Flood Hazard Area Delineation
Goldsmith Gulch

October 2022

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MHFD
MILE HIGH FLOOD DISTRICT

Southeast Metro Stormwater Authority

DENVER
THE MILE HIGH CITY

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October 28, 2022

Mr. Jim Watt, PE, CFM
Watershed Manager
Mile High Flood District
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RE: Goldsmith Gulch Flood Hazard Area Delineation Report
Agreement No. 18-01.20

Dear Mr. Watt:

Matrix Design Group, Inc. is pleased to submit the enclosed *Goldsmith Gulch Flood Hazard Area Delineation Report*. This report provides a description of the watershed, updated hydrologic modeling, detailed new hydraulic modeling, floodplain mapping and assessment of potential flood damage. The report format and submittal follow the requirements of the Mile High Flood District guidelines for Flood Hazard Area Delineation (FHAD) studies.

Goldsmith Gulch mainstem, along with Goldsmith West Tributary and Southmoor Park Tributary, drain an area of approximately 4,954 acres (7.74 square miles) from Arapahoe Road to the confluence with Cherry Creek. The major drainageway includes 7.6 miles of mainstem channel corridor, which is based upon 5.1 miles in Denver, 1.3 miles in Greenwood Village, and 1.1 miles in SEMSWA (Arapahoe County and City of Centennial). In addition, the two tributaries add 1.2 miles of stream corridor along the Goldsmith Gulch West Tributary in Greenwood Village (a short reach less than 400-feet in the unincorporated area of Arapahoe County) and 0.8 miles of stream corridor along Southmoor Park Tributary in Denver.

A total of 10.4 miles of drainageway were studied with a detailed HEC-RAS hydraulic model. Topography was based upon the USGS mapping from the fall of 2013. The U.S. Army Corps of Engineer's step backwater program HEC-RAS, Version 5.0.5, was used for the subcritical floodplain analysis of the drainageway. Cross sections for use in the HEC-RAS model were developed electronically by cutting the triangulated irregular network (TIN) developed from the one-foot, LIDAR-derived topographic contour data collected by the USGS in the fall of 2013. A total of 566 cross sections were used in the Goldsmith Gulch hydraulics analysis. Fifty-one crossing structures were physically coded in the hydraulic model using field survey data. Existing drainage facilities within the project area consist of natural channel sections, on-line and off-line detention, four roadway bridges, twenty-one roadway culverts, thirty-four pedestrian bridges/culverts, and four piped drainageway culverts. 67 grade control structures exist within the study reach. Each drop structure was modeled using at least two cross-sections to define the drop structure hydraulics. Floodway analysis was based upon a maximum rise of elevation of the hydraulic grade line (HGL) and/or the energy grade line (EGL) of no more than 0.50-foot.

Ten regional flood control detention facilities within the Goldsmith Gulch watershed have been modeled to reduce flood hazards. These facilities constructed along the main stem channel at Silo Park, Orchard Hills Park, Wallace Park North and South, Bible Park and at Iliff & Monaco, and along the West Tributary at Caley Avenue, Tommy David Park and Boston Peakview, and Southmoor Park Tributary at Southmoor Park and are included in the existing conditions hydrologic model. Hydrology is based upon existing conditions since the basin is considered to be fully developed.

This study updates the previous Goldsmith Gulch *Flood Hazard Area Delineation* that was originally published in 1976 and was updated in 1997 with a Letter of Map Revision (LOMR) in the City and County of Denver to incorporate the impact of regional detention facilities. In addition, this study also updates the 2005 FHAD completed for the upper basin reach that is upstream of Belleview Avenue.

A total of 24 habitable building structures may be impacted by a 100-year flood event. The Goldsmith Gulch watershed was generally developed after floodplain regulations were enacted so Goldsmith Gulch has relatively few buildings within the 100-year floodplain compared to other watersheds in the area. However, the lower reach within the City & County of Denver has some notable encroachments and systems with less than 100-year capacity. Underground piped sections with less than 100-year capacity result in overland spilling with wide surface flow floodplains. Within the upper reaches of Goldsmith Gulch where the channel takes on a more natural character and floodplains have been preserved, there are fewer structures within the 100-year floodplain. An exception to this is the Arapahoe Lake Subdivision in the upper watershed, which may have four structures impacted by a 100-year flood. Nine structures around the perimeter of Arapahoe Lake appear to be inundated per the LiDAR topographic contours; however, five of the nine structures have been shown by Elevation Certificates to have their finished floors at least one foot above the spillway.

The information contained in this report provides the Mile High Flood District as project sponsor along with the stakeholders of the City and County of Denver, City of Greenwood Village and Southeast Metro Stormwater Authority with updated floodplain mapping to regulate the waterway.

We appreciate the opportunity to provide this watershed analysis for management of the waterway.

Sincerely,
Matrix Design Group, Inc.

Robert Krehbiel, PE
Project Manager

Benjamin Liu, PE
Project Engineer

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1.0 INTRODUCTION

1.1 Authorization

Matrix Design Group, Inc. (Matrix) was retained by the Mile High Flood District (MHFD), formerly the Urban Drainage and Flood Control District (UDFCD), to complete this Flood Hazard Area Delineation (FHAD) for Goldsmith Gulch. The City & County of Denver (Denver), the City of Greenwood Village (Greenwood Village), Southeast Metro Stormwater Authority (SEMSWA), City of Centennial and Arapahoe County are communities impacted by this FHAD. The Agreement regarding the FHAD study for Goldsmith Gulch was executed on January 13, 2018 (Agreement No. 18-01.20).

1.2 Purpose and Scope

The purpose and scope of this project is to identify the flood hazards for the major drainageways of the Goldsmith Gulch watershed, which includes the tributaries of Goldsmith Gulch West Tributary and Southmoor Tributary (Study Area).

The Goldsmith Gulch watershed has previously been studied and multiple stormwater detention improvements have already been implemented to reduce flood hazards. In June 1976, the *Flood Hazard Area Delineation (FHAD), Goldsmith Gulch and Tributaries* was published by Gingery Associates, Inc. for UDFCD, Denver, Greenwood Village, and Arapahoe County. In 2005, the upper watershed was studied which resulted in a FHAD and Outfall Systems Plan (2005 OSP) for the upper Goldsmith Gulch watershed (south of Belleview Avenue) by Moser & Associates.

The following tasks have been completed as part of this study:

- Collect the best available and updated base topographic mapping for existing conditions.
- Collect as-built drawings for previous channel improvements.
- Solicit input from the project sponsor and stakeholders at the kickoff meeting and individual meetings.
- Obtain GIS information from City and County of Denver, Greenwood Village, SEMSWA, Arapahoe County, and DRCOG.
- Obtain land use mapping and parcel data from the City and County of Denver and Arapahoe County.
- Establish sub-watershed boundaries and parameters in accordance with the MHFD criteria to develop updated hydrology.
- Develop existing (fully developed) conditions hydrologic models using CUHP 2005, version 2.0.0, and EPA SWMM 5.1, version 5.1.012.
- Develop HEC-RAS floodplain and floodway models, Version 5.0.5, for the major drainageways.
- Map the 100-year, 500-year, and floodways for the major drainageways.
- Identify existing flood hazards.

1.3 Planning Process

The project sponsor for this study is MHFD, along with the stakeholders of the City & County of Denver, Greenwood Village, and SEMSWA. Arapahoe County and City of Centennial are also a stakeholders to this study represented by SEMSWA. This FHAD is being completed concurrently with the Master Drainageway Plan (MDP). Project goals were to update the flood hazard area, program capital improvements, and identify water quality improvement opportunities and channel stabilization opportunities.

Project sponsor and stakeholder participants are listed in Section 1.6 Acknowledgements. A project advisory committee consisting of representatives from the sponsoring jurisdictions held a kickoff meeting on March 12, 2018 at the offices of MHFD (see enclosed Meeting Minutes in Appendix A: Project Correspondence). Input and additional resources provided at this meeting were incorporated into this MDP. A meeting was held May 7, 2018 to review comments on the Baseline Hydrology Report. The kickoff meeting for the Alternatives Analysis was held August 22, 2019. A draft Alternatives Analysis Report was issued November 12, 2020. A meeting was held December 30, 2019 to discuss comment to the draft report. An updated Alternatives Analysis report was issued January 31, 2020. A conference call was held March 25, 2020 with the Goldsmith Gulch Metropolitan District to discuss Wallace Park. A meeting was held June 3, 2020 to discuss next steps. A follow-up meeting was held July 8, 2020 to prepare for the public meeting. A post card mailing was sent out in August 2021 notifying residents along Goldsmith Gulch of the website link for the narrated Goldsmith Gulch Major Drainageway Plan presentation and Flood Hazard Area Delineation viewer tutorial. MHFD and stakeholders issued the selected plan letter February 3, 2022 with directives for the Conceptual Design.

1.4 Mapping and Surveys

Mapping information for this project was obtained from several sources. Given the multi-jurisdictional makeup of the watershed, attempts were made to use the best available data. The following describes the various mapping components and their sources.

Topography

One-foot, LIDAR-derived topographic contour data, collected in the fall of 2013, was used to delineate drainage basin boundaries. The Federal Emergency Management Agency (FEMA), the United States Geological Survey (USGS), and the Denver Regional Council of Governments (DRCOG) partnered to provide this data. The data was compiled in 2014 and is herein referred to as the 2014 LiDAR mapping. The 2014 LiDAR mapping provides full coverage for Goldsmith Gulch watershed.

Aerial Photography

4-band, true color ortho-imagery, collected in the spring of 2016, was available for the watershed through DRCOG's Denver Regional Aerial Photography Project (DRAPP) at a resolution of 3-inches.

Hydrologic Soil Groups

Soils information was obtained from the Natural Resources Conservation Service (NRCS) for Arapahoe County with a publication date of October 10, 2017. Soils information is not available for Denver County.

Base Mapping

Base mapping information including street centerlines, roof footprints, impervious surfaces, storm drainage infrastructure, parcels, existing land use, future land use, zoning, parks, and jurisdictional boundaries were provided by the City and County of Denver, Greenwood Village, SEMSWA, Arapahoe County, and DRCOG. Wetlands data was available through the National Wetlands Inventory (NWI).

Crossing Structure Survey

On April 4th and June 13th, 2018, MHFD provided survey of 34 existing roadway crossing structures, 35 existing pedestrian crossing structures, and 56 existing drop structures, as shown in **Table 2-2** (Wilson & Company Structure Survey 2018). The survey was conducted by Wilson & Company, Inc. on April 2, 2018 and June 12, 2018. In addition, Denver provided a tabulation inventory of roadway crossings and sufficiency ratings for the bridges within their jurisdiction, which is included in the Appendix.

Coordinate System and Datum

All GIS mapping and data for this study were developed using the Colorado State Plane, Central Zone coordinate system in U.S. feet. The horizontal datum is NAD83 and the vertical datum is NAVD88.

1.5 Data Collection

Existing drainage studies and construction documents were collected from MHFD, City & County of Denver, SEMSWA and Greenwood Village. Flood Insurance Rate Maps (FIRMs) of the City & County of Denver and Arapahoe County were obtained from the Federal Emergency Management Agency (FEMA). The previous Goldsmith Gulch Flood Hazard Area Delineation (FHAD) studies were obtained from MHFD. The primary references used for this study are as follows:

- Flood Hazard Area Delineation: Goldsmith Gulch and Tributaries, Gingery Assoc., June 1976
- Goldsmith Gulch Major Drainageway Planning, Gingery Associates, Inc., November 1977
- Hydrology Study for the Goldsmith Gulch Drainage Basin, October 5, 1989 (1989 Study)
- Hydrology Study Appendix, Design Computations, Sellards & Grigg, 1994
- Evaluation of Debris and Flood Control, I-225 to Iliff Avenue, December 2004
- Flood Hazard Area Delineation: Upper Goldsmith Gulch, Moser & Associates, April 2005
- Outfall Systems Planning Conceptual Design Report Upper Goldsmith Gulch, Moser & Associates, November 2005
- Upper Goldsmith Gulch: Condition Assessment, CH2MHILL, October 2007
- City and County of Denver Storm Drainage Master Plan, adopted September 22, 2014
- Flood Insurance Study: City and County of Denver, Colorado, FEMA, September 4, 2020 (2020 FIS)
- Flood Insurance Study: Arapahoe County, Colorado and Incorporated Areas, September 4, 2020 (2020 FIS)
- Design Report; Goldsmith Gulch East Caley Avenue Culvert Improvements, March 11, 2011
- Design Report; Goldsmith Gulch Channel Improvements downstream of Peakview Ave, June 28, 2013
- Design Report; Goldsmith Gulch West Tributary at Orchard Road and Tommy Davis Park 2011
- As-Built Upper Goldsmith Gulch Channel Stabilization Project, March 1989
- As-built Caley Square Regional Detention Pond Phase III Construction Plans, 2004
- As-built Drainageway Maintenance on Goldsmith Gulch in Bible Park, 1997
- As-built Goldsmith Gulch – Cook Park Channel Improvements, 2011
- As-built Goldsmith Gulch Flood Control Project Phase II, Schedule II, 1994
- As-built Goldsmith Gulch Flood Control Project Phase III, Schedule II, 1994
- As-built Goldsmith Gulch Flood Control Project Phase III, Schedule III, 1994
- As-built Goldsmith Gulch Flood Control Project Phase III, Schedule IIIB, 1995
- As-built Goldsmith Gulch Phase 1 Improvements Yale to Iliff, 2006
- As-built Goldsmith Gulch Trail, 2017
- As-built Goldsmith Gulch – West Tributary Tommy Davis Park Phase I Improvements, 2008
- As-built Southmoor Tributary at Hutchinson Park, 2011
- As-built Boston Peakview Detention Pond and Village Development, 2018

1.6 Acknowledgements

A Technical Advisory Committee made up of the project sponsors, other stakeholders, and agencies provided guidance during the study process. The Technical Advisory Committee met regularly during the course of the project study. Additional agencies and individuals were also involved during the planning process. Representatives who were directly involved with this study are listed in **Table 1-1**.

Table 1-1 Project Participants

Name	Representing	Project Role
Jim Watt	MHFD	Sponsor
Stacey Thompson	MHFD (previously SEMSWA)	Sponsor
Hung-Teng Ho	MHFD (previously Matrix Design Group)	Sponsor
Morgan Lynch	City and County of Denver (previously MHFD)	Stakeholder
Jennifer Williams	City and County of Denver	Stakeholder
Sarah Anderson	City and County of Denver	Stakeholder
Jeremy Hamer	City and County of Denver	Stakeholder
David Morrisey	City and County of Denver	Stakeholder
Kevin Lewis	City and County of Denver	Stakeholder
Cincere Eades	City and County of Denver	Stakeholder
Suzanne Moore	Greenwood Village	Stakeholder
Wanda Devargas	Greenwood Village	Stakeholder
Ann Woods	Greenwood Village	Stakeholder
Alexis Cook	Greenwood Village	Stakeholder
Tiffany Clark	SEMSWA	Stakeholder
Cynthia Love	SEMSWA	Stakeholder
Robert Krehbiel	Matrix Design Group	Project Manager
Ben Liu	Matrix Design Group	Project Engineer
Chris Martin	Matrix Design Group	GIS Manager

2.0 STUDY AREA DESCRIPTION

2.1 Project Area

The study area is highlighted in **Figure 2-0, Vicinity Map** below and includes the entire Goldsmith Gulch watershed as shown in **Figure 2-1, Study Area Map**. The 1976 FHAD and 1977 MDP evaluated the entire Goldsmith Gulch watershed. Subsequent studies sub-divide the watershed into a lower basin (northern portion) and an upper basin (southern portion) along Belleview Avenue, in accordance with MHFD's watershed delineations (Basins 4601-01 and 4601-02, respectively) along jurisdictional boundaries. The Upper Goldsmith Gulch was analyzed in the *Upper Goldsmith Gulch Outfall Systems Planning Conceptual Design Repo*rt by Moser & Associates for the UDFCD, November 2005 (2005 OSP).

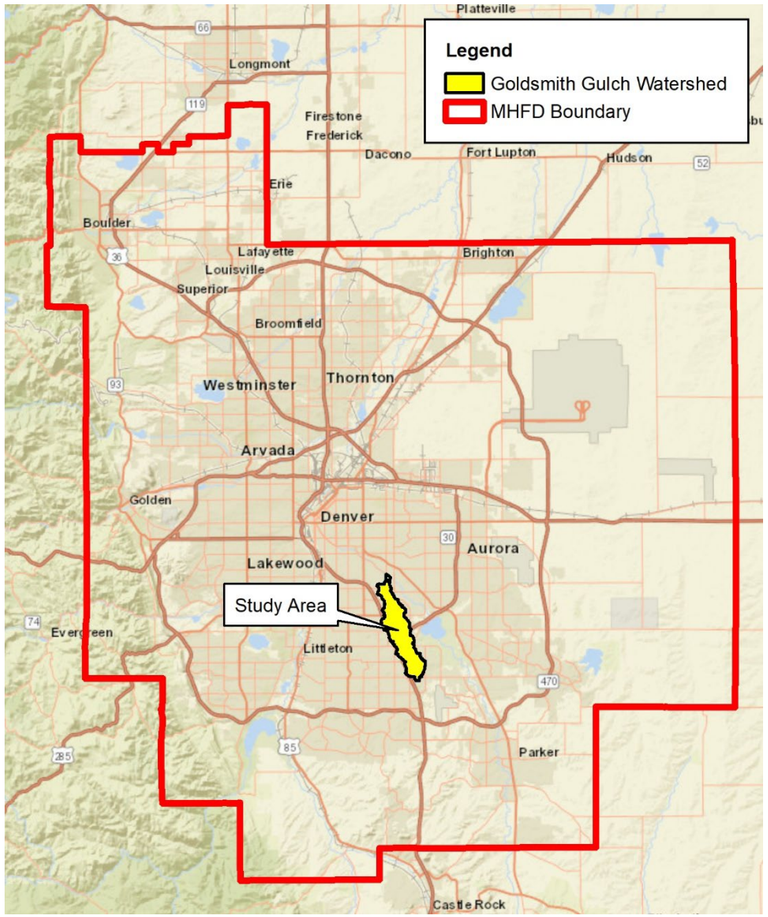


Figure 2-0 Vicinity Map

Hydrologic reaches were delineated for the upper and lower basin. Reaches 1 through 5 are within the lower basin, and Reaches 6 through 12 are within the upper basin. A map of the hydrologic reaches for the entire Goldsmith Gulch watershed is provided in **Figure 2-2, Hydrologic Reaches Map**.

Goldsmith Gulch watershed encompasses an area of 7.74 square miles (4,954 acres) from Arapahoe Road northwest to the confluence with Cherry Creek. The highest watershed elevation is 5,826 feet in the vicinity of South Clinton Street and East Costilla Avenue. The lowest watershed elevation is 5,382 feet at the outfall of the watershed into Cherry Creek. The average watershed slope is approximately 1% (0.97 percent measured following the topographic thalweg). Many channel improvements have been completed along Goldsmith Gulch to reduce the potential of flood damage. The channel has been stabilized in many areas and regional parks have been constructed along the floodplain where development is prohibited by local regulation.

2.1.1 Lower Basin – 4601-01 (City & County of Denver)

This portion of Goldsmith Gulch basin has a total drainage area of about 5.27 square miles. The lower portion of Goldsmith Gulch extends 5.1 miles from Belleview Avenue to the confluence with Cherry Creek near South Monaco Street Parkway. The Southmoor Park Tributary extends 0.82 miles from S. Oneida Way to the confluence with Goldsmith Gulch near E. Dartmouth Avenue. The basin is located in the southeast Denver metropolitan area within the City and County of Denver. Thirty-one roads and highways cross the main stem gulch in the lower basin, as shown in **Table 2-1** and **Figure 2-12**. All existing pedestrian and roadway crossings, as well as drop structures in the lower basin are shown in **Figure 2-12**.

Notable parks located along the lower basin include: Cook Park, Bible Park, Wallace Park, Southmoor Park, Hutchinson Park, and Rosamond Park (see **Figure 2-18**).

Detention facilities have also been constructed along the channel at Iliff and Monaco (off-line), Bible Park, Wallace Park north and south of E Temple Drive, and at Southmoor Park along the Southmoor Tributary. Channel slopes are generally mild with several drop structures along the reach (see **Figure 2-1**).

The High Line Canal bisects Goldsmith Gulch at E. Cornell Avenue. Goldsmith Gulch passes underneath the High Line Canal and E. Cornell Avenue through a concrete box culvert (see **Figure 2-1**).

The southern portion of the lower basin includes the I-25 Transportation Expansion (T-REX) project. New storm and detention facilities drain the I-225 and I-25 interchange to Goldsmith Gulch.

2.1.2 Upper Basin – 4601-02 (Greenwood Village, City of Centennial, SEMSWA, Arapahoe County)

This portion of Goldsmith Gulch basin has a total drainage area of about 2.47 square miles. The upper portion of Goldsmith Gulch extends 2.4 miles from Arapahoe Road to Belleview Avenue. West Goldsmith Gulch extends 1.2 miles from E. Peakview Avenue to the confluence with Goldsmith Gulch near E. Berry Avenue. The upper basin is located within City of Greenwood Village and SEMSWA (Arapahoe County and City of Centennial).

The channels along Goldsmith Gulch and the West Tributary consist of a variety of geometries and composition including concrete-lined channels, grass-lined channels, grass-lined channels with concrete

trickle channels, and wetland vegetated channels. The street crossing culverts consist of corrugated metal pipes, reinforced concrete pipes, concrete box culverts, and bridges (see **Figure 2-12**). All existing pedestrian and roadway crossings, as well as drop structures in the upper basin are shown in **Figure 2-12**.

Notable parks located along the upper basin include: Orchard Hills Park, Silo Park, and Tommy Davis Park (see **Figure 2-18**).

Detention facilities have also been constructed along the channel at Orchard Hills Park, Silo Park, Tommy Davis Park, E. Caley Avenue and Yosemite Street, and S. Boston Street and E. Peakview Avenue. Arapahoe Lake is privately owned and therefore not considered in the baseline hydrology (see **Figure 2-1**).

2.2 Land Use

In 1976, the Goldsmith Gulch FHAD noted that "For the purposes of this study, the drainage basin was considered to be fully developed." This basin can certainly be considered at this time to be fully developed; however, some areas are expected to redevelop. Therefore, *Future Condition* land use is approximated as *Existing Condition* land use. Since the basin is fully developed, only the *Existing Condition* hydrologic model was studied for this MDP.

The latest GIS land use zoning data is derived from the City and County of Denver Land Use layer (2012) and Arapahoe County Parcels layer (2018). **Section 3.3.2** provides the detailed description of watershed imperviousness. **Figure B-1 Interactive Hydrology Map** in **Appendix B** shows the land use map, sub-basin boundaries and associated percent imperviousness.

Table 2-1 Surveyed Crossing Structures.

