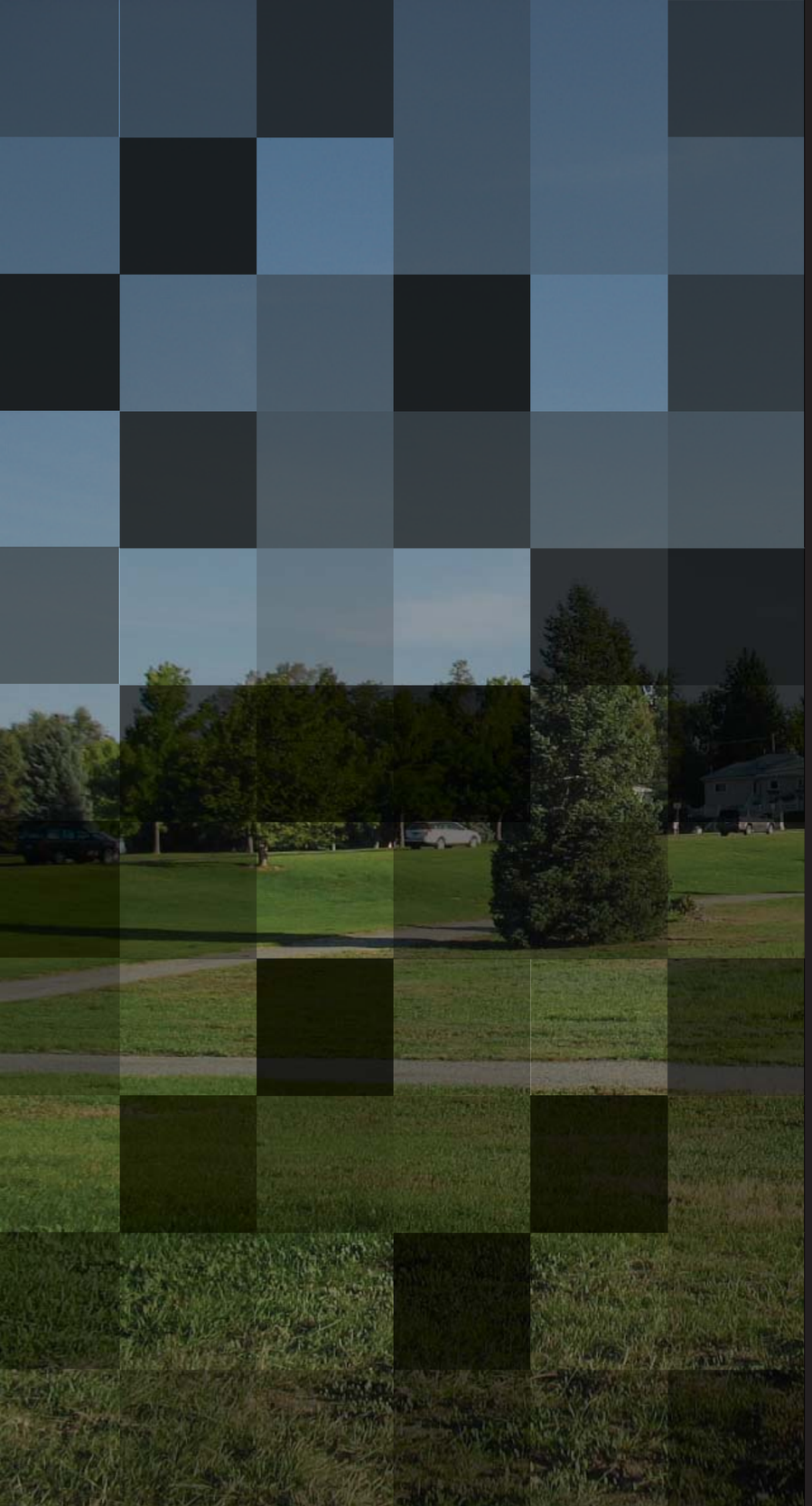









Flood Hazard Area Delineation
Harvard Gulch and Dry Gulch

February 2017



Prepared for
Urban Drainage and Flood Control District
City and County of Denver
City of Englewood

Prepared by
Matrix Design Group
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February 17, 2017

Mrs. Shea Thomas, PE
Senior Master Planning Engineer
Urban Drainage & Flood Control District
2480 W. 26th Ave., Suite 156-B
Denver, Colorado 80211

RE: Harvard Gulch Flood Hazard Area Delineation Report
Agreement No. 15-01.28

Dear Mrs. Thomas:

Matrix Design Group, Inc. is pleased to submit the enclosed *Final Harvard Gulch Flood Hazard Area Delineation (FHAD) Report*. This report provides a description of the watershed, hydrologic modeling, detailed hydraulic modeling, and assessment of potential flood damages. The report format and submittal follows the requirements of the Urban Drainage & Flood Control District guidelines for Flood Hazard Area Delineation studies.

The 7.43 square mile Harvard Gulch watershed extends from the I-25 corridor to the South Platte River and is fully developed. The Harvard Gulch drainageway flows east to west between Yale Avenue and Wesley Avenue. In addition, this study also evaluated the tributary of Dry Gulch from University Boulevard within the City of Englewood to the confluence with Dry Gulch at Harvard Avenue within Denver.

A total of 4.77 miles of waterway were studied with a detailed HEC-RAS hydraulic model for Harvard Gulch upstream of South Logan Street to South Colorado Boulevard, and Dry Gulch from East Harvard Avenue to South University Boulevard at the corporate limits of the City of Englewood. Separate models were developed for Harvard Gulch and Dry Gulch due to the complexity of the confluence area. The HEC-RAS model of Harvard Gulch analyzed 2.4 miles of the Harvard Gulch mainstem and 0.4 miles of the Harvard Gulch Split Flow Reach. The HEC-RAS model of Dry Gulch analyzed 1.93 miles of the mainstem waterway. FLO-2D was used to model the Harvard Gulch overland flow study area generally bounded by the South Platte River on the west, South Logan Street on the east, East Iowa Avenue on the north, and East Harvard Avenue on the south.

The Harvard Gulch drainageway has generally functioned well with few reported incidents of flooding since development of the watershed. Major structural improvements were made on the waterway in the 1960's and 1970's, but these improvements all have less than 25 year capacity. The underground pipe network on Dry Gulch was designed for a 2¾ year flood event. A previous *Flood Hazard Area Delineation* was published in 1979 to inform the community of the residual flood hazards from a 100-year flood event. A significant flood on Harvard Gulch is expected to result in broad overland flooding through urban areas. A total of approximately 903 habitable building structures could be impacted by a 100-year flood.

A first technical draft submittal of the FHAD model and delineation dated June 9, 2015 was reviewed by project sponsors and comments were received November 10, 2015 for HEC-RAS modeling and December 11, 2015 for FLO-2D modeling. A draft submittal of the FHAD report dated January 18, 2016 was reviewed by project sponsors and comments on technical modeling and delineation were received May 19, 2016. Review comments for the report only were received September 28, 2016. A pre-final technical submittal of the FHAD model and delineation was submitted on August 30, 2016 and comments were received October 27, 2016. A draft final report was submitted November 4, 2016 and comments were received from UDFCD on December 29, 2016 and from Denver on January 19, 2017. This report addresses those comments and includes the technical modeling and the floodplain delineation as a complete report.

Information contained in this report provides the project sponsors of the City and County of Denver, City of Englewood and the Urban Drainage & Flood Control District with an updated assessment of the potential flood hazard on Harvard Gulch and its tributary Dry Gulch. We appreciate the opportunity to provide this flood hazard assessment analysis.

Sincerely,

Matrix Design Group, Inc.

