Chapter 7
Street Drainage

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1.0 Introduction

This chapter summarizes methods to evaluate runoff conveyance for standard street cross sections and curb types and identifies acceptable upper limits of street capacity for minor and major storm events. Street sections included in this chapter are the most common types used in Woodland Park. For non-standard sections, many of the principles and criteria will still apply; however, additional hydraulic analysis will be required. All non-standard street sections must be reviewed and approved by the City Engineer and applicants proposing a project involving a non-standard street section should consult with the City Engineer early in the planning process.

This chapter also provides guidance for reducing urban runoff and pollutant loading through the use of Low Impact Development (LID) techniques, such as curbless (or intermittent curb) streets with adjacent vegetated swales. Volume III of the UDFCD Manual and Volume 2 of the Colorado Springs Manual provide additional design guidelines and criteria applicable to LID.

1.1 Primary Function of Streets

Urban streets not only carry traffic, but stormwater runoff as well. The primary function of urban streets is for traffic movement; therefore, the drainage function is subservient and must not interfere with the traffic function of the street. When runoff in the street exceeds allowable limits, a storm sewer system or open channel/swale is required to convey the excess flows.

1.2 Design Criteria Based on Frequency and Magnitude

The design criteria for the collection and conveyance of stormwater runoff on public streets are based on an allowable frequency and magnitude of traffic interference. The primary design objective is to keep the depth and spread (encroachment) of stormwater on the street below an acceptable value for a given storm event and road classification.

1.3 Street Function in Storm Events

The use of streets for drainage conveyance during storm events is allowed with limitations on the depth of flow in the curb and gutter and the spread of flow onto the roadway, given traffic considerations. The maximum allowable street capacity is determined by these limits and may be affected by the type of curb and gutter, based on the geometry of the standard street sections. The primary function of streets in a minor storm event is to convey the frequently occurring flows quickly, efficiently, and economically to the next intended water quality treatment and/or drainage conveyance system with minimal disruption to street traffic. For the major storm event, the function of streets is to provide an emergency passageway for infrequent flood flows while maintaining public safety and minimizing flood damage. In the major event, the street becomes an open channel and must be analyzed to determine when flooding depths exceed acceptable levels.

2.0 Standard Street Classification and Hydraulic Capacity

2.1 Allowable spread and depths

Streets are typically given classifications such as local, collector, arterial and others. The standard local street configuration is addressed in this manual. Other street cross-sections shall be reviewed and approved by the City Engineer. Allowable spread and depth for street classifications are presented in Table 7-1.

Table 7-1. Allowable Street Encroachment and Depth of Flow

Street Classification	Allowable Encroachment	Allowable cross-street flow	Allowable Encroachment	Allowable cross-street flow
	Minor Storm		Major Storm	
Local	No curb overtopping. Flow may spread to crown of street.	6 inches depth in crosspan.	Depth of water in gutter shall not exceed 8.5 inches, unless ground slopes up behind walk in which case depth shall not exceed 12 inches, nor extend beyond the Right-of-Way.	12 inches depth above gutter flow line.
Collector	No curb overtopping. Flow spread shall leave the equivalent of one 10 foot driving lane clear of water.	6 inches depth in crosspan.	Depth of water in gutter shall not exceed 8.5 inches, unless ground slopes up behind walk in which case depth shall not exceed 12 inches, nor extend beyond the Right-of-Way.	12 inches depth above gutter flow line.
Arterial	No curb overtopping. Flow spread shall leave the equivalent of two 10 foot driving lanes clear of water - one lane in each direction. No more than two lanes in each direction shall be flooded.	None.	Depth of water in gutter shall not exceed 12 inches, nor extend beyond the Right-of-Way.	No cross-street flow. Maximum depth of upstream gutter of 12 inches.
Curbless Streets	Where no curb exists, depth of water shall not exceed 6" or past ROW, whichever is less.	6 inches depth in crosspan.	Where no curb exists, depth of water shall not exceed 12" or past ROW, whichever is less.	6 inches depth in crosspan.

