8.0 Introduction

This chapter provides criteria and design guides for evaluating and designing storm sewer inlets. References to the UDFCD Manual are made throughout this chapter, however where criteria in this chapter conflict with those in the UDFCD Manual, those included in this chapter supercede those in the UDFCD Manual. The review of all planning submittals will be based on the criteria presented herein.

8.1 General

8.1.1 Function of Inlets. The primary purpose of storm drain inlets is to intercept excess surface runoff and convey it into a storm drainage system, thereby reducing or eliminating surface flooding. Roadway geometry often dictates the location of street inlets located along the curb and gutter. In general, inlets are placed at all low points (sumps), median breaks, intersections, crosswalks, and along continuous grade curb and gutter. The spacing of inlets along a continuous grade segment of roadway is governed by the allowable spread of flow. See further details of allowable spread of flow in Chapter 7, Street Drainage of these Criteria.

8.1.2 Types of Inlets. There are two major types of inlets approved for use within the public rights-of-way: curb opening and grate. Inlets are further classified as being on a “continuous grade” or in a “sump”. “Continuous grade” refers to an inlet placed in curb and gutter such that the grade of the street has a continuous slope past the inlet and, therefore, water ponding does not occur at the inlet. The sump condition exists whenever an inlet is located at a low point and the result is ponding water.

8.1.3 General Design Guidelines. The following guidelines shall be used when designing inlets along a street section:

1. Design and location of inlets shall take into consideration pedestrian and bicycle traffic. Inlet grates shall be pedestrian and bicycle safe. Inlets may not be placed at pedestrian ramps or within driveways.
2. Design and location of inlets shall be in accordance with the criteria established in Chapter 7, Street Drainage of these Criteria.
3. Maintenance of inlets shall be considered when determining inlet locations. The slope of the street, the potential for debris and ice accumulations, the distance between inlets and/or manholes etc., shall be considered. Maintenance access shall be provided to all inlets.
4. To avoid potential damage from large vehicles driving over the curb return, inlets shall not be placed in the curb return radii.
5. Selection of the appropriate inlet grate shall be based on a number of factors, including, but not limited to, the adjacent land use and potential for pedestrian or bicycle traffic, the potential for debris accumulation, visibility, expected loading from vehicles, and hydraulic capacity.

6. Consideration should be given to flanking inlets on each side of the low point when the depressed area has no outlet except through the system. The purpose is to provide relief if the inlet at the low point becomes clogged. Consult HEC-22 for additional information regarding this concept.
7. In many cases, inlets are necessary at grade breaks, where street or ditch grades change from steep to relative flat because of the reduced conveyance capacities. In addition, it is common for icing or sediment deposition to occur with nuisance flows in reaches where the grades are relatively mild.

8.1.4 Inlet Capacity. The procedures used to define the capacity of standard inlets under continuous grade or sump flow conditions are described in the following sections. Unless otherwise noted in the following sections, all storm drain inlet criteria shall be in accordance with the Streets/Inlets/Storm Drains Chapter of the UDFCD Manual. In general, the procedure for calculating inlet capacity consists of defining the quantity and depth of flow in the gutter and determining the theoretical flow interception by the inlet.

8.2 Standard SEMSWA Inlets

8.2.1 Selection of Inlet Type. The Streets/Inlets/Storm Drains chapter of the UDFCD Manual provides information on the appropriate application of the different types of inlets along with advantages and disadvantages of each. The information provided in that chapter shall be taken into consideration when selecting an inlet for a given site condition.

8.2.2 Standard Inlets Accepted for Use by SEMSWA. Table 8-1at the end of this chapter provides the standard inlets permitted for use. Along with the inlets in Table 8-1, there are a large number of additional inlets used in the Denver Metro Area. For retrofit situations or when special circumstances exist, other inlets may be used but will be evaluated by SEMSWA on a case-by-case basis. The UDFCD UD-Inlet software must be used for hydraulic analysis of all inlets.

8.3 Hydraulic Analysis of Inlets

All hydraulic analysis of inlets must be performed using the UDFCD UD-Inlet software and following procedures described in the Street/Inlets/Storm Drains chapter of the UDFCD Manual. The design engineer shall also ensure that all applicable street flow depths and allowances described in Chapter 7 are adhered to.

Example applications of UD-Inlet for several inlet types are provided at the end of this chapter.