Robert Krehbiel, PE
Project Manager

HungTeng Ho, PE
Project Engineer

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1.0 INTRODUCTION

1.1 Authorization

Matrix Design Group, Inc. (Matrix) was retained by Urban Drainage & Flood Control District (UDFCD) to complete a Major Drainageway Plan (MDP) and a Flood Hazard Area Delineation (FHAD) for Harvard Gulch and Dry Gulch. The project is co-sponsored by the City & County of Denver (Denver) and the City of Englewood (Englewood). The Agreement regarding the MDP and FHAD study for Harvard Gulch was executed on January 29, 2015 (Agreement No. 15-01.28).

1.2 Purpose and Scope

The purpose and scope of this FHAD is to analyze the Harvard Gulch watershed, including the tributary of Dry Gulch through the Englewood city limits (Study Area). A FHAD study previously existed, but no MDP had been completed in the past. In December 1979, the *Flood Hazard Area Delineation, Harvard Gulch, West Harvard Gulch and Dry Gulch* were published by Gingery Associates, Inc. for UDFCD, Denver and Arapahoe County.

Harvard Gulch is one of the most studied, monitored, measured and modeled watersheds in the Denver Metro area. There are five stream gages and many rainfall gages on Harvard Gulch. Harvard Gulch has functioned well with few reported incidents of flooding and minimal areas of channel instability since major structural improvements were made on the waterway in the 1960's and 1970's. The rainfall and 34 years of stream gage records collected since 1965 for this drainage basin indicate that the 1979 FHAD hydrology is reasonable and should be used as the basis for managing flood hazards.

The following tasks have been completed as part of this FHAD Report:

- Collect existing information, including the 1979 *Flood Hazard Area Delineation* (FHAD) for Harvard Gulch.
- Solicit input from the project sponsors at the kickoff meeting.
- Obtain GIS information from UDFCD and the City & County of Denver.
- Obtain existing and future land use mapping, Planned Development from the City & County of Denver, City of Englewood and Cherry Hills Village.
- Establish sub-watershed boundaries and parameters in accordance with the UDFCD criteria.
- Developed future (fully developed) conditions hydrologic models using CUHP 2005, version 1.4.4 and EPA SWMM 5.0, version 5.0.022.

1.3 Planning Process

Project sponsors are the Urban Drainage & Flood Control District, the City & County of Denver and City of Englewood. Other jurisdictions within the watershed are Cherry Hills Village and Arapahoe County, which are stakeholders to this study. Participants from the project sponsors are listed in Section 1.6 Acknowledgements.

Parallel to this study, the Denver Urban Waterways Restoration Study is a related but separate project to identify restorative improvements to three major urban waterways — Harvard Gulch, Weir Gulch, and the South Platte River from 6th to 58th Avenues — within the City & County of Denver. The Denver Urban Waterways Restoration Study project is sponsored by the United States Army Corps of Engineers (USACE), Urban Drainage and Flood Control District (UDFCD), City & County of Denver, and the Colorado Water Conservation Board (CWCB). Sponsors are conducting a series of studies to reassess the condition of these waterways considering flood risk assessment, ecosystem health, and recreational opportunities. The study began in 2015 and is scheduled to be completed in mid-2017. Following the conclusion of this study, the City & County of Denver will begin work to secure funding in partnership with USACE for future construction, which would not begin until approximately 2020. As part of a comprehensive understanding of the waterways, the City & County of Denver is conducting a study to identify neighborhood enhancement opportunities in and around Harvard Gulch. Neighborhood enhancement opportunities include trail connections, improved access areas, additional neighborhood connections to the Gulch, and recreation activity opportunities. Outcomes of the study will be incorporated into the preferred plan developed as part of the Denver Urban Waterways Restoration Study.

A project advisory committee consisting of representatives from UDFCD and Denver held a kickoff meeting on January 29, 2015 at the offices of UDFCD (see enclosed Meeting Minutes in Appendix A: Project Correspondence). Additional project sponsor progress meetings were held April 8, 2015, May 19, 2015, June 24, 2015, August 24, 2015, January 28, 2016 and May 23, 2016. Separate meetings were held with the City of Englewood staff on August 12, 2015 and October 26, 2015. In addition, special topics meetings were held April 20, 2015 with Denver Parks & Recreation, and May 27, 2015 with Denver staff for input on open channel options that would impact neighborhood circulation. A public meeting for Dry Gulch in Englewood was held November 18, 2015 to discuss the alternatives analysis. A second public meeting for Dry Gulch in Englewood was held February 16, 2017 to present the results of the FHAD. A public meeting for Harvard Gulch was held January 13, 2016 conducted by Urban Waterways and the U.S. Army Corps of Engineers to gather input from residents, stakeholders and interested parties on alternatives to reduce flood hazards to the community.

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.

Topographic Contours

One-foot, LIDAR-derived topographic contour data collected by the United State Geological Survey (USGS) in the fall of 2013 was used to delineate drainage basin boundaries.

Aerial Photography

Color aerial ortho-photography from 2012, with a half-foot pixel resolution, was provided by the City & County of Denver. Areas outside of the City & County of Denver were supplemented with a 2009 color aerial photo, with a one foot pixel resolution, provided by UDFCD.

Base Mapping

Base mapping information including street centerlines, parcels, zoning, jurisdictional boundaries, and park boundaries were provided by the City & County of Denver, Arapahoe County, Cherry Hills Village and the City of Englewood.

Crossing Structure Survey

Denver provided a tabulation inventory of roadway crossings and sufficiency ratings for the bridges within their jurisdiction, which is shown in **Table 2-1**. Field survey of all existing road crossings was completed in February 2015 by Accurate EngiSurv, LLC and provided by UDFCD, which is shown in **Appendix C**, **Figure C-3**.

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 the City & County of Denver. Flood Insurance Rate Maps (FIRMs) of the City & County of Denver were obtained from the Federal Emergency Management Agency (FEMA). The previous Harvard Gulch Flood Hazard Area Delineation (FHAD) was obtained from UDFCD. The primary references used for this study are as follows:

- *Cherry Hills Village, Zoning Map*
- *City & County of Denver, Parks and Recreation, Gulch Master Plan* (2009) (Five gulches study)
- *City & County of Denver, Storm Drainage Master Plan* (2014)
- *City & County of Denver, Evans Station Area Plan* (2009)
- *City & County of Denver, Land Use Zoning Data (2014)*
- *City of Englewood, Zoning Map (2014)*
- *UDFCD, Flood Hazard Area Delineation, Harvard Gulch, West Harvard Gulch and Dry Gulch* (1979)

1.6 Acknowledgements

Table 1-1 Project Participants

Name	Representing	Project Role
Shea Thomas	Urban Drainage & Flood Control District	Project Manager
Terri Fead	Urban Drainage & Flood Control District	Floodplain
Mike Anderson	Denver Public Works - Capital Projects Planning	Sponsor
Jennifer Williams	Denver Public Works - Capital Projects Planning	Sponsor
Jeremy Hamer	Denver Public Works – Floodplain Manager	Sponsor
Sarah Anderson	Denver Public Works - Water Quality	Sponsor
Ashlee Grace	Denver Public Works - Water Quality	Sponsor
Cincere Eades	Denver Parks Planning	Sponsor
Kevin Lewis	Denver Public Works - Wastewater Management	Sponsor
David Morrisey	Denver Public Works - Wastewater Management	Sponsor
Andy Stewart	Denver Public Works - Wastewater Management	Sponsor
Tim Watkins	Denver Community Planning and Development	Sponsor
Katie Ross	Denver Water	Stakeholder
Dave Henderson	Englewood – Engineering Services	Sponsor
Paul Weller	Englewood – Field Operation Administrator	Sponsor
Robert Krehbiel	Matrix Design Group, Inc.	Project Manager
Hung Teng Ho	Matrix Design Group, Inc.	Project Engineer
Chris Martin	Matrix Design Group, Inc.	GIS Manager
Bob Eck	Matrix Design Group, Inc.	Landscape Architect

2.0 STUDY AREA DESCRIPTION

2.1 Project Area

The study area includes the entire Harvard Gulch watershed as shown on **Figure 2-2, Study Area Map**. According to Project REUSE developed by DRCOG, the Harvard Gulch watershed is sub-divided into a lower basin and an upper basin, designated as 5200-01 and 5200-02, respectively. Denver's Storm Drainage Master Plan divided the upper basin (5200-02) into two basins, 5200-02 and 5200-03.