2.2 Local streets with curb and gutter

The cross-section of the standard local street section is defined and detailed in Figure 5.3.2 of the City of Woodland Park Engineering Standards (Standards). There are two types of standard curb and gutter that are detailed in Figures 6.4.1 and 6.4.2 of the Standards. Figures 7-1 and 7-2 show the capacity limitations for each local street with both curb types for varying slopes. When alternate roadway sections are proposed, they shall be reviewed and approved by the City Engineer, and appropriate guidance for flow spreading and depth of flow must be established. Non-standard street cross-sections may be analyzed using the UDFCD spreadsheet UD-Inlet, which can be found on the UDFCD website, and is described below. Each roadway section has a different capacity, so it is important to use the section dimensions that apply to the particular street section of interest.

2.3 Calculation Spreadsheet

The Streets, Inlets and Storm Drains Chapter of the UDFCD Manual provides documentation of hydraulic street capacity and inlet calculations, and the UDFCD UD-Inlet spreadsheet can be used for determining the minor and major storm street capacity and flow encroachments. The "Q-Allow" worksheet is contained within the UD-Inlet spreadsheet, which can be accessed via the internet at www.udfcd.org. This worksheet completes a hydraulic evaluation of theoretical street capacity for both the minor and major storms by calculating the street flow capacity based on both 1) the allowable spread and 2) the allowable gutter depth. A reduction factor is then applied to the theoretical gutter flow based on allowable depth, and the lesser of the allowable street capacities governs for the storm event. A Manning's n-value of 0.016 is recommended on pavement.

2.4 Cross-Street Flow Conditions

Cross-street flow can occur in an urban drainage system under three conditions:

1. When the runoff in a gutter spreads across the street crown to the opposite gutter—This is prohibited for most streets for the minor event to allow for at least one lane to pass traffic, but for some street classifications, this type of cross street flow is allowable in the major event.
2. When cross-pans are used—Cross-pans shall be designed to convey the minor and major storm event within the criteria presented in this chapter. The design engineer shall evaluate the carrying capacity (with calculations provided) considering water on the roadway, as well as the side street. Refer to the Colorado Springs Manual and/or CDOT standard details for cross pan design information.
3. When the flow in a drainageway exceeds the capacity of a road culvert and/or bridge and subsequently overtops the crown of the street—This type of cross-street flow is prohibited in the minor event for all street classifications and in the major event for arterial streets. For local and collector streets the depth of overtopping must not exceed 12 inches at gutter flowline or 4 inches at crown. Chapter 11 provides additional information on culvert and bridge design criteria.

3.0 Curbless Streets with Roadside Swales or ditches

3.1 Street cross-section

For roadside swales and ditches, the City Engineer shall review and approve an alternate, non-standard street section. Roadside swales provide an opportunity to minimize directly connected impervious areas and thereby reduce the volume and peak rate of runoff and enhance stormwater quality. Roadside swales are used in conjunction with curbless (or intermittent curb) streets. This chapter distinguishes between roadside swales and ditches. For the purpose of this chapter, a ditch refers to an open channel that is designed primarily for conveyance with no or incidental infiltration. Some ditches in Woodland Park are paved; although, as these areas are redeveloped, soil riprap may be a more desirable way to achieve a stable, vegetated conveyance with additional infiltration benefits. A swale is similar to a ditch in that its primary function is conveyance; however, swales are generally sized for a broader cross section and shallower flow than ditches to maximize contact between runoff and vegetation to promote infiltration.

3.2 Roadside Swale Design Considerations

Maintenance shall be considered when designing and using roadside swales, including adequate area and side slopes to allow for maintenance access and vehicles. Roadside swales shall be designed based on site-specific conditions and hydraulic capacity. However, they will generally have a minimum depth of 9 inches below the edge of the street shoulder, a bottom width of at least 2 feet, and side slopes of 4:1 or flatter. Swales shall be stabilized with vegetation such as native grasses. The slope of the swale will generally be similar to the slope of the street. At the point where the maximum capacity of the swale is reached for the design event, runoff must be intercepted in an alternate system such as a vegetated drainageway or an area inlet and storm drain. Additional information on swales can be found in the

UDFCD Manual, and criteria and guidelines for maximizing water quality benefits of swales are provided in Volume 2 of the Colorado Springs Manual and Volume 3 of the UDFCD Manual.