Reach Number	River Station	Structure Number	Description	Location	No. of Spans/ Barrels	Span/ Width (feet)[1]	Rise/ Length (feet)[2]	Shape / Material	Notes	Capacity per Baseline Hydrology (cfs)
GG-1	00+32	69	Pedestrian Crossing	Cherry Creek Greenway Trail at the confluence with Cherry Creek	2	12.3	4.3	Rectangular RCP	Within the floodway of Cherry Creek	10-Year
	01+25	68	Roadway Crossing Culvert	E. Cherry Creek S. Drive	3	12.5	8.2	Elliptical CMP		100-Year
	04+51	67	Pedestrian Bridge	Cook Park Walkway	1	20	9.7	Steel Truss		< 10-Year
	09+75	66	Pedestrian Bridge	Cook Park Walkway	1	30.5	9.7	Steel Truss		< 10-Year
	17+52	65	Roadway Crossing Culvert	E. Mexico Avenue	2	9	6	Rectangular RCP	Also, 10’ x 5’ pedestrian underpass	10-Year
	25+54	64	Roadway Crossing Culvert	S. Monaco Street Parkway	1	9	6	Rectangular RCP		10-Year
	28+28	63	Pedestrian Bridge	Skyline Acres Swim and Tennis Club	1	12	5	Single Span/ Concrete Arch		10-Year
	30+55	62	Pedestrian Bridge	Skyline Acres Swim and Tennis Club	1	9.7	8	Single Span/ Concrete		10-Year
	34+59	61	Roadway Crossing Culvert	E. Jewell Avenue	2	16	4.6	Rectangular RCP	Restrictor plates installed inside the culverts	Restricted capacity of approximate 550 cfs
	63+07	60	Roadway Crossing Culvert	E. Iliff Avenue/ E. Evans Avenue*	2	14	4.6	Rectangular RCP	* Southwest of E. Evans Avenue and S. Monaco Street Parkway at edge of parking lot (Milo’s Sports Tavern)	10-Year
GG-2	70+12	59	Pedestrian Low Flow Crossing Bridge	Goldsmith Gulch Trail	1	11	1.6	Single Span/ Concrete		< 10-Year
	93+50	58	Roadway Crossing Culverts	E. Yale Avenue	1	7.4	6.9	Rectangular RCP	Left opening	100-year
					1	17.8	8.5	Rectangular RCP	Right opening	100-Year
	101+16	57	Pedestrian Low Flow Crossing Bridge	Bible Park Walkway	1	15	16	Single Span/ Concrete	Walkway connects to Highline Canal Trail	< 10-Year
	126+16	56	Roadway Crossing Culvert	E. Cornell Avenue	4	14	4.5	Rectangular RCP	E. Cornell Avenue	≈ 50-Year
					1	10	4.5			
GG-3	135+87	55	Pedestrian Bridge	Hutchinson Park Walkway	2-spans	148	4.9	Steel Truss	Walkway connects to Goldsmith Gulch Trail	100-year
	139+96	53	Roadway Crossing Bridge	E. Eastman Avenue	4-spans	48.2	73.5	Concrete	Pier widths: 2’, 0.9’, 0.9’	100-year
	142+12	51	Pedestrian Low Flow Crossing Bridge	U/S E. Eastman Avenue	1-span	16	15	Single Span/ Concrete	Connects business areas	< 10-Year
	143+90	50	Pedestrian Bridge	U/S E. Eastman Avenue	1-span	5.9	87.2	Steel Truss	Connects business areas	100-year
	147+89	49	Pedestrian Bridge	U/S E. Eastman Avenue	1-span	77.5	5.9	Steel Truss	Connects business areas	100-year
	161+14	48	Roadway Crossing Culvert and Piped Drainageway	Hampden Avenue to parking lot of the Tiffany Plaza	1	20.3	7.9	Rectangular RCP	Approximately 600’ south of S. Tamarac Drive and E. Hampden Avenue	≈ 50-Year
	170+97	47	Roadway Crossing Culvert	S. Rosemary Way	2	15.5	5.2	Rectangular Concrete		10-Year
	194+50	46	Roadway Crossing Culvert	E. Princeton Avenue	2	15.5	5.1	Rectangular Concrete		≈ 100-Year
	198+54	45	Pedestrian Bridge	Rosamond Park Trail	1-span	18	5.7	Steel Truss		< 10-Year
	202+66	44	Pedestrian Bridge	Rosamond Park Trail	1-span	28	6	Steel Truss		< 10-Year

Reach Number	River Station	Structure Number	Description	Location	No. of Spans/ Barrels	Span/ Width (feet)[1]	Rise/ Length (feet)[2]	Shape / Material	Notes	Capacity per Baseline Hydrology (cfs)
GG-4	212+61	43	Roadway Crossing Culvert	E. Quincy Avenue	2	12.5	8.2	Squashed CMP		100-year
	223+05	42	Detention Outlet/ Culvert	Wallace Park North at I-225	2	12	6.1	Rectangular Concrete w/ Restrictor Plate	3.0’ from invert to height of restrictor plate	100-year
	239+84	41	Detention Outlet/ Culvert	Wallace Park South at E. Temple Drive	2	7	-	Round Concrete w/ Restrictor Plate	3.5’ from invert to height of restrictor plate	≈ 100-Year
	242+50	40	Concrete lid of the rectangular concrete low flow channel	Wallace Park South	1	3.5	1.1	Rectangular RCP	No trail connection.	< 10-Year
	245+70	39	Concrete lid of the rectangular concrete low flow channel	Wallace Park South	1	3.4	1.2	Rectangular RCP	No trail connection.	< 10-Year
	260+70	38	Low Flow Culvert	Drop structure 200’ south of E. Monmouth Place and S. Wabash Street	2	2.5	-	Round w/ Plate RCP	1.05’ from invert to height of restrictor plate; Part of drop structure	< 10-Year
GG-5	268+87	37	Roadway Crossing Bridge	E. Belleview Avenue	1-span	59.5	130.9	Single Span/ Concrete		500-year
	273+25	36	Roadway Crossing Bridge	E. Crescent Parkway	1	60	14.9	Arched Concrete		500-year
	284+83	35	Roadway Crossing Bridge	E. Prentice Avenue	1	62.2	11.5	Arched Concrete		500-year
	289+63	34	Pedestrian Low Flow Crossing Bridge	Access to Greenwood Village Trails	2	10	2	Arched RCP		< 10-Year
GG-6	295+15	33	Roadway Crossing Culvert	S. Yosemite Street	2	13.4	4.5	Rectangular RCP		50-year
	298+90	32	Pedestrian Low Flow Crossing Culvert	Yosemite East Trail	1	3	-	Round CMP		< 10-Year
	300+60	31	Pedestrian Low Flow Crossing Bridge	Yosemite East Trail	1-span	17.9	29.3	Single Span/ Concrete		< 10-Year
	305+63	30	Roadway Crossing Culvert	E. Berry Avenue	1	15.9	7	Arched CMP		50-year
	314+40	29	Detention Outlet/ Culvert	**Orchard Hills Park**	1	1.5	-	Circular RCP	Vertical standpipe in Orchard Hills Detention	< 10-Year
GG-7	321+10	15	Pedestrian Bridge	Orchard Hills Park Trail	1-span	14.6	8.2	Steel Truss	PVC conduit running parallel 1.1’ below the bridge low cord.	< 10-Year
	327+68	14	Pedestrian Bridge	Orchard Hills Park Trail	1-span	14.7	8	Steel Truss		< 10-Year
	335+80	13	Roadway Crossing Culvert	E. Orchard Road	1	3	-	Round CMP	Silo Park Detention outlet pipe	< 10-Year
	337+21	12	Low Flow Board Walk Bridge	**Silo Park**	5-span	60	5.5	Wooden board walk		< 10-Year
	342+32	11	Pedestrian Low Flow Crossing Bridge	Silo Park Trail	1-span	13	5.7	Wooden board walk		< 10-Year

Reach Number	River Station	Structure Number	Description	Location	No. of Spans/ Barrels	Span/ Width (feet)[1]	Rise/ Length (feet)[2]	Shape / Material	Notes	Capacity per Baseline Hydrology (cfs)
GG-8	353+80	10	Roadway Crossing Culvert and Piped Drainageway	Arapahoe Lake to Silo Park	1	9.8	4.2	Rectangular RMP	Resident's Backyard	10-Year
	359+29	9	Pedestrian Bridge	Arapahoe Lake	3-span	50.2	5.9	Cable stayed wooden bridge		500-year
	363+43	8	Pedestrian Low Flow Crossing Culvert	Arapahoe Lake	1	6	1.9	Rectangular RCP		< 10-Year
	368+40	7	Roadway Crossing Culverts	E. Caley Avenue	1	4	-	Round Concrete	Left opening	500-year
					1	5.9	4	Octagonal Concrete	Right opening	
	369+65	6	Pedestrian Bridge	U/S E. Caley Avenue	1-span	10.6	7.9	Steel Truss		< 10-Year
	372+15	5	Pedestrian Low Flow Crossing Culvert	U/S E. Caley Avenue	1	2	-	Round RCP		< 10-Year
	375+78	4	Pedestrian Culvert	Between Appletree Apartment and Avery Park Apartments	1	15	3	Rectangular Concrete		500-year
	384+00	3	Roadway Crossing Culverts	E. Peakview Avenue	1	2.8	-	Round Concrete	Left opening	500-year
					1	5.5	3.1	Elliptical Concrete	Right opening	
WG-1	00+79	28	Pedestrian Low Flow Crossing Culvert	Orchard Hills Park Trail	1	3	-	Round RCP		< 10-Year
	07+00	27	Pedestrian Bridge	Big Canyon Trail	1-span	15	7.7	Steel Truss		10-Year
	12+62	26	Pedestrian Low Flow Crossing Bridge	Big Canyon Trail	1-span	15.6	21.6	Single Span/ Concrete		< 10-Year
	13+98	25	Roadway Crossing Culverts	E. Orchard Road	1	12	8.8	Rectangular Concrete	Left portion of opening (bike path)	500-year
					1	9.8	4	Rectangular Concrete	Right portion of opening (low flow channel)	
	15+10	24	Detention Outlet/ Culvert	Tommy Davis Park	2	2	-	Round RCP	Tommy Davis Park Trail	< 10-Year
	21+28	23	Pedestrian Bridge	Tommy Davis Park Trail	1-span	27	10	Steel Truss		< 10-Year
WG-1	27+22	22	Pedestrian Bridge	Tommy Davis Park Trail at E. Maplewood Ave.	1-span	43.9	14	Steel Truss		100-Year
WG-2	34+95	21	Trail Crossing Culverts	Access to Fair North Trail	3	4	-	Round RCP		10-Year
	39+50	20	Pedestrian Low Flow Crossing Bridge	U/S E. Fair Avenue	1	13.2	-	Single span/ Concrete		50-Year
WG-3	45+25	18	Roadway Crossing Culverts	E. Caley Avenue	2	6	4	Octagonal Concrete		500-Year
	50+00	17	Roadway Crossing Culverts	E. Caley Way/ Caley Pond Trail	1	14	5	Octagonal Concrete	Inlet to Caley Detention	500-Year
	53+20	16	Roadway Crossing Culverts	Unnamed Road	1	6.9	6.8	Rectangular Concrete		500-Year
ST-1	15+40	54	Roadway Crossing Culverts	E. Eastman Avenue	1	8.2	5.7	Rectangular Concrete		10-Year
	20+96	52	Roadway Crossing Culvert and Piped Drainageway	E. Hamilton Place & Parking Lot	1	7.5	4.5	Elliptical RCP		10-Year

Source: Wilson & Company Structure Survey 2018

Notes:

1. *Span for culverts, bridge opening width for bridges. All surveyed values rounded to the nearest tenth.*
2. *Rise (Diameter) for culverts, bridge opening length for bridges. All surveyed values rounded to the nearest tenth.*

Table 2-2 Surveyed Drop Structures.

Reach	River Station	Structure Number	Description	Location	U/S Crest Elevation	D/S Toe Elevation	Drop Height (ft)	Length (ft)	U/S Survey Point	D/S Survey Point	Survey Number
GG-1	04+38	D-1	Grouted boulder drop structure	Cook Park, d/s pedestrian bridge	5392.41	5390.27	2.1	8	328397	328398	FL59
	07+97	D-2	Grouted boulder drop structure	Cook Park	5396.01	5394.67	1.3	10	328386	328387	FL60
	10+11	D-3	Grouted boulder drop structure	Cook Park, u/s pedestrian bridge	5398.10	5395.68	2.4	8	328370	328371	FL50
GG-2	94+94	D-4	Grouted boulder drop structure (Multiple Tiers)	Bible Park u/s E. Yale Avenue	5445.21	5443.57	1.6	1	328200	328201	FL65
	95+04	D-5			5446.44	5444.00	2.4	1	328198	328199	FL64
	95+36	D-6			5447.52	5445.91	1.6	2	328196	328197	FL63
	100+65	D-7	Grouted boulder drop structure (Multiple Tiers)	Bible Park, d/s pedestrian bridge	5451.53	5449.71	1.8	2	328194	328195	FL62
	100+82	D-8			5453.66	5450.66	3.0	3	328192	328193	FL61
	100+94	D-9			5455.38	5453.02	2.4	2	328190	328191	FL60
	101+37	D-10	Concrete check structure with boulders	Bible Park, u/s pedestrian bridge	5455.96	5454.55	1.4	2	328194	328195	FL56
	107+50	D-11	Concrete cap for 21" S.S.; no survey	Bible Park	-	-	-	-	-	-	-
	111+25	D-12	Broken concrete cap for 21" S.S., a portion was washed away; no survey	Bible Park	-	-	-	-	-	-	-
	113+40	D-13	Diagonal loose rock drop structure; no survey	Bible Park	-	-	-	-	-	-	-
	117+50	D-14	Grouted boulder drop structure	Bible Park	5461.64	5458.83	2.8	3	328172	328173	FL55
GG-3	128+79	D-15	Sculpted concrete drop structure	Hutchinson Park u/s E. Cornell Avenue	5473.58	5470.38	3.2	35	328143	328144	FL4
	134+33	D-16	Sculpted concrete drop structure	Hutchinson Park d/s pedestrian bridge	5476.96	5474.14	2.8	30	328139	328142	FL3
	143+13	D-17	Sculpted concrete drop structure	U/S E. Eastman Avenue between pedestrian bridges	5483.04	5480.94	2.1	4	328043	328044	FL1
	145+58	D-18	Broken concrete check structure with loose rock; no survey	U/S E. Eastman Avenue between pedestrian bridges	-	-	-	-	-	-	-
	148+42	D-19	Concrete check structure with loose rocks; no survey	D/S Hampden Avenue	-	-	-	-	-	-	-
	151+13	D-20	Concrete check structure with loose rocks; no survey	D/S Hampden Avenue	-	-	-	-	-	-	-
	162+47	D-21	Baffled concrete drop structure	South of Tiffany Plaza	5495.88	5490.06	5.8	NM	323239	323240	FL50
	176+47	D-22	Concrete check structure with loose rocks	U/S S. Rosemary Way, at approximate E Kenyon Pl	5502.80	5502.29	0.5	NM	323206	323207	FL49
	178+75	D-23	Concrete check structure with loose rocks	U/S S. Rosemary Way, at approximate E Lehigh Ave.	5504.34	5503.44	0.9	NM	323204	323205	FL48
	181+56	D-24	Concrete check structure with grouted/loose rocks	U/S S. Rosemary Way, at approximate E Lehigh Dr.	5506.44	5505.62	0.8	NM	323202	323203	FL47
	186+81	D-25	Concrete check structure with grouted/loose rocks	U/S S. Rosemary Way, at approximate S Tamarac Ct	5509.28	5508.70	0.6	NM	323200	323201	FL46
	189+79	D-26	Concrete check structure with loose rocks	D/S E. Princeton Ave. at approximate E Oxford Ave.	5511.19	5510.58	0.6	NM	323198	323199	FL45
	190+81	D-27	Concrete check structure with grouted/loose rocks	D/S E. Princeton Ave. at approximate E Oxford Ave.	5514.71	5511.88	2.8	NM	323196	323197	FL44
	194+93	D-28	Concrete check structure with boulders; no survey	U/S E. Princeton Ave.	-	-	-	-	-	-	-
	195+85	D-29	Concrete check structure with boulders; no survey	U/S E. Princeton Ave.	5523.57	5521.53	2.0	NM	323160	323161	FL43

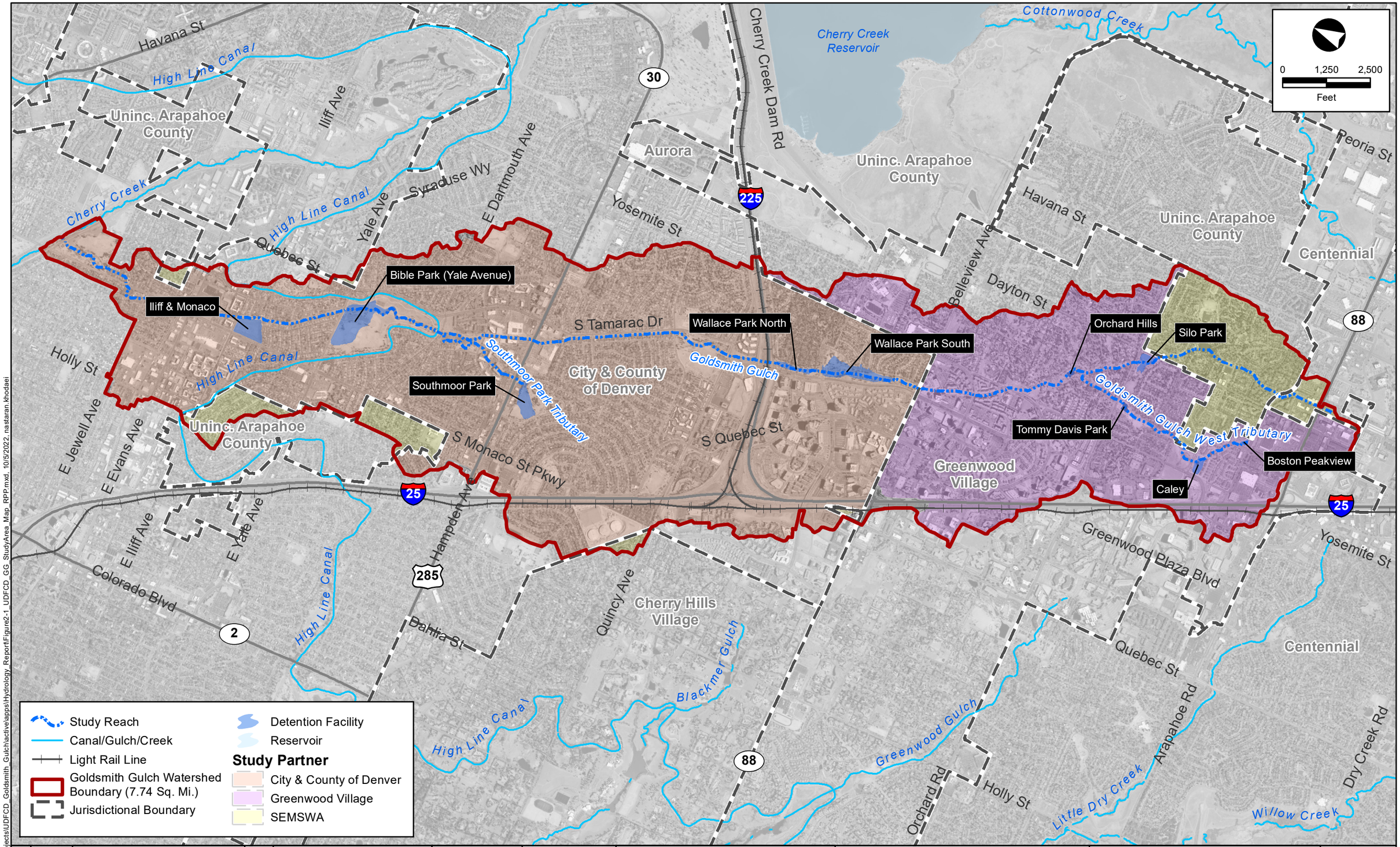
Reach	River Station	Structure Number	Description	Location	U/S Crest Elevation	D/S Toe Elevation	Drop Height (ft)	Length (ft)	U/S Survey Point	D/S Survey Point	Survey Number
GG-4	242+18	D-30	Concrete drop structure	George Wallace Park	5555.95	5554.87	1.1	NM	316328	316329	FL41
	245+55	D-31	Concrete drop structure	George Wallace Park	5557.77	5557.13	0.6	NM	316313	316314	FL40
	246+03	D-32	Concrete drop structure	George Wallace Park	5558.25	5557.68	0.6	NM	316298	316299	FL39
	250+40	D-33	Concrete drop structure (Multiple Tiers)	George Wallace Park at approximate E. Layton Ave.	5563.00	5559.42	3.6	NM	316291	316293	FL38
					5564.65	5563.08	1.6	NM	316289	316290	FL38
					5565.37	5564.91	0.5	NM	316283	316284	FL37
	261+17	D-34	Concrete drop structure (Multiple Tiers)	George Wallace Park at approximate E. Monmouth Pl.	5576.49	5575.71	0.8	NM	316252	316253	FL35
					5570.47	5569.78	0.7	NM	316249	316250	FL34
					5573.72	5571.28	2.4	NM	316247	316248	FL33
					5577.66	5573.85	3.8	NM	316245	316246	FL32
	267+87	D-35	Concrete drop structure	D/S E. Belleview Ave	5583.76	5580.70	3.1	0.37	316239	316240	FL31
GG-5	274+57	D-36	Concrete drop structure (Multiple Tiers)	U/S E. Crescent Pkwy	5592.90	5586.76	6.1	51.8	316123	316131	FL30
	283+49	D-37	Loose rock drop structure	D/S E. Prentice Ave.	5600.74	5597.75	3.0	9.75	316121	316122	FL29
	289+91	D-38	Grouted boulder drop structure	U/S E. Prentice Ave., u/s of pedestrian bridge	5606.72	5604.35	2.4	NM	316060	316061	FL28
	290+59	D-39	Unknown material	U/S E. Prentice Ave., u/s of pedestrian bridge	5607.04	5606.51	0.5	NM	316058	316059	FL27
GG-6	309+15	D-40	Concrete check structure with boulders (2-Tier)	U/S E. Berry Ave.	5619.28	5616.63	2.6	11.31	309544	309546	FL25
	310+34	D-41	Concrete check structure with boulders (2-Tier)	U/S E. Berry Ave.	5621.26	5618.7	2.56	13.43	309541	309543	FL24
	312+49	D-42	Concrete check structure with boulders (2-Tier)	U/S E. Berry Ave.	5622.66	5620.18	2.48	12.9	309538	309540	FL23
	314+07	D-43	Concrete check structure with boulders (2-Tier)	Silo Park Detention spillway	5630.7	5623.61	7.09	53.8	309517	309519	FL22
GG-7	331+45	D-44	Concrete check structure with loose rocks (2-Tier)	D/S E. Orchard Rd	5646.85	5644.99	1.86	22.92	309006	309008	FL9
	332+81	D-45	Concrete check structure with loose rocks (2-Tier)	D/S E. Orchard Rd	5648.69	5646.6	2.09	25.22	309003	309005	FL8
	333+68	D-46	Concrete check structure with loose rocks (2-Tier)	D/S E. Orchard Rd	5649.84	5648.73	1.11	27.38	309000	309002	FL7
GG-8	355+29	D-47	Concrete drop structure (Multiple Tiers)	Arapahoe Lake spillway	5696.38	5674.05	22.33	96.2	308212	308216	FL6
	373+58	D-48	Concrete check structure with grouted boulders	U/S E. Caley Ave.	5713	5709.31	3.69	14.44	308114	308115	FL4
	376+34	D-49	Grouted boulders drop structure	D/S Peakview Ave. at Appletree/Avery Park Apartment	5720.47	5716.01	4.46	17.6	308096	308097	FL3
	379+90	D-50	Grouted boulders drop structure	D/S Peakview Ave. at Appletree/Avery Park Apartment	5728.81	5724.69	4.12	20.45	308094	308095	FL2
	389+93	D-51	Concrete/grouted boulder drop structure (Multiple Tiers)	U/S Peakview Ave.	5754.94	5742.9	12.04	64.37	308047	308051	FL1

Reach	River Station	Structure Number	Description	Location	U/S Crest Elevation	D/S Toe Elevation	Drop Height (ft)	Length (ft)	U/S Survey Point	D/S Survey Point	Survey Number
WG-1	01+02	D-52	Boulder drop structure	Orchard Hill Park	5632.21	5631.04	1.17	1	309479	309480	FL21
	04+10	D-53	Boulder drop structure	Orchard Hill Park	5635.24	5633.81	1.43	2.73	309454	309465	FL20
	08+87	D-54	Boulder drop structure	D/S E. Orchard Rd	5640.53	5638.85	1.68	2.53	309436	309437	FL19
	10+76	D-55	Boulder drop structure	D/S E. Orchard Rd	5642.18	5641.49	0.69	4.36	309434	309435	FL18
	11+96	D-56	Loose rock drop structure	D/S E. Orchard Rd	5644.29	5641.71	2.58	29.76	309432	309433	FL17
	21+87	D-57	Concrete check structure (Multiple Tiers)	Tommy Davis Park	5657.24	5656.73	0.51	12.33	309305	309308	FL16
	24+81	D-58	Concrete check structure with grouted boulders	Tommy Davis Park	5659.59	5658.38	1.21	3.3	309303	309304	FL15
	25+52	D-59	Concrete check structure with grouted boulders	Tommy Davis Park	5660.51	5659.7	0.81	3.03	309301	309302	FL14
	26+29	D-60	Concrete check structure with grouted boulders	Tommy Davis Park	5662.21	5661.44	0.77	2.24	309299	309300	FL13
	27+30	D-61	Concrete check structure	Tommy Davis Park at Maplewood Ave.	5663.45	5662.64	0.81	0.84	309297	309298	FL12
WG-2	28+70	D-62	Grouted Boulder drop structure (assumed per aerial imagery); no survey	Tommy Davis Park at Maplewood Ave.	-	-	-	-	-	-	-
	35+24	D-63	Concrete check structure	U/S E. Fair Ave	5674.37	5672.08	2.29	1	As-built	As-built	As-built
	43+56	D-64	Concrete drop structure (Multiple Tiers)	D/S E. Caley Ave.	5686.82	5681.2	5.62	35.2	As-built	As-built	As-built
WG-3	46+06	D-65	Loose boulder drop structure	U/S E. Caley Ave. at d/s of the outlet structure	5694.12	5689.2	4.92	NM	309158	309171	FL11
	50+56	D-66	Grouted boulders drop structure	U/S E. Caley Way	5700.04	5693.28	6.76	8.47	309081	309082	FL10
ST-1	07+90	D-67	Grouted boulders drop structure; no survey	Hutchinson Park	-	-	-	-	-	-	-

1. Source: Mile High Flood District Survey 2018 & Goldsmith Gulch West Tributary Channel Improvement As-built Survey.

2. River stations are in feet measured along the river centerline from the confluences.

3. Locations of each structure are shown in the Flood Maps (Appendix G).



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No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by: _____
drawn by: RP
checked by: RK
project no.: 18.155.035
date: 11/12/2019

MHFD MILE HIGH FLOOD DISTRICT

MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY
AND TRIBUTARIES

STUDY AREA MAP

FIGURE
2-1

GG-1
Cherry Creek Confluence to Iliff Avenue
(1.2 mi.)

