PRELIMINARY DRAINAGE REPORT
for
8780 ROSEMARY STREET
City of Commerce City, Adams County, Colorado

Prepared For:

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LANGAN

19 August 2022
620023001

Certifications

Engineer's Statement:

I hereby certify that this preliminary study for the 8780 Rosemary Street development was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Commerce City Storm Drainage Design and Technical Criteria Manual for the owners thereof.

_____

Michael Golias, P.E.
Registered Professional Engineer
State of Colorado No. 0052156

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Introduction

This report serves to document the impact of the proposed 8780 Rosemary Street development on existing drainage facilities, and to adequately size proposed drainage facilities to service this development.

I. GENERAL LOCATION AND DESCRIPTION

A. Location

The proposed development is situated in the northwest quarter northeast quarter northwest quarter of Section 28, Township 2 South, Range 67 West of the Sixth Principal Meridian, City of Commerce City, Adams County, Colorado. A site location map has been provided in Appendix A. The site is bounded by the Ministerio Palabra De Vida and a Municipal Building to the south, a vacant lot to the east, Rosemary Street to the west, and East 88th Avenue to the north.

B. Description of Property

The property is 6.45 acres in total and is covered in gravel and native grassland with topography gently sloping from southeast to northwest at a 0 – 2.0% slope. An existing 1-story building approximately 1,700 square feet in size is located in the southwest corner of the property. A large movie screen is located in the northeast corner of the site, along with a ticket booth located along the southern property boundary. An additional 1-story building, approximately 1,300 square feet, is located in the southeast corner of the site. Primary access to the site is from a gravel access driveway off of Rosemary Street and runs parallel to the southern property boundary. A secondary gravel access driveway is located along East 88th Avenue in the northeast corner of the site. A 40-ft wide, 100-ft long gas easement is located in the northwest corner of the property. The majority of the site's stormwater runoff is conveyed via sheet flow to an existing roadside ditch on the south side of East 88th Avenue. Please reference the ALTA/Land Title Survey drawing for existing site conditions.

According to the "Geotechnical Evaluation Warehouse at 8780 Rosemary Street Commerce City, Colorado" prepared by GROUND Engineering Consultants, Inc. dated

August 6, 2021, the subsurface conditions at the time of testing generally consisted of fill material consisting of fine to medium sands with varying fractions of silts, light brown to dark brown in color. This fill was underlain with native fine to medium sands and clays, light brown to brown in color. These sands and clays were underlain with native clean to silty and clayey, fine to course sands and gravels, light brown in color. These sands and gravels were underlain by claystone bedrock interbedded locally with siltstones and sandstones. Bedrock was encountered 42 to 45 feet below existing grade. For purposes of the hydrologic analysis, predominant soil types have been classified as NRCS Hydrologic Soil Types A and C. See Appendix A for NRCS Soils Report.

Groundwater was observed in the geotechnical borings at depths ranging from 36 to 38 feet below existing grade in select test holes at the time of drilling. This corresponds to an approximate elevation between 5082 and 5080.

C. Project Description

The 8780 Rosemary Street development project will consist of one single-story industrial warehouse, totaling 80,574±SF of ground floor area, along with the construction of drive lanes, sidewalks, automobile parking spaces, trailer loading docks, supporting utility infrastructure, and landscaping. A full movement access will be added along Rosemary Street, and a right-in/right-out access along 88th Avenue. Proposed groundcover will consist of concrete and asphalt pavement, landscaped areas, and native grasses.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

The project area lies within the 14,979 acre Irondale Gulch Watershed per the Irondale Gulch Outfall Systems Plan Conceptual Design Report, published September 2011 (hereafter referred to as "IGOSP"). This watershed is located within Adam's County and is generally bounded by 56th Avenue to the South, 88th Avenue to the North, loosely by Buckley Road to the East, and the South Platte River to the West. The upper limit of the watershed is 56th Avenue. The flow path of the watershed begins at the South Platte River and extends upstream to Rocky Mountain Arsenal, but is not well defined

throughout much of its reaches. See figure ES-1 in the IGOSP Excerpts (Appendix A) for more information.

Per the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Map (FIRM) number 08001C0607H, dated March 5th, 2007, the development lies within an area determined to be outside of the 0.2% annual chance floodplain. See Appendix A for a copy of the FIRM map.

B. Sub-Basin Description

Drainage mapping from the IGOSP identifies the site to be a sub-basin of Reach 2 of Irondale Gulch, which is ultimately conveyed to the South Platte River. Drainage from the south portion of the site is conveyed from southeast to west via overland sheet flow to an existing roadside swale along the east side of Rosemary Street. Drainage from the northern portion of the site is conveyed south via overland sheet flow to an existing swale along a fence line. This swale flows west and meets the swale along Rosemary Street. Stormwater in the central portion of the site tends to pool before it flows to the west. No outfall exists, so all stormwater is retained on site.

Historically, a large portion the stormwater from surrounding off-site parcels is routed to the site. Stormwater from the parcels to the south is conveyed north via overland sheet flow to an existing swale along the southern property boundary of the site. This swale flows to the west where it meets the existing swale along Rosemary Street. Stormwater from the parcel to the east drains to the west via overland sheet flow to the existing swale along the northern fence line. See Drawing CA101 for the historic drainage patterns.

The existing O'Bryan Canal irrigation facility is located approximately 1,000 feet west of the project site. The project site drainage is not expected to influence the O'Bryan Canal, as it is located further than 100 feet away from the facility.

As identified in the IGOSP, the alternative conveyance improvements are reliant on upstream detention of the upper watersheds or sub-basins until regional detention facilities and underground conduits are constructed. A public storm sewer system is proposed to be installed in 88th Avenue, but has yet to be constructed. Therefore, runoff

captured on the developed site will need to be either detained or retained and infiltrated onsite until a connection to the proposed storm sewer can be made.

The proposed development includes the construction of a retention/infiltration basin in the available landscaped area north of the proposed building that will retain on-site flows. Two rain gardens are proposed on site to retain water from the off-site areas to the North, West, and South. These rain gardens have been sized to retain the 100-year storm event plus a 100-year storm surcharge. Runoff from the existing adjacent properties to the south will sheet flow into the site, where it will be directed to the west via the swale along the southern property line. Runoff from these properties is anticipated to affect the drainage patterns of the site. The proposed rain gardens have been sized to accommodate the flow from these properties. See Drawing CA102 for the proposed drainage patterns, and CA103 for the proposed sub basins.

C. General Soil Description

The soils on site are predominantly Nuun loam and Vona sandy loam as defined by NCRS Web Soil Survey accessed on 03/04/2021. For purposes of the hydrologic analysis, predominant soil types have been classified as NRCS Hydrologic Soil Types C and A. See Appendix A for NRCS Soils Report.

III. DRAINAGE DESIGN CRITERIA

A. Regulations

This project has been designed in accordance with the following design criteria:

- City of Commerce City Storm Drainage Design and Technical Criteria Manual (hereafter referred to as "CRITERIA") last revised March 2022
- Mile High Flood District Urban Storm Drainage Criteria Manual: Volume 1, last revised August 2018 (hereafter referred to as "MANUAL VOL. 1")
- Mile High Flood District Urban Storm Drainage Criteria Manual: Volume 2, last revised January 2016 (hereafter referred to as MANUAL VOL. 2")
- Mile High Flood District Urban Storm Drainage Criteria Manual: Volume 3, last revised November 2010 (hereafter referred to as "MANUAL VOL.3")

- State of Colorado Senate Bill 15-212

B. Development Criteria Reference and Constraints

All stormwater for the 5-year and 100-year 1-hour design storms will be retained on-site in the infiltration basin, and thus the project will not have an impact on the Irondale Gulch Drainage Area. Senate Bill 15-212 drain times will be met by infiltrating stormwater captured in the proposed basin within 120 hours. Note that retention/infiltration is not an allowable practice per the CRITERIA, however the city has directed the developer to provide a two part detention/retention facility. The infiltration basin has been provided with an outlet control structure that will be temporarily plugged. Once the proposed public storm sewer in 88th Avenue is constructed, the outlet will be connected to the storm sewer and the basin converted to the detention/sand filter configuration.

The major design constraint is the off-site area to the South that drains to the site. Because no stormwater infrastructure exists, this stormwater must be retained on-site to preserve existing regional drainage patterns. This is also a constraint with respect to stormwater flowing into the site from Rosemary Street and 88th Avenue.

C. Hydrological Criteria

The proposed drainage system is designed in accordance with the CRITERIA and MANUAL VOL. 1 - 3. Per the CRITERIA, the minor and major storms were considered to have a 5-year and 100-year 1-hour recurrence interval. The Rational Method was used to quantify rainfall and peak runoff values for the project site. One hour point-rainfall depths for the 5-year and 100-year storms are 1.37 inches and 2.58 inches, respectively. The 5-year storm is considered to be the minor storm event, and the 100-year storm is considered to be the major storm event per the CRITERIA.

Developed flow rates were calculated using composite imperviousness coefficients from the CRITERIA. Refer to Appendix A and B for detailed calculations and design aids.

D. Hydraulic Criteria

The IGOSP proposes regional detention improvements and a storm sewer network for the project's sub-watershed, but these have yet to be constructed. Therefore, this site is

required to have an independent upstream stormwater management solution. The proposed retention/infiltration basin has been designed to accommodate the 100-year storm of 24-hour duration (depth of 4.8 inches), per section 5.2 of the CRITERIA. Side slopes are designed at 3:1 horizontal to vertical, and 1 foot minimum of freeboard above the maximum retention volume water surface is provided. An emergency overflow spillway has been designed to convey the 100-year 1-hour storm event in accordance with section 13.8.3 of the CRITERIA. The basin has been designed to infiltrate the site's stormwater to the engineered soils immediately beneath the pond. The subgrade at the pond bottom will be over-excavated a minimum of 1.5 feet and replaced with highly permeable soils in accordance with the design requirements provided in Section T-6 "Sand Filter" of the MANUAL VOL. 3. The engineered soils filter layer was designed to have an infiltration rate of 1.2 inches/hour in order to meet jurisdictional drain times. A drainage maintenance easement will be granted to Commerce City in order to keep the pond operable. See Drawings CG101, CG102, and CA501 for details and Appendix C for detailed calculations and design aids. Please note that the retention/infiltration basin is intended to function in the interim. Upon the completed of the proposed public storm sewer in 88th avenue, the pond will be converted to an extended detention basin with a sand filter. The EDB with sand filter has been designed in accordance with section 13.8 of the CRITERA and the MANUAL VOL. 3.

Stormwater conveyance systems have been designed to convey the major design storm while maintaining an EGL that is at least 1 foot below grade. This is in excess of the requirements in the CRITERIA. Pipe slopes have been designed to a minimum velocity of 3 feet/second at half-full conditions per the CRITERIA. Water surface profiles were analyzed using AutoCAD Civil3D Hydraflow Storm Sewers Extension. See Appendix C for all hydraulic computations.

Proposed inlets have been designed in accordance with the CRITERIA and the MANUAL VOL. 1. Proposed sump inlets have been sized to accommodate the 100-year storm event flows. Calculations are provided in Appendix C.

IV. DRAINAGE FACILITY DESIGN

A. General Concept

The on-site stormwater is to be collected through a system of storm sewer inlets and routed to the onsite infiltration basin. Stormwater conveyance and stormwater storage facilities have been designed in accordance with the CRITERIA and the MANUAL VOL. 1 - 3. See Drawing CA102, Proposed Drainage Patterns Map, for the extents, topography, and flow rates of Basin 1.

The infiltration basin has been sized to accommodate the 24-hour, 100-year point rainfall value of 4.8 inches per the CRITERIA and equates to a storage volume of approximately 1.01 acre-feet. This basin is sized to adequately store and infiltrate the on-site and off-site drainage flowing into the basin, as shown in Drawing CA102. The outlet control structure of the proposed on-site retention facility will be plugged. This basin is intended to be converted from a retention basin to a detention basin upon the installation of the regional stormwater management infrastructure outlined in the IGOSP. The proposed on-site storage facility will not impact the IGOSP or the existing/future Irondale Gulch. Since all stormwater is retained on site, there is no impact to upstream or downstream properties.

The proposed rain gardens have been designed in excess of the requirements outlined in the MANUAL VOL. 1. These rain gardens are designed to store the 100-yr major storm event with enough storage to accommodate a surcharge from the same caliber event assuming no infiltration is possible. Calculations for each rain garden are provided in Appendix C. Rain garden detail drawings will be provided as part of the Storm Construction Plans set once the City has approved the general design.

B. Specific Details

A basin access easement will be established with Commerce City to aide in maintenance of the retention/infiltration basin. The owner shall be responsible for the maintenance of the proposed stormwater facility.

Sub basin delineations are provided in drawing CA103 to support inlet calculations, pipe sizing, etc.

V. CONCLUSIONS

A. Compliance with Standards

This final drainage report has been prepared for 8780 Rosemary Street development in compliance with the Commerce City Storm Drainage Design and Technical Criteria Manual as well as the Mile High Flood District Urban Storm Drainage Criteria Manual(s).

B. Drainage Concepts

The proposed development will have a minimal impact on the IGOSP and all upstream and downstream properties, as all water is to be retained on-site either in the infiltration basin and infiltrating at jurisdictional rates, or in proposed rain gardens designed to retain off-site flow.

VI. REFERENCES

1. Irondale Gulch Outfall Systems Plan Conceptual Design Report, Moser & Associates Engineering, Inc., dated September 2011.
2. Storm Drainage Design and Technical Criteria Manual, City of Commerce City Department of Public Works, dated 1989.
3. Urban Storm Drainage Criteria Manual: Volume 1 – Management, Hydrology, and Hydraulics, Mile High Flood District, revised August 2018.
4. Urban Storm Drainage Criteria Manual: Volume 2 – Structures, Storage, and Recreation, Mile High Flood District, revised January 2016.
5. Urban Storm Drainage Criteria Manual: Volume 3 – Best Management Practices, Mile High Flood District, revised November 2010.

Appendix A

Maps and Design Aids

- Site Location Map
- NRCS Soils Report
- Flood Insurance Rate Map
- Commerce City Storm Criteria
- Irondale Gulch Outfall Systems Plan Excerpts
- Soil Boring Locations
- Infiltration Test Results

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community; Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Project	8780 ROSEMARY ST
	COMMERCE CITY
	ADAMS COUNTY COLORADO
Drawing Title	IMAGERY WITH LABELS
Project No.	620023001
Date	8/25/2021
Scale	1:1,000
Drawn By	Site Analyzer
Submission Date	08/25/2021
Figure	1
	Sheet 1 of 1

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Spatial Reference: NAD 1983 StatePlane Colorado North FIPS 0501 Feet

United States Department of Agriculture

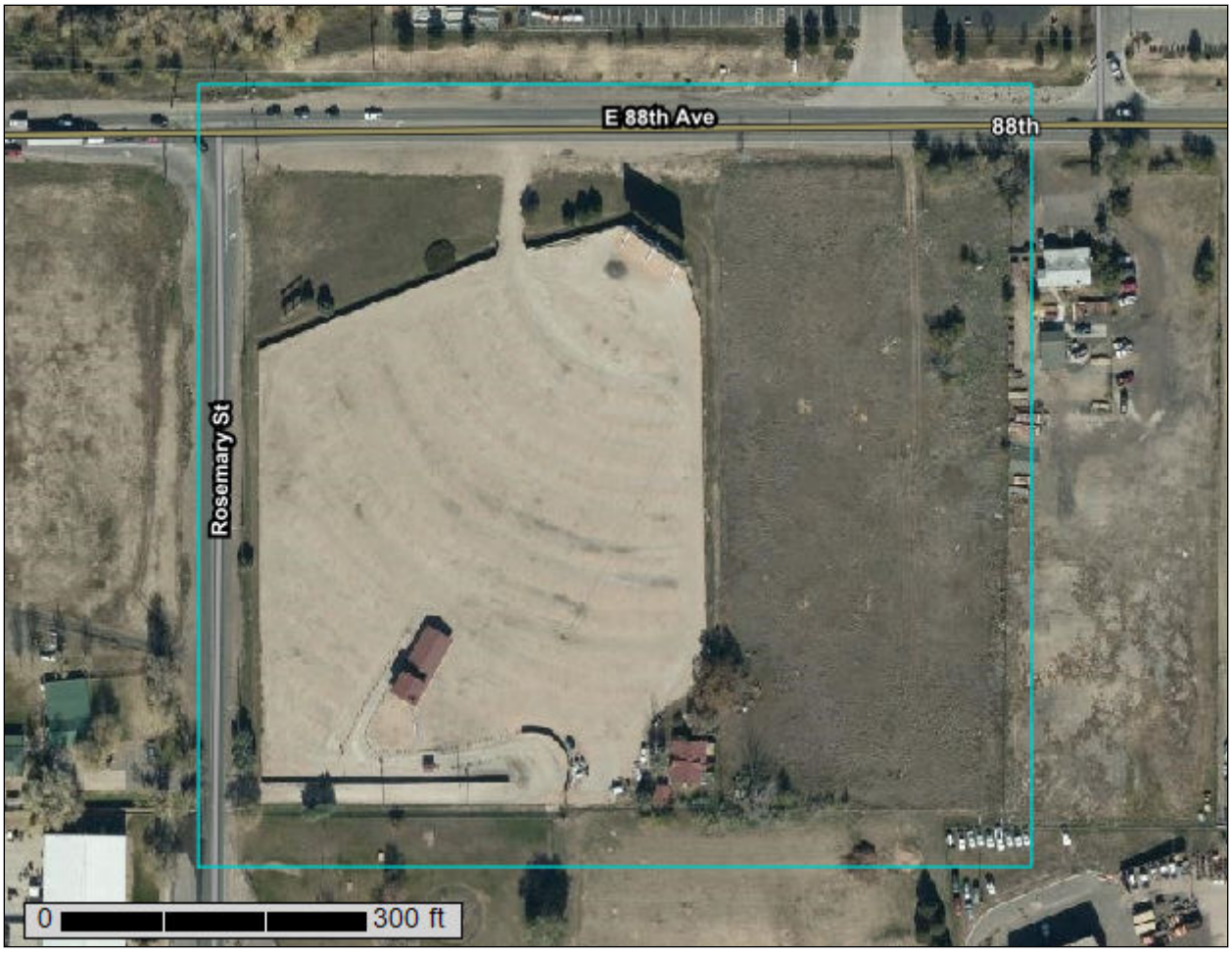
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Adams County Area, Parts of Adams and Denver Counties, Colorado

88 DRIVE IN



March 4, 2021

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

Map Scale: 1:1,980 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 25 50 100 150

Feet
0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Adams County Area, Parts of Adams and Denver Counties, Colorado
Survey Area Data: Version 17, Jun 4, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 3, 2018—Dec 4, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AsB	Ascalon sandy loam, 0 to 3 percent slopes	0.6	4.2%
NlB	Nunn loam, 1 to 3 percent slopes	7.6	52.5%
VoC	Vona sandy loam, 3 to 5 percent slopes	6.2	43.3%
Totals for Area of Interest		**14.4**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or

landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Adams County Area, Parts of Adams and Denver Counties, Colorado

AsB—Ascalon sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2swl3
Elevation: 3,870 to 5,960 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 135 to 160 days
Farmland classification: Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Map Unit Composition

Ascalon and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ascalon

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Wind-reworked alluvium and/or calcareous sandy eolian deposits

Typical profile

Ap - 0 to 6 inches: sandy loam
Bt1 - 6 to 12 inches: sandy clay loam
Bt2 - 12 to 19 inches: sandy clay loam
Bk - 19 to 35 inches: sandy clay loam
C - 35 to 80 inches: sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: B
Ecological site: R067BY024CO - Sandy Plains
Hydric soil rating: No

Minor Components

Olnest

Percent of map unit: 10 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY024CO - Sandy Plains
Hydric soil rating: No

Vona

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY024CO - Sandy Plains
Hydric soil rating: No

NIB—Nunn loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2tln2
Elevation: 3,900 to 6,250 feet
Mean annual precipitation: 13 to 16 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 135 to 160 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Nunn and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nunn

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pleistocene aged alluvium and/or eolian deposits

Typical profile

Ap - 0 to 6 inches: loam
Bt1 - 6 to 10 inches: clay loam
Bt2 - 10 to 26 inches: clay loam
Btk - 26 to 31 inches: clay loam

Bk1 - 31 to 47 inches: loam
Bk2 - 47 to 80 inches: loam

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 7 percent
Maximum salinity: Nonsaline (0.1 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 0.5
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Minor Components

Wages

Percent of map unit: 8 percent
Landform: Alluvial fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Fort collins

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Haverson, very rarely flooded

Percent of map unit: 2 percent
Landform: Drainageways, terraces, alluvial fans
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Ecological site: R067BY036CO - Overflow
Hydric soil rating: No

VoC—Vona sandy loam, 3 to 5 percent slopes

Map Unit Setting

National map unit symbol: 34xc
Elevation: 4,000 to 5,600 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 125 to 155 days
Farmland classification: Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Map Unit Composition

Vona and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Vona

Setting

Landform: Plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian sands

Typical profile

H1 - 0 to 7 inches: sandy loam
H2 - 7 to 22 inches: sandy loam
H3 - 22 to 60 inches: loamy sand

Properties and qualities

Slope: 3 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: R067BY024CO - Sandy Plains

Hydric soil rating: No

Minor Components

Truckton

Percent of map unit: 10 percent
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Hydric Rating by Map Unit

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Custom Soil Resource Report
Map—Hydric Rating by Map Unit

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Lines
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Points
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Adams County Area, Parts of Adams and Denver Counties, Colorado
Survey Area Data: Version 17, Jun 4, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 3, 2018—Dec 4, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydric Rating by Map Unit

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AsB	Ascalon sandy loam, 0 to 3 percent slopes	0	0.6	4.2%
NlB	Nunn loam, 1 to 3 percent slopes	0	7.6	52.5%
VoC	Vona sandy loam, 3 to 5 percent slopes	0	6.2	43.3%
Totals for Area of Interest			**14.4**	**100.0%**

Rating Options—Hydric Rating by Map Unit

Aggregation Method: Percent Present

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

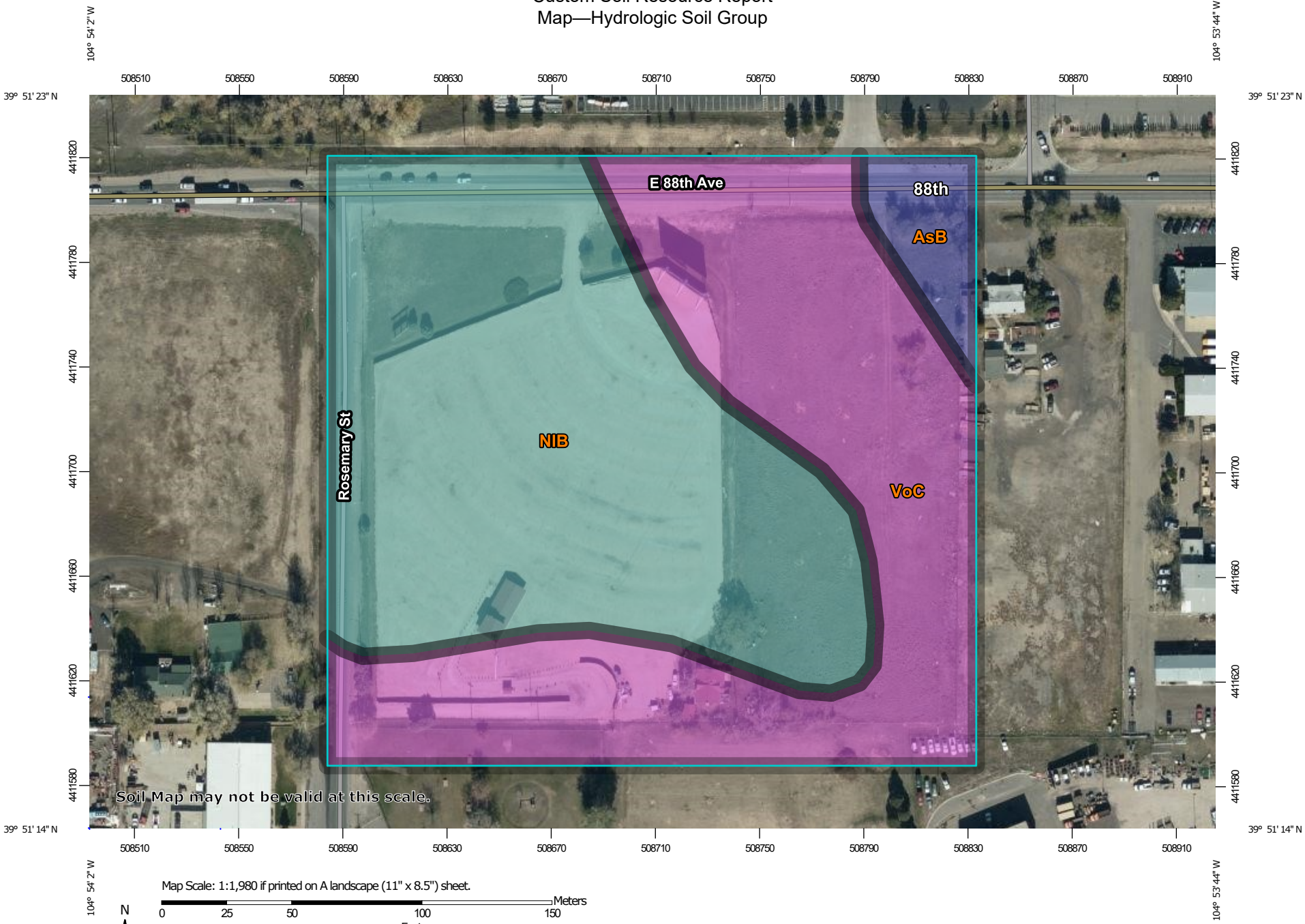
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at

or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.



Map Scale: 1:1,980 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 25 50 100 150

Feet
0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

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The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Adams County Area, Parts of Adams and Denver Counties, Colorado
Survey Area Data: Version 17, Jun 4, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 3, 2018—Dec 4, 2018

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MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AsB	Ascalon sandy loam, 0 to 3 percent slopes	B	0.6	4.2%
NlB	Nunn loam, 1 to 3 percent slopes	C	7.6	52.5%
VoC	Vona sandy loam, 3 to 5 percent slopes	A	6.2	43.3%
Totals for Area of Interest			**14.4**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC- 3, #9202
1315 East- West Highway
Silver Spring, MD 20910- 3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided by the Adams County and Commerce City GIS departments. The coordinate system used for the production of the digital FIRM is Universe Transverse Mercator, Zone 13N, referenced to North American Datum of 1983 and the GRS 80 spheroid, Western Hemisphere.

This map reflects more detailed and up- to- date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data)* may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de- annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

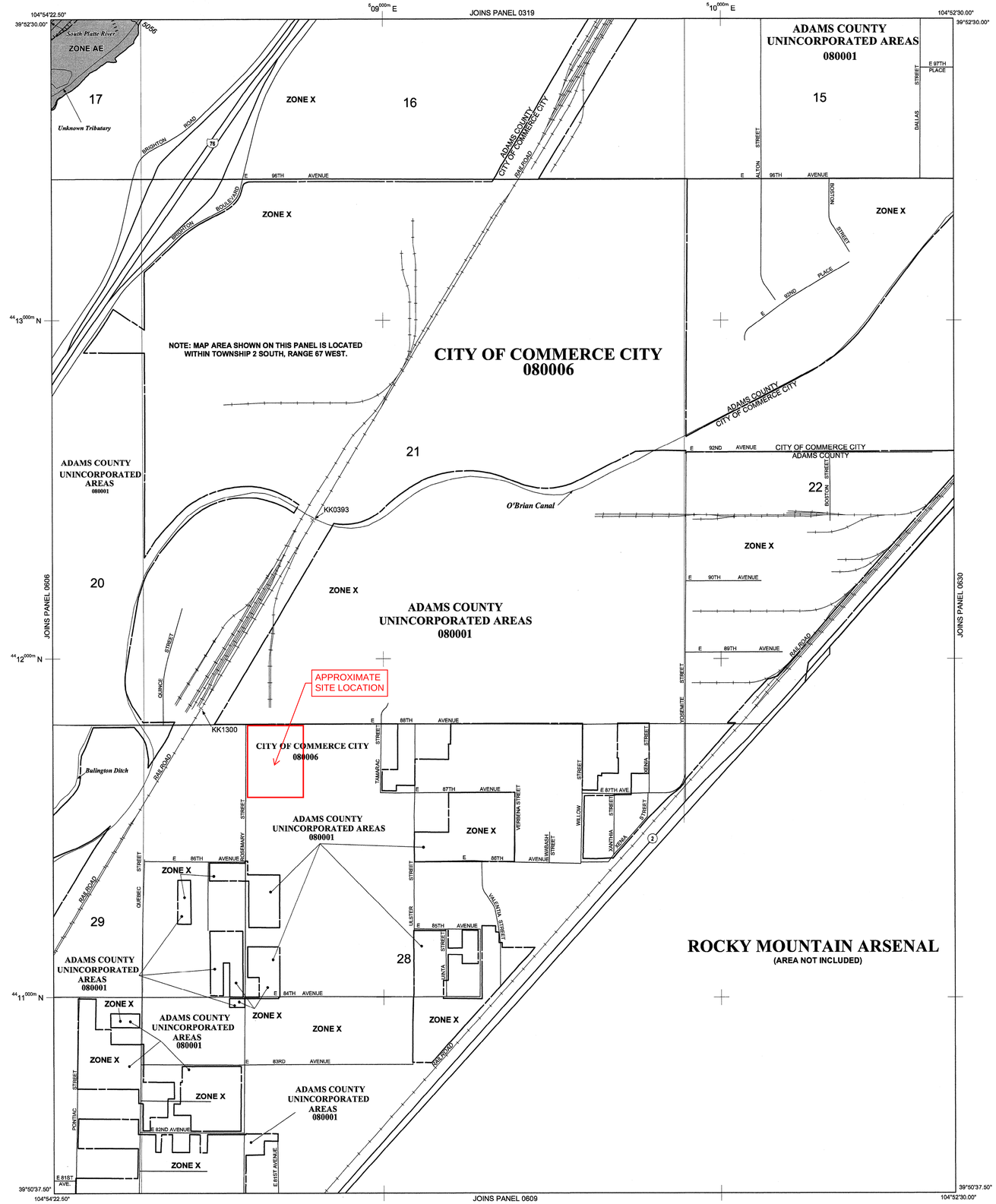
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1- 800- 358- 9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report,* and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1- 800- 358- 9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1- 877- FEMA MAP** (1- 877- 336- 2627) or visit the FEMA website at http://www.fema.gov/.

This digital Flood Insurance Rate Map (FIRM) was produced through a cooperative partnership between the State of Colorado Water Conservation Board, the Urban Drainage and Flood Control District, and the Federal Emergency Management Agency (FEMA). The State of Colorado Water Conservation Board and the Urban Drainage and Flood Control District have implemented a long-term approach of floodplain management to reduce the costs associated with flooding. As part of this effort, both the State of Colorado and the Urban Drainage and Flood Control District have joined in Cooperating Technical Partner agreements with FEMA to produce this digital FIRM.

Additional flood hazard information and resources are available from local communities, the Colorado Water Conservation Board, and the Urban Drainage and Flood Control District.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

Floodplain boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

513 — Base Flood Elevation line and value; elevation in feet*

(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A — Cross section line

23 — 23 — Transect line

97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)

4275000mN — 1000-meter Universal Transverse Mercator grid ticks, zone 13

6000000 M — 5000-foot grid ticks: Alabama State Plane coordinate system, east zone (FIPSZONE 0101), Transverse Mercator

DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)

M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
August 16, 1995
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
March 5, 2007 - to update map format.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1- 800- 638- 6620.

MAP SCALE 1" = 500'
250 0 500 1000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0607H

FIRM
FLOOD INSURANCE RATE MAP
ADAMS COUNTY, COLORADO
AND INCORPORATED AREAS

PANEL 607 OF 1150
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ADAMS COUNTY	080001	0607	H
COMMERCE CITY, CITY OF	080006	0607	H

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08001C0607H

MAP REVISED
MARCH 5, 2007

Federal Emergency Management Agency

5.0 Rainfall

5.1 Introduction

The design rainfall data to be used to complete hydrologic analyses described in the Runoff chapter of this Manual are presented in this section. More specifically, this chapter provides: 1) point precipitation values for Commerce City, 2) information on the Colorado Urban Hydrograph Procedure (CUHP), and 3) an intensity-duration-frequency table for use with the Rational Method. All hydrological analyses within Commerce City must use the rainfall data presented herein for calculating storm runoff. There may be cases where the designer needs to consider events more extreme than the 100-year storm (e.g., for public safety, critical facilities).

The design storms and intensity-duration-frequency tables for Commerce City were developed using the rainfall data from the *National Oceanic and Atmospheric Administration Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 8* (NOAA Atlas 14).

5.2 Rainfall Depth-Duration-Frequency Values

Based on mapping and data presented in the NOAA Atlas 14, variations in rainfall depths across Commerce City are minimal, and rainfall characteristics for Commerce City can be represented by a single rainfall zone. Rainfall depth-duration-frequency data are needed for both the Rational Method and for CUHP. The 1-hour point rainfall depth is used by CUHP to generate a hyetograph that is used for rainfall-runoff computations. For watersheds 15 square miles and larger, the 6-hour rainfall depth is also required for use with CUHP. Table 5-1 summarizes point rainfall values for various durations. The point rainfall depths in Table 5-1 were taken from NOAA Atlas 14 for the Commerce City Civic Center. The values in this table must be used for design rainfall in Commerce City.

Table 5-1. Point Rainfall Depths

	Rainfall Depth (inches)							
Return Period	**5-minute**	**10-minute**	**15-minute**	**30-minute**	**1-hour**	**2-hour**	**3-hour**	**6-hour**
2-year	0.27	0.40	0.48	0.68	0.84	1.00	1.09	1.29
5-year	0.36	0.53	0.65	0.90	1.12	1.33	1.44	1.68
10-year	0.45	0.65	0.80	1.11	1.37	1.63	1.76	2.04
50-year	0.68	1.00	1.22	1.69	2.08	2.47	2.66	3.05
100-year	0.80	1.17	1.43	1.97	2.43	2.88	3.10	3.54
500-year	1.11	1.63	1.98	2.72	3.35	3.98	4.27	4.83
Date: July 2019		Reference: NOAA Atlas 14, Volume 8, Version 2, 2013. Data reported for Commerce City Civic Center.						

These point rainfall depths must be distributed temporally (e.g., 5-minute increments) for use with the CUHP model. Area adjustment of these point rainfall values is required based on watershed size when using CUHP. CUHP automatically generates the rainfall hyetograph and calculates temporal adjustments to rainfall distribution for various storm events and watershed sizes in accordance with the Rainfall chapter of the MHFD Manual.

Table 5-2 provides the rainfall depth-duration-frequency values calculated for use with the Rational Method in small watersheds that are 90 acres or less in size, and Table 5-3 provides intensity-duration-frequency data. If the computed value of the time of concentration falls between the values listed in Table 5-2 or 5-3, apply linear interpolation to find the depth or intensity associated with the calculated time of concentration.

Table 5-2. Rainfall Depth-Duration-Frequency Values for Use with the Rational Method

Time (minutes)	Rainfall Depth (inches)				
	2-year	5-year	10-year	50-year	100-year
5	0.27	0.36	0.45	0.68	0.80
10	0.40	0.53	0.65	1.00	1.17
15	0.48	0.65	0.80	1.22	1.43
20	0.55	0.73	0.90	1.38	1.61
25	0.61	0.82	1.01	1.53	1.79
30	0.68	0.90	1.11	1.69	1.97
35	0.71	0.94	1.15	1.76	2.05
40	0.73	0.98	1.20	1.82	2.12
45	0.76	1.01	1.24	1.89	2.20
50	0.79	1.05	1.28	1.95	2.28
55	0.81	1.08	1.33	2.02	2.35
60	0.84	1.12	1.37	2.08	2.43

Table 5-3. Rainfall Intensity-Duration-Frequency Values for Use with the Rational Method

Time (minutes)	Rainfall Intensity (inches/hour)				
	2-year	5-year	10-year	50-year	100-year
5	3.24	4.34	5.35	8.20	9.60
10	2.38	3.18	3.92	6.00	7.02
15	1.93	2.58	3.18	4.88	5.72
20	1.64	2.20	2.70	4.13	4.83
25	1.47	1.96	2.41	3.68	4.30
30	1.36	1.81	2.22	3.38	3.94
35	1.21	1.61	1.98	3.01	3.51
40	1.10	1.46	1.80	2.73	3.19
45	1.01	1.35	1.65	2.51	2.93
50	0.94	1.26	1.54	2.34	2.73
55	0.89	1.18	1.45	2.20	2.57
60	0.84	1.12	1.37	2.08	2.43

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6.0 Runoff

6.1 Introduction

Proper calculation of runoff is critical to proper planning and sizing of storm drainage facilities. Erroneously high runoff calculations can result in higher cost facilities, while erroneously low runoff calculations can result in damage or loss of life or damage to infrastructure, property, and natural resources. This chapter identifies the methodology to be used for determining the storm runoff design peaks and volumes for preparation of storm drainage studies, plans, and facility designs in Commerce City. The background, equations, examples, and spreadsheets (e.g., UD-Rational) for these methods should be obtained from the Runoff chapter of the MHFD Manual. The Colorado Urban Hydrograph Procedure (CUHP) and the Stormwater Management Model (SWMM) computer models for calculating and routing runoff may be downloaded from the MHFD's website.

6.2 Runoff Calculation Methods

There are several methods for calculating runoff acceptable for use in Commerce City: the Rational Method, CUHP, and CUHP combined with SWMM, as described in Table 6-1. In some cases, MHFD or Commerce City have completed detailed hydrologic studies that may also be used. Criteria determining appropriateness of use are also summarized in Table 6-1. All criteria specified in the MHFD Manual must be followed for preparation of drainage reports and storm drainage facility designs in Commerce City.

Table 6-1. Runoff Calculation Methods Acceptable for Use in Commerce City

Runoff Calculation Method	Application Criteria	Requirements for Use in Commerce City
Rational Method	Simple catchments less than 90 acres in size. Should not be used when routing of hydrographs is required.	Follow MHFD Manual procedures to determine first design point Time of Concentration (T_c) for urban catchments.
CUHP	Appropriate for use in basins greater than 20 acres in size; required for areas greater than 90 acres in size. Use in combination with SWMM when routing of hydrographs is required. Can be used for smaller catchments 5-20 acres in size with smaller unit hydrograph time step.	Use design storm data from Table 5-1 for input to the CUHP computer model.
SWMM	Used to route and combine hydrographs for sub-catchments developed using CUHP. Appropriate for use in more complex basins.	Use hydrographs developed from CUHP as inputs. Provide a copy of input/output listings for the model and an electronic copy of the modeling results in the Final Drainage Report submittal.
Published hydrologic information	May be used where MHFD or Commerce City have developed detailed hydrologic studies appropriate for use in the study area.	Use values in published reports unless compelling reason to modify published values.

6.3 Assumptions for Storm Flow Analysis

When determining design storm flows, the engineer must follow the criteria and guidelines specified in the MHFD Manual and summarized in Table 6-2 to ensure that minimum design standards and uniform drainage approaches are maintained throughout Commerce City.

Table 6-2. Assumptions for Onsite and Offsite Storm Flow Analysis in Commerce City

Analysis Type	Requirements for Use in Commerce City
Onsite Analysis	The proposed fully developed land use plan must be used to determine runoff coefficients. Changes in flow patterns (from the undeveloped site conditions) caused by the proposed street alignments must be considered. The maximum time of concentration to the first design point in an urbanized area is 10 minutes.
Offsite Analysis for the Minor Storm Event	The fully developed minor runoff will be used without consideration of onsite detention. Inadvertent storage provided by road crossings, railroad embankments, and similar structures will not be credited as runoff reduction.
Offsite Analysis for the Major Storm Event	Where the offsite area is fully or partially undeveloped, the runoff must be calculated assuming the basin is fully developed as defined by the Planning Department. If this information is not available, then the runoff must be calculated using the coefficients defined in the Runoff chapter of the MHFD Manual. No runoff reduction credit will be given for onsite detention in the offsite area for any design frequency unless otherwise approved by Commerce City; however, credit may be given for permanent, publicly maintained detention facilities. Inadvertent storage provided by road crossings, railroad embankments, and similar structures will not be credited as runoff reduction.

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8.0 Inlets

8.1 Introduction

This chapter presents the criteria and methodology for design and evaluation of storm drain inlets located in Commerce City. Except as modified herein, all storm drain inlet criteria must be in accordance with the Streets/Inlets/Storm Drains chapter of the MHFD Manual. The review of all planning submittals will be based on the criteria presented herein. Important basic information on the function and types of inlets includes:

- **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), along continuous grade curb and gutter, median breaks, intersections, and crosswalks. The spacing of inlets along a continuous grade segment of roadway is governed by the allowable spread of flow and flow depth. See further details of allowable spread of flow in Chapter 7, Streets.

- **Types of Inlets:** There are three major types of inlets approved for use within Commerce City right-of-way: curb opening, grate, and combination (has both a grate and a curb opening) inlets. Inlets are further classified as being on a "continuous grade" or in a "sump." The term "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 resulting in ponding water.

8.2 Standard Inlets

The standard inlets permitted for use in Commerce City are provided in Table 8-1.

Table 8-1. Inlet Types

Inlet Type	Standard Detail	Permitted Use
Type R (Curb Opening)	CDOT M-604-12	All street types
Type C (Grated Inlet)	CDOT M-604-10	All streets with a roadside or median ditch
Type D (Grated Inlet)	CDOT M-604-11	Only outside paved roadways
Type 13 (Grated Inlet)	CDOT M-604-13	Alleys or drives with a valley gutter (private areas only)

The City may consider other inlet types such as the Denver No. 16 grated combination inlet or the Colorado Department of Transportation (CDOT) Type 13 rated combination inlet for retrofit projects if the applicant demonstrates that the City's standard inlet types

are unsuitable. The use of inlet types that are not listed in Table 8-1 will require a variance.

8.3 Inlet Design

Proper inlet design includes both the proper inlet hydraulic capacity and appropriate inlet placement. The sizes and types of inlets shall be designed based on the required hydraulic capacity of the inlet. The criteria and procedures in the Streets/Inlets/Storm Drains chapter of the MHFD Manual must be followed for inlet design in Commerce City, except as modified and supplemented herein. Additional information on hydraulic design and placement of inlets follows.

8.3.1 Hydraulic Design

Provided that the MHFD Manual criteria are met, a variety of approaches can be used to size inlets, including computer programs and charts. MHFD's Street Capacity and Inlet sizing software can be downloaded from MHFD's website and is appropriate for use with on-grade and sump inlet designs. Inlet capacity curves are provided below for convenience; however, designers are strongly encouraged to utilize MHFD's software for design.

8.3.2 Inlet Capacity Curves

Inlet capacity curves are presented in Figures 8-1 through 8-7 for Type R, Type 13, and Type C inlets. On-grade capacity curves in Figures 8-5, 8-6, and 8-7 only apply when street flow is at the **maximum allowable depth**. For lower gutter depths, the inlet interception rate will decrease. Type R, Type 13 Grated, and Type 13 Combination inlets may be used in either on-grade or sump conditions. Type C inlets may only be used in sump conditions.

The following assumptions were used for developing these curves using UD-Inlet:

1. Local depression at Type R inlets is 3 inches.

2. Local depression at No. 13 Grated and Combination inlets is 2 inches.

3. A clogging factor of 0.1 was applied to the curb openings (Type R and Type 13 Combination inlets).

4. A clogging factor of 0.7 was applied for single grate inlets (Type 13 Grated and Type 13 Combination inlet).

5. The length of a single unit for Type 13 Grated and Combination inlets was 2.98 feet and the width was 1.58 feet (according to CDOT design details).

6. All other values were the default in UD-Inlet.

7. The Type C chart was developed using orifice and weir equations with the following assumptions:

    a. The orifice coefficient is 0.67.

    b. The weir coefficient is 3.0.

    c. A clogging factor of 0.5 was used for the orifice for the Type C inlet.

    d. A clogging factor of 0.1 was used for the weir for the Type C inlet.

8.3.3 Inlet Location and Spacing

Inlets are required in the following locations:

- Sumps.
- Median breaks (e.g., where traffic turns across the median).
- Areas where street capacity (e.g., allowable design flow spread) would be exceeded without them.
- Upstream of pedestrian curb ramps with less than 1% slope on the curb return when a storm drain is available.

8.4 Design Considerations

1. In general, inlets should be located upstream of pedestrian curb ramps and spaced in a manner to prevent clogging. This is particularly critical for flat grades and sump conditions; approximately 20-foot spacing is recommended under these conditions.

2. Where significant ponding can occur such as in an underpass and in a sag-vertical curve, good engineering practice is to place flanking inlets on each side of the sag location inlet to relieve some or most of the flow burden on the inlet in sag. Flanking inlets are required in these sump conditions without overflow and in sump conditions requiring more than a triple inlet.

3. A minimum 2-foot apron must be used with valley inlets when no curb and gutter is present.

4. Inlets must be sized to accept the specified pipe sizes without knocking out any of the inlet corners.

5. All pipes entering or exiting inlets shall be cut flush with the inlet wall.

6. Other common-sense considerations regarding placement should also be taken into consideration such as placing inlets upstream rather than downstream of driveways.

7. An emergency overflow route must be provided in sump areas for new development. For other projects, the emergency overflow paths and depths must be addressed to prevent adverse impacts to properties and structures.
8. Grate inlets are not allowed at bus stops.

Figure 8-1. Allowable Inlet Capacity – Type R Inlet, Sump Conditions
(Note: See Section 8.3.2 for assumptions)

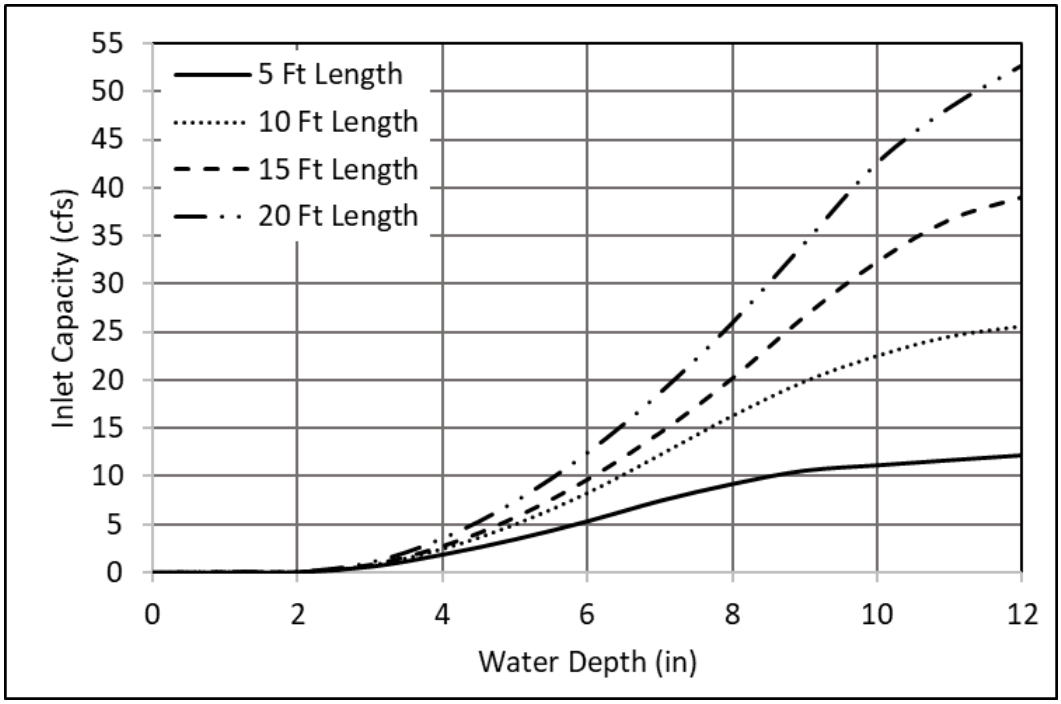


Figure 8-2. Allowable Inlet Capacity – Type 13 Grated Inlet, Sump Conditions
(Note: See Section 8.3.2 for assumptions)

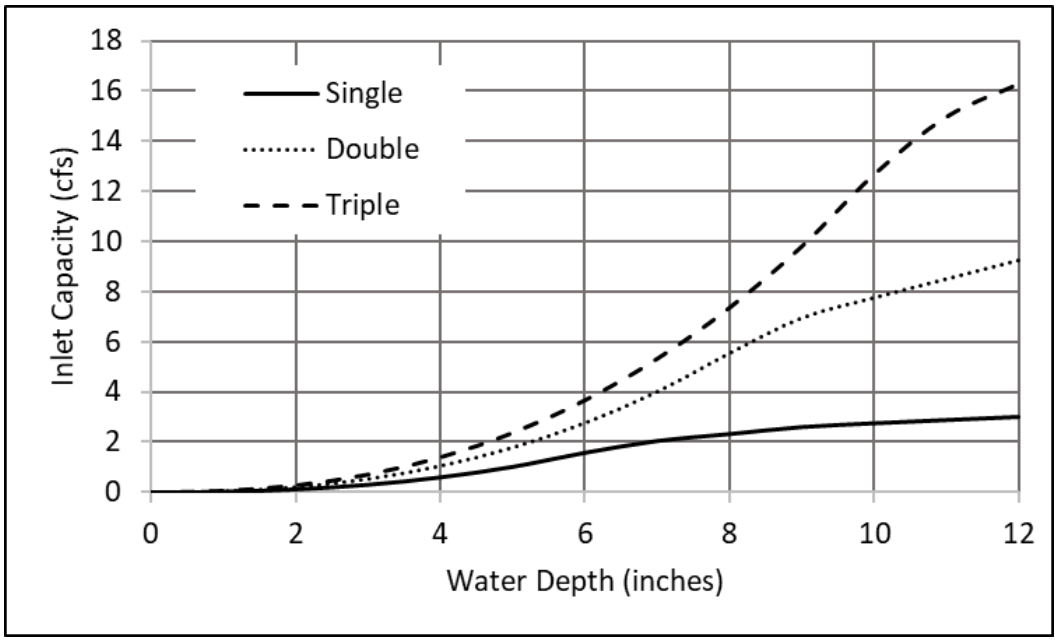


Figure 8-3. Allowable Inlet Capacity – Type 13 Combination Inlet, Sump Conditions
(Note: See Section 8.3.2 for assumptions)

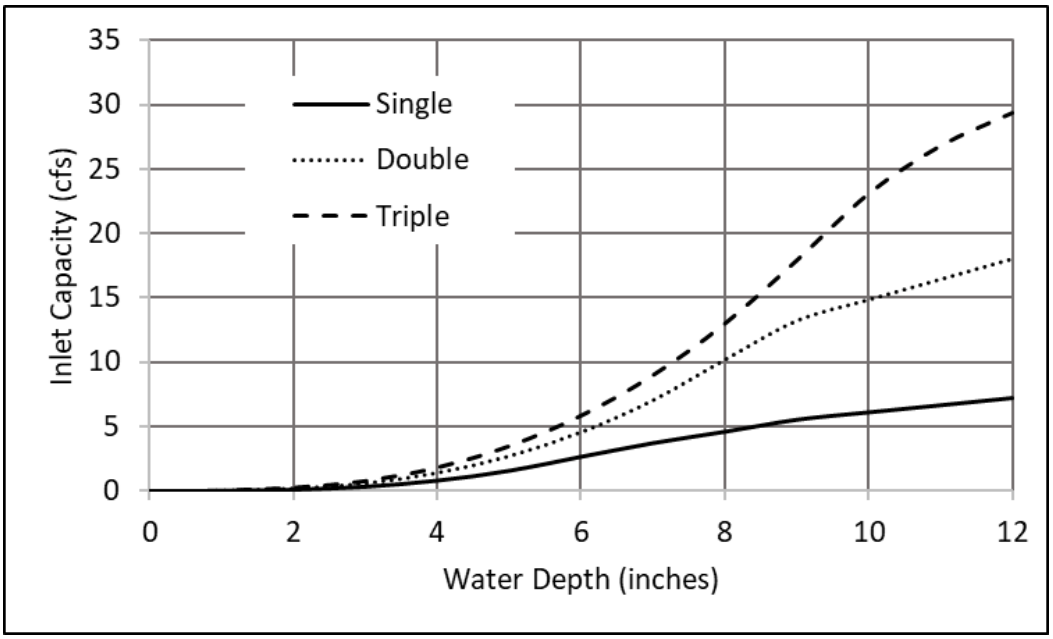


Figure 8-4. Allowable Inlet Capacity – Type C Inlet, Sump Conditions
(Note: See Section 8.3.2 for assumptions)

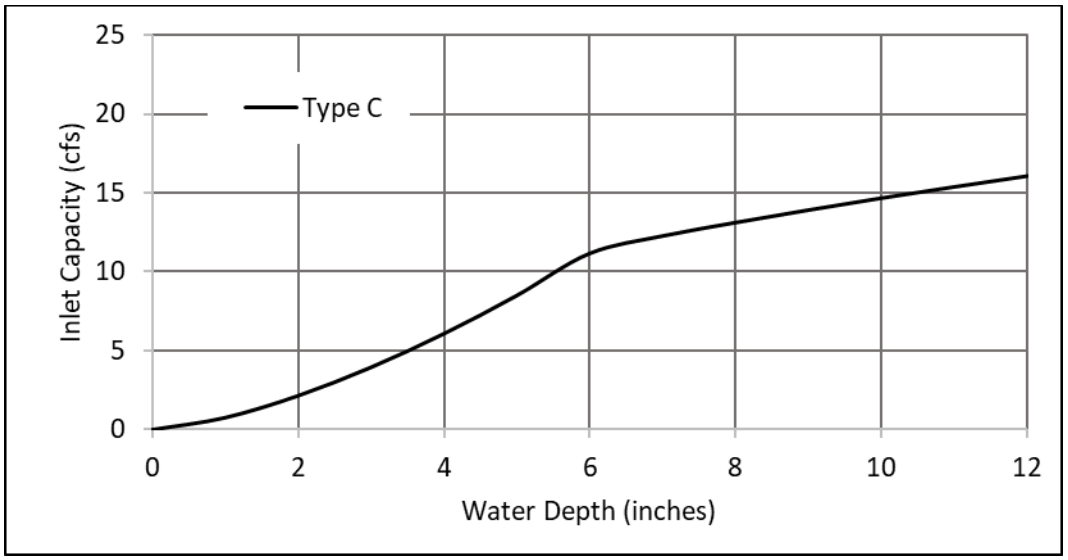


Figure 8-5. Allowable Inlet Capacity – Type R Inlet, On Grade Conditions
(Note: See Section 8.3.2 for assumptions)

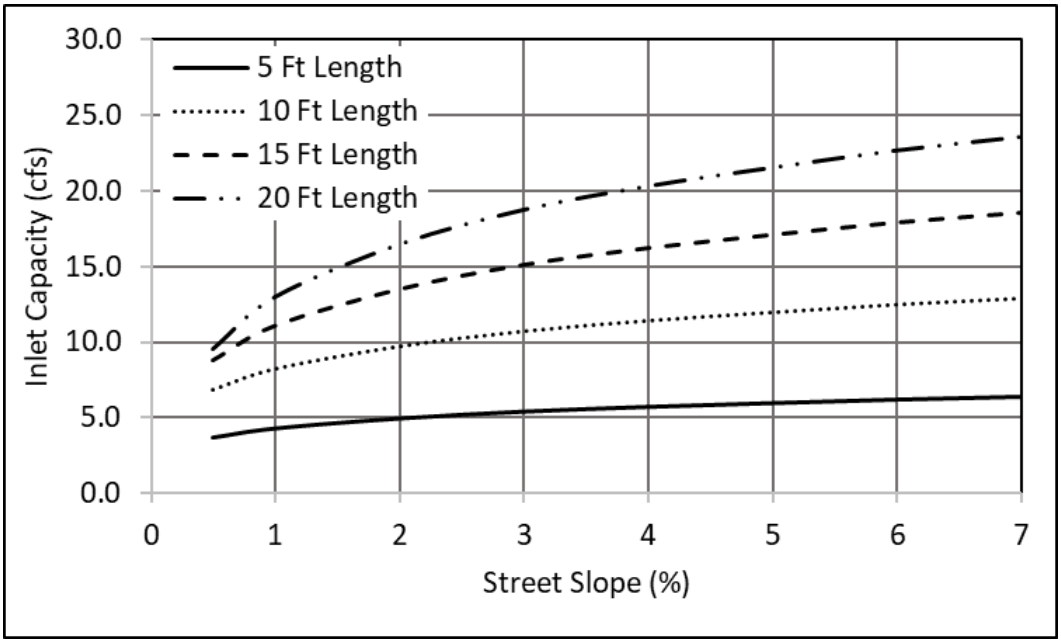


Figure 8-6. Allowable Inlet Capacity – Type 13 Grated Inlet, On Grade Conditions
(Note: See Section 8.3.2 for assumptions)

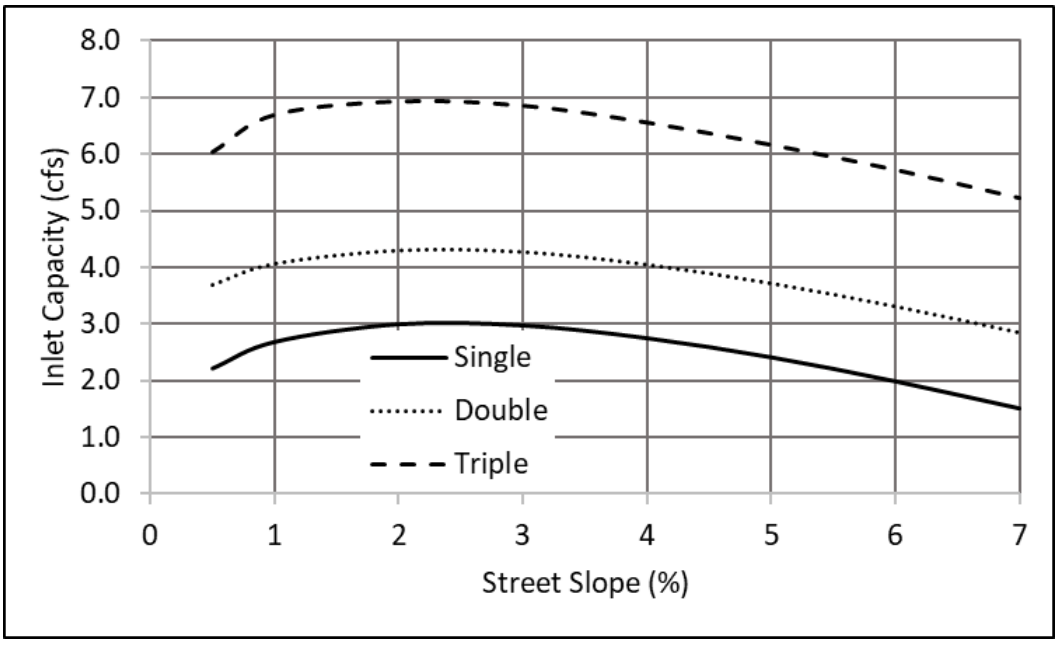
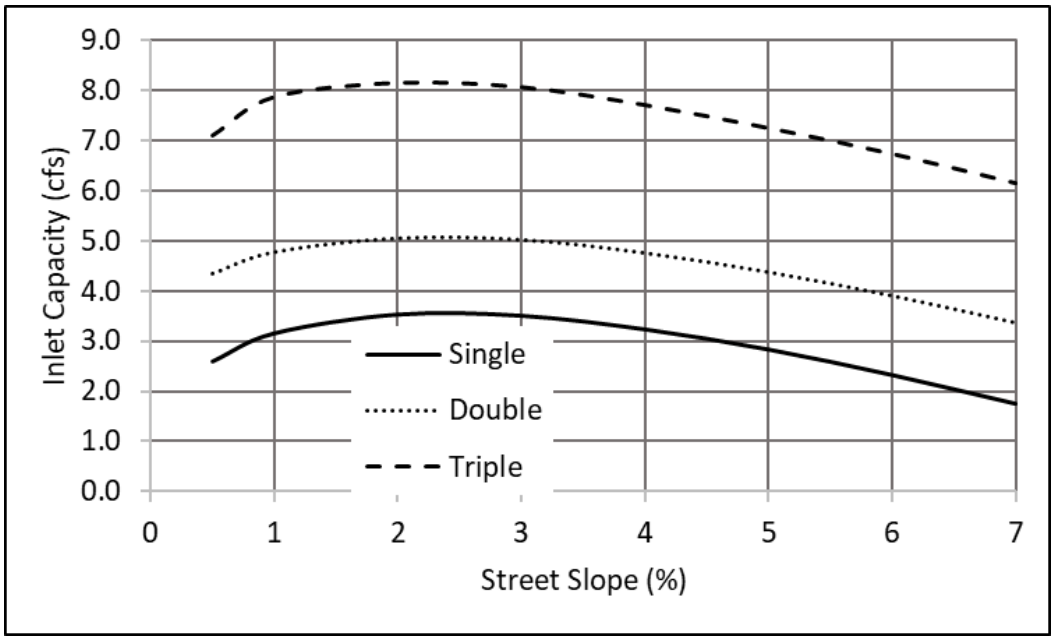


Figure 8-7. Allowable Inlet Capacity – Type 13 Combination Inlet, On Grade Conditions
(Note: See Section 8.3.2 for assumptions)



9.0 Storm Drains

9.1 Introduction

Storm drains are the portion of the urban drainage system that provide subsurface conveyance of flows to control the depth and spread of runoff in streets and other surface drainage systems. Except as modified herein, the design of storm drains must be in accordance with the Storm Drain Systems section of the Streets/Inlets/Storm Drains chapter of the MHFD Manual.

9.2 Design Storms for Sizing Storm Drain Systems

Two design storms must be considered for sizing storm drain systems, the minor (5-year) storm and the major (100-year) storm. In each case, storm drains must be sized to carry the portion of runoff that cannot be conveyed on the surface, as dictated by the available capacity in streets and swales during the minor and major storm events. When connecting to an existing storm sewer system, the Applicant must demonstrate that the proposed system will not exacerbate any existing stormwater problems and that adequate downstream capacity exists. Minimizing the peak discharge rates (i.e., over-detaining) may be required in these cases.

9.2.1 Minor Event Design Storm

At a minimum, storm drains must be sized to convey any minor storm runoff that exceeds the minor event capacity of the street or roadside swales (discussed in Chapter 7, Streets). Inlets are located at these points to intercept excess flow and route it to the storm drain. Storm drains must be designed to convey the minor storm flood peaks while flowing at most 80% of the full pipe capacity. Section 9.3 provides additional information on hydraulic design methods for the minor storm.

9.2.2 Major Event Design Storm

There are conditions when the storm drain system will be sized to convey flows greater than the minor storm runoff, including locations where:

- The street capacity for the major storm is exceeded, especially where the grade slopes down behind the curb and the major storm capacity is limited to the height of the curb.
- Regional storm drains are designed for the major storm.
- The storm drains must convey undetained flows to a regional detention basin.

If a storm drain is to be designed to carry major storm flows, the inlets to the storm drain must be designed accordingly. In pipes designed to convey up to the major storm, the hydraulic grade line (HGL) is allowed to rise above the top of the storm drain, but must be kept at least 1.0 foot below manhole lids, inlet grates and inlet curb openings. Section 9.3 provides additional information on hydraulic design methods for the major storm.

9.3 Hydraulic Design

Storm drains must be designed to convey the minor storm flood peaks while flowing at 80% of the full pipe capacity at most. To ensure that this objective is achieved, the hydraulic and energy grade lines must be calculated by accounting for pipe friction losses and pipe form losses. Total hydraulic losses must be calculated accounting for friction, expansion, contraction, bend, and junction losses following the methods in the Storm Drain Systems section of the Streets/Inlets/Storm Drains chapter of the MHFD Manual. Additionally, for convenience, a chart identifying the hydraulic properties of circular pipe is provided in Figure 9-1. This chart assumes that the friction coefficient and Manning's n do not vary with depth, which is a common design assumption. The UD-Sewer 2009 software program (downloadable from MHFD's website) or the EPA Stormwater Management Model (SWMM) may also be used to design storm drains.

The maximum velocity in all storm drains is 18 feet/second. The minimum velocity is 3 feet/second at half-full flow conditions.

The final EGL must be at or below the proposed ground surface for the design event. The HGL must not exceed the crown of the pipe for the minor storm. In cases where the conduit is designed to convey up to the full 100-year flow, the allowable HGL must be 1.0 foot below inlet elevations, or 1.0 foot below ground where no inlets are present.

9.4 Construction Materials

Storm drain construction materials must be ASTM C76 Class III reinforced concrete pipe (RCP) unless otherwise approved by the City Engineer.

9.5 Pipe Size

The minimum allowable pipe size for storm drains is dictated by ease of maintenance rather than hydraulics. The length of the pipe also affects the ability to maintain a storm drain. Table 9-1 presents the minimum pipe sizes for public storm drains.

Table 9-1. Minimum Size Criteria for Public Storm Drains

Type	Minimum Equivalent Pipe Diameter
Main Trunk	18 inches
Lateral from Inlet	15 inches

Outfall structures are considered main trunks; therefore, the minimum outfall diameter is 18 inches or equivalent.

9.6 Vertical and Horizontal Alignments

Table 9-2 provides the vertical alignment requirements for storm drains.

Table 9-2. Vertical Alignment Requirements for Storm Drains

Vertical Alignment of Storm Drain Relative to:	Minimum Vertical Clearance (above or below)	Comment
Cover	Minimum cover depends upon the pipe size, type and class, and the soil bedding condition.	The drain grade must be such that a minimum cover is maintained to withstand American Association of State Highway and Transportation Officials (AASHTO) HS-20 (or as designated by Commerce City) loading on the pipe.
Water Main	18 inches	Approval from South Adams County Water Department will be required for lesser clearances.
Sanitary	12 inches	Additionally, when a sanitary sewer main lies above a storm drain, or within 18 inches below, the sanitary sewer must have an impervious encasement or be constructed of approved sewer pipe with the nearest joint at least 10 feet from the centerline of the crossing.
Other	Varies	For vertical drops greater than 8 feet, special designs are required that address potential cavitation and energy dissipation. These situations will require special review. See *Design and Construction of Urban Stormwater Management Systems* (ASCE and WEF 1992) for guidelines for drop shaft structures. The invert of a pipe leaving a manhole should be at least 0.1 foot lower than the incoming pipe to ensure positive low flows through the manhole.

In most cases, storm drain alignment between drainage structures (inlets or manholes) must be straight, using manholes to accommodate changes in alignment. Storm drain horizontal alignment may be curvilinear for pipes with diameters of 48 inches or greater, but only when approved in writing by the Review Engineer. The applicant must demonstrate the need for a curvilinear alignment. The radius limitations for pulled-joint pipe are dependent on the pipe length and diameter and amount of opening permitted in the joint. The minimum parameters for radius-type pipe must be in accordance with the manufacturer's specifications.

