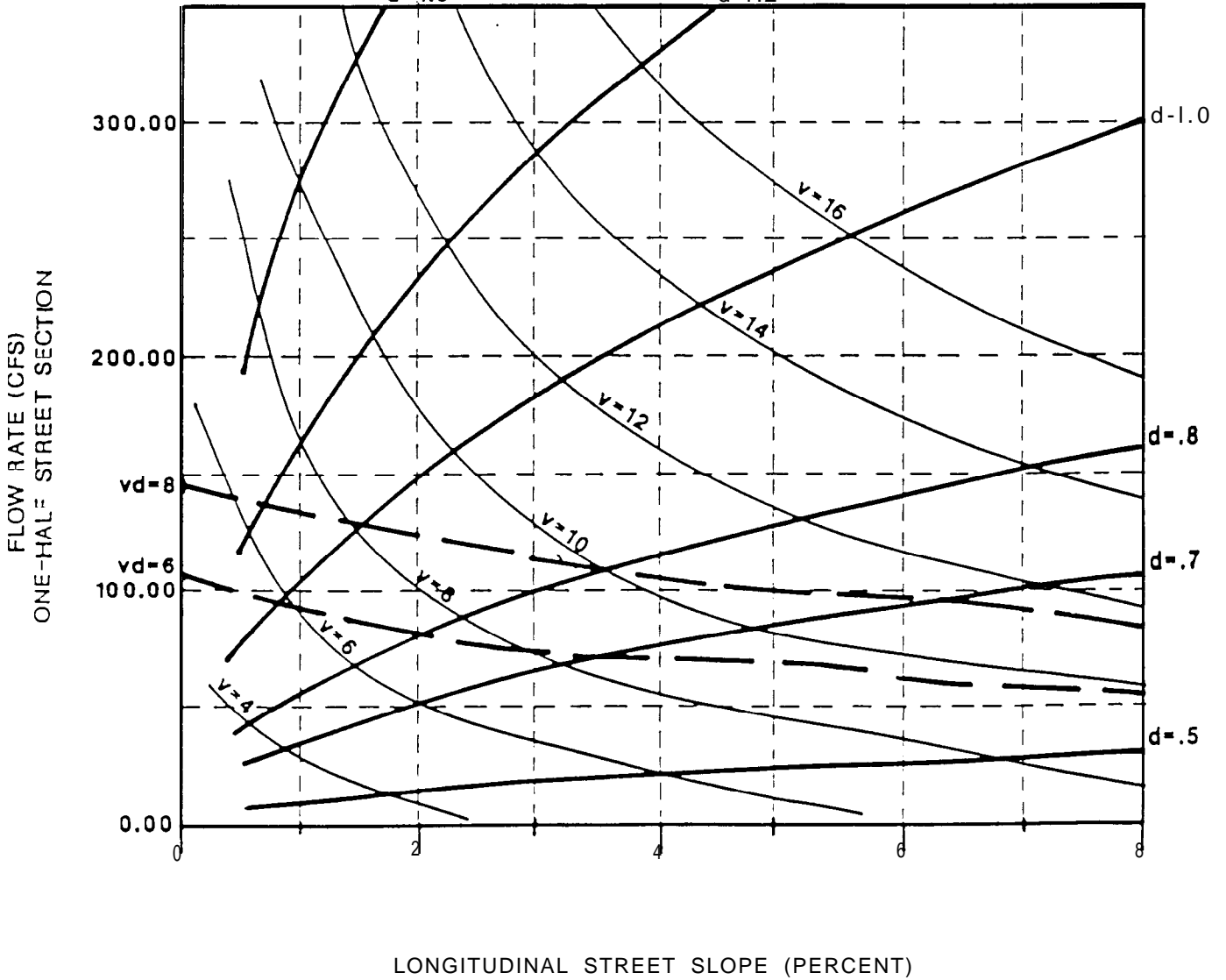
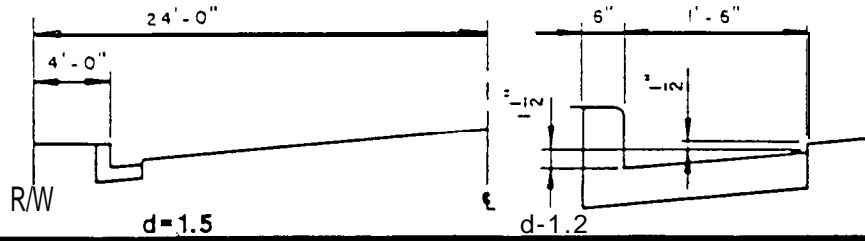
3. Therefore, if the above criteria can be met, the allowable flows for the total street section are as follows:

Minor Storm = 70 cfs

Major Storm = 380 cfs

Step 6: Compare allowable street capacity to design runoff rates. If runoff rates exceed street capacity, then a storm sewer system or channel system will be required.

STREET CAPACITY CURVES 48 FOOT ROW

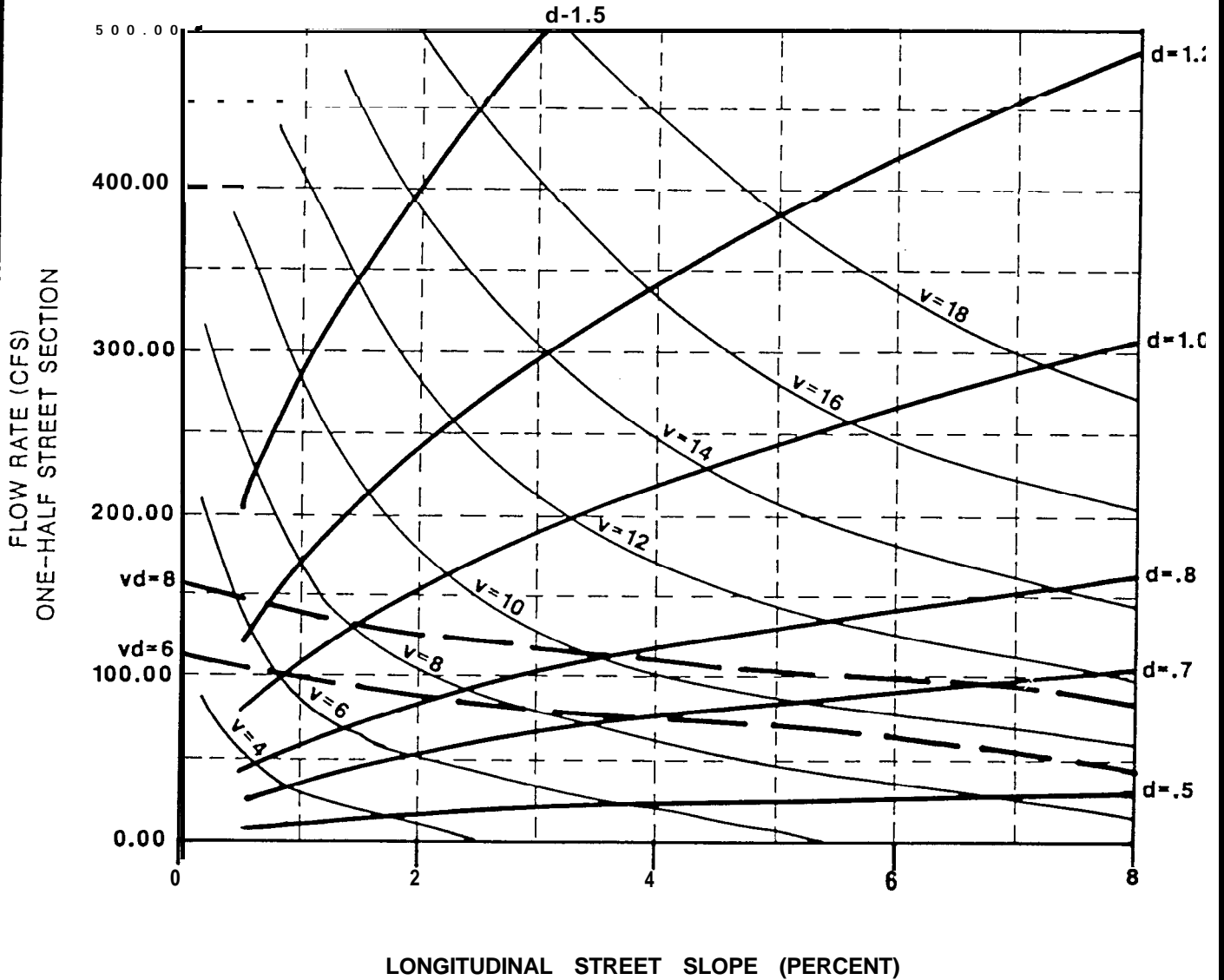
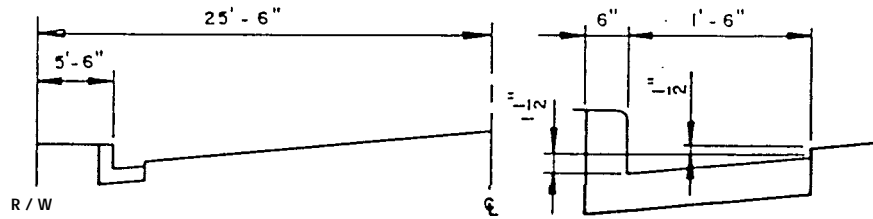