8.4 Inlets on Continuous Grade

8.4.1 Inlet Capacity Factors. The capacity of an inlet located on a continuous grade is dependent upon a variety of factors, including gutter slope, depth and velocity of flow in the gutter, height and length of the curb opening, street cross slope, and the amount of depression at the inlet. Inlets placed on continuous grades

rarely intercept all of the flow in the gutter during the minor storm. This results in flow continuing downstream of the inlet and is typically referred to as “carryover”. The amount of carryover must be accounted for in the drainage system evaluation as well as in the design of the downstream inlet.

8.4.2 Curb Opening Inlet. The capture efficiency of a curb-opening inlet is dependent on the length of the opening, the depth of flow at the curb, the street cross slope, and the longitudinal gutter slope. If the curb opening is long, the flow rate is low, and the longitudinal gutter slope is small, all of the flow will be captured by the inlet. During the minor storm event, a portion of the stormwater often bypasses the inlet as indicated by the inlet efficiency. See the Streets/Inlets/Storm Drains chapter of the UDFCD Manual for additional information on the efficiency and design of curb opening inlets on continuous grades.

8.5 Inlets in Sump Conditions

8.5.1 Capacity Calculation Factors and Inlet Selection. Inlets located in sumps (low points) must be sized to intercept all of the design storm flows at a maximum depth of ponding as summarized in Chapter 7. The capacity of an inlet in a sump is dependent upon the depth of ponding above the inlet and the amount of debris clogging the inlet. Ponded water is a nuisance and can be a hazard to the public; therefore curb opening and combination inlets (where approved for use) are highly recommended for sump conditions due to their reduced clogging potential versus grate inlet acting alone.

8.5.2 Emergency Overflow Path with Drainage Tract or Easement. A surface flow path shall be provided at all sump inlets to provide for emergency overflows if the inlet becomes clogged. The emergency overflow shall be designed to convey the major storm discharge and shall be contained within a drainage tract or easement. A drainage tract and drainage easement with common ownership such as a district or HOA is required for single-family residential subdivisions; other land use types may provide a drainage easement only. SEMSWA does not want to not burden an individual homeowner with the ownership and responsibilities of this subdivision drainage requirement. Surface treatments of the drainage easement or tract should be addressed and shown on the approved and/or recorded site plan. Overflow ponding limits for the major storm shall be determined and shown on the drainage plan if outside of the public right-of-way or drainage easement. The depth of ponding shall not exceed the maximum allowable water depth for the given street classification as summarized in Chapter 7, Street Drainage.

8.5.3 Inlet Clogging Factors. For all grates in sump conditions, a minimum clogging factor of 50% must be applied to UD-Inlet to calculate inlet capacities.

8.6 Inlet Location and Spacing

8.6.1 Inlet Location and Spacing. The location and spacing of inlets is based upon street design considerations, topography (sumps), maintenance requirements, and the allowable spread of flow within the street. A significant amount of cost savings can be realized if inlets are placed in locations where their efficiency is maximized. The greater the efficiency of an inlet, the smaller the carryover flow, which may result in a smaller number of inlets downstream. Inlets are most efficient in a sump condition or along mild continuous street grades. As discussed in Section 8.7.3, the maximum length of any inlet shall be based on a triple unit.

8.6.2 Inlet Placement on a Continuous Grade Based on Flow Spread. As the flow increases in the gutter on a long, continuous grade segment of roadway, so does the spread. Since the spread (encroachment) is not allowed to exceed the maximum spread width specified in Chapter 7, inlets need to be strategically placed to remove flow from the gutter. A properly designed storm sewer system makes efficient use of the conveyance capacity of the street gutters by positioning inlets at the point where the allowable spread is about to be exceeded for the design storm. Section 3.4 of the Streets/Inlets/Storm Sewers chapter of the UDFCD Manual provides a detailed discussion on inlet placement on continuous grades.

8.7 Other Design Considerations

8.7.1 Curb Chase Drain (Sidewalk Chase). Curb or sidewalk chase drains shall not be used in the right-of-way in place of a standard inlet to remove runoff from a street section, or to convey site runoff to the curb and gutter. Curb chase drains have limited efficiency and have poor long-term performance. Curb or sidewalk chase drains may be allowed on a case by case basis in retrofit situations or if other site conditions warrant so.