The watershed is generally bounded by the South Platte River on the west, I-25 on the east, East Evans Ave on the north and East Mansfield Ave on the south. Harvard Gulch is a right-bank tributary of the South Platte River draining a 7.43 square mile basin located in south-central Denver, along East Harvard Avenue, and outfalls to the South Platte River via an underground box beneath East Wesley Avenue.

A majority of this watershed is within the City & County of Denver. The City of Englewood and Cherry Hills Village are also within the southern portion of the watershed. Arapahoe County enclaves exist along the eastern boundary of the upper basin.

The natural open channel of Harvard Gulch west of South Logan Street was obliterated for development, likely in the 1920's when many of the buildings were constructed, and the waterway is piped underground from South Logan Street to the confluence with the South Platte River. A 4,000 foot long underground box, 14-foot wide by 9-foot tall, (transitioning to a 15x9 box downstream) carries Harvard Gulch beneath Wesley Avenue from South Logan Street to the South Platte River. The existing outfall of the Harvard Gulch major drainageway is capable of conveying runoff from approximately a 10-year storm event over the entire watershed. A 100-year flood event on Harvard Gulch will result in broad overland flooding, sending excess floodwater through neighborhoods, across Broadway, across the railroad tracks and light rail lines, and across South Santa Fe Drive. **Figure 2-1** is FEMA's publication of the regulatory Flood Insurance Rate Map (FIRM Panel No. 0800460211H) for the lower portion of Harvard Gulch, west of S Washington Street. Flooding is predicted to be shallow (one to two feet deep) and occurs along much of the Harvard Gulch waterway and extends to the northwest, into Basin 5000-03, as overland flow through the Overland Golf Course to the South Platte River. The entire FEMA FIRM was overlaid on the City & County of Denver parcel layer. **Figure 2-3** shows the parcels between South Colorado Boulevard and the South Platte River that would be affected by a 100-year frequency storm event on the Harvard Gulch and Dry Gulch watersheds. It was estimated that a total of 1,100 parcels from Colorado Boulevard to the South Platte River would be inundated by a 100-year frequency storm event on the Harvard Gulch and Dry Gulch watersheds. Of these, 627 parcels are located west of South Logan Street.

Figure 2-4 is a geologic map that shows where the historic flow path of Harvard Gulch and Dry Gulch existed pre-development of the watershed. As can be seen by comparing **Figures 2-2, 2-3** and **2-4**, the path of the effective FEMA 100-year floodplain follows the historic location of both Harvard Gulch and Dry Gulch.

2.1.1 Lower Basin – Basin 5200-01

Land use in the 0.85 square mile lower basin is predominately residential with commercial development along major transportation corridors (Broadway and Santa Fe Drive) and industrial use between the Regional Transportation District (RTD) Light Rail/Southern Pacific Railroad lines and South Delaware Street. The basin is nearly fully developed with Rosedale Park and the Community Gardens as the only remaining significant open spaces. *Blueprint Denver*, an integrated land use and transportation plan (City & County of Denver, 2002), identified a 60-acre industrial/commercial zone located between South Logan and South Sherman Streets for potential future redevelopment.

Denver's Department of Community Planning and Development prepared the Evans Station Area Plan, which was adopted on October 12, 2009, and will be used to guide decisions regarding appropriate public and private investment within ½-mile of the Evans light rail station, which lies within the Harvard Gulch 100-year floodplain.

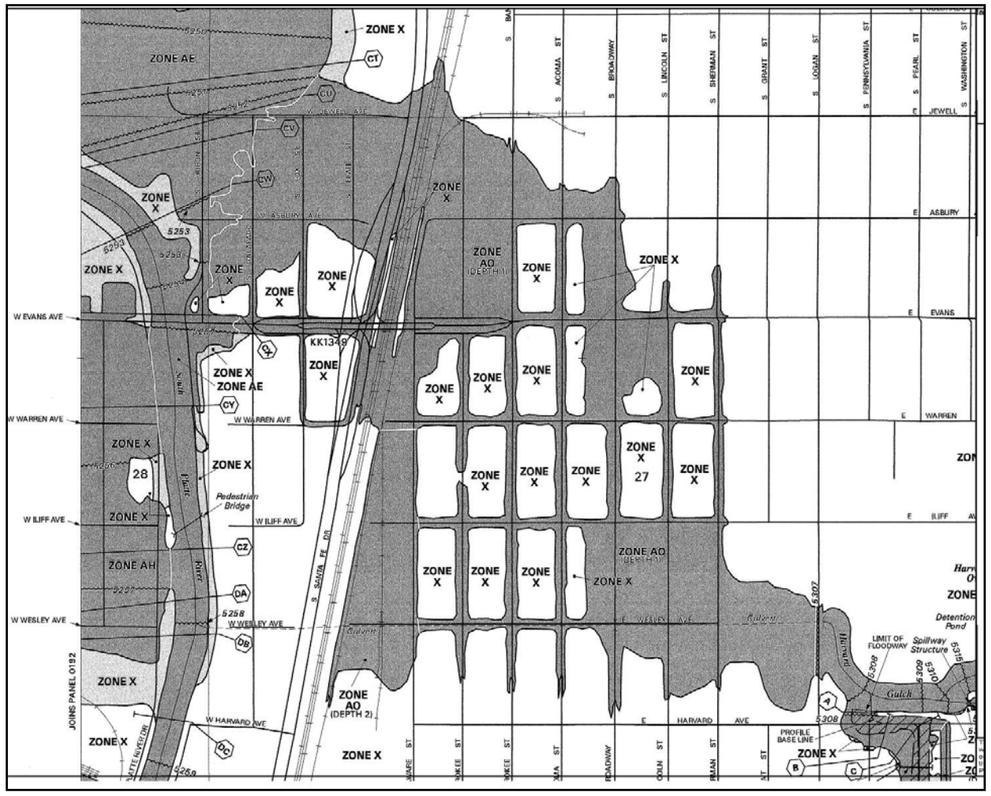
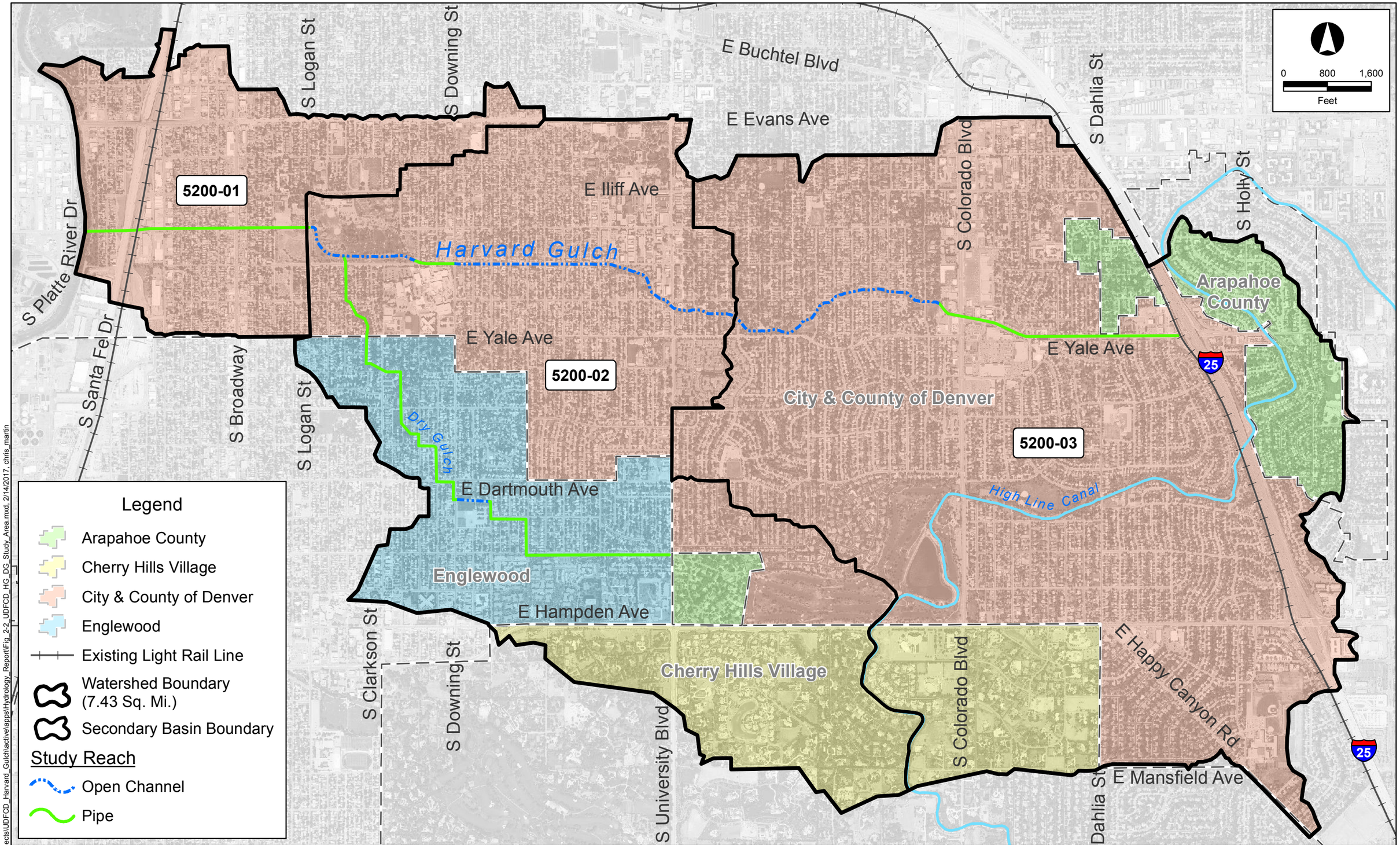