EXPLANATION

- v velocity (feet per second)
- d depth (feet)

Revision	Date

STREET CAPACITY CURVES 51 FOOT ROW



EXPLANATION

- v velocity (feet per second)
- d depth (feet)

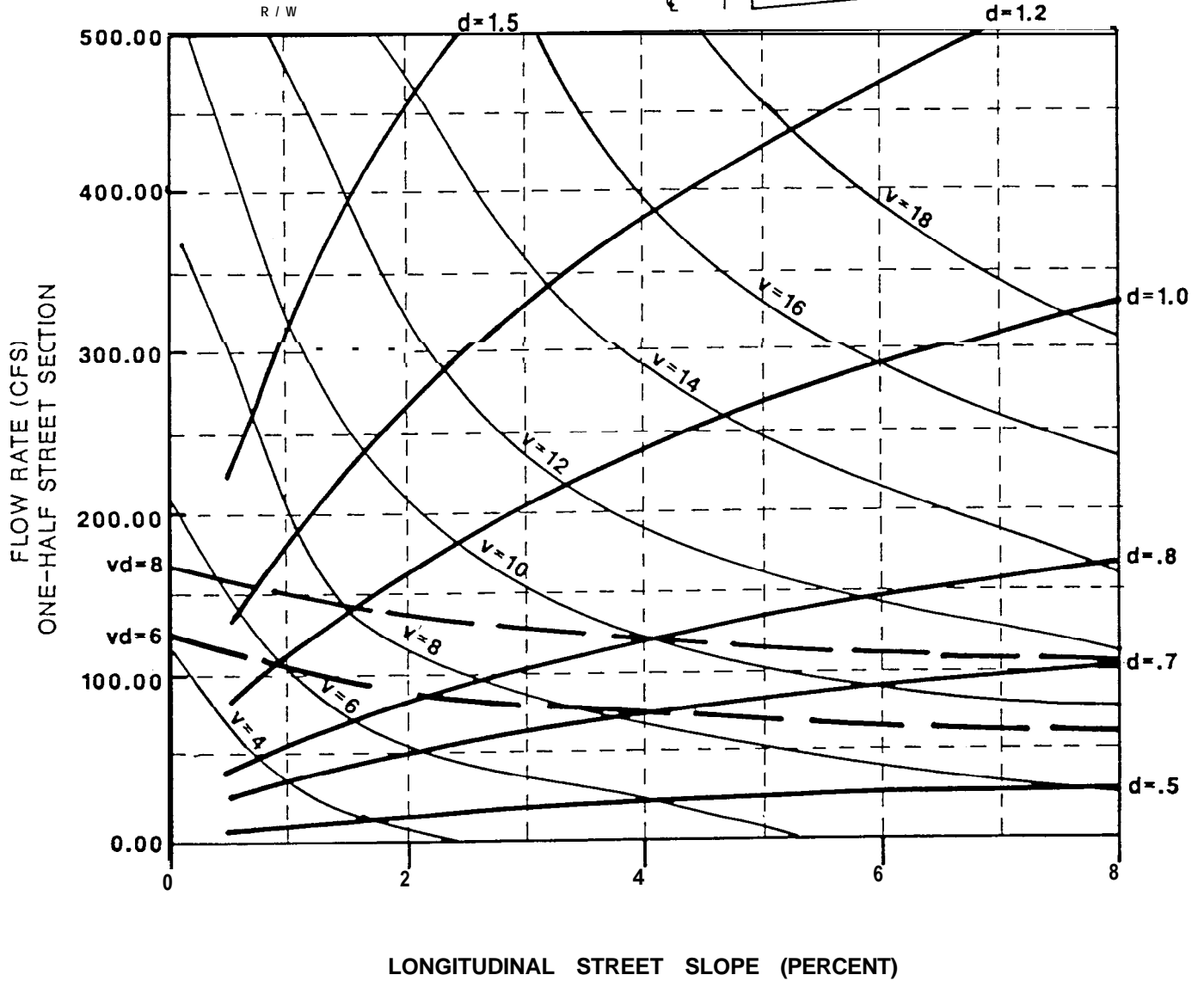
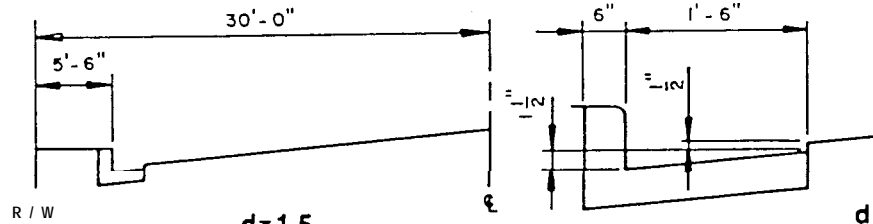
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REFERENCE:

FIGURE 902

STREET CAPACITY CURVES 60 FOOT ROW



EXPLANATION

- v velocity (feet per second)
- d depth (feet)

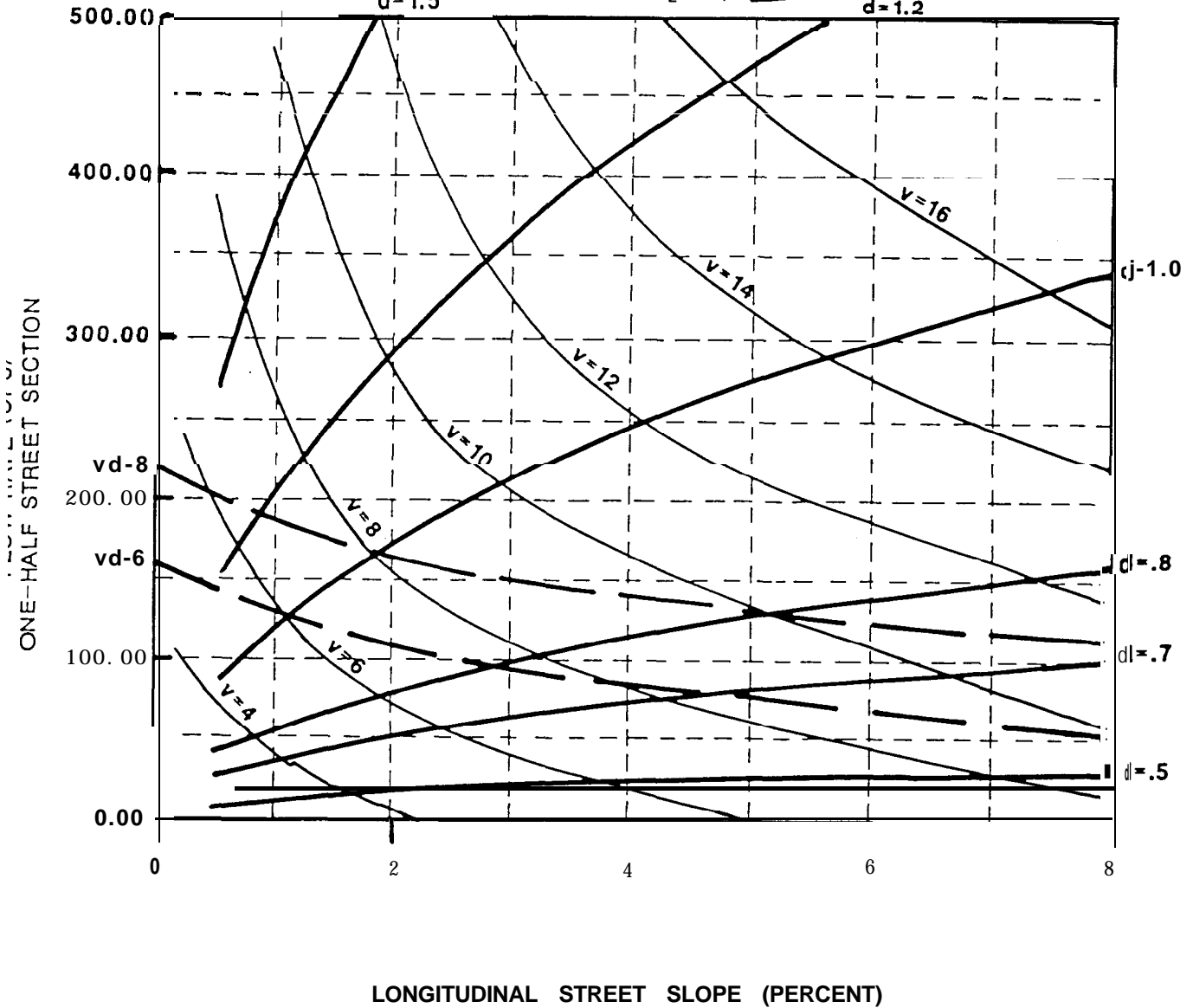
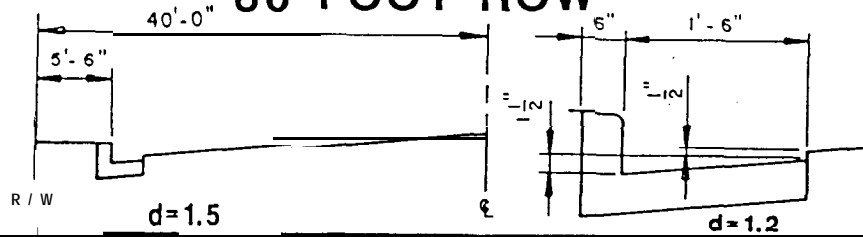
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ENGINEERING