GG-2
Iliff Avenue to E Cornell Avenue at Hutchinson Park
(1.2 mi.)

GG-3
E Cornell Avenue at Hutchinson Park to Quincy Avenue
(1.6 mi.)

GG-4
Quincy Avenue to Belleview Avenue
(1.1 mi.)

GG-5
Belleview Avenue to Yosemite Street
(0.5 mi.)

GG-6
Yosemite Street to Goldsmith Gulch West Tributary Confluence
(0.5 mi.)

GG-7
Goldsmith Gulch West Tributary Confluence to S Dayton Street at Silo Park
(0.5 mi.)

GG-8
S Dayton Street at Silo Park to Arapahoe Road
(1 mi.)

ST-1
E Cornell Avenue at Hutchinson Park to S Oneida Way at Southmoor Park
(0.8 mi.)

WG-1
Goldsmith Gulch West Tributary Confluence to Tommy Davis Park at Maplewood Avenue
(0.5 mi.)

WG-2
Tommy Davis Park at Maplewood Avenue to Caley Avenue
(0.3 mi.)

WG-3
Caley Avenue to Peakview Avenue
(0.4 mi.)

Canal/Gulch/Creek
Highway
Light Rail Line
Goldsmith Gulch Watershed Boundary (7.74 Sq. Mi.)
Jurisdictional Boundary
Detention Facility

Study Partner
City & County of Denver
Greenwood Village
SEMSWA

0 1,250 2,500
Feet

No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by:
drawn by: RP
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MHFD MILE HIGH FLOOD DISTRICT

MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY AND TRIBUTARIES

REACH MAP

FIGURE 2-2

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2.3 Reach Descriptions

Reach GG-1 – Cherry Creek Confluence to E Iliff Avenue

Reach GG-1 of Goldsmith Gulch generally consists of 0.92 miles of open channel drainageway and 0.27 miles of piped conveyance along the mainstem (1.2 miles total) from E. Iliff Avenue to Cherry Creek near S. Monaco Street Parkway within the City and County of Denver.

From E. Iliff Avenue to E. Evans Avenue, concrete box culverts ranging from 14-feet by 4.6-feet (at the upstream end) to 30-feet by 4-feet (at the downstream end). Currently, these culverts are undersized, resulting in frequent flooding of the vacant lot adjacent to the former Kmart site (2150 S. Monaco Street Parkway) as well as flooding of S. Monaco St Pkwy and E. Iliff Avenue. In addition, the culverts are reaching the end of their life span and are exhibiting some spalling of the concrete.

From E. Evans Avenue to E. Jewell Avenue, the concrete low flow channel with grassy overbanks is currently undersized, resulting in bank sloughing and sediment build up near E. Jewell Avenue.

At E. Jewell Avenue, the mainstem splits into a low flow channel and overflows through box culverts underneath S. Monaco Street Parkway. On the east side of S. Monaco Street Parkway (approximately 100-feet north of E. Colorado Drive), the low flow and overflow flow paths converge and flow through an open channel to Cook Park at E. Mexico Avenue. Low flows are directed north underneath E. Jewell Avenue through two 16-feet by 4.6-feet concrete box culverts (Crossing No. 61) to a natural drainageway on the west side of S. Monaco Street Parkway. At approximately the same latitude as E. Colorado Drive, the low flow channel makes a right angle turn and flows under S. Monaco Street Parkway through a 9-feet wide by 6-ft high culvert (Not Surveyed). From E. Jewell Avenue, Goldsmith Gulch overflows enter a dual-cell reinforced concrete box culvert (Crossing No. 64). Each cell is 120-inches wide by 72-inch high. The box culvert starts on the southwest corner of E. Jewell Avenue and S. Monaco Street Parkway, then flows north under S. Monaco Street Parkway until it daylights on the east side of S. Monaco Street Parkway and converges with the low flow channel.

From E. Mexico Avenue to the confluence with Cherry Creek, the gulch flows through Cook Park. Two 9-ft wide by 6-ft high concrete box culverts convey flows underneath E. Mexico Avenue. Three drop structures and two pedestrian bridges are located within Cook Park. At the downstream end of Cook Park, the mainstem flows underneath E. Cherry Creek S. Drive through three 12.5-ft wide by 8.2-ft high elliptical corrugated metal pipes followed by a pedestrian crossing at Cherry Creek Greenway Trail. In 2011, channel improvements, including riprap lining and installation of one drop structure, were completed (*As-Built: Goldsmith Gulch – Cook Park Channel Improvements, 2011*). Since Goldsmith Gulch is piped in some segments, trail connectivity is sporadic. There is an opportunity to extend Goldsmith Gulch Trail from E. Iliff Avenue to E. Mexico Avenue to improve trail connectivity by improvements of a greenbelt corridor. Existing drainage facilities in this area are undersized, and flooding of S. Monaco Street Parkway is shown on current FEMA maps.

Reach GG-2 – E. Iliff Avenue to Southmoor Tributary Confluence

Reach GG-2 of Goldsmith Gulch generally consists of 1.2 miles of open channel drainageway along the mainstem from the Southmoor Tributary confluence in Hutchinson Park to E. Iliff Avenue.

From the Southmoor Tributary confluence in Hutchinson Park, the gulch crosses E. Dartmouth Avenue and High Line Canal through a five-cell concrete box culvert with four 14-ft wide, and one 10-ft wide by 4.5-ft high to Bible Park (*As-Built: Goldsmith Gulch Flood Control Project Phase III, Schedule IIIB, 1995*).

In 1997, drainageway improvements were completed for the channel through Bible Park, including installation of concrete and riprap-lined low flow channels and two drop structures (As-Built: *Drainageway Maintenance on Goldsmith Gulch in Bible Park, 1997*). In total, eight drop structures are located in Bible Park. In addition, one pedestrian crossing is located within the park.

The crossing at E. Yale Avenue consists of a 6-feet by 6.25-feet (low flow) and 14-feet by 8.5-feet (pedestrian underpass/ high flow) concrete box culverts (As-built: Goldsmith Gulch Flood Control Project Phase III, Schedule II, 1994). This crossing is also the outlet for Bible Park Detention, which provides detention only.

Between E. Yale Avenue and E. Iliff Avenue, the gulch flows through an open channel drainageway. During high flow conditions (approximately the 10-year event), flows spill laterally through five 4-feet by 2-feet concrete box culverts into the off-line Iliff & Monaco Detention (see **Figure 2-3**). The basin is drained by a network of inlets and storm drain pipes located around the perimeter of the basin which convey detained flood water to an outlet is controlled by a pump station (because the detention pond bottom is lower than the channel invert and cannot be gravity drained), which ties-in to the existing concrete box culvert at E. Iliff Avenue (*As-Built: Goldsmith Gulch Flood Control Project Phase III, Schedule III, 1994*). Photos of the Iliff & Monaco basin are shown in **Figure 2-3**. In 2006, the channel from E. Yale Avenue to E. Iliff Avenue was stabilized with riprap lining and revegetated with wetland plantings, riparian prairie grasses, and trees within the floodplain. Goldsmith Gulch Trail, which is located adjacent to the channel, was completed between E. Yale Avenue and E. Iliff Avenue in 2017 (*As-Builts: Goldsmith Gulch Trail, 2017*).

Basin inlet looking northwest.

Basin looking southeast, outlet pump at left corner

Figure 2-3 Iliff & Monaco Detention.

Reach GG-3 – Southmoor Tributary Confluence to E. Quincy Avenue

Reach GG-3 of Goldsmith Gulch generally consists of 1.3 miles of open channel drainageway and 0.31 miles of piped conveyance along the mainstem (1.6 miles total) from E. Quincy Avenue to the Southmoor Tributary confluence in Hutchinson Park within the City and County of Denver.

From E. Quincy Avenue to E. Princeton Avenue, the gulch flows through Rosamond Park. The Denver SDMP illustrated the potential for new stormwater detention at this park location within the figures only. No known studies include modeled detention at this location and the outlet (two 19-feet by 5-feet concrete box culverts) is too large to provide significant detention of flows. Detention in Rosamond Park was not considered in the baseline hydrology analysis but is evaluated as part of the alternatives analysis.

From E. Princeton Avenue to E. Jarvis Place, the gulch flows within a grassy drainageway parallel to S. Tamarac Drive through a residential area. At E. Jarvis Place, the gulch flows through a drop structure before entering a 0.31 mile, 20-feet by 8-feet box culvert under a commercial lot. This transitions to three 12-feet by 9-feet concrete box culverts crossing E. Hampden Avenue. Denver Parks constructed trail improvements along this reach in 2017.

From E. Hampden Avenue to Hutchinson Park, the grassy drainageway flows through five drop structures. Within Hutchinson Park, the mainstem flows through two drop structures before converging with Southmoor Tributary directly upstream of E. Cornell Avenue. An Alert gage station is located on Goldsmith Gulch at Eastman Avenue.

Reach GG-4 – E. Quincy Avenue to Belleview Avenue

Reach GG-4 of Goldsmith Gulch generally consists of 1.1 miles of open channel drainageway along the mainstem from the Belleview Avenue to E. Quincy Avenue. This reach is located within Denver and is maintained by Goldsmith Metropolitan District as part of the Transportation Expansion (TREX) development. The TREX improvements include construction and widening of the northbound and southbound I-25 and I-225 highway/ ramps and a new light rail system as well as associated drainage upgrades and replacement.

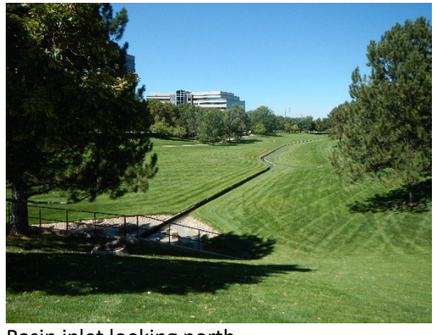
From Belleview Avenue to E. Temple Drive, the gulch flows through Wallace Park South, which also acts as a detention. The Wallace Park South Detention Basin (see **Figure 2-4**) outlet consists of two 7-feet diameter concrete pipes with restrictor plates extending 2.75-feet from the top of pipe (4.25-feet opening), providing detention only. Six drop structures are located within this section.

Basin looking south from the outlet.

Basin outlet looking north.

Figure 2-4 Wallace Park South Detention.

From E. Temple Drive to I-225, the gulch flows through Wallace Park North, which also acts as a detention basin. The Wallace Park North Detention (see **Figure 2-5**) outlet consists of two 12-feet by 6-feet concrete box culverts with restrictor plates extending 3-feet from the top of pipe (3-feet opening), providing detention only.



Basin inlet looking north.

Basin outlet looking north.

Figure 2-5 Wallace Park North Detention.

The gulch crosses I-225 through two 12-feet by 6-feet concrete box culverts. The 2003 Drainage Report for the TREX site was utilized to ensure runoff was correctly routed through this area (SECC 2003). In general, there are two primary flow paths within TREX.

- Runoff from basins L-140 and L-150 (in this study) flows to the detention basin within the JD Edwards Complex, north of E. Union Avenue, southwest of S. Ulster Street, and east of I-25. This private detention basin outlets across S. Ulster Street to Stanford Detention Basin (private). A 60-inch outlet pipe conveys flows from the Stanford basin across I-225 and through a commercial lot to the outfall in Goldsmith Gulch North Middle Park, south of E. Quincy Avenue. Runoff from basin L-330 (in this study) is also discharged at this location. This area is a potential location for formalized detention.
- Runoff from basin L-180 (in this study) is conveyed to the Interchange Detention Basin located within the I-25 / I-225 interchange. Flow from the detention basin is conveyed parallel to I-225 in a trapezoidal swale to the outfall at the intersection of DTC Boulevard and I-225. This facility is owned/ maintained by CDOT, however, due to maintenance needs, this detention was not included in the baseline hydrology. Formalizing regional detention at this CDOT facility is evaluated as part of the alternatives analysis.

Reach ST-1 – Southmoor Park at S. Oneida Way to Southmoor Tributary Confluence

Reach ST-1 of Goldsmith Gulch generally consists of 0.21 miles of open channel drainageway and 0.61 miles of piped conveyance (0.82 miles total) from Southmoor Park at S. Oneida Way to Southmoor Tributary Confluence within the City and County of Denver.

From S. Oneida Way to the alley between E. Hampden Avenue and E. Hamilton Place, the Southmoor Tributary flows through a 72-inch diameter RCP through Southmoor Park. The basin outlet consists of a Valley Inlet Type 13, which conveys surface flows from the park and contributing area to the 72-inch pipe via a 24-inch diameter pipe, which provides detention within the park (see **Figure 2-7**). Formal inlet and outlet structures could be added to this park to increase inflows to this facility as well as detention storage. Downstream, the gulch briefly daylights and flows through a concrete trapezoidal channel before flowing through another culvert crossing a parking lot and E. Hamilton Place into Hutchinson Park.

Through Hutchinson Park, the gulch consists of natural drainageway with dense overbank vegetation. One drop structure is located on Southmoor Tributary within Hutchinson Park (*As-Built: Southmoor Tributary at Hutchinson Park, 2011*). Existing emergent and forested/ shrub wetlands (see **Figure E-1**) are located along Southmoor Park Tributary and within Hutchinson Park, which provides water quality benefits and opportunities.

Basin inlet looking east (surface flow).

Basin outlet and spillway looking north.

Figure 2-6 Southmoor Park Detention.

Reach GG-5 – Belleview Avenue to Yosemite Street

Reach GG-5 of Goldsmith Gulch generally consists of 0.5 miles of open channel drainageway Yosemite Street to Belleview Avenue within Greenwood Village. In general, the gulch consists of a grassy trapezoidal channel. Downstream of approximately E. Crescent Parkway the gulch becomes channelized and flows through a concrete low flow channel with grassy overbanks.

Reach GG-6 – Yosemite Street to West Fork Goldsmith Gulch Confluence

Reach GG-6 of Goldsmith Gulch generally consists of 0.48 miles of open channel drainageway from Yosemite Street to West Fork Goldsmith Gulch Confluence within Greenwood Village.

The confluence of West Fork Goldsmith Gulch and Goldsmith Gulch is located in Orchard Hills Park directly upstream of Orchard Hills Detention Basin (see **Figure 2-7**). This basin includes a permanent wet pool. An 18-inch stand pipe conveys low flows downstream creates permanent wet pool. Larger flows spill over a pedestrian trail. Increasing storage volume at this location is evaluated as part of the alternatives analysis.

Basin outlet looking north.

Basin spillway looking east.

Figure 2-7 Orchard Hills Detention.

Reach GG-7 – West Fork Goldsmith Gulch Confluence to S. Dayton Street at Silo Park

Reach GG-7 of Goldsmith Gulch generally consists of 0.5 miles of open channel drainageway from West Fork Goldsmith Gulch Confluence to S. Dayton Street at Silo Park within Greenwood Village.

Downstream of S. Dayton Street, the channel consists of a grassy low flow channel and overbanks. Two drop structures and two pedestrian crossings are located within this reach.

Reach GG-8 – Orchard Road at Silo Park to Arapahoe Road

Reach GG-8 of Goldsmith Gulch generally consists of 1.1 miles of open channel drainageway from Orchard Road at Silo Park to Arapahoe Road. The reach is located within City of Centennial and unincorporated Arapahoe County as well as a small portion in Greenwood Village.

From Arapahoe Road to E. Peakview Avenue, the mainstem consists of a concrete trapezoidal channel through the Hyundai and Subaru car dealerships, which transitions to a concrete bottom with grassy side slopes where the channel turns west parallel to Peakview Street.

Directly downstream of E. Peakview Avenue, there is a series of three drop structures. Through this section, the channel consists of an engineered riprap low flow channel with grassy overbanks. The channel consists of a concrete low flow channel and grassy overbanks from the last drop structure to Arapahoe Lake.

Arapahoe Lake dampens peak flows in the upper basin, but the lake is privately owned and maintained so its function as a regional stormwater detention facility has not been included in the Baseline Hydrology. Houses have been constructed along the shoreline making them susceptible to flood hazards. To account for this detention occurring at Arapahoe Lake, an Adequate Assurance Agreement would be necessary to document that no changes would be made to the lake without approval. The Alternatives Analysis will consider the merits of making this lake a regional detention facility. The Homeowner's Association previously indicated they are willing to consider formalizing detention if there is a benefit to the system. The lake outlet consists of an approximately 7-foot diameter RCP pipe and spillway. Downstream of the Arapahoe Lake spillway, the gulch is conveyed through 4-feet by 8-feet RCBC to Silo Park.

The Silo Park Detention Basin (see **Figure 2-8**) is currently being redesigned. The existing basin outlet structure consists of one 36-inch CMP pipe and provides detention only. The proposed design increases the size of the culvert under Orchard Road to reduce overtopping and thus will also integrate a spillway berm upstream of Orchard Road to mimic existing detention, similar to Tommy Davis Park. The implementation of the proposed Silo Park Drainage Improvement Project is scheduled to be constructed by 2022.

Basin looking north.

Basin outlet looking north.

Figure 2-8 Silo Park Detention.

Reach WG-1 – West Fork Goldsmith Gulch Confluence to Tommy Davis Park at Maplewood Avenue

Reach WG-1 of West Fork Goldsmith Gulch generally consists of 0.52 miles of open channel drainageway from West Fork Goldsmith Gulch to Tommy Davis Park at Maplewood Avenue within Greenwood Village.

A concrete low flow channel extends from Maplewood Avenue to the Tommy Davis Park Detention Basin at Orchard Road and includes three drop structures. The Tommy Davis Park Detention Basin (see **Figure 2-9**) was constructed in 2008 and the 16-feet by 10-feet RCBC and pedestrian crossing at Orchard Road was completed in 2009. Both phases are documented in as-builts (*As-Builts: Goldsmith Gulch – West Tributary Tommy Davis Park Phase I Improvements, 2008, and Phase II Improvements, 2009*). The basin is designed for detention only and includes a permanent wet pool below the outlet. The basin outlet structure consists of two 24-inch pipes and spillway berm, both located upstream of the Orchard Road culvert.

Downstream of Orchard Road, the channel is relatively stable and consists of a partial boulder wall on the east bank, engineered riprap low flow channel, and vegetated overbanks. One drop structure is located within this reach.

Basin and inlet looking north.

Basin outlet looking north.

Figure 2-9 Tommy Davis Park Detention.

Reach WG-2 – Tommy Davis Park at Maplewood Avenue to E. Caley Avenue

Reach WG-2 of West Fork Goldsmith Gulch generally consists of 0.31 miles of natural drainageway from Tommy Davis Park at Maplewood Avenue to E. Caley Avenue within Greenwood Village and a small portion in unincorporated Arapahoe County.

Downstream of Caley Basin, a natural channel corridor project is under construction (2018) from E. Caley Avenue to E. Fair Avenue. The project includes a 6-foot drop structure and a void filled riprap channel with pools. HEC-RAS from this project will be incorporated into the FHAD hydraulic model.

From E. Fair Avenue to approximately Maplewood Avenue, a channel reconstruction project was constructed in 2020. The as-built conditions have been included in the FHAD hydraulic model.

Reach WG-3 – E. Caley Avenue to E. Peakview Avenue

Reach WG-3 of West Fork Goldsmith Gulch generally consists of 0.36 miles of natural drainageway from E. Caley Avenue to E. Peakview Avenue within Greenwood Village. Several projects are currently underway and have recently been completed within this reach.

The Boston Peakview Detention Basin (see **Figure 2-10**) was constructed in 2004/ 2005 to provide water quality via a 100-inch high by 15-inch-wide orifice plate located 20-inch above grade. The orifice plate consists of 24 rows and two columns of approximately 2-inch orifices. A 170-inch long by 7-inch high (vertical) spillway is located 120-inch from the basin bottom. The basin was designed with a micro-pool, which resulted in several citizen complaints about standing water from the adjacent Brookdale Greenwood Village. In 2018, a 3-inch orifice and a concrete pan were added to the base of the outlet structure to eliminate the micro-pool. The original as-builts and drainage report were unable to be located for this basin, but there is a Memorandum for the added orifice design (Muller 2018).

Downstream of S. Boston Street, there are a series of two wet ponds upstream of the Caley detention basin inlet. A drop structure between the two wet ponds failed and currently requires channel regrading to remove an adjacent structure from the floodplain. A capital improvement project is currently underway to rehabilitate the Bridgwater Upper Pond to include water quality, as well as drop structures, and channel improvements. As of completion of this report, LOMR 21-08-0598P issued 2/25/22 and effective 7/15/22 was completed to remove the Bridgwater Apartments from the floodplain.

Caley Detention Basin (see **Figure 2-11**) was constructed in 2004 to provide regional detention and water quality and is documented in as-builts. The adjacent pedestrian underpass was completed in 2017. The basin outlet structure consists of multi-level weirs with an orifice plate in the lowest weir to provide water quality. Once water overtops the weir structure, it is conveyed through two 6-foot by 4-foot RCBC across E. Caley Avenue. A LOMR is complete for the recently installed box culvert at the inlet to Caley basin. Caley Detention Basin is not designed to spill into the pedestrian underpass, however, since the wall is not considered a levee, the regulatory floodplain extends into this underpass. A drop structure was located at the current inlet of Caley Detention Basin and served as energy dissipation at the inlet. The project removed the drop structure and replaced it with a roadway crossing culvert. The drop structure was relocated immediately upstream at the entrance of the roadway crossing culvert and serves as energy dissipation for flow into the detention basin.

Basin and outlet looking north.