Figure 2-1 FEMA's Flood Insurance Rate Map (FIRM) Lower Harvard Gulch



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No.	DATE	DESCRIPTION	APPR.

Matrix DESIGN GROUP

designed by:
drawn by: CM
checked by: RK
project no.: 15.155.023
date: 02/14/2017

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DG

STUDY AREA MAP

FIGURE 2-2

2.1.2 Middle & Upper Basins – Basins 5200-02 and 5200-03

Land use in the 6.58 square mile watershed is primarily residential with commercial development along major transportation corridors (South University Boulevard, East Hampden Avenue, East Evans Avenue, South Colorado Boulevard, I-25, East Hampden and East Yale Avenue). Notable parks are located along the Harvard Gulch waterway, such as Harvard Gulch Golf Course, DeBoer Park, McWilliams Park and Harvard Gulch East Park. Porter Hospital and the University of Denver campus are located within the Harvard Gulch watershed. ***Blueprint Denver,*** an integrated land use and transportation plan (City & County of Denver, 2002), identified 168 acres in the upper basin as "Areas of Change". These are centered in commercial areas located at East Evans Avenue and South Colorado Boulevard.

Although a majority of the Harvard Gulch watershed is within the City & County of Denver, drainage also comes from the City of Englewood, Cherry Hills Village, and unincorporated Arapahoe County as shown on **Figure 2-2**. Approximately 2.0 square miles of the Harvard Gulch watershed lies outside of the City & County of Denver municipal boundary. Two irregular shaped Arapahoe County enclaves exist along the eastern boundary of the watershed (Holly Hills) and are bounded roughly by East Iliff Avenue on the north, East Floyd Avenue on the south, South Dahlia Street on the west, and South Monaco Street Parkway on the east with Interstate 25 dividing the two enclaves

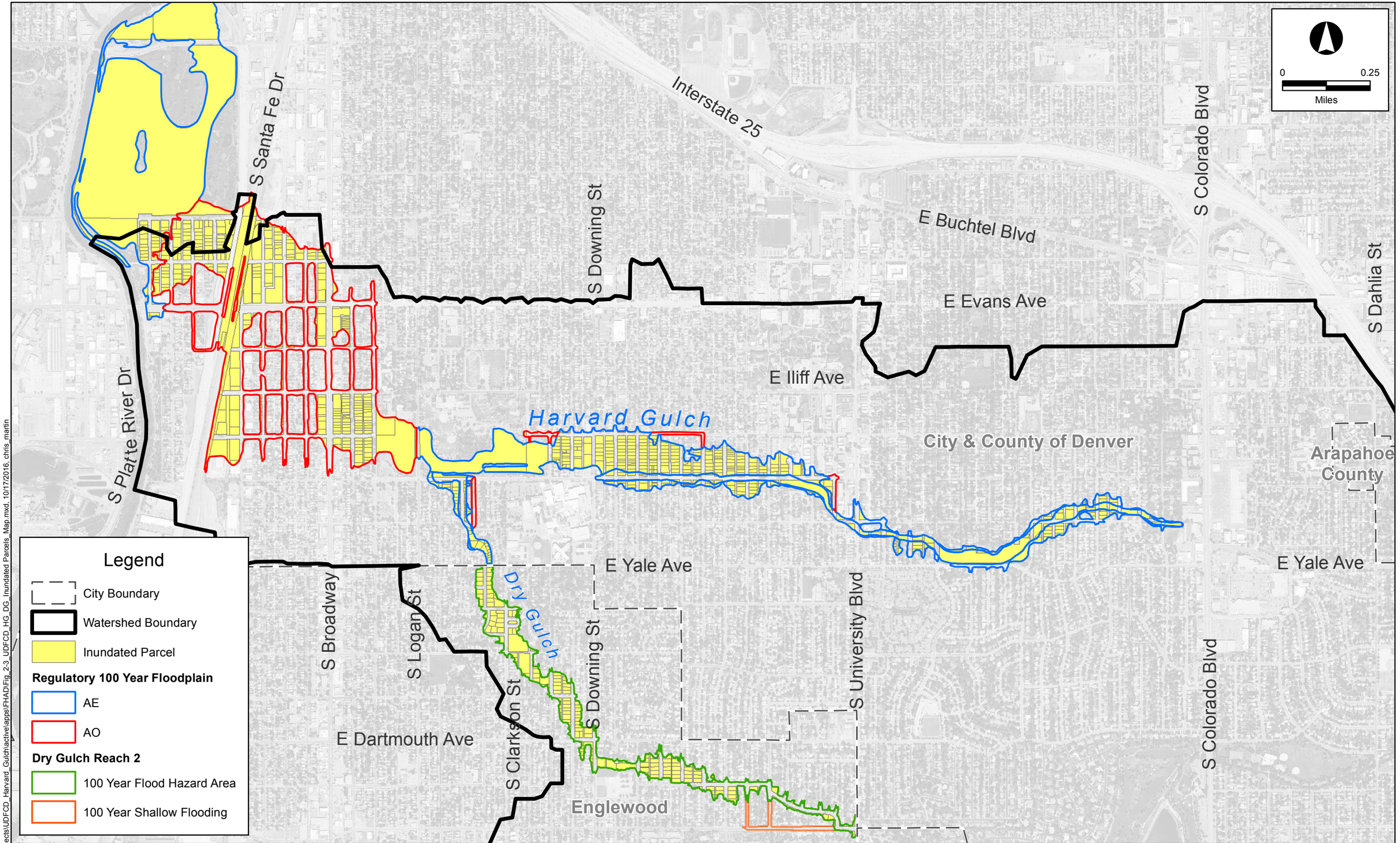
Harvard Gulch flows east to west. Upstream of South Ogden Street to South Downing Street Harvard Gulch is underground beneath East Harvard Avenue in a 14-foot by 10-foot box conduit. Upstream of South Downing Street to South Race Street, Harvard Gulch is conveyed in an open trapezoidal section of concrete channel. Upstream of South Race Street to nearly Colorado Boulevard, Harvard Gulch is a natural grass-lined open channel.