Storm drains parallel to the street must not be placed under the tree lawn or the sidewalk.

9.7 Manholes/Cleanouts

Manholes are required whenever there is a change in size, direction, elevation, grade, or where there is a junction of two or more drains. A manhole may be required at the beginning and the end of the curved section of storm drain. The maximum spacing between manholes is 500 feet for pipes with a vertical dimension of 42 inches and larger, and 400 feet for pipes with a vertical dimension of 15 to 36 inches. The required manhole size shall be as follows:

Table 9-3. Required Manhole Diameters

Sewer Diameter (inches)	Manhole Diameter (feet)
15 to 18	4
21 to 42	5
48 to 54	6
60 and larger	Appropriate manhole size from CDOT Standard Plan No. M-604-20

Larger manhole diameters or a junction structure may be required when large diameter pipe alignments are not straight through manholes or when more than one storm drain line goes through the manhole. A special structure is required for 42-inch or larger pipe when the angle of deflection is more than 45 degrees.

Cleanouts for maintenance access, instead of manholes, are allowed only for private, on-site storm drains 10 inches in diameter or smaller and must be the same size as the pipe to be cleaned. Spacing of cleanouts must conform to the requirements of the most current version of the International Plumbing Code.

9.8 Outlets

Proper design of storm drain outlets is necessary to minimize erosion at the outfall location and to protect public safety. Key guidance on these topics is presented in the following sections.

9.8.1 Conduit Outlet Protection

Adequate erosion protection must be provided at all storm drain outlets in accordance with Section 3 of the Hydraulic Structures chapter of the MHFD Manual, which provides criteria for riprap aprons, low tailwater stilling basins, concrete impact stilling basins, concrete baffle chutes, and grouted boulder outfalls.

9.8.2 Safety

Headwalls and wingwalls associated with storm drain outlets must be provided with guardrails, handrails, or fencing in conformance with Denver building codes and roadway design safety requirements. Handrails are required in all areas where the drop

from the headwall or wingwall exceeds 30 inches. The height of the handrail must be 42 inches for pedestrian walkways or open areas and 54 inches when bicycle or equestrian traffic will be near the storm drain outlet (AASHTO 2002).

9.9 Abandonment

Storm drains greater than 8 inches to be abandoned in place must be plugged with clean concrete and standard manufactured plugs or caps at both upstream and downstream ends of the abandoned section. If manholes are also abandoned in place or if the structure is to be removed completely, all storm drains must be plugged upstream and downstream of the removed structure following removal. Storm drains to be abandoned with an internal diameter of 8 inches and larger must be filled with sand, pumped grout mixtures, or flowable fill in order to minimize future subsidence attributable to the potential collapse of the abandoned facility. Storm drains with an internal diameter smaller than 8 inches must be plugged at entrance and exit ends with approved grout mixtures or concrete.

9.10 Design Considerations

All of the design criteria in this chapter must be followed. Several key considerations that the designer must take care to address include:

1. Design the EGL below the ground surface for the design event.

2. Design the HGL not to exceed the pipe's crown for the minor storm.

3. Design the HGL not to exceed 1.0 foot below inlet elevations, or 1.0 foot below ground where no inlets are present when the conduit is designed to convey the major event.

4. Account for all losses in the EGL and HGL calculations including outlet, form, bend, manhole, and junction losses.

5. Provide adequate erosion protection at the outlet of all storm drains.

6. Provide cross sections for riprap protection.

7. Check for minimum pipe cover and clearance with utilities.

8. Check overflow under sump conditions.

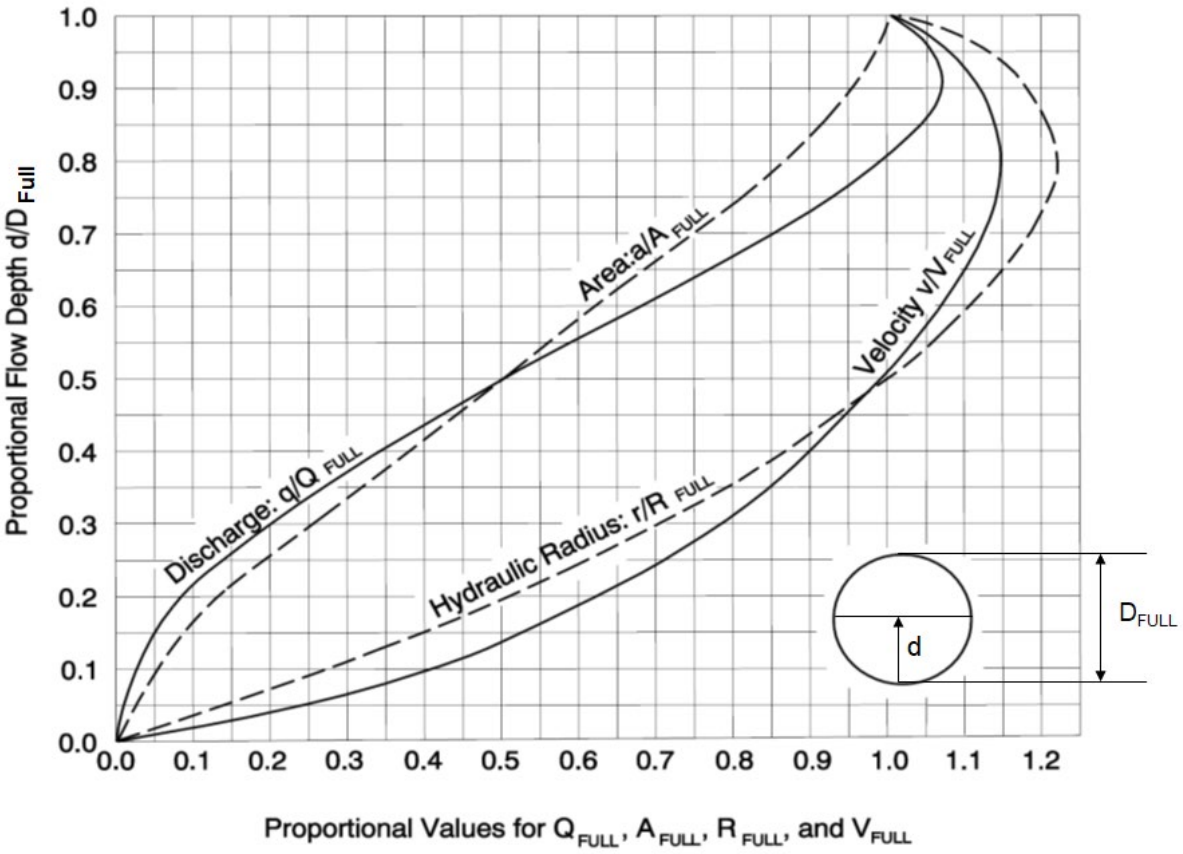
9. When a storm drain flows into a detention or water quality facility, design the invert of the inflow pipe to be higher than the anticipated water quality level in the pond.

10. Storm drain outfalls to major drainageways must be designed to meet MHFD Maintenance Eligibility Program requirements.

11. Construction of an outfall in a mapped floodplain requires a floodplain development permit.

12. Backflow prevention devices such as flap gates for storm drain outlets should only be considered as a last option.

Figure 9-1. Hydraulic Properties of Circular Pipe



Source: *Open Channel Hydraulics* (Chow 1959, reissued 1988); figure adapted from Oregon Department of Transportation Hydraulics Manual (2014).

10.0 Open Channels

10.1 Introduction

This chapter provides the minimum technical criteria for the hydraulic evaluation and design of open channels in Commerce City. In many instances, special design or evaluation techniques will be required. Design criteria in the Open Channels chapter of the MHFD Manual are hereby incorporated by reference. Except as modified herein, all open channel designs must be in accordance with the MHFD Manual.

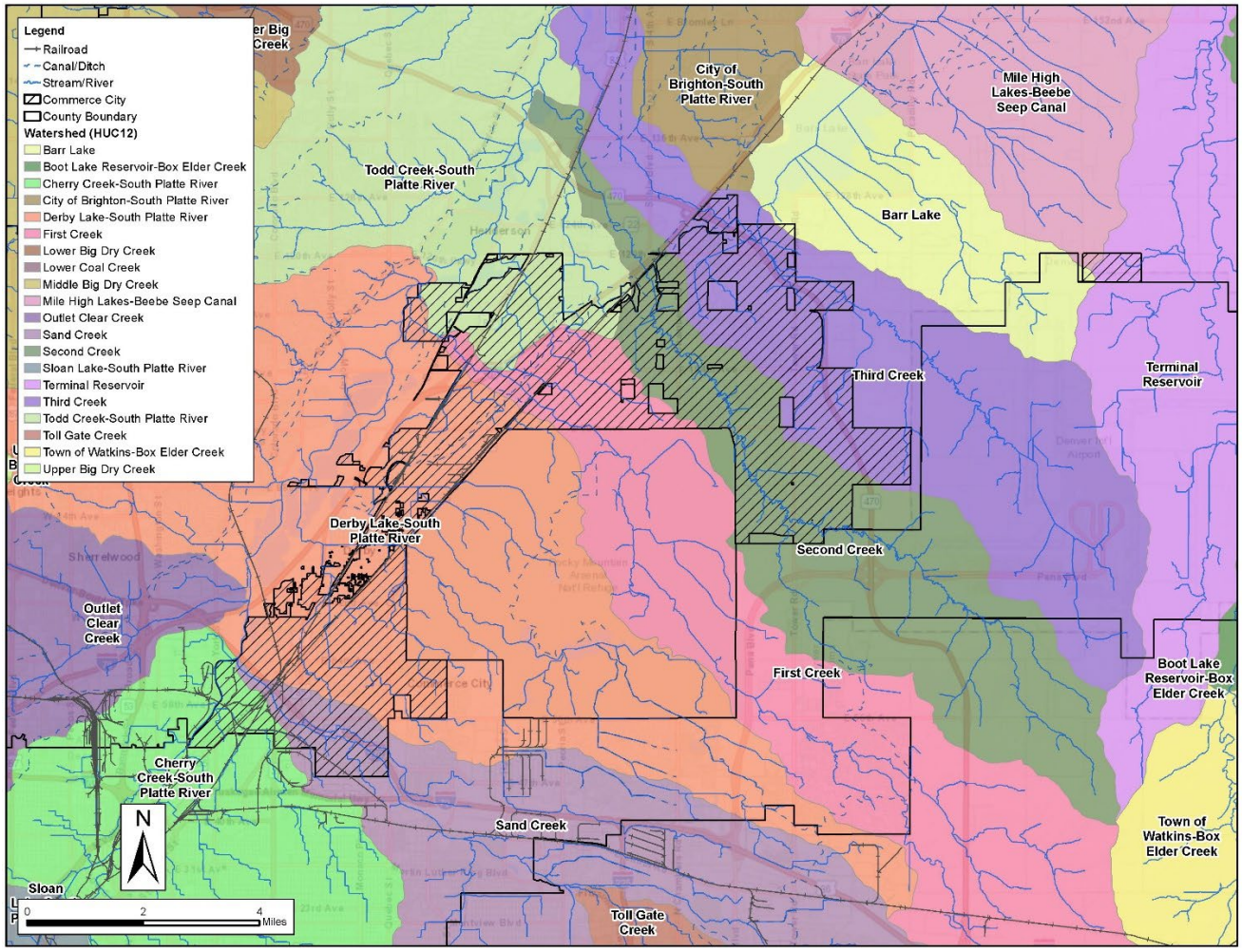
10.2 Major Drainageways

As previously discussed in Chapter 3, a major drainageway is defined as any drainage flow path with a tributary area of 130 acres or more. Major drainageways in Commerce City include portions of Sand Creek, Irondale Gulch, First Creek, Second Creek, Third Creek, and their tributaries. In addition, the South Platte River runs along portions of the City's western boundary. Figure 10-1 shows major drainageways in and near Commerce City. Not all major drainageway in Commerce City have well-defined flow paths. Many of the major drainageways in Commerce City have sandy beds and banks (Sand Creek, as an example) that are especially vulnerable to channel instability due to hydromodification/erosion. Unless design and construction of major drainageway improvements are performed with an understanding of geomorphology and sediment transport, areas of excessive aggradation or degradation are likely to develop.

A major objective of managing major drainageways in Commerce City is to provide outfalls for all major drainageways that allow positive drainage through the City and ultimately to the South Platte River. This is challenging due to many factors including barriers created by highways, railroads and ditches, the need for multi-jurisdictional cooperation, costs, and other factors. Nonetheless, for development in Commerce City to occur in a manner that protects public health, safety, and welfare, outfalls for major drainageways are a necessity. The City has worked with the MHFD to develop master plans for the major drainageways and several direct flow areas in the City that will help to achieve this important objective once implemented.

Whenever a development alters or improves a major drainageway, the developer(s) are responsible for making revisions to the floodplain maps at their own expense. All plans, details, calculations, and other requirements must be submitted through the City to FEMA according to FEMA's criteria. The City will notify the Colorado Water Conservation Board and the MHFD as required.

Figure 10-1. Major Drainageways in the Vicinity of Commerce City



10.3 Minor Drainageways

Minor drainageways convey flows from tributary areas less than 130 acres. The design principles in the MHFD Manual apply to both classifications of streams. Additionally, the MHFD Open Channels chapter provides design information for grass swales based on several standard cross-sections. Commerce City encourages the use of vegetated, open channel drainageways for minor drainage systems when feasible.

10.4 Natural Channel Design

The Open Channels chapter of the MHFD Manual emphasizes providing adequate space for the stream corridor and using naturalized channel design. The MHFD Manual provides guidance for preserving, protecting, and enhancing existing natural channels and for designing naturalized channels where new channels are to be constructed. Although much of Commerce City is urban in character, many of the streams that flow through the community can be enhanced through the natural channel design principles described in the MHFD Manual. While the use of closed-conduits may be necessary for crossing impediments to natural drainage such as roads, ditches, and railroads, in other areas natural channel design concepts should be evaluated and applied as appropriate. Application of the low-maintenance, high-functioning design concepts in the MHFD Manual will result in reduced lifecycle costs for drainageways in Commerce City.

10.5 Rock and Boulders

Sizing for riprap and boulders must follow the criteria in the Open Channels chapter of the MHFD Manual:

1. For mild slope conditions (generally subcritical flow conditions with slopes of less than 2%), Equation 8-11 in the MHFD Manual may be applied.

2. For steep slope conditions, generally 2 to 20%, apply the Colorado State University (CSU) equation, U.S. Army Corps of Engineers Steep Slope Riprap equation or the U.S. Department of Agriculture – Agricultural Research Service equations in the MHFD Manual, including the recommended concentration and scaling factors.

3. For steeper changes in grade such as drop structures and rundowns, refer to the Hydraulic Structures chapter of the MHFD Manual for criteria and guidance.

Whether in mild slope or steep slope conditions, consider a safety factor when specifying the size of riprap. Sizing methods presented in the MHFD Manual were developed under controlled laboratory conditions. Field installation of rock is much less precise compared to laboratory conditions. It is difficult to grade riprap flat across a channel bottom or in a manner that provides a uniform slope. Sometimes the riprap delivered from local quarries is slightly smaller than specified. Flow conditions in streams can be affected by a variety of elements including debris, sedimentation, vegetation, etc. and can result in flow concentrations. It is important to include a safety factor when using these equations because the variability associated with conditions in the field cannot be quantified.

10.6 Commerce City Design Criteria

The following criteria apply to natural channels and constructed naturalized channels within Commerce City:

1. **Master Plan Information**. If published MHFD or Commerce City outfall system or drainage master plans exist, channel designs should be completed with projected future condition hydrology and recommendations consistent with the intent of these plans; however, conformance to or variation from any existing master plans will be determined by the City's Review Engineer. Where master plans include outdated methodologies, MHFD and Commerce City will provide guidance as to the intent of channel improvements.

2. **Hydraulic Analysis**. A detailed hydraulic analysis of the design reach and any upstream or downstream area of influence must be conducted to inform the design following the guidance in the MHFD Manual. The analysis must be based on HEC-RAS for a suitable range of design events including the 2-year, 10-year and 100-year events, at a minimum. For major drainageways, the 50- and 500-year events must also be evaluated. In some cases, a two-dimensional hydraulic analysis may be appropriate for a project. If this is the case, the applicant must first consult the City to obtain approval for an alternative modeling approach using a two-dimensional model that the City can review using publicly available software.

3. **Regulatory Floodplain Analysis**. A regulatory floodplain analysis must be performed in conformance with Commerce City, MHFD, and FEMA floodplain permitting requirements, as approved by the Commerce City Floodplain Administrator.

4. **Filling of the Floodplain**. Filling of the floodplain to construct naturalized channels must be avoided because it generally increases erosion potential on the stream, reduces valuable channel and floodplain storage capacity, and tends to increase downstream runoff peaks. The City has adopted a zero-foot rise floodway, which means that encroachments into the 100-year floodplain are not allowed to cause an increase in the 100-year water surface elevations. Therefore, cut and fill must be carefully evaluated using a hydraulic model to achieve no rise and some export of material may be necessary.

5. **Freeboard**. A minimum of 18 inches of freeboard above the 100-year water surface to the top of bank or property lines (whichever is more restrictive) must be provided in major and minor drainageways, with 3 feet provided at bridges relative to the low chord of the bridge.

6. **Swales**. Design charts shown in Section 6 of the Open Channels chapter of the MHFD Manual may be used for 100-year design discharges up to 40 cfs.

7. **Synthetic Lining and other Proposed Materials**. Generally, stable channel conditions are to be achieved by applying the principles and materials described

in the MHFD Manual. The use of synthetic fabrics for lining of channels and other material differing from standard materials identified in the MHFD Manual (i.e., vegetation, rock, temporary coir, or biodegradable erosion control blanket) will be allowed only upon written approval of a variance from the City Engineer.

8. **Preservation of Natural Features**. Natural channel boundaries and alignments must be preserved, maintained, or enhanced in their natural condition to serve as landscape and visual amenities, to provide focal points for development projects, and to help define “edges” in and around communities. Vegetation groups, rock outcroppings, terrain form, soils, waterways, and bodies of water must be preserved to the extent practicable.

9. **Allowance for Future Vegetation**. Channel capacity must be provided to accommodate anticipated future growth of vegetation within the floodplain, as approved by the Review Engineer. Overstory canopy trees are allowed and encouraged within the floodplain outside of high hazard areas (e.g., outside of the floodway).

10. **Future Bridges**. Appropriate allowances for known future bridges or culverts, which can raise the water surface profile and cause the floodplain to be extended, must be included in the hydraulic and design analysis. The applicant must contact the City for information on future bridges and roads in undeveloped areas.

11. **Design Drawings**. The existing stream in the design reach and any proposed channel improvements must be clearly shown in plan, profile, section, and detail, as approved by the Review Engineer.

12. **Pre-submittal Meeting**. For any improvements or alterations to a major drainageway or plans to construct a naturalized channel, the applicant must meet with the City to discuss the concept and obtain the requirements for planning and design documentation.

13. **MHFD Maintenance Eligibility**. Per Colorado Revised Statues (CRS) §32-11-221(1), requirements for drainage facilities other than minor collection systems in the MHFD boundary must be approved by MHFD. All projects eligible for MHFD’s Maintenance Eligibility requirements and must satisfy the design, construction, and vegetation criteria and requirements in the most current version of MHFD’s Criteria Manual and Maintenance Eligibility Guidelines (downloadable from MHFD’s website).

14. **Environmental Permitting**. A variety of federal (e.g., 404 permit), state (e.g., dewatering, stormwater) and local permits are often required when constructing open channels. The applicant must obtain necessary permits.

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13.0 Detention (Storage)

13.1 Introduction

This chapter provides technical criteria for the planning and design of detention (storage) facilities in Commerce City. Design criteria in the Storage chapter of the MHFD Manual are hereby incorporated by reference. Except as modified herein, all detention facility designs must be in accordance with the MHFD Manual.

Detention of flood flows for all development and redevelopment projects is required in accordance with these criteria for the purposes of reducing urban drainage problems and the costs of drainage facilities. The main purpose of a detention facility is to store excess storm runoff associated with increased watershed imperviousness and release this excess runoff at a rate similar to the rate experienced from the watershed without development.

Full Spectrum Detention (FSD)

FSD is a storage-based approach to water quality, channel stability, flood control, and peak discharge attenuation. It is based on detaining the excess urban runoff volume (EURV) and releasing it over approximately 72 hours. The EURV is essentially the increase in runoff volume from undeveloped to urbanized conditions. The EURV includes the water quality capture volume (WQCV), which corresponds to the 80th percentile storm runoff event. FSD helps to offset some of the impacts that urbanization has on the downstream stream network.

Pumped detention basins are not allowed to serve as permanent water quantity or quality control measures for any development within Commerce City. This is because electromechanical systems can be unreliable, require frequent and costly maintenance, and may trigger requirements for water quality monitoring. However, temporary pumped detention basins are sometimes necessary during construction to hold water until a permanent, gravity outfall is available. Commerce City may approve such temporary pumped detention basin in a Development Agreement or other written agreement, as an interim solution, until a permanent outfall is built.

13.2 Full Spectrum Detention

All detention facilities must be designed to provide Full Spectrum Detention (FSD) in accordance with the Storage chapter of the MHFD Manual. As such, three control volumes are integrated into the design: the water quality capture volume (WQCV), the excess urban runoff volume (EURV), and the 100-year event volume.

In Commerce City, the WQCV is considered to be a “nested” part of the EURV and 100-year event volume and does not need to be added to the EURV or overall 100-year storage volume. The 100-year event volume must be provided below the crest elevation of the emergency spillway, with peak discharges in excess of the storage capacity discharged via the spillway. The embankment height must be sufficient to pass emergency spillway flows with freeboard as described below.

13.3 Integration of Water Quality and Flood Control Detention

FSD integrates water quality and flood control detention through a process described in Figure 13-1. As described in the Storage chapter of the MHFD Manual, FSD may combine the three control volumes for WQCV, EURV, and 100-year detention into one facility or have separate facilities for any of the three volume components.

Figure 13-1. Steps in Integration of Full Spectrum Detention and Water Quality in Commerce City

Step 1. Select & Design Runoff Reduction Measures:
(Required on all projects)
- Grass Buffers/Swales
- Permeable Pavements
- Disconnected Impervious Area (direct shallow drainage to receiving pervious areas)

Step 2. Calculate the WQCV for the Stormwater Practice to be Integrated with FSD:
- Bioretention
- Sand Filter
- Extended Detention Basin
- Retention (Wet) Pond
- Constructed Wetland Basin

Step 3. Size the EURV and 100-year Storage Volume:
- Check that WQCV drains in appropriate draw down time for the type of practice (12 – 40 hours, depending on BMP)
- Check that the EURV drains in ≤ 72 hours

Note: Stabilizing drainageways and providing source control measures are two additional steps in the MHFD's Four Step Process to protecting water quality. Drainageway stabilization is addressed in Chapter 10 Open Channels, and Source Controls are addressed in Chapter 14 Stormwater Quality.

Structural stormwater control measures (SCMs[1]) in Figure 13-1 that may be used to provide WQCV treatment include:

- Bioretention facilities
- Sand filters
- Extended detention basins
- Retention (wet) ponds
- Constructed wetland basins

Fact sheets for each of these types of SCMs are provided in Volume 3 of the MHFD Manual. Additional discussion of stormwater quality is provided in Chapter 14 of this Manual.

Water quality and flood control detention are required for all projects that disturb more than 5,000 square feet. For sites that fall below this threshold, runoff reduction measures must be implemented in accordance with the Runoff Reduction Fact Sheet in Volume 3 of the MHFD Manual to the maximum extent practicable. Single family, infill residential projects that disturb more than 5,000 square feet but create less than 5,000 square feet of new impervious area may be exempt from water quality and detention requirements.

For projects that create more than 5,000 square feet of disturbance but where impervious area can be managed through the use of grass buffers, swales, or other types of receiving pervious areas (RPAs), the applicant may request an exception to detention and/or water quality requirements from the Administrator. “Beat-the-peak” approaches based on timing of hydrographs from design storms to avoid detention will not be accepted by Commerce City as justification for a variance.

Commerce City requires integration of flood control detention and water quality treatment. The following references describe strategies to achieve this integration:

- Chapter 14 of this Manual
- Volume 2 of the MHFD Manual (Storage chapter)
- Volume 3 of the MHFD Manual

[1]Historically SCMs have been referred to as stormwater best management practices (BMPs). In this Manual, the acronym “SCM” is used since this is the current terminology to describe stormwater quality management practices in the City’s Phase II MS4 Permit.

13.4 Regional Detention Facilities

For Commerce City to consider regional detention facilities, the following criteria must be met:

1. A Commerce City-approved plan recommends the regional detention facility.

2. The regional detention facility is designed to accommodate the fully developed flows from the upstream watershed.

3. The regional detention facility is constructed or will be constructed in phases with the development; otherwise, temporary detention must be provided.

4. Legally-binding ownership and maintenance responsibilities by a public entity are clearly defined to ensure the proper function of the facility in perpetuity.

5. There is adequate conveyance of the fully developed flows from the site to the regional detention facility.

6. Design of the regional detention facility is completed in accordance with the MHFD Manual and the requirements in Colorado Revised Statues (CRS) §32-11-221(1) for drainage facilities. All regional facilities must be designed to meet the MHFD's Maintenance Eligibility requirements and must satisfy the design, construction, and vegetation criteria and requirements in the most current version of the MHFD Manual and Maintenance Eligibility Guidelines (downloadable from MHFD's website). The design must also consider the following criteria:

    a. For regional detention basins, designers should consider compatibility with surrounding land uses. For example, a detention basin in a residential or open space area could consider potential aesthetic and/or recreational uses, while a detention basin serving an industrial area would not likely include such considerations.

    b. The creation of jurisdictional dams is strongly discouraged. Depending on the size of the detention basin, it may not be feasible to avoid creation of a jurisdictional dam in some situations, and design should not be compromised simply to avoid creating a jurisdictional design. Nonetheless, when good design can avoid creating embankment heights that trigger state dam safety regulations, this is desirable.

    c. Regional detention basins must be located on existing publicly-owned lands whenever possible.

    d. If regional flood control detention facilities incorporate the regional WQCV for stormwater quality, developments upstream of the regional facility must provide onsite stormwater quality enhancement as identified in Chapter 14, Stormwater Quality.

13.5 Relationship to Adjacent Properties and Structures

Impacts to upstream and downstream properties relative to proposed detention facilities must be considered and minimized through appropriate facility design. Designs must take into account the location of structures near detention facilities and plan accordingly to reduce the likelihood of seepage into basements and structural damage by ensuring finished floor elevations or structures adjacent to ponds are 1.5 feet above the water surface elevation when the emergency spillway is conveying the maximum design flow or emergency flow. If a detention pond is planned adjacent to an irrigation canal, the developer/engineer is required to submit a seepage analysis to demonstrate that the development is not impacting seepage into or out of the canal or to inform the design of controls needed to mitigate potential issues.

13.6 Maintenance

All detention facilities must be designed with adequate maintenance access and in a manner that facilitates maintenance. All-weather, stable maintenance access must be provided for all detention facility elements requiring periodic maintenance. Grades should not exceed 10% for haul road surfaces and 20% for skid-loader and backhoe access surfaces. Stabilized access includes concrete, articulated concrete block, concrete grid pavement, or reinforced grass pavement. The recommended cross slope is 2%. Maintenance access also includes providing storage and staging areas for sediment and debris removal during maintenance activities. Commerce City requires all regional facilities be eligible for MHFD maintenance. Download the most current version of MHFD's Maintenance Eligibility Guidelines and contact MHFD early in the planning process to expedite their review.

An operations and maintenance plan is required for each detention facility. The minimum requirements for an operations and maintenance plan are listed in Chapter 3, Submittals.

13.7 Office of the State Engineer Coordination

13.7.1 Jurisdictional Dam Requirements

Any dam constructed for the purpose of storing water with a surface area, volume, or dam height as specified in CRS §37-87-105, as may be amended, requires the approval of the plans by the Office of the State Engineer (SEO). Those facilities subject to state statutes must be designed and constructed in accordance with the criteria of the state, in addition to the criteria in this Manual. To the extent that SEO criteria and requirements differ from the requirements in this Manual, the more restrictive requirements apply. Construction of jurisdictional dams for detention facilities is strongly discouraged due to the higher level of hazard posed by a jurisdictional dam. In some cases, depending on the size of the detention facility, creation of a jurisdictional dam may be unavoidable. In these cases, compliance with the Colorado Rules and Regulations for Dam Safety and Dam Construction (2 CCR 402-1) is required.

13.7.2 Drain Time Requirements

Detention facilities must undergo a notification process with the SEO in conformance with CRS §37-92-602(8), as may be amended, and present documentation that drain times conform with the requirements of this statute. Colorado water law requires that 97% of the 5-year or less event drain within 72 hours and that 99% of the 100-year event drain within 120 hours. Facilities that do not drain within these time periods require water rights, including plans for augmentation to replace evaporative losses and should be avoided in Commerce City. Augmentation plans are costly, both to acquire suitable water rights and to adjudicate and administer the plans.

13.8 Design Standards for Detention Facilities

The Storage chapter of the MHFD Manual provides figures illustrating typical combinations of water quality facilities such as extended dry detention basins (EDBs), sand filters, and other facilities with FSD. Individual components of an above-ground detention facility are discussed in the subsections below.

13.8.1 Grading Requirements

The bottom of the detention basin must slope toward the trickle channel. The minimum design slope of the pond bottom toward the trickle channel is 3%. Grading requirements for embankments must be in accordance with Table 13-1. All earthen embankments must be covered with a minimum of 6 inches of approved topsoil and revegetated with grass in accordance with the Revegetation chapter of the MHFD Manual. Groundwater inflow to detention facilities must be avoided. The bottom of the detention facility storage area must be at least 2 feet above the seasonal high groundwater elevation. In general, stormwater quality and detention facilities should be located outside of FEMA- and MHFD-designated 100-year floodplains so that they are not inundated by riverine flooding during a flood event. In some cases, it may not be feasible to locate these facilities outside of 100-year floodplain, and through a variance process, Commerce City may approve facilities within the 100-year floodplain so long as they are located outside of and above the 10-year floodplain level defined in the Flood Insurance Study or in a MHFD FHAD.

Table 13-1. Grading Criteria for Embankments

Embankment Height	Criteria (horizontal to vertical, H:V)
5 feet in height or less	No steeper than 4:1
Greater than 5 feet	Slopes must not be steeper than 3:1 (4:1 or milder preferred)

13.8.2 Retaining Walls

The use of retaining walls within detention basins is discouraged. However, if walls are unavoidable, low-height walls less than 30 inches high that are constructed of natural rock or landscape block are preferred. Plain-faced concrete walls are allowed in

industrial settings. Long-term maintenance access, safety, and aesthetics are important design considerations. Walls may not be continuous around a detention facility, but must allow access for maintenance equipment. Maintenance equipment must be able to safely reach the bottom of the facility, including the forebay and outlet structure, and have adequate space to operate and turn. If multiple retaining walls are used, a separation of at least 4 feet must be provided between tiered walls. Foundation walls of buildings may not be used as detention basin retaining walls. If accepted by Commerce City, a handrail may be required for any retaining walls exceeding a height of 30 inches (as measured from the ground line to the top of the wall). Detention basins with retaining walls should be located away from major pedestrian routes, and emergency egress routes from detention basins must be provided.

A registered professional engineer must perform a structural analysis of retaining walls that exceed 30 inches in height for the various loading conditions the wall(s) may encounter. The wall design and calculations must be stamped by a professional engineer and submitted to Commerce City for review. The structural design details and requirements for the retaining wall(s) must be included in the construction drawings.

13.8.3 Emergency Spillway and Freeboard

In designing the emergency spillway, the flow is the 100-year undetained flow from the contributing watershed for fully developed watershed conditions. This is in case the outlet is plugged and the pond is full during the peak rain event. For contributing drainage areas greater than or equal to 5 acres, the elevation of the top of the embankment must be a minimum of 1 foot above the water-surface elevation when the emergency spillway is conveying the maximum design or emergency flow. For contributing drainage areas of less than 5 acres, the elevation of the top of the embankment must be at least 6 inches above the water-surface elevation when the emergency spillway is conveying the maximum design or emergency flow when the outfall structure is in a 100% blocked condition.

Some situations may require more stringent emergency spillway criteria than presented in the Storage chapter of the MHFD Manual. When the storage facility falls under the jurisdiction of the SEO as a dam, the spillway's design storm is prescribed by the SEO (SEO 2020). Also, analysis of downstream hazards may indicate that the spillway design storm will need to be larger than the 100-year event.

13.8.4 Inlet and Forebay

Inlets and sediment forebays must be sized in accordance with the MHFD Manual. The intent of the forebay is to reduce loading of sediment and debris to the main body of a detention facility. Alternative designs may be considered with Commerce City's approval; however, a forebay or equivalent pre-treatment facility is required for all detention basins.

13.8.5 Trickle (Low Flow) Channel

All grassed-bottom detention basins must include a trickle channel designed according to the MHFD Manual. The MHFD Manual has options for concrete-bottom and soft-

bottom trickle channels. Commerce City's approval is required to use the soft-bottom trickle channel approach, and markers are required to provide a reference to the correct invert when removing accumulated sediment during maintenance.

13.8.6 Outlet Configuration

The MHFD Manual and website provide design guidance, design details, and examples for several detention facility outlet configurations. See the Outlet Structure Fact Sheet in Chapter 4 of Volume 3 of the MHFD Manual for criteria related to outlet structure design, including criteria for orifice plates, micropools, trash racks, and safety grates.

All detention facilities in Commerce City must incorporate the following:

1. All mounting hardware for the orifice plate and trash racks must be stainless steel.

2. Orifice plates must be stainless steel.

3. The WQCV and/or EURV orifice plate must have a neoprene gasket between the plate and outlet structure to prevent leakage.

4. The configuration of the orifice plate openings must be in accordance with the Outlet Structures Fact Sheet in Volume 3 of the MHFD Manual. In general, fewer large orifices are preferable to many small orifices to reduce the likelihood of plugging, while still meeting required drain times stipulated in the Chapter 4 of Volume 3 and in the Storage chapter of the MHFD Manual. The 100-year orifice control typically is located at the entrance to the outlet pipe. The MHFD-Detention workbook is a tool that can be used for sizing the openings of the orifice plate and other outlet hydraulic controls.

5. If orifices are 1 inches square or 1.25 inches in diameter or larger, fabricated bar grating with nominal openings of 1 by 4 inches is recommended in lieu of a well screen.

6. Outlets must incorporate micropools in conformance with the Outlet Structure Fact Sheet in Volume 3, and the well screen (or bar grating as appropriate) must extend to the bottom of the micropool.

7. All outlets must be designed to minimize unauthorized modifications that affect proper function. A sign with a minimum area of 1.5 square feet must be attached to the outlet or posted nearby (if unable to be posted to the outlet) with the following message:

WARNING
This is a Water Quality Treatment Facility.
Keep screen and grate clean.
Unauthorized modification of this outlet is a code violation.

13.8.7 Landscaping Requirements

Detention areas and embankments should be designed and constructed to blend with their surroundings, creating site amenities rather than eyesores. In open space or natural areas, techniques to be considered include creation of topographic changes that mimic natural conditions (including a variety of slope changes), using natural materials such as stone, blending with the textures and patterns of the surrounding landscape, and using materials that match the local environment. No plain-faced precast or cast-in-place concrete is allowed in residential and commercial areas; although these types of concrete may be allowed in industrial areas. Existing drainage patterns should be preserved whenever possible.

Vegetate all above-ground detention basins in accordance with the criteria in the Revegetation chapter of Volume 2 of the MHFD Manual. Landscaping improvements should enhance the aesthetics of the basin. When determining landscaping, long-term maintainability of the facility should be a high priority. The following is a list of guidelines (adapted from Douglas County Storm Drainage Criteria Manual, 2005) for basin landscaping:

1. In areas that will be viewed by the public, detention areas should be designed as natural-looking features that fit into the surrounding landscape and add to the overall character of an area. The shape of the detention basin should be as natural looking as practical, with terracing of the slopes and a bottom sloping toward the trickle channel. The tops and the toes of slopes should vary, and there should be an undulation in the shape and grading of the sides of the detention area. In industrial settings with restricted public access, a natural-looking appearance may be less important, and other factors such as ease of maintenance may be higher design priorities. In general, the landscaping and aesthetics of detention facilities should be designed for compatibility with adjacent and nearby land uses.

2. Slopes should be well vegetated to prevent erosion. The use of appropriate groundcovers and grasses at the tops of slopes help to soften the appearance of the detention area and can incorporate the detention area into the surrounding landscape. Appropriate plant material, such as wetland species or drought-tolerant species, should be planted in the detention area and on the slopes. Shrubs and trees should be offset from the top of the slope and placed so that they do not interfere with maintenance and so that tree roots will not cause structural issues. Native and perennial species should be used to the extent practical. Water rights or water service from the South Adams County Water and Sanitation District will be required for any irrigation of vegetation.

3. The use of wood mulch in and adjacent to detention facilities is discouraged because of its potential to be displaced and clog outlet structures. Mulch placed over filter fabric is particularly susceptible to displacement and should not be used on slopes greater than 6 (horizontal) to 1 (vertical) or below the 100-year water surface elevation. The use of rock mulch is discouraged because it is difficult to remove sediment from the rock.

Typically, runoff is conveyed to detention facilities in a storm drain pipe. When runoff is conveyed to the detention facility via a swale or when the storm drain pipe discharges higher up on the pond embankment, rundowns may be needed to minimize erosion at inflow points. When rock or concrete rundowns are used, they should be attractive and compatible with the overall design.

13.8.8 Multiple Use Considerations

Multiple uses of detention facilities are encouraged; however, it is critical to minimize conflicting uses. In some portions of Commerce City, including areas of residential development, multi-use facilities that provide benefits related to aesthetics, wildlife, and recreation are desirable. Park and detention facility conflicts may relate to the time required for the detention area to drain and dry out, safety in areas used for child play, mosquito-borne illness (e.g., West Nile virus) concerns, and protection and enhancement of wildlife. In other settings, such as industrial areas, multi-uses including aesthetics and recreation may not be compatible; although, other multi-uses such as combining stormwater management and parking through the use of permeable pavements may still be beneficial.

Considerations for multi-use facilities include:

- Compatibility of the facility design with constraints related to surrounding land uses, cultural and historical preservation requirements, or other protective constraints such as those related to aquatic or terrestrial wildlife habitat.
- Compatibility with recreational uses. The level of organized and informal activity in a park must be considered as well as passive versus active recreation objectives.
- Technical constraints and opportunities including soil characteristics, turf management, or terrain, and irrigation requirements.
- Potential for new natural areas and wildlife corridors.
- Size and configuration of the park. For example, a small neighborhood park under 5 acres would probably not be appropriate for a large detention facility.
- Maintenance and operations, funding resources, successful techniques for dealing with silt, debris, trash, etc. (These considerations should be reflected in the facility O&M plan.)
- The configuration and easements for underground utilities and their impact on the existing park land.
- Potential for total rehabilitation of existing sites to accommodate multi-purpose uses.
- Integration with other aspects of the open space system.

- Multi-use does not result in the any direct, active use of water impounded in or passing through the facility. For example, water may not be pumped out of the facility for irrigation purposes.

13.9 Design Standards for Parking Lot Detention

Parking lot detention is allowed in Commerce City only when designed and constructed using permeable pavements with void storage so that the runoff being detained is infiltrated to the subgrade and detained in void space, rather than on the surface of the parking lot.

13.9.1 Depth Limitation

Surface ponding in parking areas is allowed only to the extent that it is necessary to infiltrate runoff into a permeable pavement system for below-grade detention of the WQCV, EURV, and/or 100-year flood control volume. To limit the potential for surface ponding in permeable pavement parking lot detention areas, the ratio of impervious drainage area to the permeable pavement area must not exceed 3:1 (impervious drainage area to permeable pavement area). Higher ratios may be allowed on a case-by-case basis through a variance process if the applicant can demonstrate through hydrologic routing, accounting for reduced permeable pavement infiltration rates over time, that the temporary maximum ponding depth would not exceed 6 inches for the 100-year event.

13.9.2 Outlet

The outlet for parking lot detention is provided via the permeable pavement system and consists of infiltration into underlying soils and/or discharge via an underdrain system. When an underdrain is used for the outlet, the underdrain must be designed to drain the WQCV in 12 hours, the EURV in 72 hours, and the 100-year event at the specified release rate. For events that are larger than the 100-year design event, the designer must provide an overflow path that is clear of obstructions and will not impact structures.

13.9.3 Performance and Maintenance

The outlet for parking lot detention is provided via the permeable pavement system and consists of infiltration into underlying soils or discharge via an underdrain system. When an underdrain is used for the outlet, the underdrain must be designed to drain the WQCV in 12 hours, the EURV in 72 hours, and the 100-year event at the specified release rate. For events that are larger than the 100-year design event, the designer must provide an overflow path that is clear of obstructions and will not impact structures.

The City requires an inspection, operation, and maintenance plan for parking lot permeable pavement system detention sites. Additionally, the City will require a bond to ensure operation and maintenance at these sites.

13.9.4 Flood Hazard Warning

All parking lot detention areas must have multiple signs posted identifying the detention basin area. The signs must have a minimum area of 1.5 square feet and contain the following message:

WARNING
This area is a stormwater detention facility and is subject to periodic flooding.

Any suitable materials and geometry of the sign are permissible, subject to approval by the Department of Public Works.

13.10 Underground Water Quality and Detention Facilities

Underground water quality and detention facilities are prohibited in Commerce City for the following reasons:

- Underground water quality and detention facilities are not visible; therefore, these types of facilities tend to be “out-of-sight, out-of-mind.” As a result, these devices may not receive regular maintenance or performance evaluation.
- Maintenance access may be more complex, which can be a deterrent to maintenance. Additionally, confined space entry and special safety requirements may apply, depending on the installation.
- Anaerobic (absence of dissolved oxygen) conditions in bottom sediments are more likely to develop in underground devices. This condition can release pollutants that were bound to the sediment and cause bad odors.
- Vegetation within above-ground systems provides benefits beyond stormwater management, including the removal of air pollutants, mitigation of the urban heat island effect, and improvement of habitat.

Generally, there is sufficient land available in Commerce City to implement surface-based water quality and detention practices. Underground practices may be considered on a case-by-case basis if the applicant can demonstrate that reasonable surface-based alternatives are infeasible. The use of underground practices requires approval by the City Engineer through the variance process. The following criteria must be met for consideration of underground water quality and detention facilities:

1. The applicant has demonstrated that surface-based practices are infeasible. Analysis by the applicant must include analysis of alternative site layouts, consideration of reduced intensity of development, and sizing and conceptual design of surface-based practices to demonstrate that surface-based practices are not feasible given the ultimate use of the site and site characteristics.

2. The applicant has provided adequate assurances for long-term operation and maintenance of the facility, including arrangements for regular inspection and maintenance using appropriate equipment for the type of facility.

3. The design provides for access hatches or manholes for accessing the underground facility in areas where access will not be restricted by parked vehicles or other surface uses of the area.

4. The performance of the underground facility will be comparable to above-ground facilities in Volume 3 of the MHFD Manual.

The facility meets the criteria in the Volume 3 of the MHFD Manual for Underground SCMs.

13.11 Design Standards for Retention (Wet) Ponds

13.11.1 Allowable Use

See the Storage chapter and Retention Pond Fact Sheet of the MHFD Manual for allowable uses for retention ponds. Commerce City allows retention ponds to be used as a water quality practices, but water rights are required for such uses. Retention ponds used for water quality have a permanent pool that remains between storm events and a surcharge volume that fills and drains during periods of runoff. Retention of stormwater runoff is not an allowable flood control practice in Commerce City. Any existing retention ponds in Commerce City must be converted to detention (fill and drain) facilities as soon as an adequate outfall is available to receive flow releases from the facility, in order to avoid costly water rights acquisitions and adjudications. Colorado water law requires that 97% of the 5-year or less event must drain within 72 hours and that 99% of the 100-year event must drain within 120 hours. Existing retention facilities must be retrofit to meet these drain time criteria to comply with Colorado water law, or a water right must be obtained (CRS §37-92-602(8) Frequently Asked Questions, 2015). Development agreements may require a cash-in-lieu fees to be made to the City for future conversions of retentions pond to detention.

13.11.2 Design Standards for Retention Ponds

See the Retention Pond Fact Sheet in Volume 3 of the MHFD Manual for applicable design standards.

13.12 Summary of Key Design Considerations

All of the design criteria in this chapter must be followed. Several key considerations that the designer must take care to address include:

1. Grade earth slopes per Section 13.9.1.

2. Provide trickle channels in areas that are not permanently inundated.

3. Provide proper trash racks and micro-pools at all outlet structures.

4. Provide signage as needed.

5. Provide maintenance access to all structures (inlets, forebays, trickle channel, outlet and spillway).

6. Provide an emergency spillway and check the emergency overflow path.

7. Check finished floor elevations of any structures near the detention basin to verify adequate freeboard.

8. Design the invert of the inflow pipe to the detention basin to be higher than the WQCV level.

9. The bottom elevation the detention basin storage area must be at least 4 feet above the seasonal high groundwater. Groundwater inflow into detention systems is not allowed.

14.0 Stormwater Quality

14.1 Introduction

Commerce City requires permanent stormwater control measures (SCMs), formerly known as best management practices (BMPs), to be implemented on development and redevelopment projects to protect the City's streams, lakes, and wetlands. These requirements are also necessary for the City to comply with Colorado's water quality regulations and the City's Municipal Separate Storm Sewer System (MS4) discharge permit, as well as total maximum daily load (TMDL) requirements for the South Platte River. The City incorporates Volume 3 of the MHFD Manual as the basis for its design criteria.

Terminology

"Stormwater control measure" (SCM) refers to any best management practice (BMP) or other method used to prevent or reduce the discharge of pollutants to Waters of the State. SCMs include, but are not limited to, BMPs, green infrastructure (GI), green stormwater infrastructure (GSI), and low impact development (LID).

14.2 Applicability

All development and redevelopment projects in the City must implement stormwater control measures to enhance the water quality of storm runoff, as described in Table 14-1. If a proposed development or redevelopment is part of a larger common plan of development or sale, then requirements in Table 14-1 also apply. Table 14-1 contains two thresholds: a 1-acre threshold for the area of disturbance that arises from MS4 Permit requirements and a 5,000-square-foot threshold for area of disturbance, which is a Commerce City criterion. Proposed projects must comply with the more restrictive of these two thresholds when determining post-construction water quality requirements for a site. When post-construction SCMs are required, WQCV-based stormwater controls must be sized to provide the WQCV for the entire upgradient watershed, assuming future developed conditions.

Definition of Larger Common Plan of Development or Sale

The Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (Division) defines a "larger common plan of development or sale" as a part of the General Permit for Stormwater Discharges Associated with Construction Activities and in the General Phase II MS4 Permit. This term is defined as "a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules, but remain related. The Division has determined that "contiguous" means construction activities located in close proximity to each other (within ¼ mile). Construction activities are considered to be "related" if they share the same development plan, builder or contractor, equipment, storage areas, etc."

Table 14-1. Permanent Stormwater Quality Control Measure Requirements

Project Conditions	Runoff Reduction/ MDCIA[1]	Permanent Stormwater Quality Control Measure Requirements
Total Disturbance ≥ 1 acre	Required	Must satisfy one of the MS4 Permit design standards (for the area of disturbance).
Total Disturbance < 1 acre, and Total Disturbance Area ≥ 5,000 square feet	Required	Must satisfy one of the MS4 Permit treatment standards for new impervious area. For sites that have small amounts of additional impervious area, runoff reduction through the use of grass buffers, swales, and other types of RPAs may be used to satisfy this requirement.
Total Disturbance < 5,000 square feet	Required	Not required

[1]Minimized Directly Connected Impervious Area (MDCIA) must be implemented in a manner that does not cause adverse impacts to structures or adjacent property.

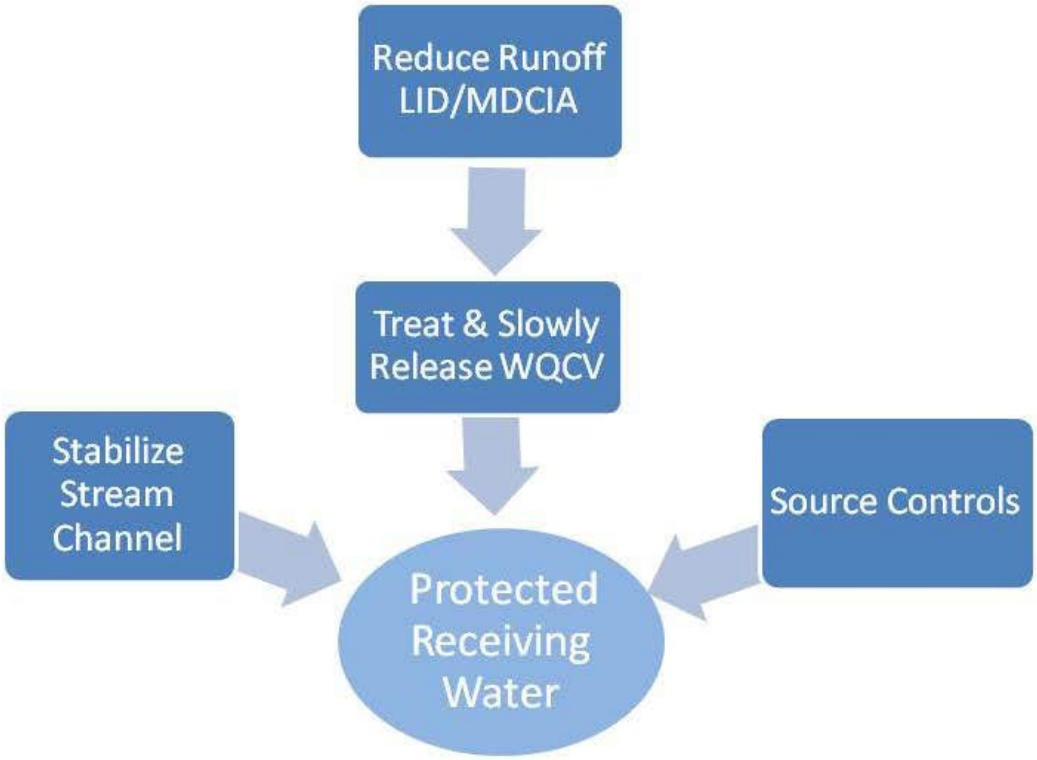
14.3 Design Approach

Stormwater quality management approaches in Commerce City are based on the "Four-Step Process" described in Volume 3 of the MHFD Manual (Figure 14-1). Additionally, Commerce City encourages integration of water quality and flood control in full spectrum detention facilities, as discussed in Chapter 13 Detention.

As described in Volume 3 of the MHFD Manual, effective stormwater management: 1) integrates pollutant source controls, 2) reduces runoff volumes through minimized directly connected impervious area (MDCIA), 3) treats the water quality capture volume (WQCV), and 4) incorporates stream stabilization. This chapter focuses on runoff reduction (MDCIA) and treatment of the WQCV.

Commerce City strongly encourages the use of practices that infiltrate runoff when soil properties, underlying groundwater conditions, and adjacent development characteristics are compatible with infiltration. In all cases, runoff reduction through minimization of directly connected impervious area is required to the extent practical. To successfully plan, design, and construct infiltration-based SCMs, data related to soil characteristics, infiltration rates, depth to groundwater, and other related information are needed. Commerce City incorporates the criteria in Chapter 4 of Volume 3 of the MHFD Manual for geotechnical investigations and data collection for infiltration-based stormwater control measures. See Section 14.3.3, below, for additional information.

Figure 14-1. MHFD's Four-Step Process for Stormwater Quality Management



To effectively implement MDCIA on a site, it must be considered early in the land development planning process. On some small sites, it may be possible to meet stormwater quality management requirements through the use of MDCIA alone. On larger sites, the size of WQCV facilities may be reduced through the implementation of MDCIA. The City adopts MHFD's method for quantifying volume reduction described in Volume 3 of the MHFD Manual. Volume 3 provides guidance on selecting permanent SCMs, considering factors such as watershed size, soils, depths to groundwater and bedrock, baseflows, watershed conditions, and targeted pollutants.

Conserving Existing Amenities

During the planning phase of development, identify portions of the site that provide stormwater quality benefits and should be protected or improved. Such areas may include mature trees, stream corridors, wetlands, and Hydrologic Soil Group (HSG) A and B soils with higher infiltration rates. Natural areas to be preserved must be protected from compaction during the construction phase. Consider temporary construction fence for this purpose. In areas where disturbance cannot practically be avoided, rototilling and soil amendments should be integrated to restore the infiltration capacity of areas that will be restored with vegetation.

14.3.1 Scale of Application

There are three general approaches to providing stormwater quality treatment in Commerce City: 1) onsite, 2) sub-regional, and 3) regional. Onsite facilities serve individual lots. Sub-regional facilities serve two or more lots with a total contributing drainage area of less than 130 acres. Regional facilities serve drainage areas between 130 acres up to 1 square mile and may be applicable for larger development and redevelopment projects. Regional facilities that provide stormwater quality treatment must comply with the regional detention facility requirements described in Chapter 13 Detention.

If regional or sub-regional facilities provide stormwater quality treatment, then the following conditions must be met:

1. **MDCIA Requirement:** Before discharging to a Water of the State, at least 20% of the upstream imperviousness of the applicable development site must be disconnected from the storm drainage system and drain through a receiving pervious area control measure comprising a footprint of at least 10% of the upstream disconnected impervious area of the applicable development site. The receiving pervious area must consist of some combination of landscaped buffers, swales, or permeable pavement. Other sizing criteria may be more restrictive—this criterion applies only to disconnection of small onsite impervious areas via drainage as sheet flow to pervious, vegetated areas. (For example, more restrictive criteria apply to permeable pavement: a 10:1 run-on ratio would not be acceptable due to the need to reduce the potential for clogging and to avoid the need for frequent maintenance.)

2. **Stream Stabilization:** All surface conveyances leading to the regional or sub-regional water quality facility must be fully stabilized. Any new or existing outfalls leading to a regional drainageway must be designed, constructed, and stabilized in accordance with MHFD criteria and must be approved through the MHFD Maintenance Eligibility Program.

3. **Source Controls:** Where applicable in industrial areas or other developments that have the potential for significant source pollution, source control measures are required for the individual parcels upstream of the regional or sub-regional facility.

The contributing drainage area is an important consideration both at the site level and at the regional level. At the site level, there is a practical minimum size for certain SCMs, largely related to the ability to drain the WQCV over the required drain time. For example, it is technically possible to size the WQCV for an extended detention basin for a half-acre site; however, designing a functional outlet to release the WQCV over a 40-hour drain time is practically impossible due to the very small orifices that would be required. For this size watershed, a bioretention SCM would be more appropriate. At the other end of the spectrum, there must be a limit on the maximum drainage area for a regional facility to ensure adequate treatment of rainfall events that may produce runoff from only a portion of the area draining to the SCM. If the overall drainage area is too

large, events that produce runoff from only a portion of the contributing area will pass through the outlet (sized for the full drainage area) without adequate residence time in the SCM. As a practical limit, the maximum drainage area contributing to a regional water quality facility should be no larger than 1 square mile.

14.3.2 Design Criteria

Design of conveyance-based SCMs (e.g., grass buffers, swales) is based on flow rates for design events, as specified in Volume 3 of the MHFD Manual. Storage-based SCMs (e.g., extended detention basins, bioretention, sand filters) are based on storing and slowly releasing the WQCV unless Full Spectrum Detention designs are implemented to provide treatment of the Excess Urban Runoff Volume (EURV), as described in Chapter 13 Detention of this Manual and in Volume 2 of the MHFD Manual. The WQCV is calculated using methods in Volume 3. MHFD's UD-BMP spreadsheet can be used as a design aid for SCM selection and sizing, as well as to quantify runoff reduction achieved through disconnection of impervious area. The City requires treatment of the full WQCV unless the required treatment volume is reduced through the implementation of runoff reduction methods. Reductions in WQCV treatment volumes must be quantified using the Runoff Reduction Method described in Volume 3.

Volume 3 of the MHFD Manual provides design criteria for SCM types appropriate for use in Commerce City. The City adopts MHFD's design criteria for SCMs listed in Table 14-2. Additionally, the City may approve use of other SCM types with demonstrated performance on a case-by-case basis. The use of SCMs that are not included in the MHFD Manual requires a variance.

Table 14-2. Stormwater Control Measures (SCMs) Allowed in Commerce City

SCM Type[1,2]	Comment
Grass Buffers and Grass Swales	Can be used to disconnect impervious area and provide volume reduction. If used as a stand-alone practice, these must be designed to satisfy the volume reduction design standard in the MS4 Permit. They do not treat the WQCV and are usually part of a treatment train with other practices that provide the WQCV. They can also be used to provide pretreatment.
Bioretention	Can be designed for WQCV or EURV. Well suited for smaller sites, infill, and redevelopment. Not suited for sub-regional or regional applications unless a pretreatment forebay following EDB sizing criteria is provided and depth and area guidelines are strictly followed. Partial- and full-infiltration configurations are not suitable for sites where soil or groundwater contamination may exist or are known to exist.
Green Roof	Primarily provides volume reduction.
Extended Detention Basin	Not recommended for drainage areas with less than 2 impervious acres, and not allowed for sites with less than 1 impervious acre. Can be designed for WQCV or EURV.
Sand Filter	Most suitable for drainage areas less than 1 acre. Partial- and full-infiltration configurations are not suitable for sites where soil or groundwater contamination may exist or is known to exist. A variance is required to use underground sand filter design variations, such as below-ground vaults. Underground SCMs are considered practices of last resort, and surface-based SCMs are usually feasible in Commerce City. Additional requirements for underground facilities apply, as described in Chapter 13 Detention. Can be designed for WQCV or EURV.
Retention Pond (Wet Pond)	Water rights and space constraints may limit application in Commerce City. Only permitted for drainage areas greater than 1 acre. Can be designed for WQCV or EURV. Retention is allowed as a water quality practice when the WQCV is stored above the permanent pool. It is subject to satisfying requirements for water rights. Retention is prohibited as a flood control practice in Commerce City.
Constructed Wetland Pond	Water rights and space constraints may limit application in Commerce City. Only permitted for drainage areas greater than 1 acre. Can be designed for WQCV or EURV.
Permeable Pavement	Suitable for parking areas, alleys, and low-use areas without the potential for groundwater contamination. Enables use of SCM surface area for other purposes. Can be designed for WQCV and flood control.
Underground SCMs	The City prefers above-ground treatment approaches. Underground SCMs are considered practices of last resort and surface-based SCMs are usually feasible in Commerce City. May be used for pretreatment or approved on a case-by-case basis when no above-ground alternatives are feasible. A variance approved by the City Engineer is required for underground SCMs.

[1]The City encourages the use of SCMs in sequence (treatment trains) and the use of forebays as part of SCM designs to facilitate maintenance.

[2]The City reserves the right to also accept SCMs detailed in future editions of the MHFD Manual when those SCMs meet the intent of these criteria.

14.3.3 Additional Requirements for Infiltration-Based Practices

Soils with good permeability, typically associated with HSGs A and B, provide opportunities for infiltration of runoff and are well-suited to infiltration-based SCMs such as bioretention, permeable pavement systems, sand filters, grass swales, and grass buffers, often without the need for an underdrain system. Even when soil permeability is low, these types of SCMs may be feasible if soils are amended to increase permeability or if an underdrain system is used. In some cases, however, soils restrict the use of infiltration-based SCMs. When soils with moderate to high swell potential are present, infiltration should be avoided to minimize damage to adjacent structures due to water-induced swelling. In some cases, these SCMs can still be used if an impermeable liner and underdrain system are included in the design.

Infiltration-based practices are generally not appropriate for sub-regional or regional water quality facilities, due to the large area and shallow depth requirements that should be strictly adhered to in all cases. If sub-regional or regional infiltration practices can meet these design requirements, additional pre-treatment must be provided to reduce sediment loading, which will otherwise reduce the effectiveness of the SCM over time due to clogging.

Infiltration-based practices are also not appropriate for sites where the potential for groundwater or soil contamination may exist or is known to exist, unless a no-infiltration configuration is utilized. It is incumbent upon the designer to ensure that the selected SCM does not result in additional contamination or the spread of existing contamination if a partial- or full-infiltration configuration is utilized. Potential resources for identifying known or suspected contamination are provided in Table 3-2 in the Submittals chapter. Figure 14-2 provides a flow chart for determining how to address areas of known contamination in post-construction stormwater control design.

In all cases, consultation with a geotechnical engineer is necessary for evaluating the suitability of soils for various infiltration-based SCMs and establishing minimum distances between infiltration SCMs and structures. See the Submittals chapter for geotechnical report requirements and Chapter 4 of Volume 3 for data collection and testing requirements for infiltration-based SCMs. Typical evaluations include evaluating Natural Resource Conservation Service (NRCS) mapping and soil properties, geotechnical investigations including boring on site and soil sampling and laboratory analysis to characterize soil properties, and in situ testing of infiltration rates of the soils beneath a proposed control measure using a double-ring infiltrometer (American Society for Testing and Materials [ASTM] D 3385) or other comparable methods identified in Volume 3 of the MHFD Manual.

14.3.4 Safety

SCMs must be designed and maintained in a manner that protects the safety of both the public and maintenance personnel. Design criteria in Volume 3 of the MHFD Manual incorporate safety considerations.

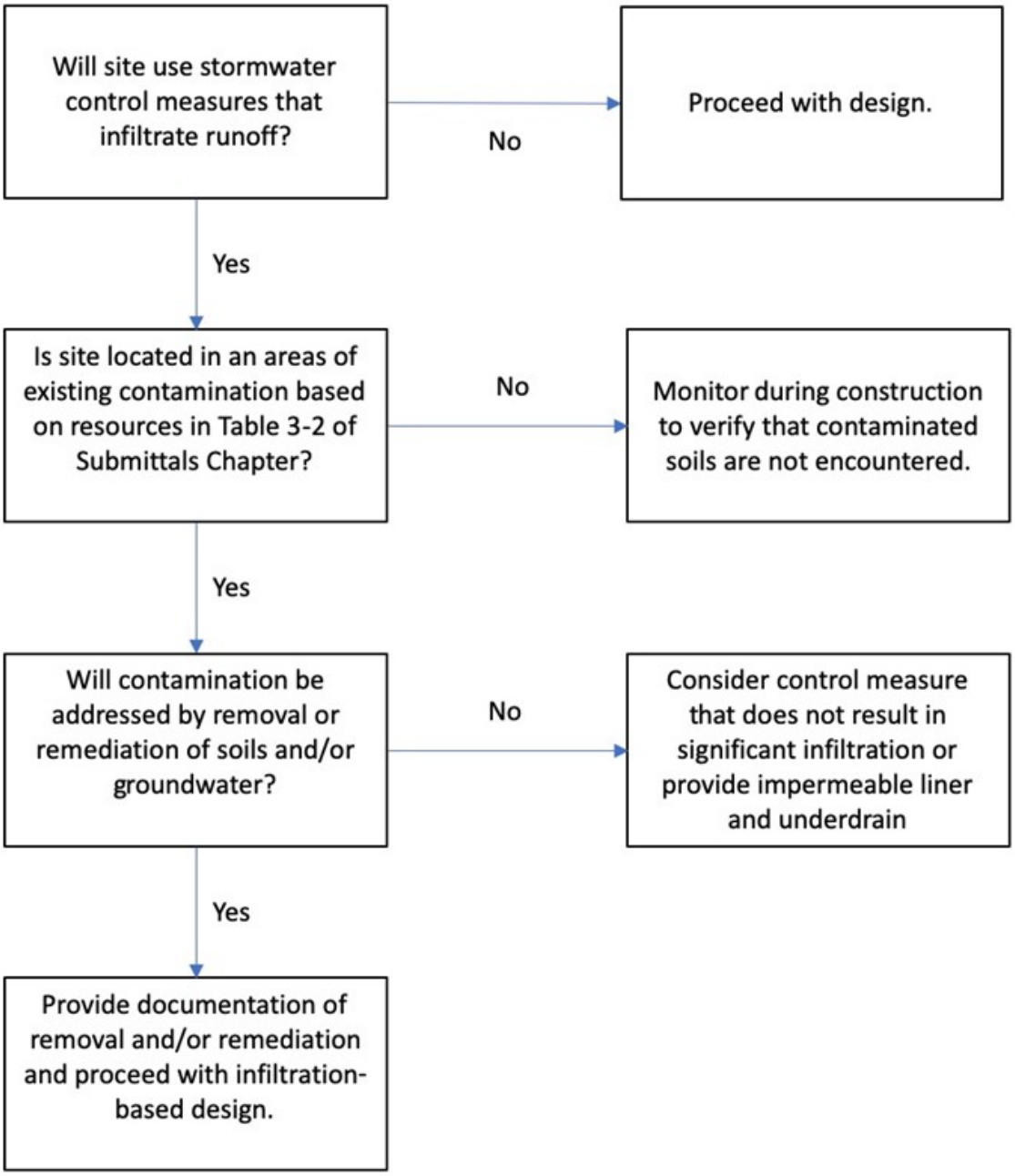
14.3.5 Aesthetics

SCMs should be designed to be aesthetically compatible with surrounding land use. Consultation with a landscape architect is recommended. Volume 3 of the MHFD Manual provides recommendations for aesthetically-pleasing designs that complement, rather than detract from, the development.

14.3.6 Maintenance

All SCMs must be designed with adequate maintenance and access provisions and in a manner that facilitates maintenance. The City requires that an Operation and Maintenance Plan be completed for all permanent SCMs. A copy of the Operation and Maintenance Plan is to be provided to both the City and to the owner of the facility or facilities to which it applies. Operations and Maintenance Plan contents are described in the Submittals chapter.

Figure 14-2. Flow Chart for Sites with Potential Contamination



14.4 Water Rights Reporting Requirements for Stormwater Facilities

CRS §37-92-602 (8) provides water rights-related legal protection for any regional or individual site stormwater detention and infiltration facility in Colorado, provided the facility meets these criteria:

1. It is owned or operated by a governmental entity or is subject to oversight by a governmental entity (e.g., required under an MS4 Permit).

2. It continuously releases or infiltrates at least 97% of all of the runoff from a rainfall event that is less than or equal to a 5-year storm within 72 hours after the end of the event.

3. It continuously releases or infiltrates as quickly as practicable, but in all cases releases or infiltrates at least 99% of the runoff within 120 hours after the end of events greater than a 5-year storm.

4. It operates passively and does not subject the stormwater runoff to any active treatment process (e.g., coagulation, flocculation, disinfection, etc.).