8.7.2 Median Inlets. In some situations, it is desirable to construct medians with a “catch” curb and gutter, and to provide inlets along the median to reduce ponding at curb and gutter low points and to eliminate concentrated flow crossing over the lanes of traffic at the nose of the median. Figure 8-1, Special Median Inlet Details, presents conceptual representations of options available for placing median nose inlets. The final design and construction drawings must address inlet sizing, dimensions, and required curb and gutter transitions. If a street is constructed with concrete, it is acceptable for the median curb and gutter to be constructed as a “spill” section.

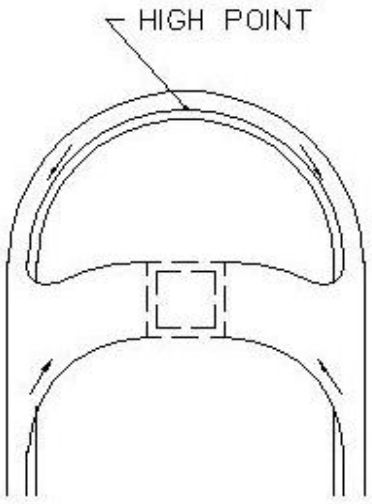
8.7.3 Maximum Inlet Length. Inlets shall be designed to blend in with the streetscape, and not present a dramatic structural departure from the general surroundings. The use of extremely long inlets is discouraged, as they are generally not aesthetic, require increased maintenance, and are viewed as a hazard by the public. The maximum length of an inlet in a specific location shall not exceed the length of a triple unit (i.e. 15 ft. for a Type R inlet, 9 ft. for Type 16, 9 ft. for Type 13).

8.7.4 Median Underdrain. In some situations, underdrains may be necessary within median. If necessary, they shall include cleanouts at both ends and at junctions with laterals, with a maximum spacing of 100 feet between cleanouts. Underdrains shall NOT be wrapped in filter fabric and shall be installed in an aggregate layer as specified in Fact Sheet T-2 Grass Swales in Volume 3 of the UDFCD Manual.

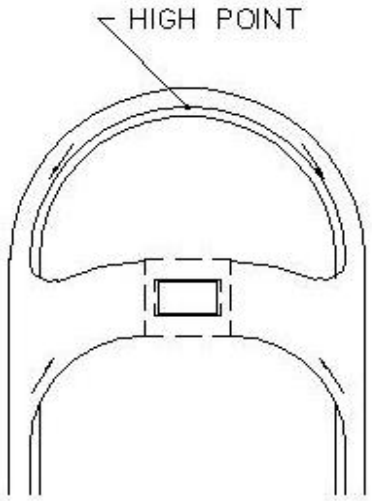
TABLE 8-1
STANDARD SEMSWA INLETS

Inlet Type	Permitted Use	Standard Details
Curb-Opening Inlet – Type R	All street types with 6-inch vertical curb and gutter and 4-inch mountable curb and gutter, with appropriate transitions.	CDOT M-604-12 Standard Plans
Grate Inlet – Type C	Roadside or median grass swales; Landscaped area drains; used in sump condition	CDOT M-604-10 Standard Plans
Grate Inlet – Type D	Roadside or median grass swales; Landscaped area drains; used in sump condition	CDOT M-604-11 Standard Plans
Combination – Type 16	All street types with 6-inch vertical curb and gutter and 4-inch mountable curb and gutter, with appropriate transitions (e.g. bicycle safe grate).	Denver S-616.1, S-616.2, S-616.3 Standard Plans
Combination – Type 13	All street types with 6-inch vertical curb and gutter and 4-inch mountable curb and gutter, with appropriate transitions (e.g. bicycle safe grate).	CDOT M-604-13 Standard Plans
Note: Type 13 and 16 inlets shall only be used when site conditions warrant their use and when Type R, C, or D cannot be used.		