Dry Gulch, a tributary of Harvard Gulch, consists of open channel throughout Harvard Gulch Park (from South Logan Street to South Ogden Street). The Dry Gulch waterway is comprised of 700 feet of parallel twin 68-inch by 43-inch buried elliptical pipes, and 800 feet of 72-inch buried circular pipe extending south from Harvard Gulch Park to the southern City & County of Denver boundary. Additional buried circular pipe ranging in size from 33-inch to 72-inch extends into Arapahoe County (the Cities of Englewood and Cherry Hills Village). The 1979 FHAD found that the Dry Gulch drainage improvements carry only 250 cfs of the 1,320 cfs 100-year flood event underground, indicating that its approximate capacity is a 2-year frequency storm event. Excess flood waters flow overland following the historical channel flow path through residential single family properties and continue down South Pearl Street to the confluence with Harvard Gulch.

The High Line Canal, owned, operated and maintained by Denver Water, is a major irrigation ditch that flows across the Harvard Gulch watershed, which has intercepted some storm flows from the headwaters. City Ditch also historically flows across the Harvard Gulch watershed. City Ditch filled two lakes in Washington Park in Denver, the Denver Country Club, and then made its way to fill the lake in City Park. Built in the 1860s, this 26-mile hand-dug ditch carried water from the South Platte River. The ditch originates at Chatfield Reservoir and carries the waters of the South Platte River as it winds its way for more than twenty miles through Englewood and Denver. Significant portions of the original open ditch were replaced with underground pipe in the 1930's. In the early 2000's, the Denver Water Board abandoned the historic ditch in order to not rebuild a transition under Interstate 25 to accompany the highway widening project and to begin serving Washington Park, Denver County Club and City Park with reclaimed water. City Ditch is conveyed underground near Porter Hospital at East Harvard Avenue in a 36-inch pipe where it discharges into Harvard Gulch at South Ogden Street through a 42-inch pipe with flap gate.



City Ditch outfalls into Harvard Gulch near Porter Hospital (Station 63+00)



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No.	DATE	DESCRIPTION	APPR.

Matrix DESIGN GROUP

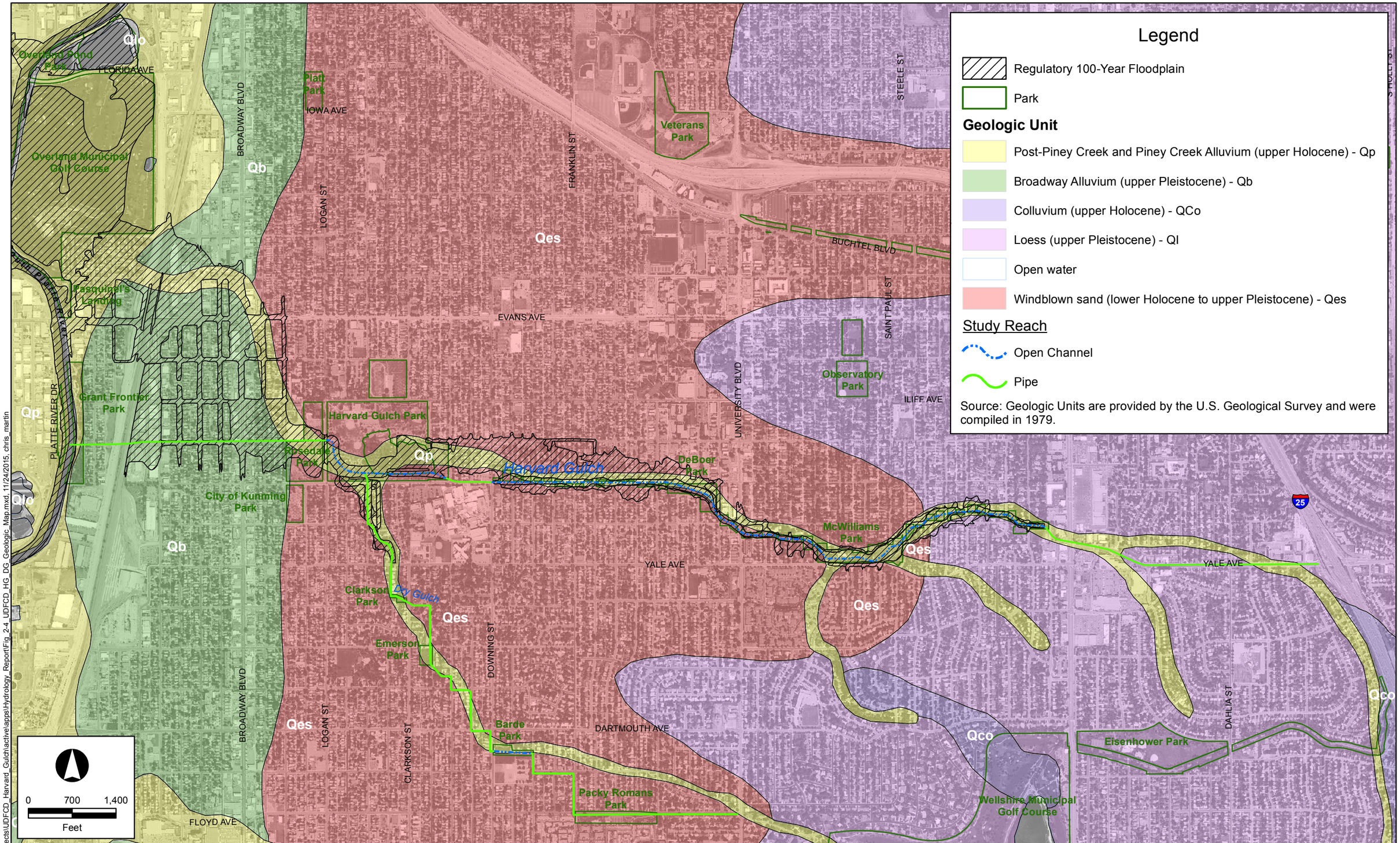
designed by:
drawn by: CM
checked by: RK
project no.: 15.155.023
date: 10/17/2016

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

PARCELS INUNDATED BY THE 100-YEAR FLOODPLAIN
HARVARD GULCH AND DRY GULCH

FIGURE 2-3



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Matrix DESIGN GROUP

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drawn by: CM
checked by: RK
project no.: 15.155.023
date: 11/24/2015

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

GEOLOGIC MAP
LOWER HARVARD GULCH

FIGURE 2-4

2.2 Land Use

In 1979, the Harvard Gulch FHAD noted that the drainage basin had already "essentially reached a full development condition with the exception of a few scattered, vacant lots." This basin is fully developed; however, some areas are expected to redevelop as noted in ***Blueprint Denver*** as "Areas of Change". Thus, the land use of the *Future Condition* is estimated to be approximated by *Existing Condition*. Since the basin is fully developed, only the *Future Condition* hydrologic model was studied for this FHAD.