This statute specifies that runoff treated in stormwater detention and infiltration facilities must not be used for any other purpose by the owner/operator/overseer (or that entity's designees), must not be released for subsequent diversion or storage by the owner/operator/overseer (or that entity's designees) and must not be the basis for a water right or credit (MHFD 2016).

Under this statute, new stormwater detention and infiltration facilities must complete certain reporting requirements facilitated by an on-line mapping system for Stormwater Detention and Infiltration Facility Notification (https://maperture.digitaldataservices.com/gvh/?viewer=cswdif). This information must be filed prior to operation of the facility and include the following:

1. Location.

2. Approximate surface area at design volume.

3. Data that demonstrate that the facility has been designed to comply with the release rate requirements described above. (The MHFD-Detention workbook available at www.MHFD.org can be used to demonstrate compliance with release rates.)

Not all stormwater facilities are required to complete filing requirements, and certain types of facilities are not protected under this statute, as summarized in Table 14-3. Neither retention facilities nor constructed wetlands are protected under CRS §37-92-602 (8). These facilities expressly require a water right. Temporary construction and sedimentation basins should not be uploaded to the online portal unless they will be used as permanent detention basins. In such cases, the final detention configuration should be completed before uploading the record.

Table 14-3. Stormwater Facility Reporting Requirements under Senate Bill 15-212 (MHFD 2016)

SCM Type	Water Quality Only	Flood Control Included
Grass Buffers	Not Required	Not Required
Grass Swales	Not Required	Not Required
Bioretention (with or without underdrain)	Not Required	Required
Green Roof	Not Required	Not Required
Extended Detention Basin	Required	Required
Sand Filter	Not Required	Required
Permeable Pavement Systems	Not Required	Required
Media Filter Drain	Not Required	Not Required
Underground Detention Vaults	Required	Required
Constructed Wetland Pond	N/A, Subject to Water Rights	
Retention Pond	N/A, Subject to Water Rights	

IRONDALE GULCH

OUTFALL SYSTEMS PLAN

CONCEPTUAL DESIGN REPORT

Project Sponsors

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

COMMERCE CITY

Prepared by:

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September 2011

September 8, 2011

Ms. Shea Thomas:
Senior Project Engineer
Urban Drainage and Flood Control District
2480 West 26th Avenue, Suite 156-B
Denver, CO 80211

Subject: Irondale Gulch Outfall Systems Plan
Conceptual Design Report
UDFCD Agreement No. 09-07.15

Dear Ms. Thomas:

Moser & Associates Engineering is pleased to submit this report entitled *Irondale Gulch Outfall Systems Plan Conceptual Design Report*, dated September 2011.

We would like to acknowledge the help and support from Commerce City, the City of Thornton, the Fish and Wildlife Service, and the Urban Drainage and Flood Control District in the preparation of this report.

The enclosed text and drawings present the Conceptual Design for the Irondale Gulch Drainageway from the Rocky Mountain Arsenal to the South Platte River. The Selected Plan was provided by the project sponsors which closely followed the Recommended Plan from the Alternatives Evaluation Report. The Conceptual Design included some minor changes to the Selected Plan as more detailed analysis revealed utility and ROW conflicts. The Conceptual Design defines an outfall to the South Platte River and defines a drainage path from SH 2 through Commerce City, minimizing the potential impacts of flooding, and strives to preserve the water quality and overall health of the watershed.

Thank you for the opportunity to complete the final phase of this project. We have enjoyed working on this effort throughout the preparation of this report.

Best regards,
MOSER & ASSOCIATES ENGINEERING, INC.

Rick R. Moser, P.E.
Principal-In-Charge

Richard Ommert, P.E.
Project Manager

Teresa L. Patterson, P.E.
Technical Advisor

Lee D. Rosen, E.I.
Project Engineer

EXECUTIVE SUMMARY

The Conceptual Design for the Outfall Systems Plan for Irondale Gulch is presented herein, in the "*Irondale Gulch Outfall Systems Plan – Conceptual Design Report*". On October 27, 2009, the Urban Drainage and Flood Control District (UDFCD), in joint sponsorship with Commerce City, contracted with Moser & Associates Engineering for the provision of engineering services for an Outfall Systems Planning (OSP) Study for the Irondale Gulch Watershed (Burlington Northern Railroad to South Platte River). The study area is illustrated in Figure ES-1.

This Conceptual Design Report presents the Conceptual Design which was selected from the alternatives developed for the Irondale Gulch (Study Area) within Commerce City, City of Thornton and Unincorporated Adams County. The objective of the study is to evaluate the existing drainage concerns in the Irondale Gulch area and subsequently to develop conceptual plans to provide the safe conveyance of stormwater and define a proper outfall for the watershed. The Conceptual Design integrates flood conveyance, stormwater quality, erosion control, and aesthetics into one drainage master planning document.

This report provides conceptual plan maps, profile drawings, cost estimates, and an implementation plan for the selected drainage improvements.

ES.1 PURPOSE AND OBJECTIVES

The purpose of the study is to supply a master plan for the Irondale Gulch watershed which provides guidance to the project sponsors for future construction projects and development plans. The objective of the study is to evaluate the existing drainage concerns in the Irondale Gulch area and subsequently to develop conceptual plans to provide the safe conveyance of stormwater and define a proper outfall for the watershed.

The Outfall Systems Planning (OSP) Study consists of three phases: the Baseline Hydrology Phase which was completed in September 2010, the Alternatives Evaluation Phase which was completed in January 2011, and the Conceptual Design Phase for which this Conceptual Design Report is published.

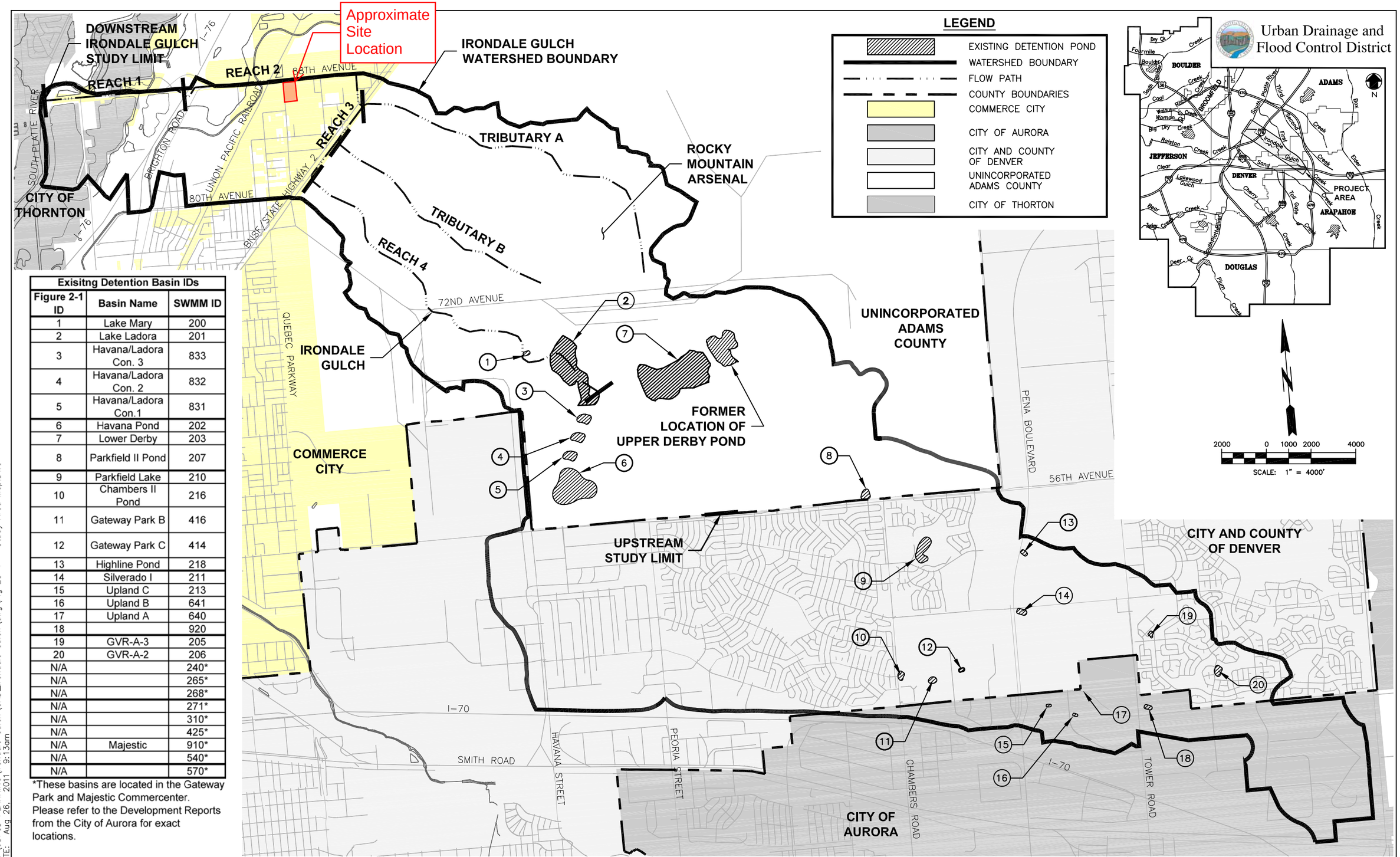
ES.2 PLANNING PROCESS

The study commenced when notice to proceed was issued November 17, 2009. Since that time, a series of progress meetings has taken place to exchange information, discuss ideas and findings, and present results during each phase of the study. Numerous stakeholders, including representatives from UDFCD, Commerce City, City of Thornton, Adams County, and Fish and Wildlife have attended the progress meetings to participate in the planning process. There were a total of eleven (11) progress meetings and one (1) public meeting.

The following individuals and representing project sponsors have attended the progress meetings and given input to the study.

Shea Thomas	Urban Drainage and Flood Control District
Ken MacKenzie	Urban Drainage and Flood Control District
David Mallory	Urban Drainage and Flood Control District
Chris Sveum	Commerce City
Matt Wiederspahn	Commerce City
Tom Jackson	Fish and Wildlife Service
Pete Brezall	City of Thornton
Walt Jenkins	City of Thornton
Jim Kaiser	City of Thornton

In addition to the meetings, a project website was created to inform the public of the progress of the study and gather input on specific issues. The website provides project information, posted notices to upcoming meetings, meeting minutes, study reports, and contact information. The website can be accessed at http://udfcd.org/projects/proj_msplan.htm.



Exisitng Detention Basin IDs		
Figure 2-1 ID	Basin Name	SWMM ID
1	Lake Mary	200
2	Lake Ladora	201
3	Havana/Ladora Con. 3	833
4	Havana/Ladora Con. 2	832
5	Havana/Ladora Con.1	831
6	Havana Pond	202
7	Lower Derby	203
8	Parkfield II Pond	207
9	Parkfield Lake	210
10	Chambers II Pond	216
11	Gateway Park B	416
12	Gateway Park C	414
13	Highline Pond	218
14	Silverado I	211
15	Upland C	213
16	Upland B	641
17	Upland A	640
18		920
19	GVR-A-3	205
20	GVR-A-2	206
N/A		240*
N/A		265*
N/A		268*
N/A		271*
N/A		310*
N/A		425*
N/A	Majestic	910*
N/A		540*
N/A		570*

*These basins are located in the Gateway Park and Majestic Commercenter. Please refer to the Development Reports from the City of Aurora for exact locations.

NAME: Z:\UDFCD PLANNING\Irondale Gulch\CAD_Irondale Gulch\dwg\Fig ES-1 - Study Area Map.DWG
PLOT DATE: Aug 26, 2011 9:13am

TOPOGRAPHIC METHOD: LIDAR
TOPOGRAPHIC MAPPING BY:
TOPOGRAPHIC MAPPING QA/QC BY:
CONTOUR INTERVAL: 2 FOOT
DATE FLOWN: 2008

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DESIGNED AGC DATE 10/10/10
DRAWN RWM DATE 11/15/10
CHECKED RCO DATE 1/20/11
REVISED DATE

COMMERCE CITY URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

IRONDALE GULCH OUTFALL SYSTEMS PLAN

STUDY AREA

FIGURE ES-1

ES.3 PROJECT AREA

The project area consists of the Irondale Gulch watershed which is located within Adams County, the City of Aurora, the City and County of Denver, Commerce City, and the City of Thornton. The total watershed area is 14,979 acres or 23.4 square miles.

The study limits are bounded generally on the south by 56th Avenue, on the north by 88th Avenue, and the east loosely by Buckley Road, and on the west by the South Platte River (SPR). Originally the upstream limit of the study area was at State Highway 2 (SH 2); however the elimination of Upper Derby Lake as a detention facility resulted in expanding the limits upstream to 56th Avenue. This expansion of the study area is entirely within the undeveloped land of the Rocky Mountain Arsenal (RMA). There are twenty-eight existing regional detention facilities within the project area.

The flow path of Irondale Gulch begins at the SPR boundary and moves upstream towards SH 2. In the area from the river to SH 2, there is generally no well defined flow path. Flows in this area pass through the Derby and Dupont developments and cross I-76, Vasquez Road, Brighton Road, the Union Pacific Railroad (UPRR), the Burlington Northern Santa Fe Railway (BNSF), and SH 2. The majority of the runoff here travels to the SPR as sheet flow. From SH 2 continuing upstream to 56th Avenue, both Irondale Gulch and Tributary A travel through natural and engineered channels through the RMA. The RMA is undeveloped and contains no major road crossings. Please see the Study Area Map (Figure ES-1) for locations.

General watershed parameters include:

- Highest watershed elevation (approximate) = 5520 feet
- Lowest watershed elevation (approximate) = 5070 feet
- Average slope of channel = 0.0097 feet/foot
- Watershed shape (length/width) = 3

ES.4 HYDROLOGIC ANALYSIS

The purpose of the hydrologic analysis was to update the previous hydrology models developed for Irondale Gulch as well as to add both the Direct Flow Area (DFA) and the Commerce City region between State Highway 2 and the South Platte River to the model. The major drainageways include Irondale Gulch, Tributary A and Tributary B, all of which were defined during this study. There are numerous minor tributaries that were evaluated, but are not individually discussed in this report (e.g. the Montbello Tributary, the Highline Lateral, etc.).

The hydrology model provided by UDFCD was originally created in 1990. The model has been modified several times since 1990, most recently by Boyle Engineering in 2003. The Boyle 2003 model represents future infrastructure only, therefore some modifications were necessary to create the Baseline Hydrology Model (i.e. existing infrastructure) model. All future infrastructure (including detention basins and engineered channels) were removed from the model. The subwatershed boundaries and routing essentially remained the same, however numerous subwatersheds were added to the main watershed: to the north (the DFA), to the west (the Commerce City area), and a few within the RMA that were not defined in the Boyle 2003 Study. For subwatersheds that were part of previous studies, subwatershed characteristics (including land use values, soils, rainfall information, and areas) remained unchanged except where the data appeared to be erroneous. However, in the Gateway Park and Majestic Commercenter area erroneous subwatersheds were not corrected (refer to the end of Section 3.5 for more information on this exception). For subwatersheds in areas that were added as part of the current study, new subwatershed characteristics (including land use values, soils, rainfall information, and areas) were assigned accordingly. The twenty-eight existing publicly owned and maintained detention basins within the Irondale Gulch watershed area were evaluated as part of the hydrologic analysis.

The storm runoff hydrographs and routing for the study were generated using CUHP 2005 Version 1.3.3 and the Environmental Protection Agency's Stormwater Management Model (EPA SWMM) Version 5.0 Build 5.0.013.

ES.5 ALTERNATIVES EVALUATION

The alternative development phase began with a consideration of all possible solutions to the drainage concerns in the Irondale Gulch Study Area. The objective of this initial investigation is to identify potential alternatives in a broad and complete manner to ensure all feasible solutions were considered.

Eight alternative categories were initially considered for each reach of Irondale Gulch, Tributary A, and Tributary B. The options naturally separated into two main categories: detention alternatives and conveyance alternatives. The following describes each of these options and the assumptions used to screen the initial options.

1. No Detention Improvements – used to evaluate the implications of taking no action in a reach, however, routine maintenance on existing detention elements is still considered as part of costs.
2. Regional Detention – detention facilities that are publicly-owned and maintained are implemented to reduce downstream peak flows.
3. Regional Retention using Natural Depressions – existing natural depressions in the RMA will be utilized as publicly owned and maintained as regional retention facilities.
4. Natural Depression Retention with Supplementary Detention – existing natural depressions in the RMA will be utilized as publicly owned and maintained as regional retention facilities and supplemented with additional detention facilities.
5. No Conveyance Improvements – used to evaluate the implications of taking no action in a reach, however, routine maintenance on existing conveyance elements is still considered as part of costs.
6. Engineered Channel – an engineered, grass-lined, trapezoidal channel will be constructed to convey the 100-year peak flows to contain flood flows and minimize the flooding and ponding.
7. Underground Conduits – examines transporting the 100-year event flood conveyance through enclosed pipes and associated inlets instead of open channels to transport the 100-year storm event.
8. Engineered Channel/Underground Conduits Combined - allows for a mixture of both options to convey the 100-year event within one reach.

Once the options were screened to determine the "best" alternatives for further investigation, the development of the alternative plans was divided into two main categories: Detention Alternatives and Conveyance Alternatives. The Detention Alternatives encompass the "Regional Detention" and "Regional Retention" options from the initial screening. Conveyance Alternatives investigate directing runoff safely through the watershed and towards the outfall in engineered channels, in underground conduits, or in a combination of the two. Note that Reach One, where the outfall to the SPR is being designed, required an additional Conveyance Alternative analysis to investigate the different alignments to the river.

The two categories were necessary because the design of each affects different variables. Detention improvements affect the peak flow and roadway crossing structure size. Similarly, conveyance improvements affect the alignment and costs, but do not affect the condition of the detention ponds or the associated roadway crossing structures. By separating the two, it is possible to combine the most effective alternatives from each category and thus achieve the most favorable improvement plan. **It was decided that the Detention Alternatives Recommended Plan would be defined first, and that these peak flows from the detention alternatives would be used to evaluate and design the Conveyance Alternatives.** This allows for the conveyance improvements to be designed for peak flows produced from the detention alternative that is most likely to be implemented.

The Alternatives Evaluation naturally fell into three geographic groups: the RMA (east of SH 2, Reaches 3 and 4), the area from SH 2 to I-76 (Reach 2), and the area from I-76 to the SPR (Reach 1). The RMA is undeveloped, therefore, only detention alternatives were evaluated for this area. Conveyance improvements are not necessary in the RMA. The area from SH 2 to I-76 is developed, has issues with flooding, and has no defined flowpath. Therefore, because both types of infrastructure could be accommodated, it was evaluated for both Conveyance Alternatives and Detention Alternatives. The area from I-76 to the SPR is developed, has issues with flooding, has no defined flowpath, and has no defined outfall to the SPR. Detention could not be accommodated in this area, thus only conveyance alternatives were evaluated. Outfall Alignment Options were evaluated for this area as well. The area upstream of Reach 4 on the mainstem does not require any improvements, therefore per discussions with the Urban Drainage and Flood Control District it was not included in the alternatives evaluation.

Alternative plans for each of the reaches were developed for the best alternatives as determined by the Initial Alternatives Screening Matrix and the Outfall Options Screening Matrix. These plans identified the probable costs for construction, maintenance, land value, and contingencies costs associated with construction.

ES.6 RECOMMENDED PLAN

The Irondale Gulch Watershed is still primarily undeveloped in the upper reaches of the study area. This area is generally stable and does not have erosion issues. Because it is undeveloped, flooding is not a hazard. The lower reaches of the Irondale Gulch Watershed are developed and are presently experiencing local flooding issues due to lack of detention, lack of channelization, and the absence of a defined outfall. Therefore, many of the Outfall Systems Plan's recommendations address preventative measures to mitigate future flooding resulting from development. Future development in this watershed will increase the overall imperviousness, therefore flooding hazards are expected to worsen if there is no intervention. The development will not only increase the peak flows, but will also increase the total runoff volume. In the past, this increase in peak flows and volume has shown to cause the majority of damage from frequent storm events. By installing drainage infrastructure including channels, storm sewers, and detention facilities,

runoff is detained and contained so that the waterways are less likely to cause flooding, erode, yield water quality issues, or cause maintenance problems.

The Recommended Plan takes a conservative, preventative approach to management of the Study Area. In general, the recommendations target reducing peak flow of runoff with detention and retention as well as minimizing flooding hazards and sheet flow issues with conveyance infrastructure. Preserving existing channels, utilizing existing topography, and being sensitive to the natural landscape were considered when developing the plan. Exceptions are made in locations where existing conveyance is not well-defined, has an insufficient capacity, or is non-existent. It is important to note, for reduction of peaks flows on Irondale Gulch's construction of the Railroad Detention in Reach 4 should be a priority due to the lost volume in the Upper Derby Detention Pond.

The recommended Detention Alternatives vary per reach. They address improvements along Irondale Gulch and Tributaries A and B to reduce peak flows as much as possible upstream of SH 2, and also to detain runoff generated from the developed area of the watershed within Commerce City (see Table 7.1-1 for peak flow comparisons). The existing topography was utilized where possible, and both construction costs and environmental disturbance were minimized. The recommended Detention Alternatives are outlined in Table ES.6-1.

Table ES.6-1 Recommended Plan Detention Cost Estimate
(information as developed in the Alternatives Evaluation Phase)

Recommended Plan		Estimate of Probable Cost (50 Year Life Cycle)				
		Construction	Maintenance	Land Value	Contingencies	Total
IG Reach 1						
	No Action	-	-	-	-	-
IG Reach 2						
	Alternative 2 - Detention	$4,126,540	$4,950,000	$13,068,000	$5,536,597	$27,681,137
IG Reach 3						
	No Action	-	-	-	-	-
IG Reach 4						
	Alternative 2 - Detention	$12,771,303	$6,435,000	$0	$7,024,217	$26,230,520
Tributary A						
	Alternative 4 - Natural Retention & Detention	$1,544,400	$2,775,000	$0	$849,420	$5,168,820
Tributary B						
	Alternative 3 - Natural Retention	$2,200	$1,800,000	$0	$1,210	$1,803,410
TOTALS						
Detention Alternative Totals		$18,442,243	$14,160,000	$13,068,000	$13,410,234	$59,080,477

All of the recommended conveyance improvements are designed for the 100-year storm event and are designed to minimize sheet flow and flooding as well as to create an outfall to the South Platte River (SPR). The recommended conveyance improvements vary by reach and are outlined in Table ES.6-2.

Table ES.6-2 Recommended Plan Conveyance Cost Estimate
(information as developed in the Alternatives Evaluation Phase)

Recommended Plan		Estimate of Probable Cost (50 Year Life Cycle Cost)				
		Construction	Maintenance	Land Value	Contingencies	Total
IG Reach 1						
	Alternative 7 - Underground Conduits	$4,948,725	$714,900	$0	$2,721,799	$8,385,423
IG Reach 2						
	Alternative 8 - Channels & Conduits	$3,813,814	$144,798	$0	$2,097,598	$6,056,211
IG Reach 3						
	Alternative 6 - Engineered Channel	$352,739	$1,302,266	$0	$194,006	$1,849,011
IG Reach 4						
	No Improvements	-	-	-	-	-
Tributary A						
	No Improvements	-	-	-	-	-
Tributary B						
	No Improvements	-	-	-	-	-
TOTALS						
Conveyance Totals		$9,115,278	$2,161,964	$0	$5,013,403	$16,290,645

ES.7 SELECTED PLAN AND CONCEPTUAL DESIGN

The Conceptual Design generally follows the indications of the Selected Plan, however during the development of the design a few additional modifications were made.

- Although the Recommended/Selected Plan listed Alignment E for Reach 1, it was decided that due to a conflict with the slurry wall along the North Dahlia Pit, that Alignment C along 88th Avenue should be used instead. Because the outfall is one of the lowest priority recommendations and will not be constructed in the near future, the other Alignment options (A-E) listed in Appendix D may want to be considered depending on what has changed between the time of this study and construction.
- The routing was updated from the Baseline Hydrology within Reach 2 to more accurately reflect the drainage patterns to the proposed detention basins. The locations, dimensions, and flow characteristics of the detention basins were updated during the conceptual design process and do not match the Alternatives phase characteristics. Detention Basin 8957 was added to Reach 2. A figure has been included within this section showing the updated routing.
- All of the improvements have been modeled with the Selected Plan CUHP and EPA SWMM model.

The resulting Conceptual Design is a combination of regional detention, regional retention in natural depressions, engineered channels, and underground conduits. Preliminary estimates for capital improvement costs as well as annual operation and maintenance were developed in greater detail than those in the Alternatives Evaluation Phase. See Figure ES-2 for an overview of the Conceptual Design improvements.

The phasing and prioritization of the Conceptual Design improvements is largely dependent on the reducing upstream peak flows as much as possible. The cost of constructing the outfall is expensive and funds will most likely not be available in the immediate future. It is important the detention facilities are constructed with the future outfall in mind to link the systems with minimal additional cost and overlapping. It is recommended that the local jurisdictions give special attention to changes in hydrology as the watershed land uses become more impervious and begin to implement the proposed improvements.

For the purposes of this report, two (2) prioritization categories have been identified. Phase 1 improvements consist of detention and retention to reduce peak flows to minimize flooding. The Phase 1 improvements need to be implemented prior to the Phase 2 improvements which include creating an outfall based on detained future peak flows. The Phase 1 improvements are more reasonable to be installed based on projected available future funds and will provide the largest improvement with regard to flooding and safety of the public within the study area.

Phase 1 Improvements

Upstream detention and maintaining natural depression retention (within Reach 4, Tributary A and Tributary B) would have the biggest impact in reducing flooding within the Irondale Gulch Watershed. Establishing the seven (7) retention basins and constructing Railroad Detention (Detention Basin 209) and Detention Basin 8911 would dramatically reduce peak flows at the BNSF/SH 2 area and lower the chance of overtopping into the developed areas of Commerce City. This area would also be the most economically feasible and create the least amount of disturbance since it is completely within the RMA. Land does not have to be acquired and there would be no disturbance to the public when implementing these additions.

Establishing the six (6) proposed detention basins within Reach 2 as retention basins would also help minimize the existing peak flows within Commerce City. As the watershed continues to develop the conveyance channels should be added to convey flows to the detention basins. When the 60-inch RCP within 88th Avenue and the 10'x3' CBC outfall to the SPR are installed the retention basins could then be converted to detention basins with full spectrum detention.

Phase 2 Improvements

Due to the high cost and funds that are not anticipated to be available in the near futures, establishing the trunk line within 88th Avenue and the outfall to the SPR will be difficult. The Reach 1 outfall to the SPR should be constructed first in Phase 2 improvement sequence, followed by the 60-inch RCP within 88th Avenue.

A comparison of the Conceptual Design peak flows to the Baseline Hydrology and Recommended Plan are shown below in Table ES.7-1.

Table ES.7-1 Conceptual Design Peak Flow Comparison Table

Location	Node	100-Yr Peak Flow (cfs)		
		Baseline Hydrology	Recommended Plan	Conceptual Design
Outfall to South Platte River	9642	***2694***	***152***	***141***
88th Avenue at UPRR	9532	***2023***	***144***	***115***
88th Avenue East of Rosemary St.	9501	***1347***	***123***	***101***
Upstream of State Highway 2	9111	***834***	***115***	***91***
Tributary A	9110	45	562	561
Tributary A Downstream Node	8911_out	-	24	4
Tributary B	9130	46	112	112
Tributary B Downstream Node	9913_out	-	0	0
Upstream of Railroad Detention	junct_259	***713***	***723***	***723***
Downstream of Railroad Detention	junct_260	***713***	***110***	***88***

*Flows in **Bold** used the adjusted rainfall*

Table ES.7-2 lists the approximate costs of implementing the Conceptual Design by reach and Table ES.7-3 totals the approximate costs by jurisdiction. The cost estimate was developed using the UDFCD Cost Estimator for Master Planning Version 1.1. The cost estimate is further refined from the costs developed during Alternatives Evaluation Phase, however it is still preliminary in nature. Conceptual Design Maps and Conceptual Design Profiles illustrate the proposed improvements and are located in Appendix F and G, respectively. For detailed cost estimates, see the respective reach discussion in Section 8.3.

Table ES.7-2 Conceptual Design Improvement Cost Estimate Summary by Reach

REACH	CAPITAL	EASEMENT /ROW	ENGINEERING	LEGAL/ ADMINISTRATIVE	CONTRACT ADMIN/CM	CONTINGENCY	REACH COST
1	$5,880,827	$0	$882,124	$294,041	$588,083	$1,470,207	$9,115,282
2	$11,093,608	$11,761,200	$1,664,041	$554,680	$1,109,361	$5,713,702	$31,896,592
3	$398,939	$0	$59,841	$19,947	$39,894	$99,735	$618,355
4	$2,405,811	$0	$360,872	$120,291	$240,581	$601,453	$3,729,008
Trib A	$830,393	$0	$124,559	$41,520	$83,039	$207,598	$1,287,109
Trib B	$38,991	$0	$5,849	$1,950	$3,899	$9,748	$60,436
Total	**$20,648,569**	**$11,761,200**	**$3,097,285**	**$1,032,428**	**$2,064,857**	**$8,102,442**	**$46,706,782**

Table ES.7-3 Conceptual Design Improvement Cost Estimate Summary by Jurisdiction

JURISDICTION	CAPITAL	EASEMENT/ ROW	ENGINEERING	LEGAL/ ADMINISTRATIVE	CONTRACT ADMIN/CM	CONTINGENCY	TOTAL
Unincorporated Adams County	$8,986,080	$4,029,300	$1,347,912	$449,304	$898,608	$3,253,845	$18,965,049
Commerce City	$9,551,168	$7,731,900	$1,432,675	$477,558	$955,117	$4,320,767	$24,469,186
City of Thornton	$2,111,321	$0	$316,698	$105,566	$211,132	$527,830	$3,272,547
Totals	**$20,648,569**	**$11,761,200**	**$3,097,285**	**$1,032,428**	**$2,064,857**	**$8,102,442**	**$46,706,782**

Table ES.7-4 Conceptual Design Maintenance Cost Estimate Summary by Jurisdiction and Reach

REACH	UNINCORPORATED ADAMS COUNTY	COMMERCE CITY	CITY OF THORNTON
1	$5,859	$4,941	$4,887
2	$49,122	$111,475	-
3	$20,471	-	-
4	$151,800	-	-
Trib A	$123,708	-	-
Trib B	$33,825	-	-
Total	**$384,785**	**$116,416**	**$4,887**

Approximate Site Location

NOTE: REACH 2 EXTENDS FROM I-76 TO STATE HIGHWAY 2 AND INCLUDES AREA FROM 80TH TO 88TH AVENUE.

CITY OF THORNTON

I-76 ROADWAY CROSSING
3-48" RCP (JACKED)

STATE HIGHWAY 2/BNSF ROADWAY CROSSING
60" RCP (JACKED)

REACH 1

REACH 2

88TH AVENUE

1-10'x3' CBC

30" RCP

60" RCP

24" RCP

36" RCP

30" RCP

30" RCP

D-1 D-2 D-3 D-4 D-5 D-6 D-7 D-8

R-1 R-2 R-3 R-4 R-5 R-6 R-7

REACH 3

REACH 4

80TH AVENUE

72ND AVENUE

56TH AVENUE

GRASS LINED TRAPEZOIDAL CHANNEL
WIDTH = 30 FT
DEPTH = 3 FT

TRIBUTARY A

TRIBUTARY B

SOUTH PLATTE RIVER

I-76

BRIGHTON ROAD

VASQUEZ BOULEVARD

UNION PACIFIC RAILROAD

BNSF/STATE HIGHWAY 2

QUEBEC PARKWAY

COMMERCE CITY

UNINCORPORATED ADAMS COUNTY

CITY AND COUNTY OF DENVER

1500 0 750 1500 3000

SCALE: 1" = 3000'

LEGEND

- JURISDICTIONAL BOUNDARIES
- WATERSHED BOUNDARY
- FLOW PATH
- REACH LIMIT
- DETENTION/RETENTION BASIN
- TRAPEZOIDAL CHANNEL
- UNDERGROUND CONDUIT

NATURAL DEPRESSION RETENTION BASIN INFORMATION TABLE

ID	NAME	VOL (AC-FT)	$Q_{100\ IN}$ (CFS)	$Q_{100\ OUT}$ (CFS)
R-1	9912	2.9	28.4	0.0
R-2	9913	10.7	111.9	0.0
R-3	9916	12.8	561.0	547.6
R-4	9917	3.9	47.4	0.0
R-5	9918	10.1	121.8	0.0
R-6	9921	14.1	376.1	235.7
R-7	9922	4.2	47.8	0.0

DETENTION BASIN INFORMATION TABLE

ID	NAME	VOL (AC-FT)	$Q_{100\ IN}$ (CFS)	$Q_{100\ OUT}$ (CFS)
D-1	209	646.3	723.5	89.0
D-2	8911	48.8	561.2	4.3
D-3	8950	11.4	291.7	6.6
D-4	8951	27.5	560.0	8.3
D-5	8953	18.9	406.5	20.7
D-6	8955	19.7	417.0	8.5
D-7	8957	14.5	269.8	8.8
D-8	8961	42.2	696.4	22.7

NAME: Z:\UDFCD PLANNING\Irondale Gulch\CAD_Irondale Gulch\dwg\Fig ES-2 - Conceptual Design Plan.DWG
PLOT DATE: Sep 07, 2011 3:19pm

TOPOGRAPHIC METHOD: LIDAR
TOPOGRAPHIC MAPPING BY:
TOPOGRAPHIC MAPPING QA/QC BY:
CONTOUR INTERVAL: 2 FOOT
DATE FLOWN: 2008

MOSER & associates ENGINEERING
720 S. COLORADO BLVD.
SUITE 410 S
DENVER, CO 80246
PHONE: 303-757-3655
FAX: 303-300-1635

DESIGNED AGC DATE 10/10/10
DRAWN RWM DATE 11/15/10
CHECKED RCO DATE 1/20/11
REVISED DATE

COMMERCE CITY URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

IRONDALE GULCH OUTFALL SYSTEMS PLAN

CONCEPTUAL DESIGN PLAN

FIGURE ES-2

Approximate Site Location

88TH AVENUE

80TH AVENUE

72ND AVENUE

56TH AVENUE

CITY OF THORNTON

COMMERCE CITY

CITY AND COUNTY OF DENVER

UNINCORPORATED ADAMS COUNTY

HAVANA/ LADORA CONNECTION

HAVANA POND

PARKFIELD II

SOUTH PLATTE RIVER

I-76

I-70

BRIGHTON BOULEVARD

VASQUEZ BOULEVARD

UNION PACIFIC RAILROAD

BNSF/ STATE HIGHWAY

QUEBEC PARKWAY

MATCHLINE SHEET 2 OF 2

1500 0 750 1500 3000

SCALE: 1" = 3000'

LEGEND

- XXXX — DETENTION ELEMENT
- XXXX — CONVEYENCE ELEMENT
- XXXX — DESIGN POINT –AREA ADJUSTED RAINFALL BASIN
- XXXX — DESIGN POINT
- XXX — SUB–WATERSHED ID
- WATERSHED BOUNDARY
- SUB–WATERSHED BOUNDARY
- FLOW PATH

NAME: Z:\UDFCD PLANNING\Irondale Gulch\CAD_Irondale Gulch\dwg\Fig 3-2 – 3-3 EPA SWMM Routing Map_Existing.DWG
PLOT DATE: Aug 26, 2011 9:42am

TOPOGRAPHIC METHOD:	
TOPOGRAPHIC MAPPING BY:	USGS
TOPOGRAPHIC MAPPING QA/QC BY:	
CONTOUR INTERVAL:	
DATE FLOWN:	

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DESIGNED	AGC	DATE	10/10/10
DRAWN	RWM	DATE	11/15/10
CHECKED	RCO	DATE	1/20/11
REVISED		DATE	

COMMERCE CITY URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

IRONDALE GULCH OUTFALL SYSTEMS PLAN

BASELINE HYDROLOGY EPA SWMM ROUTING MAP

FIGURE 3-2

CITY AND COUNTY OF DENVER

UNINCORPORATED ADAMS COUNTY

CITY OF AURORA

56TH AVENUE

PENA BOULEVARD

MATCHLINE SHEET 1 OF 2

56TH AVENUE

I-70

HAVANA STREET

PEORIA STREET

SMITH ROAD

CHAMBERS ROAD

TOWER ROAD

1500 0 750 1500 3000

SCALE: 1" = 3000'

SEE CITY OF AURORA MASTER DRAINAGE REPORTS FOR GATEWAY PARK AND MAJESTIC COMMERCENTER CHARACTERISTICS

LEGEND

- DETENTION ELEMENT
- CONVEYENCE ELEMENT
- DESIGN POINT –AREA ADJUSTED RAINFALL BASIN
- DESIGN POINT
- SUB–WATERSHED ID
- WATERSHED BOUNDARY
- SUB–WATERSHED BOUNDARY
- FLOW PATH

NAME: Z:\UDFCD PLANNING\Irondale Gulch\CAD_Irondale Gulch\dwg\Fig 3-2 – 3-3 EPA SWMM Routing Map_Existing.DWG
PLOT DATE: Aug 26, 2011 9:41am

TOPOGRAPHIC METHOD:	
TOPOGRAPHIC MAPPING BY:	USGS
TOPOGRAPHIC MAPPING QA/QC BY:	
CONTOUR INTERVAL:	
DATE FLOWN:	

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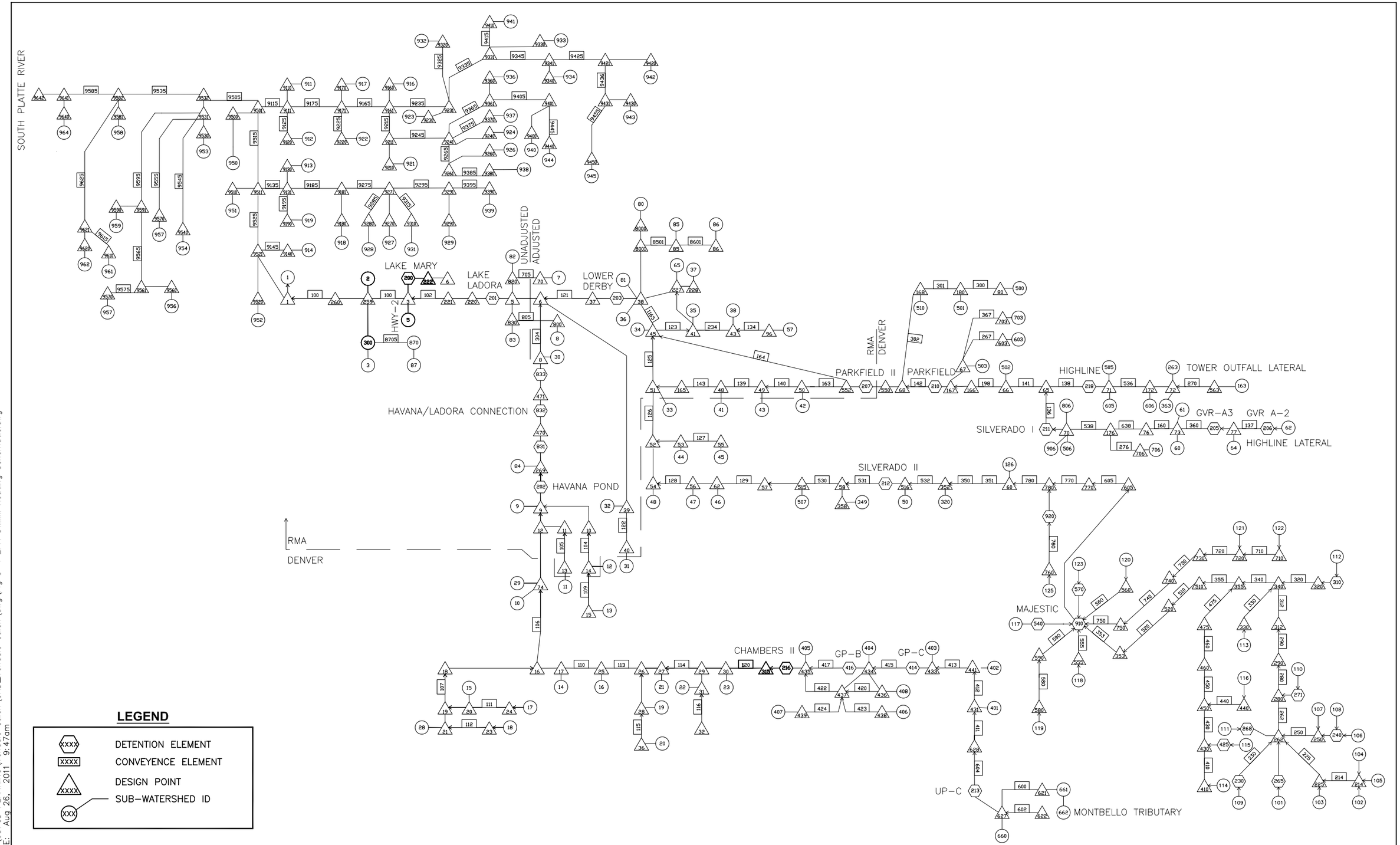
DESIGNED	AGC	DATE	10/10/10
DRAWN	RWM	DATE	11/15/10
CHECKED	RCO	DATE	1/20/11
REVISED		DATE	

COMMERCE CITY URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

IRONDALE GULCH OUTFALL SYSTEMS PLAN

BASELINE HYDROLOGY EPA SWMM ROUTING MAP

FIGURE 3-3



NAME: Z:\UDFCD PLANNING\Irondale Gulch\CAD_Irondale Gulch\dwg\Fig 3-4 EPA SWMM Routing Schematic.dwg
PLOT DATE: Aug 26, 2011 9:47am

TOPOGRAPHIC METHOD:	LIDAR
TOPOGRAPHIC MAPPING BY:	
TOPOGRAPHIC MAPPING QA/QC BY:	
CONTOUR INTERVAL:	2 FOOT
DATE FLOWN:	2008

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FAX: 303-300-1635

DESIGNED	AGC	DATE 10/10/10
DRAWN	RWM	DATE 11/15/10
CHECKED	RCO	DATE 1/20/11
REVISED		DATE

Commerce CITY

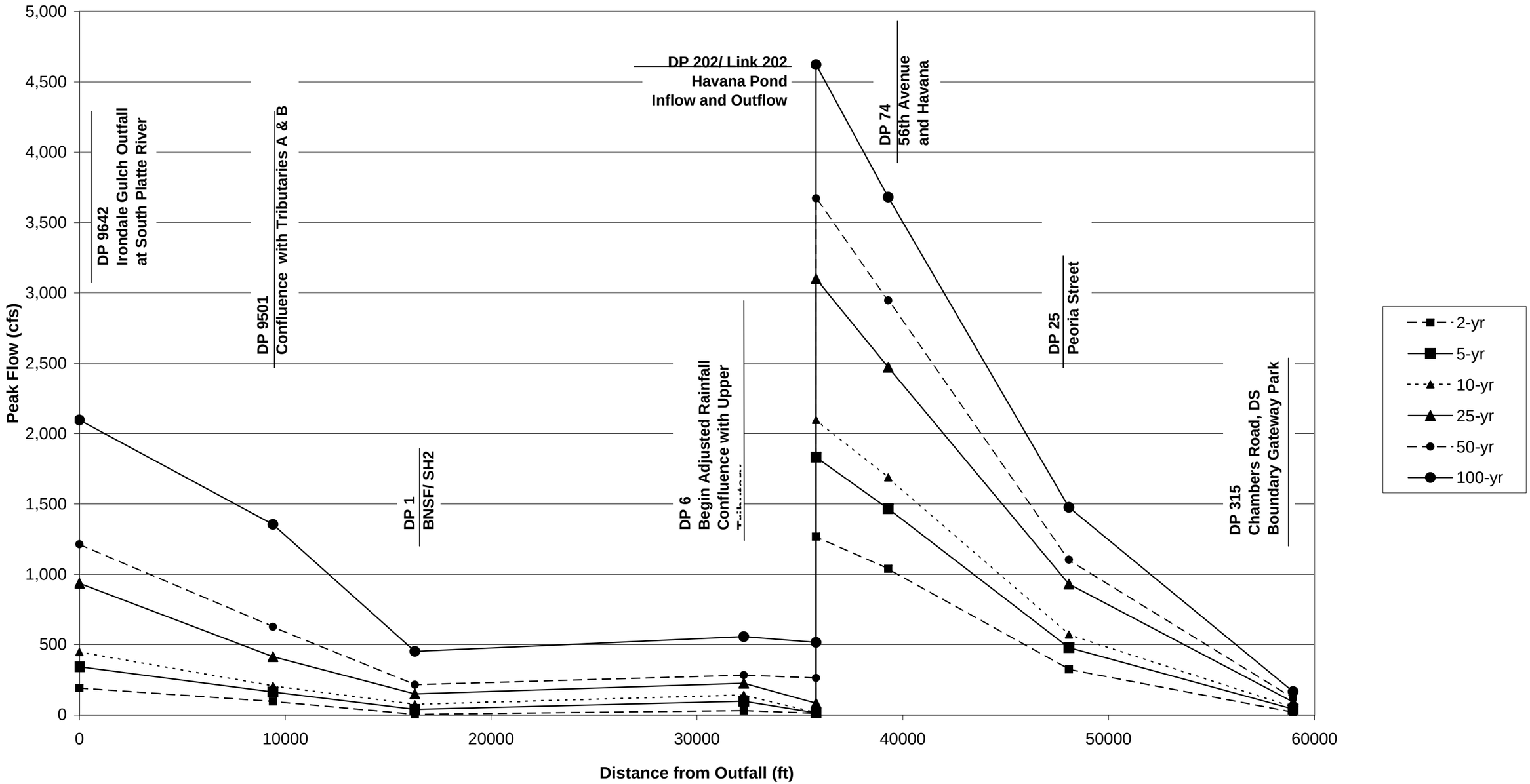
COMMERCE CITY
URBAN DRAINAGE AND
FLOOD CONTROL DISTRICT

IRONDALE GULCH
OUTFALL SYSTEMS
PLAN

BASELINE HYDROLOGY
EPA SWMM DIAGRAM

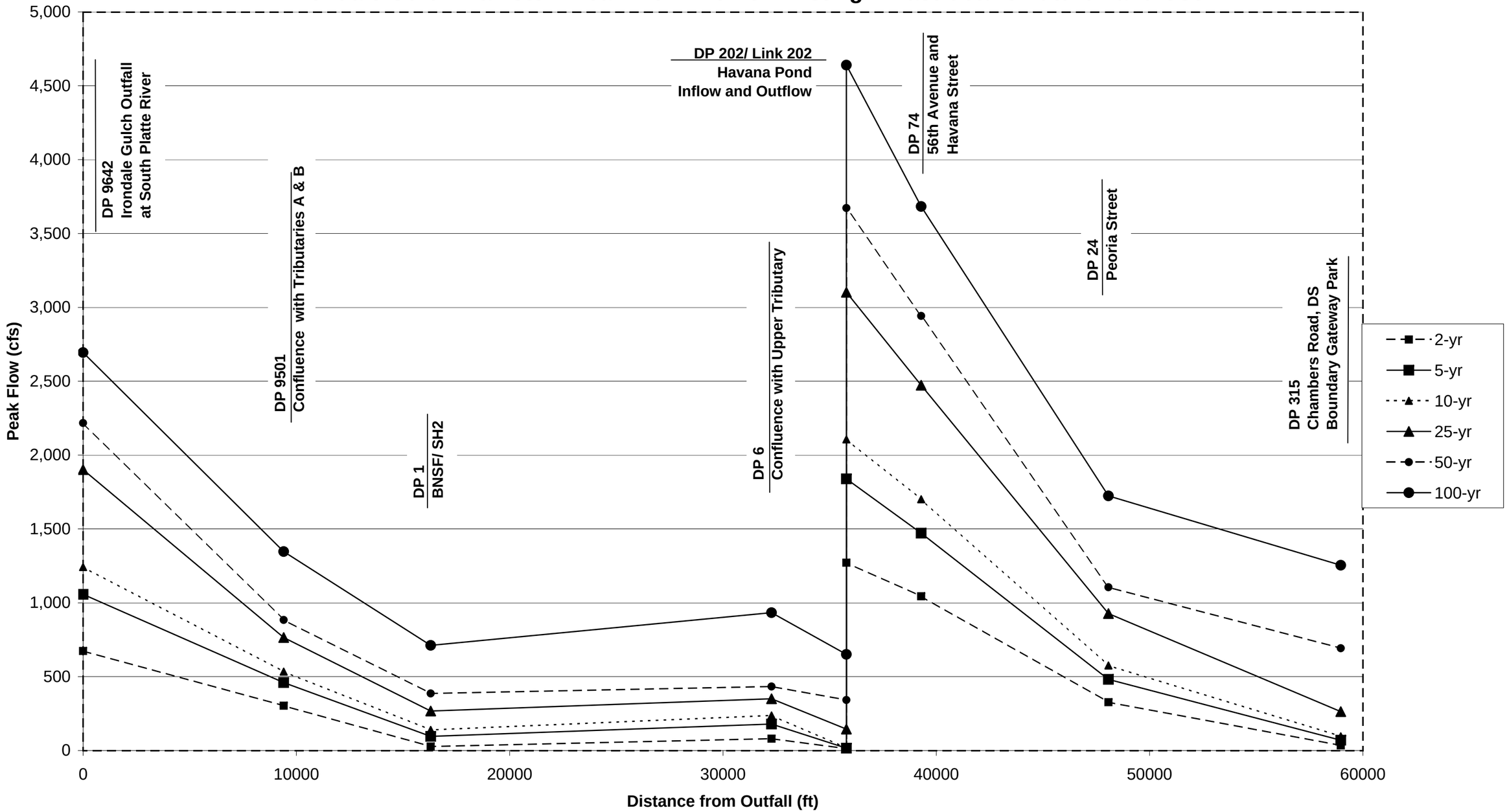
FIGURE 3-4

Figure 3-5
Irondale Gulch Mainstem Peak Flow Profile: Existing Infrastructure Existing Land Use



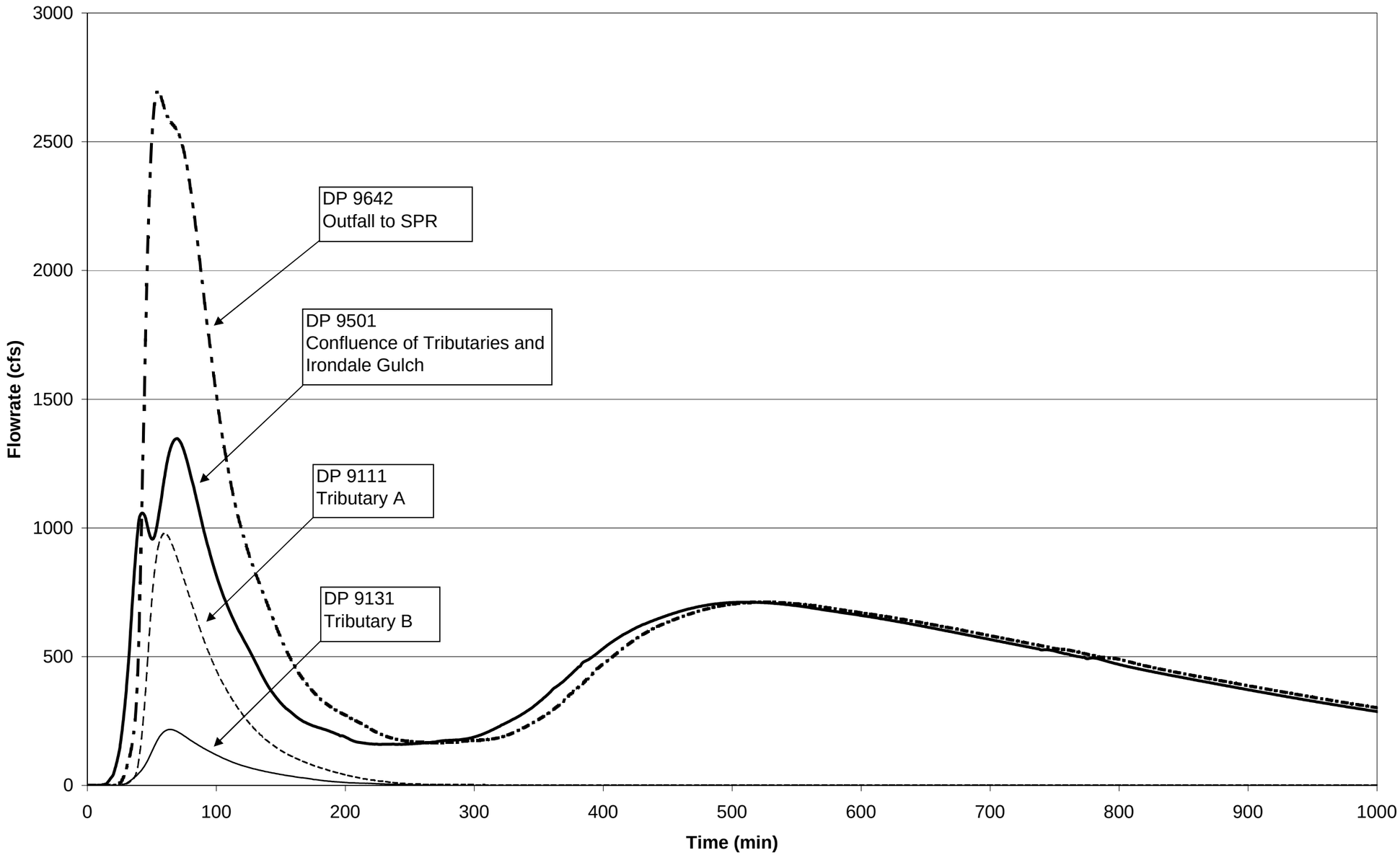
Z:\UDFCD PLANNING\Irondale Gulch\Excel\Baseline Hydrology Report\Table 3-6 Peak Flow SummaryEx Pk Fl Prof LFC

Figure 3-7
Irondale Gulch Mainstem Peak Flow Profile: Existing Infrastructure Future Land Use



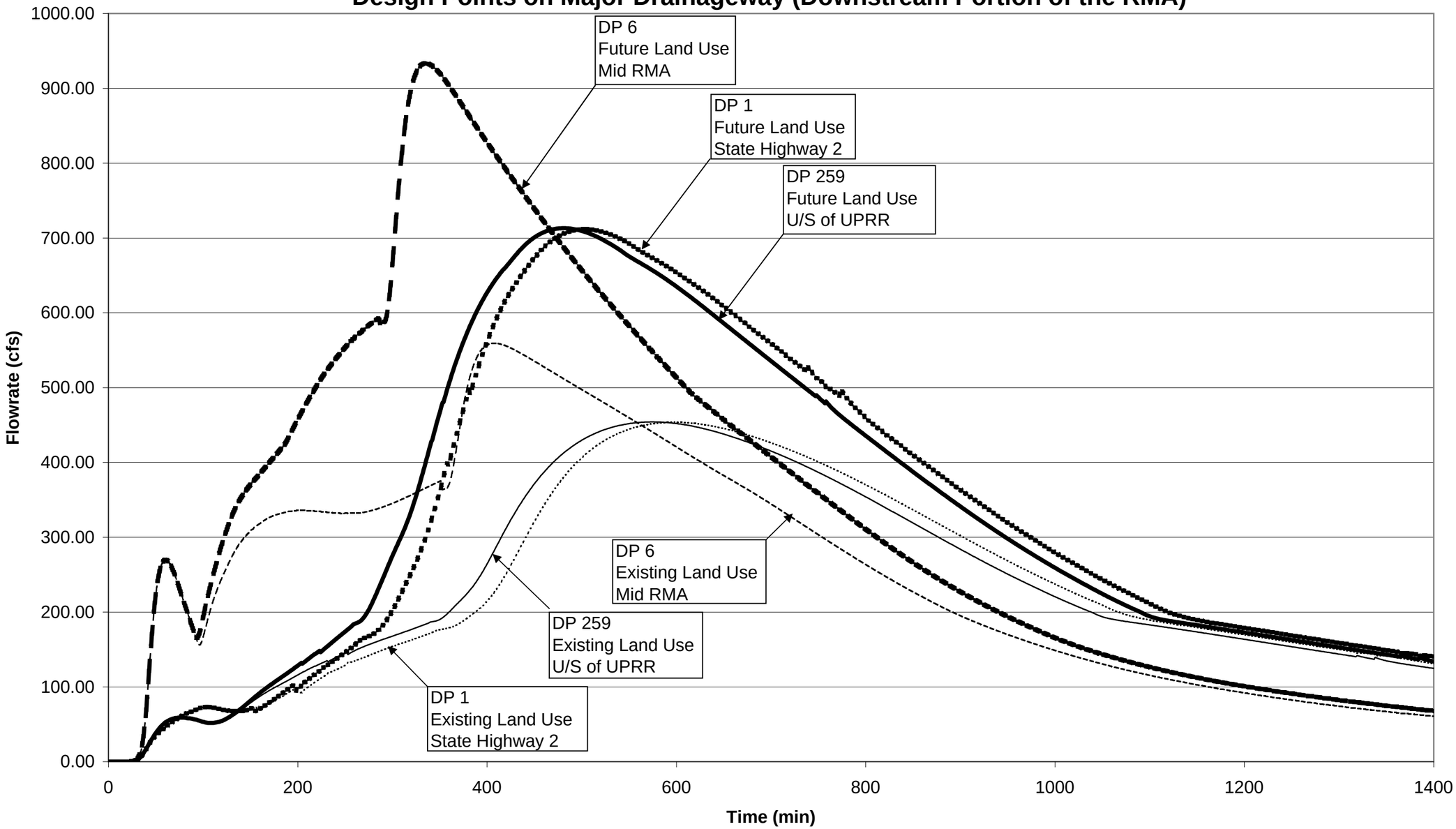
Z:\UDFCD PLANNING\Irondale Gulch\Excel\Baseline Hydrology Report\Table 3-6 Peak Flow SummaryEx Pk Fl Prof UFC

FIGURE 3-9
Baseline Hydrology 100-Year Peak Flow Hydrograph
Direct Flow/ Commerce City Area



Z:\UDFCD PLANNING\Irondale Gulch\Excel\Baseline Hydrology Report\Figs 3-9 to 3-12 HydrographsFIGURE 3-9

FIGURE 3-10
100-Year Peak Flow Hydrographs: Existing Land Use vs. Future Land Use
Design Points on Major Drainageway (Downstream Portion of the RMA)



5.1 ALTERNATIVE DEVELOPMENT PROCESS

The alternative development phase began with a consideration of all possible solutions to the drainage concerns in the Irondale Gulch Study Area. The objective of this initial investigation is to identify potential alternatives in a broad and complete manner to ensure all feasible solutions were considered.

As part of the initial screening, a rating criteria was developed to evaluate the alternatives for Irondale Gulch, Tributary A, and Tributary B. An Alternatives Screening Matrix was developed for each. Note that as part of the initial screening, professional engineering judgment as well as discussions with the project sponsors and participants were used to assign the rating for each of the categories. Neither cost estimates nor detailed evaluation of the impacts were prepared. See Section 5.3 for further discussion about the Initial Alternatives Screening Matrix.

The most feasible alternatives as determined by the Alternatives Screening Matrix were further developed in great detail. This examination included quantifying and estimating the cost for construction items, recurring maintenance, and the right-of-way/easement requirements for each alternative. The evaluation process naturally unfolded into two parts: detention and retention options and conveyance options. The alternatives development process is further discussed in Section 5.4.

5.2 ALTERNATIVE DEVELOPMENT CONSIDERATIONS

5.2.1 Criteria and Constraints

The alternatives were developed to address flooding issues, absence of conveyance within Commerce City, 100-year peak flows that are higher than desired, and the lack of an outfall to the South Platte River (SPR). Conveyance alternatives are examined from State Highway 2 (SH 2) and downstream since the existing conveyance within the Rocky Mountain Arsenal (RMA) is sufficient. Only the future land use condition was examined to account for the effects of development: there are numerous development plans already in place within the study area and the RMA will remain undeveloped into perpetuity. The alternatives aim to be sensitive to the need to maintain existing habitat by minimizing construction within the floodplain as well as minimizing disturbance in undeveloped areas. The criteria for the channel options and the detention alternatives are discussed in Section 5.3 in greater detail.

5.2.2 Problems Identified

The upper reaches of Irondale Gulch watershed consists of undeveloped land (the RMA area), however the lower reaches are moderately developed (Commerce City). Within this study there are several issues that have been identified and addressed through the alternatives evaluation.

- There is no outfall to the SPR.
- There are no defined flow paths west of SH 2. This area is largely developed, yet experiences issues with flooding and ponding.
- There is no detention along Tributaries A and B which results in potentially high 100-year peak flows entering the Irondale Gulch mainstem.
- There is no detention in Commerce City, further contributing to high peak flows at the outfall.
- There are no existing culverts under SH 2 and the BNSF to convey runoff, thus potentially causing overtopping of the road and railroad as well as sheet flow through developed areas downstream.
- Conveyance of runoff under the UPRR and I-76 needs to be investigated and designed.
- Some detention basins, both existing and proposed, are overtopping.

Please see Figure C-1 in Appendix C for an illustration of the problem areas.

5.2.3 Estimates of Probable Costs

Cost estimates for the best alternatives are calculated to quantify the costs associated with implementing each of the alternatives. Quantities are estimated by approximating the average quantity for each item and applying to the length or volume of improvement. The cost estimates are broken down into total capital costs and annual operation and maintenance costs. The capital costs are tabulated by construction costs (e.g. earthwork, grade control structures, revegetation, etc.), land value [in the form of acquiring right of way (ROW) and easements], and contingencies (contingencies, engineering, and administration costs).

The unit prices used in the cost estimates were developed from several sources including:

- The UDFCD Cost Estimator for Master Planning.
- Construction bid results from UDFCD and other Denver Metropolitan area construction projects.
- Collecting material prices from local pipe manufacturers and applying a multiplier to account for the total project prices.
- Operation and maintenance costs were acquired through conversations with UDFCD maintenance personnel to estimate budgetary numbers for maintenance.
- Previous planning studies.

Table C-3 in Appendix C lists the unit prices used to estimate costs for the best alternatives discussed in detail in Section 5.5. Cost Estimates per reach for each alternative evaluated are also included in Section 5.5.

5.2.4 Hydraulic Calculations

Trapezoidal channels and culverts were evaluated with Flowmaster to approximate channel geometries and pipe sizes necessary to convey runoff to the SPR. Channels were designed with a maximum 100-year velocity of 5 feet per second (ft/s), maximum side slopes of 3:1 (though 4:1 side slopes are specified where possible), and a maximum depth of 5 feet. Stage discharge rating curves for outlet structures of new detention basins were designed using inlet control nomagraphs.

5.3 INITIAL SCREENING OF ALTERNATIVE PLANS

To determine the "best" alternatives for conducting a detailed analysis, a broad range of alternatives were initially screened for feasibility. A rating criteria was developed to rank the alternatives for each of the reaches of Irondale Gulch, Tributary A, and Tributary B. Numeric values were determined for the following criteria:

- Construction and right-of-way costs
- Maintenance costs
- Environmental and aesthetic impacts
- Implementation feasibility

An Alternatives Screening Matrix was developed for Reaches 1 through 4 of the mainstem, Tributary A, and Tributary B. Although there are two potential reaches with significant flow paths upstream of Reach 4, it was determined that no action is required in these areas and therefore they were not evaluated. Note that as part of the initial screening, professional engineering judgment was used to assign the rating for each of the above categories. Neither cost estimates nor detailed evaluation of the impacts were prepared for the evaluation.

Eight alternative categories were initially considered for each reach of Irondale Gulch, Tributary A, and Tributary B. The options naturally separated into two main categories: detention alternatives and conveyance alternatives. The following describes each of these options and the assumptions used to screen the initial options.

Alternative 1 – No Detention Improvements

The No Detention Improvements alternative is used to evaluate the implications of taking no action in a reach. While weighing this option, implications on downstream reaches of taking no action were considered in the rating. The No Detention Improvements alternative assumes that:

- The flow channel is preserved in its current location.
- Peak flows remain the same as in the Future Infrastructure Model.

Alternative 2 – Regional Detention

In the Regional Detention option, detention facilities that are publicly-owned and maintained are implemented to reduce downstream peak flows. This is done to minimize threats of flooding downstream, to minimize the downstream drainage infrastructure costs, and/or to protect existing downstream drainage infrastructure. This alternative assumes that:

- The regional detention facility will be owned or maintained by local government in order to be recognized jurisdictionally as a flow-reducing detention facility.
- Detention facilities will be subject to routine maintenance. A maintenance trail will be constructed. Debris and sediment removal will take place routinely so that the detention volume remains the same through time.
- Improvements to downstream conveyance facilities and roadway crossings will be downsized and may or may not even be necessary.
- The construction and maintenance costs of downstream conveyance infrastructure will be less.

Alternative 3 – Regional Retention using Natural Depressions

In the Regional Retention using Natural Depressions option, existing natural depressions in the RMA will be utilized as publicly owned and maintained as regional retention facilities. The aim is to take advantage of the existing topography and sandy soils in order to reduce downstream peak flows. Implementing regional retention minimizes threats of flooding downstream, minimizes the downstream drainage infrastructure costs, and/or protects existing downstream drainage infrastructure. This Regional Retention using Natural Depressions alternative also greatly reduces construction costs, outlet costs, and destruction of habitat when compared to the Detention option. This alternative assumes that:

- The regional retention facility will be owned or maintained by local government in order to be recognized jurisdictionally as a flow-reducing detention facility.

- Retention facilities will be maintained similarly to detention basins. A maintenance trail will be constructed. Debris and sediment removal will take place routinely so that the retention volume remains the same through time.
- The construction and maintenance costs of downstream stormwater conveyance infrastructure will be minimized.

Alternative 4 –Natural Depression Retention with Supplementary Detention

In the Natural Depression Retention with Supplementary Detention option, existing natural depressions in the RMA will be utilized as publicly owned and maintained as regional retention facilities. The aim is to make the most of the existing topography and sandy soils in order to reduce downstream peak flows. Implementing regional retention minimizes threats of flooding downstream, minimizes the downstream drainage infrastructure costs, and/or protects existing downstream drainage infrastructure. This Natural Depression Retention with Supplementary Detention alternative also greatly reduces construction costs, outlet costs, and destruction of habitat when compared to the Regional Detention option. Costs may be slightly higher than in Alternative 3 (Retention using Improved Natural Depressions), however this is offset by the benefit of achieving a greater reduction in peak flows. This alternative assumes that:

- The regional retention facility will be owned or maintained by local government in order to be recognized jurisdictionally as a flow-reducing flood control facility.
- Improvements will be made to existing natural depressions when down stream peak flows are higher than desired. In this instance, the existing depression will be excavated in order to increase the volume of the basin.
- Retention facilities will be maintained similarly to detention basins. Thus a maintenance trail will be constructed. Debris and sediment removal is important so that the retention volume remains the same through time.
- The construction and maintenance costs of downstream stormwater conveyance infrastructure will be minimized.