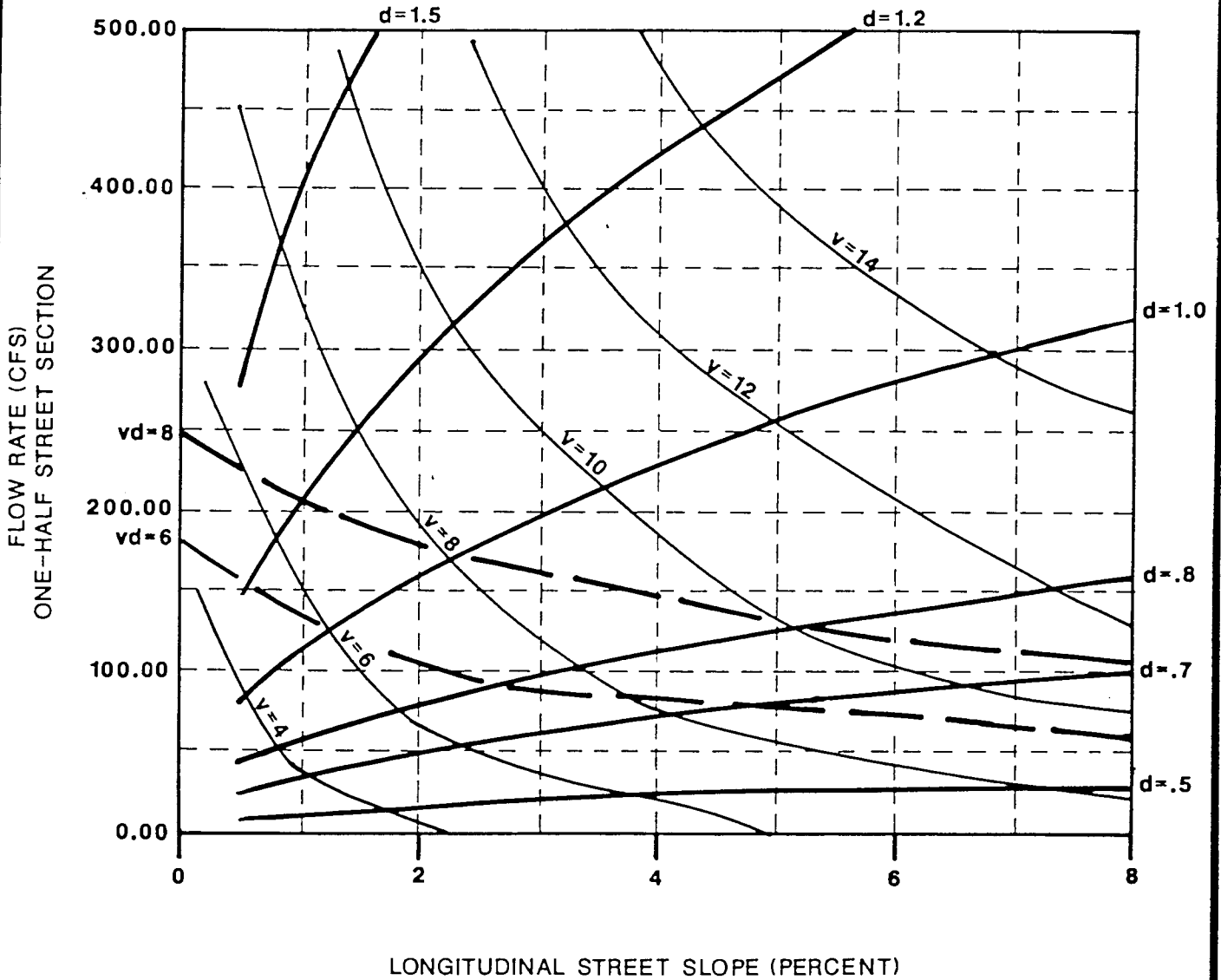
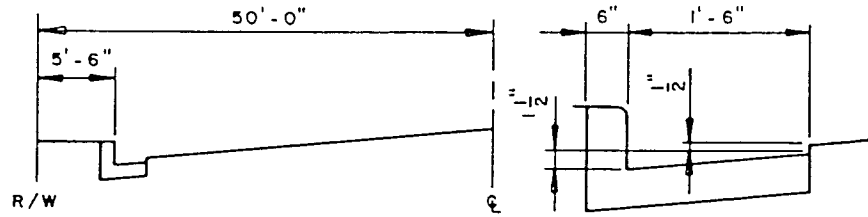
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FIGURE 903