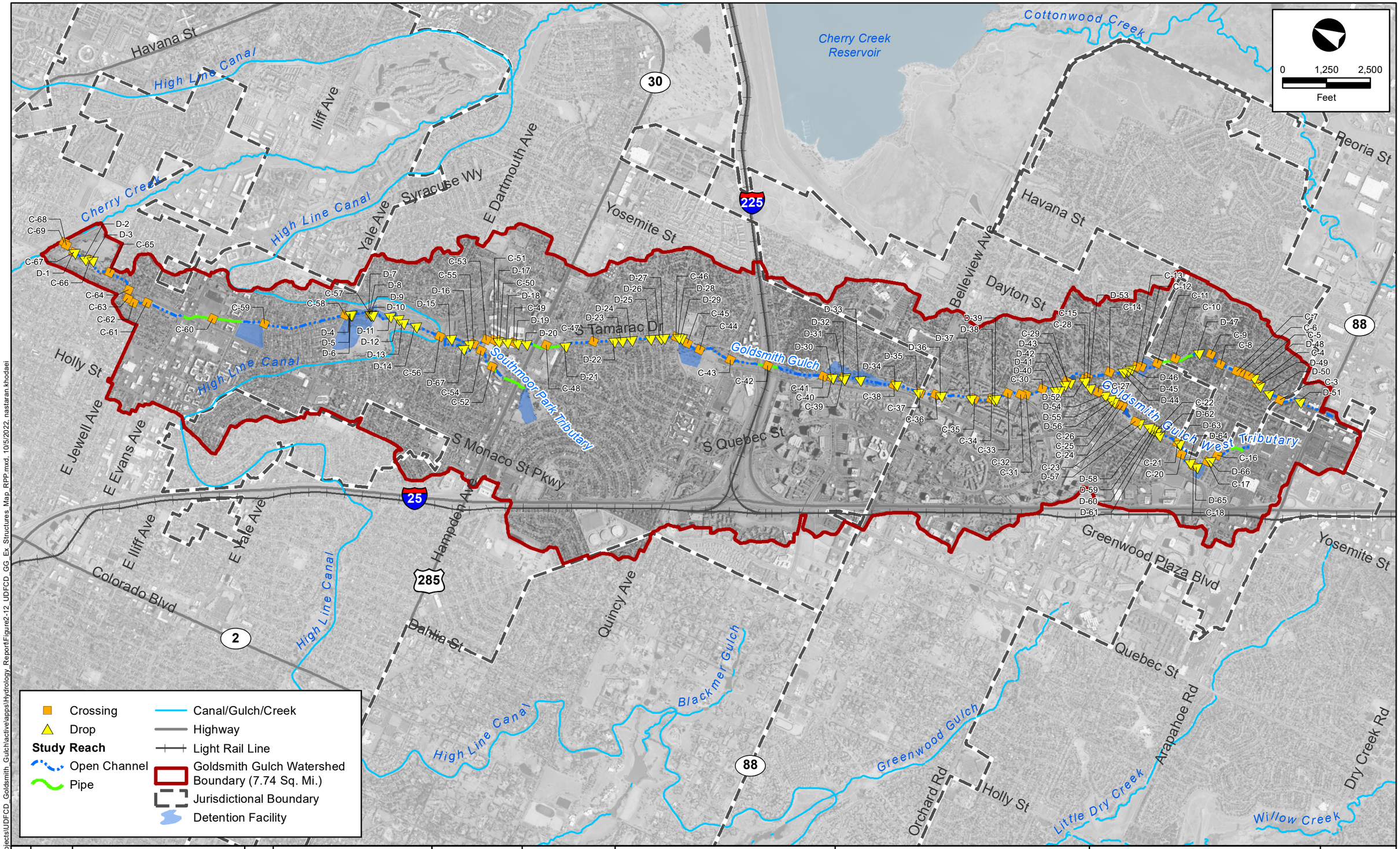
Basin outlet looking north.

Figure 2-10 Boston Peakview Detention.

Basin inlet looking south.

Basin outlet looking south.

Figure 2-11 Caley Detention.



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No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by: _____
drawn by: RP
checked by: RK
project no.: 18.155.035
date: 11/12/2019

MHFD MILE HIGH FLOOD DISTRICT

MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY
AND TRIBUTARIES

EXISTING STRUCTURES
MAP

FIGURE
2-12

2.4 Flood History

The waterway has generally functioned adequately in the recent past without major flood damage. Three MHFD Alert flood warning stream gages have flood records on Goldsmith Gulch and its tributaries. The gages are located at Wallace Park South Detention Basin (Temple Pond) (1987), Goldsmith Gulch at Eastman Avenue (Goldsmith @ Eastman) (1989), and Iliff & Monaco Detention Basin (Goldsmith @ Iliff Pond and Iliff Pond) (2004). All of the gages are active stream peak flow gages and are operated by MHFD. These gages are primarily for flood warning with limited calibration; therefore the reported discharge values are approximate and the exact values should be used with caution. Limited flooding history is known prior to the 1976 FHAD due to lack of recordkeeping and gage records.

On May 5 and 6, 1973, a large storm causing heavy rainfall and local flooding along the mainstem of Goldsmith Gulch. The estimated flood frequency resulting from this long duration storm was approximately 5-year to 10-year. Capacities of the crossings at Dartmouth and Yale Avenues were exceeded. Photos from the 1973 flood are shown in **Figure 2-14.**

On May 23, 1991, a hailstorm with heavy rain occurred in Arapahoe County near Goldsmith and Harvard Gulch in the afternoon between 2:00 pm and 3:00 pm. A total of 1.75 inches of rain fell causing increased runoff and localized flooding in both Goldsmith and Harvard Gulch.

On July 27, 1997, Goldsmith Gulch was hit by heavy rains with 1.66 inches falling at the Denver Tech Center. Downstream floodwaters approached 10-year levels causing the side-channel detention facility, constructed a year earlier in 1996 near Iliff Avenue and Monaco, to activate and was credited with preventing damages downstream. A minor glitch did occur, however, when the pump that drains the facility failed to start.

On July 28, 1997 Goldsmith Gulch was hit hard for the second consecutive day, exceeding the prior day's peak at Eastman Avenue by one foot and setting a new record of 2,040 cfs. Upstream at Temple Pond, Goldsmith floodwaters pooled to a depth of 9.5 feet releasing 500 cfs. Downstream of Eastman at Yale Avenue, the peak flow was estimated at 1,850 cfs (see **Figure 2-15**) and classified as a 10-year event. According to the Goldsmith Gulch design hydrology model, the discharge at Eastman approached the 50-year mark.

On July 16, 2000, strong thunderstorms developed between 7:30 pm and 9:00 pm. Very moist and unstable conditions, combined with upslope during the late afternoon and evening hours, triggered widespread urban and small stream flooding in and around the Denver metropolitan area. Rainfall amounts generally ranged from 1 to 3 inches, with the heaviest rainfall occurring during the evening hours. In Greenwood Village however, near Peoria and Belleview, the road was closed for several hours as 2 feet of standing water covered the roadway.

On July 8, 2001, significant flooding again occurred. Up to 4.5 inches of rain fell across portions of western Arapahoe County. The underpass of Interstate I-225 and Parker Road was inundated with 5 feet of water. **Figure 2-16** illustrates conditions at Goldsmith Gulch upstream of Mexico Avenue during the 2001 flood.

On July 13, 2001, three inches of rain reportedly fell near the Greenwood Village Police Department in a span of 15 minutes.

On July 19, 2003, heavy thunderstorms caused flash flooding across parts of western Arapahoe and southern Denver Counties. Automated rain gages indicated 2 to 3 inches of rain fell in less than one hour. The heavy runoff caused many intersections and underpasses to flood, stranding motorists. As a result, sections of Interstate 25 and Interstate 225 were closed.

On August 18, 2004, several intersections in southern Aurora were impassable due to flood waters. Two feet of water covered portions of the roadway near Park Meadows Mall. One person had to be rescued near the intersection of Arapahoe Road and Liverpool.

A storm on June 3, 2005, resulted in significant flooding in the parking lot of apartment complex on the north side of Iliff Avenue (see **Figure 2-17**). While this flooding occurred, the Iliff & Monaco detention basin was less than a quarter full. Up to 3 feet of standing water was reported over East Orchard Road. Several motorists were stranded in their vehicles and needed to be rescued.

On August 1, 2006, high water inundated Arapahoe Road between Holly and Quebec. Flooding of Park Meadows Mall and areas of Greenwood Village was reported.

On July 3, 2009, flooding was reported at the intersection of Monaco & Evans. UDFCD ALERT gage at Iliff Detention Basin two blocks south indicates 1.22 inches rain fell in approximately 25 minutes.

A major event occurred on September 12, 2013 (**Figure 2-19**). According to the UDFCD 2013 Flood Peak Estimate Interactive Map, flows reached 420 cfs at Wallace Park South Detention Basin, 752 cfs at Goldsmith Gulch at Eastman Avenue, and 461 cfs at Iliff & Monaco Detention Basin.

Flooding was also noted on August 13, 2006, May 12, 2011 (**Figure 2-18**), July 13-14, 2011, and June 11, 2015 (**Figure 2-19**), according to the gage records, but no specific information is available regarding flood impacts.

Annual peak flows from the Alert gages for the Temple Pond, Goldsmith @ Eastman, and Goldsmith @ Iliff Pond are presented in **Figure 2-21**. Comparison of annual peak stage within Iliff Pond and Goldsmith @ Iliff Pond is presented in **Figure 2-22** (these stages do not necessarily occur at the same time or day).

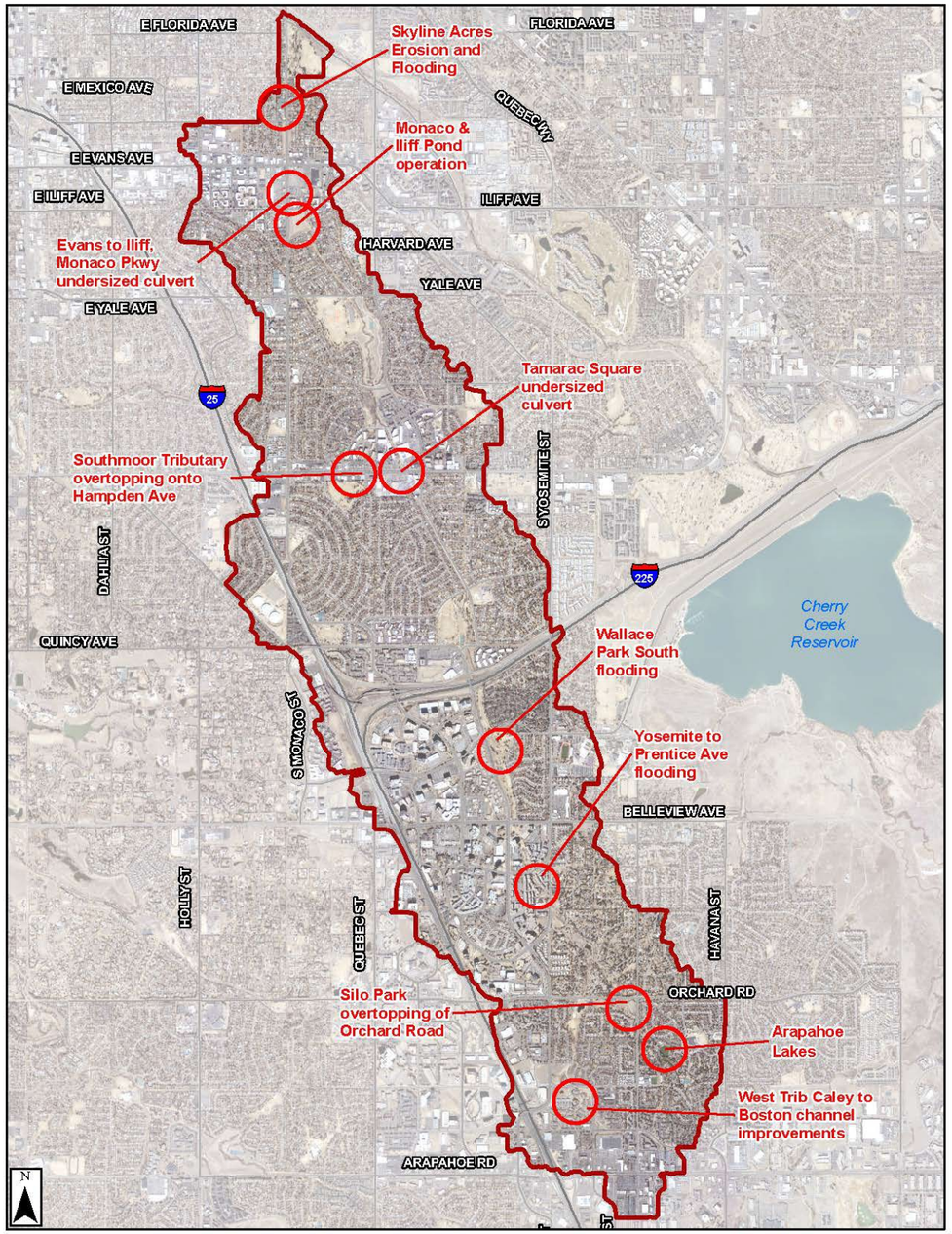
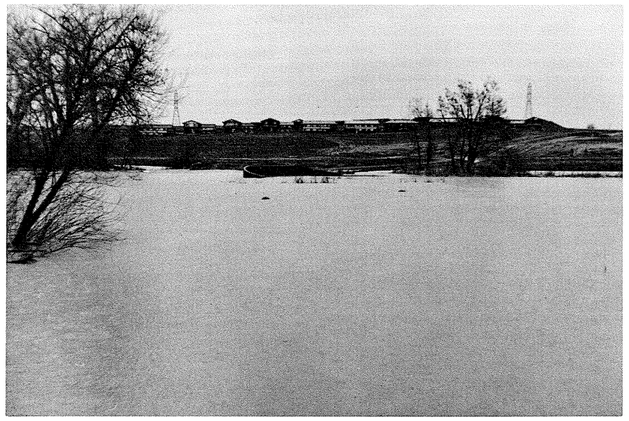


Figure 2-13 Major Drainageway Problem Areas within Goldsmith Gulch



Goldsmith Gulch at Dartmouth Avenue and High Line Canal, May 6, 1973. View looking downstream.

Goldsmith Gulch at Yale Avenue, May 6, 1973. View looking west along Yale Avenue.

Photographs from 1976 FHAD (Source: Leonard Rice Consulting Water Engineers).

Figure 2-14 1973 Flooding Event

Figure 2-15 Goldsmith Gulch downstream of Yale Avenue on July 28, 1997

Figure 2-16 Goldsmith Gulch upstream of Mexico Avenue on July 8, 2001

Goldsmith Gulch at Iliff Avenue looking west along Iliff Avenue towards the detention basin.

Goldsmith Gulch upstream of Iliff Avenue looking west towards the detention basin.

Goldsmith Gulch in the parking lot of the apartment complex on the north side of Iliff Avenue.

Water level in apartment complex parking lot.

Figure 2-17 June 3, 2005 Flooding Event.

Tommy Davis Park detention outlet (on south side of berm) looking west.

Tommy Davis Park detention outlet (on north side of berm in underpass) looking south.

Orchard Hills Park.

Orchard Hills detention spillway looking east.

Figure 2-18 May 12, 2011 Flooding Event.

Orchard Hills Park

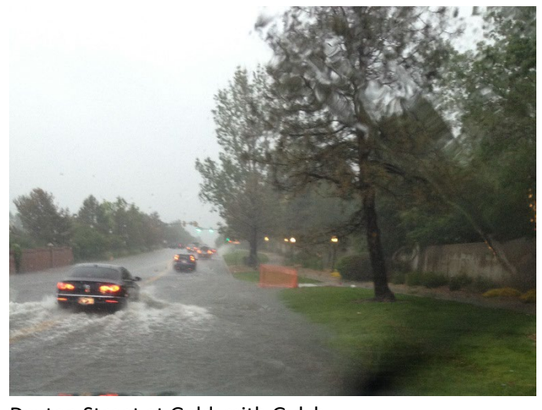
Orchard Hills Park

Downstream of Berry Stables

Silo Park Basin

Figure 2-19 September 12, 2013 Flooding Event.

Orchard Road Under Crossing at West Tributary



Dayton Street at Goldsmith Gulch

Figure 2-20 June 11, 2015 Flooding Event.

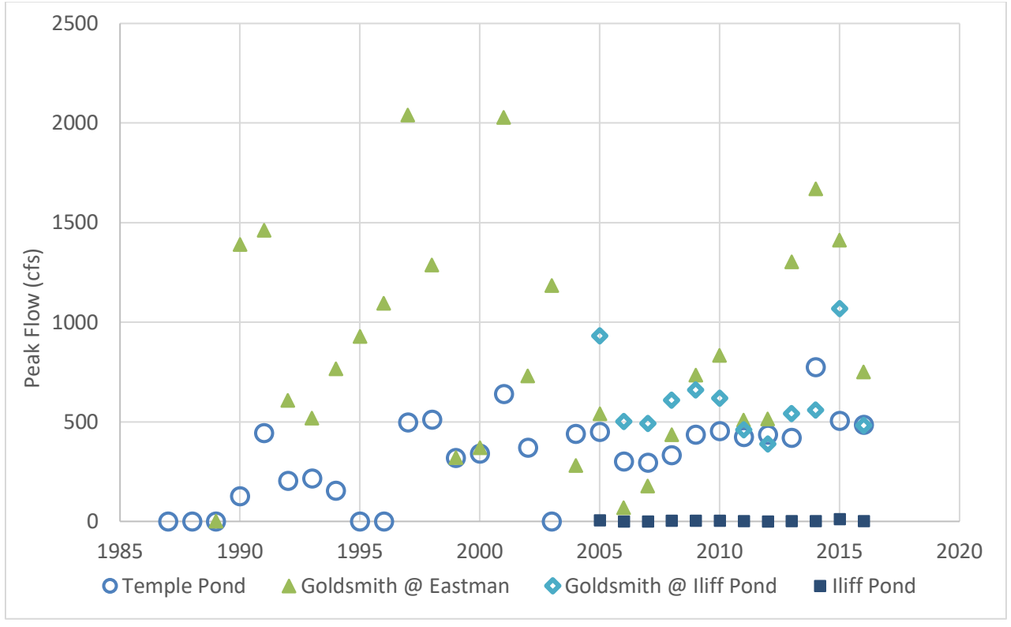


Figure 2-21 ALERT Gage Annual Peak Flows.

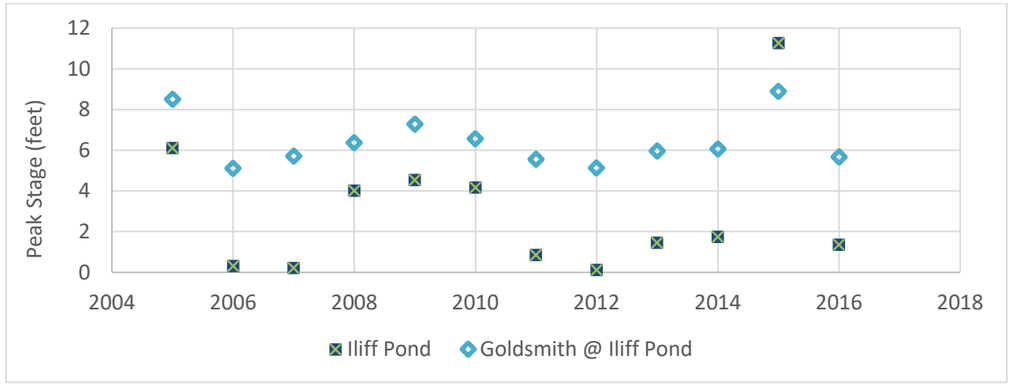


Figure 2-22 ALERT Gage Annual Peak Stage at E. Iliff Avenue.

Note: These stages do not necessarily occur at the same time or day.

2.5 Environmental Assessment

Parks and Open Space

Figure 2-23 identifies city-owned land. **Figure 2-23** identifies Parks and Open Space. **Figure 2-24** also identifies existing trail systems to highlight gaps in connectivity. Trail connectivity is a prioritization criterion considered in the alternatives analysis.

Wetlands and Riparian Zones

The vegetation along the mainstem, Southmoor Tributary, and West Tributary drainageways consists of a mix of turf grass, prairie grassland, and riparian vegetation communities with some wetlands directly adjacent to the low-flow channel. The streambanks and floodplains along the drainageway are well vegetated. Some areas are heavily vegetated, particularly along Goldsmith Gulch between Yosemite Street and Prentice Avenue. A formal Wetland and Riparian Zone inventory was not conducted for this study; however, **Figure E-1** in **Appendix E** illustrates the general location of wetland and riparian zone vegetation based on National Wetlands Inventory (NWI) datasets.

Threatened and Endangered Species

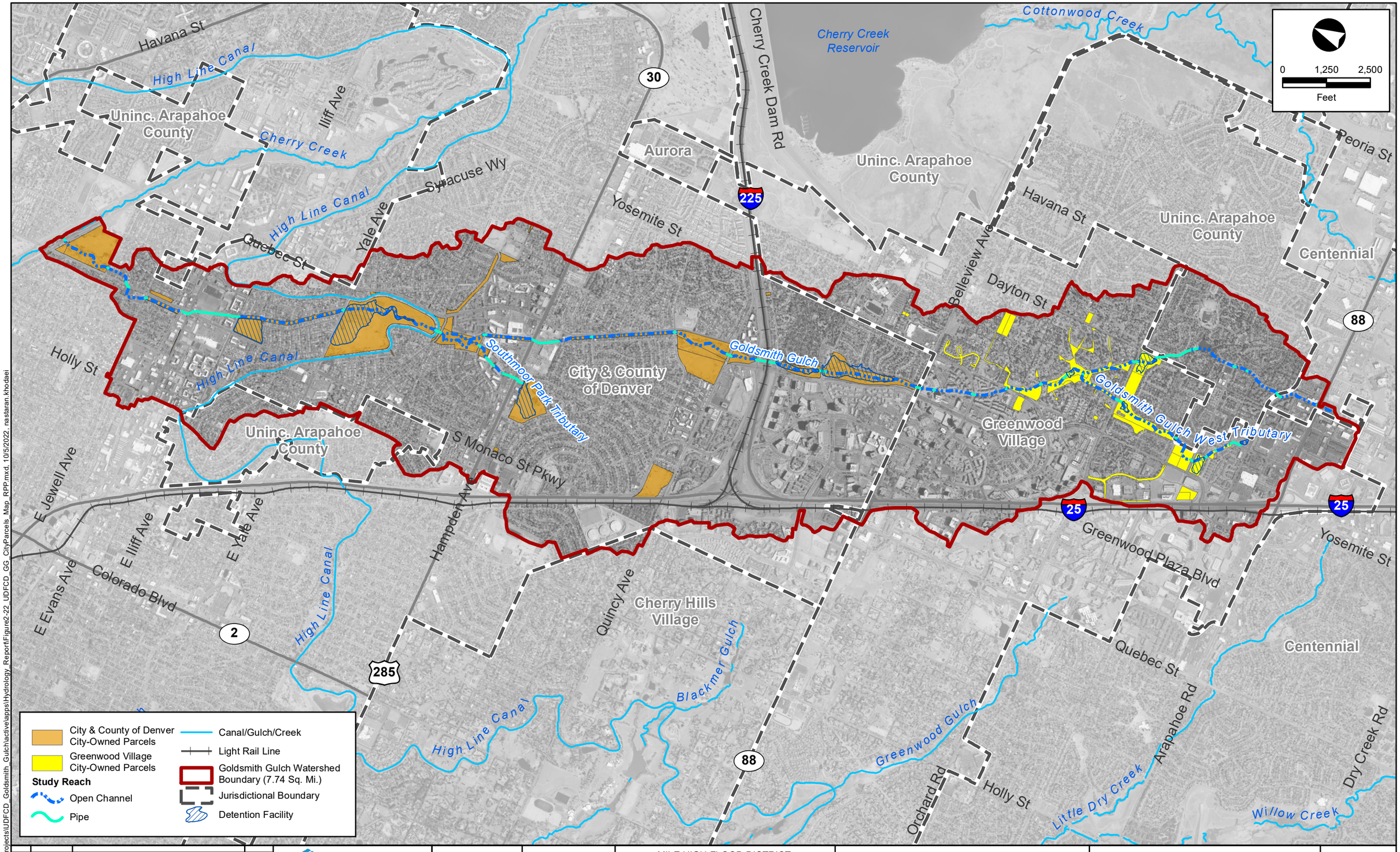
The U.S. Fish and Wildlife Service (USFWS) currently lists the Mexican spotted owl, Ute ladies'-tresses orchid, western prairie fringed orchid, and Preble's jumping mouse as threatened, and the Least tern as endangered species for Denver County and Arapahoe County per the listing on http://www.fws.gov/endangered/. These species should not be a concern for projects within the Goldsmith Gulch watershed. The entirety of the Goldsmith Gulch watershed is outside of the Denver metropolitan Block Clearance. Future design projects will require more detailed assessments of any potential threatened and endangered species habitat resources within the project limits.