The latest GIS land use zoning data were obtained from the City & County of Denver. The Evans Station Area Plan was provided by the City & County of Denver and was incorporated into the land use analysis. Land use for the City of Englewood was digitized into the GIS layer from the *City of Englewood Zoning Map*, amended July 2014. Land use for Cherry Hills Village was digitized into the GIS layer using the Cherry Hills Village Zoning Map. Table RO-3 of UDFCD's Urban Storm Drainage Criteria Manual (USDCM) was used to determine the percent imperviousness for each land use zoning. The composite percent imperviousness for each sub-basin was calculated by overlaying the land use data within the sub-basin boundary. **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.

2.3 Reach Description

Harvard Gulch is unique in that the residential neighborhoods embrace the gulch as if it were an extension of its front, side or backyard. The asphalt and dirt trails are heavily used for walking, bicycling and running even though they are sometimes in poor condition. Some at-grade trail crossings along Harvard Gulch do not provide direct handicap access at local street intersections. Due to the significant amount of irrigated turf in the watershed, significant nutrient loading is impacting water quality in the channel. The low flow channel has been stabilized throughout the natural channel reach. A total of 19 grade control structures are in place along Harvard Gulch to establish the longitudinal slopes of low flow channel between 0.001 to 0.0064 ft/ft; however local bank scour, aggradation and degradation can be seen in some locations. The most significant area between South Monroe Street and South Cook Street has eroded one to two feet in some locations. There is minor bank erosion along the low flow channel which created vertical edges and can be found throughout the natural channel reach. Sediment generated during erosion is depositing in areas along the channel and flattening the channel slope. This deposition causes the water to pond and impedes the base flow which is most evident between South Garfield Street and South Cook Street.



Trail crossings do not have handicap access ramps

For this study Harvard Gulch has been divided into 7 reaches, and Dry Gulch has been divided into 1 reach within City & County of Denver boundary and 1 reach within City of Englewood. Descriptions of the reaches are provided in the following sections and reach limits are illustrated in **Figure 2-5**. Major crossings are marked on **Figure 2-6** and listed in **Table 2-1**. **Figure C-3** in **Appendix C** shows the photographic inventory and measurement of these crossings. There are currently 6 drop structures 12 concrete cutoff walls and 1 steel sheet pile wall on Harvard Gulch which are marked on **Figure 2-6**. **Table 2-2** provides an inventory of existing drop structures and cutoff walls.

Harvard Gulch

Reach 1 – South Platte River to South Logan Street (Station 1+00 to 41+00)

Existing Harvard Gulch Outfall – West Wesley Avenue



Harvard Gulch Outfall at S Platte River (Station 1+00)

The existing 15-foot by 9-foot box storm conduit discharges to the South Platte River through a baffle block energy dissipater designed as part of the first phase of the Harvard Gulch box outfall in 1965. The baffle block energy dissipater minimizes erosion at Harvard Gulch's confluence with the South Platte River.

Existing Storm Conduit – Wesley Avenue

The existing outfall of the Harvard Gulch major drainageway consists of a 15-foot by 9-foot buried box storm conduit under West Wesley Avenue extending easterly from the South Platte River to South Santa Fe Drive. The storm conduit changes in size to 14-foot by 9-foot at South Elati Street projection and extends under Wesley Avenue from South Santa Fe Drive to South Logan Street. The total length is 4,013 feet from South Logan Street to the South Platte River.

The existing storm conduit was analyzed based on a reinforced concrete box with a Manning's n-value of 0.015. Maximum velocity was limited, per the original design, to 21 ft/sec. The design capacity of the conduit is 2,100 to 2,300 cfs due to the restriction in inlet capacity at South Logan Street, with the box flowing at 80% of full flow capacity per the 1967 Wright-McLaughlin Engineers Design Report.

Existing Storm Sewer Inlet – South Logan Street

The existing improved inlet consists of a 40-foot wide by 4-foot high opening that initially acts as a weir and then as an orifice upon reaching full flow. The South Logan Street slope tapered inlet was designed based upon model studies performed at Colorado State University (CSU) in 1965. The performance of the inlet was established as 2,100 to 2,300 cfs per the 1967 Harvard Gulch Flood Control Project article in the American Society of Civil Engineers' Journal of the Irrigation and Drainage Division.

A sill was constructed at the face of the opening thus limiting and controlling the flow into the slope-tapered inlet to prevent pressure flow in the box.



Storm Conduit Inlet at South Logan Street (Station 41+00)

Reach 2 – South Logan Street to South Ogden Street (Station 41+00 to 63+70)

This reach starts at the storm conduit inlet at South Logan Street and extends approximately 2,270 feet upstream to South Ogden Street and is located entirely inside Harvard Gulch Park. **Figure 2-5** and **Figure 2-6** show the reach boundaries and structure locations.

In this reach, the channel is grass-lined adjacent to Harvard Gulch Golf Course. The low flow channel is stable and the alignment is very straight with 3:1 bank slopes. A 10.5-foot tall baffled sloping concrete chute is located approximately 1,000 feet downstream of South Ogden Street and serves as a grade control structure.



Harvard Gulch Park at Confluence with Dry Gulch (Station 50+00)

Harvard Gulch is designed to spill over a 174-foot long side channel weir structure during a major flood to gain 10 acre-feet of flood control detention in Harvard Gulch Park Irrigation Pond before the spillway is overtopped.

Bank erosion was classified as “C” condition (needs some stabilization) and the stabilized channel slope was classified as “B” condition (good – near equilibrium) in the 2009 Denver Parks Gulch Master Plan.



Baffled Sloping Concrete Chute 10.5 foot tall (Station 54+30)



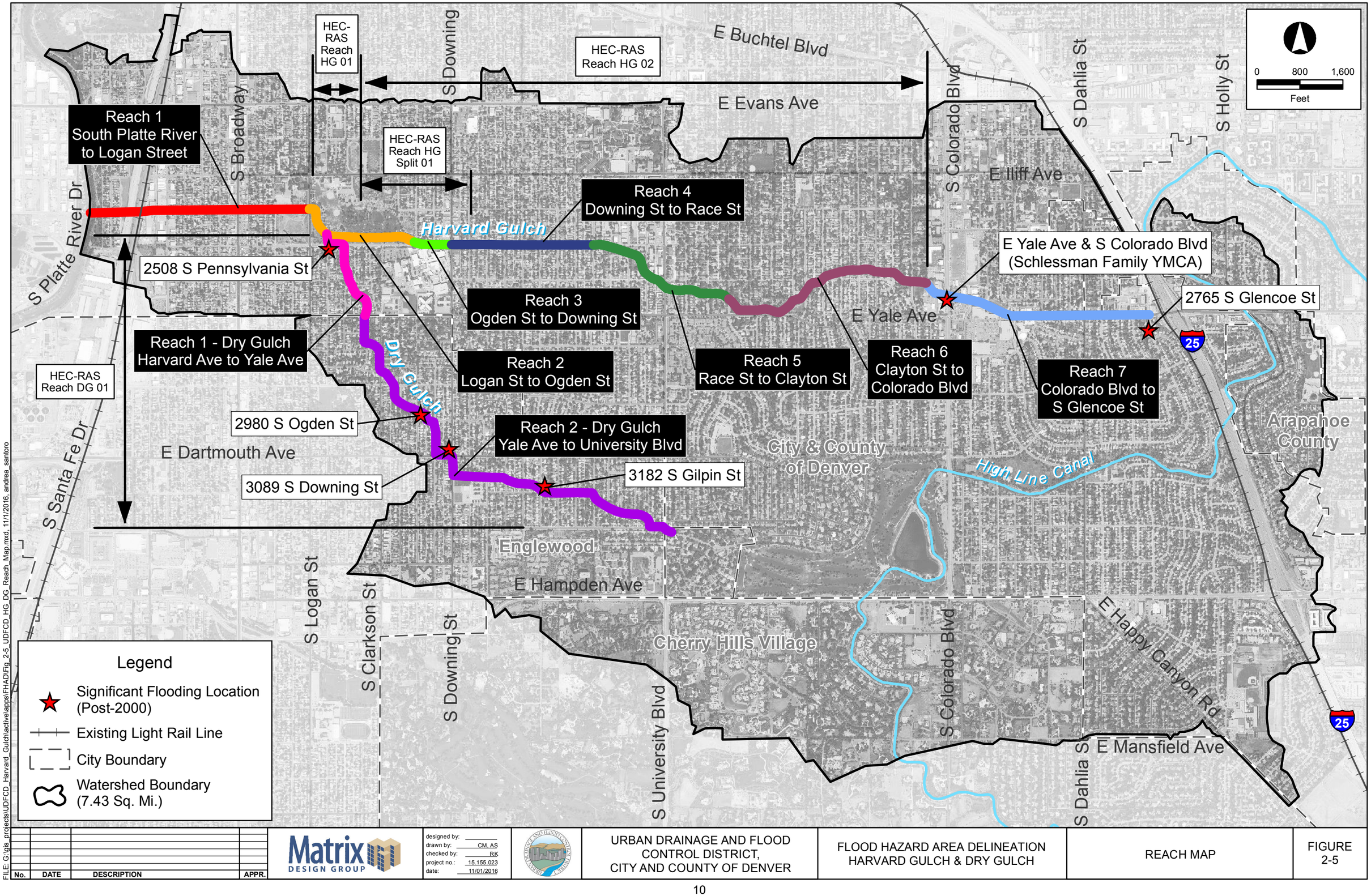
Adjacent Harvard Gulch Golf Course With Earthen Berm and USGS Gage 06711575 (Station 63+00)