3.3 Roadside Ditch Design Considerations

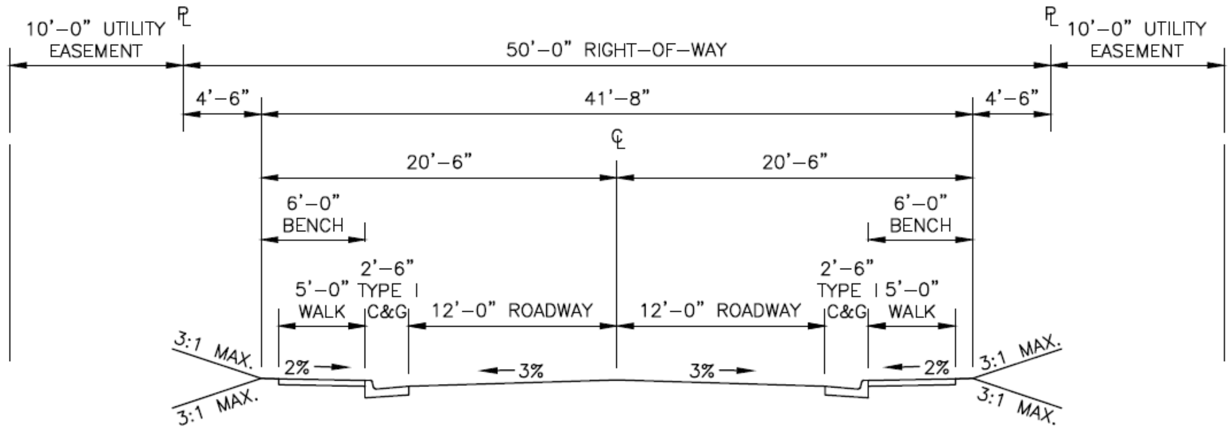
Maintenance shall be considered when designing and using roadside ditches, including adequate area and side slopes to allow for maintenance access and vehicles. Rural roadside ditches shall be designed in accordance with the criteria for minor drainageway grass-lined channels shown in Chapter 12, Open Channel Design. Grade control structures may be required to maintain velocities less than the maximum allowable.

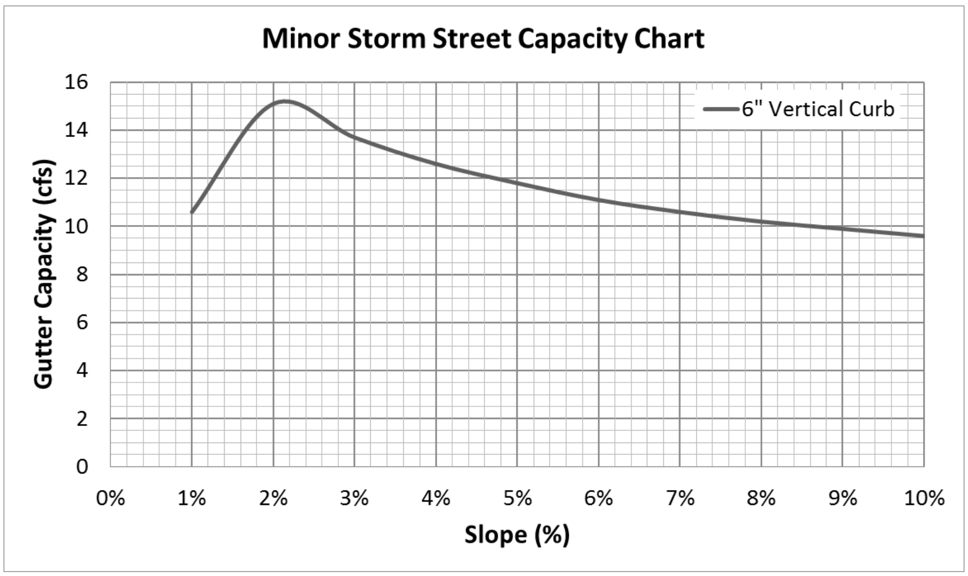
There are cases when the roadside ditch criteria may need to be more stringent due to the function of the rural road. Even if a rural road has a low traffic volume, it may be important for emergency access to several properties and therefore require special design criteria. More stringent criteria for single point access roads may also be required.