Landfills

Approximate areas of known or suspected areas of landfill zones were identified and provided by the City & County of Denver. **Figure D-1** in **Appendix D** shows the approximate boundaries of landfill areas. Known landfills exist along Southmoor Tributary downstream of Southmoor Park to the confluence with Goldsmith Gulch and along Goldsmith Gulch from E. Kenyon Avenue to the confluence with Southmoor Tributary. Another known landfill is located at E. Dartmouth Avenue and S. Ulster Street.

Water Quality

Goldsmith Gulch mainstream is a Category 5 303(d)-listed waterbody for E. Coli and Selenium, according to the Colorado Department of Public Health and Environment (CDPHE) WQCD dataset, last updated April 8, 2016 (CDPHE 2012). The waterbody identification for Goldsmith Gulch is COSPCH04a and the unique assessment unit identification is COSPCH04a_B. Currently, reach-scale TMDLs are not required for Cherry Creek or Goldsmith Gulch.



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No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by:
drawn by: RP
checked by: RK
project no.: 18.155.035
date: 11/12/2019

MILE HIGH FLOOD DISTRICT

MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY
AND TRIBUTARIES

CITY-OWNED PARCELS

FIGURE
2-23

Old Cavalcade Trail
Cook (Judge Joseph E) Park
Highline Canal (Colorado to Parker)
Bible (James A) Park
Hampden Heights West Park
Hutchinson East Park
Goldsmith Gulch
Goldsmith Gulch North
Wallace (George M) Park
Chenago Park
Hoffman Park
Sundance Park
Orchard Hills Park
Silo Park
Tommy Davis Park
Huntington Acres Park
Highline Canal (Colorado to Parker)
Hutchinson (Theodore A) Park
Southmoor Park
Eastmoor Park
Jefferson Square Park
Rosamond Park
Wallace (George M) Park North
Goldsmith Gulch North Middle
Greenwood Village Open Space

Havana St
High Line Canal
Uninc. Arapahoe County
Iliff Ave
Cherry Creek
Cherry Creek Reservoir
Cherry Creek Dam Rd
Cottonwood Creek
Aurora
Yosemite St
Peoria St
Centennial
Belleview Ave
Dayton St
Quebec St
Yale Ave
Holly St
City & County of Denver
Southmoor Park Tributary
Goldsmith Gulch
Goldsmith Gulch West Tributary
Greenwood Village
S Monaco St Pkwy
Hampden Ave
E Jewell Ave
E Iliff Ave
E Yale Ave
E Evans Ave
Colorado Blvd
Greenwood Plaza Blvd
Quincy Ave
Cherry Hills Village
Blackmer Gulch
Greenwood Gulch
Orchard Rd
Little Dry Creek
Arapahoe Rd
Dry Creek Rd
Willow Creek

30
225
88
25
2
285

0 1,250 2,500
Feet

Trail
Study Reach
Open Channel
Pipe
Canal/Gulch/Creek
Light Rail Line
Goldsmith Gulch Watershed Boundary (7.74 Sq. Mi.)
Park
Jurisdictional Boundary
Detention Facility

No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by:
drawn by: RP
checked by: RK
project no.: 18.155.035
date: 11/12/2019

MHFD MILE HIGH FLOOD DISTRICT

MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY AND TRIBUTARIES

PARKS AND OPEN SPACE

FIGURE 2-24

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3.0 HYDROLOGIC ANALYSES

3.1 Overview

Goldsmith Gulch along with Goldsmith Gulch West Tributary and Southmoor Park Tributary drain an area of approximately 4,954 acres (7.74 square miles) from Arapahoe Road to the confluence with Cherry Creek. The major drainageway includes 7.6 miles of mainstem channel corridor, which is based upon 5.1 miles in Denver, 1.3 miles in Greenwood Village, and 1.1 miles in SEMSWA (Arapahoe County and City of Centennial). In addition, 1.2 miles of tributary stream corridor along Goldsmith Gulch West Tributary in Greenwood Village (a short reach less than 400-feet in the unincorporated area of Arapahoe County) and 0.8 miles of tributary stream corridor along Southmoor Park Tributary in Denver. The purpose of this study is to update the major drainageway design flood flows based upon current criteria for the entirety of the Goldsmith Gulch watershed, including Goldsmith Gulch West Tributary and Southmoor Park Tributary. The updated peak discharge rates along the major drainageway will be used by project sponsors and communities as a base for regulating future development, re-development, floodplain management and infrastructure design. The hydrologic calculations were approved by MHFD on August 17, 2018. The following sections depict the detailed study and findings.

3.1.1 Previous/Concurrent Studies and Hydrologic Models

As described in the previous sections, there are several completed studies for the Goldsmith Gulch Drainageway. However, the model inputs and modeling methodology do not meet the current criteria.

In 1989, a *Hydrology Study for the Goldsmith Gulch Drainage Basin* (**1989 Study**) was developed by James C.Y. Guo in collaboration with Hydrosystems Engineering Consulting Services (HECS) (Guo 1989). This study updated the hydrology of the 1976 FHAD and MDP (Gingery Associates Inc 1976 and 1977, respectively) based on the changing land use conditions and additional detention facilities at Wallace Park North and South and Bible Park. In 1994, an appendix to the 1989 Study was completed by Sellards & Grigg (**1989 Study Appendix)** (Sellards & Grigg 1994). This appendix added on-line detention at Wallace Park (North and South) and Bible Park to the 1989 Study model. In addition, the off-line detention at Iliff & Monaco was modeled using an Interconnected Pond Routing model. The 1989 Study Report and Appendix are the basis of the **2020 FIS** at Goldsmith Gulch. In 2005, a FHAD and OSP was developed for the upper basin (south of Belleview Avenue) by Moser and Associates (**2005 OSP**) (Moser 2005).

The lower Goldsmith Gulch watershed (north of Belleview Avenue) within the City and County of Denver was studied in the Denver Storm Drainage Master Plan basin to model the storm drain system but not the drainageway (**2014 SDMP**) (Matrix 2014). The hydrologic models were run with CUHP 2000 and UDSWMM 2000 for each sub-watershed or local drainage system. However, the hydrographs for each sub-watershed were not routed through the Goldsmith Gulch major drainageway. The hydrologic models for the Denver Storm Drainage Plan were not used directly as the basis for developing this study's hydrologic model for the lower basin due to lack of modeling continuity, but the sub-basin delineation was incorporated into this study.

The Upper Goldsmith Gulch OSP in 2005 was analyzed with the hydrologic models CUHP 2000 and UDSWMM 2000. The hydrologic models from the 2005 OSP were provided by MHFD and converted into CUHP 2.0 and EPA SWMM 5.1 to be used as the base for hydrologic analysis for the upper watershed (south of Belleview Avenue).

The TREX Drainage Report included two detention basins: a CDOT facility and a private facility near I-25 and I-225. Privately owned facilities cannot be considered in the Baseline Hydrology. The CDOT detention is primarily a water quality treatment facility and was designed based on 50-year return period. City and County of Denver staff confirmed that water quality detention is inspected and maintained at a regular basis. However, use of the facility for 100-year flood control has not been confirmed. The TREX drainage schematics were used to identify the sub-basin delineation and routing, however, the CDOT and private detention were not incorporated into the Baseline Hydrologic model.

There is a concurrent study to evaluate Silo Park for drainage improvements. As described in Section 2.3, the implementation of the proposed Silo Park Drainage Improvement Project is scheduled to be constructed by 2022. However, the design is not complete at the time of this study and there is not a detention rating curve for the proposed Silo Park improvements. Therefore, the existing condition detention rating curve, refined by the study, was used in the Baseline Hydrologic model.

Arapahoe Lake physically acts to reduce downstream hydrology but is privately owned so the resulting detention storage and resulting reduction in hydrology is not considered in the Baseline Hydrology analysis. To include Arapahoe Lake in the baseline hydrology would require that SEMSWA or Arapahoe County obtain an Adequate Assurance Agreement documenting that no changes will be made to the lake without approval.

The 2005 OSP and 2014 SDMP were used as the framework for the upper and lower basins, respectively, in study. In addition, the 1989 Study was used to supplement information where needed, particularly for the lower basin. The following sections describe the major changes to previous models.

3.1.2 General Changes to Hydrology

The major changes to hydrology from previous studies include:

- Rainfall depth was updated to use NOAA 14.
- Percent imperviousness was updated for all sub-basins based on current data. Percent imperviousness difference is shown for the upper basin compared to the 2005 OSP in **Figure 3-1.** Percent difference is not provided for the lower basin due to substantial changes in sub-basin delineation.
- MHFD criteria was recently updated to require DARFs for watersheds between 2 and 15 square miles for the 2- to 10-year events.
- CUHP, version 2.0.0, and SWMM, version 5.1, were utilized.

3.1.3 Revisions to Upper Basin Model

Major revisions to the upper basin model from the 2005 study include:

- Sub-basin numbering was updated to be consistent with the lower basin while still maintaining a reference to the 2005 OSP numbering. A "U-" was added to the beginning of the numbering and a "0" was appended to the end of the 2005 OSP number (i.e. 77 is now U-770).
- One of the sub-basins from the 2005 OSP model were merged into an adjacent sub-basin to conform with current MHFD guidelines for basin geometry. Sub-basins 64 and 65 were merged into U-640. Sub-basin parameters, such as length, slope, and area were updated for this basin.
- Several sub-basin boundaries were slightly revised based on current topology and storm data, including: U-310, U-440, U-450, U-460, and U-770. Sub-basin parameters, such as length, slope, and area were updated for these basins.
- The 2005 OSP model included a design point for each sub-basin with a dummy link to an on-line design point. Redundant nodes and links were merged into the downstream design point.
- The 2005 OSP model did not include design point elevations. Design point elevations were added to each design point based on current topography. Outlet offset was used to adjust the slope to remove sudden elevation changes due to drop structures.
- Detention curves were updated to reflect current best available information. More detail is provided in subsequent sections.
- The Boston Peakview detention node was added to the model.

3.1.4 Revisions to Lower Basin Model

- Sub-basins, design points, and conveyance links within the 2014 SDMP model were delineated based on the storm system versus the drainageway. Significant revisions were made to the sub-basins to reflect current topography, storm system, existing detention, and the TREX drainage report. The 1989 Study sub-basins were too large and coarse and did not meet current MHFD guidelines.
- The 2014 SDMP model did not include any detention. Existing detention identified in the 1989 Study Appendix was included in this Baseline Study model. The 1989 Study Appendix detention curves were updated to reflect current best available information.

3.1.5 Hydrologic Modeling Methodology

The objective of the existing condition hydrologic analysis is to study the Upper and Lower Goldsmith Gulch basins using the Colorado Unit Hydrograph Procedure (CUHP), Version 2.0.0 to generate hydrographs for each sub-watershed. Hydrographs for the sub-watersheds were routed through the drainage network using the Environmental Protection Agency Stormwater Management Model (EPA SWMM), Version 5.1.012, to determine peak discharge rates along the major drainageway at key design points.

High Line Canal flows across the Goldsmith Gulch watershed and intercepts some storm flows from the headwaters. *Section 3.3.4.1 of the City & County of Denver's Storm Drainage Design and Technical Criteria Manual* states that "Irrigation facilities such as ditches and reservoirs shall not be used as drainage facilities…" Therefore, initial storm flows were modeled as being conveyed across the High Line Canal to the downstream storm drain network. In the High Line Canal Master Plan, which is currently in development, stormwater inflow into the canal is allowed with analysis and approval. Use of the High Line Canal for stormwater interception for water quality purposes only is evaluated in the Major Drainageway Plan, but does not affect the Flood Hazard Area Delineation hydrology.

3.2 Design Rainfall

Rainfall depth and distribution has been updated to current MHFD criteria for use in the baseline hydrologic model. Precipitation from NOAA Atlas 14 was used in this study per the Urban Storm Drainage Criteria Manual (USDCM) revised March 2017. Depth-area reduction factors (DARF's) applied to point rainfall depths used within CUHP vary with the size of the watershed being analyzed. The total contributing drainage area for the Goldsmith Gulch watershed to the Cherry Creek is 7.74 square miles. For watersheds less than 15 square miles, the MHFD-USDCM stipulates that the 1-hour point precipitation depth be used for the 25-, 50-, 100-, and 500-year events without applying a DARF. For watersheds between 2 and 15 square miles, the MHFD-USDCM stipulates that the 1-hour point precipitation depth be applied for the 2-, 5-, and 10-year events with the DARFs from Table 5-3 in Volume 1 of the MHFD-USDCM. Based on the MHFD-USDCM criteria, DARFs were applied for the 2-, 5-, and 10-year events only.

The one-hour point rainfall depths for the 2-, 5-, 10-, 25-, 50-, 100- and 500-year events were obtained from *NOAA Atlas 14 at Cherry Creek Dam (Site ID: 05-1547).* Selected one-hour and six-hour point rainfall depths for these design events are given in **Table 3-1** below. **Table B-1** in **Appendix B** shows the detailed rainfall temporal distributions for each event.

Table 3-1 One-Hour and Six-Hour Point Rainfall Depths (Inches)

Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
1-hour	0.87	1.12	1.36	1.72	2.02	2.35	3.20
6-hour	1.41	1.78	2.13	2.67	3.14	3.64	4.97

3.3 Subwatershed Characteristics

A summary of the CUHP model parameters can be found in **Appendix B, Table B-2**. For the subwatersheds within the study area, 1-foot contour topography was used to determine the existing conditions flow path lengths, slopes and distance to the centroid from outfall following the drainage path.

3.3.1 Subwatershed Delineation

The subwatersheds within the study area were delineated based on the 2005 Upper Goldsmith Gulch FHAD & Outfall Systems Planning (Moser 2005) and Denver Storm Drainage Master Plan (2014). Minor revisions were made to the upper subwatershed delineations, including merging subwatershed U-650 into U-640 to mitigate unacceptable basin length-to-area relationships in CUHP. More extensive revisions were made to the lower subwatershed delineations since the original delineations were created to model pipes during minor events.

Three subwatersheds, L-340, L-450, and L-700, in the lower watershed exceed 130-acres in area because further sub-division of these areas is not appropriate. The subwatersheds averaged no more than 100 acres per standard guidance from MHFD. A total of 110 subwatersheds were delineated in this Goldsmith Gulch study area. The minimum, maximum and average sizes of the subwatersheds are summarized in **Table 3-2**.

The highest watershed elevation is 5,826 feet at the southernmost watershed boundary, in the vicinity of South Clinton Street and East Costilla Avenue. The lowest watershed elevation is 5,382 feet on Cherry Creek at the northwest corner of the watershed. The average watershed slope is 0.97 percent measured following the topographic thalweg.

Table 3-2 Summary of Subwatersheds Delineation

Watershed	Total Area (sq. mi.)	Sub-basin Area (acre)			Total No. of Sub-basins
		Average	Minimum	Maximum	
Lower Watershed (North of Belleview Ave)	5.27	56.2	8.96	158	60
Upper Watershed (South of Belleview Ave)	2.47	31.6	5.76	81.9	50
Total Watershed	7.74	45.0	5.76	158	110

3.3.2 Watershed Imperviousness

A GIS-based approach was used to calculate the percent of imperviousness within the watershed based upon an impervious surface dataset. DRCOG collected planimetric data in the spring of 2016 for the entire watershed. By merging impervious surfaces available in the driveways, edge of pavement, parking, roof footprints, and sidewalks datasets, a compiled impervious surfaces dataset was created. GIS data representing the impervious surfaces were intersected with subwatershed polygons to calculate percent imperviousness for each subwatershed. Since the watershed is fully developed, existing and future imperviousness are assumed to be equivalent. The percent imperviousness used for each land use is shown in **Table 3-3**. Percent impervious values for existing conditions are shown in **Figure B-1 Interactive Hydrology Map**. The average percent impervious for the entire watershed is 50%.

Table 3-3 Imperviousness by Land Use

Existing/Future Land Use	Percent Imperviousness*
Cemetery	10%
Park	10%
Residential: Single-family, 0.75 - 2.5 acres	20%
Residential: Single-family, 0.25 - 0.75 acres	30%
Residential: Single-family, 0.25 acres or less	45%
Residential: Apartments	75%
Business: Suburban Areas	75%
Business: Downtown Areas	95%
Streets: Paved	100%
Right-of-way	90%
Water	100%

* Percent imperviousness were determined using MHFD-USDCM Table 6-3

3.3.3 Depression Loss

Depression losses were determined using Table 6-6 in Volume 1 of the MHFD-USDCM. The pervious depression loss of 0.35 inches and impervious depression loss of 0.1 inches were used for the watershed.

3.3.4 Infiltration

The soil in the watershed was assumed to be hydrologic soils group (HSG) C / D, as defined by the NRCS. The soils are generally characterized by below average (0.05-0.15 in/hr) to low (≤ 0.05 in/hr) infiltration rates. For HSG C soils, the initial infiltration rate was 3.0 inches per hour, the final infiltration rate was 0.5 inches per hour. The decay coefficient was calibrated to 0.0018. NRCS HSGs (2017), are shown on **Figure B-1 Interactive Hydrology Map** in **Appendix B**.

3.4 Detention

MHFD's policy is to model only regional, publicly-owned and maintained detention facilities. Inadvertent detention areas are not modeled since their use and function cannot be predicted in the future.

The following ten detention basin facilities were included in the hydrologic model:

Name	Ownership
Iliff & Monaco (off-line)	Denver
Bible Park	Denver
Wallace Park North	Denver
Wallace Park South	Denver
Southmoor Park	Denver
Caley (includes water quality)	Greenwood Village
Tommy Davis Park	Greenwood Village
Orchard Hills	Greenwood Village
Silo Park	Greenwood Village
Boston Peakview (includes water quality)	Greenwood Village

Previous studies have simulated detention in SWMM using a storage (ac-ft)-discharge (cfs) rating curve. Due to the importance of detention in this watershed, the stage-storage-discharge curves were re-evaluated and modeled using stage-surface area curves and outlet depth-discharge rating curves. The stage-surface area curves were derived from the latest topography data as described in Section 1.4, as-built plans, and survey. The detention rating curves and calculation are included in **Table B-3** in **Appendix B**.

3.4.1 Detention Rating Curves

Eight detention basins were included in the 1989 Study Appendix to manage the hydrology of Goldsmith Gulch watershed at the confluence with Cherry Creek at a peak discharge of 2,200 cfs, which was reduced from 5,300 cfs in the 1976 FHAD. The rating curves in the previous modeling were based on the relationship between storage and discharge. The current versions of the hydrologic model require a more sophisticated relationship between the storage depth versus storage area and discharge. The detention volume and discharge were re-investigated as a part of this hydrologic update. The detention surface areas were re-measured using the contours generated from the 2014 LiDAR. As-built plans and Wilson & Company Structure Survey 2018 information were used to update the outlet structure and calculate discharge through outlet structure. Nomographs of the Federal Highway Administration HDS 5 *Hydraulic Design of Highway Culverts* and UD_Detention worksheet were the tool used to establish the relationship between the hydraulic head versus discharge. In addition, the Caley Detention and Boston/Peakview Detention were added as new detention facilities after the 1994 Study which are included into the hydrologic model for this study.

A detailed hydrologic modeling approach to establish the baseline hydrology is described in Sections 3.2 to 3.5.

3.5 Hydrograph Routing

Parameters for the SWMM model conveyance elements were determined using the mapping and existing storm GIS layers described in Section 1.4. Manning's roughness values were determined based on the 2016 aerial imagery and supplemented by field observation. **Table 3-4** provides the Manning's ***n*** values selected for use in the Baseline Hydrology Model and also provides the 1976 FHAD study and 2005 OSP values for comparison. In the SWMM routing model, the Manning's ***n*** values were increased by 25 percent per MHFD criteria.

Storm drains routing upland subwatershed flows to the mainstems of Goldsmith Gulch, Goldsmith Gulch West Tributary, and Southmoor Park Tributary were modeled, as well as major storm system facilities greater than 36-inches in diameter, or equivalent. All underground storm system facilities were modeled with parallel overflow elements to route surface flows exceeding the capacity of the storm pipes without causing inadvertent detention. These overflow elements were modeled as shallow trapezoidal channels in the SWMM model.

Table 3-4 Manning's Roughness Coefficient & Comparison

Goldsmith Gulch Hydrologic Model (this study)		
Routing Element Description	**Original 'n'**	**Increase 'n' by 25%***
Reinforced Concrete Pipe	0.013 – 0.015	0.016 – 0.019
Asphalt Pavement	0.016	0.020
Concrete Open Channel	0.013 – 0.015	0.016 – 0.019
Grassy Drainageway	0.033	0.045
Natural Drainageway with Intermittent Shrubs/ Trees	0.045 – 0.055	-
Natural Drainageway with Dense Shrubs/ Trees	0.055 – 0.07	-
Engineered Channel, Riprap	0.038	0.054
2005 OSP - Upper Goldsmith Gulch		
Concrete Open Channel	0.016	N/A
Natural Open Channel	0.045 – 0.054	N/A
Overbank	0.045	N/A
1976 FHAD – Goldsmith Gulch and Its Tributaries		
Channel	0.030 – 0.045	N/A
Overbank	0.035 – 0.055	N/A

* Per CUHP Guidance Document for routing elements

Split flows result where the storm system contravenes topography. Specifically, pipes are routed down streets and do not follow surface flows based upon topography and diversions to off-line detention. There are four split flows in the model. The first occurs at JUNCT_U-540 along E. Peakview Avenue on the West Tributary. Major event flow is directed down E. Peakview Avenue and low flow is directed to Boston Peakview Detention Basin for water quality treatment per Boston Street and Peakview Avenue Pond Drainage Letter by Muller Engineering Company, November 20, 2018. The second occurs at JUNCT_L-460. Pipe flow is directed along E. Yale Avenue and overflows are directed to Bible Park Detention Basin. The third occurs at JUNCT_L-706 into Southmoor Detention Basin. Overflows at this node are directed into the basin, however, pipe flow will enter Goldsmith Gulch downstream of Southmoor Park without treatment. The fourth occurs at the Iliff & Monaco Detention

Basin. A diversion rating curve is used to divert flows into the off-line detention Basin, as shown in **Table B-3** in **Appendix B**.

EPA SWMM 5.1 model elements, including subwatersheds, design points and conveyance elements are shown on **Figure B-1 Interactive Hydrology Map** in **Appendix B**.

3.6 FEMA Floodplains

Flood Insurance Studies exist within the Goldsmith Gulch watershed for the City and County of Denver (2020 FIS) and Arapahoe County, CO and Incorporated Areas (2020 FIS). FEMA mapped floodplains and floodways include AE, AO, and X (shaded) designations. The map panel numbers for Arapahoe County and Incorporated Areas panels include: 08005C0457K, and 08005C0476L. The map panel numbers for City and County of Denver include: 0800460208H, 0800460216H, 0800460217J, and 0800460219H.