Alternative 5 – No Conveyance Improvements

The No Conveyance Improvements alternative is used to evaluate the implications of taking no action in a reach. Routine maintenance on existing detention facilities is still considered as part of costs. While weighing this option, implications on downstream reaches of taking no action were considered in the rating. The No Conveyance Improvements alternative assumes that:

- The flow channel is preserved in its current location.
- Peak flows remain the same as in the Future Infrastructure Model.

Alternative 6 – Engineered Channel

In the Engineered Channel option, an engineered, grass-lined, trapezoidal channel will be constructed to convey the 100-year peak flows to contain flood flows and minimize the flooding and ponding. This alternative examines grass-lined channel sections. Where needed, channel invert and bank stability measures will be implemented to protect the main channel from excessive vertical degradation and lateral movement. However, because the study area is very flat, this might not be necessary. This alternative assumes that:

- Channel improvements create an engineered trapezoidal channel to convey the 100-year storm event. The existing low flow channel will be preserved where one exists.
- Bank toe protection might be required in selected locations.
- Maintenance access is constructed along the entire length of the channel to allow for routine maintenance operations where sufficient access does not already exist.

Alternative 7 – Underground Conduits

The Underground Conduits alternative examines transporting the 100-year event flood conveyance through enclosed pipes and associated inlets instead of open channels to transport the 100-year storm event. This alternative assumes that:

- All of the 100-year peak flows can be captured and conveyed below ground or in cooperation with available street capacity, where available.
- Maintenance access is constructed to allow for routine maintenance operations where sufficient access does not already exist.

Alternative 8 – Engineered Channel/ Underground Conduits Combined

The Engineered Channel/Underground Conduits Combined alternative allows for a mixture of both options to convey the 100-year event within one reach. This alternative is especially suited to reaches that lend themselves to open channels in some areas and underground conduits in others. This alternative assumes that:

- Channel improvements create an engineered trapezoidal channel to convey the 100-year storm event. The existing low flow channel will be preserved where one exists.
- Bank toe protection might be required in selected locations.
- Where channels are not viable, 100-year peak flows can be captured and conveyed below ground or in cooperation with available street capacity, where available.
- Maintenance access is constructed to allow for routine maintenance operations where sufficient access does not already exist.

Table 5.3 summarizes the results of the Initial Alternatives Screening Matrix. Table C-1, the detailed Initial Alternatives Screening Matrix is included in Appendix C.

Table 5.3: Initial Alternatives Screening Matrix Summary

Irondale Gulch OSP Initial Alternatives Screening Matrix - Summary Table									
		Detention Alternatives				Conveyance Alternatives			
Reach ID	Reach Name	Alternative 1 - No Detention Improvements	Alternative 2 - Regional Detention	Alternative 3 - Retention: Natural Depressions	Alternative 4 - Natural Depressions Retention w/ Supplementary Detention	Alternative 5 - No Conveyance Improvements	Alternative 6 - Engineered Channel	Alternative 7 - Underground Conduits	Alternative 8 - Channels/ Conduits Combined
1	Downstream Limit to I-76 & 88th Ave.	7	6	11	10	10	7	11	10
2	I-76 & 88th Ave. to SH 2 & 88th Ave.	8	12	11	10	10	10	11	11
3	SH 2 & 88th Ave. to SH 2 & 80th Ave.	11	8	13	11	20	10	7	7
4	SH 2 & 80th Ave. to Design Point 6	7	12	13	11	20	5	6	6
Tributary A	Tributary A	9	12	18	16	20	5	6	6
Tributary B	Tributary B	9	12	18	16	20	5	6	6

Note 1: A detailed Initial Screening Matrix is provided in Appendix C Table C-1.
Note 2: Higher numbers indicate options warranting further investigation.

5.4 BEST ALTERNATIVE CATEGORIES

Once the options were screened to determine the "best" alternatives for further investigation, the development of the alternative plans was divided into two main categories: Detention Alternatives and Conveyance Alternatives. The Detention Alternatives encompass the "Regional Detention" and "Regional Retention" options from the initial screening. Conveyance Alternatives investigate directing runoff safely through the watershed and towards the outfall in engineered channels, in underground conduits, or in a combination of the two. Note that Reach One, where the outfall to the SPR is being designed, required an additional Conveyance Alternative analysis to investigate the different alignments to the river.

The two categories were necessary because the design of each affects different variables. Detention improvements affect the peak flow and roadway crossing structure size. Similarly, conveyance improvements affect the alignment and costs, but do not affect the condition of the detention ponds or the associated roadway crossing structures. By separating the two, it is possible to combine the most effective alternatives from each category and thus achieve the most favorable improvement plan. **It was decided that the Detention Alternatives Recommended Plan would be defined first, and that these peak flows from the detention alternatives would be used to evaluate and design the Conveyance Alternatives.** This allows for the conveyance improvements to be designed for peak flows produced from the detention alternative that is most likely to be implemented.

The Detention Options will be discussed first in Section 5.4.1 followed by the Conveyance Alternatives in Section 5.4.2.

5.4.1 Detention and Retention Alternatives

The Detention and Retention Alternatives (Detention Alternatives) explore using regional detention or retention that is publicly-owned and maintained to reduce hazardous downstream peak flows. The Detention Alternatives also aim to add storage within Reach 4 to make up for the storage lost when Upper Derby Pond was breached. These alternatives also reduce the risk of downstream flood hazards and reduce the costs of downstream drainage infrastructure.

Detention and/or retention options were evaluated for all reaches except for Reach One. Reach One was not included because there are numerous lakes along this reach (yielding a high groundwater elevation) as well as very little undeveloped land on which to construct detention or retention. Therefore, detention was utilized upstream to mitigate peak flows to a manageable level. Please see Figures 5.5-2 to 5.5-6 for detention and retention locations. Please note that Alternative 1, the No Detention Improvements Alternative, was not evaluated in depth or further discussed below. It was determined with the Initial Alternatives Screening Matrix that Alternative 1 was not a strong option for any of the reaches within this study. A summary of Alternative 1 can be found in Section 5.3.

5.4.1.1 Detention and Retention Alternative 2: Regional Detention

Detention Alternative 2 aims to implement the regional detention basins within the Boyle 2003 study according to the existing design and storage volumes and to implement additional detention where necessary.

Alternative 2 assumes that:

- All regional detention facilities will be owned or maintained by the appropriate municipality in order to be recognized jurisdictionally as a flow-reducing detention facility.
- Detention basins will incorporate water quality within the developed areas (Commerce City).
- Property acquisition in the form of ROW/easements is required to ensure that the facility remains in perpetuity and to allow maintenance access. However, land acquisition is not necessary in the RMA because this area is already owned by the government.
- Any excavation taking place in the RMA will be followed with reseeding to restore the area to native prairie.
- Outlet structure unit cost includes all infrastructure associated with the outlet structure including pipes, flared end sections, headwalls, and wingwalls.
- Routine maintenance operations include debris and sediment removal as well as mowing.
- Maintenance access is constructed to allow for routine maintenance operations.

5.4.1.2 Detention and Retention Alternative 3: Regional Retention in Natural Depressions

Detention Alternative 3 aims to utilize the natural depressions along Tributaries A and B in the RMA to retain runoff generated in this area and reduce peak flows. Using these natural depressions have many benefits compared to regional detention, and include no construction costs, no outlet structure costs, and fewer disturbances to the natural ecosystem.

Alternative 3 assumes that:

- All regional retention facilities will be owned or maintained by the appropriate municipality in order to be recognized jurisdictionally as a flow-reducing detention facility.
- Property acquisition in the form of ROW/easements is not required and is not necessary because all natural depressions are in the RMA and this area is already owned by the government.
- Any excavation taking place in the RMA will be followed with reseeding to restore the area to native prairie.
- Routine maintenance is necessary for retention basins and operations include debris removal and mowing.
- Maintenance access is constructed to allow for routine maintenance operations.

5.4.1.3 Detention and Retention Alternative 4: Regional Retention in Natural Depressions with Improvements

Detention Alternative 4 aims to utilize the natural depressions along Tributaries A and B in the RMA to retain runoff generated in this area and reduce peak flows. However, this alternative differs from alternative 3 in that if peak flows are not reduced greatly at SH 2, the natural depressions will be excavated to provide additional retention volume and thus further decrease peak flows. This alternative will involve some construction costs. However, the quantity of excavation will be lower than that of the detention basins in Alternative 2 which do not utilize natural depressions. Additionally, there will be no costs for outlet structures in this alternative.

Alternative 4 assumes that:

- All regional retention facilities will be owned or maintained by the appropriate municipality in order to be recognized jurisdictionally as a flow-reducing detention facility.
- Property acquisition in the form of ROW/easements is not required and is not necessary because all natural depressions and the proposed detention facility are located within the RMA and already owned by the government.
- Any excavation taking place in the RMA will be followed with reseeding to restore the area to native prairie.
- Routine maintenance is necessary for retention and detention basins and operations include debris and sediment removal as well as mowing.
- Maintenance access is constructed to allow for routine maintenance operations.

5.4.2 Conveyance Alternatives

The Conveyance Alternatives address approaches to channelization of runoff. There are areas with no natural flow path or insufficient conveyance infrastructure, leading to problems with sheet flow, flooding, and ponding. Conveyance Alternatives aim to reduce flooding hazards, convey runoff to an outfall, and ensure maintenance of proposed infrastructure.

Each reach of Irondale Gulch, Tributary A, and Tributary B was evaluated in the screening matrix for feasibility of four Conveyance Alternatives. This was used so that only viable alternative options for each reach were considered in the detailed analysis. This matrix is further discussed in Section 5.4.2.

5.4.2.1 Alternative 5: No Conveyance Improvements

Alternative 5 addresses reaches that do not need any major conveyance improvements. This applies to the four reaches within the RMA. Because the land within the RMA is undeveloped and will remain so into perpetuity, flooding and lack of channelization are acceptable there. Therefore, within this alternative, the existing flowpaths are preserved.

Alternative 5 assumes that:

- No improvements are necessary.
- The existing flowpath does not encroach on existing or proposed development including adjacent buildings and roadways.

Note that all conveyance alternatives have been evaluated using the peak flows and detention from the Recommended Plan detention alternative. This yields the most accurate cost since future land use peak flows will not reach SH 2.

5.4.2.2 Alternative 6: Engineered Channel

Alternative 6 proposes construction of an engineered grass lined trapezoidal channel to convey the 100-year storm event in an effort to reduce flooding and sheet flow in areas with no defined flow channel (primarily in Commerce City). Because the study has a relatively low slope, channel invert and bank stability measures to protect the proposed channels from degradation and lateral movement are not necessary.

Alternative 6 assumes that:

- Channel improvements create an engineered trapezoidal channel to convey the 100-year event.
- The engineered channel will include a low flow channel which will be constructed to convey the 5-year event.
- Depth of the channel shall not exceed 5 feet.
- Velocity within the channel shall not exceed 5 ft/s.
- Bank toe protection may be required in selected locations.
- Property acquisition in the form of ROW and easements may be required to gain access for construction and maintenance access. Where feasible, channels beside roadways will be built in the existing ROW.
- A maintenance trail will be constructed along the entire length of the engineered channel.
- Routine maintenance and mowing will be completed regularly.

Note that all conveyance alternatives have been evaluated using the peak flows and detention from the Recommended Plan detention alternative. This yields the most accurate cost since developed peak flows will not reach SH 2.

5.4.2.3 Alternative 7 – Underground Conduits

Alternative 7 proposes construction of underground conduits to convey the 100-year storm event flood conveyance through enclosed pipes or culverts and associated inlets instead of open channels to transport the 100-year storm event. This alternative is preferred when conveyance is necessary, however certain constraints (e.g. existing development, lack of grade) can limit the feasibility of an engineered channel.

Alternative 7 assumes that:

- All of the 100-year peak flows can be captured and conveyed below ground or in cooperation with available street capacity, where available.
- Maintenance access is constructed to allow for routine maintenance operations.

5.4.2.4 Alternative 8: Engineered Channels and Underground Conduits Combined

Alternative 8 proposes construction of a combination of engineered, grass lined trapezoidal channels and underground conduits to convey the 100-year storm event. These improvements are proposed in an effort to reduce flooding and sheet flow in areas with no defined flow channel (primarily in Commerce City). Because the study has a relatively low slope, channel invert and bank stability measures to protect the proposed channels from degradation and lateral movement are not necessary. This alternative is preferred when some areas of a reach are suited to engineered channels but others require underground pipes.

Alternative 8 assumes that:

- Channel improvements create an engineered trapezoidal channel where feasible to convey the 100-year event. Otherwise, underground conduits will be installed.
- In the case of underground conduits, 100-year peak flows will be captured and conveyed below ground or in cooperation with available street capacity, where available.

- Maintenance access is constructed to allow for routine maintenance operations.
- The engineered channel will have:
  - A low flow channel which will be constructed to convey the 5-year event.
  - Depth not exceeding 5 feet and velocity that shall not exceed 5 ft/s.
  - Bank toe protection where required.
- Property acquisition in the form of ROW and easements may be required to gain access for construction and maintenance access. Where feasible, channels beside roadways will be built in the existing ROW.
- A maintenance trail will be constructed where necessary and routine maintenance will be completed regularly.

5.4.3 Outfall Options Screening

The Initial Alternatives Screening Matrix revealed that underground conduits are most suitable method for conveying runoff through Reach 1 to the outfall. There is not adequate space to make an engineered channel practical. During the alternatives development process, the Conveyance Alternatives for the outfall within Reach 1 were further screened to examine potential alignments. This allowed selection of the best options for an even more detailed evaluation.

The potential outfall alignments were examined through field visits and by studying aerials, topographic maps, and hydrologic models of the area. Engineers from the City of Thornton and from Commerce City also provided information about the outfall area. The outfall options were assessed using the following criteria.

- Slope from I-76 and 88th Avenue to the potential outfall location on the SPR.
- Available ROW for construction.
- Amount of traffic that would be disrupted during conduit implementation.
- Potential utility relocation.
- Existing culverts or canals that would have to be crossed (i.e. the Bull Seep).

See Table 5.4.3 for a summary of the Outfall Options Screening Matrix. See Figure 2-1 in Section 2 for the Study Area Map that illustrates the limits of each reach, Figure C-2 in Appendix C which illustrates the Outfall Options that were evaluated, and Table C-2 in Appendix C for the complete Outfall Alternatives Screening Matrix.

Table 5.4.3 Outfall Options Screening Matrix Summary

Outfall Alternative (see Figure C-2)	Description	CR	EA	IF	T
A	Down 88th to SPR at 88th	1	7	2	10
B	Down 88th to Dahlia Outfall North of 88th to SPR	2	8	7	17
C	88th then adjacent to Thornton pond to Fish Hatchery Road to SPR below drop structure	4	7	9	20
D	88th through Acquired Land to Fish Hatchery Road to SPR below drop structure	0	7	0	7
E	88th to Fish Hatchery Road to SPR below drop structure	5	7	4	17

Rating Criteria	
CR=Construction and ROW Costs	0=high, 10=low
EA = Environmental & Aesthetic Impacts	0=high, 10=low
IF = Implementation Feasibility/ Overall Benefit	0=low, 10=high
T = Total	Sum of above

These options should be reviewed prior to implementation.

5.5 ALTERNATIVE PLANS

The Alternatives Evaluation naturally fell into three geographic groups: the RMA (east of SH 2, Reaches 3 and 4), the area from SH 2 to I-76 (Reach 2), and the area from I-76 to the SPR (Reach 1). The RMA is undeveloped, therefore, only detention alternatives were evaluated for this area. Conveyance improvements are not necessary since flooding occurs but is not hazardous in the RMA. The area from SH 2 to I-76 is developed, has issues with flooding, and has no defined flowpath. Therefore, because both types of infrastructure could be accommodated, it was evaluated for both Conveyance Alternatives and Detention Alternatives. The area from I-76 to the SPR is developed, has issues with flooding, has no defined flowpath, and has no defined outfall to the SPR. Detention could not be accommodated in this area, thus only conveyance alternatives were evaluated. Outfall Alignment Options were evaluated for this area as well. The area upstream of Reach 4 on the mainstem does not require any improvements, therefore per discussions with the Urban Drainage and Flood Control District it was not included in the alternatives evaluation.

Alternative plans for each of the reaches were developed for the best alternatives as determined by the Initial Alternatives Screening Matrix and the Outfall Options Screening Matrix. These plans identify the probable costs for construction, maintenance, land value, and contingencies costs associated with construction. At this stage in the project conceptualization the costs identified are approximate. The

quantities and costs are suitable for the comparison of the alternatives, but will be refined and revised in the Conceptual Design Phase of the study.

The following sections describe in detail the improvements that are required for the developed alternatives and the associated maintenance activities per each reach within the study area. A cost estimate outlines the estimated cost to implement the alternatives. The accompanying figures illustrate the location of the reach and the proposed improvements for each Alternative that was evaluated. The reaches are discussed in order, working from downstream to upstream starting with Irondale Gulch, followed by Tributary A, and Tributary B.

5.5.2 Irondale Gulch Reach 2: I-76 at 88th Avenue to State Highway 2 at 88th Avenue

Reach 2 of Irondale Gulch is within Commerce City and is bound by State Highway 2 (SH 2) on the east, I-76 on the west, 80th Avenue on the south, and 88th Avenue on the north. It consists primarily of developed land, both residential and industrial, with some undeveloped areas.

Alternatives 2 and 8 were evaluated for Reach 2.

Alternative 2: Regional Detention

The purpose of Alternative 2 is to reduce peak flows along the Irondale Gulch in order to minimize stormwater conveyance. The lower peak flows reduce costs of downstream drainage infrastructure and also minimize threats from floods.

Costs for all detention excavation account for 100% of the volume of the facility due to the flat nature of this location. Costs for the outlet structure include all associated infrastructure except for pipe extensions and flared end sections connceting to other infrastructure. Outlet structure costs are included in the cost estimate as a lump sum for each structure. Construction of a maintenance trail for access to the detention basins is also included in the Construction Costs.

The routine maintenance for Alternative 2 includes removal of debris and sediment three (3) times a year and mowing three (3) times a year.

Within Reach 2, this alternative assumes that ROW and/or easements will need to be obtained to gain access to the land for construction and routine maintenance purposes, although this may be negotiated at the time of development.

Please note that the detention basins within this reach will be constructed in two phases. In the first phase, the determined detention volume will be excavated and will be used for retention. This will be aided by the sandy soils in the area since they support infiltration. This is partly due to the fact that the outfall is being constructed on a much longer timescale, and the outfall is necessary for detention outlet structures to connect to. When the outfall is constructed, the retention basins will be further developed into detention basins with water quality outlet structures. This is desirable because standing water will be present for a shorter amount of time. The function and effects of the retention basins will be studied in more detail in the Conceptual Design Phase (if this alternative is part of the Selected Plan).

Alternative 8: Channels/ Conduits Combined

The purpose of Alternative 8 is to safely and effectively convey 100-year storm event runoff downstream to the SPR in engineered channels and underground conduits. It was decided to use a combination of the two types of conveyance because of varied space constraints along different roadways. Along the Union Pacific Railroad (UPRR) and I-76 there is room for an engineered channel. Therefore, grass lined trapezoidal channels are proposed in those locations.

However, along 88th Avenue, not only is the development more dense, but peak flows are higher necessitating larger conveyance infrastructure. A channel would be prohibitive, therefore a 60-inch RCP is proposed along the major flow path from SH 2, north along Birch Street, and to the proposed culverts under I-76. Box base manholes will be installed as needed along the RCP. Additionally, the trapezoidal channels will ultimately flow into the 60-inch RCP through an inlet into a box base manhole. And finally, the pipe will connect to the culverts under SH 2 and I-76 also via a box based manhole.

Also, throughout the area south of 88th Avenue, trapezoidal channels are proposed upstream of the detention basins to capture runoff and convey it to the facility. These channels are all 3-feet deep with a 20-foot top width and 3:1 side slopes. This design was used based on assumptions about available ROW next to these minor streets.

Costs for all channel excavation account for 100% of the volume of the channel due to the flat nature of the Study Area. All side slopes steeper than 4:1 and flatter than 2.5:1 will be reinforced with erosion control blanket, which is included in the stormwater management/erosion control cost.

Refer to Figure 5.5-2 for an illustration of the proposed improvements.

The routine maintenance for Alternative 8 includes mowing three (3) times a year (for trapezoidal channels) and removal of debris and sediment three (3) times a year. Access for maintenance will be gained via the adjacent roadways/ roadway shoulders.

Within Reach 2, this alternative assumes that ROW and/or easements will not need to be obtained to gain access to the land for construction and routine maintenance purposes. This is because the channels and pipe will pass along roadways and through land that is already owned by the city.

Table 5.5.2-1: Reach 2 Cost Estimate – Alternative 2

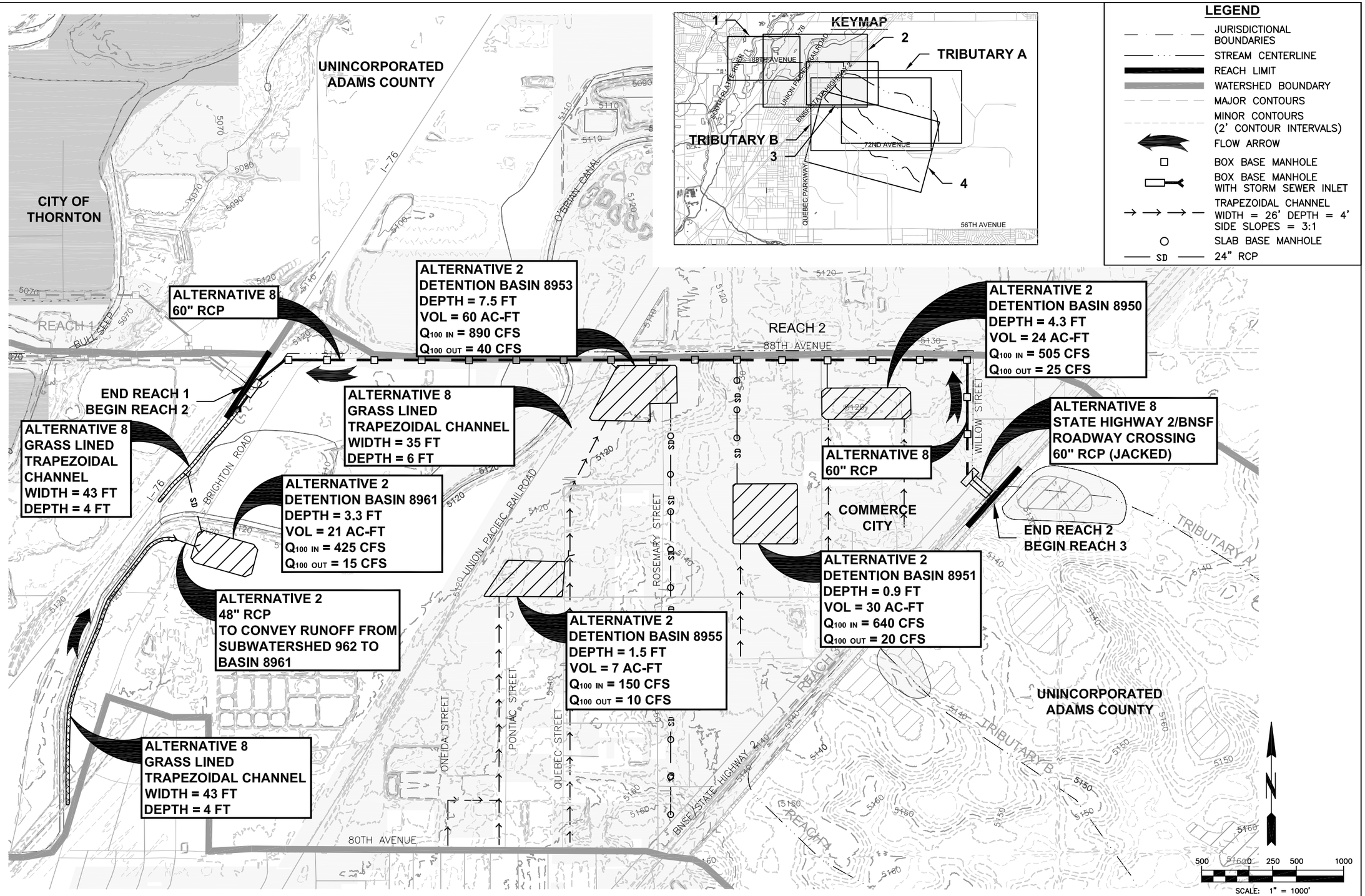
DESCRIPTION	QUANTITY	UNIT	UNIT COST	COST
Detention/Water Quality Facilities				
Detention (User Entered Quantities)				
Excavation, Mid Range	229093	C.Y.	$15.00	$3,436,400.00
Outlet Works	5	EA	$50,000.00	$250,000.00
Landscaping and Maintenance Improvements				
Reclamation & seeding (native grasses)	60	ACRE	$1,000.00	$60,000.00
Trail/Path, Crusher Fines (10' Width)	500	L.F.	$10.00	$5,000.00
Land Acquisition				
Easement/ROW Acquisition	60.00	ACRE	$217,800.00	$13,068,000.00
Master Plan Improvement Cost Summary				
Capital Improvement Costs				
Pipe Culverts and Storm Drains				$0.00
Concrete Box Culverts				$0.00
Hydraulic Structures				$0.00
Channel Improvements				$0.00
Detention/Water Quality Facilities				$3,686,400.00
Removals				$0.00
Landscaping and Maintenance Improvements				$65,000.00
Special Items (User Defined)				$0.00
Subtotal Capital Improvement Costs				**$3,751,400.00**
Additional Capital Construction Costs				
Dewatering		L.S.		$0.00
Mobilization	5%			$187,570.00
Traffic Control		L.S.		$0.00
Utility Coordination/Relocation		L.S.		$0.00
Stormwater Management/Erosion Control	5%			$187,570.00
Subtotal Additional Capital Improvement Costs				**$375,140.00**
Land Acquisition				
ROW/Easements				$13,068,000.00
Subtotal Land Acquistion				**$13,068,000.00**
Other Costs (percentage of Capital Improvement Costs)				
Engineering	15%			$618,981.00
Legal/Administrative	5%			$206,327.00
Contract Admin/Construction Management	10%			$412,654.00
Contingency	25%			$4,298,635.00
Subtotal Other Costs				**$5,536,597.00**
Totals				**$22,731,137.00**

ANNUAL OPERATION AND MAINTENANCE COSTS						
DESCRIPTION			QUANTITY	UNIT	UNIT COST	COST
Detention / Retention Operations and Maintenance						
Mowing			60	ACRE	$150.00	$9,000.00
Debris Removal			60	ACRE	$1,500.00	$90,000.00
Grand Total						**$99,000.00**

Table 5.5.2-2: Reach 2 Cost Estimate - Alternative 8

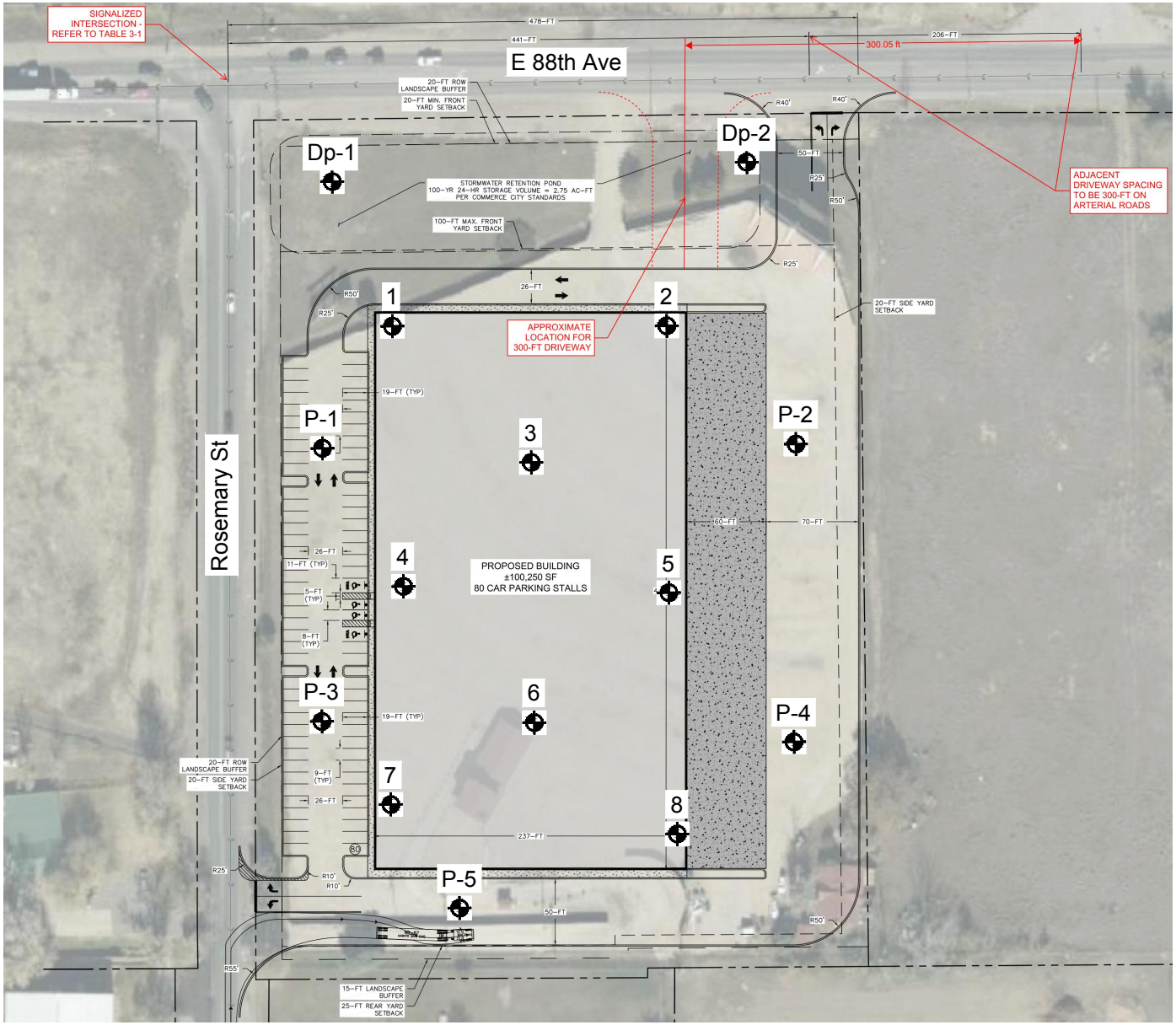
DESCRIPTION			QUANTITY	UNIT	UNIT COST	COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				
60-inch	8775	1	8775	L.F.	$210.00	$1,842,750.00
60-inch	260	1	260	L.F.	$210.00	$54,600.00
48-inch	205	1	205	L.F.	$168.00	$34,440.00
24-inch	75	1	75	L.F.	$84.00	$6,300.00
24-inch	4350	1	4350	L.F.	$84.00	$365,400.00
24-inch	1280	1	1280	L.F.	$84.00	$107,520.00
24-inch	260	1	260	L.F.	$84.00	$21,840.00
24-inch	595	1	595	L.F.	$84.00	$49,980.00
Flare End Sections						
Diameter (in)	**Applicable**	**No. of Barrels**				
48-inch	Yes	1	2	EA	$2,000.00	$4,000.00
24-inch	Yes	1	1	EA	$850.00	$850.00
24-inch	Yes	1	1	EA	$850.00	$850.00
Headwalls						
Diameter (in)	**Applicable**	**No. of Barrels**				
60-inch	Yes	1	1	EA	$1,833.80	$1,833.80
Wingwalls (includes concrete apron)						
Diameter (in)		**No. of Barrels**				
60-inch		1	1	EA	$10,335.53	$10,335.53
Manholes and Inlets						
Type B Manhole (Pipe Dia. 48" and larger, deflection < 10 degrees)			4	EA	$10,000.00	$40,000.00
Type P Manhole (Pipe Dia. 48" and larger, deflection > 10 degrees)			3	EA	$15,000.00	$45,000.00
Channel Improvements						
Excavation, Mid Range			26680	C.Y.	$15.00	$400,200.00
Landscaping and Maintenance Improvements						
Reclamation & seeding (native grasses)			16	ACRE	$1,000.00	$16,067.26
Trail/Path, Crusher Fines (10' Width)			9450	L.F.	$10.00	$94,500.00
Special Items (User Defined)						
Jacked 60-inch RCP Labor and Installation	**<----User Defined Items**		260	LF	$800.00	$208,000.00
Asphalt Resurfacing	**<----User Defined Items**		1490	TON	$100.00	$149,000.00
Master Plan Improvement Cost Summary						
Capital Improvement Costs						
Pipe Culverts and Storm Drains						$2,585,700.33
Concrete Box Culverts						$0.00
Hydraulic Structures						$0.00
Channel Improvements						$400,200.00
Detention/Water Quality Facilities						$0.00
Removals						$0.00
Landscaping and Maintenance Improvements						$110,567.26
Special Items (User Defined)						$357,000.00
Subtotal Capital Improvement Costs						**$3,453,467.60**
Additional Capital Construction Costs						
Dewatering				L.S.		$0.00
Mobilization			5%			$172,673.38
Traffic Control			$15,000.00	L.S.		$15,000.00
Utility Coordination/Relocation				L.S.		$0.00
Stormwater Management/Erosion Control			5%			$172,673.38
Subtotal Additional Capital Improvement Costs						**$360,346.76**
Land Acquisition						
ROW/Easements						$0.00
Subtotal Land Acquistion						**$0.00**
Other Costs (percentage of Capital Improvement Costs)						
Engineering			15%			$572,072.15
Legal/Administrative			5%			$190,690.72
Contract Admin/Construction Management			10%			$381,381.44
Contingency			25%			$953,453.59
Subtotal Other Costs						**$2,097,597.90**
Totals						**$5,911,412.25**

ANNUAL OPERATION AND MAINTENANCE COSTS						
DESCRIPTION			**QUANTITY**	**UNIT**	**UNIT COST**	**COST**
Channel Operations and Maintenance						
Mowing			11.589	ACRE	$150.00	$1,738.35
Debris Removal			11120	L.F.	$3.00	$33,360.00
Restorative Maintenance and Rehabilitation			2.1	MI	$5,000.00	$10,530.00
Mowing			16	ACRE	$150.00	$2,400.00
Debris Removal			20740	L.F.	$3.00	$62,220.00
Restorative Maintenance and Rehabilitation			0.025	MI	$5,000.00	$125.00
Debris Removal			11475	L.F.	$3.00	$34,425.00
Grand Total						**$144,798.35**



NAME: Z:\UDFCD PLANNING\Irondale Gulch\CAD_Irondale Gulch\dwg\2- Alt Report\Fig 5.5-2 - Reach 2.dwg
PLOT DATE: Aug 26, 2011 10:00am

TOPOGRAPHIC METHOD: LIDAR TOPOGRAPHIC MAPPING BY: TOPOGRAPHIC MAPPING QA/QC BY: CONTOUR INTERVAL: 2 FOOT DATE FLOWN: 2008	MOSER & associates ENGINEERING	720 S. COLORADO BLVD. SUITE 410 S DENVER, CO 80246 PHONE: 303-757-3655 FAX: 303-300-1635	DESIGNED AGC DATE 10/10/10 DRAWN RWM DATE 11/15/10 CHECKED RCO DATE 1/20/11 REVISED DATE	Commerce CITY	COMMERCE CITY URBAN DRAINAGE AND FLOOD CONTROL DISTRICT	IRONDALE GULCH OUTFALL SYSTEMS PLAN	REACH 2 ALTERNATIVES EVALUATED	FIGURE 5.5-2



1
Indicates test hole number and approximate location.

SITE PLAN PROVIDED BY CLIENT

NOT TO SCALE

GROUND ENGINEERING

JOB NO.: 21-3049

FIGURE: 1

LOCATION OF TEST HOLES

GROUND
ENGINEERING

May 27, 2022

Subject: Geotechnical Data Report, Stormwater Pond Infiltration Rate Testing, **Warehouse at 8780 Rosemary Street,** Commerce City, Colorado

Job No. 22-3026

Jim Knopka
First Industrial Realty Trust, Inc.
17 East Gay Street, Suite 302
West Chester, Pennsylvania 19380

Dear Mr. Knopka:

This letter summarizes the geotechnical data collected by GROUND Engineering Consultants, Inc. (GROUND) to provide soil infiltration rate information for the design of the proposed stormwater pond at the Warehouse at 8780 Rosemary project in Commerce City, Colorado. This service was conducted in general accordance with GROUND's Proposal No. 2205-0845, dated May 3, 2022, and associated change order.

GROUND previously completed a geotechnical evaluation for this project, and the results of that evaluation were provided in our report dated August 6, 2021.[1] Reference is made to GROUND's 2021 report for a description of the site surface and subsurface conditions, our geotechnical conclusions and parameters, and the limitations on our work, which also apply to the data provided herein. We consider all parameters and considerations in our 2021 report not specifically superseded herein to remain valid for the project.

Infiltration Rate Testing Infiltration rate testing was performed in May 2022 using Modified Philip Dunne testing equipment. Testing was performed at 3 locations within the approximate proposed stormwater pond footprint test pits excavations performed by others. The test pits were excavated to the approximate pond bottom elevation, roughly 7 feet below existing grades. The locations of the tests are presented in Figure A. A summary of the data obtained during the testing are provided in *Appendix A*. A brief summary of the resulting **Ksat** (saturated hydraulic

[1] GROUND Engineering Consultants, Inc., 2022, *Geotechnical Evaluation, Warehouse at 8780 Rosemary Street, Commerce City, Colorado,* Job No. 21-3049, prepared for First Industrial Realty Trust, Inc., dated August 6.

conductivity) values is provided below. Corresponding "infiltration rate" values also are provided below. The "infiltration rates" are based on the **Ksat** values and are considered to represent infiltration in the stabilized condition after the soil has become saturated locally and the rate of infiltration has become effectively constant. They are presented in the 'minutes per inch' units of a traditional percolation test result.

MODIFIED PHILLIP-DUNNE INFILTROMETER TEST RESULTS SUMMARY

Infiltration Test	***Ksat*** *(in/hr)/(cm/s)*	***Infiltration Rate*** *(minutes/in)*
DP-1	1.37 (9.7×10^{-4})	44
DP-2	1.85 (1.3×10^{-3})	32
DP-3	2.02 (9.7×10^{-4})	30

Additionally, a vertical hydraulic conductivity test was performed on a sample of site soils from Test Hole D-2, which was located within the proposed pond, during our 2021 evaluation. This testing indicated a vertical hydraulic conductivity of 3.1×10^{-5} cm/s for a sample of clayey sand collected from a depth of about 8 feet below existing grade. That value indicates a somewhat slower "infiltration rate" than those tabulated above. Likewise, it should be noted that hydraulic conductivity (permeability) and infiltration rate can vary greater over short distances (both vertical and horizontal) and both field and laboratory testing may not effectively indicate local areas of either significantly higher or lower hydraulic conductivity. A qualified engineer should evaluate the results of these test before they are used in design. Similarly, it may be beneficial to perform additional infiltration rate testing, once the storm water pond is completed to verify design infiltration rates.

Limitations This letter has been prepared for First Industrial Realty Trust, Inc., to present the geotechnical data herein. It should not be assumed to contain sufficient information for other parties or other purposes.

The geotechnical data in this report relied upon testing at a limited number of exploration points as discussed herein. It is not possible to guarantee the values obtained are representative of other locations on the site.

GROUND makes no warranties, either expressed or implied, as to the professional data, opinions or conclusions contained herein. This document is intended only for the specific purpose and client for which it was prepared. Reuse of, or improper reliance on this document without written authorization and adaption by GROUND Engineering Consultants, Inc., shall be without liability to GROUND Engineering Consultants, Inc.

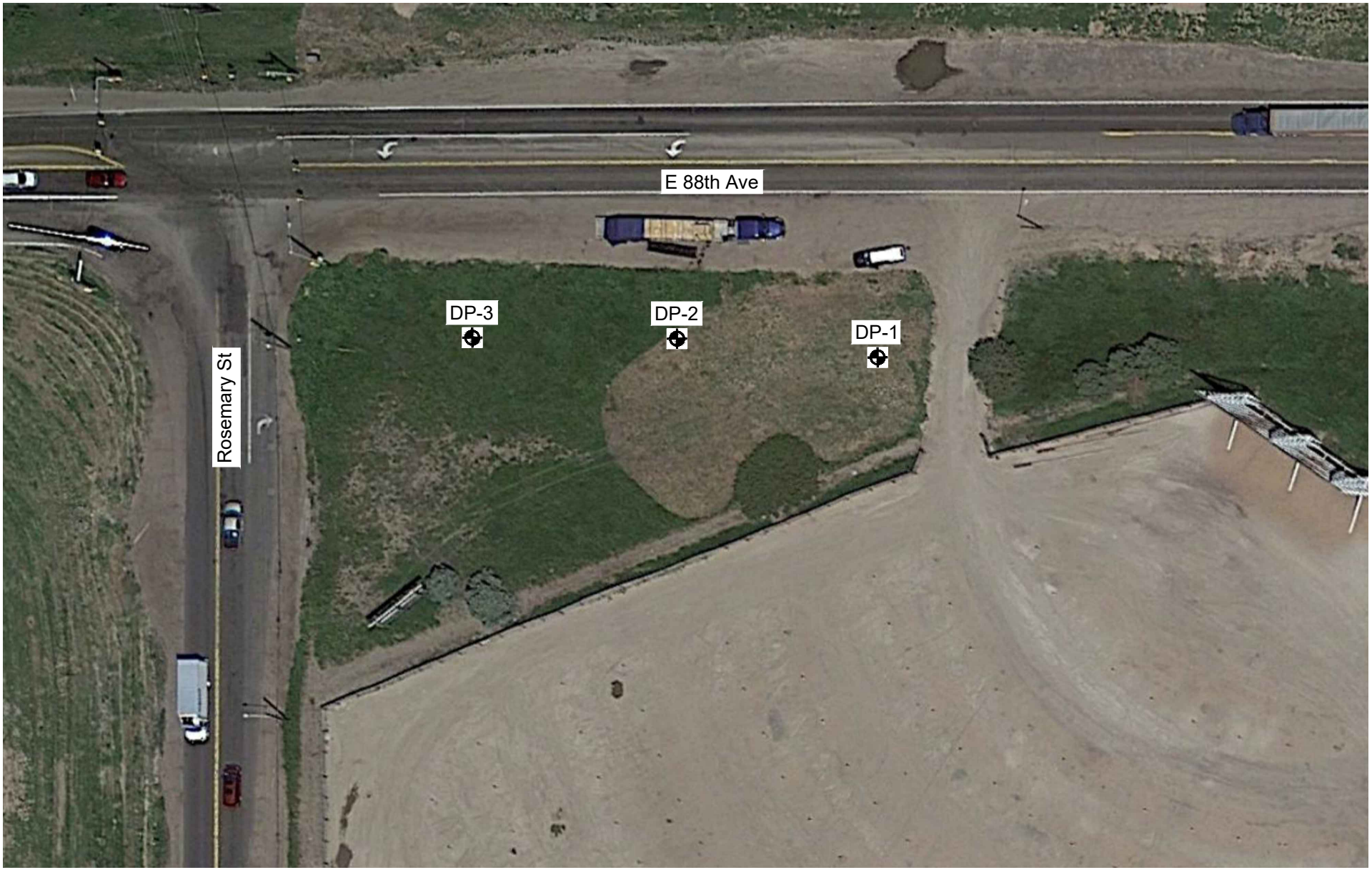
We trust that this provides the information that you needed at this time. If you have any questions, please contact this office.

Sincerely,

GROUND Engineering Consultants, Inc.

Ben Fellbaum, P.G., E.I.

Reviewed by Brian H. Reck, P.G., C.E.G., P.E.



1

Indicates test hole number and approximate location.

GOOGLE EARTH AERIAL IMAGE (6/10/2021)

NOT TO SCALE

GROUND ENGINEERING

JOB NO.: 22-3026

FIGURE: 1

LOCATION OF TEST HOLES

Appendix A

Summary of Modified Philip-Dunne Test Results

MPD INFILTROMETER
www.upstreamtechnologies.us

Infiltration Report

GROUND Engineering Consultants, Inc.

Upstream Technologies
651.237.5123

Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

This report summarizes the results of a set of Modified Philip Dunne (MPD) Infiltrometer tests performed at the above referenced site. GROUND Engineering Consultants, Inc. personnel performed the field tests. The software used to compute saturated hydraulic conductivity (K_{sat}) and generate this report assumes that the field personnel used infiltrometers manufactured by Upstream Technologies Inc. and followed the procedures outlined in “Manual – Modified Philip - Dunne Infiltrometer” by Ahmed, Gulliver, and Nieber.

The following paragraphs describe the individual tests, input values used in the analysis, and methods used to compute the K_{sat} value.

After individual K_{sat} values were calculated, the method used to determine the overall site K_{sat}value ($K_{best\text{-}fit}$) is described in "Effective Saturated Hydraulic Conductivity of an Infiltration-Based Stormwater Control Measure" by Weiss and Gulliver 2015, "A relationship to more consistently and accurately predict the best-fit value of saturated hydraulic conductivity used a weighted sum of 0.32 times the arithmetic mean and 0.68 times the geometric mean."

METHOD USED TO COMPUTE K_{sat}

The MPD Infiltrometer software uses the following procedure described in "The Comparison of Infiltration Devices and Modification of the Philip-Dunne Permeameter for the Assessment of Rain Gardens" by Rebecca Nestigen, University of Minnesota, November 2007.

The steps are as follows:

1. For each measurement of head, use the following equation to find the corresponding distance to the sharp wetting front.

$$[H_0 - H(t)]r_1^2 = \frac{\theta_1 - \theta_2}{3}[2[R(t)]^3 + 3[R(t)]^2 L_{max} - L_{max}^3 - 4r_0^3]$$

2. Estimate the change in head with respect to time and the change in wetting front distance with respect to time by using the backward difference for all values of R(t) equal to or greater than the distance $\sqrt{r_1^2 + L_{max}^2}$

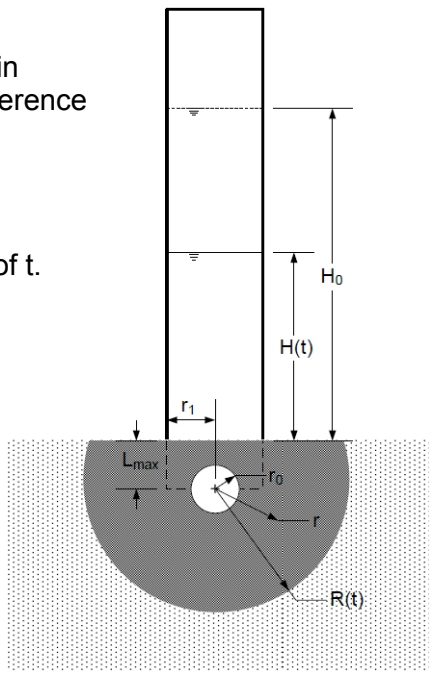
3. Make initial guesses for K and C.

4. Solve the following equations for ΔP(t) at each incremental value of t.

$$\Delta P(t) = \frac{\pi^2}{8}\left\{\theta_1 - \theta_0 \frac{[R(t)^2] + [R(t)]L_{max}}{K}\frac{dr}{dt} - 2r_0^2\right\}\frac{ln\left[\frac{R(t)[r_0 + L_{max}]}{r_0[R(t) + L_{max}]}\right]}{L_{max}}$$

$$\Delta P(t) = C - H(t) - L_{max} + \frac{L_{max}}{K}\frac{dh}{dt}$$

5. Minimize the absolute difference between the two solutions found in Step 4 by adjusting the values of K and C.



Parameters for Equations

Θ_0 = volumetric water content of soil before MPD test

Θ_1 = volumetric water content of soil after MPD test

MPD INFILTROMETER
www.upstreamtechnologies.us

Infiltration Report

GROUND Engineering Consultants, Inc.

Upstream Technologies
651.237.5123

Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

DP1

Date	5/19/2022
Time	9:41 AM
Latitude	39.856039
Longitude	-104.898658
Initial Volumetric Moisture	25.00 %
Final Volumetric Moisture	70.00 %
Cylinder Size	3 Liter

DP1 Results

Map Pin #	1
Test Number	21986
Ksat - mm/hr	35
Ksat - in/hr	1.37
Capillary Pressure C mm	-283.6
RMS Error of Regression	2.1
Normalized RMS	0.1%

Readings

#	Time	Head	#	Time	Head	#	Time	Head	#	Time	Head
1	0 s	33.19 cm	25	720 s	26.01 cm	49	1440 s	20.52 cm	73	2160 s	15.7 cm
2	30 s	32.74 cm	26	750 s	25.77 cm	50	1470 s	20.31 cm	74	2190 s	15.51 cm
3	60 s	32.36 cm	27	780 s	25.51 cm	51	1500 s	20.09 cm	75	2220 s	15.32 cm
4	90 s	32.01 cm	28	810 s	25.28 cm	52	1530 s	19.88 cm	76	2250 s	15.13 cm
5	120 s	31.66 cm	29	840 s	25.03 cm	53	1560 s	19.68 cm	77	2280 s	14.94 cm
6	150 s	31.32 cm	30	870 s	24.8 cm	54	1590 s	19.48 cm	78	2310 s	14.76 cm
7	180 s	30.99 cm	31	900 s	24.57 cm	55	1620 s	19.26 cm	79	2340 s	14.57 cm
8	210 s	30.67 cm	32	930 s	24.33 cm	56	1650 s	19.06 cm	80	2370 s	14.37 cm
9	240 s	30.36 cm	33	960 s	24.09 cm	57	1680 s	18.86 cm	81	2400 s	14.18 cm
10	270 s	30.05 cm	34	990 s	23.85 cm	58	1710 s	18.65 cm	82	2430 s	13.99 cm
11	300 s	29.75 cm	35	1020 s	23.62 cm	59	1740 s	18.45 cm	83	2460 s	13.81 cm
12	330 s	29.46 cm	36	1050 s	23.39 cm	60	1770 s	18.24 cm	84	2490 s	13.62 cm
13	360 s	29.17 cm	37	1080 s	23.17 cm	61	1800 s	18.04 cm	85	2520 s	13.44 cm
14	390 s	28.89 cm	38	1110 s	22.94 cm	62	1830 s	17.85 cm	86	2550 s	13.26 cm
15	420 s	28.61 cm	39	1140 s	22.72 cm	63	1860 s	17.64 cm	87	2580 s	13.07 cm
16	450 s	28.34 cm	40	1170 s	22.5 cm	64	1890 s	17.44 cm			
17	480 s	28.07 cm	41	1200 s	22.27 cm	65	1920 s	17.25 cm			
18	510 s	27.81 cm	42	1230 s	22.04 cm	66	1950 s	17.06 cm			
19	540 s	27.55 cm	43	1260 s	21.82 cm	67	1980 s	16.87 cm			
20	570 s	27.28 cm	44	1290 s	21.59 cm	68	2010 s	16.67 cm			
21	600 s	27.03 cm	45	1320 s	21.38 cm	69	2040 s	16.47 cm			
22	630 s	26.77 cm	46	1350 s	21.17 cm	70	2070 s	16.28 cm			
23	660 s	26.51 cm	47	1380 s	20.94 cm	71	2100 s	16.09 cm			
24	690 s	26.27 cm	48	1410 s	20.73 cm	72	2130 s	15.9 cm			

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Infiltration Report

GROUND Engineering Consultants, Inc.

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Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

DP2

Date	5/19/2022
Time	10:08 AM
Latitude	39.856057
Longitude	-104.898942
Initial Volumetric Moisture	20.00 %
Final Volumetric Moisture	21.00 %
Cylinder Size	3 Liter

DP2 Results

Map Pin #	2
Test Number	21987
Ksat - mm/hr	47
Ksat - in/hr	1.85
Capillary Pressure C mm	176.3
RMS Error of Regression	152
Normalized RMS	2.5%

Readings

#	Time	Head	#	Time	Head	#	Time	Head	#	Time	Head
1	0 s	33.19 cm	25	719 s	30.52 cm	49	1439 s	28.87 cm	73	2159 s	27.54 cm
2	29 s	32.93 cm	26	749 s	30.44 cm	50	1469 s	28.83 cm	74	2189 s	27.48 cm
3	59 s	32.8 cm	27	779 s	30.36 cm	51	1499 s	28.75 cm	75	2219 s	27.44 cm
4	89 s	32.67 cm	28	809 s	30.28 cm	52	1529 s	28.71 cm	76	2249 s	27.39 cm
5	119 s	32.56 cm	29	839 s	30.2 cm	53	1559 s	28.64 cm	77	2279 s	27.33 cm
6	149 s	32.46 cm	30	869 s	30.14 cm	54	1589 s	28.59 cm	78	2309 s	27.28 cm
7	179 s	32.34 cm	31	899 s	30.04 cm	55	1619 s	28.54 cm	79	2339 s	27.24 cm
8	209 s	32.24 cm	32	929 s	29.97 cm	56	1649 s	28.47 cm	80	2369 s	27.2 cm
9	239 s	32.13 cm	33	959 s	29.9 cm	57	1679 s	28.42 cm	81	2399 s	27.14 cm
10	269 s	32.02 cm	34	989 s	29.83 cm	58	1709 s	28.37 cm	82	2429 s	27.09 cm
11	299 s	31.9 cm	35	1019 s	29.76 cm	59	1739 s	28.3 cm	83	2459 s	27.05 cm
12	329 s	31.8 cm	36	1049 s	29.69 cm	60	1769 s	28.24 cm	84	2489 s	27.0 cm
13	359 s	31.69 cm	37	1079 s	29.62 cm	61	1799 s	28.19 cm	85	2519 s	26.96 cm
14	389 s	31.58 cm	38	1109 s	29.54 cm	62	1829 s	28.13 cm	86	2549 s	26.91 cm
15	419 s	31.48 cm	39	1139 s	29.5 cm	63	1859 s	28.07 cm	87	2579 s	26.84 cm
16	449 s	31.37 cm	40	1169 s	29.42 cm	64	1889 s	28.02 cm	88	2609 s	26.81 cm
17	479 s	31.28 cm	41	1199 s	29.36 cm	65	1919 s	27.95 cm	89	2639 s	26.78 cm
18	509 s	31.17 cm	42	1229 s	29.29 cm	66	1949 s	27.9 cm	90	2669 s	26.72 cm
19	539 s	31.07 cm	43	1259 s	29.23 cm	67	1979 s	27.87 cm	91	2699 s	26.67 cm
20	569 s	30.98 cm	44	1289 s	29.17 cm	68	2009 s	27.79 cm	92	2729 s	26.61 cm
21	599 s	30.88 cm	45	1319 s	29.11 cm	69	2039 s	27.74 cm	93	2759 s	26.57 cm
22	629 s	30.79 cm	46	1349 s	29.05 cm	70	2069 s	27.7 cm	94	2789 s	26.51 cm
23	659 s	30.69 cm	47	1379 s	29.0 cm	71	2099 s	27.64 cm	95	2819 s	26.47 cm
24	689 s	30.6 cm	48	1409 s	28.93 cm	72	2129 s	27.59 cm	96	2849 s	26.43 cm

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Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

DP2 Readings continued

#	Time	Head	#	Time	Head	#	Time	Head	#	Time	Head
97	2879 s	26.38 cm	129	3839 s	24.93 cm	161	4799 s	23.67 cm	193	5759 s	22.4 cm
98	2909 s	26.33 cm	130	3869 s	24.91 cm	162	4829 s	23.63 cm	194	5789 s	22.37 cm
99	2939 s	26.29 cm	131	3899 s	24.86 cm	163	4859 s	23.59 cm	195	5819 s	22.32 cm
100	2969 s	26.24 cm	132	3929 s	24.81 cm	164	4889 s	23.54 cm	196	5849 s	22.29 cm
101	2999 s	26.2 cm	133	3959 s	24.78 cm	165	4919 s	23.51 cm	197	5879 s	22.24 cm
102	3029 s	26.14 cm	134	3989 s	24.74 cm	166	4949 s	23.47 cm	198	5909 s	22.21 cm
103	3059 s	26.11 cm	135	4019 s	24.69 cm	167	4979 s	23.43 cm	199	5939 s	22.17 cm
104	3089 s	26.06 cm	136	4049 s	24.66 cm	168	5009 s	23.38 cm	200	5969 s	22.13 cm
105	3119 s	26.01 cm	137	4079 s	24.61 cm	169	5039 s	23.34 cm	201	5999 s	22.08 cm
106	3149 s	25.97 cm	138	4109 s	24.58 cm	170	5069 s	23.31 cm	202	6029 s	22.04 cm
107	3179 s	25.93 cm	139	4139 s	24.53 cm	171	5099 s	23.27 cm	203	6059 s	22.0 cm
108	3209 s	25.88 cm	140	4169 s	24.48 cm	172	5129 s	23.23 cm	204	6089 s	21.96 cm
109	3239 s	25.83 cm	141	4199 s	24.45 cm	173	5159 s	23.19 cm	205	6119 s	21.92 cm
110	3269 s	25.79 cm	142	4229 s	24.41 cm	174	5189 s	23.15 cm	206	6149 s	21.88 cm
111	3299 s	25.74 cm	143	4259 s	24.37 cm	175	5219 s	23.12 cm	207	6179 s	21.85 cm
112	3329 s	25.69 cm	144	4289 s	24.33 cm	176	5249 s	23.07 cm	208	6209 s	21.81 cm
113	3359 s	25.65 cm	145	4319 s	24.28 cm	177	5279 s	23.03 cm	209	6239 s	21.78 cm
114	3389 s	25.6 cm	146	4349 s	24.26 cm	178	5309 s	22.99 cm	210	6269 s	21.73 cm
115	3419 s	25.56 cm	147	4379 s	24.21 cm	179	5339 s	22.95 cm	211	6299 s	21.69 cm
116	3449 s	25.51 cm	148	4409 s	24.17 cm	180	5369 s	22.91 cm	212	6329 s	21.65 cm
117	3479 s	25.46 cm	149	4439 s	24.11 cm	181	5399 s	22.87 cm	213	6359 s	21.62 cm
118	3509 s	25.42 cm	150	4469 s	24.09 cm	182	5429 s	22.83 cm	214	6389 s	21.58 cm
119	3539 s	25.38 cm	151	4499 s	24.04 cm	183	5459 s	22.8 cm	215	6419 s	21.54 cm
120	3569 s	25.32 cm	152	4529 s	24.0 cm	184	5489 s	22.77 cm	216	6449 s	21.49 cm
121	3599 s	25.29 cm	153	4559 s	23.97 cm	185	5519 s	22.72 cm	217	6479 s	21.45 cm
122	3629 s	25.25 cm	154	4589 s	23.92 cm	186	5549 s	22.68 cm	218	6509 s	21.4 cm
123	3659 s	25.2 cm	155	4619 s	23.89 cm	187	5579 s	22.64 cm	219	6539 s	21.36 cm
124	3689 s	25.16 cm	156	4649 s	23.85 cm	188	5609 s	22.6 cm	220	6569 s	21.32 cm
125	3719 s	25.13 cm	157	4679 s	23.81 cm	189	5639 s	22.56 cm	221	6599 s	21.27 cm
126	3749 s	25.08 cm	158	4709 s	23.78 cm	190	5669 s	22.52 cm	222	6629 s	21.23 cm
127	3779 s	25.03 cm	159	4739 s	23.72 cm	191	5699 s	22.48 cm	223	6659 s	21.2 cm
128	3809 s	24.98 cm	160	4769 s	23.69 cm	192	5729 s	22.45 cm	224	6689 s	21.16 cm

Infiltration Report

GROUND Engineering Consultants, Inc.

Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

DP2 Readings continued

#	Time	Head
225	6719 s	21.12 cm

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Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

DP3

Date	5/19/2022
Time	10:35 AM
Latitude	39.856060
Longitude	-104.899230
Initial Volumetric Moisture	20.00 %
Final Volumetric Moisture	21.00 %
Cylinder Size	3 Liter

DP3 Results

Map Pin #	3
Test Number	21988
Ksat - mm/hr	51
Ksat - in/hr	2.02
Capillary Pressure C mm	20.8
RMS Error of Regression	43
Normalized RMS	1.1%

Readings

#	Time	Head	#	Time	Head	#	Time	Head	#	Time	Head
1	0 s	32.17 cm	25	718 s	27.82 cm	49	1438 s	24.57 cm	73	2158 s	21.75 cm
2	28 s	31.85 cm	26	748 s	27.68 cm	50	1468 s	24.45 cm	74	2188 s	21.64 cm
3	58 s	31.59 cm	27	778 s	27.53 cm	51	1498 s	24.33 cm	75	2218 s	21.52 cm
4	88 s	31.37 cm	28	808 s	27.38 cm	52	1528 s	24.2 cm	76	2248 s	21.41 cm
5	118 s	31.16 cm	29	838 s	27.24 cm	53	1558 s	24.08 cm	77	2278 s	21.31 cm
6	148 s	30.96 cm	30	868 s	27.09 cm	54	1588 s	23.96 cm	78	2308 s	21.2 cm
7	178 s	30.74 cm	31	898 s	26.95 cm	55	1618 s	23.84 cm	79	2338 s	21.08 cm
8	208 s	30.57 cm	32	928 s	26.8 cm	56	1648 s	23.72 cm	80	2368 s	20.99 cm
9	238 s	30.39 cm	33	958 s	26.66 cm	57	1678 s	23.61 cm	81	2398 s	20.88 cm
10	268 s	30.21 cm	34	988 s	26.53 cm	58	1708 s	23.49 cm	82	2428 s	20.77 cm
11	298 s	30.04 cm	35	1018 s	26.4 cm	59	1738 s	23.36 cm	83	2458 s	20.67 cm
12	328 s	29.87 cm	36	1048 s	26.25 cm	60	1768 s	23.25 cm	84	2488 s	20.57 cm
13	358 s	29.7 cm	37	1078 s	26.12 cm	61	1798 s	23.13 cm	85	2518 s	20.45 cm
14	388 s	29.54 cm	38	1108 s	25.98 cm	62	1828 s	23.01 cm	86	2548 s	20.36 cm
15	418 s	29.38 cm	39	1138 s	25.84 cm	63	1858 s	22.89 cm	87	2578 s	20.25 cm
16	448 s	29.22 cm	40	1168 s	25.72 cm	64	1888 s	22.78 cm	88	2608 s	20.16 cm
17	478 s	29.06 cm	41	1198 s	25.58 cm	65	1918 s	22.66 cm	89	2638 s	20.05 cm
18	508 s	28.91 cm	42	1228 s	25.45 cm	66	1948 s	22.54 cm	90	2668 s	19.95 cm
19	538 s	28.75 cm	43	1258 s	25.31 cm	67	1978 s	22.43 cm	91	2698 s	19.85 cm
20	568 s	28.6 cm	44	1288 s	25.18 cm	68	2008 s	22.32 cm	92	2728 s	19.75 cm
21	598 s	28.44 cm	45	1318 s	25.06 cm	69	2038 s	22.2 cm	93	2758 s	19.65 cm
22	628 s	28.28 cm	46	1348 s	24.94 cm	70	2068 s	22.09 cm	94	2788 s	19.55 cm
23	658 s	28.13 cm	47	1378 s	24.81 cm	71	2098 s	21.98 cm	95	2818 s	19.44 cm
24	688 s	27.97 cm	48	1408 s	24.69 cm	72	2128 s	21.86 cm	96	2848 s	19.35 cm

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Warehouse at 8780 Rosemary Street Infiltration Testing - 22-3026 - 8780 Rosemary Street Commerce City, Colorado

DP3 Readings continued

#	Time	Head	#	Time	Head
97	2878 s	19.25 cm	129	3838 s	16.29 cm
98	2908 s	19.14 cm	130	3868 s	16.19 cm
99	2938 s	19.04 cm	131	3898 s	16.11 cm
100	2968 s	18.94 cm	132	3928 s	16.01 cm
101	2998 s	18.86 cm	133	3958 s	15.93 cm
102	3028 s	18.75 cm	134	3988 s	15.83 cm
103	3058 s	18.67 cm	135	4018 s	15.74 cm
104	3088 s	18.58 cm	136	4048 s	15.65 cm
105	3118 s	18.47 cm	137	4078 s	15.57 cm
106	3148 s	18.38 cm	138	4108 s	15.47 cm
107	3178 s	18.29 cm	139	4138 s	15.37 cm
108	3208 s	18.2 cm	140	4168 s	15.29 cm
109	3238 s	18.11 cm	141	4198 s	15.19 cm
110	3268 s	18.02 cm	142	4228 s	15.11 cm
111	3298 s	17.92 cm	143	4258 s	15.01 cm
112	3328 s	17.82 cm	144	4288 s	14.93 cm
113	3358 s	17.74 cm	145	4318 s	14.84 cm
114	3388 s	17.64 cm			
115	3418 s	17.56 cm			
116	3448 s	17.46 cm			
117	3478 s	17.38 cm			
118	3508 s	17.29 cm			
119	3538 s	17.2 cm			
120	3568 s	17.11 cm			
121	3598 s	17.01 cm			
122	3628 s	16.92 cm			
123	3658 s	16.82 cm			
124	3688 s	16.74 cm			
125	3718 s	16.65 cm			
126	3748 s	16.56 cm			
127	3778 s	16.47 cm			
128	3808 s	16.38 cm			

Appendix B

Hydrologic Computations

- Historic & Proposed Standard Form 1
- Historic & Proposed Standard Form 2

PERCENT IMPERVIOUS AND C-VALUE
8780 ROSEMARY STREET
CITY OF COMMERCE CITY, ADAMS COUNTY, COLORADO

PERCENT IMPERVIOUS VALUES [1]	
LAWNS, SANDY SOIL	2
GRAVEL	40
ROOFS	90
DRIVE AND WALKS	90
HISTORIC	2

RUNOFF COEFFICIENTS [1]

Soil Type	5-YR	10-YR	100-YR
A	$0.86i^{1.276}$	$0.87i^{1.232}$	0.78i+0.110
B	$0.86i^{1.088}$	0.81i+0.057	0.47i+0.462
C/D	0.82i+0.035	0.74i+0.132	0.41i+0.393

COMPOSITE PERCENT IMPERVIOUS AND RUNOFF COEFFIECENTS

SUB-BASIN	OVERALL AREA (SF)	LAWNS, SANDY SOIL (SF)	GRAVEL (SF)	ROOFS (SF)	PAVED STREETS (SF)	HISTORIC (SF)	5-YR COEFF. [2]	10-YR COEFF. [2]	100-YR COEFF. [2]	PERCENT IMPERVIOUS [2]
HISTORIC BASINS (SOIL TYPE)										
On-site (A)	57810	0	39889	1217	462	16242	0.28	0.34	0.49	31%
On-site (C)	222937	0	176829	1744	950	43414				33%
Off-site 1 (A)	228286	0	2431	0	2880	222975	0.04	0.04	0.16	4%
Off-site 1 (C)	12269	0	5353	0	6048	873				62%
Off-site 2 (A)	61549	0	2750	464	5853	52482	0.16	0.19	0.33	13%
Off-site 2 (B)	5234	0	375	0	65	4794				6%
Off-site 2 (C)	27978	0	10226	130	9460	8162				46%
Historic Basin B Total	616063	0	237853	3555	25718	348942	0.17	0.20	0.34	21%

NOTES:

1. Percent Impervious Values and Runoff Coefficients obtained from Table 6-3 and Table 6-5 of the MHFD Urban Storm Drainage

2. Percent impervious calculated as a weighted average.

MODIFIED STANDARD FORM SF-1
TIME OF CONCENTRATION
8780 ROSEMARY STREET
CITY OF COMMERCE CITY, ADAMS COUNTY, COLORADO

CALCULATED BY: SJS DATE: 4/19/2022

HISTORIC SUB-BASIN DATA							Initial/Overland Time (ti)			Travel Time (tt)					tc	tc Check (Urbanized Basin)			FINAL tc (min) (Note 4)
Sub- Basin	Design Point	Area (ac)	I (%)	C5	C10	C100	Length (ft)	Slope (%)	t_i (min) (Note 1)	Length (ft)	Slope (%)	K (Note 3)	Velocity (fps)	t_t (min) (Note 2)	t_c (min) (Note 5)	Total Length (ft)	t_i (min)	t_c (min) (Note 6)	
HISTORIC BASINS																			
On-site	B	6.45	0.33	0.28	0.34	0.49	0	0.00	0.00	721	0.48	15	10.39	1.16	10.00	721	14.01	15.16	10.00
Off-site 1	B	5.52	0.06	0.04	0.04	0.16	300	1.33	29.95	429	3.20	7	12.52	0.57	30.52	729	14.05	14.62	14.62
Off-site 2	B	2.18	0.22	0.16	0.19	0.33	119	2.37	13.40	233	3.92	15	29.70	0.13	13.53	352	11.96	12.09	12.09
Historic Basin B Total	**B**	**14.14**	**0.21**																

NOTES:

1. Initial/Overland time calculated as non-urbanized Basin using Equation 503 of the Commerce City Storm Drainage Design and Technical Criteria Manual

2. Travel time calculated from Equatio 6-4 of the Mile High Flood District Urban Storm Drainage Criteria Manual Volume 1

3. K Values obtained from Table 6-2 of the Mile High Flood District Urban Storm Drainage Criteria Manual Volume 1

4. Time of Concentration calculated as the sum of ti and tt. A check was performed to see if the Equation 503 of 504 of the Commerce City Storm Drainage Design and Technical Criteria Manual produced a smaller ti, and that smaller ti was used in calculation of tc.