At the point where the maximum capacity of the ditch is reached for the design event, runoff must be intercepted in an alternate system such as a vegetated drainageway or an area inlet and storm drain. Criteria for inlets are found in Chapter 8 of this Manual. When practical, the use of vegetated swales is preferred to the use of storm drains to provide contact of runoff with vegetation and soil and increase infiltration potential. In more urban portions of the City and along major roadways, storm drains will typically be the most practical solution. However, in residential areas of the City, there are many opportunities for roadside swales/ditches, and areas with existing hardened roadside conveyances (e.g. concrete or asphalt ditches) present retrofit opportunities as redevelopment occurs to provide enhanced water quality treatment as a part of the drainage conveyance system.

3.4 Driveways

In general, driveways or sidewalks that cross a roadside swale or ditch must provide conveyance under the driveway. Installation of a driveway culvert is recommended. Hydraulic capacity of the culvert must conform to the required street classification design considerations for depth and spread of flow. The ends of the culvert shall be protected either by installation of a flared-end section or concrete headwall, and other appropriate outlet protection as described in Chapter 10. Criteria for culvert design are presented in Chapter 11.





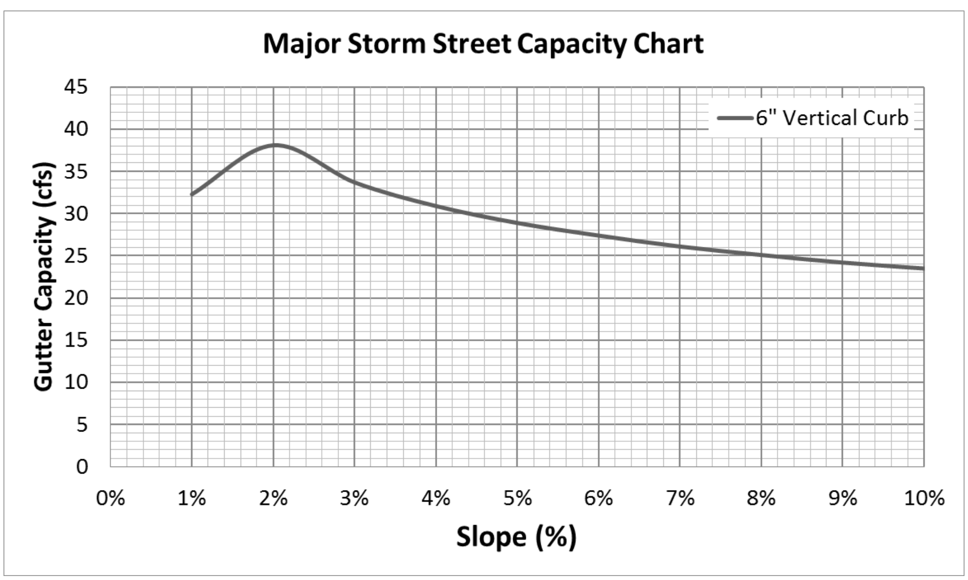


Figure 7-1. Street Capacity Chart Local Type I

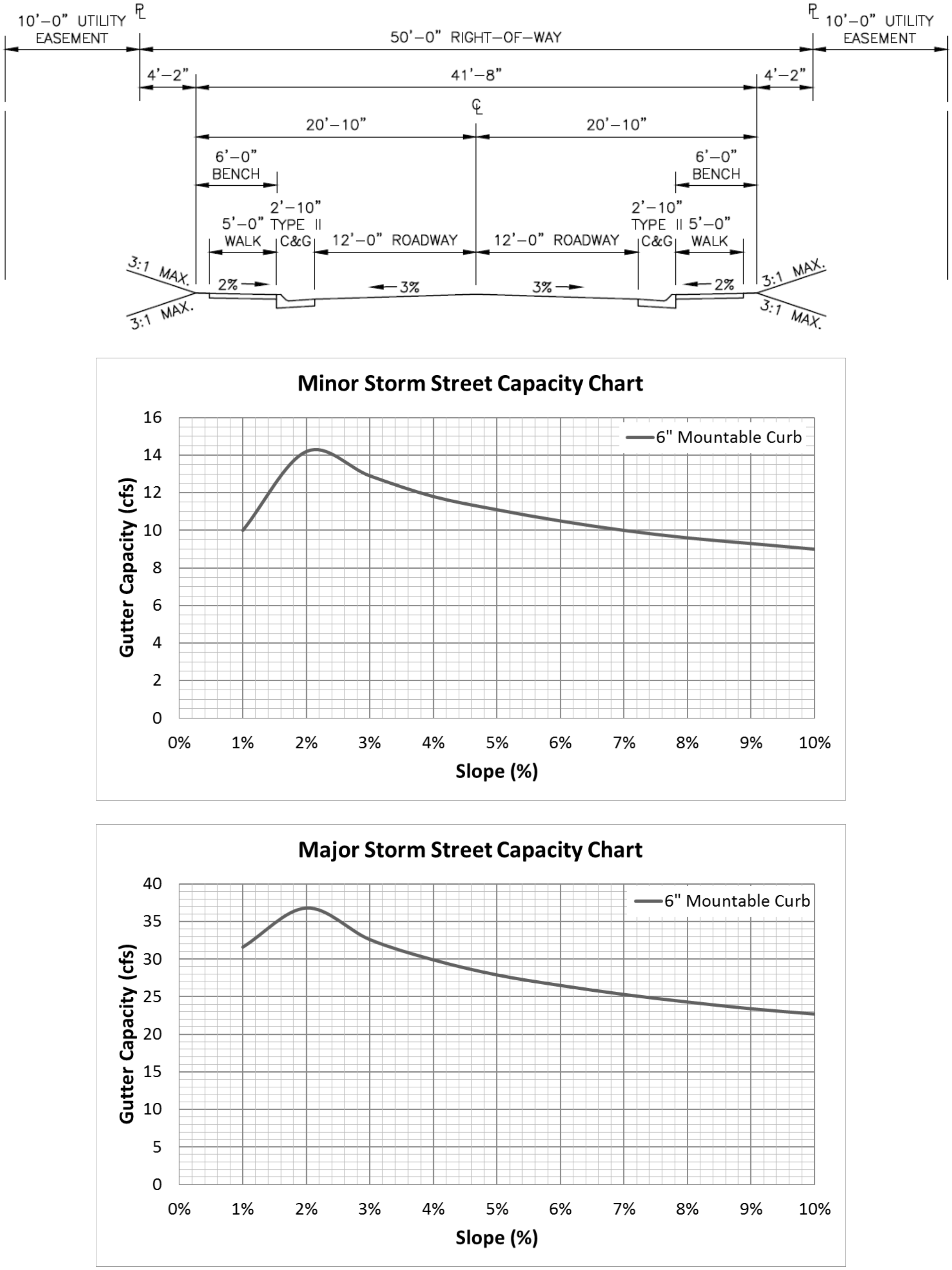


Figure 7-2. Street Capacity Chart Local Type II

Note for Figure 7-1 and Figure 7-2:

These charts shall only be used for the standard street sections as shown. The capacity shown is based on ½ the street section as calculated by the UD-Inlet spreadsheets. Minor storm capacities are based on no crown overtopping, curb height or maximum allowable spread widths. Major storm capacities are based on flow being containing within the public right-of-way, including conveyance capacity behind the curb. The UDFCD Safety Reduction Factor was applied. An 'n_{STREET}' of 0.016 and 'n_{BACK}' of 0.020 was used.