3.7 Result of Analysis

The computed baseline peak discharges and volumes for the 2-, 5-, 10-, 25-, 50-, 100- and 500-year storm events for all of the EPA SWMM 5.0 design points can be found in **Tables B-4** in Appendix B. A summary of peak flow rates and runoff volumes at key design points are provided in **Table 3-10.**

The modeled peak discharges were compared with previous studies at the key locations as shown in the **Table 3-5** below. In addition, peak flows at two interim model revision stages are included.

- **"Interim 1"** corresponds to the upper basin results using the unmodified 2005 OSP model using the updated CUHP, version 2.0.0, hydrologic model (changed model version and rainfall to current values).
- **"Interim 2"** corresponds to baseline model framework, but with the 1989 Study Appendix and 2005 detention curves (changed model version and rainfall and updated model input, but no change to rating curves). As a result, Boston Peakview Detention, which was not included in previous models was not modelled in Interim 2.
- **"Baseline"** updates the hydrologic model and rainfall to current conditions, updates hydrologic input and updates all detention rating curves. Results established the hydrology for this report.

In general, the flow rates resulting from this analysis are higher than the effective flows of the 2020 FIS at the outfall, but are lower at upstream locations. The upper basin flow comparison to the 2005 OSP also shows a consistent reduction in peak flows. The causes of the differences were further investigated in this study and depicted below.

Table 3-5 100-Year Peak Flow Comparison with Previous Studies

River	Jurisdiction	Location	Design Point	This Study			2005 OSP	1989 Study Appendix	2020 FIS Denver	2020 FIS Arapahoe
				Baseline	Interim 1	Interim 2				
Goldsmith Gulch West Tributary	Greenwood Village	Orchard Road (Tommy Davis Park downstream)	U-411	632	812	655	965	1,202	-	1,000
		Orchard Road (Silo Park downstream)	U-621	578	519	584	756	501	-	-
Goldsmith Gulch	Greenwood Village	Confluence with Goldsmith Gulch West Tributary	U-601	1,270	1,404	1,290	1,993	1,594	-	-
		Orchard Hills Park downstream	U-215	1,275	1,472	1,327	1,939	1,353	-	-
		E Belleview Ave	U-100	1,499	1,924	1,522	2,555	1,760	1,760	2,250
	Denver	E Temple Drive	L-055	830	-	820	-	811	-	-
		I-225	L-115	846	-	821	-	1,104	-	-
		E Quincy Avenue	L-335	1,451	-	1,393	-	1,470	-	-
		E Hampden Avenue	L-405	2,280	-	2,407	-	2,332	-	-
		E Cornell Avenue (d/s of confluence with Southmoor Tributary)	L-445	3,290	-	3,195	-	3,224	-	-
		Bible Park at E Yale Avenue	Bible Park	3,443	-	3,480	-	3,572	-	-
		E Yale Avenue downstream	L-505	2,642	-	2,373	-	2,420	-	-
		Iliff-Monaco Detention upstream	L-580	2,704	-	2,409	-	2,464	-	-
		E Iliff Avenue	L-565	2,220	-	2,027	-	2,077	-	-
		E Jewell Avenue	L-635	2,368	-	2,119	-	2,247	-	-
		Confluence with Cherry Creek	Outfall_Goldsmith	2,400	-	2,135	-	2,200	2,200	-
Southmoor Tributary	Denver	Hutchinson Park (u/s of confluence with Goldsmith Gulch)	L-436	699	-	700	-	1,320	500	-

Notes:

- **"Interim 1"** corresponds to the Upper Basin results using the unmodified 2005 OSP model using the updated CUHP, version 2.0.0, hydrologic model (changed model version and rainfall to current values). Shows a reduction from the 2005 OSP.
- **"Interim 2"** updated model input. Corresponds to final baseline model framework, but with the 1989 Study Appendix and 2005 detention curves (changed model version and rainfall and updated model input, but no change to rating curves). As a result, Boston Peakview Detention, which was not included in previous models was not modelled in Interim 2.
- **"Baseline"** updates the hydrologic model and rainfall to current conditions, updates hydrologic input and updates all detention rating curves. Results for the Final version established the hydrology for this report.

3.7.1 One-hour Point Rainfall Depths

The new hydrology utilizes lower rainfall depths than previous effective hydrology and 2005 OSP. The new one-hour point rainfall depths are based on NOAA Atlas 14 data (versus NOAA Atlas 2). **Table 3-6** shows a comparison of the one-hour point rainfall depths used for each study. The decrease of one-hour point rainfall depth, approximate 9% of reduction, helped to reduce runoff at the Belleview Avenue design point by comparison to the 2005 OSP.

Table 3-6 1-Hour 100-Year Rainfall Depth Comparison with Previous Studies

Study	Rainfall Depth (in)
This Study with NOAA Atlas 14	2.35
2005 OSP NOAA Atlas 2	2.58
1989 Study Report and Appendix	2.58

Notes:

1. *Approximately 9% of reduction on the 100-year one-hour point rainfall depth.*

3.7.2 Increased Density in Land Use

The percent imperviousness based on land use has been increased largely from the 1989 Study Appendix which generates higher runoff from the upper watershed. **Table 3-7** shows comparison of percent imperviousness between each study. **Figure 3-1** shows percent differences in imperviousness compared to the 2005 OSP for the upper watershed only (south of Belleview Avenue). According to the 2005 OSP, "The watershed imperviousness was determined only for the existing land-use condition due to the area's fully-developed state. The mapping provided by the District along with site reviews was used to identify levels of existing imperviousness. Seven different categories of imperviousness were identified and ranged from 5 percent to 95 percent." This study also assumes existing and future percent imperviousness are equivalent due to built-out conditions, but takes a more detailed approach to calculating percent imperviousness using current information (see Section 3.3.2).

Table 3-7 Watershed Land Use

Watershed	% Imperviousness		
	This Study	2005 OSP	1989 Study Appendix
Lower Watershed (North of Belleview Ave)	48.8	-	41.8
Upper Watershed (South of Belleview Ave)	52.6	61.0	38.7

3.7.3 New Hydrologic Modeling Methodology

The current CUHP Version 2.0.0 hydrologic model has been updated to mitigate the impact from sub-basin delineation discretization that usually generates higher peak flows for further detailed sub-division of watershed. However, the peak discharge at Belleview Avenue was reduced approximately 28% from the values reported in the 2005 OSP, due to the impact from the reduction of the one-hour point rainfall depth). In addition, DARFs were applied for the 2- to 10-year events per Table 5-3 in Volume 1 of the MHFD-USDCM, although this does not impact the 100-year comparison.

3.7.4 Differences of Detention Rating Curves

As discussed in the previous section, the detention basins within the Goldsmith Gulch watershed play a significant role in the hydrologic control on the Goldsmith Gulch major drainageway. As a result of the updated detention rating curves, the hydrology shown in this study differs from previous studies. In general, previous studies over-estimated the available detention volume which was also reported in 2005 OSP, as shown in **Table 3-8**. The detention rating curves and calculations included in **Table B-3** in **Appendix B** also show the comparison of storage-discharge curves between this study versus previous studies wherever applicable.

Table 3-8 Maximum 100-Year Detention Storage Volume (Acre-feet)

Reach Number	Detention Name	This Study (acre-feet)	2005 OSP (acre-feet/% change)	1989 Study (acre-feet/% change)
GG-2	Iliff & Monaco	66.3	-	84.5 (22%)
GG-2	Bible Park	56.3	-	93.8 (40%)
GG-4	Wallace Park North	7.1	-	19.1 (63%)
GG-4	Wallace Park South	122.3	-	122.4 (0%)
GG-6	Orchard Hills	7.4	12 (38%)	30.2 (75%)
GG-8	Silo Park	22.6	26.2 (14%)	35 (35%)
WG-1	Tommy Davis Park	15.3	17.2 (11%)	22.6 (32%)
WG-3	Caley Detention	10.8	15.1 (29%)	-
WG-3	Boston Peakview	3.3	-	-
ST-1	Southmoor Park	19.8	-	47.8 (58%)

Notes:

- *Numbers in parentheses indicate the percent difference between the previous study and current result, (Old – New)/ Old.*

Table 3-9 shows a more detailed comparison of the impact from the existing detention basins. In general, the new detention curves differ from previous studies by eliminating surcharge elevations that previously showed detention storage above the spillway elevations. Survey from MHFD was used to verify and determine the bottom, outlet, and spillway elevations for each detention basin to ground truth this study's rating curves. The final detention rating curves for this study are compared to previous study rating curves in **Figure 3-2**. The Wallace Park North detention's 1989 Study rating curve had a significant peak storage because of an erroneous spillway crest elevation that has been confirmed with the Wilson & Company Structure Survey 2018. The same error was corrected for the Orchard Hills and Southmoor Park detention basin rating curves.

3.7.5 Differences of Detention Routing

There are ten existing detention facilities in this baseline analysis as listed above in Table 3-7. Previous studies did not account for Boston Peakview detention (2004 / 2005) or the improvements to Tommy Davis Park Detention (2008 / 2009). In addition, the 1989 Study Appendix did not include Caley Detention (2004).

The Southmoor Park Tributary is piped from north of E. Hampden Avenue, through Southmoor Park and extends to S. Monaco Parkway/I-25 and S. Niagara Way, consisting of pipe sizes from 54-inch to 84-inch diameter. In the previous study, the hydrograph generated from the upper Southmoor Park Tributary watershed was completely routed into the Southmoor Park detention and ignored the diversion of the pipe capacity. However, the capacity of the storm drainage system is not negligible, and the Southmoor Park detention basin has not been reported as storing stormwater in the past several decades per City and County of Denver Wastewater staff. The hydrograph routing was revised to count the diversion for the storm drainage system and the overflow was routed into the Southmoor Park Detention.

At the Iliff/Monaco Detention basin, the outflow was routed out of the hydrologic modeling system instead of returning to Goldsmith Gulch per the 1989 Study Appendix. The return flow was added in the hydrologic model for this study.

3.7.6 Inadvertent Detention

The 1989 Study Appendix added an inadvertent detention design point in the sub-basin which represents the neighborhood of the Denver Technical Center in the hydrologic model. A conveyance element was provided in the hydrologic model to choke the runoff from this sub-basin and created approximate 15.5 ac-ft of storage volume at this design point. No documentation explained the modeling setup could be found for this study. The inadvertent detention was removed for this study.

3.7.7 Detention Findings

Of the ten detention facilities, the most effective detention basins for reducing flows on the main stem of Goldsmith Gulch are in order of importance:

1. Wallace Park South
2. Bible Park
3. Iliff and Monaco

Legend

- Study Reach
- Canal/Gulch/Creek
- Light Rail Line
- Goldsmith Gulch Watershed Boundary (7.74 Sq. Mi.)
- Subbasin
- Jurisdictional Boundary
- Detention Facility

% Impervious Difference

- < 50% decrease
- 25% to 50% decrease
- 25% to 0% decrease
- 0% to 5% increase
- > 5% increase

U-330 Sub-basin Number
64% Imperviousness for this study
11% Change from 2005 OSP

0 500 1,000 Feet

Centennial

Dayton St

Belleview Ave

Goldsmith Gulch West Tributary

Greenwood Village

DTC Pkwy

Greenwood Plaza Blvd

Yosemite St

88

25

U-100 64% 11%
U-110 67% 8%
U-120 61% 14%
U-130 48% 18%
U-140 67% 2%
U-150 25% 4%
U-160 59% 1%
U-170 29% 11%
U-180 45% 2%
U-190 23% 12%
U-200 29% 13%
U-210 25% 11%
U-300 63% 12%
U-320 69% 6%
U-330 64% 11%
U-340 68% 6%
U-350 67% 18%
U-400 31% 4%
U-410 36% 5%
U-420 66% 13%
U-430 46% 6%
U-440 42% 13%
U-450 18% 63%
U-460 60% 15%
U-470 85% 3%
U-480 72% 13%
U-490 78% 17%
U-500 69% 26%
U-510 59% 29%
U-520 90% 5%
U-530 71% 14%
U-540 79% 16%
U-600 26% 9%
U-610 31% 10%
U-620 44% 7%
U-630 41% 3%
U-640 46% 1%
U-660 40% 5%
U-670 46% 0%
U-680 42% 3%
U-690 46% 0%
U-700 46% 2%
U-710 47% 2%
U-720 59% 10%
U-730 59% 15%
U-740 79% 8%
U-750 83% 12%
U-760 80% 15%
U-770 86% 9%

FILE: G:\gis_projects\UDFCD_Goldsmith_Gulch\active\apps\Hydrology_Report\Figure3-1_UDFCD_GG_OSP_Impervious_Future_Difference_Map_RPP.mxd, 4/14/2022, alex.trout

No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by: _____
drawn by: RP
checked by: RK
project no.: 18.155.035
date: 11/12/2019

MHFD MILE HIGH FLOOD DISTRICT

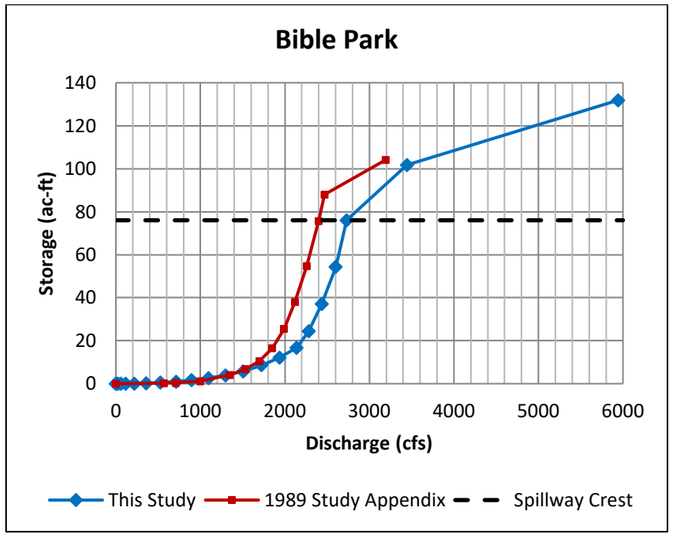
MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

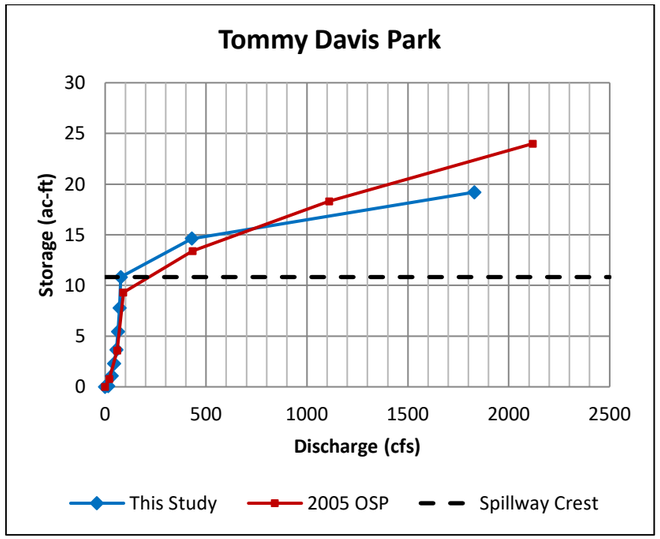
FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY
AND TRIBUTARIES

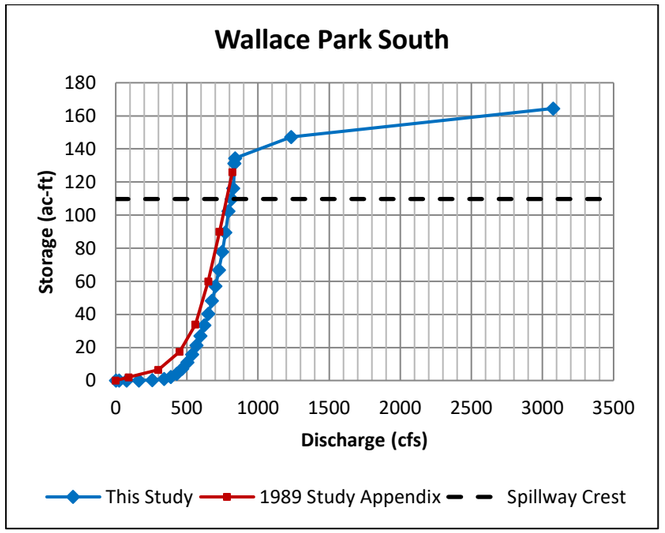
PERCENT IMPERVIOUS DIFFERENCE
FUTURE CONDITIONS MAP

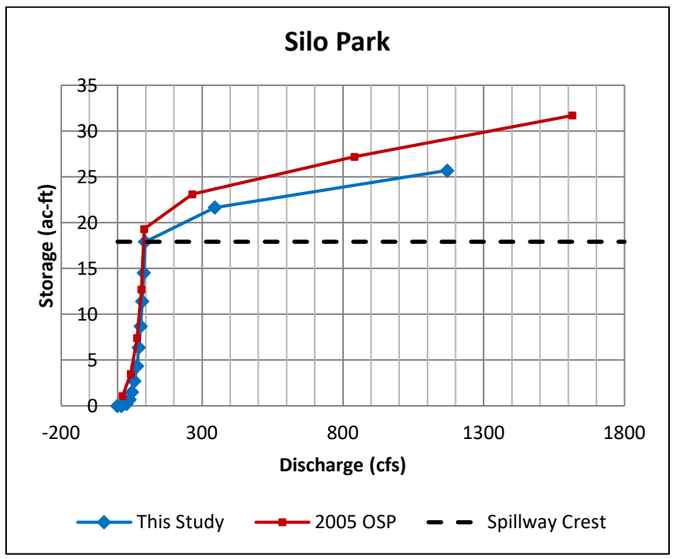
FIGURE
3-1

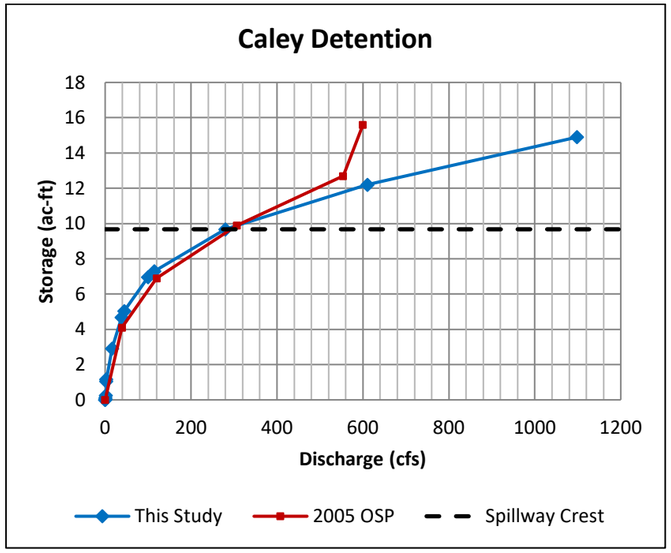
Figure 3-2 Detention Rating Curve Comparison.

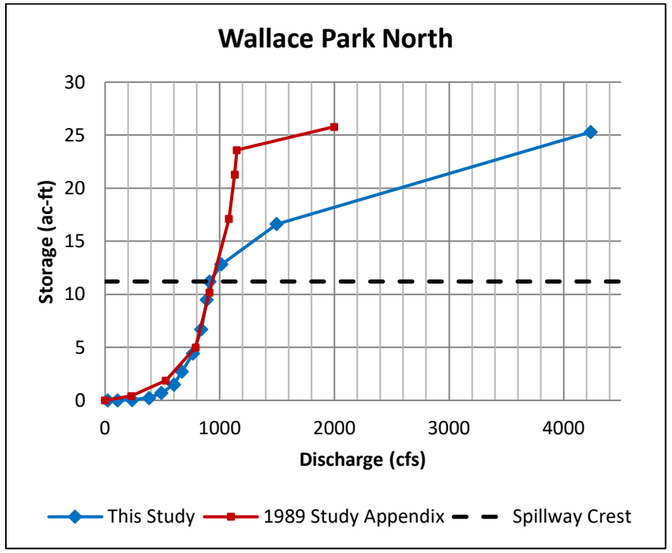


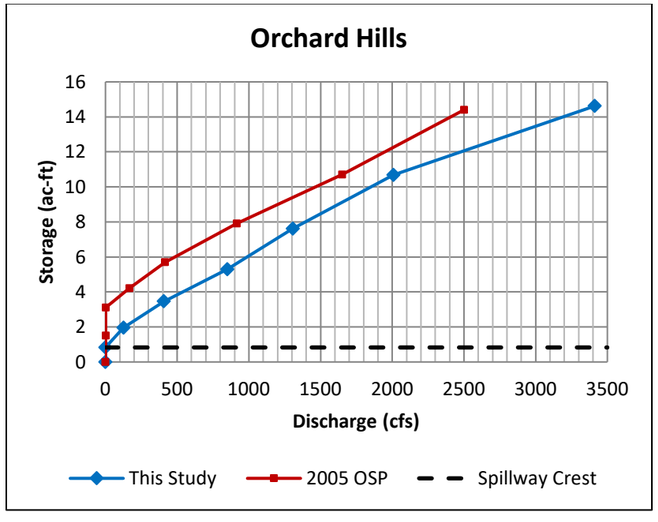


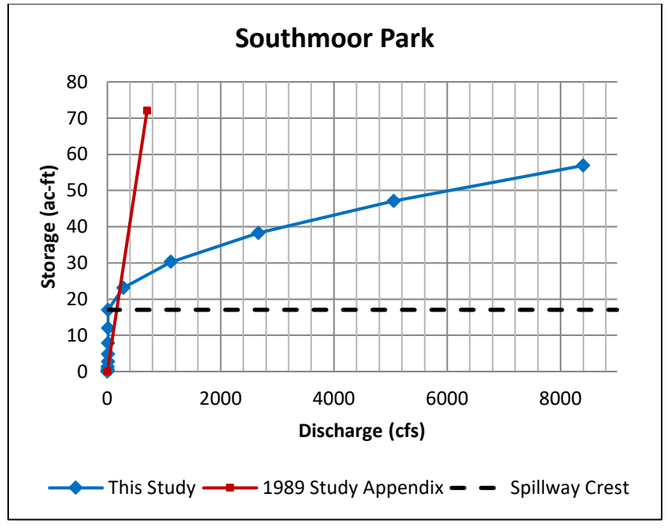


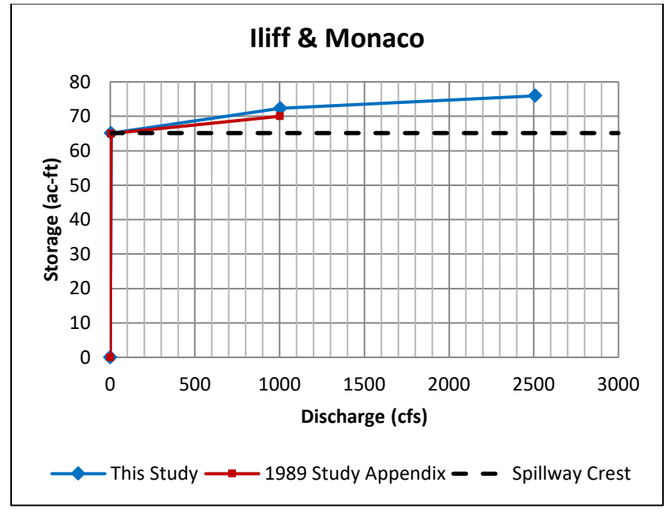












Note: Dashed black line is 2018 Spillway Crest elevation.