5. Minimum Tc non-urbanized = 10 min

6. Minimum Tc urbanized = 5 min

7.Maximum overland flow length is 300 ft

STANDARD FORM SF-1
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)
8780 ROSEMARY STREET

DESIGN STORM: 5-YEAR P5 (Note 3) = 1.37
CALCULATED BY SJS DATE: 4/19/2022

Sub-Basin Data			Direct Runoff					Remarks
Sub- Basin	Design Point	Area (ac)	C5	tc (min)	C x A	I5 (in/hr) (Note 1)	Q5 (cfs) (Note 2)	
HISTORIC BASINS								
On-site	B	6.45	0.28	10.00	1.83	3.71	6.77	
Off-site 1	B	5.52	0.04	14.62	0.22	3.15	0.68	
Off-site 2	B	2.18	0.16	12.09	0.36	3.43	1.22	
Historic Basin B Total	**B**	**14.14**					**8.67**	

NOTES:
1. Rainfall intensities calculated using Equation 5-1 of the Mile High Flood District Urban Storm Drainage Criteria Manual, Volume 1
2. Q calculated using the Rational Method, where Q=CIA
3. 1-hr pt rainfall from the Commerce City Storm Drainage Design and Technical Criteria Manual

STANDARD FORM SF-1
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)
8780 ROSEMARY STREET

DESIGN STORM: 10-YEAR — P5 (Note 3) = 1.55
CALCULATED BY SJS — DATE: 4/19/2022

Sub-Basin Data			Direct Runoff					
Sub- Basin	Design Point	Area (ac)	C5	tc (min)	C x A	I10 (in/hr) (Note 1)	Q10 (cfs) (Note 2)	**Remarks**
HISTORIC BASINS								
On-site	B	6.45	0.34	10.00	2.20	4.19	9.24	
Off-site 1	B	5.52	0.04	14.62	0.24	3.56	0.85	
Off-site 2	B	2.18	0.19	12.09	0.41	3.88	1.60	
Historic Basin B Total	**B**	**14.14**					**11.70**	

NOTES:
1. Rainfall intensities calculated using Equation 5-1 of the Mile High Flood District Urban Storm Drainage Criteria Manual, Volume 1
2. Q calculated using the Rational Method, where Q=CIA
3. 1-hr pt rainfall from the Commerce City Storm Drainage Design and Technical Criteria Manual

STANDARD FORM SF-1
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)
8780 ROSEMARY STREET

DESIGN STORM: 100-YEAR — P100 (Note 3) = 2.58
CALCULATED BY SJS — DATE: 4/19/2022

Sub-Basin Data			Direct Runoff					Remarks
Sub- Basin	Design Point	Area (ac)	C100	tc (min)	C x A	I100 (in/hr) (Note 1)	Q100 (cfs) (Note 2)	
HISTORIC BASINS								
On-site	B	6.45	0.49	10.00	3.17	6.98	22.15	
Off-site 1	B	5.52	0.16	14.62	0.90	5.93	5.35	
Off-site 2	B	2.18	0.33	12.09	0.73	6.46	4.70	
Historic Basin B Total	**B**	**14.14**					**32.20**	

NOTES:
1. Rainfall intensities calculated using Equation 5-1 of the Mile High Flood District Urban Storm Drainage Criteria Manual, Volume 1
2. Q calculated using the Rational Method, where Q=CIA
3. 1-hr pt rainfall from the Commerce City Storm Drainage Design and Technical Criteria Manual

PERCENT IMPERVIOUS AND C-VALUE
8780 ROSEMARY STREET
CITY OF COMMERCE CITY, ADAMS COUNTY, COLORADO

PERCENT IMPERVIOUS VALUES [1]	
LAWNS, SANDY SOIL	2
GRAVEL	40
ROOFS	90
DRIVE AND WALKS	90
HISTORIC	2

RUNOFF COEFFICIENTS [1]			
Soil Type	5-YR	10-YR	100-YR
A	$0.86i^{1.276}$	$0.87i^{1.232}$	0.78i+0.110
B	$0.86i^{1.088}$	0.81i+0.057	0.47i+0.462
C/D	0.82i+0.035	0.74i+0.132	0.41i+0.393

COMPOSITE PERCENT IMPERVIOUS AND RUNOFF COEFFIECENTS

SUB-BASIN (SOIL TYPE)	OVERALL AREA (SF)	LAWNS, SANDY SOIL (SF)	GRAVEL (SF)	ROOFS (SF)	DRIVE AND WALKS (SF)	HISTORIC (SF)	5-YR COEFF. [2]	10-YR COEFF. [2]	100-YR COEFF. [2]	PERCENT IMPERVIOUS [2]
PROPOSED MAJOR BASINS										
PR Storm System (A)	40439	5578	0	4069	30792	0	0.74	0.76	0.85	78%
PR Storm System (C)	162049	1424	0	76505	84120	0				89%
Direct Runoff to Basin A (A)	2906	2906	0	0	0	0	0.05	0.13	0.37	2%
Direct Runoff to Basin A (C)	24130	24130	0	0	0	0				2%
Off-site 2 (A)	2088	2088	0	0	0	0	0.01	0.01	0.13	2%
Off-site 3 (A)	4893	0	0	0	4893	0	0.75	0.76	0.81	90%
Direct Runoff to Basin B (A)	5103	0	0	0	5103	0	0.22	0.30	0.50	90%
Direct Runoff to Basin B (C)	19101	18368	0	0	733	0				5%
Off-site 1A(A)	182973	179885	1400	0	1688	0	0.01	0.01	0.13	3%
Off-site 1B(A)	48588	48588	0	0	0	0	0.01	0.01	0.13	2%
Off-Site 5(A)	3115	3115	0	0	0	0	0.45	0.48	0.55	2%
Off-Site 5(C)	12371	437	5770	0	6164	0				64%
Direct Runoff to Basin C (C)	16749	16749	0	0	0	0	0.01	0.01	0.13	2%
Off-site 4(A)	4290	179	0	0	4111	0	0.63	0.67	0.70	86%
Off-site 4(C)	18935	1226	5070	0	12639	0				71%
Undetained 1 (A)	21315	21315	0	0	0	0	0.01	0.02	0.15	2%
Undetained 1 (C)	2076	2076	0	0	0	0				2%
Undetained 2 (A)	30655	28760	658	0	1237	0	0.03	0.04	0.21	6%
Undetained 2 (B)	5233	4791	377	0	65	0				6%
Major Basin A Total	236505	36126	0	80574	119805	0	0.65	0.68	0.79	77%
Major Basin B Total	271251	250393	7170	0	13688	0	0.05	0.06	0.19	7%
Major Basin C Total	39974	18154	5070	0	16750	0	0.58	0.58	0.63	44%
Major Basin D Total	59279	56942	1035	0	1302	0	0.39	0.42	0.45	5%
PROPOSED SUB-BASINS										
CB-301 (A)	9565	0	0	0	9565	0	0.76	0.78	0.85	90%
CB-301 (C)	9573	0	0	0	9573	0				90%
CB-302 (A)	5134	0	0	0	5134	0	0.77	0.79	0.87	90%
CB-302(C)	14637	0	0	0	14637	0				90%
CB-303 (C)	18269	0	0	0	18269	0	0.77	0.80	0.76	90%
CB-304 (A)	8599	3637	0	0	4962	0	0.63	0.65	0.75	53%
CB-304 (C)	15555	163	0	0	15392	0				89%
CB-305 (A)	19794	3827	0	0	15967	0	0.57	0.58	0.68	73%
CB-305 (C)	612	431	0	0	181	0				28%
CB-306 (C)	8547	813	0	0	7734	0	0.70	0.74	0.73	82%
CB-307 (C)	11156	255	0	0	10901	0	0.76	0.78	0.75	88%
CB-308 (C)	7445	0	0	0	7445	0	0.77	0.80	0.76	90%
MH-302 (ROOF)	22276	0	0	22276	0	0	0.77	0.80	0.76	90%
CB-302 (ROOF)	19393	0	0	19393	0	0	0.77	0.80	0.76	90%
CB-303 (ROOF)	19451	0	0	19451	0	0	0.77	0.80	0.76	90%
CB-304 (ROOF)	19454	0	0	19454	0	0	0.77	0.80	0.76	90%
FES-401 (A)	43092	7464	0	0	35628	0	0.64	0.67	0.79	75%
FES-401 (C)	139220	594	0	58298	58052	0				75%
FES-402 (C)	27148	1068	0	0	26080	0	0.74	0.77	0.75	87%
BASIN A (A)	2906	2906	0	0	0	0	0.05	0.13	0.43	2%
BAISN A (C)	24130	24130	0	0	0	0				2%
SWALE 1A (A)	182973	179885	1400	0	1688	0	0.01	0.01	0.13	3%
SWALE 1B (A)	48588	48588	0	0	0	0	0.01	0.01	0.13	2%
RG-1 Direct (A)	8219	0	0	0	8219	0	0.35	0.42	0.63	90%
RG-1 Direct (C)	31471	19537	5770	0	6164	0				26%
RG-2 Direct (A)	4418	307	0	0	4111	0	0.35	0.41	0.66	84%
RG-2 Direct (C)	35518	17815	5064	0	12639	0				39%
UD-1 (A)	21315	21315	0	0	0	0	0.01	0.02	0.15	2%
UD-1 (C)	2076	2076	0	0	0	0				2%
UD-2 (A)	30655	28760	658	0	1237	0	0.03	0.04	0.21	6%
UD-2 (B)	5233	4791	377	0	65	0				6%

NOTES:

1.Percent Impervious Values and Runoff Coefficients obtained from Table 6-3 and Table 6-5 of the MHFD Urban Storm Drainage Criteria Manual Volume 1

2. Percent impervious calculated as a weighted average.

MODIFIED STANDARD FORM SF-2
TIME OF CONCENTRATION
8780 ROSEMARY STREET
CITY OF COMMERCE CITY, ADAMS COUNTY, COLORADO

CALCULATED BY: SJS — DATE: 4/19/2022

PROPOSED SUB-BASIN DATA							Initial/Overland Time (ti)			Travel Time (tt)					tc	tc Check (Urbanized Basin)			FINAL tc (min) (Note 4)
Sub Basin	Design Point	Area (ac)	I (%)	C5	C10	C100	Length (ft)	Slope (%)	t_i (min) (Note 1)	Length (ft)	Slope (%)	K (Note 3)	Velocity (fps)	t_t (min) (Note 2)	t_c (min) (Note 5)	Total Length (ft)	t_i (min)	t_c (min) (Note 5)	
PROPOSED MAJOR BASINS																			
PR Storm System	A	4.65	87%	0.74	0.76	0.85	205	2.9	6.11	752	1	20	2.00	6.27	12.38	957	15.32	21.58	12.38
Direct Runoff to Basin A	A	0.62	2%	0.05	0.13	0.37	58	19.2	4.96	0	0	7	0.00	0.00	5.00	58	10.32	10.32	5.00
Off-site 2	A	0.05	2%	0.01	0.01	0.13	147	1.21	22.38	0	0	7	0.00	0.00	22.38	147	10.82	10.82	10.82
Off-site 3	A	0.11	90%	0.75	0.76	0.81	108	2.07	4.93	113	1.38	20	2.35	0.80	5.73	221	11.23	12.03	5.73
Direct Runoff to Basin B	B	0.56	23%	0.22	0.30	0.50	30	2.4	5.92	71	2.5	20	3.16	0.37	6.29	101	10.56	10.94	6.29
Off-site 1A	B	4.20	3%	0.01	0.01	0.13	300	1.33	30.84	429	1.1	7	0.73	9.74	40.58	729	14.05	23.79	23.79
Off-site 1B	B	1.12	2%	0.01	0.01	0.13	300	3.76	21.91	37	3.67	7	1.34	0.46	22.37	337	11.87	12.33	12.33
Off-site 5	B	0.36	51%	0.45	0.48	0.55	198	1	15.64	0	0	15	0.00	0.00	15.64	198	11.10	11.10	11.10
Direct Runoff to Basin C	C	0.38	2%	0.01	0.01	0.13	46	13.26	5.64	0	0	15	0.00	0.00	5.64	46	10.26	10.26	5.64
Off-site 4	C	0.53	74%	0.63	0.67	0.70	130	2.33	6.66	338	1.85	20	2.72	2.07	8.73	468	12.60	14.67	8.73
Undetained 1	D	0.54	2%	0.01	0.02	0.15	216	6.14	15.61	0	0	7	0.00	0.00	15.61	216	11.20	11.20	11.20
Undetained 2	D	0.82	6%	0.03	0.04	0.21	118	2.44	15.39	246	4.11	7	1.42	2.89	18.28	364	12.02	14.91	14.91
Major Basin A Total	**A**	**5.43**	**77%**																
Major Basin B Total	**B**	**6.23**	**7%**																
Major Basin C Total	**C**	**0.92**	**44%**																
Major Basin D Total	**D**	**1.36**	**5%**																
PROPOSED SUB-BASINS																			
CB-301	301	0.44	90%	0.76	0.78	0.85	107	2.91	4.16	226	3.13	20	3.54	0.00	5.00	333	11.85	11.85	5.00
CB-302	302	0.45	90%	0.77	0.79	0.87	106.5	2.62	4.19	63.5	1.17	20	2.16	0.49	5.00	170	10.94	11.43	5.00
CB-303	303	0.42	90%	0.77	0.80	0.76	133	0.9	6.49	0	0.0	20	0.00	0.00	6.49	133	10.74	10.74	6.49
CB-304	304	0.55	76%	0.63	0.65	0.75	188.5	4.5	6.73	62	1.1	20	2.13	0.49	7.22	250.5	11.39	11.88	7.22
CB-305	305	0.47	72%	0.57	0.58	0.68	205	1.9	10.76	0	0.0	20	0.00	0.00	10.76	205	11.14	11.14	10.76
CB-306	306	0.20	82%	0.70	0.74	0.73	86	1.9	4.90	35	1.0	20	2.00	0.29	5.20	121	10.67	10.96	5.20
CB-307	307	0.26	88%	0.76	0.78	0.75	86	1.9	4.27	35	1.0	20	2.00	0.29	5.00	121	10.67	10.96	5.00
CB-308	308	0.17	90%	0.77	0.80	0.76	86	1.9	4.08	35	1.0	20	2.00	0.29	5.00	121	10.67	10.96	5.00
MH-302 (ROOF)	401	0.51	90%	0.77	0.80	0.76	0	0.0	0.00	78	0.5	20	1.41	0.92	5.00	78	10.43	11.35	5.00
CB-302 (ROOF)	302	0.45	90%	0.77	0.80	0.76	0	0.0	0.00	78	0.5	20	1.41	0.92	5.00	78	10.43	11.35	5.00
CB-303 (ROOF)	303	0.45	90%	0.77	0.80	0.76	0	0.0	0.00	78	0.5	20	1.41	0.92	5.00	78	10.43	11.35	5.00
CB-304 (ROOF)	304	0.45	90%	0.77	0.80	0.76	0	0.0	0.00	78	0.5	20	1.41	0.92	5.00	78	10.43	11.35	5.00
FES-401	401	4.19	75%	0.64	0.67	0.79	205	2.9	7.78	752	1	20	2.00	6.27	14.05	957	15.32	21.58	14.05
FES-402	402	0.62	87%	0.74	0.77	0.75	86	1.9	4.42	482	2.28	20	3.02	2.66	7.08	568	13.16	15.82	7.08
BASIN A	B-A	0.62	2%	0.05	0.13	0.43	58	19.2	4.96	0	0	7	0.00	0.00	5.00	58	10.32	10.32	5.00
SWALE 1A	S-1A	4.20	3%	0.01	0.01	0.13	300	1.33	30.84	429	1.1	7	0.73	9.74	40.58	729	14.05	23.79	23.79
SWALE 1B	S-2A	1.12	2%	0.01	0.01	0.13	300	3.76	21.91	37	3.67	7	1.34	0.46	22.37	337	11.87	12.33	12.33
RG-1	RG-1	0.91	39%	0.35	0.42	0.63	203	1.1	16.98	0	0	20	0.00	0.00	16.98	203	11.13	11.13	11.13
RG-2	RG-2	0.92	44%	0.35	0.41	0.66	130	2.15	11.02	375	1.87	20	2.73	0.00	11.02	505	12.81	12.81	11.02
UD-1	UD-1	0.54	2%	0.01	0.02	0.15	216	6.14	15.61	0	0	7	0.00	0.00	15.61	216	11.20	11.20	11.20
UD-2	UD-2	0.82	6%	0.03	0.04	0.21	118	2.44	15.39	246	4.11	7	1.42	2.89	18.28	364	12.02	14.91	14.91

NOTES:

1. Initial/Overland time calculated as non-urbanized Basin using Equation 503 of the Commerce City Storm Drainage Design and Technical Criteria Manual
2. Travel time calculated from Equation 6-4 of the Mile High Flood District Urban Storm Drainage Criteria Manual Volume 1
3. K Values obtained from Table 6-2 of the Mile High Flood District Urban Storm Drainage Criteria Manual Volume 1
4. Time of Concentration calculated as the sum of ti and tt. A check was performed to see if the Equation 503 of 504 of the Commerce City Storm Drainage Design and Technical Criteria Manual produced a smaller ti, and that smaller ti was used in calculation of tc.
5. Minimum Tc urbanized = 5 min
6.Maximum overland flow length is 300 ft

STANDARD FORM SF-2
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)
8780 ROSEMARY STREET

DESIGN STORM: 5-YEAR P5 (Note 3) = 1.37
CALCULATED By: SJS DATE 4/19/2022

Sub-Basin Data			Direct Runoff				
Sub- Basin	Design Point	Area (ac)	C5	tc (min)	C x A	I5 (in/hr) (Note 1)	Q5 (cfs) (Note 2)
MAJOR BASINS							
PR Storm System	A	4.65	0.74	12.38	3.43	3.39	11.65
Direct Runoff to Basin A	A	0.62	0.05	5.00	0.03	4.65	0.13
Off-site 2	A	0.05	0.01	10.82	0.00	3.59	0.00
Off-site 3	A	0.11	0.75	5.73	0.08	4.48	0.38
Direct Runoff to Basin B	B	0.56	0.22	6.29	0.12	4.36	0.53
Off-site 1A	B	4.20	0.01	23.79	0.04	2.45	0.11
Off-site 1B	B	1.12	0.01	12.33	0.01	3.40	0.02
Off-site 5	B	0.36	0.45	11.10	0.16	3.55	0.56
Direct Runoff to Basin C	C	0.38	0.01	5.64	0.00	4.50	0.01
Off-site 4	C	0.53	0.63	8.73	0.34	3.90	1.32
Undetained 1	C	0.54	0.01	11.20	0.01	3.54	0.02
Undetained 2	C	0.82	0.03	14.91	0.02	3.12	0.07
Major Basin A Total	**A**	**5.43**					**12.16**
Major Basin B Total	**B**	**6.23**					**1.23**
Major Basin C Total	**C**	**0.92**					**1.33**
Major Basin D Total	**D**	**1.36**					**0.09**
SUB-BASINS							
CB-301	301	0.44	0.76	5.00	0.33	4.65	1.56
CB-302	302	0.45	0.77	5.00	0.35	4.65	1.62
CB-303	303	0.42	0.77	6.49	0.32	4.31	1.40
CB-304	304	0.55	0.63	7.22	0.35	4.17	1.45
CB-305	305	0.47	0.57	10.76	0.27	3.60	0.95
CB-306	306	0.20	0.70	5.20	0.14	4.60	0.64
CB-307	307	0.26	0.76	5.00	0.19	4.65	0.90
CB-308	308	0.17	0.77	5.00	0.13	4.65	0.61
MH-302 (ROOF)	401	0.51	0.77	5.00	0.40	4.65	1.84
CB-302 (ROOF)	302	0.45	0.77	5.00	0.34	4.65	1.60
CB-303 (ROOF)	303	0.45	0.77	5.00	0.35	4.65	1.60
CB-304 (ROOF)	304	0.45	0.77	5.00	0.35	4.65	1.60
FES-401	401	4.19	0.64	14.05	2.67	3.21	8.56
FES-402	402	0.62	0.74	7.08	0.46	4.20	1.95
BASIN A	B-A	0.62	0.05	5.00	0.03	4.65	0.13
SWALE 1A	S-1A	4.20	0.01	23.79	0.04	2.45	0.11
SWALE 1B	S-2A	1.12	0.01	12.33	0.01	3.40	0.02
RG-1	RG-1	0.91	0.35	11.13	0.32	3.55	1.14
RG-2	RG-2	0.92	0.35	11.02	0.32	3.56	1.14
UD-1	UD-1	0.54	0.01	11.20	0.00	3.54	0.01
UD-2	UD-2	0.82	0.03	14.91	0.02	3.12	0.07

NOTES:
1. Rainfall intensities calculated using Equation 5-1 of the Mile High Flood Criteria Manual, Volume 1
2. Q calculated using the Rational Method, where Q=CIA
3. 1-hr pt rainfall from the Commerce City Storm Drainage Design and Technical Criteria Manual

STANDARD FORM SF-2
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)
8780 ROSEMARY STREET

DESIGN STORM: 5-YEAR P5 (Note 3) = 1.55
CALCULATED By: SJS DATE 4/19/2022

Sub-Basin Data			Direct Runoff				
Sub- Basin	Design Point	Area (ac)	C10	tc (min)	C x A	I10 (in/hr) (Note 1)	Q10 (cfs) (Note 2)
MAJOR BASINS							
PR Storm System	A	4.65	0.76	12.38	3.54	3.84	13.59
Direct Runoff to Basin A	A	0.62	0.13	5.00	0.08	5.26	0.43
Off-site 2	A	0.05	0.01	10.82	0.00	4.06	0.00
Off-site 3	A	0.11	0.76	5.73	0.09	5.06	0.43
Direct Runoff to Basin B	B	0.56	0.30	6.29	0.16	4.93	0.81
Off-site 1A	B	4.20	0.01	23.79	0.05	2.78	0.14
Off-site 1B	B	1.12	0.01	12.33	0.01	3.85	0.03
Off-site 5	B	0.36	0.48	11.10	0.17	4.02	0.69
Direct Runoff to Basin C	C	0.38	0.01	5.64	0.00	5.09	0.01
Off-site 4	C	0.53	0.67	8.73	0.36	4.41	1.58
Undetained 1	C	0.54	0.02	11.20	0.01	4.01	0.04
Undetained 2	C	0.82	0.04	14.91	0.03	3.53	0.12
Major Basin A Total	**A**	**5.43**					**14.46**
Major Basin B Total	**B**	**6.23**					**1.67**
Major Basin C Total	**C**	**0.92**					**1.59**
Major Basin D Total	**D**	**1.36**					**0.16**
SUB-BASINS							
CB-301	301	0.44	0.78	5.00	0.34	5.26	1.80
CB-302	302	0.45	0.79	5.00	0.36	5.26	1.88
CB-303	303	0.42	0.80	6.49	0.33	4.88	1.63
CB-304	304	0.55	0.65	7.22	0.36	4.72	1.70
CB-305	305	0.47	0.58	10.76	0.27	4.07	1.11
CB-306	306	0.20	0.74	5.20	0.14	5.20	0.75
CB-307	307	0.26	0.78	5.00	0.20	5.26	1.05
CB-308	308	0.17	0.80	5.00	0.14	5.26	0.72
MH-302 (ROOF)	401	0.51	0.80	5.00	0.41	5.26	2.15
CB-302 (ROOF)	302	0.45	0.80	5.00	0.36	5.26	1.87
CB-303 (ROOF)	303	0.45	0.80	5.00	0.36	5.26	1.87
CB-304 (ROOF)	304	0.45	0.80	5.00	0.36	5.26	1.87
FES-401	401	4.19	0.67	14.05	2.80	3.63	10.17
FES-402	402	0.62	0.77	7.08	0.48	4.75	2.29
BASIN A	B-A	4.20	0.13	5.00	0.55	5.26	2.91
SWALE 1A	S-1A	1.12	0.01	23.79	0.01	2.78	0.04
SWALE 1B	S-2A	0.91	0.01	12.33	0.01	3.85	0.02
RG-1	RG-1	0.92	0.42	11.13	0.38	4.02	1.53
RG-2	RG-2	0.82	0.41	11.02	0.34	4.03	1.35
UD-1	UD-1	0.00	0.02	11.20	0.00	4.01	0.00
UD-2	UD-2	0.00	0.04	14.91	0.00	3.53	0.00

NOTES:

1. Rainfall intensities calculated using Equation 5-1 of the Mile High Flood Criteria Manual, Volume 1

2. Q calculated using the Rational Method, where Q=CIA

3. 1-hr pt rainfall from the Commerce City Storm Drainage Design and Technical Criteria Manual

STANDARD FORM SF-2
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)
8780 ROSEMARY STREET

DESIGN STORM: 100-YEAR P100 (Note 3) = 2.58
CALCULATED BY: SJS DATE 4/19/2022

Sub-Basin Data			Direct Runoff				
Sub- Basin	Design Point	Area (ac)	C100	tc (min)	C x A	I100 (in/hr) (Note 1)	Q100 (cfs) (Note 2)
MAJOR BASINS							
PR Storm System	A	4.65	0.85	12.38	3.94	6.39	25.20
Direct Runoff to Basin A	A	0.62	0.37	5.00	0.23	8.75	2.02
Off-site 2	A	0.05	0.13	10.82	0.01	6.76	0.04
Off-site 3	A	0.11	0.81	5.73	0.09	8.43	0.77
Direct Runoff to Basin B	B	0.56	0.50	6.29	0.28	8.20	2.27
Off-site 1A	B	4.20	0.13	23.79	0.56	4.62	2.61
Off-site 1B	B	1.12	0.13	12.33	0.14	6.40	0.90
Off-site 5	B	0.36	0.55	11.10	0.19	6.69	1.30
Direct Runoff to Basin C	C	0.38	0.13	5.64	0.05	8.47	0.41
Off-site 4	C	0.53	0.70	8.73	0.37	7.35	2.75
Undetained 1	C	0.54	0.15	11.20	0.08	6.67	0.54
Undetained 2	C	0.82	0.21	14.91	0.17	5.87	1.01
Major Basin A Total	**A**	**5.43**					**28.03**
Major Basin B Total	**B**	**6.23**					**7.08**
Major Basin C Total	**C**	**0.92**					**3.16**
Major Basin D Total	**D**	**1.36**					**1.54**
SUB-BASINS							
CB-301	301	0.44	0.85	5.00	0.37	8.75	3.26
CB-302	302	0.45	0.87	5.00	0.39	8.75	3.44
CB-303	303	0.42	0.76	6.49	0.32	8.12	2.60
CB-304	304	0.55	0.75	7.22	0.42	7.85	3.28
CB-305	305	0.47	0.68	10.76	0.32	6.78	2.15
CB-306	306	0.20	0.73	5.20	0.14	8.66	1.24
CB-307	307	0.26	0.75	5.00	0.19	8.75	1.69
CB-308	308	0.17	0.76	5.00	0.13	8.75	1.14
MH-302 (ROOF)	401	0.51	0.76	5.00	0.39	8.75	3.41
CB-302 (ROOF)	302	0.45	0.76	5.00	0.34	8.75	2.97
CB-303 (ROOF)	303	0.45	0.76	5.00	0.34	8.75	2.98
CB-304 (ROOF)	304	0.45	0.76	5.00	0.34	8.75	2.98
FES-401	401	4.19	0.79	14.05	3.29	6.04	19.88
FES-402	402	0.62	0.75	7.08	0.47	7.90	3.68
BASIN A	B-A	0.62	0.43	5.00	0.27	8.75	2.36
SWALE 1A	S-1A	4.20	0.13	23.79	0.56	4.62	2.61
SWALE 1B	S-2A	1.12	0.13	12.33	0.14	6.40	0.90
RG-1	RG-1	0.91	0.63	11.13	0.58	6.69	3.85
RG-2	RG-2	0.92	0.66	11.02	0.60	6.71	4.05
UD-1	UD-1	0.54	0.15	11.20	0.08	6.67	0.54
UD-2	UD-2	0.82	0.21	14.91	0.17	5.87	1.01

NOTES:
1. Rainfall intensities calculated using Equation 5-1 of the Mile High Flood Criteria Manual, Volume 1
2. Q calculated using the Rational Method, where Q=CIA
3. 1-hr pt rainfall from the Commerce City Storm Drainage Design and Technical Criteria Manual

BASIN RUNOFF SUMMARY							
Sub- Basin	Design Point	Area (ac)	% Impervious	C5	C100	Q5	Q100
CB-301	301	0.44	0.90	0.76	0.85	1.56	3.26
CB-302	302	0.45	0.90	0.77	0.87	1.62	3.44
CB-303	303	0.42	0.90	0.77	0.76	1.40	2.60
CB-304	304	0.55	0.76	0.63	0.75	1.45	3.28
CB-305	305	0.47	0.72	0.57	0.68	0.95	2.15
CB-306	306	0.20	0.82	0.70	0.73	0.64	1.24
CB-307	307	0.26	0.88	0.76	0.75	0.90	1.69
CB-308	308	0.17	0.90	0.77	0.76	0.61	1.14
MH-302 (ROOF)	401	0.51	0.90	0.77	0.76	1.84	3.41
CB-302 (ROOF)	302	0.45	0.90	0.77	0.76	1.60	2.97
CB-303 (ROOF)	303	0.45	0.90	0.77	0.76	1.60	2.98
CB-304 (ROOF)	304	0.45	0.90	0.77	0.76	1.60	2.98
FES-401	401	4.19	0.75	0.64	0.79	8.56	19.88
FES-402	402	0.62	0.87	0.74	0.75	1.95	3.68
BASIN A	B-A	0.62	0.02	0.05	0.43	0.13	2.36
SWALE 1A	S-1A	4.20	0.03	0.01	0.13	0.11	2.61
SWALE 1B	S-2A	1.12	0.02	0.01	0.13	0.02	0.90
RG-1	RG-1	0.91	0.39	0.35	0.63	1.14	3.85
RG-2	RG-2	0.92	0.44	0.35	0.66	1.14	4.05
UD-1	UD-1	0.54	0.02	0.01	0.15	0.01	0.54
UD-2	UD-2	0.82	0.06	0.03	0.21	0.07	1.01

Appendix C

Hydraulic Computations

- Infiltration Calculations
- SDI Compliance Worksheet
- Emergency Spillway Sizing
- Sand Filter Worksheet
- Rain Garden 1 Calculations
- Rain Garden 2 Calculations
- Forebay Sizing Calculations
- UD-Inlet Calculations
- Hydraflow Storm Sewers
    - Minor Event Capacity Routing
    - Minor Event Hydraulic and Energy Grade Line
    - Major Event Capacity Routing
    - Major Event hydraulic and Energy Grade Line
- Culvert Calculations
- Minimum Pipe Slope Calculations

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PROJECT:	**8780 Rosemary Street**
PROJECT NO.:	**620023001**
DATE:	**8/17/2022**
CALCULATED BY:	**SJS**
CHECKED BY:	**MCB**

BASIN 1 INFILTRATION CALCULATIONS		
Basin 1 Tributary Area	236531	SF
% Imperviousness	0.77	
Required Flat Area	2277	SF
Required Flat Area[(1)]	0.05	AC
Required WQCV	0.112	AC-FT
WQCV Depth	0.897	FT
Time to Drain WQCV	12	HR
WQCV Infiltration Rate	0.07	FT/HR
Recommended Infiltration Rate[(2)]	0.15	FT/HR
Engineered Infiltration Rate	0.15	FT/HR
Available Flat Area	0.13	AC
Available Flat Area	5459	SF
100-YR 24-HR Retention Volume	94612	CF
100-YR 24-HR Retention Volume	2.17	AC-FT
Required 100-YR Drain Time	120	HR
Required Release Rate	0.22	CFS
Available Release Rate	0.23	CFS
100-YR Infiltration Volume[(4)]	40638	CF
Required Basin Storage Volume	53975	CF
Required Basin Storage Volume	1.24	AC-FT

1. Minimum flat surface area determined using Equation SF-2 for sand filters in Volume 3 of the CRITERIA.

2. Native soils have an infiltration constant of approximately 1.37 in/hr. UDFCD recommends a minimum infiltration rate of 2 times the rate needed to drain the WQCV over 12 hours. Sand will be imported to the site meeting or exceeding an in-place infiltration constant of 1.8 in/hr above the groundwater table.

3. At the time of geotechnical drilling, groundwater elevations in the vicinity of the pond ranged from 5070 to 5071.

4. Volume for 100-YR storm event taken from SDI Compliance worksheet.

Stormwater Detention and Infiltration Design Data Sheet

SDI-Design Data v2.00, Released January 2020

Stormwater Facility Name: **8780 ROSEMARY STREET BASIN A**

Facility Location & Jurisdiction: **COMMERCE CITY, CO**

User Input: Watershed Characteristics

Sand Filter (SF)	SF	
Watershed Area =	5.43	acres
Watershed Length =	957	ft
Watershed Length to Centroid =	479	ft
Watershed Slope =	0.013	ft/ft
Watershed Imperviousness =	77.0%	percent
Percentage Hydrologic Soil Group A =	19.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	81.0%	percent
Target WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths (use dropdown):		
User Input		

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

Once CUHP has been run and the Stage-Area-Discharge information has been provided, click 'Process Data' to interpolate the Stage-Area-Volume-Discharge data and generate summary results in the table below. Once this is complete, click 'Print to PDF'.

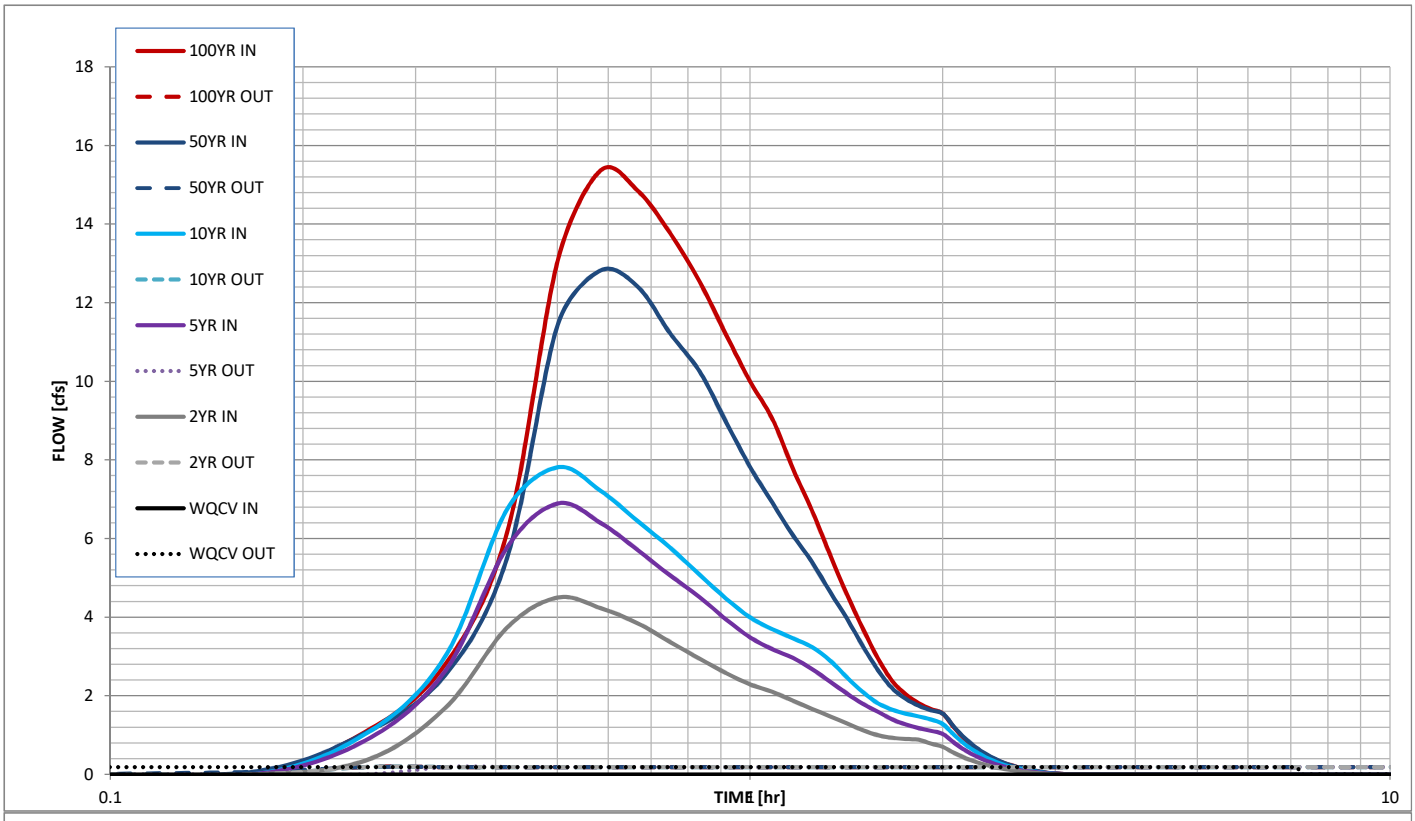
User Defined Stage [ft]	User Defined Area [ft^2]	User Defined Stage [ft]	User Defined Discharge [cfs]
0.00	5,459	0.00	0.19
1.00	6,898	1.00	0.19
2.00	8,394	2.00	0.19
3.00	9,946	3.00	0.19
4.00	11,555	4.00	0.19
5.00	13,220	5.00	0.19
6.00	14,942	6.00	0.19
6.55	15,913	6.55	0.19
7.00	16,721	7.00	0.19
8.00	18,555	8.00	0.19

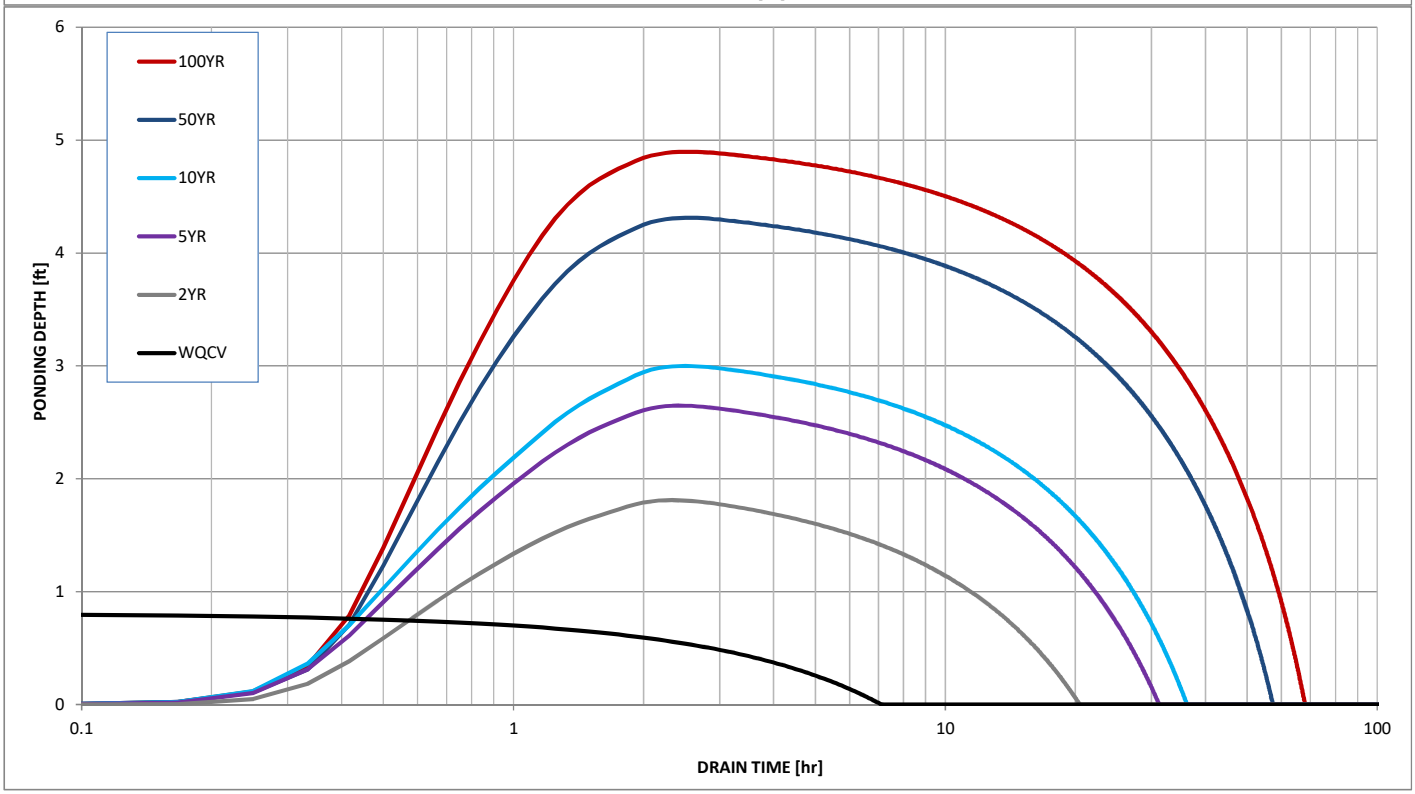
After completing and printing this worksheet to a pdf, go to:
https://maperture.digitaldataservices.com/gvh/?viewer=cswdif
Create a new stormwater facility, and attach the PDF of this worksheet to that record.

Routed Hydrograph Results

Design Storm Return Period =	WQCV	2 Year	5 Year	10 Year	50 Year	100 Year	
One-Hour Rainfall Depth =	N/A	0.97	1.37	1.55	2.24	2.58	in
CUHP Runoff Volume =	0.112	0.320	0.489	0.568	0.900	1.069	acre-ft
Inflow Hydrograph Volume =	N/A	0.320	0.489	0.568	0.900	1.069	acre-ft
Time to Drain 97% of Inflow Volume =	6.9	19.9	**30.3**	35.3	55.7	66.1	hours
Time to Drain 99% of Inflow Volume =	7.1	20.3	31.0	35.9	56.8	**67.4**	hours
Maximum Ponding Depth =	0.81	1.81	2.65	3.00	4.31	4.90	ft
Maximum Ponded Area =	0.15	0.19	0.22	0.23	0.28	**0.30**	acres
Maximum Volume Stored =	0.113	0.281	0.448	0.527	0.858	1.027	acre-ft

Stormwater Detention and Infiltration Design Data Sheet





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Technical Excellence
Practical Experience
Client Responsiveness

PROJECT:	**8780 ROSEMARY ST**
PROJECT NO.:	**620023001**
DATE:	**8/17/2022**
CALCULATED BY:	**SJS**
CHECKED BY:	**MCB**

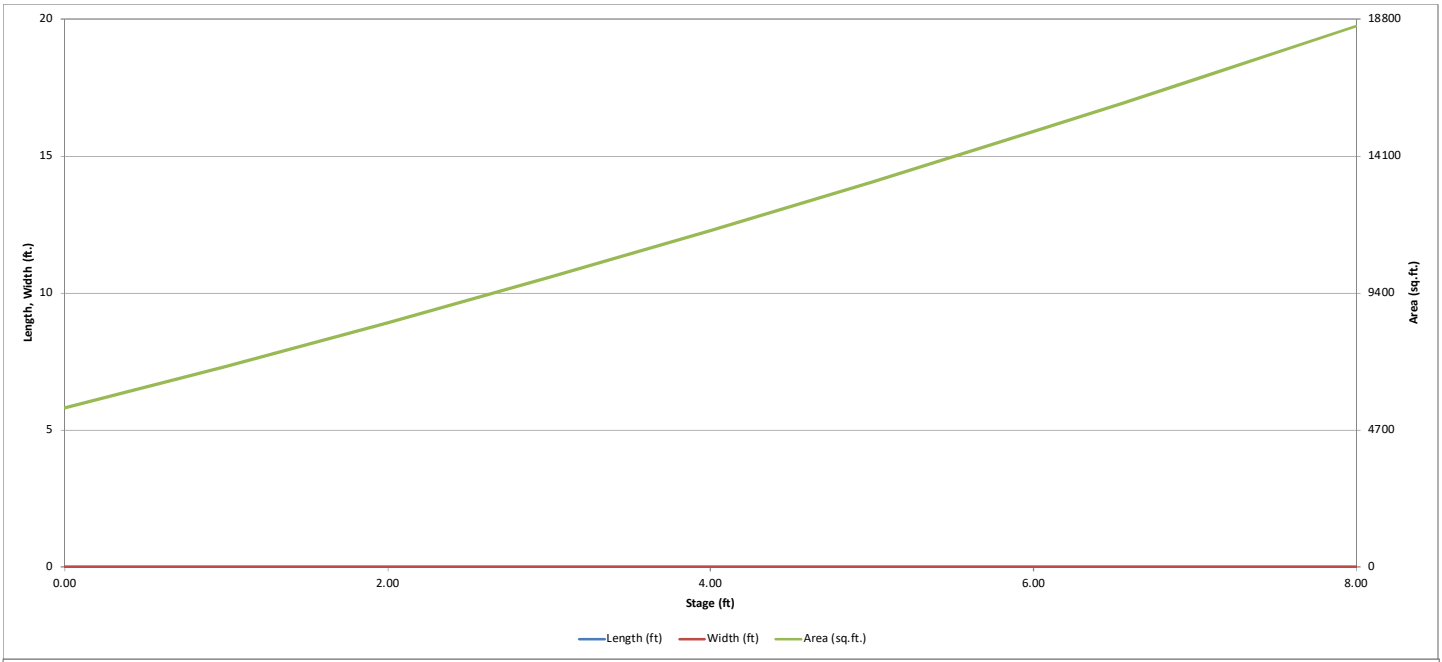
BASIN 1 EMERGENCY SPILLWAY SIZING				
EQUATION	**SPILLWAY SIDE SLOPE**	**WEIR COEFFICIENT "C"**	**H (FT)**	**Q (CFS)**
SLOPING	3	3.0	0.25	0.11

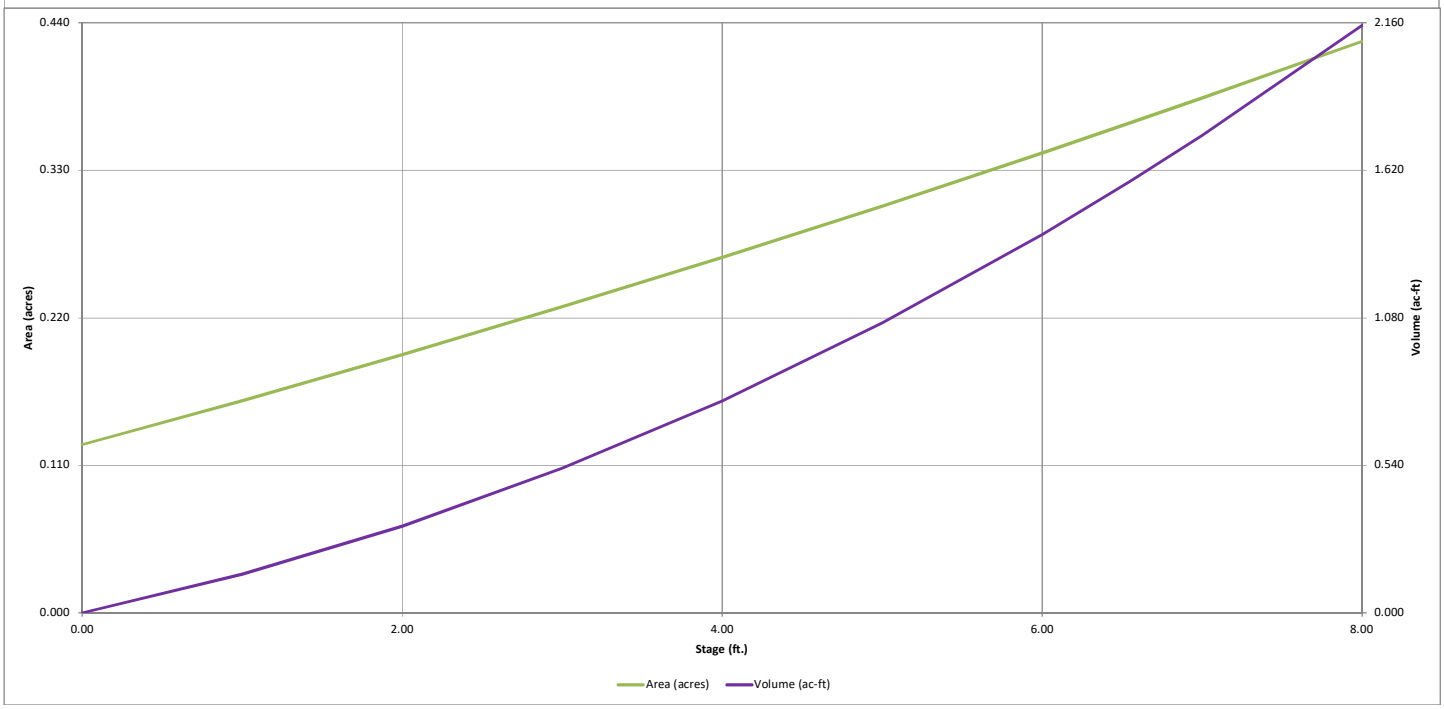
SPILLWAY CAPACITY = 100-YR FLOW (CFS)	28.03

EQUATION	**Q (CFS)**	**WEIR COEFFICIENT "C"**	**H (FT)**	**MINIMUM SPILLWAY LENGTH "L" (FT)**
BROAD-CRESTED	27.92	3.0	0.25	74.45

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)



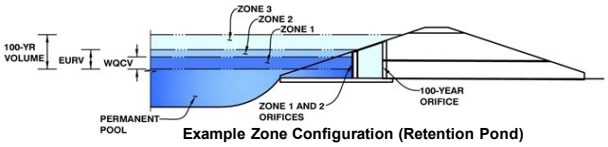


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)

Project: 8780 Rosemary Street

Basin ID: Basin A



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	SF	
Watershed Area =	5.43	acres
Watershed Length =	957	ft
Watershed Length to Centroid =	479	ft
Watershed Slope =	0.013	ft/ft
Watershed Imperviousness =	77.00%	percent
Percentage Hydrologic Soil Group A =	19.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	81.0%	percent
Target WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths =	Commerce City - Civic Center	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.112	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.435	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.97 in.) =	0.320	acre-feet	0.97	inches
5-yr Runoff Volume (P1 = 1.37 in.) =	0.489	acre-feet	1.37	inches
10-yr Runoff Volume (P1 = 1.55 in.) =	0.568	acre-feet	1.55	inches
25-yr Runoff Volume (P1 = 1.75 in.) =	0.672	acre-feet		inches
50-yr Runoff Volume (P1 = 2.24 in.) =	0.900	acre-feet	2.24	inches
100-yr Runoff Volume (P1 = 2.58 in.) =	1.069	acre-feet	2.58	inches
500-yr Runoff Volume (P1 = 3.35 in.) =	1.436	acre-feet		inches
Approximate 2-yr Detention Volume =	0.299	acre-feet		
Approximate 5-yr Detention Volume =	0.456	acre-feet		
Approximate 10-yr Detention Volume =	0.512	acre-feet		
Approximate 25-yr Detention Volume =	0.548	acre-feet		
Approximate 50-yr Detention Volume =	0.648	acre-feet		
Approximate 100-yr Detention Volume =	0.711	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.112	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.323	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.276	acre-feet
Total Detention Basin Volume =	0.711	acre-feet
Initial Surcharge Volume (ISV) =	N/A	ft^3
Initial Surcharge Depth (ISD) =	N/A	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	N/A	ft
Slope of Trickle Channel (S_{TC}) =	N/A	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = ft

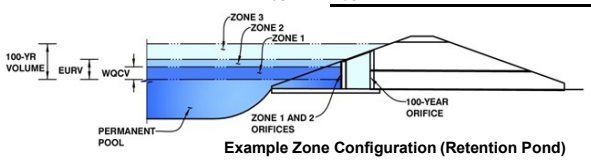
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Media Surface	--	0.00	--	--	--	5,459	0.125		
5112	--	1.00	--	--	--	6,898	0.158	6,178	0.142
5113	--	2.00	--	--	--	8,394	0.193	13,824	0.317
5114	--	3.00	--	--	--	9,946	0.228	22,994	0.528
5115	--	4.00	--	--	--	11,555	0.265	33,745	0.775
5116	--	5.00	--	--	--	13,220	0.303	46,132	1.059
5117	--	6.00	--	--	--	14,942	0.343	60,213	1.382
5117.55	--	6.55	--	--	--	15,913	0.365	68,699	1.577
5118	--	7.00	--	--	--	16,721	0.384	76,041	1.746
5119	--	8.00	--	--	--	18,555	0.426	93,679	2.151

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)

Project: 8780 Rosemary Street

Basin ID: Basin A



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.82	0.112	Filtration Media
Zone 2 (EURV)	2.58	0.323	Orifice Plate
Zone 3 (100-year)	3.76	0.276	Weir&Pipe (Restrict)
Total (all zones)		0.711	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	2.62	ft (distance below the filtration media surface)	Underdrain Orifice Area =	0.0	ft^2
Underdrain Orifice Diameter =	1.58	inches	Underdrain Orifice Centroid =	0.07	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice =	0.82	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	N/A	ft^2
Depth at top of Zone using Orifice Plate =	2.58	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	sq. inches	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.82							
Orifice Area (sq. inches)	0.11							

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.50	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	4.83	N/A	feet
Overflow Weir Front Edge Length =	25.00	N/A	feet	Overflow Weir Slope Length =	4.22	N/A	feet
Overflow Weir Grate Slope =	3.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	188.41	N/A	
Horiz. Length of Weir Sides =	4.00	N/A	feet	Overflow Grate Open Area w/o Debris =	73.36	N/A	ft^2
Overflow Grate Type =	Type C Grate	N/A		Overflow Grate Open Area w/ Debris =	36.68	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	3.62	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.39	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.24	N/A	feet
Restrictor Plate Height Above Pipe Invert =	4.90		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.10	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.55	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.16	feet
Spillway Crest Length =	78.80	feet	Stage at Top of Freeboard =	7.91	feet
Spillway End Slopes =	3.00	H:V	Basin Area at Top of Freeboard =	0.42	acres
Freeboard above Max Water Surface =	1.20	feet	Basin Volume at Top of Freeboard =	2.11	acre-ft

Calculated Parameters for Spillway

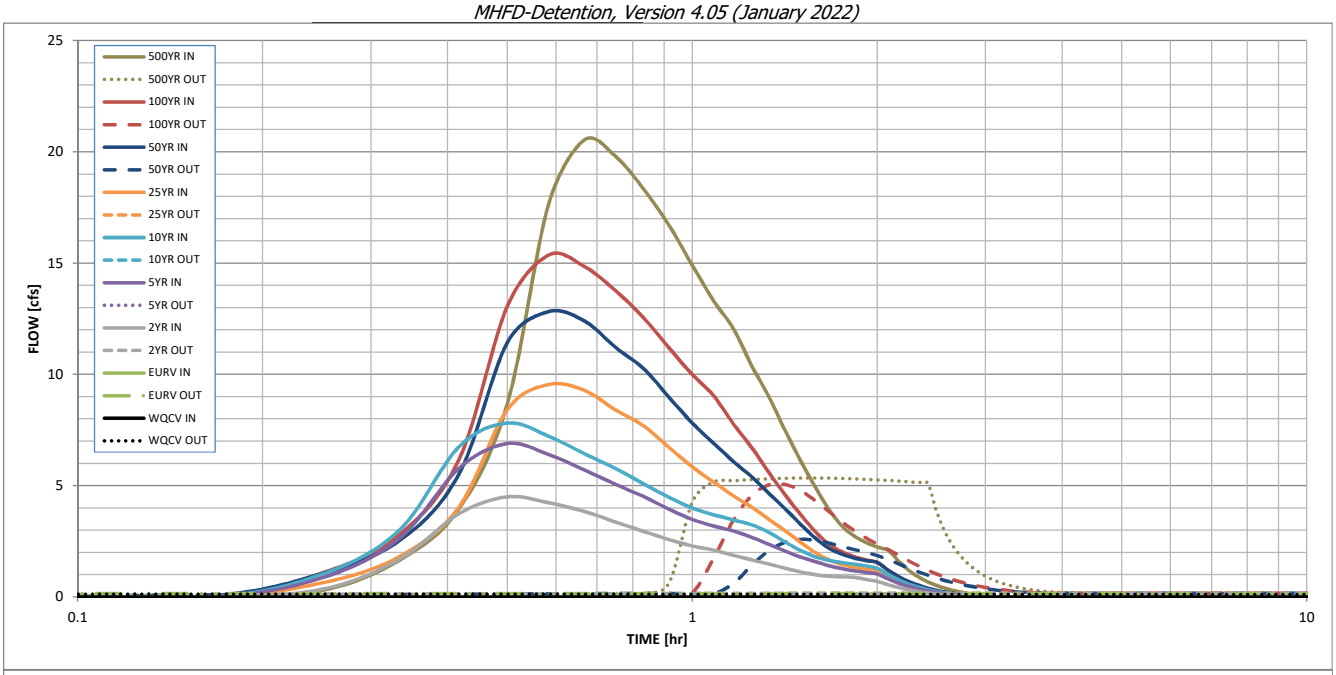
Routed Hydrograph Results

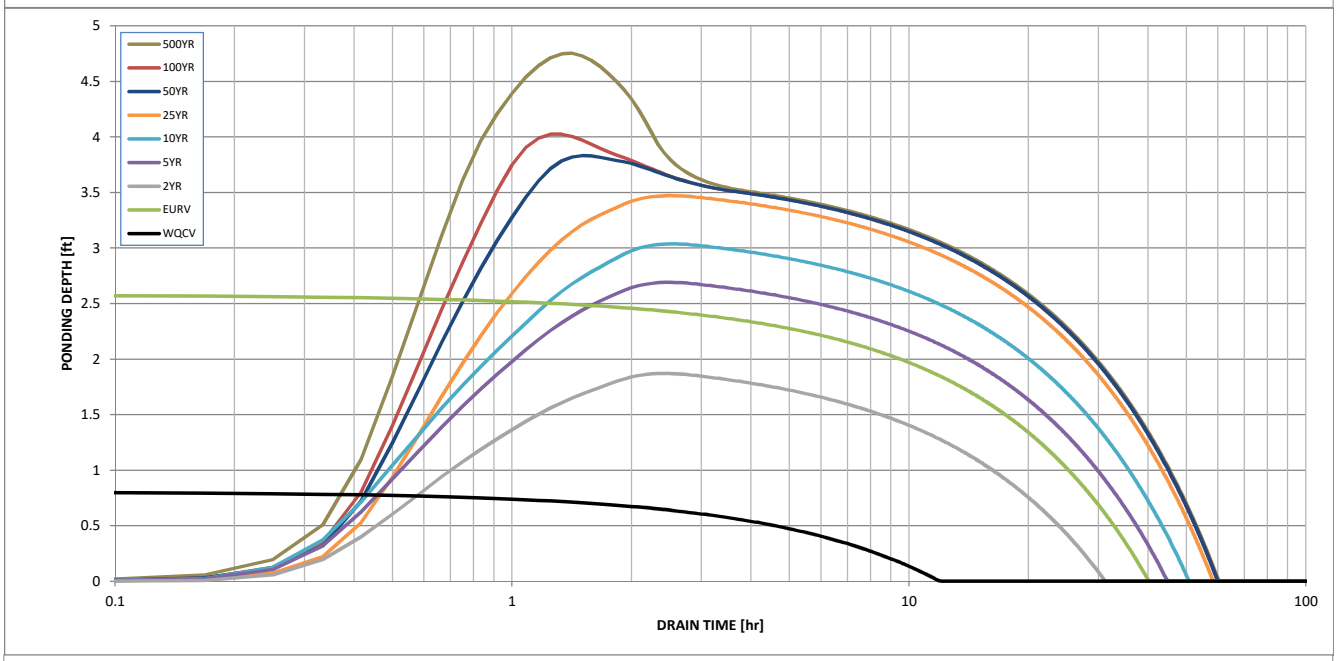
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

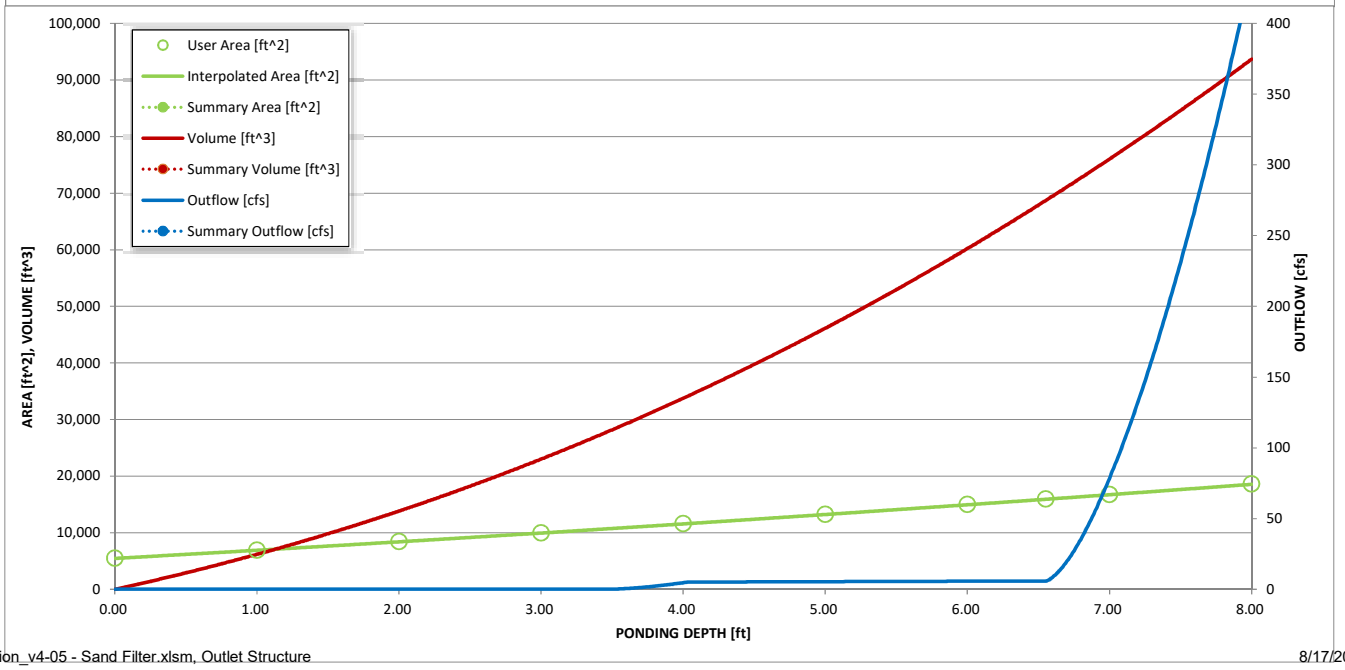
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.97	1.37	1.55	1.75	2.24	2.58	3.35
CUHP Runoff Volume (acre-ft) =	0.112	0.435	0.320	0.489	0.568	0.672	0.900	1.069	1.436
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.320	0.489	0.568	0.672	0.900	1.069	1.436
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.1	0.8	1.3	2.5	4.1	5.5	8.2
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.15	0.23	0.46	0.76	1.02	1.51
Peak Inflow Q (cfs) =	N/A	N/A	4.5	6.9	7.8	9.5	12.8	15.4	20.5
Peak Outflow Q (cfs) =	0.1	0.2	0.1	0.2	0.2	0.2	2.6	5.1	5.3
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.2	0.1	0.1	0.6	0.9	0.7
Structure Controlling Flow =	Filtration Media	Plate	Plate	Plate	Plate	Plate	Overflow Weir 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	0.0	0.1	0.1
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	12	39	30	43	49	56	57	57	56
Time to Drain 99% of Inflow Volume (hours) =	**12**	40	31	44	50	58	59	59	59
Maximum Ponding Depth (ft) =	0.81	2.58	1.87	2.69	3.04	3.47	3.83	4.03	4.75
Area at Maximum Ponding Depth (acres) =	0.15	0.21	0.19	0.22	0.23	0.25	0.26	0.27	0.29
Maximum Volume Stored (acre-ft) =	0.112	0.435	0.293	0.459	0.535	0.639	0.730	0.780	0.984

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)







DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.03	0.30
	0:15:00	0.00	0.00	0.35	0.86	1.03	0.64	1.06	1.08	1.64
	0:20:00	0.00	0.00	1.68	2.62	2.99	1.81	2.52	2.79	3.94
	0:25:00	0.00	0.00	3.73	5.77	6.74	4.02	5.50	6.15	8.68
	0:30:00	0.00	0.00	4.50	6.89	7.82	8.42	11.44	13.07	17.63
	0:35:00	0.00	0.00	4.23	6.40	7.22	9.55	12.82	15.36	20.53
	0:40:00	0.00	0.00	3.85	5.71	6.45	9.29	12.41	14.86	19.80
	0:45:00	0.00	0.00	3.37	5.06	5.77	8.41	11.22	13.76	18.33
	0:50:00	0.00	0.00	2.95	4.51	5.08	7.69	10.26	12.54	16.70
	0:55:00	0.00	0.00	2.58	3.95	4.48	6.72	8.97	11.19	14.90
	1:00:00	0.00	0.00	2.29	3.49	4.00	5.85	7.82	10.00	13.31
	1:05:00	0.00	0.00	2.10	3.19	3.70	5.16	6.91	9.04	12.06
	1:10:00	0.00	0.00	1.88	2.96	3.46	4.54	6.09	7.77	10.39
	1:15:00	0.00	0.00	1.67	2.68	3.24	4.03	5.40	6.70	8.98
	1:20:00	0.00	0.00	1.48	2.36	2.90	3.48	4.65	5.58	7.47
	1:25:00	0.00	0.00	1.30	2.06	2.47	2.97	3.96	4.58	6.13
	1:30:00	0.00	0.00	1.13	1.80	2.09	2.46	3.27	3.71	4.96
	1:35:00	0.00	0.00	1.00	1.60	1.81	2.01	2.66	2.96	3.96
	1:40:00	0.00	0.00	0.93	1.40	1.65	1.67	2.20	2.38	3.20
	1:45:00	0.00	0.00	0.90	1.27	1.55	1.47	1.93	2.04	2.75
	1:50:00	0.00	0.00	0.88	1.18	1.48	1.34	1.75	1.82	2.45
	1:55:00	0.00	0.00	0.79	1.11	1.40	1.25	1.63	1.66	2.24
	2:00:00	0.00	0.00	0.70	1.03	1.28	1.19	1.55	1.55	2.09
	2:05:00	0.00	0.00	0.55	0.81	1.00	0.93	1.21	1.19	1.61
	2:10:00	0.00	0.00	0.42	0.62	0.77	0.71	0.92	0.89	1.20
	2:15:00	0.00	0.00	0.32	0.47	0.58	0.54	0.70	0.67	0.90
	2:20:00	0.00	0.00	0.25	0.36	0.44	0.41	0.53	0.51	0.68
	2:25:00	0.00	0.00	0.19	0.27	0.33	0.31	0.39	0.38	0.51
	2:30:00	0.00	0.00	0.14	0.20	0.24	0.23	0.29	0.28	0.38
	2:35:00	0.00	0.00	0.10	0.14	0.18	0.17	0.21	0.21	0.28
	2:40:00	0.00	0.00	0.07	0.10	0.13	0.12	0.16	0.16	0.21
	2:45:00	0.00	0.00	0.05	0.07	0.09	0.09	0.11	0.11	0.15
	2:50:00	0.00	0.00	0.03	0.05	0.06	0.06	0.07	0.07	0.10
	2:55:00	0.00	0.00	0.02	0.03	0.03	0.03	0.04	0.04	0.06
	3:00:00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.03
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LANGAN

Technical Excellence
Practical Experience
Client Responsiveness

PROJECT:	**8780 ROSEMARY ST**
PROJECT NO.:	**620023001**
DATE:	**8/17/2022**
CALCULATED BY:	**SJS**
CHECKED BY:	**MCB**

RAIN GARDEN 1

Storage Volume Calculation

Area of Watershed	271251.0	ft^2	6.227	ac-ft
WCQV	0.039	watershed-inches		
WCQV (override from UD-Detention)	871.2	ft^3	0.020	ac-ft
Design Volume (WQCV)	887.6	ft^3	0.020	ac-ft
Design Volume Override (100yr Volume)	4791.6	ft^3	0.110	ac-ft
Surcharge Volume	4791.6	ft^3	0.110	ac-ft
Total Design Volume	9583.2	ft^3	0.220	ac-ft

Flat Area Calculation

Area of Watershed	271251	ft^2
Imperviousness (%)	0.07	
Min. Flat Filter Area	379.8	ft^2

Underdrain Diameter Calculation

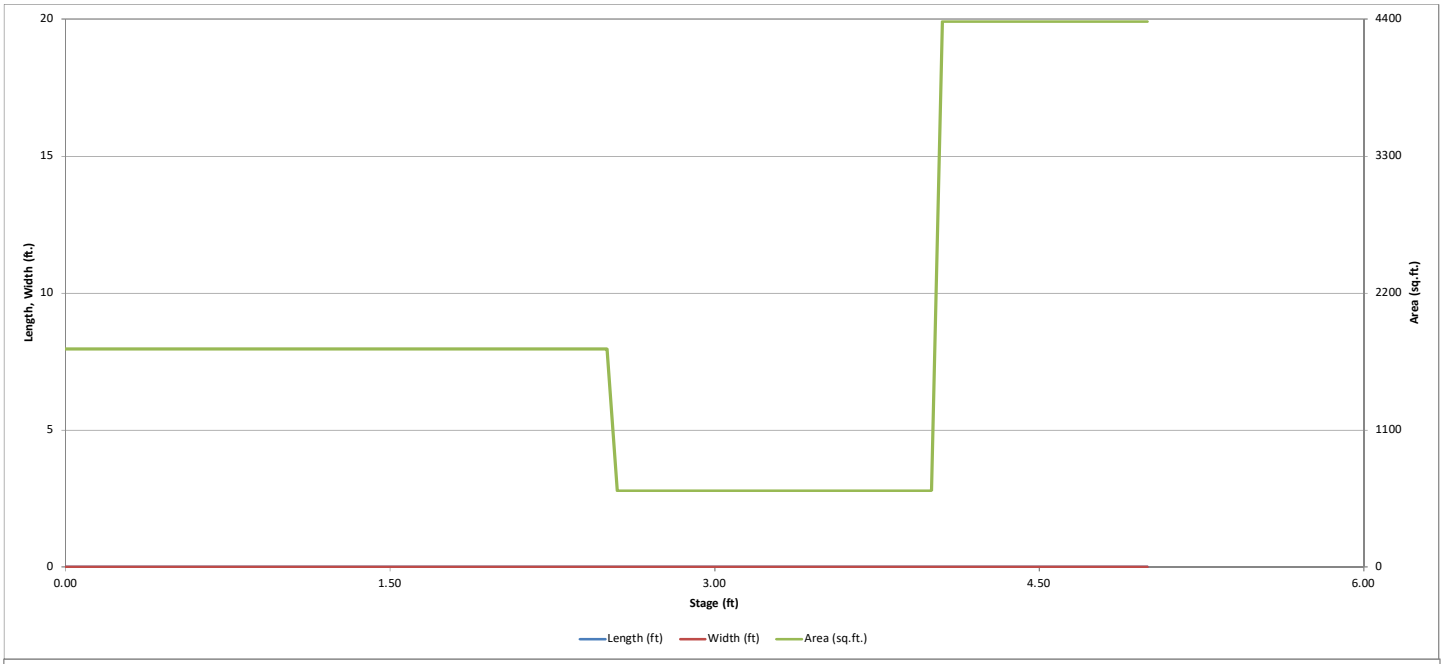
y	2.388	ft	28.65	in
V	871.2	ft^3	0.020	ac-ft
D for 12hr Drain Time (change this)	0.70	in		
D for 12hr Drain Time (must be less than above)	0.66	in		

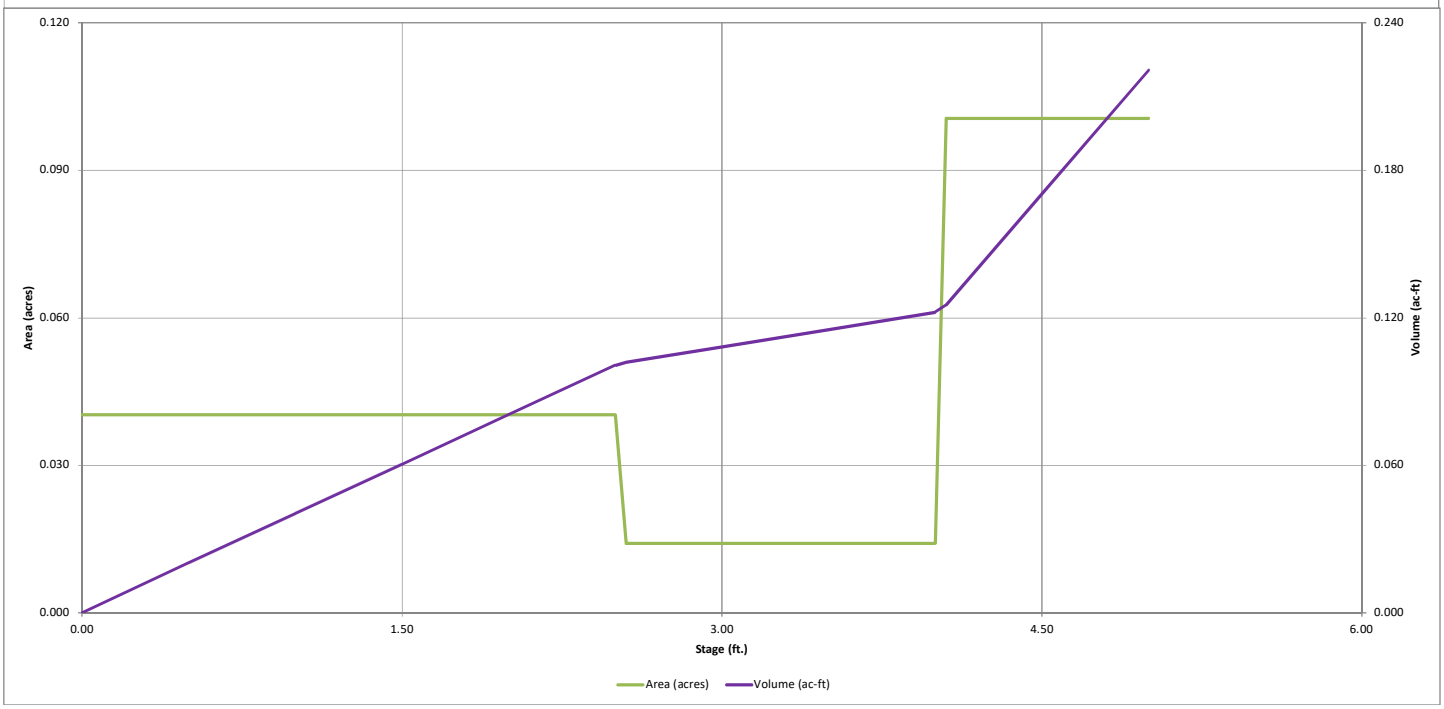
Volume Calculation (for square geometry)

H (inches)	12	Ponding	V(ft^3) =	4380
Void Ratio	1			
H (inches)	18	Growing Media	V(ft^3) =	919.8
Void Ratio	0.14			
H (inches)	30	Filter Material	V(ft^3) =	4380
Void Ratio	0.4			
Rain Garden Width (ft)	12	Total Area (ft^3) =	4380	
Rain Garden Length (ft)	365	Total V (ft^3) =	9679.8	

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)



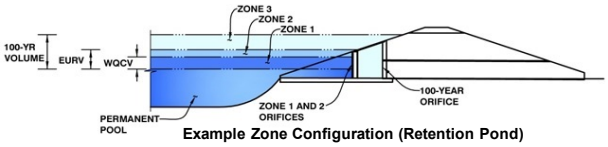


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)

Project: 8780 Rosemary Street

Basin ID: Raingarden 1



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**RG**	
Watershed Area =	6.23	acres
Watershed Length =	861	ft
Watershed Length to Centroid =	431	ft
Watershed Slope =	0.021	ft/ft
Watershed Imperviousness =	7.00%	percent
Percentage Hydrologic Soil Group A =	88.4%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	11.6%	percent
Target WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths =	Commerce City - Civic Center	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.020	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.030	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.97 in.) =	0.008	acre-feet	0.97	inches
5-yr Runoff Volume (P1 = 1.37 in.) =	0.023	acre-feet	1.37	inches
10-yr Runoff Volume (P1 = 1.55 in.) =	0.030	acre-feet	1.55	inches
25-yr Runoff Volume (P1 = 1.75 in.) =	0.087	acre-feet		inches
50-yr Runoff Volume (P1 = 2.24 in.) =	0.250	acre-feet	2.24	inches
100-yr Runoff Volume (P1 = 2.58 in.) =	0.415	acre-feet	2.58	inches
500-yr Runoff Volume (P1 = 3.35 in.) =	0.781	acre-feet		inches
Approximate 2-yr Detention Volume =	0.015	acre-feet		
Approximate 5-yr Detention Volume =	0.027	acre-feet		
Approximate 10-yr Detention Volume =	0.036	acre-feet		
Approximate 25-yr Detention Volume =	0.047	acre-feet		
Approximate 50-yr Detention Volume =	0.072	acre-feet		
Approximate 100-yr Detention Volume =	0.130	acre-feet		

Define Zones and Basin Geometry

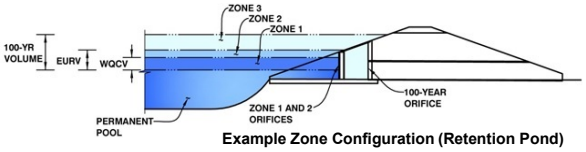
Zone 1 Volume (WQCV) =	0.020	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.009	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.100	acre-feet
Total Detention Basin Volume =	0.130	acre-feet
Initial Surcharge Volume (ISV) =	N/A	ft^3
Initial Surcharge Depth (ISD) =	N/A	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	N/A	ft
Slope of Trickle Channel (S_{TC}) =	N/A	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Media Surface	--	0.00	--	--	--	1,752	0.040		
5113.75	--	0.50	--	--	--	1,752	0.040	876	0.020
5114.25	--	1.00	--	--	--	1,752	0.040	1,752	0.040
5114.75	--	1.50	--	--	--	1,752	0.040	2,628	0.060
5115.25	--	2.00	--	--	--	1,752	0.040	3,504	0.080
5115.75	--	2.50	--	--	--	1,752	0.040	4,380	0.101
5115.8	--	2.55	--	--	--	613	0.014	4,439	0.102
5116.25	--	3.00	--	--	--	613	0.014	4,715	0.108
5116.75	--	3.50	--	--	--	613	0.014	5,022	0.115
5117.25	--	4.00	--	--	--	613	0.014	5,328	0.122
5117.3	--	4.05	--	--	--	4,380	0.101	5,452	0.125
5117.75	--	4.50	--	--	--	4,380	0.101	7,423	0.170
5118.25	--	5.00	--	--	--	4,380	0.101	9,613	0.221

Project: 8780 Rosemary Street

Basin ID: Raingarden 1



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.51	0.020	Filtration Media
Zone 2 (EURV)	0.74	0.009	Not Utilized
Zone 3 (100-year)	4.10	0.100	Weir&Pipe (Restrict)
Total (all zones)		0.130	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	4.92	ft (distance below the filtration media surface)	Underdrain Orifice Area =	0.0	ft^2
Underdrain Orifice Diameter =	0.58	inches	Underdrain Orifice Centroid =	0.02	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice =	N/A	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	N/A	ft^2
Depth at top of Zone using Orifice Plate =	N/A	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	sq. inches	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (optional)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.60	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	4.60	N/A	feet
Overflow Weir Front Edge Length =	10.00	N/A	feet	Overflow Weir Slope Length =	0.00	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	0.00	N/A	
Horiz. Length of Weir Sides =	0.00	N/A	feet	Overflow Grate Open Area w/o Debris =	0.00	N/A	ft^2
Overflow Grate Type =	Close Mesh Grate	N/A		Overflow Grate Open Area w/ Debris =	0.00	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	5.08	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.76	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.39	N/A	feet
Restrictor Plate Height Above Pipe Invert =	8.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.46	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.86	feet
Spillway Crest Length =	2.00	feet	Stage at Top of Freeboard =	6.86	feet
Spillway End Slopes =	0.00	H:V	Basin Area at Top of Freeboard =	0.10	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	0.22	acre-ft

Calculated Parameters for Spillway

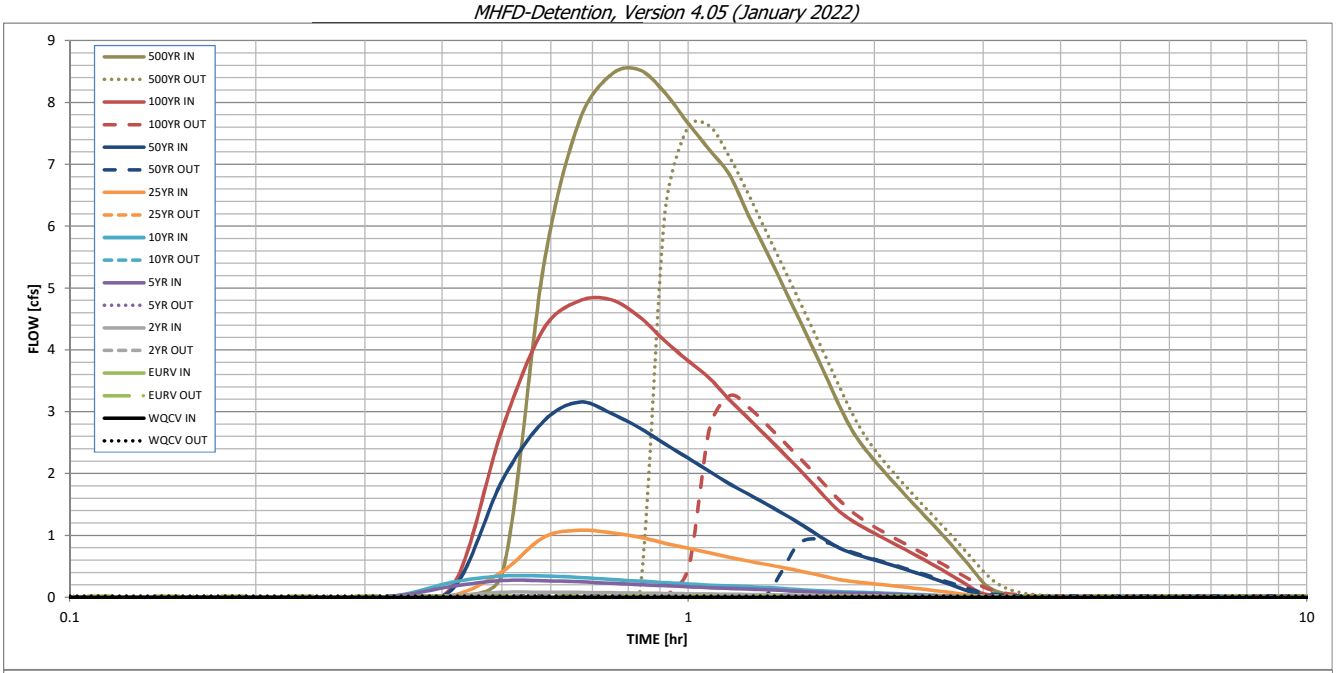
Routed Hydrograph Results

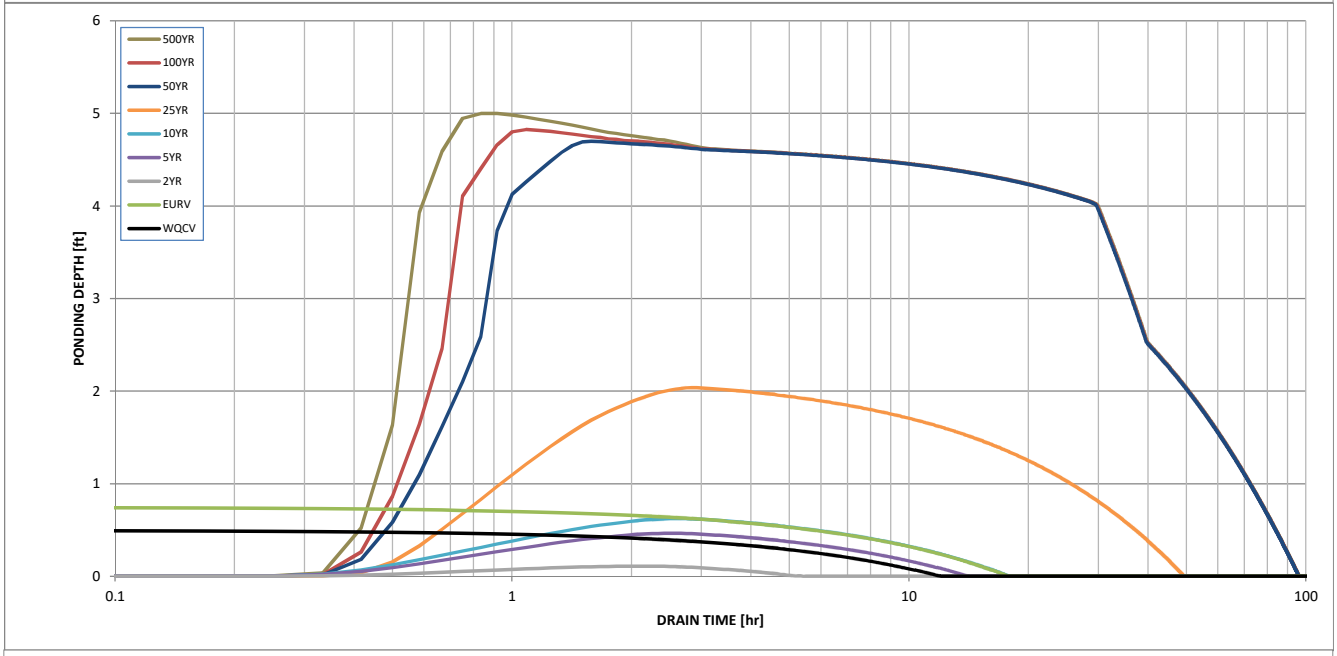
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

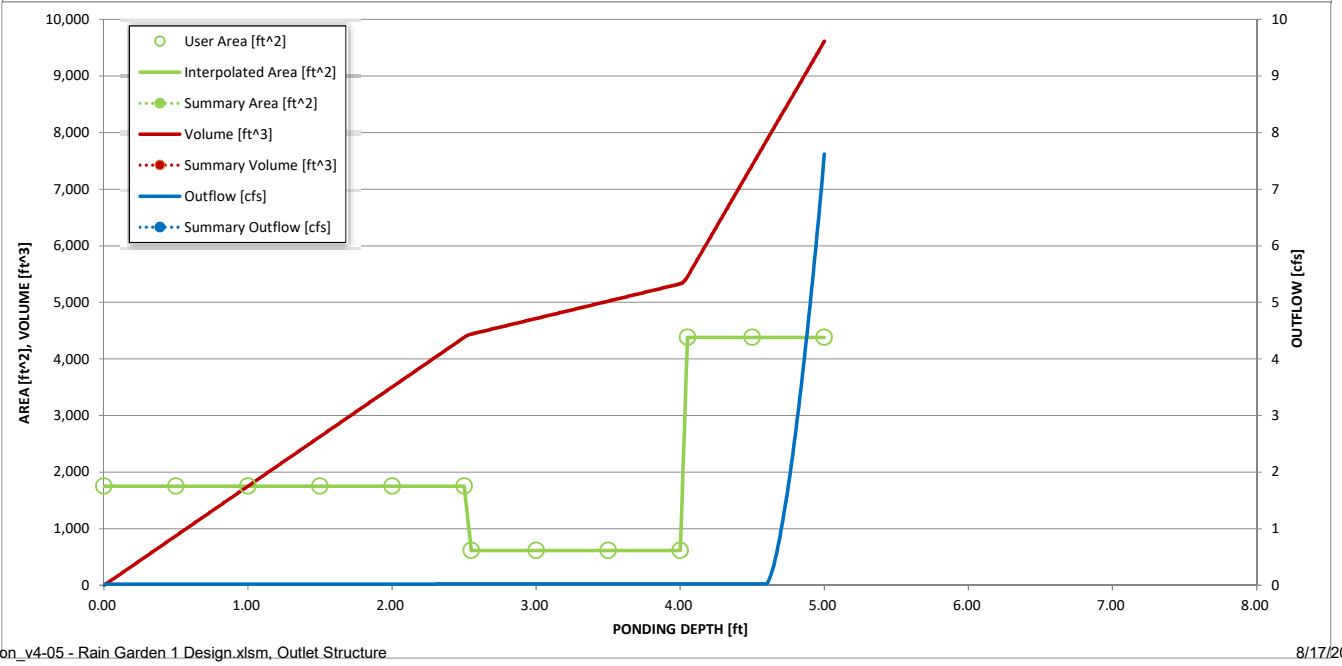
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.97	1.37	1.55	1.75	2.24	2.58	3.35
CUHP Runoff Volume (acre-ft) =	0.020	0.030	0.008	0.023	0.030	0.087	0.250	0.415	0.781
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.008	0.023	0.030	0.087	0.250	0.415	0.781
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.1	0.1	0.7	2.8	4.4	8.1
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.00	0.01	0.02	0.12	0.45	0.71	1.31
Peak Inflow Q (cfs) =	N/A	N/A	0.1	0.3	0.3	1.1	3.2	4.8	8.5
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.3	7.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.3	0.2	0.0	0.3	0.7	0.9
Structure Controlling Flow =	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Overflow Weir 1	Overflow Weir 1	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	12	17	5	14	18	48	92	89	82
Time to Drain 99% of Inflow Volume (hours) =	**12**	18	6	14	18	49	95	94	92
Maximum Ponding Depth (ft) =	0.50	0.75	0.11	0.47	0.62	2.04	4.70	4.83	5.00
Area at Maximum Ponding Depth (acres) =	0.04	0.04	0.04	0.04	0.04	0.04	0.10	0.10	0.10
Maximum Volume Stored (acre-ft) =	0.020	0.030	0.004	0.019	0.025	0.082	0.190	0.203	0.221

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)







DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:15:00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01
	0:20:00	0.00	0.00	0.01	0.02	0.02	0.01	0.02	0.02	0.03
	0:25:00	0.00	0.00	0.03	0.18	0.25	0.04	0.15	0.20	0.38
	0:30:00	0.00	0.00	0.08	0.27	0.35	0.42	1.89	2.72	5.35
	0:35:00	0.00	0.00	0.08	0.27	0.35	0.97	2.85	4.34	7.71
	0:40:00	0.00	0.00	0.08	0.25	0.32	1.09	3.16	4.79	8.45
	0:45:00	0.00	0.00	0.08	0.23	0.29	1.04	2.98	4.81	8.53
	0:50:00	0.00	0.00	0.07	0.21	0.26	0.97	2.74	4.54	8.16
	0:55:00	0.00	0.00	0.06	0.19	0.24	0.87	2.48	4.15	7.66
	1:00:00	0.00	0.00	0.06	0.17	0.22	0.79	2.25	3.82	7.23
	1:05:00	0.00	0.00	0.06	0.16	0.20	0.72	2.03	3.54	6.83
	1:10:00	0.00	0.00	0.05	0.15	0.19	0.65	1.83	3.19	6.18
	1:15:00	0.00	0.00	0.05	0.13	0.18	0.59	1.67	2.90	5.62
	1:20:00	0.00	0.00	0.05	0.12	0.16	0.54	1.52	2.62	5.08
	1:25:00	0.00	0.00	0.04	0.11	0.15	0.49	1.37	2.36	4.56
	1:30:00	0.00	0.00	0.04	0.10	0.13	0.44	1.22	2.11	4.07
	1:35:00	0.00	0.00	0.04	0.09	0.11	0.39	1.07	1.86	3.59
	1:40:00	0.00	0.00	0.03	0.08	0.10	0.34	0.93	1.61	3.13
	1:45:00	0.00	0.00	0.03	0.07	0.09	0.29	0.80	1.40	2.73
	1:50:00	0.00	0.00	0.03	0.07	0.09	0.26	0.72	1.25	2.44
	1:55:00	0.00	0.00	0.03	0.06	0.08	0.24	0.66	1.14	2.21
	2:00:00	0.00	0.00	0.03	0.06	0.08	0.22	0.61	1.04	2.01
	2:05:00	0.00	0.00	0.02	0.05	0.07	0.20	0.55	0.94	1.82
	2:10:00	0.00	0.00	0.02	0.05	0.06	0.18	0.50	0.85	1.64
	2:15:00	0.00	0.00	0.02	0.04	0.05	0.16	0.45	0.77	1.47
	2:20:00	0.00	0.00	0.02	0.04	0.05	0.15	0.40	0.68	1.31
	2:25:00	0.00	0.00	0.01	0.03	0.04	0.13	0.35	0.60	1.15
	2:30:00	0.00	0.00	0.01	0.03	0.03	0.11	0.30	0.52	1.00
	2:35:00	0.00	0.00	0.01	0.02	0.03	0.09	0.25	0.43	0.84
	2:40:00	0.00	0.00	0.01	0.02	0.02	0.08	0.20	0.35	0.69
	2:45:00	0.00	0.00	0.01	0.01	0.02	0.06	0.15	0.27	0.54
	2:50:00	0.00	0.00	0.00	0.01	0.01	0.04	0.10	0.19	0.38
	2:55:00	0.00	0.00	0.00	0.01	0.01	0.02	0.05	0.11	0.23
	3:00:00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.06	0.14
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.09
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LANGAN

Technical Excellence
Practical Experience
Client Responsiveness

PROJECT:	**8780 ROSEMARY ST**
PROJECT NO.:	**620023001**
DATE:	**8/17/2022**
CALCULATED BY:	**SJS**
CHECKED BY:	**MCB**

RAIN GARDEN 2

Storage Volume Calculation

Area of Watershed	39974.0	ft^2	0.918	ac-ft
WCQV	0.152	watershed-inches		
WCQV (override from UD-Detention)	522.7	ft^3	0.012	ac-ft
Design Volume (WQCV)	507.2	ft^3	0.012	ac-ft
Design Volume Override (100yr Volume)	3397.7	ft^3	0.078	ac-ft
Surcharge Volume	3397.7	ft^3	0.012	ac-ft
Total Design Volume	6795.4	ft^3	0.090	ac-ft

Flat Area Calculation

Area of Watershed	39974	ft^2
Imperviousness (%)	0.44	
Min. Flat Filter Area	351.8	ft^2

Underdrain Diameter Calculation

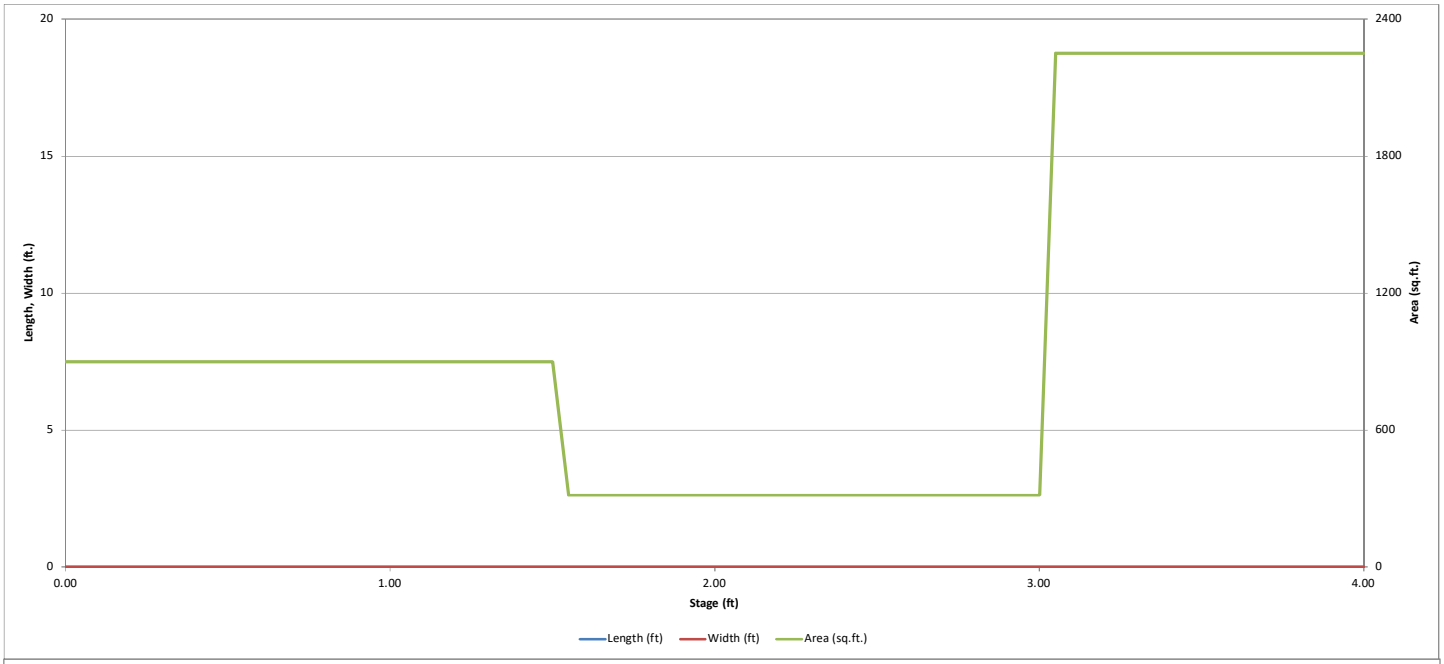
y	2.896	ft	34.75	in
V	522.7	ft^3	0.012	ac-ft
D for 12hr Drain Time (change this)	0.50	in		
D for 12hr Drain Time (must be less than above)	0.49	in		

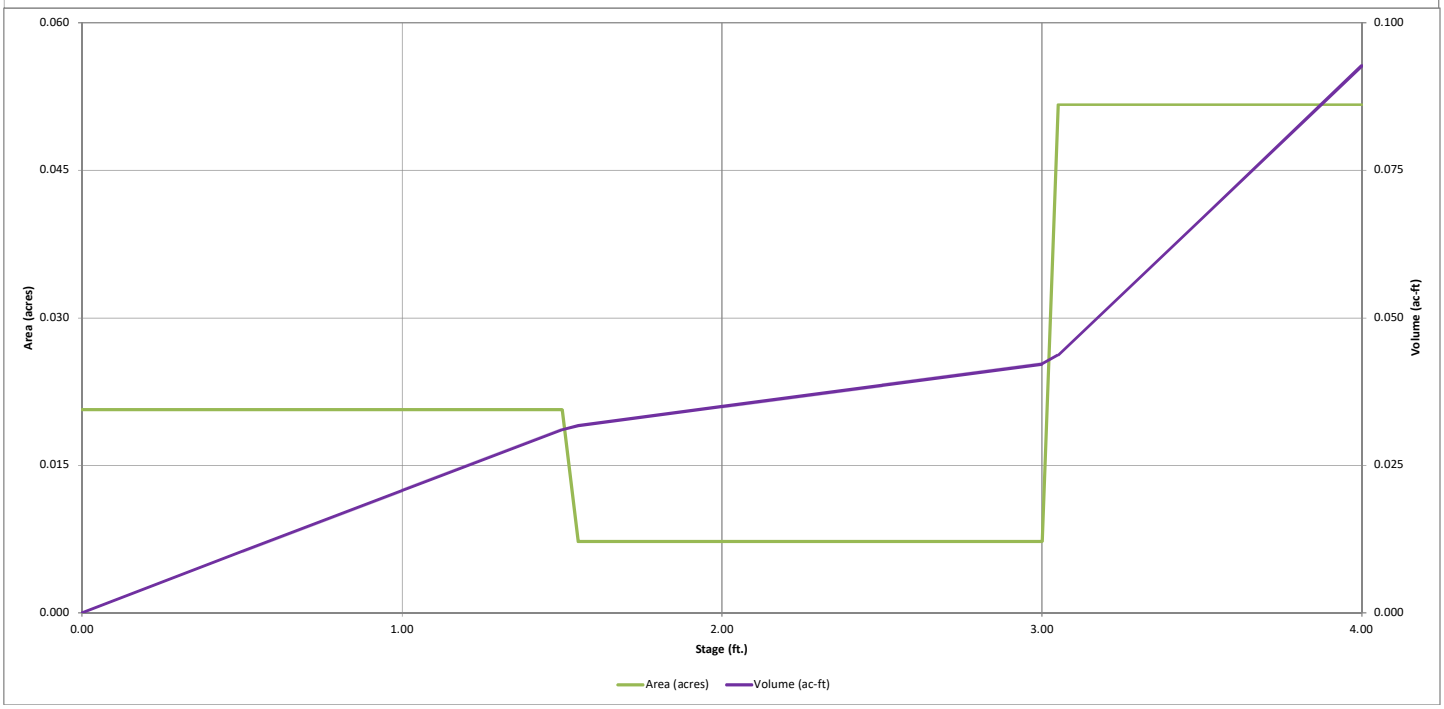
Volume Calculation (for square geometry)

H (inches)	18	Ponding	V(ft^3) =	3600
Void Ratio	1			
H (inches)	18	Growing Media	V(ft^3) =	504
Void Ratio	0.14			
H (inches)	36	Filter Material	V(ft^3) =	2880
Void Ratio	0.4			
Rain Garden Width (ft)	30	Total Area (ft^3) =	2400	
Rain Garden Length (ft)	80	Total V (ft^3) =	6984	

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)



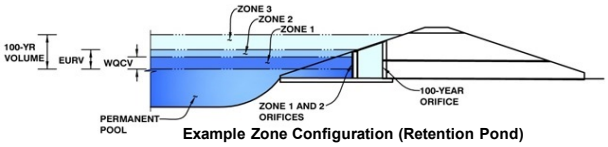


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)

Project: 8780 Rosemary Street

Basin ID: Raingarden 2



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	SF	
Watershed Area =	0.92	acres
Watershed Length =	505	ft
Watershed Length to Centroid =	253	ft
Watershed Slope =	0.019	ft/ft
Watershed Imperviousness =	44.00%	percent
Percentage Hydrologic Soil Group A =	10.7%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	89.3%	percent
Target WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths =	Commerce City - Civic Center	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.012	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.039	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.97 in.) =	0.030	acre-feet	0.97	inches
5-yr Runoff Volume (P1 = 1.37 in.) =	0.054	acre-feet	1.37	inches
10-yr Runoff Volume (P1 = 1.55 in.) =	0.066	acre-feet	1.55	inches
25-yr Runoff Volume (P1 = 1.75 in.) =	0.085	acre-feet		inches
50-yr Runoff Volume (P1 = 2.24 in.) =	0.122	acre-feet	2.24	inches
100-yr Runoff Volume (P1 = 2.58 in.) =	0.151	acre-feet	2.58	inches
500-yr Runoff Volume (P1 = 3.35 in.) =	0.212	acre-feet		inches
Approximate 2-yr Detention Volume =	0.027	acre-feet		
Approximate 5-yr Detention Volume =	0.045	acre-feet		
Approximate 10-yr Detention Volume =	0.050	acre-feet		
Approximate 25-yr Detention Volume =	0.055	acre-feet		
Approximate 50-yr Detention Volume =	0.065	acre-feet		
Approximate 100-yr Detention Volume =	0.078	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.012	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.027	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.039	acre-feet
Total Detention Basin Volume =	0.078	acre-feet
Initial Surcharge Volume (ISV) =	N/A	ft^3
Initial Surcharge Depth (ISD) =	N/A	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	N/A	ft
Slope of Trickle Channel (S_{TC}) =	N/A	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = ft

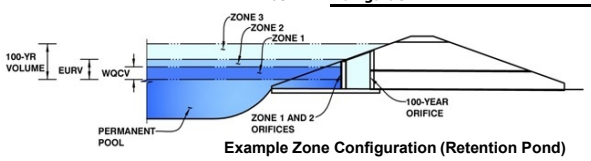
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Media Surface	--	0.00	--	--	--	900	0.021		
5114	--	0.50	--	--	--	900	0.021	450	0.010
5114.5	--	1.00	--	--	--	900	0.021	900	0.021
5115	--	1.50	--	--	--	900	0.021	1,350	0.031
5115.05	--	1.55	--	--	--	315	0.007	1,380	0.032
5115.5	--	2.00	--	--	--	315	0.007	1,522	0.035
5116	--	2.50	--	--	--	315	0.007	1,680	0.039
5116.5	--	3.00	--	--	--	315	0.007	1,837	0.042
5116.55	--	3.05	--	--	--	2,250	0.052	1,901	0.044
5117	--	3.50	--	--	--	2,250	0.052	2,913	0.067
5117.5	--	4.00	--	--	--	2,250	0.052	4,038	0.093

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)

Project: 8780 Rosemary Street

Basin ID: Raingarden 2



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.57	0.012	Filtration Media
Zone 2 (EURV)	2.52	0.027	Not Utilized
Zone 3 (100-year)	3.72	0.039	Weir&Pipe (Restrict)
Total (all zones)		0.078	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	3.92	ft (distance below the filtration media surface)	Underdrain Orifice Area =	0.0	ft^2
Underdrain Orifice Diameter =	0.48	inches	Underdrain Orifice Centroid =	0.02	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice =	N/A	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	N/A	ft^2
Depth at top of Zone using Orifice Plate =	N/A	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	sq. inches	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (optional)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.80	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.80	N/A	feet
Overflow Weir Front Edge Length =	16.00	N/A	feet	Overflow Weir Slope Length =	0.00	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	0.00	N/A	
Horiz. Length of Weir Sides =	0.00	N/A	feet	Overflow Grate Open Area w/o Debris =	0.00	N/A	ft^2
Overflow Grate Type =	Close Mesh Grate	N/A		Overflow Grate Open Area w/ Debris =	0.00	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	5.08	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.04	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.05	N/A	feet
Restrictor Plate Height Above Pipe Invert =	1.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	0.48	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=		ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=		feet
Spillway Crest Length =		feet	Stage at Top of Freeboard =		feet
Spillway End Slopes =		H:V	Basin Area at Top of Freeboard =		acres
Freeboard above Max Water Surface =		feet	Basin Volume at Top of Freeboard =		acre-ft

Calculated Parameters for Spillway

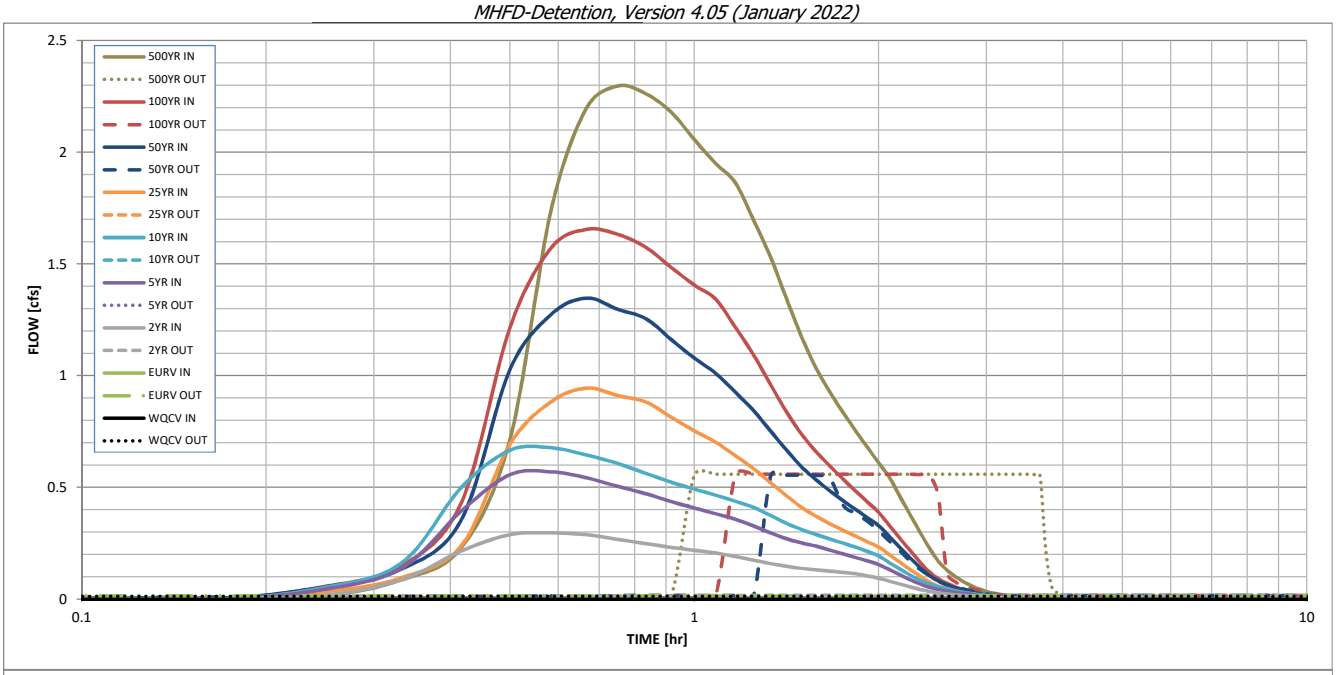
Routed Hydrograph Results

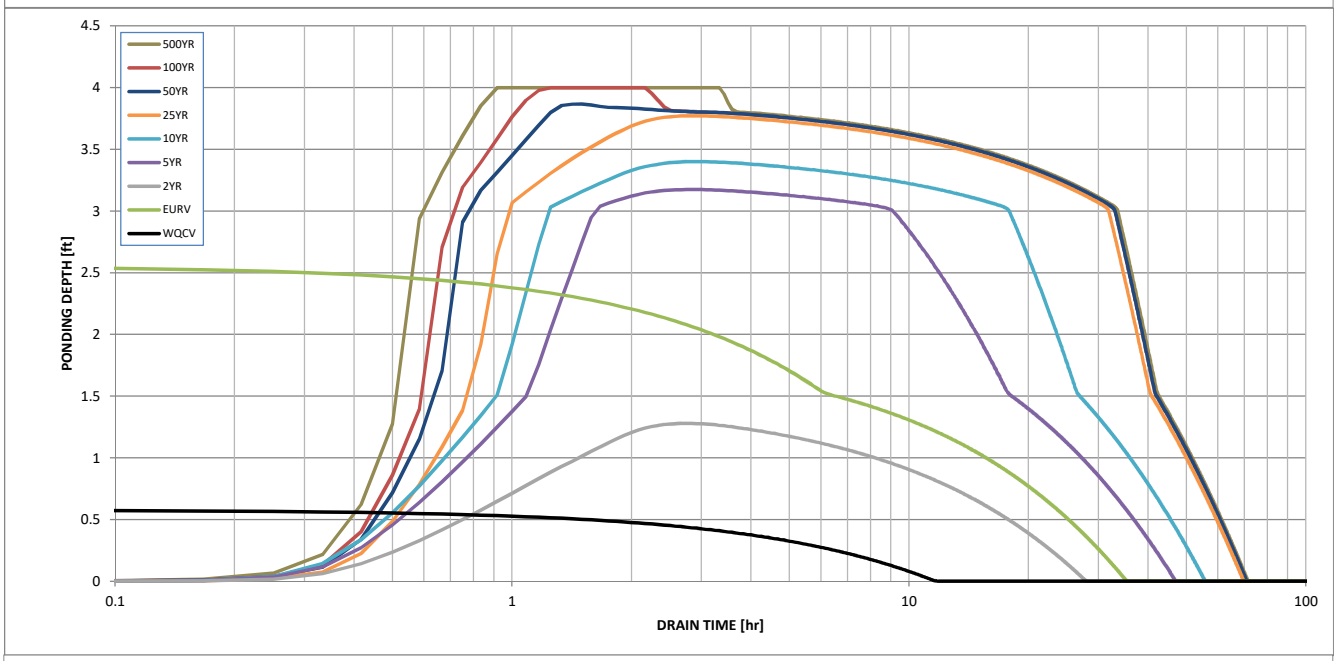
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

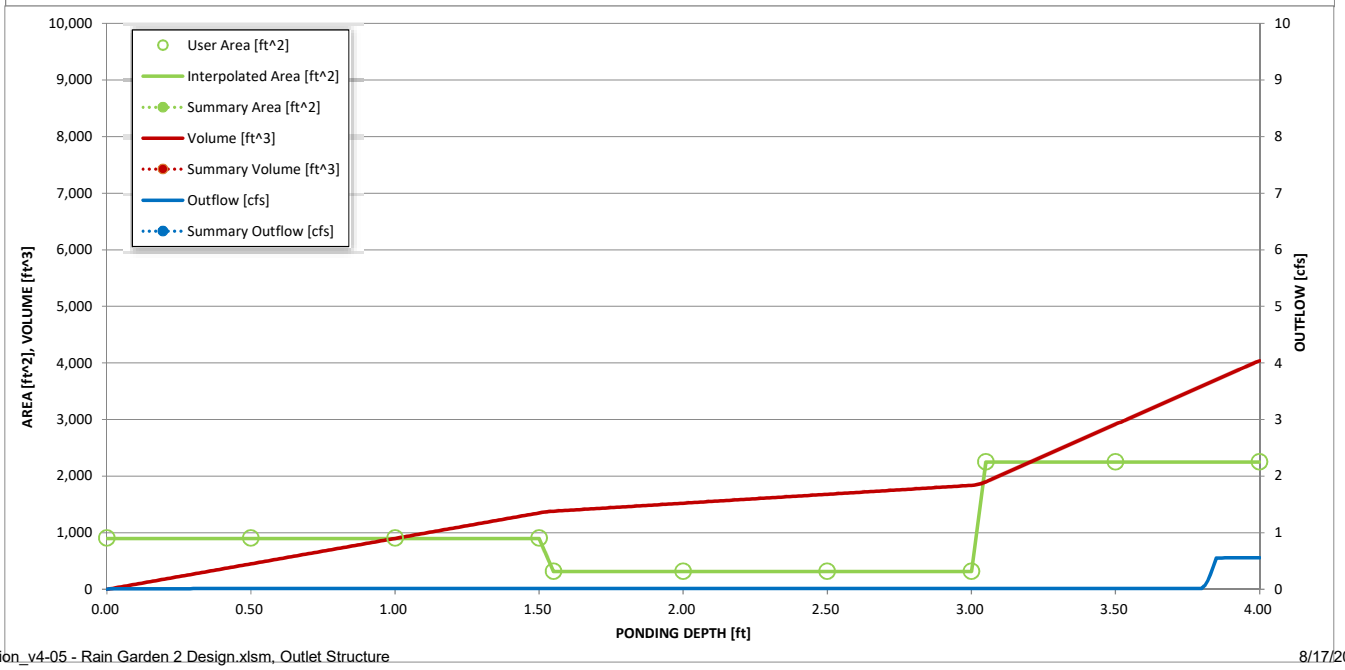
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.97	1.37	1.55	1.75	2.24	2.58	3.35
CUHP Runoff Volume (acre-ft) =	0.012	0.039	0.030	0.054	0.066	0.085	0.122	0.151	0.212
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.030	0.054	0.066	0.085	0.122	0.151	0.212
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.2	0.2	0.4	0.7	0.9	1.3
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.17	0.24	0.45	0.73	0.97	1.43
Peak Inflow Q (cfs) =	N/A	N/A	0.3	0.6	0.7	0.9	1.3	1.7	2.3
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.1	0.0	0.8	0.6	0.4
Structure Controlling Flow =	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Filtration Media	Outlet Plate 1	N/A	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	11	34	27	45	54	67	67	66	65
Time to Drain 99% of Inflow Volume (hours) =	**12**	35	28	47	55	69	70	69	69
Maximum Ponding Depth (ft) =	0.59	2.57	1.28	3.17	3.40	3.77	3.87	4.00	4.00
Area at Maximum Ponding Depth (acres) =	0.02	0.01	0.02	0.05	0.05	0.05	0.05	0.05	0.05
Maximum Volume Stored (acre-ft) =	0.012	0.039	0.026	0.050	0.062	0.081	0.085	0.093	0.093

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)







DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	0:15:00	0.00	0.00	0.02	0.04	0.05	0.03	0.06	0.06	0.09
	0:20:00	0.00	0.00	0.09	0.14	0.16	0.10	0.14	0.15	0.23
	0:25:00	0.00	0.00	0.22	0.40	0.50	0.24	0.36	0.43	0.71
	0:30:00	0.00	0.00	0.29	0.56	0.67	0.69	1.03	1.21	1.74
	0:35:00	0.00	0.00	0.30	0.57	0.68	0.88	1.27	1.57	2.20
	0:40:00	0.00	0.00	0.29	0.54	0.65	0.94	1.35	1.65	2.30
	0:45:00	0.00	0.00	0.27	0.50	0.61	0.91	1.30	1.63	2.26
	0:50:00	0.00	0.00	0.25	0.47	0.56	0.88	1.26	1.57	2.18
	0:55:00	0.00	0.00	0.23	0.44	0.52	0.81	1.16	1.49	2.06
	1:00:00	0.00	0.00	0.22	0.41	0.49	0.75	1.08	1.41	1.95
	1:05:00	0.00	0.00	0.21	0.38	0.47	0.70	1.01	1.34	1.86
	1:10:00	0.00	0.00	0.19	0.36	0.44	0.64	0.93	1.22	1.69
	1:15:00	0.00	0.00	0.17	0.33	0.41	0.58	0.84	1.09	1.53
	1:20:00	0.00	0.00	0.16	0.30	0.37	0.52	0.75	0.96	1.34
	1:25:00	0.00	0.00	0.15	0.27	0.34	0.46	0.67	0.84	1.17
	1:30:00	0.00	0.00	0.14	0.25	0.31	0.41	0.59	0.74	1.03
	1:35:00	0.00	0.00	0.13	0.24	0.29	0.37	0.53	0.66	0.92
	1:40:00	0.00	0.00	0.12	0.22	0.27	0.34	0.48	0.59	0.83
	1:45:00	0.00	0.00	0.12	0.20	0.25	0.31	0.44	0.54	0.75
	1:50:00	0.00	0.00	0.11	0.19	0.23	0.28	0.40	0.48	0.68
	1:55:00	0.00	0.00	0.10	0.17	0.21	0.26	0.36	0.44	0.61
	2:00:00	0.00	0.00	0.09	0.16	0.19	0.23	0.33	0.39	0.54
	2:05:00	0.00	0.00	0.08	0.13	0.16	0.20	0.28	0.33	0.46
	2:10:00	0.00	0.00	0.07	0.11	0.13	0.17	0.23	0.27	0.38
	2:15:00	0.00	0.00	0.05	0.09	0.11	0.13	0.19	0.22	0.30
	2:20:00	0.00	0.00	0.04	0.07	0.09	0.10	0.14	0.17	0.23
	2:25:00	0.00	0.00	0.04	0.05	0.07	0.08	0.11	0.12	0.17
	2:30:00	0.00	0.00	0.03	0.04	0.06	0.06	0.08	0.09	0.13
	2:35:00	0.00	0.00	0.02	0.04	0.05	0.05	0.06	0.07	0.10
	2:40:00	0.00	0.00	0.02	0.03	0.04	0.04	0.05	0.05	0.08
	2:45:00	0.00	0.00	0.02	0.02	0.03	0.03	0.04	0.04	0.06
	2:50:00	0.00	0.00	0.01	0.02	0.03	0.02	0.03	0.03	0.05
	2:55:00	0.00	0.00	0.01	0.02	0.02	0.02	0.03	0.02	0.03
	3:00:00	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.02	0.03
	3:05:00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.02
	3:10:00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02
	3:15:00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	3:20:00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LANGAN

Technical Excellence
Practical Experience
Client Responsiveness

PROJECT:	**8780 ROSEMARY ST**
PROJECT NO.:	**620023001**
DATE:	**4/25/2022**
CALCULATED BY:	**SJS**
CHECKED BY:	**MCB**

EDB 1 FOREBAY SIZING - VOLUME					
FOREBAY NAME	**DRAINAGE AREA (SF)**	**REQUIRED VOLUME (CF)**	**AREA (SF)**	**DEPTH (FT)**	**VOLUME (CF)**
FOREBAY-401	182312	48	193	0.50	97
FOREBAY-402	27148	7	35	0.25	9

EDB 1 FOREBAY SIZING - OUTLET				
FOREBAY NAME	**100-YEAR PEAK INFLOW (CFS)**	**OUTLET ALLOWABLE RELEASE RATE (CFS)**	**OUTLET WIDTH (FT)**	**OUTLET DEPTH (FT)**
FOREBAY-401	19.88	0.40	0.37	0.50
FOREBAY-402	3.68	0.074	0.20	0.25

Add

Forebays need to be proportional to the detention pond in which they are located. Forebay volumes shall be determined using the following equation:

Volume Required (cubic feet) = 0.000265 x Tributary Area (square feet)

The forebay outlet shall be designed to release 2% of the 100-year peak inflow. Forebay dimensions shall be proportional to each other, e.g. the length and width should be similar.

$$Q = C_{BCW} L H^{1.5}$$ Equation 12-8

Where:

Q = discharge (cfs)

C_{BCW} = broad-crested weir coefficient (This ranges from 2.6 to 3.0. A value of 3.0 is often used in practice.) See Hydraulic Engineering Circular No. 22 for additional information.