Reach 3 – South Ogden Street to South Downing Street (Station 63+70 to 71+00)

From South Ogden Street to South Downing Street, the waterway is confined to a 14-foot wide by 10-foot tall underground box conduit with a total length of approximately 730 feet. The trail cannot follow the waterway. As a result, pedestrians and bicycles are disconnected from the existing park trails upstream and downstream, and pedestrians must use the sidewalks while bicyclists must use the street.



14.1’ X 9.6’ Concrete Box Conduit South Downing Street (Station 71+00)



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No.	DATE	DESCRIPTION	APPR.

Matrix DESIGN GROUP

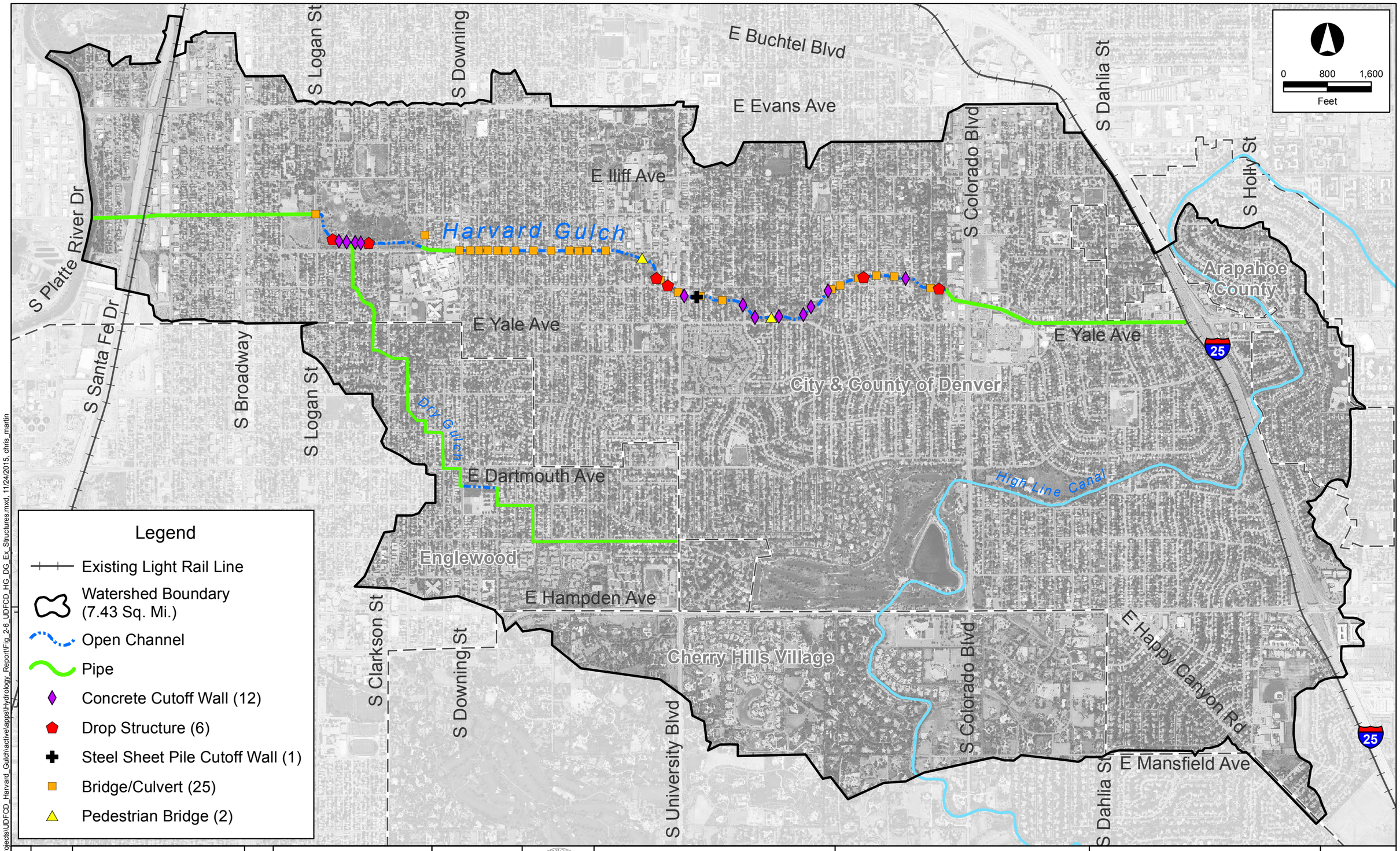
designed by:
drawn by: CM, AS
checked by: RK
project no.: 15.155.023
date: 11/01/2016

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

REACH MAP

FIGURE 2-5



Legend

- Existing Light Rail Line
- Watershed Boundary (7.43 Sq. Mi.)
- Open Channel
- Pipe
- Concrete Cutoff Wall (12)
- Drop Structure (6)
- Steel Sheet Pile Cutoff Wall (1)
- Bridge/Culvert (25)
- Pedestrian Bridge (2)

No.	DATE	DESCRIPTION	APPR.