Table 3-9 Comparison of 100-Year Detention at Select Locations

River	Reach Number	Detention	This Study			2005 Study			1989 Study Appendix		
			Inflow (cfs)	Outflow (cfs)	Storage (ac-ft)	Inflow (cfs)	Outflow (cfs)	Storage (ac-ft)	Inflow (cfs)	Outflow (cfs)	Storage (ac-ft)
Goldsmith Gulch	GG-2	Iliff & Monaco	487	150	66.3	-	-	-	386	-	84.5
	GG-2	Bible Park	3,443	2,612	56.3	-	-	-	3,572	2,423	93.8
	GG-4	Wallace Park North	897	846	7.1	-	-	-	1,690	1,104	19.1
	GG-4	Wallace Park South	2,143	830	122.3	-	-	-	1,849	812	122.4
	GG-6	Orchard Hills	1,328	1,275	7.4	1,993	1,939	12.0	1,594	1,353	30.2
	GG-8	Silo Park	731	536	22.6	1004	756	26.2	932	500	35.0
Goldsmith Gulch West Tributary	WG-1	Tommy Davis Park	650	632	15.3	1026	965	17.2	1,370	1,290	22.6
	WG-3	Caley Detention	452	412	10.8	883	593	15.1	-	-	-
	WG-3	Boston Peakview	114	101	3.3	-	-	-	-	-	-
Southmoor Tributary	ST-1	Southmoor Park	444	138	19.8	-	-	-	1,320	465	47.8

Table 3-10 Peak Flow and Runoff Volumes (Existing Conditions)

Hydrologic Reach	Locations (Downstream to Upstream)	Design Points/ Conveyance Elements	River Station	Total Drainage Area		U100 (cfs/ acre)[1]	Existing/ Future Conditions Peak Flow (cfs)							Existing/ Future Conditions Peak Volume (ac-ft)						
				(acres)	(mi2)		Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{500}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}	V_{500}
Goldsmith Gulch																				
GG-1	Confluence with Cherry Creek	Outfall_Goldsmith	0+00	4954	7.7	0.5	782	903	1144	1959	2245	2400	4094	146.4	201.1	267.7	478.9	601.7	733.7	1111.3
GG-2	E Iliff Avenue (D/S Iliff & Monaco Detention)	JUNCT_L-565	63+40	4522	7.1	0.5	667	857	1069	1846	2102	2220	4075	127.4	179.6	239.8	426.7	537.3	657.0	1003.9
	Iliff & Monaco Split Flow (Diversion)	JUNCT_L-580	66+50	4522	7.1	0.6	667	911	1197	2212	2502	2704	4395	127.7	180.8	246.8	460.5	586.4	718.4	1065.3
	E Yale Avenue (D/S Bible Detention)	OUTLET_BiblePark	94+50	4338	6.8	0.6	649	883	1153	2136	2415	2612	4234	-	-	-	-	-	-	-
	Bible Detention Inflow	DP_Bible	94+50	4338	6.8	0.8	650	885	1161	2360	2983	3443	5207	121.3	171.9	234.2	435.9	558.7	681.5	1016.2
GG-3	Confluence with Southmoor Tributary (E Dartmouth Avenue)	JUNCT_L-445	126+50	4031	6.3	0.8	659	889	1157	2339	2934	3290	4927	117.0	165.5	224.7	414.5	528.0	644.7	954.8
	E Hampden Avenue	JUNCT_L-405	153+13	3086	4.8	0.7	534	689	853	1661	2125	2280	3485	90.9	128.3	174.1	319.3	408.3	494.3	733.7
GG-4	E Quincy Avenue	JUNCT_L-335	213+30	2519	3.9	0.6	465	576	679	1074	1237	1451	3372	76.8	108.1	145.8	261.6	328.5	405.2	601.7
	I-225 (D/S Wallace Park N Detention)	OUTLET_Wallace_N	226+60	2134	3.3	0.4	378	457	525	709	777	846	2768	-	-	-	-	-	-	-
	Wallace Park N Detention Inflow	DP_Wallace_N	226+60	2134	3.3	0.4	379	458	527	721	796	897	2789	65.7	92.4	124.6	222.6	278.1	343.8	503.5
	E Temple Drive (D/S Wallace Park S Detention)	OUTLET_Wallace_S	240+90	1988	3.1	0.4	348	416	473	655	743	830	2744	-	-	-	-	-	-	-
	Wallace Park S Detention Inflow	DP_Wallace_S	240+90	1988	3.1	1.1	372	506	646	1351	1696	2143	3230	61.1	86.0	115.7	207.2	259.1	319.3	469.7
GG-5	Belleview Avenue	JUNCT_U-100	269+50	1579	2.5	0.9	232	307	373	816	1025	1499	2787	46.7	66.3	89.6	162.4	203.8	252.4	371.5
GG-6	Yosemite Street	JUNCT_U-155	292+60	1235	1.9	1.1	129	171	221	546	880	1392	2519	33.5	47.6	65.4	122.2	154.7	192.8	284.3
	Pedestrian Trail (D/S Orchard Hills Detention)	OUTLET_Orchard	314+35	977	1.5	1.3	110	142	169	503	802	1275	2218	-	-	-	-	-	-	-
	Orchard Hills Detention West Fork Goldsmith Gulch	DP_Orchard	314+35	977	1.5	1.4	111	142	169	508	811	1328	2247	28.0	39.6	53.7	98.9	124.6	154.4	226.9
GG-7	Upstream of West Fork Confluence	JUNCT_U-600	321+00	442	0.7	1.4	66	82	97	196	366	625	1081	11.9	16.7	22.8	42.7	54.6	67.8	100.1
GG-8	Orchard Road at Silo Park (D/S Silo Park Detention)	OUTLET_Silo	336+00	349	0.55	1.5	58	70	79	168	309	536	911	-	-	-	-	-	-	-
	Silo Park Detention	DP_Silo	336+00	349	0.55	2.1	106	150	206	492	626	731	1081	10.2	14.2	19.2	34.7	44.5	54.6	79.8
	E Maplewood Avenue	JUNCT_U-660	356+00	234	0.4	2.2	80	112	151	336	419	521	760	7.3	10.1	13.5	23.8	29.6	36.5	53.4
	E Caley Avenue	JUNCT_U-710	369+10	108	0.2	2.7	55	74	96	193	237	290	414	4.3	5.9	7.6	12.3	15.1	18.3	26.2
	Arapahoe Road	JUNCT_U-770	395+90	22	0.03	2.2	12	15	19	33	40	48	67	1.2	1.6	2.0	3.0	3.5	4.2	5.9
Off-line Detention	Iliff & Monaco Detention Inflow	DP_Iliff	66+50	4522	7.1	0.1	0	54	129	369	402	487	1904	0.0	2.7	9.8	39.0	55.0	76.1	212.1
	Iliff & Monaco Detention Outflow	Iliff_OUTLET	63+40	4522	7.1	0.1	0	1	2	4	4	150	1584	-	-	-	-	-	-	-

Hydrologic Reach	Locations (Downstream to Upstream)	Design Points/ Conveyance Elements	River Station	Total Drainage Area		U100 (cfs/ acre)[1]	Existing/ Future Conditions Peak Flow (cfs)							Existing/ Future Conditions Peak Volume (ac-ft)						
				(acres)	(mi2)		Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{500}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}	V_{500}
Southmoor Tributary																				
ST-1	Confluence with Goldsmith Gulch	JUNCT_L-425	0+00	558	0.9	1.1	147	209	275	527	549	596	1143	15.3	21.7	29.9	56.5	71.2	87.8	129.9
	E Hampton Road	JUNCT_L-755	15+20	501	0.8	1.2	131	186	242	471	479	588	1071	12.8	18.5	25.7	49.7	62.9	78.0	115.7
	Southmoor Outlet (D/S Southmoor Detention)	OUTLET_Southmoor	21+00	471	0.74	0.3	4	6	7	10	12	138	622	-	-	-	-	-	-	-
	Southmoor Detention Inflow	DP_Southmoor	21+00	471	0.74	0.9	7	10	16	132	264	444	860	0.8	1.3	2.0	7.6	14.6	26.0	54.0
	Southmoor Park at S Oneida Way	JUNCT_L-706	31+50	416	0.65	1.9	114	165	215	500	624	787	1171	10.5	15.1	21.1	40.8	51.6	64.8	96.1
West Fork Goldsmith Gulch																				
WG-1	Confluence with Goldsmith Gulch	JUNCT_U-400	0+00	469	0.7	1.4	41	56	72	290	416	649	1091	15.4	21.7	29.0	51.0	63.2	77.7	113.0
	Orchard Road at Tommy Davis Park (D/S Tommy Davis Detention)	OUTLET_Tommy	14+55	441	0.69	1.4	39	56	71	283	402	632	1050	-	-	-	-	-	-	-
	Tommy Davis Detention Inflow	DP_Tommy	19+00	441	0.69	1.5	62	86	113	311	437	650	1060	15.0	21.0	28.0	48.5	59.9	73.7	106.8
	Tommy Davis Park at Maplewood Avenue	JUNCT_U-430	27+70	327	0.51	1.6	31	59	95	264	365	526	858	11.3	15.8	21.0	35.9	44.2	54.3	78.9
WG-2	E Fair Avenue	JUNCT_U-440	35+00	285	0.45	1.7	30	56	90	244	334	476	774	10.3	14.3	18.9	31.9	39.3	48.2	69.4
WG-3	E Caley Avenue (D/S Caley Detention)	OUTLET_Caley	45+90	237	0.37	1.7	28	52	82	214	291	412	672	-	-	-	-	-	-	-
	Caley Detention Inflow	DP_Caley	49+40	237	0.37	1.9	80	108	137	279	366	452	713	9.6	13.3	17.3	28.0	34.4	41.4	59.3
	S Boston Street (D/S Boston Peakview)	JUNCT_U-515	57+10	97	0.15	2.0	22	41	55	117	152	196	298	4.2	5.9	7.6	12.0	14.6	17.6	25.0
	Boston Peakview Detention Outflow	OUTLET_Peakview	62+20	97	0.15	1.0	22	41	55	78	88	101	133	-	-	-	-	-	-	-
	Boston Peakview Detention Inflow	DP_Boston_Peakview	63+50	97	0.15	1.2	47	61	70	92	102	114	141	4.5	6.1	7.7	9.7	10.9	12.0	14.9
	E Peakview Avenue Split Flow	JUNCT_U-540	65+00	68	0.11	2.3	37	46	57	105	127	154	218	3.5	4.8	6.0	9.2	11.0	13.1	18.4

Notes:

1. *Unit runoff (100-Year Peak Flow / Drainage Area)*
2. *Peak discharges versus channel stations are included in Figure B-3 of Appendix B*

4.0 HYDRAULIC ANALYSIS

Flood Insurance Studies exist within the Goldsmith Gulch watershed for the City and County of Denver (2020 FIS) and Arapahoe County, CO and Incorporated Areas (2020 FIS). The 2020 FIS defined two distinct flow paths of Goldsmith Gulch from E. Iliff Avenue to the confluence with Cherry Creek. Three independent flood profiles were used to define the water surface elevation in these two distinct flow paths. These flood profiles are Goldsmith Gulch (downstream of E. Evans Avenue to the confluence with Cherry Creek), Goldsmith Gulch (upstream of Iliff Avenue) and South Monaco Street Parkway Overflow (from E. Iliff Avenue to E. Florida Avenue). The river centerlines of the main stem are discontinued between E. Iliff Avenue and E. Evans Avenue and crossing the river centerline of the overland flow. This study updated the flood profiles with three independent flood profiles: a continuous flood profile for Goldsmith Gulch main stem and separate South Monaco Street Parkway Overflows at E. Colorado Drive and E. Iliff Avenue. The updated Monaco Street Parkway Overflow starts from a point at the Monaco Street Parkway Culvert at Skyline Acres Swim and Tennis Club to E. Florida Avenue. The updated Goldsmith Gulch main stem hydraulic model becomes a continuous hydraulic model which includes the overland flow reach from E. Iliff Avenue to Skyline Acres Club. The hydraulics analysis, assumptions, and decision to support the development of the HEC-RAS hydraulic model is included in **Appendix C**.

A total of 10.4 miles of drainageway were studied with a detailed HEC-RAS hydraulic model including Goldsmith Gulch Main Stem from E. Arapahoe Road to the confluence with Cherry Creek, Goldsmith Gulch West Tributary from the S. Boston St./E. Peakview Ave detention to the confluence with Goldsmith Gulch at Orchard Hills Park and Southmoor Park Tributary from S. Oneida Way to the confluence with Goldsmith Gulch at Hutchinson Park, and three overflow reaches, Monaco Pkwy Overflow at E. Colorado Drive, Monaco Pkwy Overflow at E. Iliff Avenue, and Hampden Avenue Overflow. The reaches studied with the detailed method are summarized in Table 4-1.

The U.S. Army Corps of Engineer's step backwater program HEC-RAS, Version 5.0.5, was used for the subcritical floodplain analysis of the drainageway. Cross sections for use in the HEC-RAS model were developed electronically by cutting the triangulated irregular network (TIN) developed from the one-foot, LIDAR-derived topographic contour data collected by the USGS in the fall of 2013. The TINs were processed from contour data to facilitate splicing in as-built contours at multiple locations, and because efforts to use LiDAR points (LAS files) in previous studies resulted in too much extraneous data.

Floodplain maps were developed showing the detailed 100-year and 500-year floodplain and floodway delineations. The purpose of the Flood Hazard Area Delineation (FHAD) mapping was to identify areas, building structures, and properties which have the potential of being inundated in a 100-year flood event. A floodway has been defined along the drainageway to establish the portion of the channel that must remain free from obstructions and new development to preserve conveyance of the 100-year flood. A maximum of 0.5-foot rise on both hydraulic grade line (HGL) and energy grade line (EGL) was utilized in this study to define the floodway, in accordance with the updated Colorado Water Conservation Board Rules and Regulations. The floodplain mapping and channel profiles show the location of cross-sections for the channel and all hydraulic structures.

Table 4-1 Summary of HEC-RAS Hydraulic Models

River Name	Reach Length (ft)	River Station (ft)	Reference Location	Jurisdiction
Goldsmith Gulch Main Stem	26,875	0+00 - 268+75	Confluence with Cherry Creek to E. Belleview Ave.	Denver
	7,550	268+75 - 344+25	E Belleview Avenue to S. Dayton St.	Greenwood Village
	5,160	344+25 - 395+85	S. Dayton St. to E. Arapahoe Rd.	SEMSWA
Goldsmith Gulch West Tributary	6,354	0+00 - 63+85	Confluence with Goldsmith Gulch at Orchard Hills Park to S. Boston St./E. Peakview Ave. detention	Greenwood Village
Monaco Pkwy Overflow	2,499	0+00 - 24+99	Confluence with Cherry Creek to E. Colorado Dr.	Denver
Monaco Pkwy Overflow @ Iliff	385	0+00 - 6+74	Confluence with Goldsmith Gulch at Private Rd. to E. Iliff Ave.	Denver
Southmoor Park Tributary	4,249	0+00 - 42+49	Confluence with Goldsmith Gulch at Hutchinson Park to S. Oneida Way	Denver
Hampden Avenue Overflow	1,186	0+00 - 11+86	Confluence with Goldsmith Gulch to S. Poplar St.	Denver

A total of 566 cross sections were used in the Goldsmith Gulch hydraulics analysis. 401 cross-sections were used in the Goldsmith Gulch *Main Stem* hydraulic model, 119 cross-sections were used in the Goldsmith Gulch West Tributary, 21 cross-sections were used in the Monaco Street Parkway Overflow and 25 cross-sections were used in the Southmoor Park Tributary including Hampden Avenue Overflow hydraulic model. The junction option in the HEC-RAS program was used to connect the split flow reaches with the main stem reach. A total of 3 junctions were used in the hydraulic model. One of the junctions is in Goldsmith Gulch at the confluence with Goldsmith Gulch West Tributary. One junction is in Southmoor Park Tributary at the confluence with the Hampden Avenue Overflow. The last junction is in Goldsmith Gulch at the confluence with Monaco Pkwy Overflow at Iliff. Details of the hydraulic analyses, such as model setup, flow data, geometry and parameters, are described in the following sections. Input data for the model is summarized in **Table 4-2** below:

Table 4-2 Summary of Geometry Input

River Name	Reach Length (ft)	Culvert	Bridge	Lateral Structure	Number of Cross-section	Average Spacing (ft)	Average Slope (%)
Goldsmith Gulch	39,585	15	23	7	399	99	0.97%
Goldsmith Gulch West Tributary	6,354	6	5	1	109	58	1.52%
Monaco Pkwy Overflow	2,499	-	-	4	16	156	0.85%
Monaco Pkwy Overflow @ Iliff	385	-	-	-	5	77	0.70%
Southmoor Park Tributary	4,249	2	-	-	22	193	1.04%
Hampden Avenue Overflow	1,186	-	-	1	3	395	1.73%

Estimates of channel roughness for existing conditions were made from aerial photographs and field observation. The Manning's ***n*** values were established based upon dense growth of natural areas for a healthy stream corridor, and not a regularly mowed turf grass. Refer to **Appendix C** for pictures illustrating the Manning's ***n*** values for sample cross-sections. Estimates of overbank roughness are based upon the impact of the obstructions from buildings, landscape features and privacy fences. Recommended Manning's n values are summarized in **Table 4-3** below:

Table 4-3 Recommended Manning's n

Manning's n	Channel	Overbank Floodplain
0.015	Smooth concrete	Smooth concrete, bare land
0.02	Roadway asphalt, aged concrete low flow channel including grass low flow bank area	Roadway asphalt including curbs
0.03	Clean straight, smooth water, pond	Mowed lawn areas/parks/detention
0.035	Grass lined/riprapped/loose rock in low flow channel	Parking space/asphalt with curbs, vehicles and obstacles
0.04	Grouted boulder, some weeds,	Mowed lawn areas/parks with trees, landscapes, etc.
0.045	Rock and some weeds in low flow channel, high grass at low flow bank area	High grass, scattered brush
0.05	Same as above but weedier	Scattered brush, trees, heavy weeds
0.06	Weedy, deep pool	Light brush and trees, in summer
0.07	Weedy, deep pool and few brush	Medium to dense brush and trees, in summer
0.08	Tall weeds and brush	Dense brush and trees in summer
0.1	Very weedy reaches, deep pools, or floodway with heavy stands of timber and brush	Dense weeds, brush and trees in summer
0.15	N/A	Residential areas with building, shrubs, trees, landscapes and fences

Flow data in the HEC-RAS model was derived from the results of the EPA SWMM 5.0 hydrograph routing for the future land-use /existing conditions topographic and infrastructure model. A steady flow analysis was utilized to determine the flood profiles for the 10-, 50-, 100-, and 500-year storm events. Flow change locations were established at critical design points where there are significant changes in hydrology as determined by the EPA SWMM model. Between flow change locations, steady flow is maintained for defined channel segments along the reach. The capacity of the existing storm drain was subtracted from the peak flows derived from the results of the EPA SWMM 5.0 hydrograph routing. Where the entire flow is conveyed in storm drain or culverts, a placeholder discharge of 0.1 cfs was used for the overland cross sections. The flow changes, flow change locations, relevant hydrologic design points of the EPA SWMM model and flow diversions (including overland flow by subtraction of the capacity of existing storm drains), are included in the **HEC-RAS Flows and Flow Change Locations** table in **Appendix C**.

Lateral Structures in the HEC-RAS hydraulic model were used to calculate the flow split from the main stem to the receiving water body. The flow optimization option in the steady flow analysis was used to allow the program to subtract the amount of flow from the main channel and add the discharge to the receiving water body. However, the discharges in the main stem were not subtracted from the main stem unless the flows splits into a formalized known drainageway or detention facility. A lateral structure was used in Cook Park to separate the riverine flood hazard of the main channel from the shallow overland flow hazard in the athletic fields.

Table 4-4 summarizes the hydrology used in the hydraulic model and the model cross sections where the flow change has been applied.

Table 4-4 Steady Flow Input in HEC-RAS Model

HEC -RAS Flow Change Locations		Flood Profile Names and Flow Rates (cfs)			
Reference Locations	**River Station**	**Q10**	**Q50**	**Q100**	**Q500**
Goldsmith Gulch					
D/S of E Arapahoe Road	395+85	19	40	48	67
Approx. 450' U/S of E Peakview Avenue	389+24	59	127	155	216
Avery Park Apartment/ Appletree Apartment	376+71	78	180	219	311
U/S of E Caley Avenue	369+99	100	248	304	435
Arapahoe Lake	360+98	151	419	521	760
D/S of E Maplewood Ave.	353+77	0.1	29	116	333
E Pinewood Avenue	345+44	37	179	252	543
D/S of S Dayton St	342+61	206	626	731	1081
U/S Orchard Road	336+54	79	309	536	911
Orchard Road	335+96	0.1	205	430	803
D/S Orchard Road	334+96	86	336	578	989
Goldsmith Drive	327+75	97	366	625	1081
Downstream of West Fork Confluence	319+83	159	774	1270	2141
Upstream of Orchard Hills Detention	317+37	169	811	1328	2247
Pedestrian Trail (Berm of Orchard Hills Detention)	314+34	169	802	1275	2218
D/S of Orchard Hills Detention	309+15	175	816	1295	2264
U/S of Yosemite Street	295+42	193	853	1351	2382
D/S of Yosemite Street	292+57	221	880	1392	2519

HEC -RAS Flow Change Locations		Flood Profile Names and Flow Rates (cfs)			
Reference Locations	**River Station**	**Q10**	**Q50**	**Q100**	**Q500**
Goldsmith Gulch					
U/S E Prentice Avenue	285+38	243	901	1421	2592
U/S Belleview Avenue	269+83	373	1025	1499	2787
D/S Belleview Avenue	268+01	433	1180	1547	2891
E Chenango Avenue	255+24	470	1282	1620	2956
E Layton Avenue	249+59	511	1377	1741	2977
George Wallace Park S Detention	241+56	646	1696	2143	3230
U/S E Temple Drive	240+92	473	743	830	2744
E Temple Drive (D/S Wallace Park S Detention)	240+29	0.1	0.1	0.1	1872
D/S E Temple Drive	238+70	473	743	830	2744
Wallace Park N Detention	234+66	527	796	897	2789
I-225 (D/S Wallace Park N Detention)	226+58	525	777	846	2768
D/S I-225	220+32	525	777	846	2768
U/S of E Quincy Avenue	216+36	680	1238	1453	3390
U/S of E Princeton Ave/ E Mansfield Ave	200+67	739	1466	1763	3390
E Nassau Ave/ E Lehigh Dr.	181+56	763	1553	1879	3403
S Rosemary Way/ E Kenyon Ave	171+34	798	1680	2050	3434
U/S of Tiffany Plaza Culvert	161+91	824	1763	2165	3448
Tiffany Plaza Southeast Corner	160+86	0.1	0.1	317	1442
U/S E Hampden Avenue	154+49	0.1	0.1	0.1	877
D/S E Hampden Avenue	153+09	860	2137	2418	3805
	144+36	860	2137	2418	3752
	143+95	860	2137	2418	3687
	143+33	860	2137	2418	3676
	143+13	860	2137	2418	3668
	143+06	860	2137	2418	3659
	142+79	860	2137	2418	3621
	142+31	860	2137	2418	3544
U/S E Eastman Avenue	140+76	885	2192	2501	3371
U/S E Eastman Avenue	140+76	885	2192	2501	3805
	140+43	885	2192	2501	3347
D/S of Hutchinson Park Pedestrian Bridge	134+89	1157	2934	3290	4927
Bible Park (Approx. E Cornell Ave)	113+65	1174	2986	3370	5044
U/S of Bible Park Low Flow Crossing	101+37	1161	2983	3443	5207
Bible Park Outlet Structure	94+66	1153	2415	2612	4234

HEC -RAS Flow Change Locations		Flood Profile Names and Flow Rates (cfs)			
Reference Locations	**River Station**	**Q10**	**Q50**	**Q100**	**Q500**
Goldsmith Gulch					
U/S of Yale Ave	94+26	0.1	0.1	0.1	1316
D/S E Yale Avenue	92+77	1171	2446	2642	4296
Approx. E Harvard Ave/E La Salle Pl	75+04	1197	2502	2704	4395
Approx. E Iliff Pl	65+92	1069	2102	2220	4075
D/S of E Iliff Avenue	63+40	0.1	760	880	2710
	59+57	0.1	758	877	2688
	58+99	0.1	743	858	2618
	58+10	0.1	718	825	2419
	57+19	0.1	641	735	2159
	56+60	0.1	641	735	2153
Memorial Way	54+31	0.1	760	880	2710
U/S of E Evans Avenue	48+88	0.1	793	914	2719
Outlet of Iliff/Evans Culvert	45+70	1118	2182	2308	4156
U/S of E Jewell Avenue	37+71	1141	2226	2368	4156
E Jewell Avenue	34+53	0.1	73	169	1803
D/S of E Jewell Avenue (Skyline Acres Club	34+10	195	568	679	2375
D/S of Monaco Culvert at Skyline Acres Club	24+39	1142	2126	2167	2557
D/S Mexico Avenue	17+15	1142	2134	2189	2842
	14+67	1142	2134	2189	2996
	9+17	1142	2134	2189	3248