L = broad-crested weir length (ft)

H = head above weir crest (ft)

Version 4.06 Released August 2018

INLET MANAGEMENT

Worksheet Protected

INLET NAME	CB-301	CB-302	CB-303	CB-304	CB-305	CB-306
Site Type (Urban or Rural)						
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	In Sump	In Sump	In Sump	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT/Denver 13 Valley Grate	CDOT/Denver 13 Valley Grate	CDOT/Denver 13 Valley Grate	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	1.6	1.6	1.4	1.5	1.0	0.6
Major Q_{Known} (cfs)	3.3	3.4	2.6	3.3	2.2	1.2

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)						
Percent Impervious						
NRCS Soil Type						

Watershed Profile

Overland Slope (ft/ft)						
Overland Length (ft)						
Channel Slope (ft/ft)						
Channel Length (ft)						

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)						
One-Hour Precipitation, P_1 (inches)						

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)						
One-Hour Precipitation, P_1 (inches)						

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**1.6**	**1.6**	**1.4**	**1.5**	**1.0**	**0.6**
Major Total Design Peak Flow, Q (cfs)	**3.3**	**3.4**	**2.6**	**3.3**	**2.2**	**1.2**
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	N/A	N/A	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	N/A	N/A	N/A	N/A

Minor Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A	N/A	N/A

Major Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A	N/A	N/A

Version 4.06 Released August 2018

INLET MANAGEMENT

Worksheet Protected

INLET NAME	CB-307	CB-308
Site Type (Urban or Rural)		
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	In Sump	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	0.9	0.6
Major Q_{Known} (cfs)	1.7	1.1

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)		
Percent Impervious		
NRCS Soil Type		

Watershed Profile

Overland Slope (ft/ft)		
Overland Length (ft)		
Channel Slope (ft/ft)		
Channel Length (ft)		

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)		
One-Hour Precipitation, P_1 (inches)		

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)		
One-Hour Precipitation, P_1 (inches)		

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**0.9**	**0.6**
Major Total Design Peak Flow, Q (cfs)	**1.7**	**1.1**
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A

Minor Storm (Calculated) Analysis of Flow T

C	N/A	N/A
C_s	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A
Overland Flow Time, Ti	N/A	N/A
Channel Travel Time, Tt	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A
Regional T_c	N/A	N/A
Recommended T_c	N/A	N/A
T_c selected by User	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A

Major Storm (Calculated) Analysis of Flow T

C	N/A	N/A
C_s	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A
Overland Flow Time, Ti	N/A	N/A
Channel Travel Time, Tt	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A
Regional T_c	N/A	N/A
Recommended T_c	N/A	N/A
T_c selected by User	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A

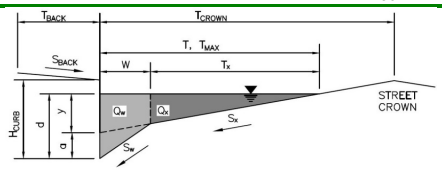
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-301



Gutter Geometry (Enter data in the blue cells)

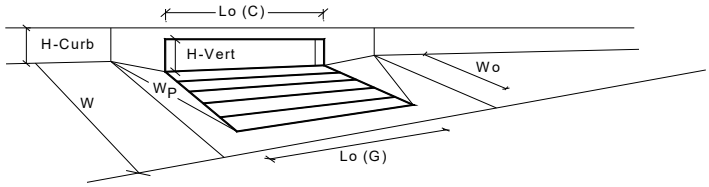
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	26.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.009	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	26.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	3.9	4.6 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 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) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.16	0.22 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.50	0.59
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**1.8**	**2.8** **cfs**
WARNING: Inlet Capacity less than Q Peak for Major Storm		$Q_{PEAK\ REQUIRED}$ =	1.6	3.3 cfs

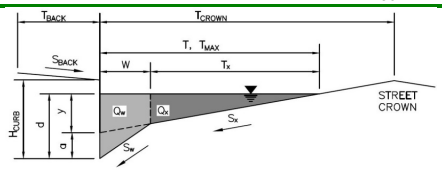
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-302



Gutter Geometry (Enter data in the blue cells)

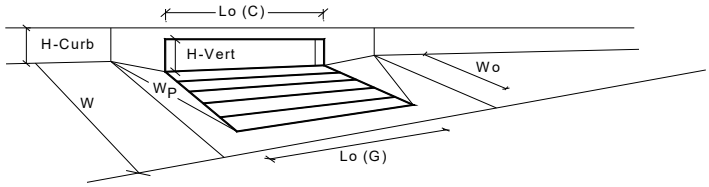
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	20.0	ft
Gutter Width	W =	4.00	ft
Street Transverse Slope	S_X =	0.030	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	20.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =			inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**			**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT/Denver 13 Valley Grate	Type =	CDOT/Denver 13 Valley Grate	
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 =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	8.0 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} =	0.43	0.43
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) =	3.30	3.30
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) =	N/A	N/A feet
Height of Vertical Curb Opening in Inches		H_{vert} =	N/A	N/A inches
Height of Curb Orifice Throat in Inches		H_{throat} =	N/A	N/A inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	N/A	N/A degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	N/A	N/A feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	N/A	N/A
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	N/A	N/A
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	N/A	N/A
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	0.559	0.725 ft
Depth for Curb Opening Weir Equation		d_{Curb} =	N/A	N/A ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	N/A	N/A
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	N/A	N/A
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	0.94	1.00
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**2.9**	**4.3** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	1.6	3.4 cfs

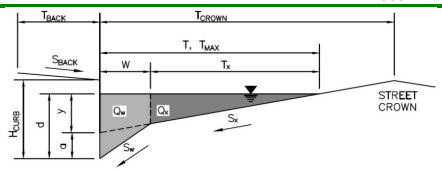
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-303



Gutter Geometry (Enter data in the blue cells)

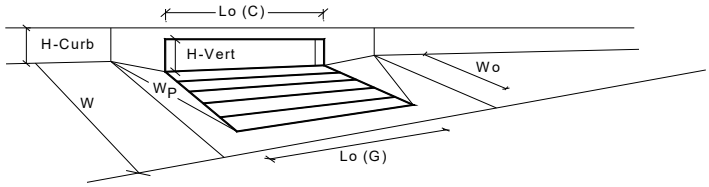
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	20.0	ft
Gutter Width	W =	4.00	ft
Street Transverse Slope	S_X =	0.030	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	20.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT/Denver 13 Valley Grate	Type =	CDOT/Denver 13 Valley Grate	
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 =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	8.0 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} =	0.43	0.43
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) =	3.30	3.30
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) =	N/A	N/A feet
Height of Vertical Curb Opening in Inches		H_{vert} =	N/A	N/A inches
Height of Curb Orifice Throat in Inches		H_{throat} =	N/A	N/A inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	N/A	N/A degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	N/A	N/A feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	N/A	N/A
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	N/A	N/A
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	N/A	N/A
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	0.559	0.725 ft
Depth for Curb Opening Weir Equation		d_{Curb} =	N/A	N/A ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	N/A	N/A
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	N/A	N/A
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	0.94	1.00
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**2.9**	**4.3** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	1.4	2.6 cfs

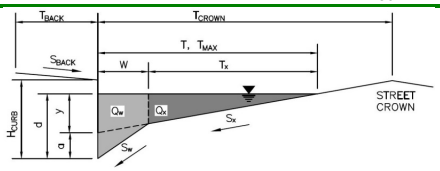
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-304



Gutter Geometry (Enter data in the blue cells)

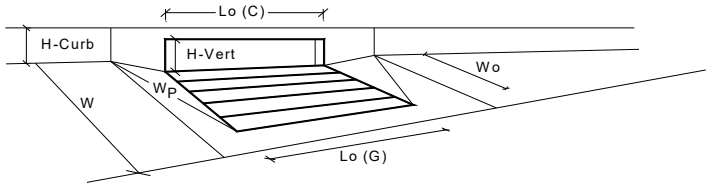
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	20.0	ft
Gutter Width	W =	4.00	ft
Street Transverse Slope	S_X =	0.030	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	20.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT/Denver 13 Valley Grate	Type =	CDOT/Denver 13 Valley Grate	
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 =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	8.0 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} =	0.43	0.43
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) =	3.30	3.30
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) =	N/A	N/A feet
Height of Vertical Curb Opening in Inches		H_{vert} =	N/A	N/A inches
Height of Curb Orifice Throat in Inches		H_{throat} =	N/A	N/A inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	N/A	N/A degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	N/A	N/A feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	N/A	N/A
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	N/A	N/A
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	N/A	N/A
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	0.559	0.725 ft
Depth for Curb Opening Weir Equation		d_{Curb} =	N/A	N/A ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	N/A	N/A
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	N/A	N/A
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	0.94	1.00
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**2.9**	**4.3** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	1.5	3.3 cfs

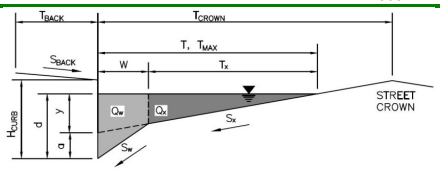
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-305



Gutter Geometry (Enter data in the blue cells)

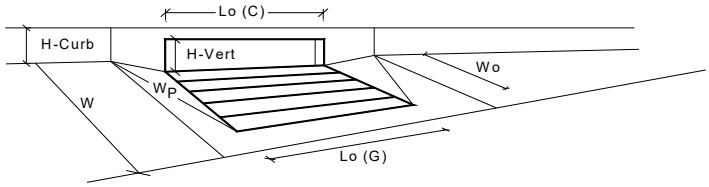
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	25.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.010	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	25.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	4.2	4.8 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 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) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.18	0.23 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.53	0.61
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**2.1**	**3.1** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	1.0	2.2 cfs

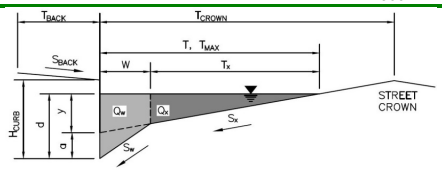
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-306



Gutter Geometry (Enter data in the blue cells)

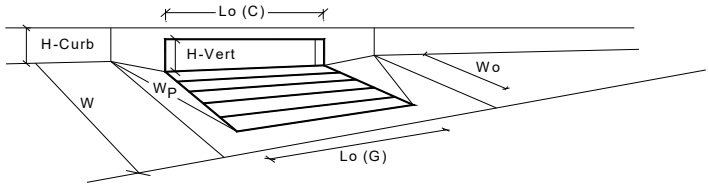
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	64.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.027	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	12.0	14.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	5.2	5.9 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 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) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.27	0.32 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.67	0.75
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**3.9**	**5.1** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	0.6	1.2 cfs

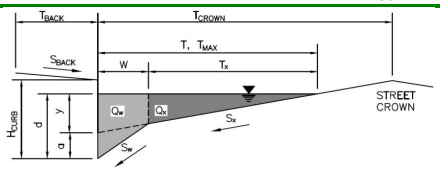
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-307



Gutter Geometry (Enter data in the blue cells)

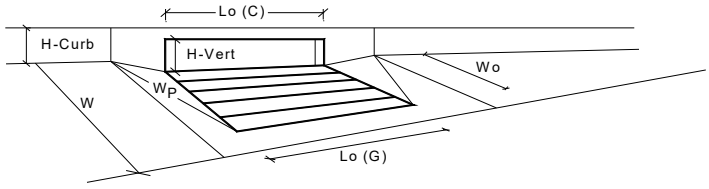
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	64.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.027	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	30.0	32.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	8.0 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 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) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.50 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.77	1.00
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**5.4**	**9.3** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	0.9	1.7 cfs

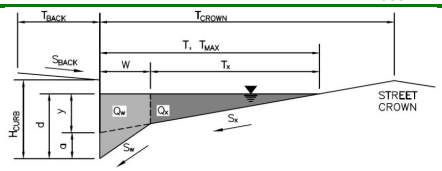
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: 620023001 - 8780 Rosemary Street

Inlet ID: CB-308



Gutter Geometry (Enter data in the blue cells)

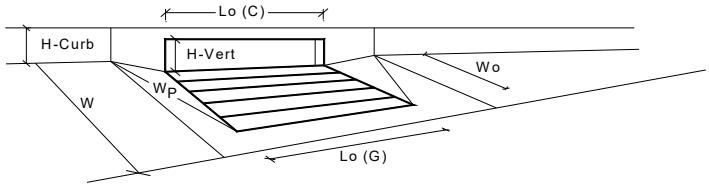
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	64.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.027	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	30.0	32.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

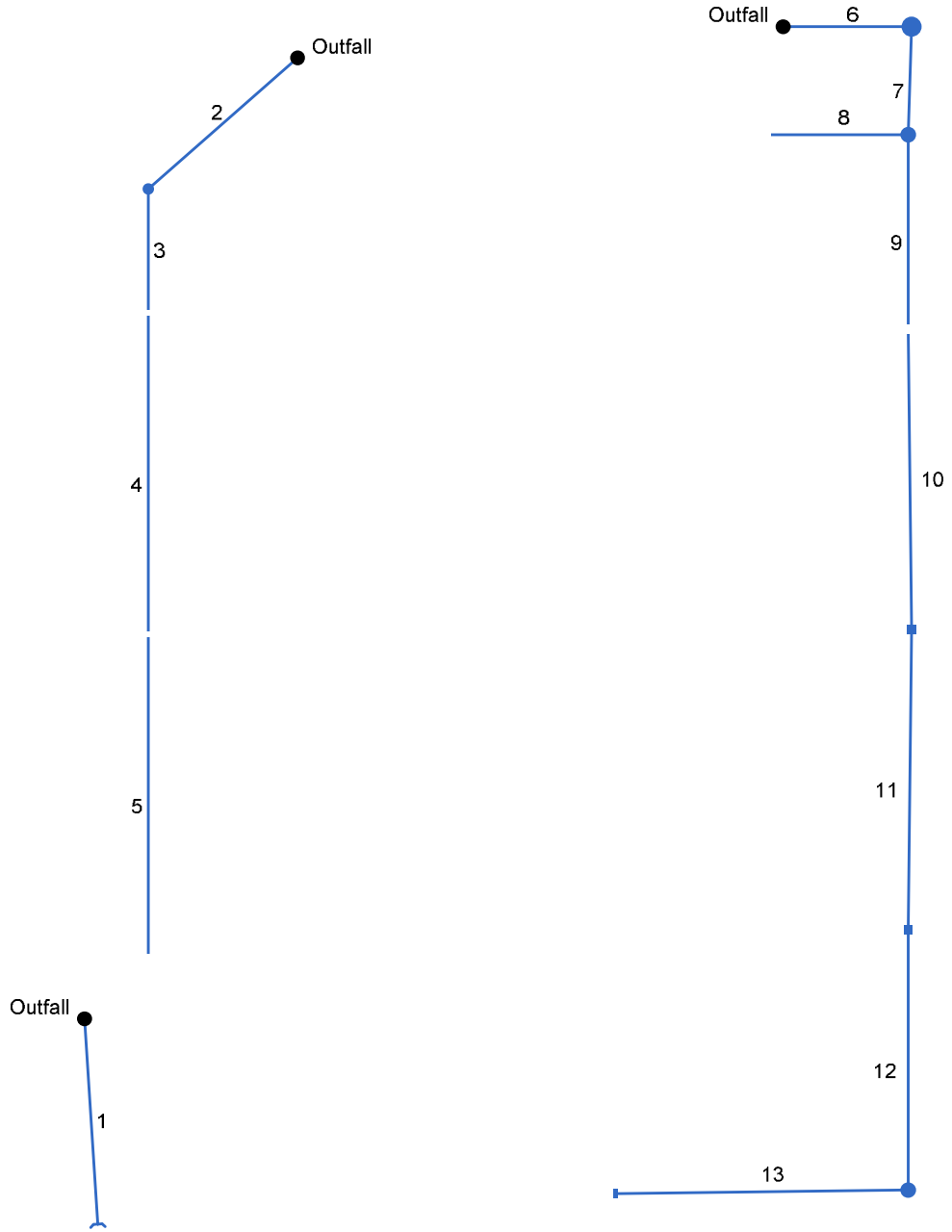
Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	8.0 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 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) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.50 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.77	1.00
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**5.4**	**9.3** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	0.6	1.1 cfs

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan

MINOR EVENT STORM SEWER CONVEYANCE CALCULATIONS



Project File: 5-YR (2022-08-15).stm	Number of lines: 13	Date: 8/18/2022

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	95.962	86.320	Hdwl	0.13	0.00	0.00	0.0	5117.25	0.42	5117.65	18	Cir	0.015	1.00	5119.48	FES-403 TO HW-401
2	End	92.401	138.608	MH	0.00	0.00	0.00	0.0	5111.00	0.98	5111.91	15	Cir	0.015	0.79	5120.25	MH-305 TO FES-402
3	2	57.712	-48.618	Comb	0.64	0.00	0.00	0.0	5111.91	1.02	5112.50	15	Cir	0.015	0.50	5122.18	CB-306 TO MH-305
4	3	149.975	0.010	Comb	0.90	0.00	0.00	0.0	5112.50	1.50	5114.75	15	Cir	0.015	0.50	5122.19	CB-307 TO CB-306
5	4	150.000	0.000	Comb	0.61	0.00	0.00	0.0	5114.75	1.50	5117.00	15	Cir	0.015	1.00	5122.24	CB-308 TO CB-307
6	End	59.592	0.000	MH	0.00	0.00	0.00	0.0	5111.00	0.12	5111.07	42	Cir	0.015	1.00	5121.22	MH-301 TO FES-401
7	6	50.278	91.719	MH	0.00	0.00	0.00	0.0	5111.12	0.12	5111.18	42	Cir	0.015	1.00	5119.81	MH-302 TO MH-301
8	7	64.973	88.276	Comb	1.56	0.00	0.00	0.0	5113.43	1.00	5114.08	15	Cir	0.015	1.00	5119.08	CB-301 TO MH-302
9	7	90.799	-1.719	Grate	3.46	0.00	0.00	0.0	5111.23	0.12	5111.34	42	Cir	0.015	0.50	5118.80	CB-302 TO MH-302
10	9	139.964	-0.610	Grate	3.00	0.00	0.00	0.0	5111.39	0.12	5111.56	42	Cir	0.015	0.50	5118.85	CB-303 TO CB-302
11	10	140.052	1.218	Grate	3.06	0.00	0.00	0.0	5111.61	0.12	5111.78	42	Cir	0.015	0.50	5118.80	CB-304 TO CB-303
12	11	121.332	-0.598	MH	1.60	0.00	0.00	0.0	5111.83	0.14	5112.00	36	Cir	0.015	1.00	5120.77	MH-303 TO CB-304
13	12	135.851	89.257	Comb	0.95	0.00	0.00	0.0	5112.05	0.23	5112.36	24	Cir	0.015	1.00	5118.49	CB-305 TO MH-303

Project File: 5-YR (2022-08-15).stm | Number of lines: 13 | Date: 8/18/2022

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	95.962	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.13	5.88	1.36	18	0.42	5117.25	5117.65	5117.40	5117.81	5119.00	5119.48	FES-403 TO HW-
2	End	92.401	0.00	0.00	0.00	0.00	0.00	0.0	2.9	0.0	2.15	5.54	1.75	15	0.98	5111.00	5111.91	5113.65	5113.79	5112.54	5120.25	MH-305 TO FES-
3	2	57.712	0.00	0.00	0.00	0.00	0.00	0.0	2.3	0.0	2.15	5.66	1.75	15	1.02	5111.91	5112.50	5113.82	5113.91	5120.25	5122.18	CB-306 TO MH-3
4	3	149.975	0.00	0.00	0.00	0.00	0.00	0.0	1.2	0.0	1.51	6.85	2.32	15	1.50	5112.50	5114.75	5113.93	5115.23	5122.18	5122.19	CB-307 TO CB-30
5	4	150.000	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.61	6.85	2.01	15	1.50	5114.75	5117.00	5115.23	5117.30	5122.19	5122.24	CB-308 TO CB-30
6	End	59.592	0.00	0.00	0.00	0.00	0.00	0.0	16.3	0.0	13.63	30.05	1.76	42	0.12	5111.00	5111.07	5113.65	5113.66	5115.04	5121.22	MH-301 TO FES-
7	6	50.278	0.00	0.00	0.00	0.00	0.00	0.0	15.9	0.0	13.63	30.14	1.80	42	0.12	5111.12	5111.18	5113.71	5113.73	5121.22	5119.81	MH-302 TO MH-3
8	7	64.973	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	1.56	5.60	3.68	15	1.00	5113.43	5114.08	5113.88	5114.58	5119.81	5119.08	CB-301 TO MH-3
9	7	90.799	0.00	0.00	0.00	0.00	0.00	0.0	15.0	0.0	12.07	30.19	1.64	42	0.12	5111.23	5111.34	5113.78	5113.80	5119.81	5118.80	CB-302 TO MH-3
10	9	139.964	0.00	0.00	0.00	0.00	0.00	0.0	13.1	0.0	8.61	30.21	1.25	42	0.12	5111.39	5111.56	5113.82	5113.84	5118.80	5118.85	CB-303 TO CB-30
11	10	140.052	0.00	0.00	0.00	0.00	0.00	0.0	10.5	0.0	5.61	30.20	0.90	42	0.12	5111.61	5111.78	5113.85	5113.87	5118.85	5118.80	CB-304 TO CB-30
12	11	121.332	0.00	0.00	0.00	0.00	0.00	0.0	6.6	0.0	2.55	21.63	0.52	36	0.14	5111.83	5112.00	5113.87	5113.88	5118.80	5120.77	MH-303 TO CB-3
13	12	135.851	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.95	9.39	0.34	24	0.23	5112.05	5112.36	5113.88	5113.88	5120.77	5118.49	CB-305 TO MH-3

Project File: 5-YR (2022-08-15).stm | Number of lines: 13 | Run Date: 8/18/2022

NOTES:Known Qs only ; c = cir e = ellip b = box

Hydraulic Grade Line Computations

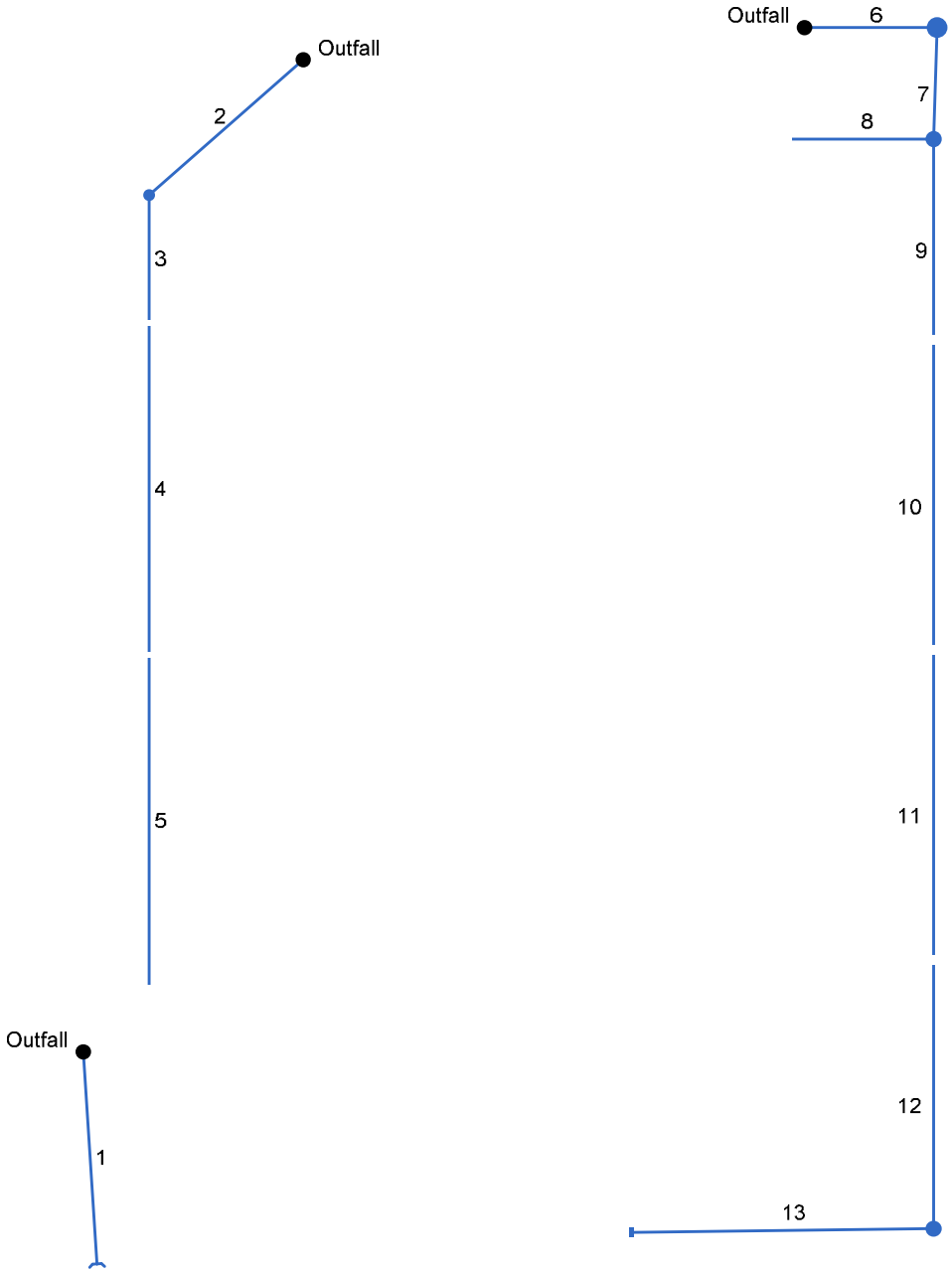
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.13	5117.25	5117.40	0.15	0.09	1.41	0.03	5117.43	0.470	95.962	5117.65	5117.81	0.16	0.10	1.30	0.03	5117.84	0.368	0.419	0.402	1.00	0.03
2	15	2.15	5111.00	5113.65	1.25	1.23	1.75	0.05	5113.70	0.148	92.401	5111.91	5113.79	1.25	1.23	1.75	0.05	5113.83	0.148	0.148	0.136	0.79	0.04
3	15	2.15	5111.91	5113.82	1.25	1.23	1.75	0.05	5113.87	0.148	57.712	5112.50	5113.91	1.25	1.23	1.75	0.05	5113.96	0.148	0.148	0.085	0.50	0.02
4	15	1.51	5112.50	5113.93	1.25	0.44	1.23	0.02	5113.96	0.073	149.975	5114.75	5115.23 j	0.49**	0.44	3.42	0.18	5115.41	0.710	0.391	n/a	0.50	0.09
5	15	0.61	5114.75	5115.23	0.49	0.23	1.38	0.11	5115.34	0.000	150.000	5117.00	5117.30 j	0.30**	0.23	2.64	0.11	5117.41	0.000	0.000	n/a	1.00	0.11
6	42	13.63	5111.00	5113.65	2.65	7.82	1.74	0.05	5113.70	0.029	59.592	5111.07	5113.66	2.59	7.64	1.78	0.05	5113.71	0.030	0.029	0.018	1.00	0.05
7	42	13.63	5111.12	5113.71	2.59	7.64	1.78	0.05	5113.76	0.030	50.278	5111.18	5113.73	2.55	7.50	1.82	0.05	5113.78	0.032	0.031	0.016	1.00	0.05
8	15	1.56	5113.43	5113.88	0.45*	0.40	3.90	0.19	5114.07	0.000	64.973	5114.08	5114.58	0.49**	0.45	3.45	0.19	5114.76	0.000	0.000	n/a	1.00	0.19
9	42	12.07	5111.23	5113.78	2.55	7.50	1.61	0.04	5113.82	0.025	90.799	5111.34	5113.80	2.46	7.22	1.67	0.04	5113.84	0.027	0.026	0.024	0.50	0.02
10	42	8.61	5111.39	5113.82	2.43	7.12	1.21	0.02	5113.84	0.014	139.964	5111.56	5113.84	2.28	6.64	1.30	0.03	5113.87	0.017	0.016	0.022	0.50	0.01
11	42	5.61	5111.61	5113.85	2.24	6.52	0.86	0.01	5113.87	0.008	140.052	5111.78	5113.87	2.09	5.99	0.94	0.01	5113.88	0.009	0.008	0.012	0.50	0.01
12	36	2.55	5111.83	5113.87	2.04	5.13	0.50	0.00	5113.88	0.003	121.332	5112.00	5113.88	1.88	4.66	0.55	0.00	5113.88	0.004	0.003	0.004	1.00	0.00
13	24	0.95	5112.05	5113.88	1.84	3.02	0.31	0.00	5113.88	0.002	135.851	5112.36	5113.88	1.52	2.57	0.37	0.00	5113.89	0.003	0.002	0.003	1.00	0.00

Project File: 5-YR (2022-08-15).stm | Number of lines: 13 | Run Date: 8/18/2022

Notes: * depth assumed; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan

MAJOR EVENT STORM SEWER CONVEYANCE CALCULATIONS



Project File: 100-YR (2022-08-15).stm	Number of lines: 13	Date: 8/18/2022

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	95.962	86.320	Hdwl	3.51	0.00	0.00	0.0	5117.25	0.42	5117.65	18	Cir	0.015	1.00	5119.48	FES-403 TO HW-401
2	End	92.401	138.608	MH	0.00	0.00	0.00	0.0	5111.00	0.99	5111.91	15	Cir	0.015	0.79	5120.25	MH-305 TO FES-402
3	2	57.712	-48.618	Comb	1.24	0.00	0.00	0.0	5112.01	1.02	5112.60	15	Cir	0.015	0.50	5122.18	CB-306 TO MH-305
4	3	149.975	0.010	Comb	1.69	0.00	0.00	0.0	5112.70	1.50	5114.95	15	Cir	0.015	0.50	5122.19	CB-307 TO CB-306
5	4	150.000	0.000	Comb	1.14	0.00	0.00	0.0	5115.05	1.50	5117.30	15	Cir	0.015	1.00	5122.24	CB-308 TO CB-307
6	End	59.592	0.000	MH	0.00	0.00	0.00	0.0	5111.00	0.12	5111.07	42	Cir	0.015	1.00	5121.22	MH-301 TO FES-401
7	6	50.278	91.719	MH	0.00	0.00	0.00	0.0	5111.12	0.12	5111.18	42	Cir	0.015	1.00	5119.81	MH-302 TO MH-301
8	7	64.973	88.276	Comb	3.26	0.00	0.00	0.0	5113.43	1.00	5114.08	15	Cir	0.015	1.00	5119.08	CB-301 TO MH-302
9	7	90.800	-1.719	Grate	6.85	0.00	0.00	0.0	5111.23	0.12	5111.34	42	Cir	0.015	0.50	5118.80	CB-302 TO MH-302
10	9	139.956	0.001	Grate	5.56	0.00	0.00	0.0	5111.39	0.12	5111.56	42	Cir	0.015	0.50	5118.80	CB-303 TO CB-302
11	10	140.044	0.000	Grate	6.26	0.00	0.00	0.0	5111.61	0.12	5111.78	42	Cir	0.015	0.50	5118.80	CB-304 TO CB-303
12	11	121.332	0.011	MH	2.98	0.00	0.00	0.0	5111.83	0.14	5112.00	36	Cir	0.015	1.00	5120.77	MH-303 TO CB-304
13	12	135.850	89.257	Comb	2.15	0.00	0.00	0.0	5112.05	0.23	5112.36	24	Cir	0.015	1.00	5118.49	CB-305 TO MH-303

Project File: 100-YR (2022-08-15).stm | Number of lines: 13 | Date: 8/18/2022

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	95.962	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	3.51	5.88	3.46	18	0.42	5117.25	5117.65	5118.09	5118.48	5119.00	5119.48	FES-403 TO HW-
2	End	92.401	0.00	0.00	0.00	0.00	0.00	0.0	2.6	0.0	4.07	5.55	3.32	15	0.99	5111.00	5111.91	5115.90	5116.39	5112.54	5120.25	MH-305 TO FES-
3	2	57.712	0.00	0.00	0.00	0.00	0.00	0.0	2.3	0.0	4.07	5.66	3.32	15	1.02	5112.01	5112.60	5116.52	5116.83	5120.25	5122.18	CB-306 TO MH-3
4	3	149.975	0.00	0.00	0.00	0.00	0.00	0.0	1.3	0.0	2.83	6.85	2.31	15	1.50	5112.70	5114.95	5116.92	5117.30	5122.18	5122.19	CB-307 TO CB-30
5	4	150.000	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	1.14	6.85	1.99	15	1.50	5115.05	5117.30	5117.34	5117.73	5122.19	5122.24	CB-308 TO CB-30
6	End	59.592	0.00	0.00	0.00	0.00	0.00	0.0	10.3	0.0	27.06	30.05	2.81	42	0.12	5111.00	5111.07	5115.90	5115.96	5115.04	5121.22	MH-301 TO FES-
7	6	50.278	0.00	0.00	0.00	0.00	0.00	0.0	10.0	0.0	27.06	30.14	2.81	42	0.12	5111.12	5111.18	5116.08	5116.13	5121.22	5119.81	MH-302 TO MH-3
8	7	64.973	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	3.26	5.60	2.66	15	1.00	5113.43	5114.08	5116.25	5116.47	5119.81	5119.08	CB-301 TO MH-3
9	7	90.800	0.00	0.00	0.00	0.00	0.00	0.0	9.4	0.0	23.80	30.19	2.47	42	0.12	5111.23	5111.34	5116.25	5116.32	5119.81	5118.80	CB-302 TO MH-3
10	9	139.956	0.00	0.00	0.00	0.00	0.00	0.0	8.1	0.0	16.95	30.21	1.76	42	0.12	5111.39	5111.56	5116.37	5116.42	5118.80	5118.80	CB-303 TO CB-30
11	10	140.044	0.00	0.00	0.00	0.00	0.00	0.0	6.1	0.0	11.39	30.20	1.18	42	0.12	5111.61	5111.78	5116.44	5116.47	5118.80	5118.80	CB-304 TO CB-30
12	11	121.332	0.00	0.00	0.00	0.00	0.00	0.0	3.3	0.0	5.13	21.63	0.73	36	0.14	5111.83	5112.00	5116.48	5116.49	5118.80	5120.77	MH-303 TO CB-3
13	12	135.850	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	2.15	9.39	0.68	24	0.23	5112.05	5112.36	5116.50	5116.51	5120.77	5118.49	CB-305 TO MH-3

Project File: 100-YR (2022-08-15).stm

Number of lines: 13

Run Date: 8/18/2022

NOTES:Known Qs only ; c = cir e = ellip b = box

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
	(in)	(cfs)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(%)	(ft)	(K)	(ft)
1	18	3.51	5117.25	5118.09	0.84	1.02	3.45	0.18	5118.28	0.409	95.962	5117.65	5118.48	0.83	1.01	3.48	0.19	5118.67	0.419	0.414	0.397	1.00	0.19
2	15	4.07	5111.00	5115.90	1.25	1.23	3.32	0.17	5116.07	0.529	92.401	5111.91	5116.39	1.25	1.23	3.32	0.17	5116.56	0.529	0.529	0.489	0.79	0.14
3	15	4.07	5112.01	5116.52	1.25	1.23	3.32	0.17	5116.70	0.529	57.712	5112.60	5116.83	1.25	1.23	3.32	0.17	5117.00	0.529	0.529	0.305	0.50	0.09
4	15	2.83	5112.70	5116.92	1.25	1.23	2.31	0.08	5117.00	0.256	149.975	5114.95	5117.30	1.25	1.23	2.31	0.08	5117.38	0.256	0.256	0.384	0.50	0.04
5	15	1.14	5115.05	5117.34	1.25	0.36	0.93	0.01	5117.35	0.042	150.000	5117.30	5117.73 j	0.43**	0.37	3.06	0.15	5117.88	0.646	0.344	0.516	1.00	0.15
6	42	27.06	5111.00	5115.90	3.50	9.62	2.81	0.12	5116.02	0.096	59.592	5111.07	5115.96	3.50	9.62	2.81	0.12	5116.08	0.096	0.096	0.057	1.00	0.12
7	42	27.06	5111.12	5116.08	3.50	9.62	2.81	0.12	5116.20	0.096	50.278	5111.18	5116.13	3.50	9.62	2.81	0.12	5116.25	0.096	0.096	0.048	1.00	0.12
8	15	3.26	5113.43	5116.25	1.25	1.23	2.66	0.11	5116.36	0.339	64.973	5114.08	5116.47	1.25	1.23	2.66	0.11	5116.58	0.339	0.339	0.221	1.00	0.11
9	42	23.80	5111.23	5116.25	3.50	9.62	2.47	0.10	5116.35	0.075	90.800	5111.34	5116.32	3.50	9.62	2.47	0.10	5116.42	0.075	0.075	0.068	0.50	0.05
10	42	16.95	5111.39	5116.37	3.50	9.62	1.76	0.05	5116.42	0.038	139.956	5111.56	5116.42	3.50	9.62	1.76	0.05	5116.47	0.038	0.038	0.053	0.50	0.02
11	42	11.39	5111.61	5116.44	3.50	9.62	1.18	0.02	5116.47	0.017	140.044	5111.78	5116.47	3.50	9.62	1.18	0.02	5116.49	0.017	0.017	0.024	0.50	0.01
12	36	5.13	5111.83	5116.48	3.00	7.07	0.73	0.01	5116.49	0.008	121.332	5112.00	5116.49	3.00	7.07	0.73	0.01	5116.50	0.008	0.008	0.010	1.00	0.01
13	24	2.15	5112.05	5116.50	2.00	3.14	0.68	0.01	5116.50	0.012	135.850	5112.36	5116.51	2.00	3.14	0.68	0.01	5116.52	0.012	0.012	0.016	1.00	0.01

Project File: 100-YR (2022-08-15).stm | Number of lines: 13 | Run Date: 8/18/2022

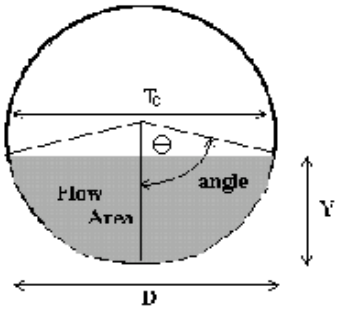
Notes: ; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: 8780 ROSEMARY STREET

Pipe ID: FES-403 to HW-401



Design Information (Input)			
Pipe Invert Slope	So =	0.0042	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	18.00	inches
Design discharge	Q =	3.61	cfs

Full-Flow Capacity (Calculated)			
Full-flow area	Af =	1.77	sq ft
Full-flow wetted perimeter	Pf =	4.71	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	6.83	cfs

Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.60	radians
Flow area	An =	0.92	sq ft
Top width	Tn =	1.50	ft
Wetted perimeter	Pn =	2.41	ft
Flow depth	Yn =	0.78	ft
Flow velocity	Vn =	3.92	fps
Discharge	Qn =	3.61	cfs
Percent of Full Flow	Flow =	52.9%	of full flow
Normal Depth Froude Number	Fr_n =	0.88	subcritical

Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	1.54	radians
Critical flow area	Ac =	0.85	sq ft
Critical top width	Tc =	1.50	ft
Critical flow depth	Yc =	0.73	ft
Critical flow velocity	Vc =	4.26	fps
Critical Depth Froude Number	Fr_c =	1.00	

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Thursday, Aug 18 2022

15-IN RCP Velocity

Circular

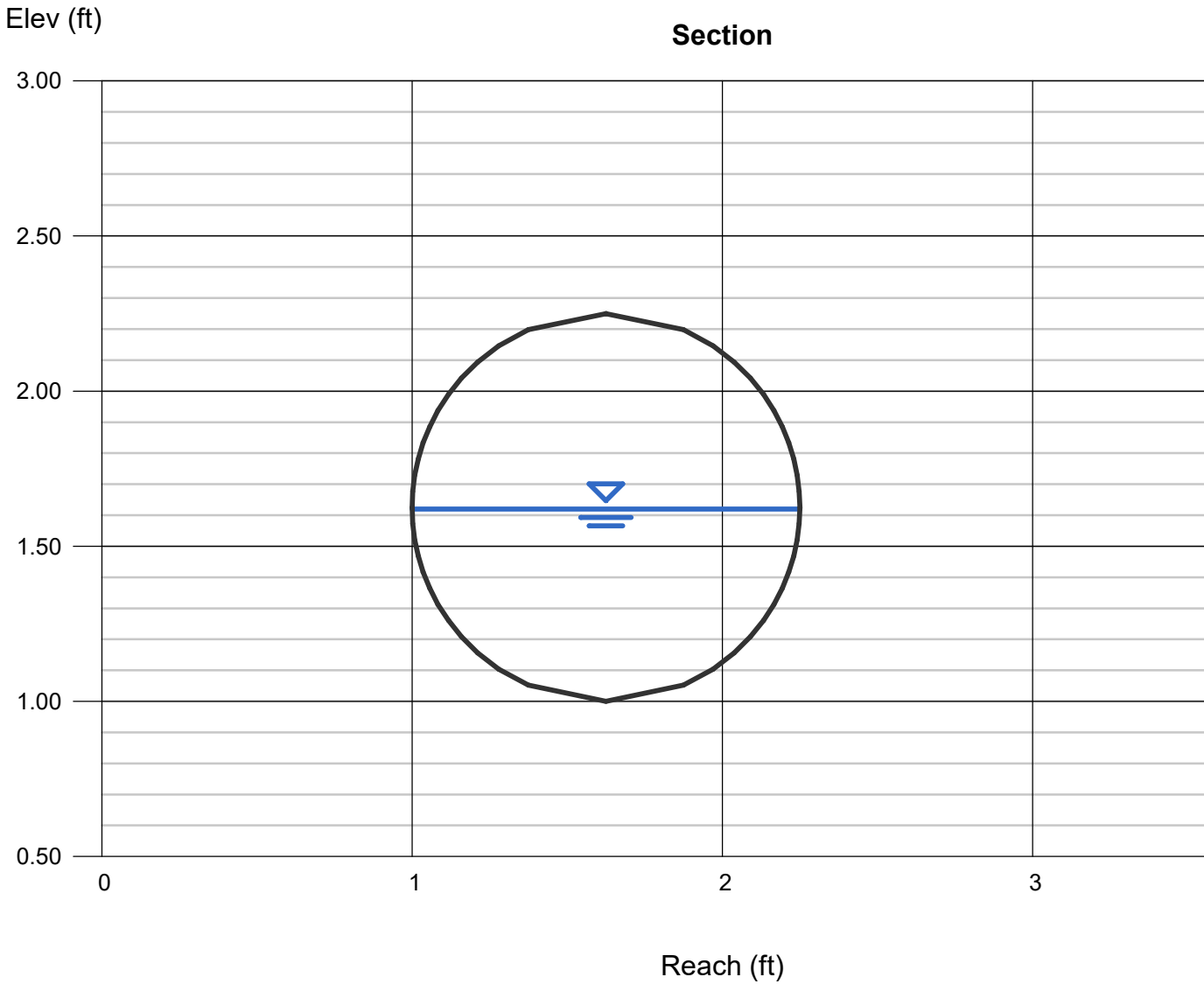
Diameter (ft)	= 1.25
Invert Elev (ft)	= 1.00
Slope (%)	= 1.00
N-Value	= 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 0.62

Highlighted

Depth (ft)	= 0.62
Q (cfs)	= 2.771
Area (sqft)	= 0.61
Velocity (ft/s)	= 4.55
Wetted Perim (ft)	= 1.96
Crit Depth, Yc (ft)	= 0.67
Top Width (ft)	= 1.25
EGL (ft)	= 0.94



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Thursday, Aug 18 2022

18-IN RCP Velocity

Circular

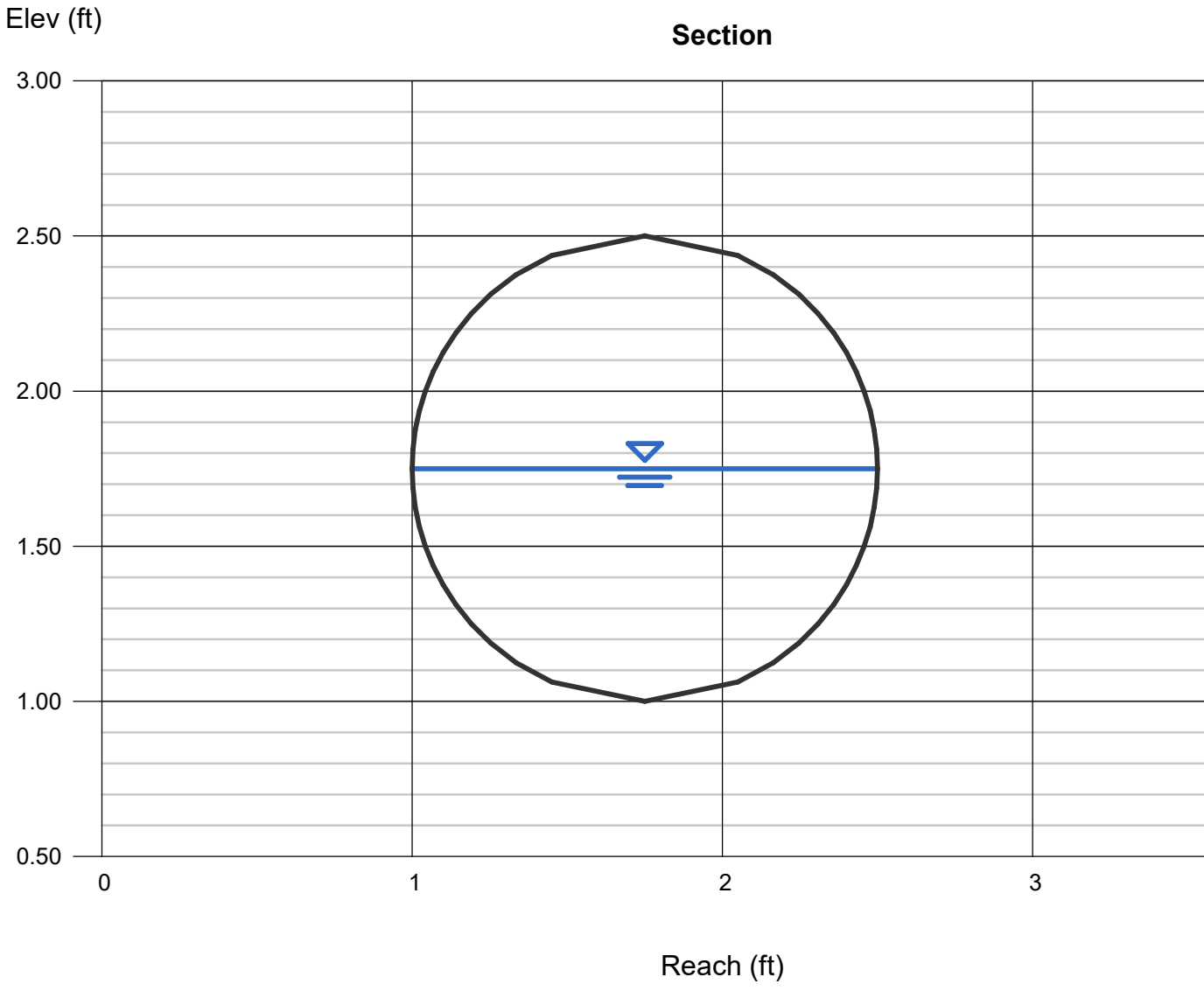
Diameter (ft)	= 1.50
Invert Elev (ft)	= 1.00
Slope (%)	= 0.34
N-Value	= 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 0.75

Highlighted

Depth (ft)	= 0.75
Q (cfs)	= 2.672
Area (sqft)	= 0.89
Velocity (ft/s)	= 3.01
Wetted Perim (ft)	= 2.36
Crit Depth, Yc (ft)	= 0.62
Top Width (ft)	= 1.50
EGL (ft)	= 0.89



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Thursday, Aug 18 2022

24-IN RCP Velocity

Circular

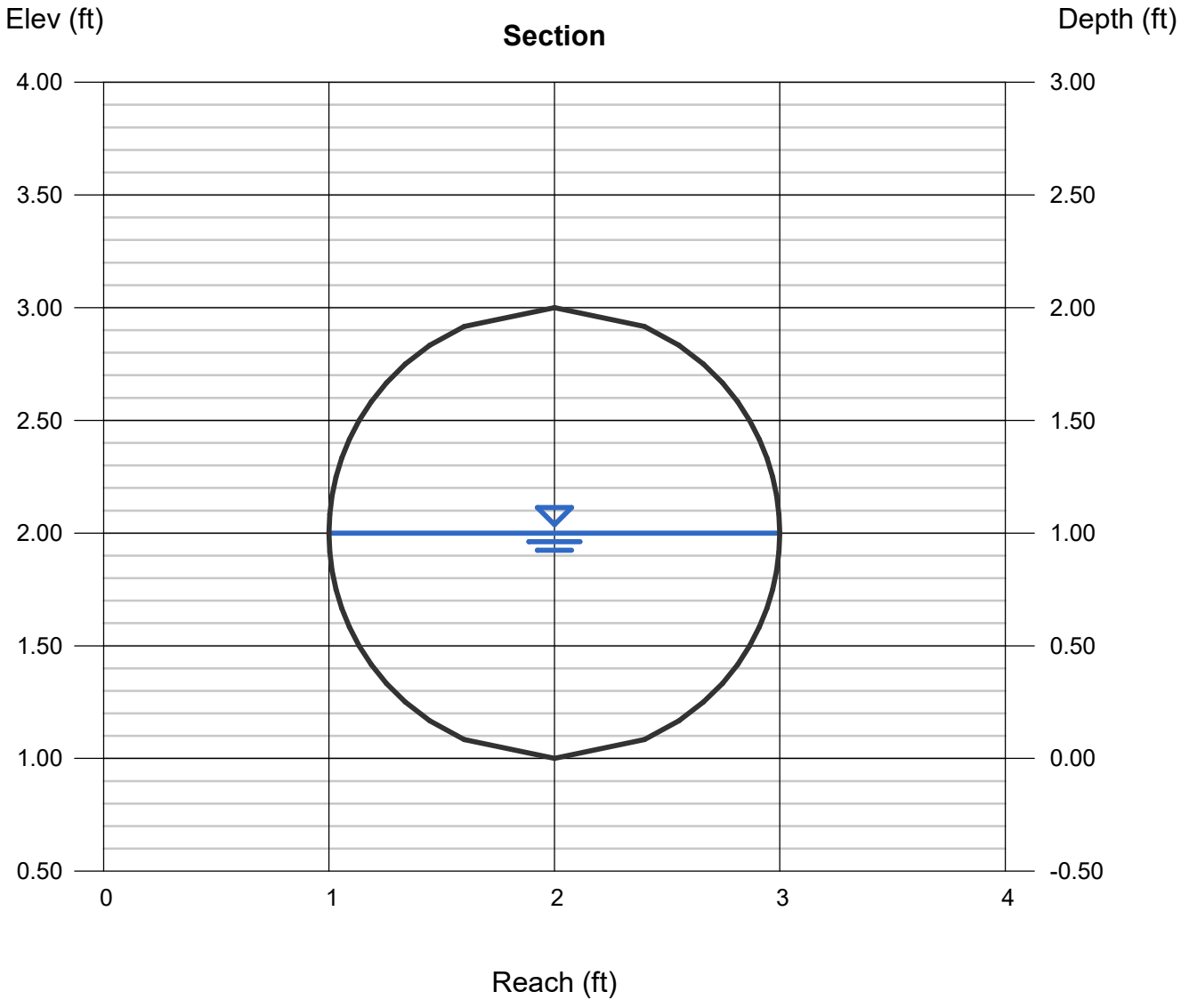
Diameter (ft)	= 2.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.23
N-Value	= 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 1.00

Highlighted

Depth (ft)	= 1.00
Q (cfs)	= 4.734
Area (sqft)	= 1.58
Velocity (ft/s)	= 3.00
Wetted Perim (ft)	= 3.15
Crit Depth, Yc (ft)	= 0.77
Top Width (ft)	= 2.00
EGL (ft)	= 1.14



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Thursday, Aug 18 2022

30-IN RCP Velocity

Circular

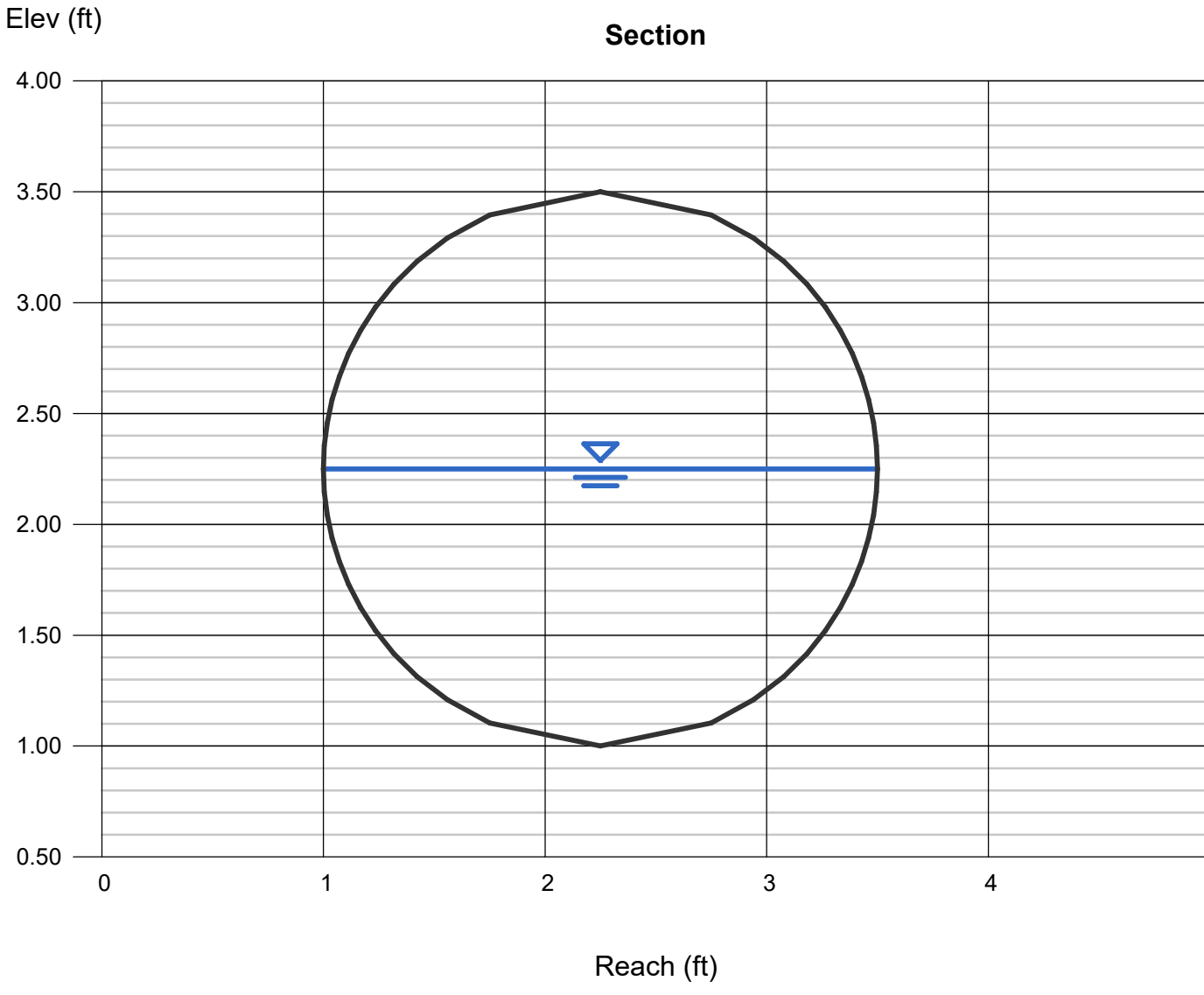
Diameter (ft)	= 2.50
Invert Elev (ft)	= 1.00
Slope (%)	= 0.18
N-Value	= 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 1.25

Highlighted

Depth (ft)	= 1.25
Q (cfs)	= 7.594
Area (sqft)	= 2.47
Velocity (ft/s)	= 3.08
Wetted Perim (ft)	= 3.94
Crit Depth, Yc (ft)	= 0.92
Top Width (ft)	= 2.50
EGL (ft)	= 1.40



Channel Report

36-IN RCP Velocity

Circular

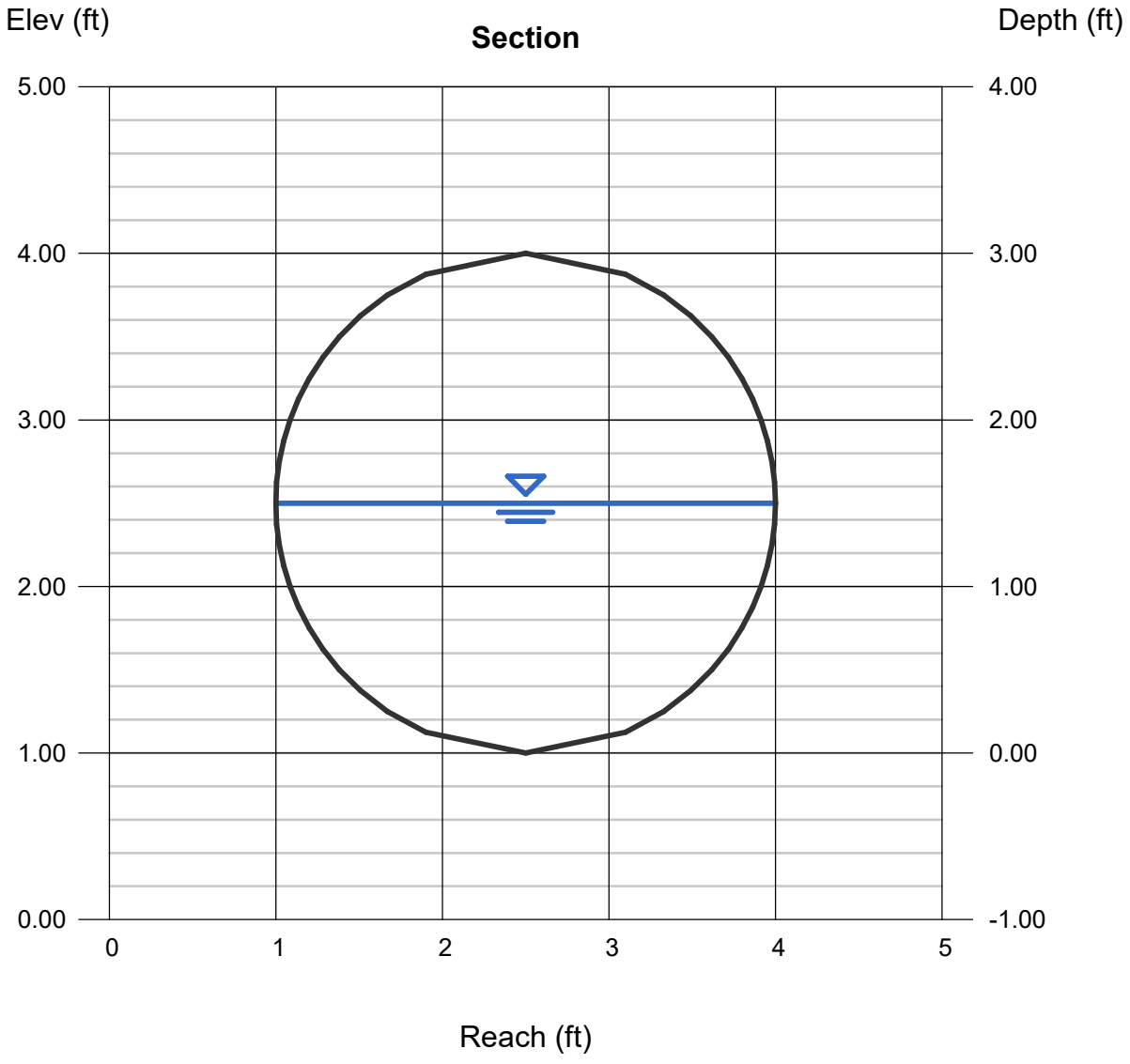
Diameter (ft)	= 3.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.14
N-Value	= 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 1.50

Highlighted

Depth (ft)	= 1.50
Q (cfs)	= 10.89
Area (sqft)	= 3.55
Velocity (ft/s)	= 3.06
Wetted Perim (ft)	= 4.72
Crit Depth, Yc (ft)	= 1.05
Top Width (ft)	= 3.00
EGL (ft)	= 1.65



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Thursday, Aug 18 2022

42-IN RCP Velocity

Circular

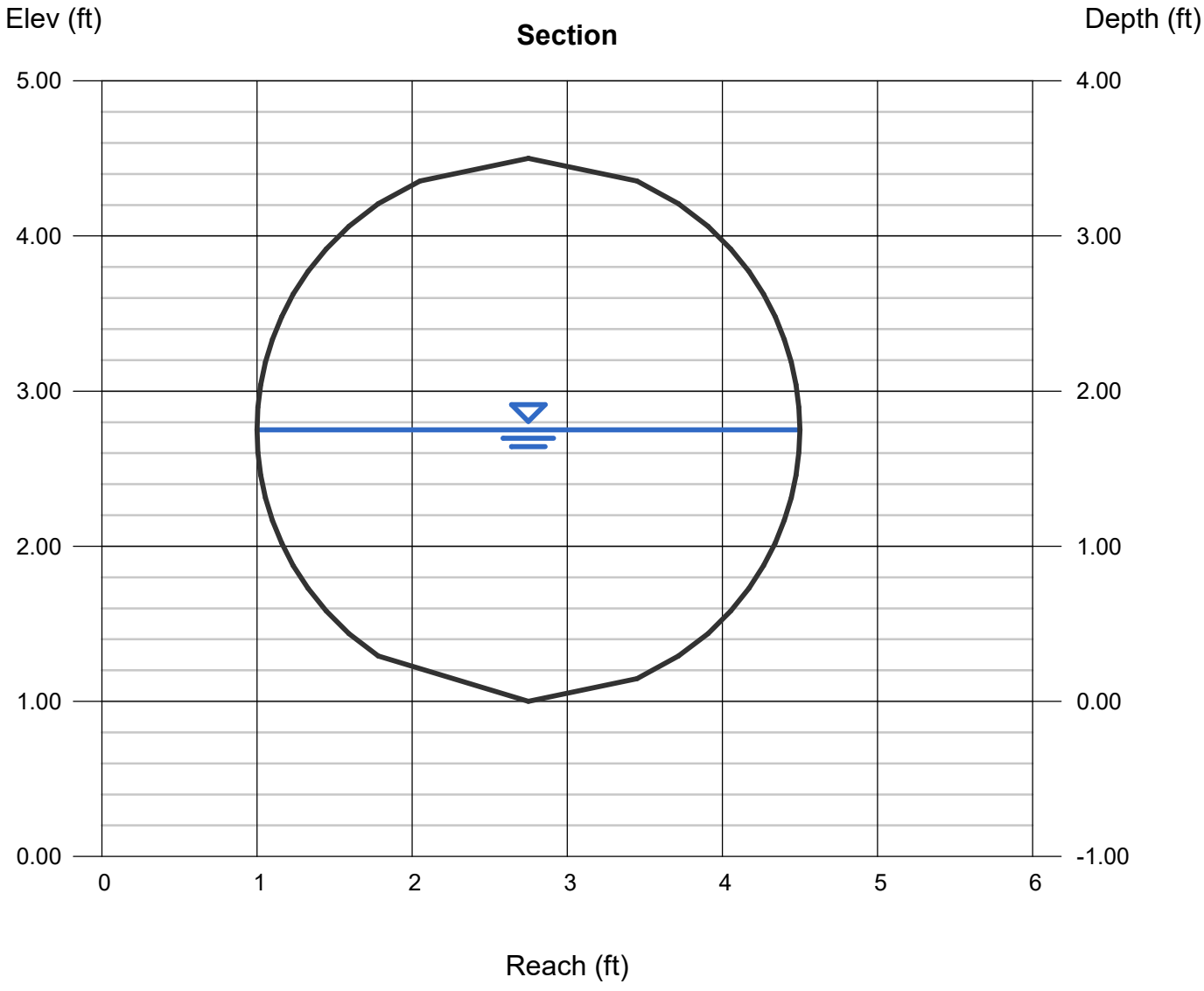
Diameter (ft)	= 3.50
Invert Elev (ft)	= 1.00
Slope (%)	= 0.12
N-Value	= 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 1.75

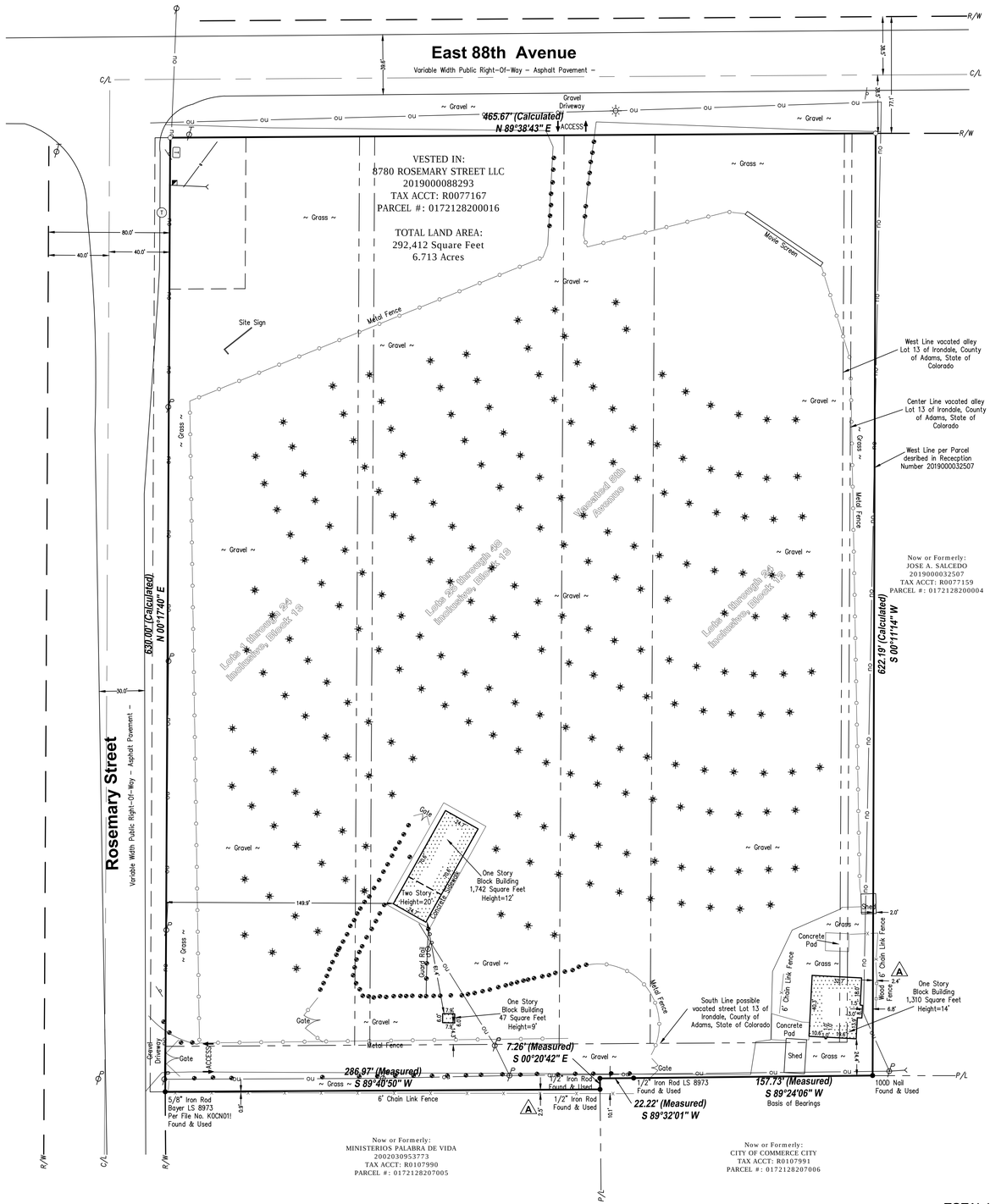
Highlighted

Depth (ft)	= 1.75
Q (cfs)	= 15.21
Area (sqft)	= 4.84
Velocity (ft/s)	= 3.14
Wetted Perim (ft)	= 5.51
Crit Depth, Yc (ft)	= 1.19
Top Width (ft)	= 3.50
EGL (ft)	= 1.90



Drawings

- ALTA – ALTA/NSPS Land Title Survey
- CA101 – Historic Drainage Patterns Map
- CA102 – Proposed Drainage Patterns Map
- CA103 – Proposed Sub Basin Map
- CA501 – Retention Basin Detail
- CA502 - Rain Garden 1 Detail
- CA503 – Rain Garden 2 Detail
- CG101 – Overall Grading Plan
- CG102 – Overall Drainage Plan
- CU100 – Preliminary Utility Plan



FLOOD ZONE:

By scaled map location and graphic plotting only, the subject property appears to lie entirely in Zone X-Unshaded (Areas determined to be outside the 0.2% annual chance floodplain.) according to the Flood Insurance Rate Map for the County of Adams, State of Colorado, Community Panel No. 08001C0607H, Effective Date March 5, 2007.

TOTAL LAND AREA:

292,412 Square Feet
6.713 Acres

PARKING:

There are no striped parking spaces on the subject property.

FIRST AMERICAN TITLE INSURANCE COMPANY COMMITMENT NO. NCS-1061014-CHI2 - SCHEDULE A:

The Land referred to herein below is situated in the County of Adams, State of Colorado, and is described as follows:

Lots 1 through 24 inclusive, Block 12 (now vacated) and the Westerly one-half of vacated alley running North and South through said Block 12 and Lots 1 through 48, Block 13 (now vacated) and the vacated alley running North and South through said Block 13, and that portion of vacated Fifth Avenue lying between said Blocks 12 and 13, all in Irondale, County of Adams, State of Colorado,

LESS AND EXCEPT, that portion of Block 13 conveyed to Adams County by Resolution and Deed recorded December 29, 1971 in Book 1769 at Page 109, in the records of the Clerk and Recorder, Adams County, State of Colorado.

FIRST AMERICAN TITLE INSURANCE COMPANY COMMITMENT NO. NCS-1061014-CHI2 - SCHEDULE B, SECTION II:

Numbers correspond with survey-related Schedule B exception items contained in the above referenced Title Commitment.

9. Easements, notes, covenants, restrictions and rights-of-way as shown on the plat of Irondale, recorded March 5, 1889 in Plat Book 3 at Page 20.

NOTE: Declaration of Partial Vacation of Plat (Blocks 10, 11, 12 and 13) in connection therewith recorded August 3, 1909 in Book 41 at Page 380.

NOTE: Vacation of Plat in connection therewith recorded October 18, 1924 in Plat Book 2 at Page 19. **(MAY AFFECT SUBJECT PROPERTY – NO PLOTTABLE COURSES)**

10. An easement for utilities and incidental purposes as reserved in Vacation of Alley in Block 13 Irondale Subdivision recorded November 18, 1970 in Book 1645 at Page 16. **(AFFECTS SUBJECT PROPERTY – VACATION OF BLOCK 13 ALLEY)**

11. An easement for utilities and incidental purposes as reserved in Vacation of 5th Avenue (Syracuse Street) in Irondale recorded February 22, 1971 in Book 1669 at Page 310. **(AFFECTS SUBJECT PROPERTY – VACATION OF 5TH AVENUE)**

12. Ordinance No. AN-29-79, Amended, for annexation, recorded January 16, 1980 in Book 2421 at Page 958. **(AFFECTS SUBJECT PROPERTY – BLANKET IN NATURE)**

13. Annexation Plat recorded January 16, 1980 at Reception No. 244012. **(AFFECTS SUBJECT PROPERTY – BLANKET IN NATURE)**

14. Ordinance No. AN-65-85, for annexation, recorded December 5, 1985 in Book 3081 at Page 358. **(MAY AFFECT SUBJECT PROPERTY – NO PLOTTABLE COURSES)**

15. Annexation Map recorded December 5, 1985 at Reception No. 616460. **(AFFECTS SUBJECT PROPERTY – BLANKET IN NATURE)**

16. Any tax, lien, fee or assessment by reason of inclusion of subject property in the Adams County Water and Sanitation District, as evidenced by instrument recorded June 22, 1990 in Book 3685 at Page 721. **(NOT A SURVEY MATTER)**

17. Terms, conditions, provisions, obligations, easements and agreements as set forth in the Gas Easement recorded February 9, 2011 at Reception No. 2011000009625. **(AFFECTS SUBJECT PROPERTY – PLOTTED AND SHOWN HEREON)**

ZONING:

As of May 5, 2021, we have not yet received the current zoning information for the subject property.

BASIS OF BEARING:

The basis for all bearings shown hereon is the South line of subject property, assumed as being S 89°24'06" W, and is used to denote angles only.

SURVEYOR'S OBSERVATIONS:

(A) Subject's Fence appears to lie over property line. Maximum distance shown hereon.

MISCELLANEOUS NOTES:

1. There is direct access to the subject property via East 88th Avenue, a public right-of-way.
2. The locations of all utilities shown on the survey are from visible surface evidence only.
3. The posted address on site is 8780 Rosemary Street, Commerce City, CO 80640.
4. At the time of this survey, there was no observable surface evidence of earth moving work, building construction or building additions within recent months.
5. At the time of this survey, there was no observable evidence of the subject property being used as a solid waste dump, sump or sanitary landfill.
6. At the time of this survey, there was no observable evidence of any recent changes in street right-of-way lines either completed or proposed, and available from the controlling jurisdiction.
7. At the time of this survey, there was no observable evidence of any recent street or sidewalk construction or repairs.
8. The Property surveyed and shown hereon is the same property described in Schedule A of First American Title Insurance Company Title Commitment No. NCS-1061014-CHI2 with an effective date of April 15, 2021 at 5:00 PM.
9. Orthophotography was not used to draft this survey.

CERTIFICATION:

To: First Industrial Acquisitions, II, LLC, a Delaware limited liability company; First American Title Insurance Company;

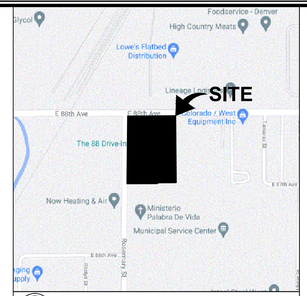
This is to certify that this map or plat and the survey on which it is based were made in accordance with the 2021 Minimum Standard Detail Requirements for ALTA/NSPS Land Title Surveys, jointly established and adopted by ALTA and NSPS, and includes Items 1, 2, 3, 4, 6(a), 7(a), 7(b)(1), 7(c), 8, 9, 13, 14, 15, 16, 17, and 19 of Table A thereof. The field work was completed on May 4, 2021.

Date of Plat or Map: May 5, 2021 .

By: _____
Jennifer L Whitley, PLS
Colorado Professional Land Surveyor No. 0038453
For and on behalf of Millman Surveying, Inc.

REVISION HISTORY

BY:	DATE:	COMMENT:



VICINITY MAP
NOT TO SCALE

SYMBOL LEGEND

R/W	– Right-of-Way
P/L	– Adjoiner Property Line
C/L	– Centerline
●	– Monumentation Found as Noted
○	– 5/8" Iron Pin w/Cap Set Stamped FISH PLS 38524
	– Schedule B-Section II Item
(A)	– Surveyor's Observation
T	– Telephone Vault
	– Bollard / Electric Box
	– Light Pole
	– Utility Pole
	– Guy Wire
	– Traffic Pole
	– Telephone Pedestal
T	– Telephone Manhole
	– Sign
	– Bollard Post
	– Guardrail
—X—	– Fence (As Noted)
—□—□—	– Wood Fence (As Noted)
—○—○—	– Steel Fence (As Noted)
—g—	– Underground Gas Pipeline
—ou—	– Overhead Utilities
	– Building Area

millman
National Land Services
Transforming the Industry
Surveying
Zoning
Environmental
Real Support - Title Review
Millman Surveying, Inc.
Corporate Headquarters
4111 Bradley Circle NW
Canton, OH 44718
Phone: 800-520-1010
Fax: 330-342-0834
www.millmanland.com
landsurveyors@millmanland.com

ALTA/NSPS LAND TITLE SURVEY PREPARED FOR:

First Industrial Realty Trust, Inc.

One North Wacker Dr
Suite 4200
Chicago, IL 60606

8780 Rosemary St.
City of Commerce City
County of Adams
State of Colorado
80640

NORTH

GRAPHIC SCALE
0 40' 80'
1 INCH = 40 FT.