STREET CAPACITY CURVES 80 FOOT ROW



STREET CAPACITY CURVES
100 FOOT ROW

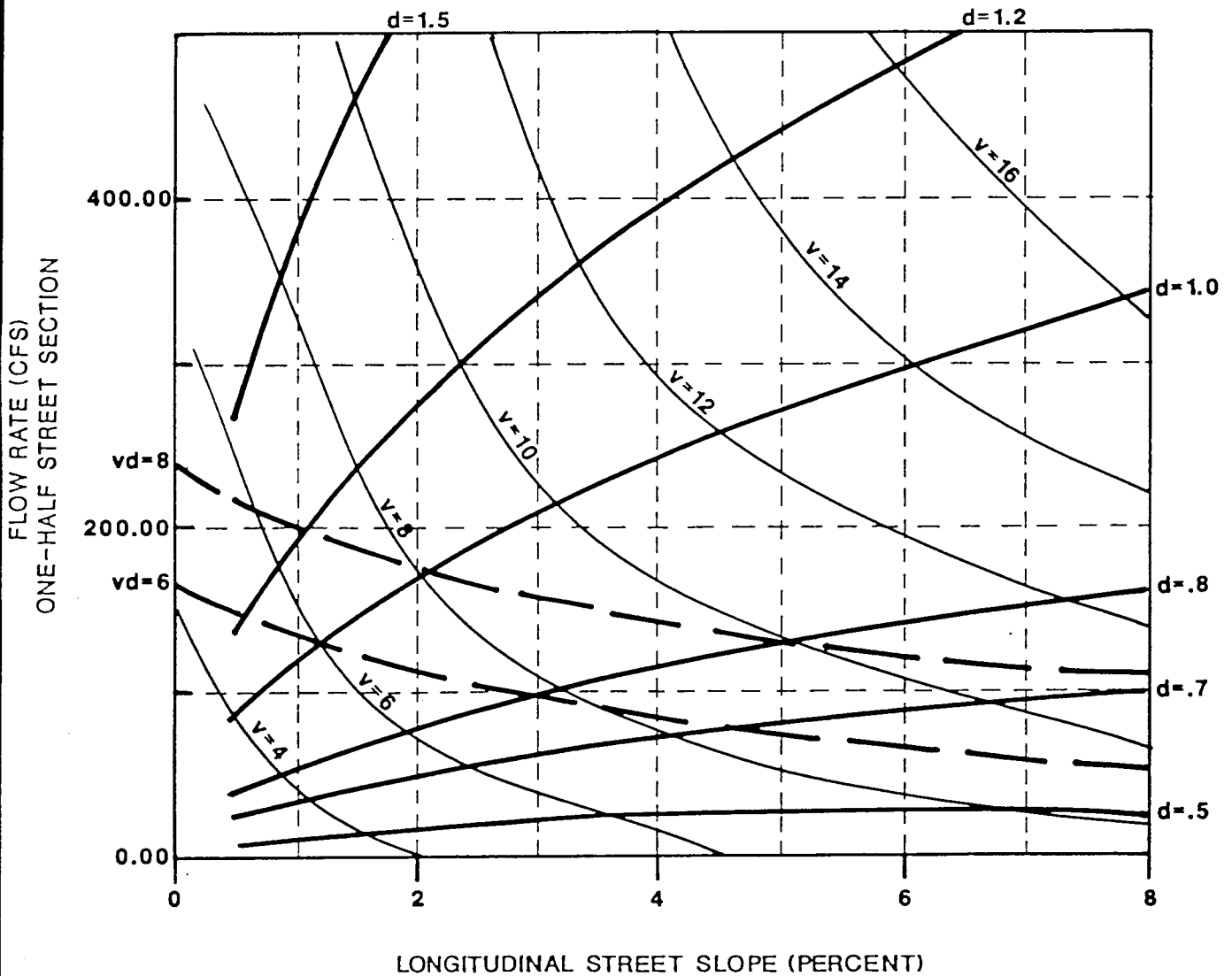
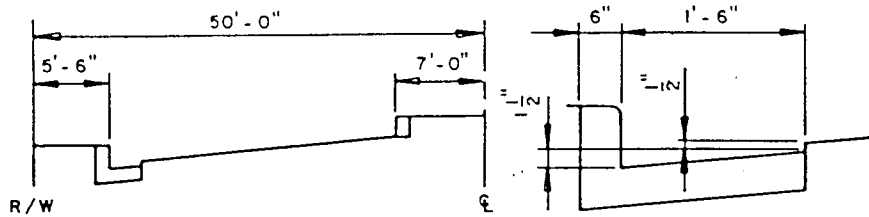


EXPLANATION

- v velocity (feet per second)
- d depth (feet)

Revision	Date

STREET CAPACITY CURVES
100 FOOT ROW WITH MEDIAN



EXPLANATION

- v velocity (feet per second)
- d depth (feet)

Revision	Date

WRC
ENGINEERING

REFERENCE:

FIGURE 906