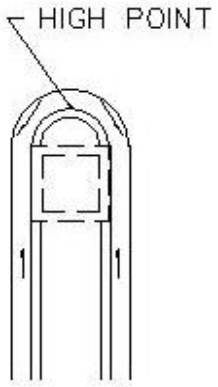
FIGURE 8-1
SPECIAL MEDIAN INLET DETAILS



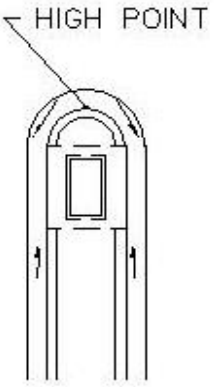
16' Median w/
Type C Inlet



16' Median w/
Grated Inlet Type 13



4' Median w/
Type C Inlet



4' Median w/
Grated Inlet Type
13

EXAMPLE APPLICATIONS OF UD-INLET FOR HYDRAULIC ANALYSIS

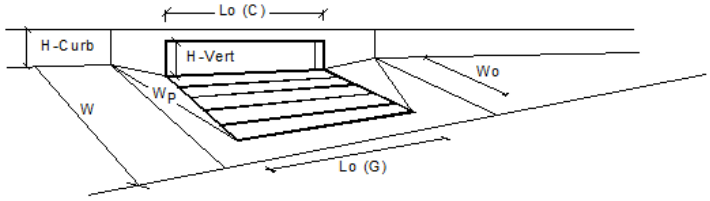
This section includes a brief discussion and procedures for applying the UD-Inlet software to design, evaluate and select different inlets in a variety of conditions. In all cases, the user must first perform the appropriate street capacity calculations in UD-Inlet, as discussed in Chapter 7 of this manual, as the inlet calculations are dependent on those calculations and input parameters. Additional examples and discussion on appropriate use of UD-Inlet are provided the Streets, Inlets and Storm Drains chapter of the UDFCD Manual.

UD-Inlet contains two primary algorithms, one for Inlets on a Continuous Grade and one for Inlets in Sump or Sag Conditions. If the value for S_O (street longitudinal slope) = 0.000, UD-Inlet will automatically show the interface for modeling Inlets in a Sump or Sag condition (Figure 8-2). If S_O > 0.000, UD-Inlet will automatically show the interface for modeling Inlets on a Continous Grade (Figure 8-3).

FIGURE 8-3
UD-Inlet Interface for Inlet in a Sump or Sag Condition

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



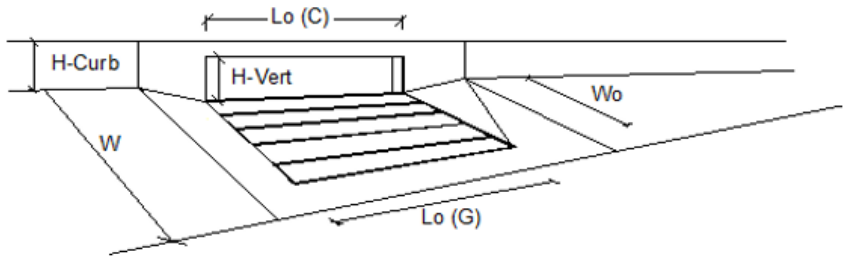
Show Details
Reset Defaults
Clear Worksheet

Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	Denver No. 16 Combination		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	2	2	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	5.4	5.4	inches
Grate Information		MINOR	MAJOR	Override Depths
Length of a Unit Grate	L_o (G) =	3.00	3.00	feet
Width of a Unit Grate	W_o =	1.73	1.73	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	0.60	0.60	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	3.00	3.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.50	6.50	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	5.25	5.25	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	0.00	0.00	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.70	3.70	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.66	0.66	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	0.469	0.469	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.28	0.28	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.63	0.63	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	0.63	0.63	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**4.6**	**4.6**	**cfs**
WARNING: Inlet Capacity less than Q Peak for Minor and Major Storms	$Q_{PEAK\ REQUIRED}$ =	75.0	75.0	cfs

FIGURE 8-2
UD-Inlet Interface for Inlet on a Continuous Grade

INLET ON A CONTINUOUS GRADE

Version 4.05 Released March 2017



Show Details
Reset Defaults
Clear Worksheet

CDOT Type R Curb Opening

Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	3	3	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: WARNING: Q > ALLOWABLE Q FOR MINOR STORM'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**25.6**	**25.6**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**49.4**	**49.4**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**34**	**34**	**%**

Procedure:

1. Select inlet type from the dropdown menu. UD-Inlet will automatically populate multiple fields based on the inlet type. Carefully review each of the values to make sure they are applicable to the project. All cells bordered in blue are user-editable. All cells bordered in green are calculated values.
2. The primary design factor will be the Total Number of Units in the Inlet and/or the Length of a Single Unit Inlet. Adding consecutive inlets and/or increasing inlet length will generally increase capture efficiency.
3. Review outputs for total captured flow and modify design as needed. Carry-over flow must be accounted for in downstream inlet calculations.