HEC -RAS Flow Change Locations		Flood Profile Names and Flow Rates (cfs)			
Reference Locations	**River Station**	**Q10**	**Q50**	**Q100**	**Q500**
Goldsmith Gulch West Tributary					
Boston Peakview Detention Inflow	63+72	70	102	114	141
Boston Peakview Detention Outflow	62+38	0.1	33	46	78
S Boston Street (D/S Boston Peakview Detention)	57+25	55	152	196	298
Caley Detention Inflow	49+59	137	366	452	713
U/S E Caley Avenue	46+24	82	291	412	672
D/S E Caley Avenue	44+72	84	306	433	706
E Fair Avenue	35+73	90	334	476	774
Tommy Davis Park at Maplewood Avenue	27+47	95	365	526	858
Tommy Davis Detention Inflow	18+96	113	437	650	1060

Orchard Road at Tommy Davis Park (Tommy Davis Detention)	16+00	71	402	632	1050
Confluence with Goldsmith Gulch	7+09	72	416	649	1091

HEC -RAS Flow Change Locations		Flood Profile Names and Flow Rates (cfs)			
Reference Locations	**River Station**	**Q10**	**Q50**	**Q100**	**Q500**
Monaco Pkwy Overflow					
Monaco Pkwy Culvert at Skyline Acre Club	24+99	0.1	103	206	1863
D/S Monaco Pkwy Culvert at Skyline Acre Club	24+29	0.1	103	206	1636
	23+51	0.1	103	206	1601
U/S E Mexico Ave	19+94	8	127	236	1646
D/S E Mexico Ave	19+39	8	127	236	1643
	17+91	8	119	214	1361
	16+07	8	119	214	1318
	15+10	8	119	214	1210
D/S E Iowa Avenue	14+58	8	119	214	1205
	11+32	8	119	214	1068
Monaco Pkwy Overflow at Iliff					
D/S E Iliff Ave	3+85	0.1	2	3	22
	3+65	0.1	17	22	92
	3+26	0.1	42	55	291
	2+36	0.1	119	145	551
	1+52	0.1	119	145	557
Southmoor Tributary					
Southmoor Detention Inflow	42+49	16	264	444	860
Southmoor Outlet (D/S Southmoor Detention)	34+36	7	12	138	622
Poplar St D/S (north) of the intersection of Hampden Ave and Poplar St	29+37	0.1	0.1	0.1	302
At the end of Southmoor Park Detention outlet pipe (north of E Hampton Ave.)	25+70	242	442	479	745
U/S Eastman Avenue	16+87	242	442	479	1006
Confluence with Goldsmith Gulch	12+89	275	541	580	1268
Hampden Avenue Overflow					
Southmoor Outlet (D/S Southmoor Detention)	10+16	7	12	138	320

The downstream hydraulic control for the HEC-RAS model of Goldsmith Gulch was set at the corresponding 10-, 50- and 100-year known water surface elevations in Cherry Creek. The 100-year known water surface elevation was also used for the 500-year model downstream hydraulic control because the Cherry Creek FHAD did not define a 500-year flood profile. The downstream hydraulic controls for the HEC-RAS model of the Goldsmith Gulch West Tributary and Monaco Pkwy Overflow at Iliff were controlled by the junction condition at each respective confluence with Goldsmith Gulch. The downstream hydraulic control for the HEC-RAS model of Southmoor Park Tributary was set at the known water surface elevation of Goldsmith Gulch for each recurrence interval (i.e., 10, 50, 100 and 500). The downstream hydraulic control for the HEC-RAS model of Hampden Avenue Overflow was set at normal depth with the downstream slope of 0.028 ft/ft. A rating curve was used for the downstream hydraulic control for the HEC-RAS model of Monaco Pkwy Overflow, developed by analyzing inlet capacities at Monaco Pkwy and Florida Ave (analysis included in **Appendix C**). Since the model was run in the subcritical mode, no upstream boundary was specified within the model.

Fifteen rating curves were developed as a part of this study because the HEC-RAS hydraulic model cannot properly model the complex hydraulic conditions of detention outlet structures, long culverts with bends and varied dimension and culvert groups including restrictor plates and diversion culverts. Nine rating curves were developed for the detention basins as a part of the Baseline Hydrology analysis. Detailed analysis of the rating curves is included in **Appendix B**. Four rating curves were developed for the long culverts and two rating curves were developed for the inlets of major storm drainage systems at Florida Avenue and Tiffany Plaza at E. Hampden Avenue. Detailed analysis of the rating curves is included in **Appendix C**. The rating curve of Arapahoe Lake was not included in the hydraulic model because the lake is not a publicly owned and maintained storm facility. Arapahoe Lake was modeled as an open channel with the channel invert set at the normal operating pool elevation. The rating curves used in the hydraulic model are summarized in **Table 4-5** below:

Table 4-5 Rating Curves for Hydraulics Control

River	River Station	Sources/ Types of Rating Curve	Reference Location
Goldsmith Gulch	35+10	Culvert capacity rating curve	E. Jewel Avenue
	63+81	Culvert capacity rating curve	Iliff/Evans Culvert at E. Iliff Avenue
	94+66	Detention rating curve	Bible Park at E. Yale Avenue
	154+49	Inlet capacity rating curve	Tiffany Plaza at E. Hampden Avenue
	161+21	Culvert capacity rating curve	Tiffany Plaza Culvert Entrance
	226+58	Detention rating curve	Wallace Park North at I-225
	240+92	Detention rating curve	Wallace Park South at E. Temple Drive
	314+53	Detention rating curve	Orchard Hills Park
	336+54	Detention rating curve	Silo Park at E. Orchard Road
	353+85	Culvert Capacity rating curve	Downstream of Arapahoe Lake
Goldsmith Gulch West Tributary	16+00	Detention rating curve	Tommy Davis Park
	46+06	Detention rating curve	Caley Detention at E. Caley Avenue
	63+54	Detention rating curve	Boston/Peakview Detention at S. Boston Street
Southmoor Tributary	34+36	Detention rating curve	Southmoor Park
Monaco Pkwy Overflow	5+59	Inlet capacity rating curve	E. Florida Avenue

Fifty-one crossing structures were physically coded in the hydraulic model using field survey data. When flow overtops the structures, the *High Flow* methods of the *Bridge Modeling Approach* were carefully examined in

the HEC-RAS model, and engineering judgment was used to determine the most appropriate modeling approach for each bridge. Twelve roadway/trail crossing structures including outlet structures of detention basins and long culverts were modeled with rating curves instead of being physically coded in the hydraulic model. Surface cross sections were sometimes defined at underground crossings to delineate the 500-year flood hazard and provide better detail for surface flow over the structure.

Ineffective flow was utilized to account for flow areas with little or no flow conveyance. Blocked obstructions were utilized to block out the non-realistic flow distribution areas in sump conditions within overbank areas.

The hydraulic analysis for this study was based upon unobstructed flow through the openings of all bridge and culvert structures. The model was set up to assume that all bridges and channels remain free of silt and debris. Flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Normal depth calculations were utilized to determine the overland shallow flooding of the 100- and/or 500-year event of Cook Park from Cherry Creek to E. Mexico Ave., Locust Street Overflow from E. Minnesota Dr. to E. Florida Ave., Southmoor Tributary Overland along S. Poplar St. and near E. Hamilton Pl., Hampden Avenue Overflow between Goldsmith Gulch and S. Poplar St., and Goldsmith Gulch West Tributary Overflow between E. Caley Way and S. Boston St. The details of calculations for overland shallow flow are provided in **Appendix C**.

Floodways were defined for Goldsmith Gulch from E. Cherry Creek S. Drive to the upstream study limit at E. Arapahoe Road; for Goldsmith Gulch West Tributary from Orchard Hills Park to the upstream study limit at S. Boston Street/E. Peakview Avenue detention; for Southmoor Park Tributary from Hutchinson Park to the upstream study limit at S. Oneida Way, for Monaco Pkwy Overflow from E. Florida Avenue to the upstream study limit at E. Colorado Drive, and for Monaco Pkwy Overflow from Private Drive to the upstream study limit near E. Iliff Avenue. A floodway was not defined for Hampden Avenue Overflow. The floodway defines the highest hazard area of the floodplain that must be preserved for flood conveyance. Floodway analysis was based upon either a rise of elevation of the hydraulic grade line (HGL) or the energy grade line (EGL) to be no more than 0.50-foot. Floodways were defined utilizing an approach of equal conveyance reduction of left and right overbanks. In certain isolated locations, equal encroachment is not appropriate where one bank is dramatically steeper than the other. Along cross sections such as these, the encroachment of the floodway is based upon encroaching more on the milder slope bank having shallower flow. The goal is to define a floodway for the area of the cross section with the greatest flood conveyance, having the deepest and highest velocity flow (see figure below for an example cross section without equal encroachment). Per FEMA criteria, encroachment is limited to the overbank areas only and is not allowed within the main channel conveyance area.

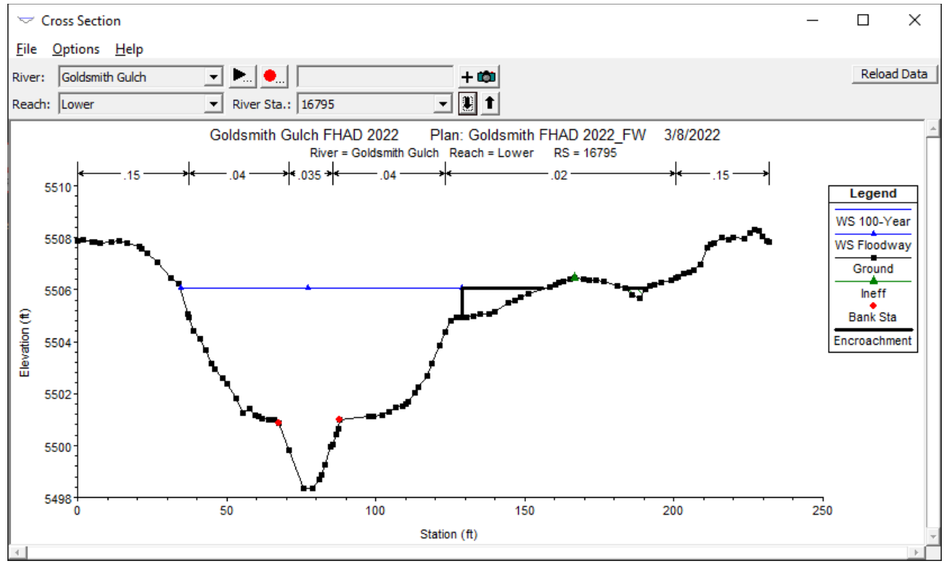


Figure 4-1 Example floodway encroachment

The floodway was set to be coincident with the floodplain where an engineered channel confined the 100-year event flow or the floodplain in the park and detention is dedicated for preservation already.

4.1 Evaluation of Existing Facilities

Existing drainage facilities within the project area consist of natural channel sections, on-line and off-line detention, four roadway bridges, twenty-one roadway culverts, thirty-four pedestrian bridges/culverts, and four piped drainageway culverts. An existing infrastructure inventory (**Table 2-1**) along the drainageways was compiled based on the detailed survey information and field measurements provided by MHFD. **Table 2-1** also includes the hydraulic capacities of the existing infrastructure based on the Baseline Hydrology. Half of these roadway crossing structures can pass 10-year event flow, and a few can pass up to 50-year event flow. The other half of these roadway crossing structures have 100-year event flow capacity and higher. Most of the pedestrian crossing bridges and culverts are less than 10-year capacity.

A total of 67 grade control structures (**Table 2-2**) including concrete check structures, grouted/non-grouted boulder drop structures and sculpted concrete drop structures exist within the study reach. Each drop structure was modeled using at least two cross-sections to define the drop structure hydraulics. The standard four cross-sections were used for the drop structures that have significant impact to the 100-year event flood elevation.

Figure 2-12 identifies the location and type of all existing roadway crossings (bridges and culverts) and hydraulic structures along the channels of Goldsmith Gulch, Goldsmith Gulch West Tributary and Southmoor Park Tributary within the study area. Pictures of the existing crossing structures are shown in the Existing Structure Inventory in **Appendix C**.

4.2 Flood Hazards

The Goldsmith Gulch, Goldsmith Gulch West Tributary and Southmoor Park Tributary are fully developed. Approximately 24 inundated habitable buildings in the 100-year floodplain were identified by this study. **Table 4-6** lists the inundated structures within each reach per jurisdiction, and **Figure 4-2** shows an overview of the locations of these structures.

Table 4-6 Habitable Structures in 100-Year Floodplain

Denver (15 Buildings)			
Flood Sources	**Reach**	**Inundated Buildings**	**Reference Location**
Goldsmith Gulch	**GG-1**	3	Skyline Acres Swim & Tennis Club
		6	E. Iliff Ave. to E. Evans Ave.
	GG-2	2	E. Iliff Ave.
	GG-4	1	South Wallace Park Detention
Southmoor Park Tributary	**ST-1**	3	E. Hampden Ave./ S. Poplar St.
Greenwood Village (5 Buildings)			
Flood Sources	**Reach**	**Inundated Buildings**	**Reference Location**
Goldsmith Gulch	**GG-5**	4	D/S S. Yosemite St.
	GG-6	1	U/S E. Berry Ave.
	WG-3	0	Per LOMR 21-08-0598P*
SEMSWA (4 Buildings)			
Flood Sources	**Reach**	**Inundated Buildings**	**Reference Location**
Goldsmith Gulch	**GG-8**	4	Perimeter of Arapahoe Lake**

** A capital improvement project was completed to rehabilitate the Bridgwater Upper Pond to include water quality, as well as drop structures, and channel improvements. As of completion of this report, LOMR 21-08-0598P issued February 25, 2022 and effective July 15, 2022 removed the Bridgwater Apartments from the floodplain.*

*** FIRM does not include inundated structures around Arapahoe Lake. However, there are two structures reportedly with basements below the 100-year flood elevation*. Elevation Certificates are necessary to confirm the actual number of buildings within the Special Flood Hazard Area.

Two buildings of the Bridgwater Apartments are shown to be located within the 100-year flood hazard area downstream of S. Boston Street. The FHAD HEC-RAS hydraulic modeling shows 7 cfs overtopping the channel banks into Bridgwater Apartments in a 100-year event. During the writing of this FHAD study, improvements were made to the open channel to achieve 100-year capacity and minimize flood hazards. A capital improvement project rehabilitated the Bridgwater Upper Pond to include water quality, as well as drop structures, and channel improvements. As of completion of this report, LOMR 21-08-0598P issued February 25, 2022 and effective July 15, 2022 was completed to remove the multi-family Bridgwater Apartments from the floodplain. The LOMR supersedes this FHAD study and will be included in the Physical Map Revision (PMR) adoption process.

Nine structures around the perimeter of Arapahoe Lake appear to be inundated per the LiDAR topographic contours; however, five of the nine structures have been shown by Elevation Certificates to have their finished floors at least one foot above the spillway. Two structures have walk-out basements at the same elevation of the spillway and may be susceptible to flooding. This study uses the same approach as used in the 2005 FHAD by not recognizing flood attenuation and downstream peak flow reduction at Arapahoe Lake since there is not a public drainage easement covering the lake area.

The Arapahoe Lake subdivision was designed in 1976 per the drainage study completed by J.W. Williams & Associates. The 100-year design flow used in the 1976 study is lower than the current hydrology shown in both the 2005 FHAD and this study. An excerpt from the Moser and Associates Engineering, *Goldsmith Gulch Improvements – Arapahoe Lake*, October 26, 2007 prepared for SEMSWA states, *"Based on the original design, the dam relied on the roadway overtopping by 1.0 foot to attain a total release rate of 220 cfs."* **Table 4-7** compares the flow rates and spillway overtopping of the previous studies with this study.

Table 4-7 Arapahoe Lake Discharges and Spillway Overtopping

Item	1976 Drainage Study	2005 OSP	This Study
100-year Peak flow at Spillway	462 cfs	767 cfs	521 cfs
100-year Release Rate	220 cfs	627 cfs	521 cfs
Spillway Overtopping Depth	1 ft	1.4 ft	1.46 ft

4.3 Previous Analyses

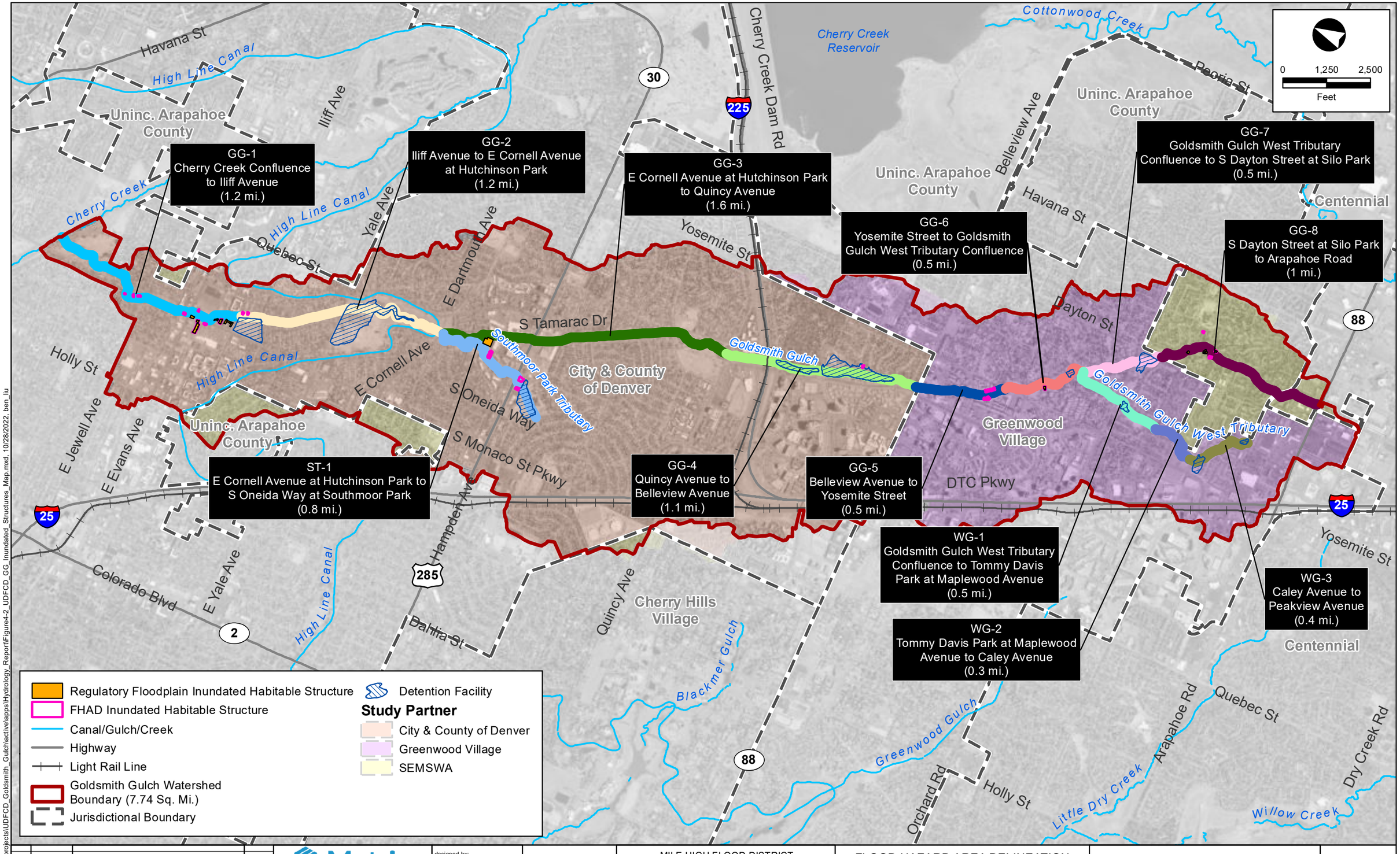
Flood Insurance Studies exist within the Goldsmith Gulch watershed for the City and County of Denver (2020 FIS) and Arapahoe County, CO and Incorporated Areas (2020 FIS). FEMA mapped floodplains and floodways include AE, AO, and X (shaded) designations. The 2020 FIS for Goldsmith Gulch and Southmoor Park Tributary within the City and County of Denver was based on the Goldsmith Gulch Letter of Map Revision (LOMR) Case Number 97-08-009P, effective date January 8, 1997. The 2020 FIS for the upper Goldsmith Gulch upstream of Belleview Avenue in Arapahoe County is based upon the 2005 Urban Drainage and Flood Control District Flood Hazard Area Delineation. A Letter of Map Revision Case Number 15-08-0521P revised FIRM panels for a bridge and channelization project within Cook Park (effective December 28, 2018), but this and other LOMRs were incorporated into the effective 2020 FIS (Denver) and 2020 FIS (Arapahoe County). The map panel numbers for Arapahoe County and Incorporated Areas panels include: 08005C0457K, and 08005C0476L. The map panel numbers for City and County of Denver include: 0800460208H, 0800460216H, 0800460217J, 0800460218G and 0800460219H.

A comparison was made between the information presented in the FEMA FIS and this floodplain study. In general, the 100-year floodplain delineation along Goldsmith Gulch, Goldsmith Gulch West Tributary and Southmoor Park Tributary are similar but smaller; however, there are some areas where the floodplain is larger compared to the effective FIS floodplain. The differences between the regulatory and study floodplains were caused by the updated hydrology, new topography and new hydraulic model. The 2013 topographic mapping provides a higher resolution of ground information than that used for the 1997 LOMR and 2005 FHAD. In the City and County of Denver, the regulatory floodplain was analyzed using a HEC-2 hydraulic model; however, HEC-RAS was used for this study, which has an updated hydraulic module. HEC-RAS usually calculates very different water surface elevations at hydraulic structures than HEC-2.

There were 9 structures in the FEMA Effective floodplains of Goldsmith Gulch, West Tributary and Southmoor Tributary (see Table 4-8 below). There are 13 building features in the GIS layer that intersect the effective floodplain mapping, but only 9 are habitable structures (1 structure is a parking structure and 3 are at Arapahoe Lake that have Elevation Certificates).

Table 4-8 Floodplain Inundated Structures this FHAD compared to the 2020 FEMA Effective

Reaches	This Study Structure Count	Regulatory Floodplain Structure Count
GG-1	9	6
GG-2	2	0
GG-3	0	0
GG-4	1	0
GG-5	4	0
GG-6	1	1
GG-7	0	0
GG-8	4	2
ST-1	3	0
WG-1	0	0
WG-2	0	0
Total	**24**	**9**



FILE: G:\gis_projects\UDFCD_Goldsmith_Gulch\active\apps\Hydrology_Report\Figure4-2_UDFCD_GG_Inundated_Structures_Map.mxd, 10/28/2022, ben_liu

No.	DATE	DESCRIPTION	APPR.

Matrix Excellence by Design

designed by:
drawn by: CM
checked by: RK
project no.: 18.155.035
date: 10/26/2022

MHFD MILE HIGH FLOOD DISTRICT

MILE HIGH FLOOD DISTRICT
CITY AND COUNTY OF DENVER
GREENWOOD VILLAGE
SEMSWA

FLOOD HAZARD AREA DELINEATION
GOLDSMITH GULCH DRAINAGEWAY AND TRIBUTARIES

INUNDATED STRUCTURES MAP

FIGURE 4-2

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