PRELIMINARY FOR REVIEW ONLY

Surveyor's Seal

Sheet No. 1 of 1

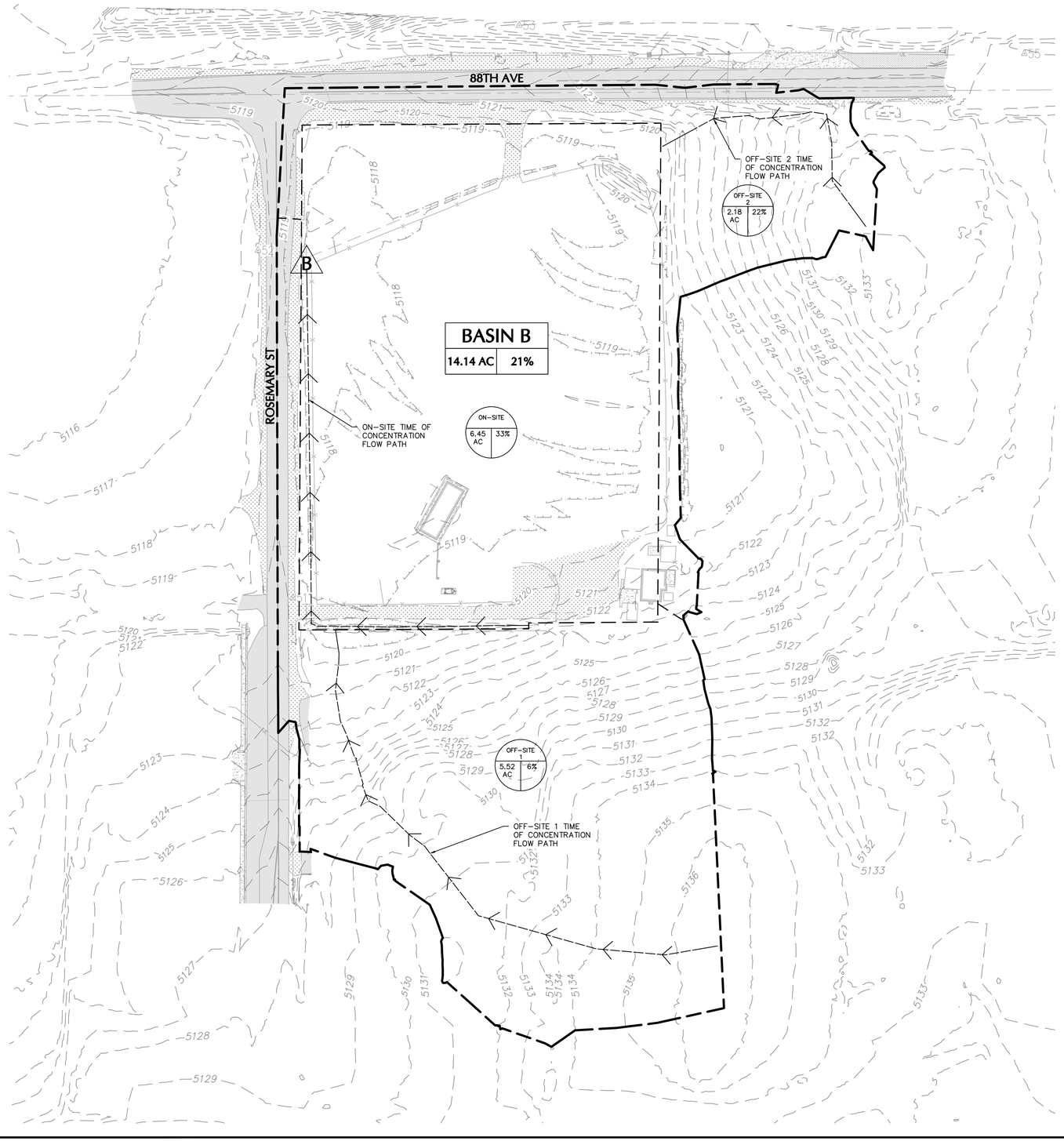
MSI Project No.49919

PC: ERF
PM: ARM Drafter: JAJ

8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



N

LEGEND

- BASIN BOUNDARY
- FLOW PATH
- DESIGN POINT
- BASIN (X; AREA (AC); PERCENT IMPERVIOUS)
- SUB-BASIN (X; AREA (AC); PERCENT IMPERVIOUS)

HYDROLOGY REVIEW

DESIGN POINT	CONTRIBUTING BASINS	CONTRIBUTING AREA (ACRES)	5-YEAR RUNOFF (CFS)	100-YR RUNOFF (CFS)
B	ON-SITE OFF-SITE 1 OFF-SITE 2	14.14	8.67	32.20

70 0 35 70
SCALE: 1 INCH = 70 FEET

CITY STAFF CERTIFICATE:

APPROVED BY THE DEPARTMENT OF COMMUNITY DEVELOPMENT OF THE CITY OF COMMERCE CITY, THIS _____ DAY OF _____, 20____.

_____
DEPARTMENT OF COMMUNITY DEVELOPMENT

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

LANGAN
Langan Engineering and Environmental Services, Inc.
300 Union Boulevard, Suite 405
Lakewood, CO 80228
T: 303.262.2000 F: 303.262.2001 www.langan.com
E: jeckersley@langan.com

Project

8780 ROSEMARY ST
DEVELOPMENT PLAN SET

COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title

HISTORIC DRAINAGE PATTERNS MAP

Project No.	Figure
620023001	CA101
Date: 10/15/2021	
Drawn By: SJS	
Checked By: JWE	Sheet 1 of 9

LANGAN Project No. 620023001

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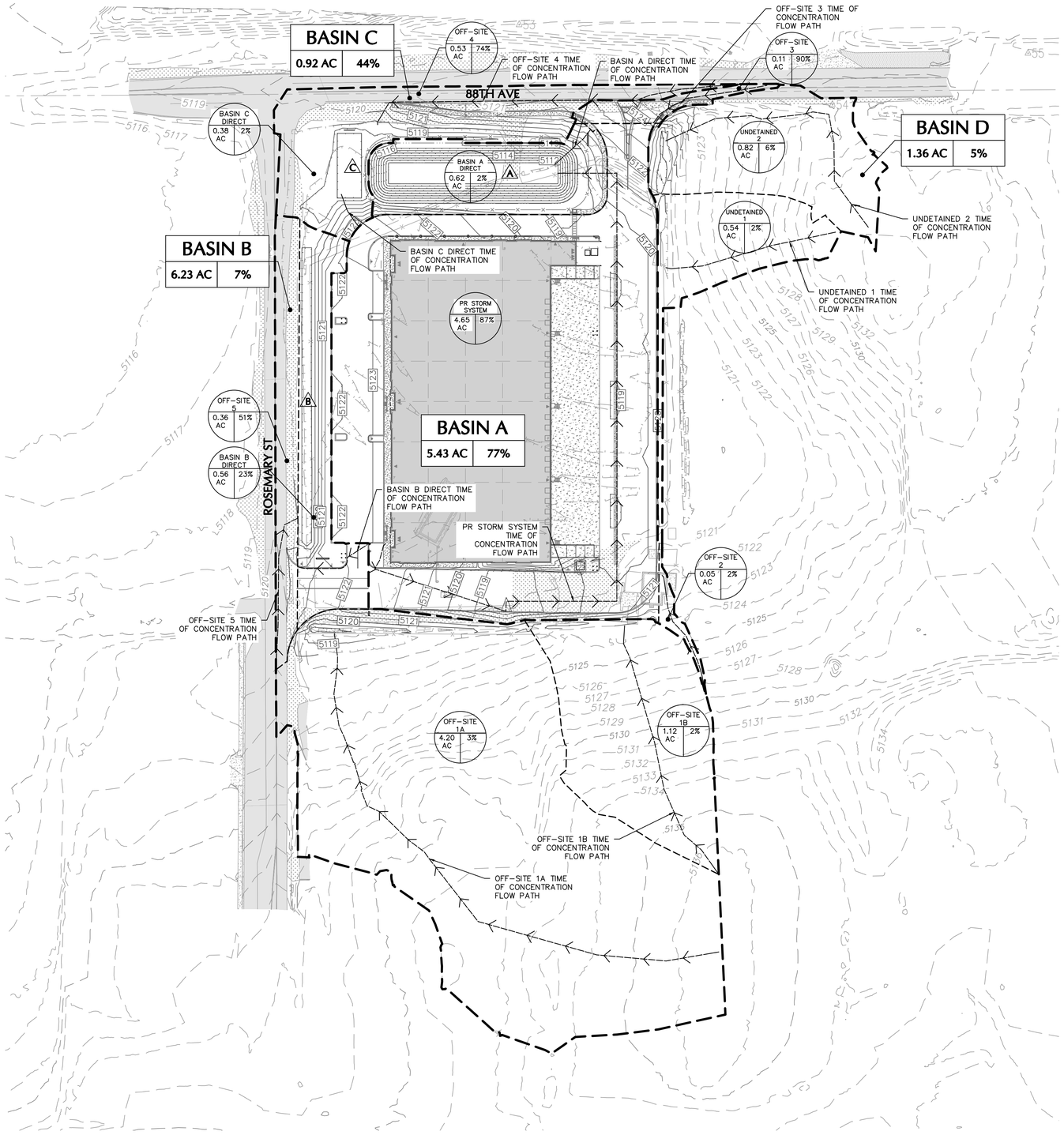
8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



N

LEGEND

- BASIN BOUNDARY
- FLOW PATH
- DESIGN POINT
- BASIN (X; AREA (AC); PERCENT IMPERVIOUS)
- SUB-BASIN (X; AREA (AC); PERCENT IMPERVIOUS)

HYDROLOGY REVIEW

DESIGN POINT	CONTRIBUTING BASINS	CONTRIBUTING AREA (ACRES)	5-YEAR RUNOFF (CFS)	100-YR RUNOFF (CFS)
A	PR STORM SYSTEM DIRECT RUNOFF TO BASIN A OFF-SITE 2 OFF-SITE 3	5.43	12.16	28.03
B	DIRECT RUNOFF TO BASIN B OFF-SITE 1A OFF-SITE 1B OFF-SITE 5	6.23	1.23	7.08
C	DIRECT RUNOFF TO BASIN C OFF-SITE 4	0.92	1.33	3.16
D	UNDETAINED 1 UNDETAINED 2	1.36	0.09	1.54

70 0 35 70
SCALE: 1 INCH = 70 FEET

CITY STAFF CERTIFICATE:

APPROVED BY THE DEPARTMENT OF COMMUNITY DEVELOPMENT OF THE CITY OF COMMERCE CITY, THIS _____ DAY OF _____, 20____.

_____
DEPARTMENT OF COMMUNITY DEVELOPMENT

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

LANGAN
Langan Engineering and Environmental Services, Inc.
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Project
8780 ROSEMARY ST
DEVELOPMENT PLAN SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
PROPOSED DRAINAGE PATTERNS MAP

Project No.	Figure
620023001	CA102
Date: 10/15/2021	
Drawn By: SJS	
Checked By: JWE	Sheet 2 of 9

LANGAN
Project No. 620023001

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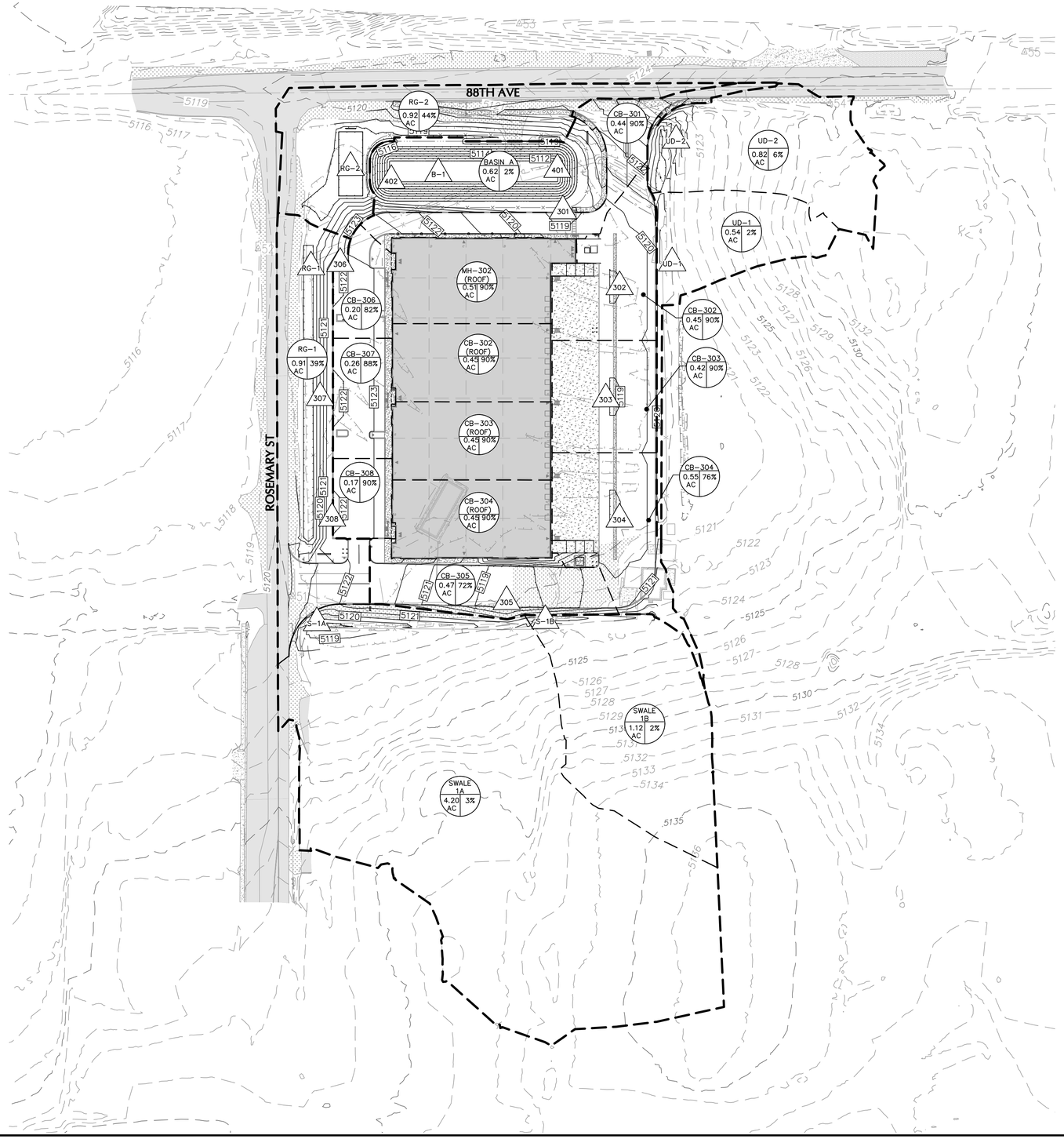
8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



LEGEND

- BASIN BOUNDARY
- DESIGN POINT
- SUB-BASIN
- AREA (AC)
- PERCENT IMPERVIOUS

BASIN RUNOFF SUMMARY

Sub- Basin	Design Point	Area (ac)	% Impervious	C5	C100	Q5	Q100
CB-301	301	0.44	0.90	0.76	0.85	1.56	3.26
CB-302	302	0.45	0.90	0.77	0.87	1.62	3.44
CB-303	303	0.42	0.90	0.77	0.76	1.40	2.60
CB-304	304	0.55	0.76	0.63	0.75	1.45	3.28
CB-305	305	0.47	0.72	0.57	0.68	0.95	2.15
CB-306	306	0.20	0.82	0.70	0.73	0.64	1.24
CB-307	307	0.26	0.88	0.76	0.75	0.90	1.69
CB-308	308	0.17	0.90	0.77	0.76	0.61	1.14
MH-302 (ROOF)	401	0.51	0.90	0.77	0.76	1.84	3.41
CB-302 (ROOF)	302	0.45	0.90	0.77	0.76	1.60	2.97
CB-303 (ROOF)	303	0.45	0.90	0.77	0.76	1.60	2.98
CB-304 (ROOF)	304	0.45	0.90	0.77	0.76	1.60	2.98
FES-401	401	4.19	0.75	0.64	0.79	8.56	19.88
FES-402	402	0.62	0.87	0.74	0.75	1.95	3.68
BASIN A	B-A	0.62	0.02	0.05	0.43	0.13	2.36
SWALE 1A	S-1A	4.20	0.03	0.01	0.13	0.11	2.61
SWALE 1B	S-2A	1.12	0.02	0.01	0.13	0.02	0.90
RG-1	RG-1	0.91	0.39	0.35	0.63	1.14	3.85
RG-2	RG-2	0.92	0.44	0.35	0.66	1.14	4.05
UD-1	UD-1	0.54	0.02	0.01	0.15	0.01	0.54
UD-2	UD-2	0.82	0.06	0.03	0.21	0.07	1.01

60 0 20 40 60
SCALE: 1 INCH = 60 FEET

CITY STAFF CERTIFICATE:

APPROVED BY THE DEPARTMENT OF COMMUNITY DEVELOPMENT OF THE CITY OF COMMERCE CITY, THIS _____ DAY OF _____, 20____.

_____
DEPARTMENT OF COMMUNITY DEVELOPMENT

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

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Project
8780 ROSEMARY ST
DEVELOPMENT PLAN SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
PROPOSED SUB-BASIN MAP

Project No.	Figure
620023001	CA103
Date: 10/15/2021	
Drawn By: SJS	
Checked By: JWE	

Sheet 3 of 9

LANGAN
Project No. 620023001

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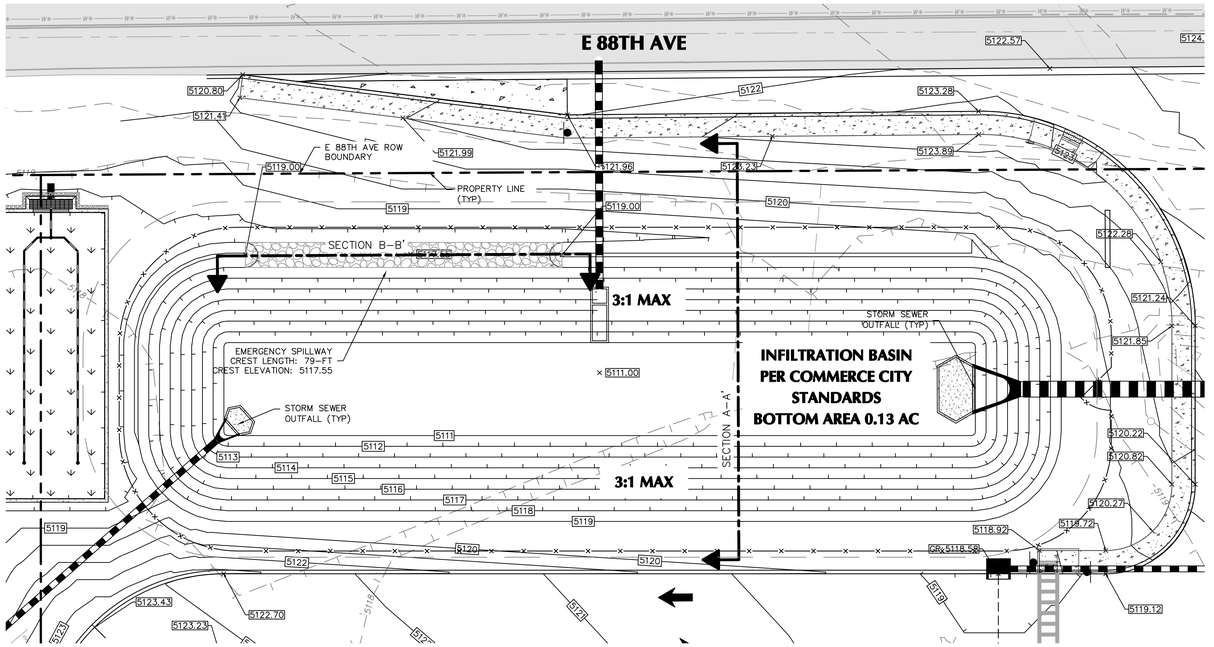
Date: 8/17/2022 Time: 13:26 User: ssessock Style Table: Langan.stb Layout: CA-102 Document Code: FG02-620023001-0101-CA104-0103

8780 ROSEMARY STREET - FILING NO. 1, LOT 1

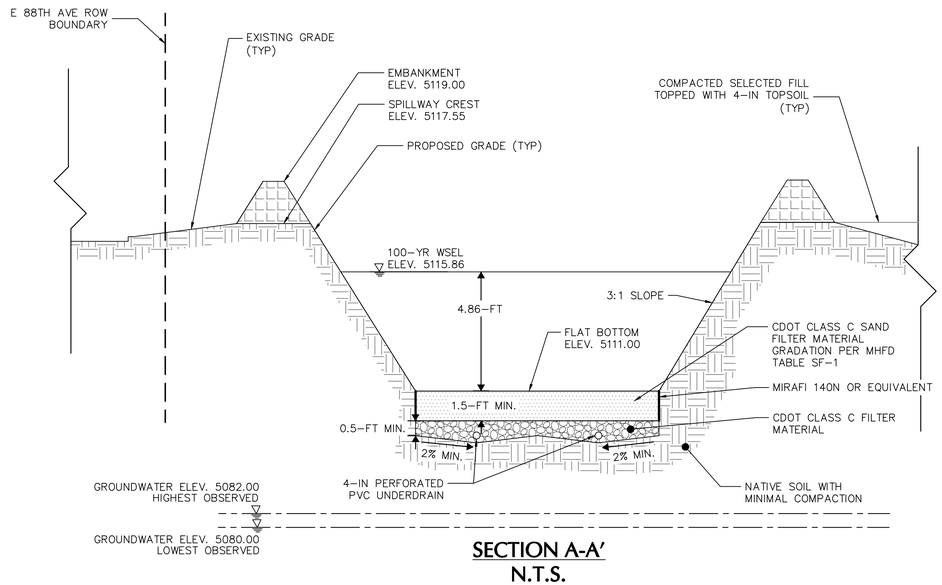
LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN

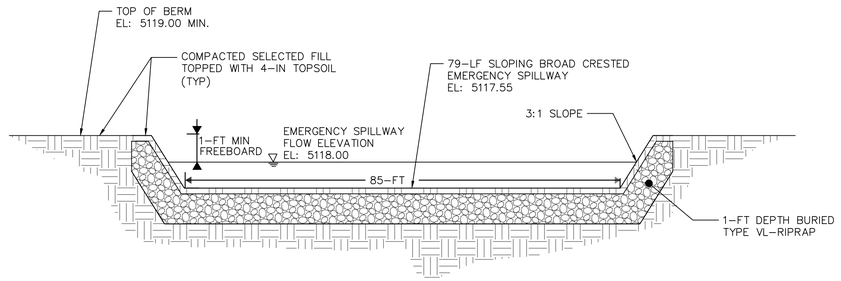


BASIN 1
SCALE: 1′ = 20′

SCALE IN FEET



SECTION A-A′
N.T.S.



SECTION B-B′
N.T.S.

Included for reference only. Not an approved design.

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

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Project
8780 ROSEMARY ST
STORM CONSTRUCTION SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
RETENTION BASIN DETAIL

Project No.	Drawing No.
620023001	CA501
Date: 5/13/2021	
Drawn By: SJS	
Checked By: JWE	Sheet 4 of 9

Project No. 620023001

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8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
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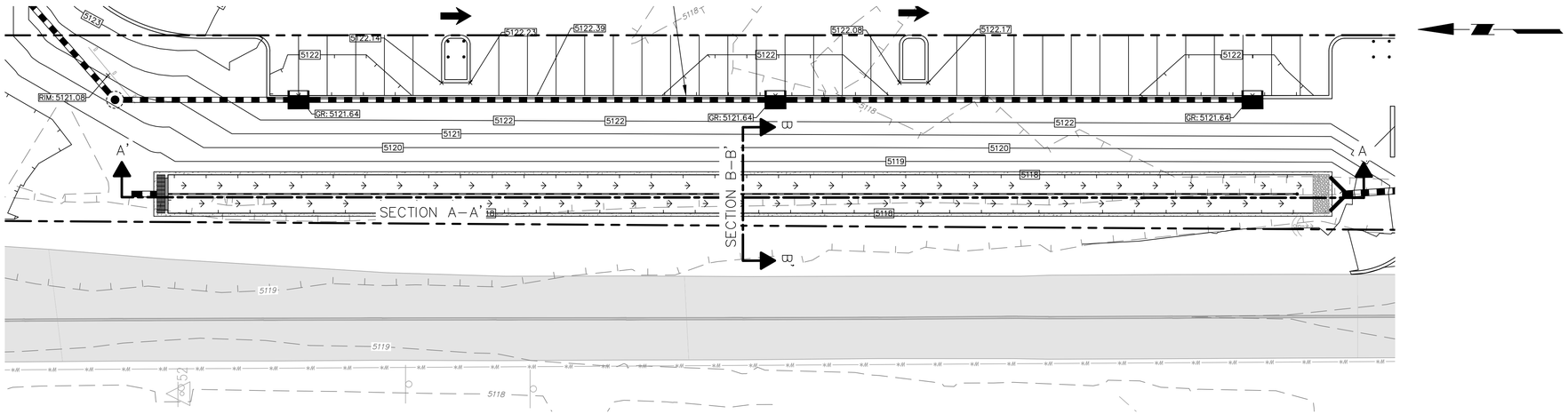
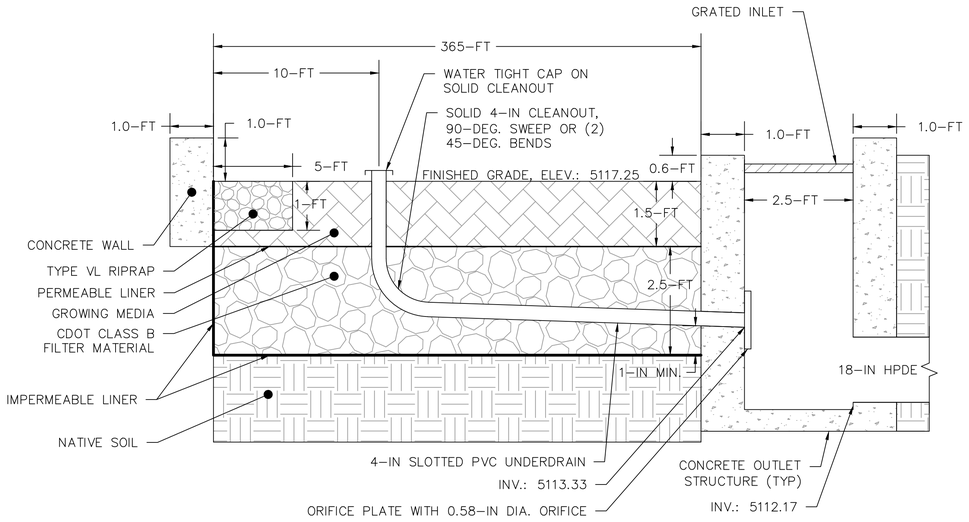
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN

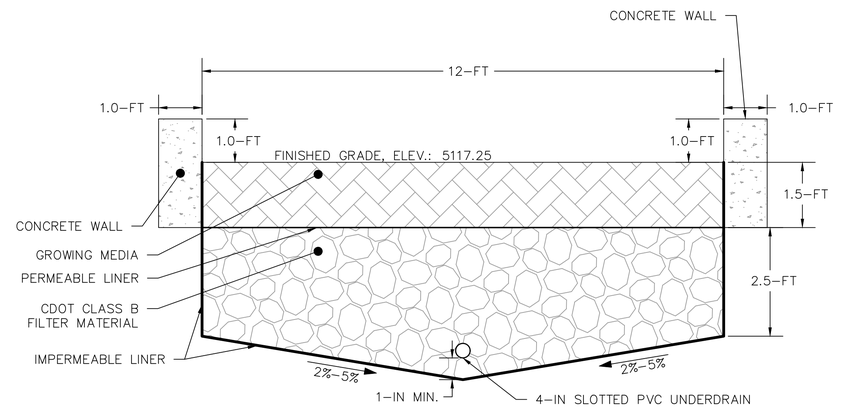


RAIN GARDEN 1
SCALE: 1' = 20'

20 0 10 20
SCALE IN FEET



RAIN GARDEN 1 - SECTION A-A'
NTS



RAIN GARDEN 1 - SECTION B-B'
NTS

NOTES:
1. GROWING MEDIA, UNDERDRAIN PIPE AND IMPERMEABLE LINER SHALL CONFORM TO THE SPECIFICATIONS IN TABLE B–1, "MATERIAL SPECIFICATIONS FOR BIORETENTION/RAIN GARDEN FACILITIES", USDCM VOLUME 3.
2. SEE LANDSCAPE PLANS ON SHEET XXXX FOR PLANTING SCHEDULE.

Included for reference only. Not an approved design.

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

LANGAN
Langan Engineering and Environmental Services, Inc.
300 Union Boulevard, Suite 405
Lakewood, CO 80228
T: 303.262.2600 F: 303.262.2001 www.langan.com

Project
8780 ROSEMARY ST
STORM CONSTRUCTION SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
RAIN GARDEN 1 DETAIL

Project No.	Drawing No.
620023001	CA502
Date: 5/13/2021	
Drawn By: SJS	
Checked By: JWE	Sheet 5 of 9

LANGAN Project No. 620023001
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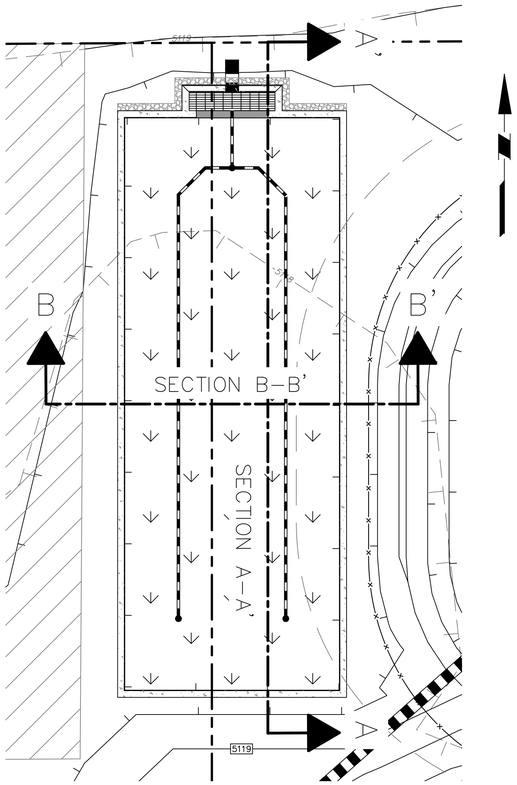
8780 ROSEMARY STREET - FILING NO. 1, LOT 1

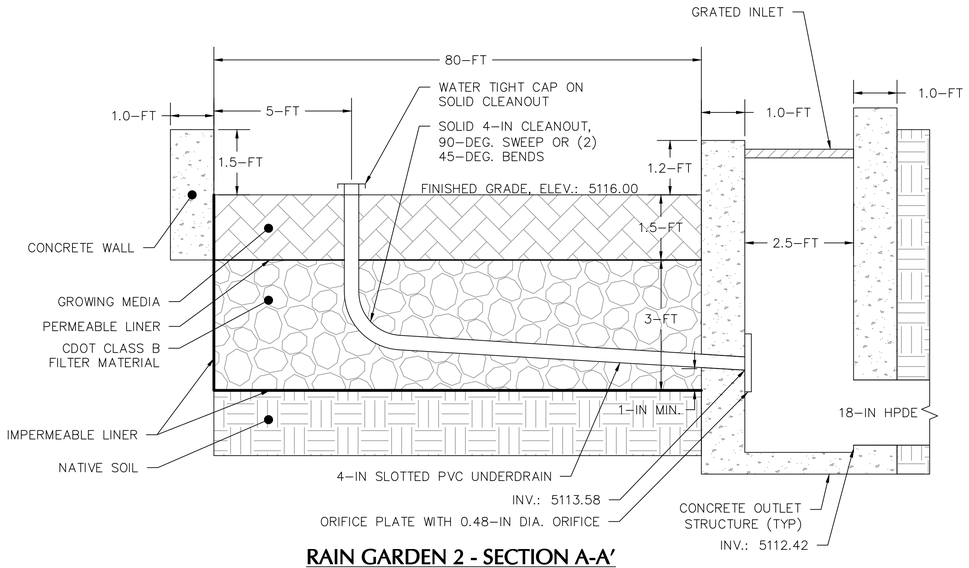
LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



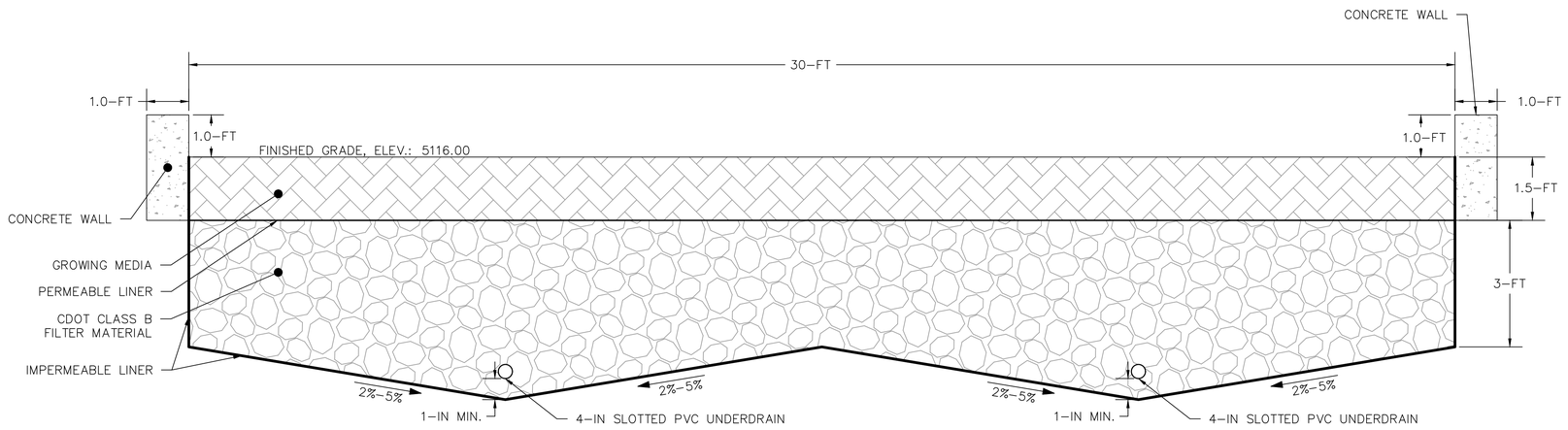
RAIN GARDEN 2
SCALE: 1' = 10'

10 0 5 10
SCALE IN FEET



RAIN GARDEN 2 - SECTION A-A'
NTS

NOTES:
1. GROWING MEDIA, UNDERDRAIN PIPE AND IMPERMEABLE LINER SHALL CONFORM TO THE SPECIFICATIONS IN TABLE B–1, "MATERIAL SPECIFICATIONS FOR BIORETENTION/RAIN GARDEN FACILITIES", USDCM VOLUME 3.
2. SEE LANDSCAPE PLANS ON SHEET XXXX FOR PLANTING SCHEDULE.



RAIN GARDEN 2 - SECTION B-B'
NTS

Included for reference only. Not an approved design.

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

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300 Union Boulevard, Suite 405
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T: 303.262.2600 F: 303.262.2001 www.langan.com

Project
8780 ROSEMARY ST
STORM CONSTRUCTION SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
RAIN GARDEN 2 DETAIL

Project No.	Drawing No.
620023001	CA503
Date: 5/13/2021	
Drawn By: SJS	
Checked By: JWE	

Sheet 6 of 9

LANGAN Project No. 620023001

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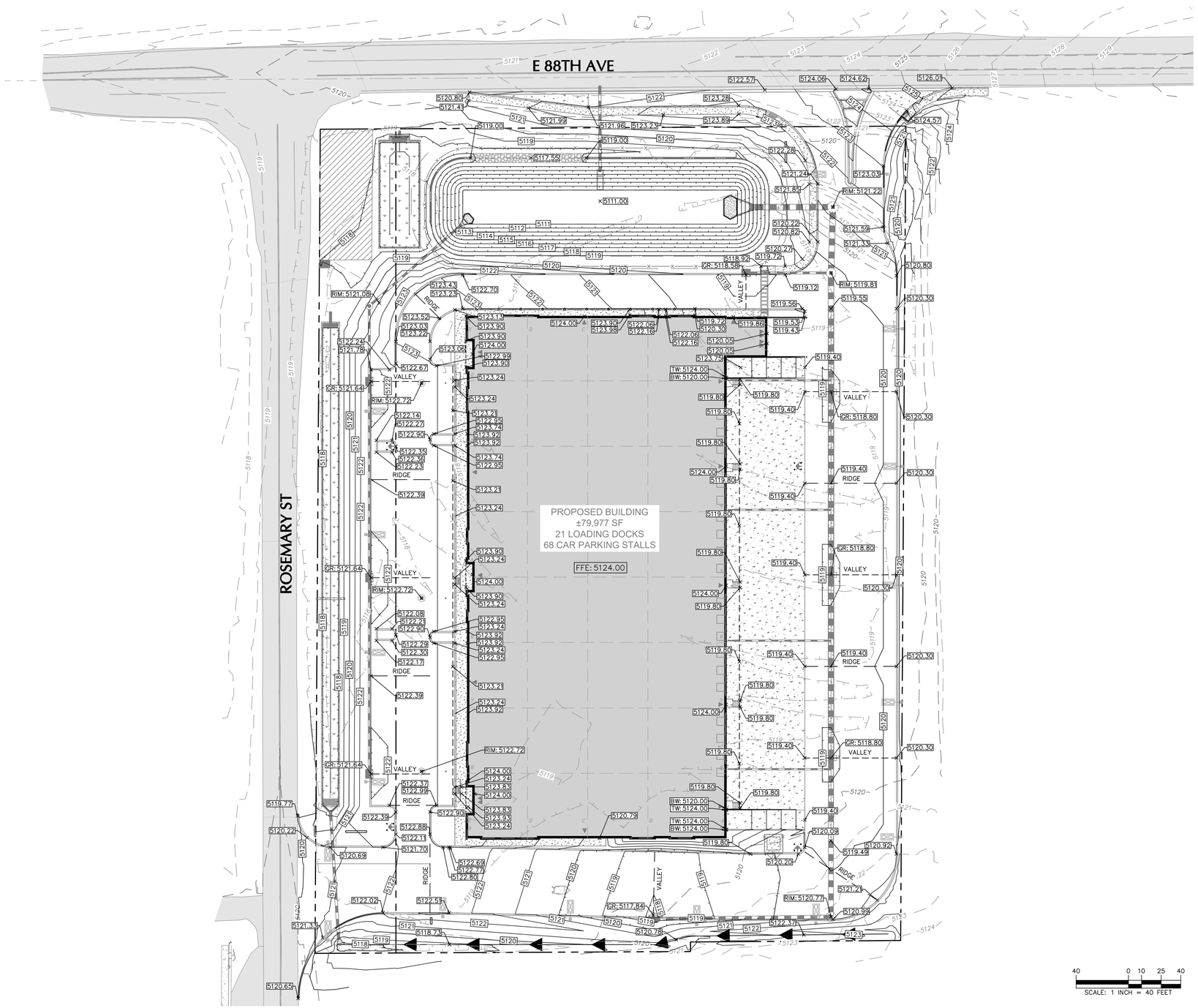
8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



LEGEND

	EXISTING	PROPOSED
ROW BOUNDARY		
PROPERTY LINE		
MAJOR CONTOUR	5100	5100
MINOR CONTOUR	5099	5099
SPOT ELEVATION	G5101.79	5099.26
STORM LINE		
SANITARY LINE		
FIRE WATER LINE		FW
WATER LINE		W
ELECTRIC UNDERGROUND		E
TELEPHONE LINE UNDERGROUND		T
OVERHEAD UTILITY	OU	
CABLE TV UNDERGROUND		
GAS LINE UNDERGROUND		G
SANITARY MANHOLE		
STORM MANHOLE		
STORM INLET		
STORM FES		
WATER FIRE HYDRANT		
WATER METER		
METAL FENCE		
CHAIN LINK FENCE		
BORING LOCATION		

GENERAL GRADING AND DRAINAGE NOTES:

1. EXISTING TOPOGRAPHY AND UTILITY INFORMATION FROM CAD FILES RECEIVED ELECTRONICALLY FROM AZTEC CONSULTANTS, INC. ON 09/09/2021. CONTRACTOR SHALL FIELD VERIFY EXISTING TOPOGRAPHY, TIE IN ELEVATIONS, AND INVERTS PRIOR TO STARTING CONSTRUCTION.
2. EXISTING CONTOURS/INVERTS ARE PRESENTED IN NAVD 88 AS REPRESENTED ON THE ABOVE REFERENCED SURVEY. LANGAN CLAIMS NO RESPONSIBILITY FOR THIS INFORMATION. CONTRACTOR SHALL FIELD VERIFY TIE IN ELEVATIONS AND INVERTS PRIOR TO STARTING CONSTRUCTION.
3. SITE GRADING AND ALL REQUIRED UNDERCUTS SHALL BE PERFORMED IN ACCORDANCE WITH THESE PLANS AND SPECIFICATIONS. THE FILL MATERIAL, PLACEMENT OF FILL, COMPACTION REQUIREMENTS AND THE COMPACTION TESTING REQUIREMENTS ARE DEFINED IN THE GEOTECHNICAL REPORT.
4. THE CONTRACTOR SHALL BE RESPONSIBLE TO CALL UTILITY "ONE-CALL" NUMBER 72 HOURS PRIOR TO ANY EXCAVATION ON THIS SITE. CONTRACTOR SHALL ALSO NOTIFY LOCAL WATER AND SEWER DEPARTMENTS TO MARK OUT THEIR UTILITIES.
5. REFER TO ARCHITECTURAL AND PLUMBING DRAWINGS FOR EXACT ROOF LEADER CONNECTION LOCATIONS. WHERE CONFLICTS EXIST BETWEEN THESE PLANS AND ARCHITECTURAL PLANS, CONTRACTOR TO NOTIFY THE ENGINEER BEFORE CONSTRUCTION.
6. ALL GRADING SHALL BE A MINIMUM OF 1% AND A MAXIMUM OF THREE (3) FEET HORIZONTALLY TO ONE (1) FOOT VERTICALLY ACROSS ALL LAWN/LANDSCAPE AREAS UNLESS REQUIRED BY ADA OR BARRIER FREE REQUIREMENTS.
7. ALL AREAS SHALL BE WELL GRADED TO MINIMIZE FLAT AREAS, TO PROVIDE PROPER DRAINAGE, AND TO PREVENT LOCALIZED PONDING.
8. LOCATIONS OF SPILL/CATCH CURB TRANSITIONS TO BE FIELD LOCATED BY THE CONTRACTOR BASED ON GRADING AS SHOWN IN CG101-CG103.

SPOT ELEVATION NOTES:

1. PROPOSED SPOT ELEVATIONS REFER TO THE BOTTOM OF THE FACE OF THE CURB (TC=BC+0.5 FT) AND/OR BOTTOM OF DITCH/SWALE AND/OR TOP OF PAVEMENT SURFACE UNLESS OTHERWISE NOTED..
2. GR = FLOW LINE OR TOP OF INLET LIP (BOTTOM OF CURB)

STORM STRUCTURE NOTE:

1. CATCH BASIN GRATE TYPES ARE LISTED WITH THE NAME OF EACH STRUCTURE.
2. CONTRACTOR SHALL PROVIDE SHOP DRAWINGS FOR CUSTOM INLETS.

Included for reference only. Not an approved design.

CITY STAFF CERTIFICATE:

APPROVED BY THE DEPARTMENT OF COMMUNITY DEVELOPMENT OF THE CITY OF COMMERCE CITY, THIS _____ DAY OF _____, 20____.

_____
DEPARTMENT OF COMMUNITY DEVELOPMENT

40 0 10 25 40
SCALE: 1 INCH = 40 FEET

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

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E: jeckersley@langan.com

Project
8780 ROSEMARY ST
DEVELOPMENT PLAN SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
OVERALL GRADING PLAN

Project No.	Drawing No.
620023001	CG101
Date: 10/15/2021	
Drawn By: SJS	
Checked By: JWE	Sheet 7 of 9

LANGAN
Project No. 620023001

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8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
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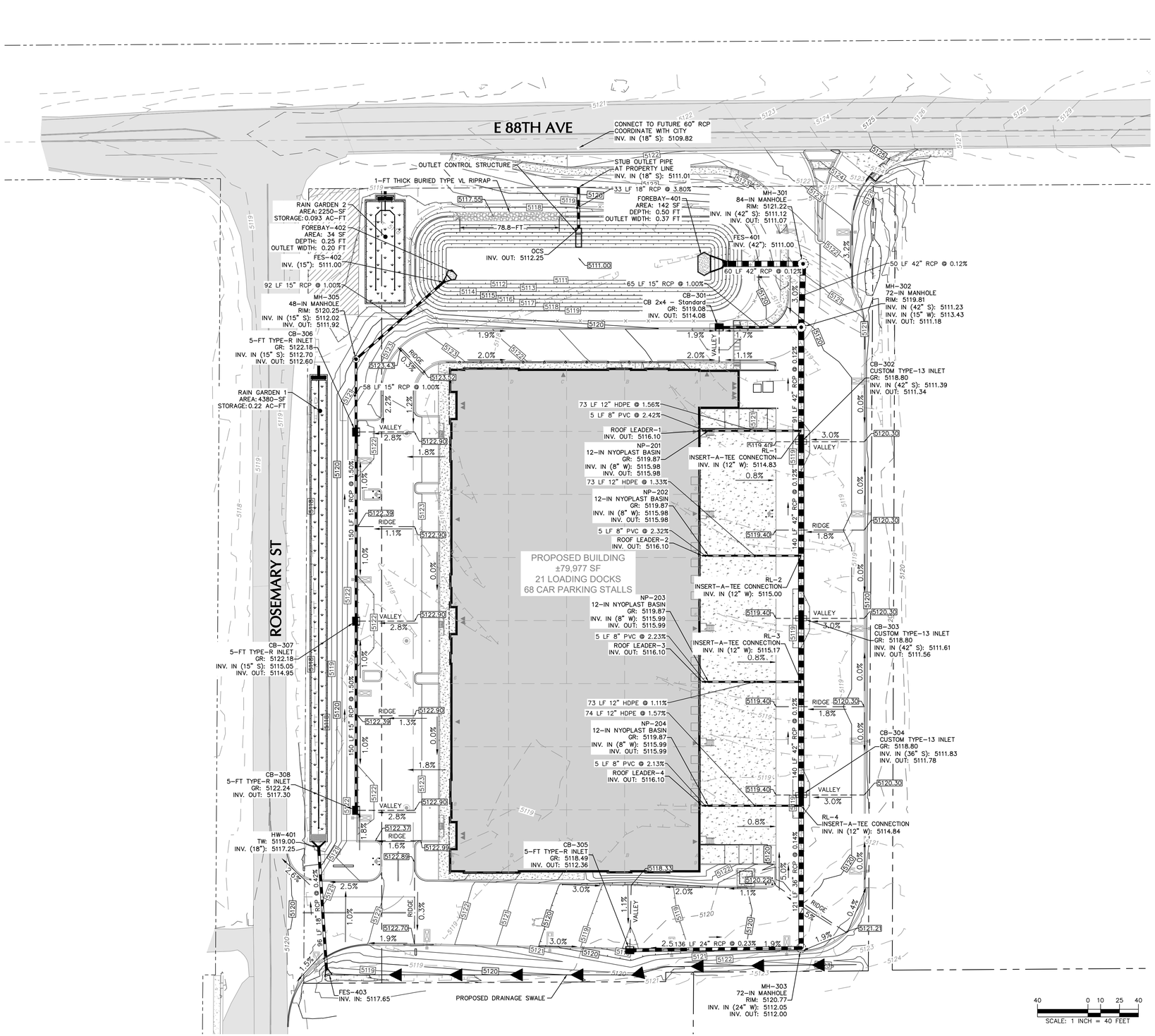
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



LEGEND

	EXISTING	PROPOSED
ROW BOUNDARY		
PROPERTY LINE		
MAJOR CONTOUR	5100	5100
MINOR CONTOUR	5099	5099
SPOT ELEVATION	G5101.79	5099.39
STORM LINE		
SANITARY LINE		
FIRE WATER LINE		FW
WATER LINE		W
ELECTRIC UNDERGROUND		E
TELEPHONE LINE UNDERGROUND		T
OVERHEAD UTILITY	OU	
CABLE TV UNDERGROUND		
GAS LINE UNDERGROUND		G
SANITARY MANHOLE		
STORM MANHOLE		
STORM INLET		
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CHAIN LINK FENCE		
BORING LOCATION		

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Included for reference only. Not an approved design.

CITY STAFF CERTIFICATE:

APPROVED BY THE DEPARTMENT OF COMMUNITY DEVELOPMENT OF THE CITY OF COMMERCE CITY, THIS _____ DAY OF _____, 20____.

_____
DEPARTMENT OF COMMUNITY DEVELOPMENT

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
5/6/2021	1ST ROUND DP COMMENTS	1

Revisions

Signature Date

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Project
8780 ROSEMARY ST
DEVELOPMENT PLAN SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
OVERALL DRAINAGE PLAN

Project No.	620023001
Date	10/15/2021
Drawn By	SJS
Checked By	JWE
Drawing No.	CG102
Sheet	8 of 9

LANGAN
Project No. 620023001

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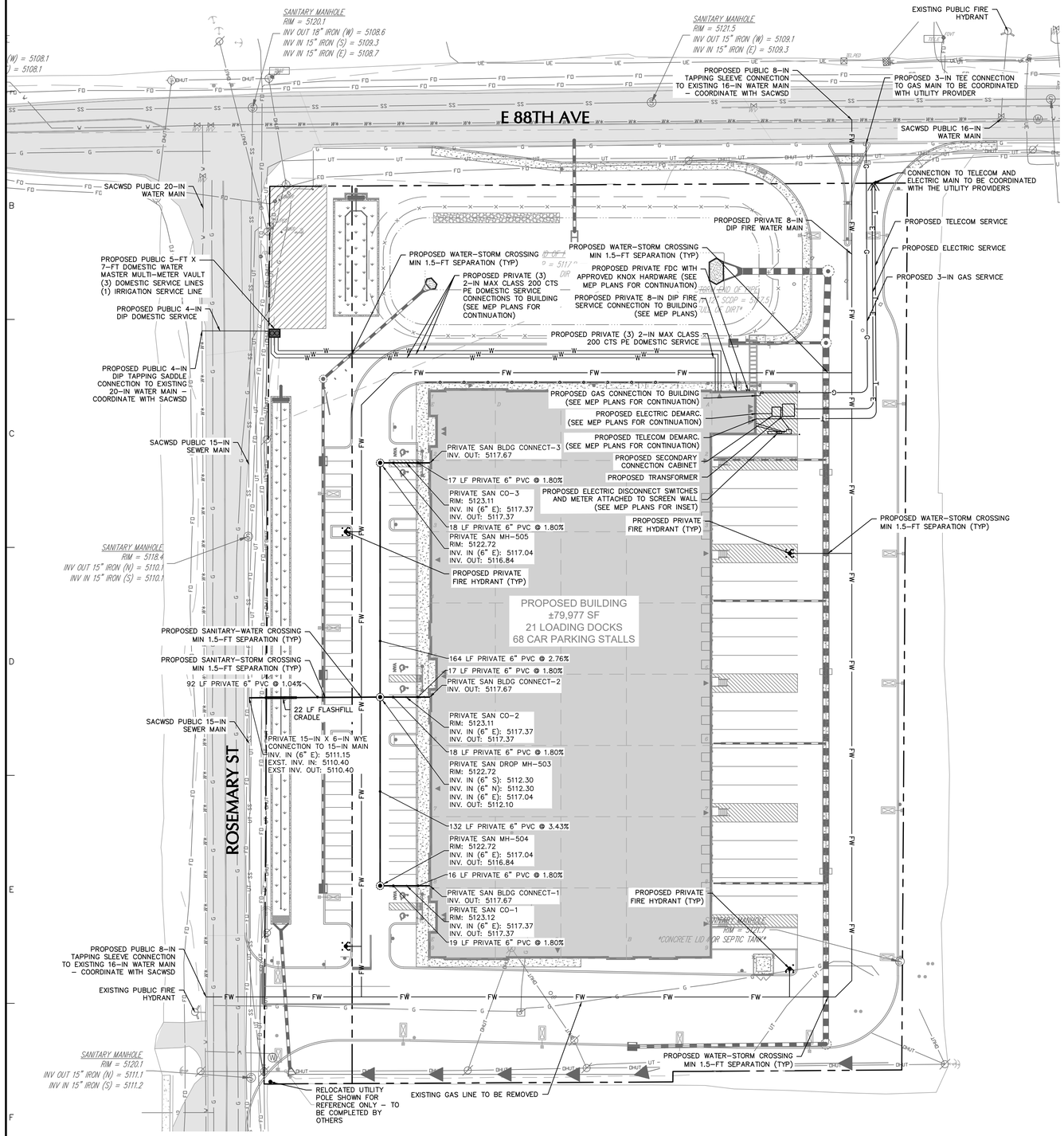
8780 ROSEMARY STREET - FILING NO. 1, LOT 1

LOCATED IN THE NORTHWEST QUARTER OF SECTION 28,
TOWNSHIP 2 SOUTH, RANGE 67 WEST
CITY OF COMMERCE CITY, COUNTY OF ADAMS, STATE OF COLORADO
TOTAL AREA = 280,752 SF OR 6.445 AC. (PIN: 0172128200016)

DEVELOPMENT PLAN



LEGEND

	EXISTING	PROPOSED
SANITARY SEWER	SS	
WATER LINE (SURVEY)	W	W
WATER LINE (GIS)	W/A	W/A
UNDERGROUND ELECTRIC LINE	UE	E
UNDERGROUND TELECOM LINE	UT	T
GAS LINE	G	G
FIRE WATER LINE		FW
STORM SEWER		
OVERHEAD UTILITY	OU	
DOMESTIC WATER MULTI-METER VAULT		DS
STORM INLET		
STORM MANHOLE		
SANITARY MANHOLE	S	
STORM FES		
WATER FIRE HYDRANT		
ELECTRIC POLE		
BOLLARD WITH ELECTRIC BOX		
TELEPHONE MANHOLE		
TELEPHONE PEDESTAL		
TELEPHONE		

SCALE: 1 INCH = 40 FEET

SACWSD GENERAL UTILITY PLAN NOTES

PROPERTY OWNER(S) ACKNOWLEDGE AND AGREE TO THE FOLLOWING UPON APPROVAL OF UTILITY PLAN:

1. SOUTH ADAMS COUNTY WATER AND SANITARY DISTRICT (SACWSD) SHALL MAKE THE FINAL DETERMINATION OF THE LOCATION OF ALL WATER, WASTEWATER, ELECTRIC AND GAS FACILITIES, WHICH MAY NOT BE THE SAME LOCATION AS SHOWN ON THIS UTILITY PLAN.
2. PROPERTY OWNER(S) ("OWNER") ACKNOWLEDGES THAT THE CONNECTION AND/OR EXTENSION OF UTILITY SERVICES TO THE PROPERTY IDENTIFIED IN THIS UTILITY PLAN ("PROPERTY") SHALL BE IN ACCORD WITH ALL APPLICABLE CODES AND REGULATIONS, TARIFFS, COMMERCE CITY CODE, RESOLUTIONS, AND POLICIES, AND SACWSD CODES, IN EFFECT AT THE TIME OF UTILITY SERVICE CONNECTION AND/OR EXTENSION.
3. OWNER ACKNOWLEDGES RESPONSIBILITY FOR THE COSTS OF EXTENSIONS OR UTILITY SYSTEM IMPROVEMENTS THAT SACWSD DETERMINES NECESSARY TO PROVIDE UTILITY SERVICES TO THE PROPERTY OR TO ENSURE TIMELY DEVELOPMENT OF INTEGRATED UTILITY SYSTEMS SERVING THE PROPERTY AND AREAS OUTSIDE THE PROPERTY (INCLUDING THE COSTS TO DESIGN AND INSTALL WATER SYSTEMS, WASTEWATER COLLECTION SYSTEMS, AND ANY GAS OR ELECTRIC LINES TO AND WITHIN THE PROPERTY). OWNER MAY BE ELIGIBLE FOR A COST RECOVERY AGREEMENT AS PROVIDED IN UTILITIES' RULES AND REGULATIONS.
4. THE RELOCATION OR ALTERATION OF ANY EXISTING UTILITY FACILITIES WITHIN THE PROPERTY WILL BE AT THE OWNER'S SOLE COST AND EXPENSE. IF SACWSD DETERMINES THAT OWNER'S RELOCATION OR ALTERATION REQUIRES NEW OR UPDATED EASEMENTS, OWNER SHALL CONVEY THOSE EASEMENTS PRIOR TO RELOCATING OR ALTERING THE EXISTING UTILITY FACILITIES.
5. OWNER SHALL DEDICATE BY PLAT AND/OR CONVEY BY RECORDED DOCUMENT, ALL PROPERTY AND EASEMENTS THAT SACWSD DETERMINES ARE REQUIRED FOR ALL UTILITY SYSTEM FACILITIES NECESSARY TO SERVE THE PROPERTY OR TO ENSURE DEVELOPMENT OF AN INTEGRATED UTILITY SYSTEM. ALL EASEMENTS GRANTED BY SEPARATE INSTRUMENT SHALL UTILIZE SACWSD'S THEN-CURRENT PERMANENT EASEMENT AGREEMENT FORM.
6. THE WATER SYSTEM FACILITIES MUST MEET SACWSD CRITERIA FOR WATER QUALITY, RELIABILITY AND PRESSURE, INCLUDING LOOPING REQUIREMENTS.
7. OWNER RECOGNIZES THAT THE EXTENSION OF WATER SYSTEM FACILITIES MAY AFFECT THE QUALITY OF WATER IN THE SACWSD WATER SYSTEM. WHEN WATER QUALITY IS AFFECTED, OWNER ACKNOWLEDGES RESPONSIBILITY FOR ANY COSTS THAT SACWSD DETERMINES NECESSARY IN ORDER TO MAINTAIN WATER QUALITY IN ITS SYSTEM AS A RESULT OF OWNER'S WATER SYSTEM EXTENSIONS. OWNER MAY BE REQUIRED TO SUBMIT A WATER QUALITY PLAN FOR THE PROJECT.
8. OWNER MUST CONTACT SACWSD TO DETERMINE THE LOCATION OF ALL NATURAL GAS AND ELECTRIC METERS AND TRANSFORMERS AND TO SECURE APPROVAL OF GAS-SERVICE-LINE PRESSURES IN EXCESS OF SPRINGS UTILITIES STANDARD GAS SYSTEM PRESSURE.
9. IT SHALL NOT BE PERMISSIBLE FOR ANY PERSON TO MODIFY THE GRADE OF THE EARTH WITHIN ANY SACWSD EASEMENT OR RIGHTS OF WAY WITHOUT THE WRITTEN APPROVAL OF SACWSD. IMPROVEMENTS, STRUCTURES AND TREES SHALL NOT BE LOCATED WITHIN UTILITY EASEMENT, SHALL NOT VIOLATE NATIONAL ELECTRIC SAFETY CODE (NESC) PROVISIONS AND CLEARANCES, AND SHALL NOT IMPAIR ACCESS OR THE ABILITY TO MAINTAIN UTILITY FACILITIES.
10. SACWSD APPROVAL OF THIS UTILITY PLAN SHALL NOT BE CONSTRUED AS A LIMITATION UPON THE AUTHORITY OF SACWSD TO APPLY ITS STANDARDS; AND IF THERE ARE ANY CONFLICTS BETWEEN ANY APPROVED DRAWINGS AND ANY PROVISION OF STANDARDS OR THE CITY CODE, THEN THE STANDARDS OR CITY CODE SHALL APPLY. SACWSD APPROVAL OF THIS PRELIMINARY UTILITY PLAN SHALL NOT BE CONSTRUED AS A LIMITATION UPON THE AUTHORITY OF THE CITY OF COMMERCE CITY OR SACWSD TO ADOPT DIFFERENT ORDINANCES, RULES, REGULATIONS, RESOLUTIONS, POLICIES OR CODES WHICH CHANGE ANY OF THE PROVISIONS OF THE STANDARDS SO LONG AS THESE APPLY TO THE CITY GENERALLY AND ARE IN ACCORD WITH THE THEN-CURRENT TARIFFS, RATES AND POLICIES OF SPRINGS UTILITIES.
11. ALL SANITARY SEWERS ARE PRIVATE UNLESS OTHERWISE NOTED.
12. ALL PIPES WITH A BURIAL DEPTH GREATER THAN 20-FT SHALL BE SDR-26 PVC.
13. MINIMUM HORIZONTAL SEPARATIONS SHALL BE AS FOLLOWS:
    - POTABLE WATER MAIN TO SANITARY SEWER, IRRIGATION MAIN, OR STORM SEWER: 10-FT
    - POTABLE WATER MAIN TO LIP OF CONCRETE GUTTER: 5-FT
    - SANITARY SEWER TO IRRIGATION MAIN, OR STORM SEWER: 5-FT
    - IRRIGATION MAIN TO STORM SEWER, OR EDGE OF CONCRETE GUTTER: 5-FT
14. MINIMUM VERTICAL SEPARATIONS SHALL BE AS FOLLOWS:
    - POTABLE WATER MAIN TO ALL OTHER UTILITIES: 18-IN
    - SANITARY SEWER TO IRRIGATION MAIN, OR STORM SEWER: 12-IN
    - IRRIGATION MAIN TO STORM SEWER OR OTHER UTILITIES: 12-IN

SOUTH ADAMS COUNTY FIRE DEPARTMENT PRIVATE WATER LINE AND FIRE HYDRANT NOTES:

1. PRIVATE FIRE SERVICE MAINS AND APPURTENANCES SHALL BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH SOUTH ADAMS COUNTY WATER AND SANITATION DISTRICT AND NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 24.
2. UNDERGROUND WATER SUPPLY CONTRACTORS INSTALLING PRIVATE FIRE SERVICE MAINS AND APPURTENANCES SHALL BE LICENSED WITH THE STATE OF COLORADO DIVISION OF FIRE PREVENTION AND CONTROL AS A FIRE SUPPRESSION SYSTEMS CONTRACTOR – UNDERGROUND. THE STATE OF COLORADO LICENSE SHALL BE SUBMITTED TO THE SOUTH ADAMS COUNTY FIRE DEPARTMENT.
3. PRIVATE FIRE SERVICE MAINS AND APPURTENANCES INCLUDING SPECIFICATION DATA SHEETS SHALL BE SUBMITTED TO THE SOUTH ADAMS COUNTY FIRE DEPARTMENT FOR REVIEW AND APPROVAL.
4. PRIVATE FIRE HYDRANTS SHALL BE PAINTED RED AND MARKED IN ACCORDANCE WITH NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 291.
5. FIRE FLOW TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 291 AND DOCUMENTATION PROVIDED TO THE SOUTH ADAMS COUNTY FIRE DEPARTMENT FOR FINAL APPROVAL OF THE PRIVATE WATER SUPPLY SYSTEM.
6. A THREE (3) FOOT CLEAR SPACE SHALL BE MAINTAINED AROUND THE CIRCUMFERENCE OF FIRE HYDRANTS.
7. INSPECTIONS AND TESTS ON PRIVATE FIRE SERVICE MAINS AND APPURTENANCES SHALL BE IN ACCORDANCE WITH SOUTH ADAMS COUNTY WATER AND SANITATION DISTRICT STANDARDS, NFPA 13 STANDARD, AND NFPA 24 STANDARD. THE SOUTH ADAMS COUNTY FIRE DEPARTMENT WILL INSPECT AND WITNESS THE INSTALLATION OF THE PRIVATE WATER MAIN, PRIVATE FIRE HYDRANTS, FIRE SERVICE LINE, THE 2-HOUR HYDROSTATIC TEST, AND THE FLUSHING OF THE PIPE. THE SOUTH ADAMS COUNTY WATER AND SANITATION DISTRICT WILL CONDUCT THE INSPECTION ON THE PRIVATE WATER LINE TIE INTO THEIR SYSTEM AND THE CHLORINATION AND CLEAN WATER TESTS ON THE PRIVATE WATER MAINS AND FIRE SERVICE LINE.
8. HYDRANTS SHOULD BE CLASSIFIED IN ACCORDANCE WITH THEIR RATED CAPACITIES (AT 20 PSI RESIDUAL PRESSURE OR OTHER DESIGNATED VALUE) AS FOLLOWS:
    (1) CLASS AA – RATED CAPACITY OF 1,500 GPM OR GREATER
    (2) CLASS A – RATED CAPACITY OF 1,000 – 1,499 GPM
    (3) CLASS B – RATED CAPACITY OF 500 – 999 GPM
    (4) CLASS C – RATED CAPACITY OF LESS THAN 500 GPM
9. THE TOPS AND NOZZLE CAPS SHOULD BE PAINTED WITH THE FOLLOWING CAPACITY-INDICATING COLOR SCHEME TO PROVIDE SIMPLICITY AND CONSISTENCY WITH COLORS USED IN SIGNAL WORK FOR SAFETY, DANGER, AND INTERMEDIATE CONDITION:
    (1) CLASS AA – BLUE – SHERWIN WILLIAMS 400 SERIES SAFETY BLUE SW 4086
    (2) CLASS A – GREEN – SHERWIN WILLIAMS 400 SERIES SAFETY GREEN SW 4085
    (3) CLASS B – ORANGE – SHERWIN WILLIAMS 400 SERIES SAFETY ORANGE SW 4083
    (4) CLASS C – RED – SHERWIN WILLIAMS 400 SERIES SAFETY RED SW 4081

FOR RAPID IDENTIFICATION AT NIGHT, THE CAPACITY COLORS SHALL BE OF A REFLECTIVE-TYPE PAINT.

10. MUELLER HYDRANT DEFENDERS SECURITY DEVICES SHALL BE PLACED ON ALL PRIVATE FIRE HYDRANTS AND MASTER LOCK BREAKAWAY PADLOCKS SHALL BE INSTALLED ON THE DEFENDERS.

Included for reference only.
Not an approved design.

CITY STAFF CERTIFICATE:

APPROVED BY THE DEPARTMENT OF COMMUNITY DEVELOPMENT OF THE CITY OF COMMERCE CITY, THIS _____ DAY OF _____, 20____.

_____
DEPARTMENT OF COMMUNITY DEVELOPMENT

Date	Description	No.
8/19/2022	2ND ROUND DP COMMENTS	2
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Revisions

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Project
8780 ROSEMARY ST
DEVELOPMENT PLAN SET
COMMERCE CITY
ADAMS COUNTY COLORADO

Drawing Title
PRELIMINARY UTILITY PLAN

Project No. 620023001	Drawing No. CU100
Date 10/15/2021	
Drawn By SJS	
Checked By JWE	Sheet 9 of 9

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