Matrix DESIGN GROUP

designed by:
drawn by: CM
checked by: RK
project no.: 15.155.023
date: 11/24/2015

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

EXISTING STRUCTURES MAP

FIGURE 2-6

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Table 2-1 Harvard Gulch and Dry Gulch Crossings and Structures

Harvard Gulch	Type of Channel	River Station	GIS Structure Number	Location	Crossing Type (FEATURE _CARRIED)	Description / Size (attributes in GIS & other info)	Year Built	Category: Major or Minor Structure	Main Spans	Total Length (ft)	Total Width (ft)	Posted for Loads (Y/N)	2012-2013 Stantec Consulting Sufficiency Rating	Comments from Bridge Group	Baseline Hydrology Report Capacity
Reach 1	Box culvert	1+00 to 41+00	n/a	In West Wesley Avenue: S. Platte River to S. Logan Street	n/a	14'W x 9' H RCB	1966	n/a							10-Year
Reach 2	Natural	40+80	D13HGE020	S Logan Street	Roadway	CBC 14' x 9' / Opening is 40' and narrows to 14'	1966	Major	2	40	52	No	96.2		10-Year
Reach 3	Box culvert	63+70 to 71+10	D13HGE030	E Harvard Ave between S Ogden & S Downing	Roadway	CBC 14.1' X 9.6'	1966	n/a	1	719	36				10-Year
Reach 4	Concrete Trapezoidal	72+43	D13HGE050	S Downing/S Marion Alley	Alley	1 Span, 13" Reinforced Conc. Deck w/WP mbrn and 2" overlay	1967	Major	1	30	19.5	Yes	52.2		10-Year
	Concrete Trapezoidal	74+08	D13HGE060	S Marion Street	Roadway	12.5" Conc. Slab w/WP mbrn and 3" overlay	1967	Major	1	29	44.5	No	93.9		< 10-Year
	Concrete Trapezoidal	75+72	D13HGE070	S Marion/ S Lafayette Alley	Alley	1 Span, 12.5" Conc. Slab w/WP mbrn and 2" overlay	1967	Major	1	29	19.5	No	73.6		< 10-Year
	Concrete Trapezoidal	77+38	D13HGE080	S Lafayette Street	Roadway	1 Span, 12.5" Conc. Deck w/WP mbrn and 4" overlay	1967	Major	1	29	44.5	Yes	71.1		< 10-Year
	Concrete Trapezoidal	79+03	D13HGE090	S Lafayette / S Humboldt Alley	Alley	1 Span, 12.5" Conc. Deck w/WP mbrn and 2" overlay	1967	Major	1	29	19.5	Yes	51.3		< 10-Year
	Concrete Trapezoidal	80+68	D13HGE100	S Humboldt Street	Roadway	1 Span, 12.5" Conc. Deck w/WP mbrn and 2" overlay	1967	Major	1	29	44.5	Yes	73		< 10-Year
	Concrete Trapezoidal	84+00	D13HGE110	S Franklin Street	Roadway	1 Span, 13" Conc. Slab w/WP mbrn and 3" overlay	1967	Major	1	30	44.5	Yes	74.5		10-Year
	Concrete Trapezoidal	87+25	D13HGE120	S Gilpin Street	Roadway	1 Span, 13" Conc. Slab w/WP mbrn and 2" overlay	1967	Major	1	30	44.5	Yes	77.1		10-Year
	Concrete Trapezoidal	90+55	D13HGE130	S Williams Street	Roadway	1 Span, 13" Conc. Deck w/WP mbrn and 3" overlay	1967	Major	1	30	44.5	Yes	75.5		10-Year
	Concrete Trapezoidal	92+20	D13HGE140	S Williams / S High Alley	Alley	1 Span, 14" Conc. Slab w/WP mbrn and 2" overlay	1967	Major	1	32	19.5	Yes	52.7		10-Year
	Concrete Trapezoidal	93+90	D13HGE150	S High Street	Roadway	1 Span, 14" Conc. Slab w/WP mbrn and 4" overlay	1967	Major	1	32	44.5	Yes	76.5		< 10-Year
	Concrete Trapezoidal	97+15	D13HGE160	S Race Street	Roadway	1 Span, 14.5" Conc. Slab w/WP mbrn and 3" overlay	1967	Major	1	33	44.5	Yes	78.3		10-Year
Reach 5	Natural	104+00	D13HGE170A	S Gaylord Street	Pedestrian/Bike Low Flow	1 Span, COR10, Conc. Abuts	2001	Minor	1	30	5.6				< 10-Year
	Natural	109+50	D13HGE180	S York Street	Roadway	5 - 5.25' x 9.42 CBC's, 9" Conc. Slab w/6" overlay	1967	Major	5	69	44.5	No	96.9		10-Year
	Natural	113+70	D12HGE190	S University Blvd	Roadway	5 - 5.25' x 9.42 CBC's, 9" Conc. Slab w/2" overlay	1967	Major	5	69	56.67	No	76	Stantec Report: Functionally Obsolete	10-Year
	Natural	118+00	D13HGE200	S Josephine Street	Roadway	2 Spans, 14" Conc. Slab w/WP mbrn and 3" overlay	1967	Major	2	53	52.5	No	97		< 10-Year
	Natural	122+10	D13HGE210	S Columbine Street	Roadway	2 Spans, 14" Conc. Deck w/WP mbrn and 3" overlay	1967	Major	2	53	44.5	No	96.9		10-Year
Reach 6	Natural	132+30	D13HGE220A	S Fillmore Street-McWilliams Park	Pedestrian/Bike	Steel with Concrete Deck	2012	Minor	1	n/a	n/a				< 10-Year
	Natural	145+75	D13HGE230	S Steele / S Adams Alley	Alley	2 Spans, 16" Reinforced Conc. Deck w/WP mbrn and 3" overlay	1967	Major	2	48	19.6	No	83.8		10-Year
	Natural	147+50	D13HGE240	S Adams Street / E Vassar Avenue	Roadway	6 - 7' x 3.5' CBC, 9" Conc. Slab w/ 7" overlay	1967	Major	6	64	80.6	No	84.8		< 10-Year
	Natural	151+30	D13HGE250	S Cook Street	Roadway	2 Spans, 13" Reinforced Conc. Deck w/WP mbrn and 4" overlay	1967	Major	2	44	44.6	No	94.8		10-Year
	Natural	154+60	D13HGE260	S Madison Street	Roadway	2 Spans, 12" Conc. Slab w/WP mbrn and 3" overlay	1967	Major	2	38	44.6	No	91.9		10-Year
	Natural	158+00	D13HGE270	S Monroe Street	Roadway	2 Spans, 12" Conc. Slab w/WP mbrn and 6" overlay	1967	Major	2	39	44.6	No	89.2		10-Year
	Natural	165+20	D13HGE280	S Jackson Street	Roadway	1 Span, 14.5" Conc. Slab w/WP mbrn and 2" overlay	1967	Major	1	33	44.6	Yes	78.4		< 10-Year
Reach 7	Box culvert	168+00 to 172+00	D13HGE290	S Jackson/Colorado alley to S Colorado	n/a	14'W x 9' H RCB	null	null	null	null	null				100-Year
	Storm Drain	172+00 to 211+00	n/a	upstream of S Colorado Blvd	n/a	48" CMP at Colorado---> 18" RCP at I-25	unknown	n/a							2-Year

Note:
River Station in feet
from confluence with South Platte River.

Crossing Counts
Roadway = 19
Alley = 5
Pedestrian/Bike = 2
Total: 26

Notes:
* Minor structure: less that 20' span
* Major structure: more than 20' span

Dry Gulch	Type of Channel	River Station	GIS Structure Number	Location	Crossing Type (FEATURE _CARRIED)	Description / Size (As-built Information)	Year Built	Category: Major or Minor Structure	Main Spans	Total Length (ft)	Total Width (ft)	Posted for Loads (Y/N)	2012-2013 Stantec Consulting Sufficiency Rating	Comments from Bridge Group	Baseline Hydrology Report Capacity
Reach 1	Storm Drain	0+00 to 19+40	n/a	E Harvard Avenue to E Yale Avenue	n/a	Twin-68"x43" transitions to 72" RCP at E Vassar Avenue	1972	null	null	null	null	null	null	null	2-Year
Reach 2	Storm Drain	19+40 to 59+30	n/a	E Yale Avenue to S Downing St at Barde Park	n/a	66" RCP	1972	null	null	null	null	null	null	null	2-Year
	Natural	59+30 to 64+25	n/a	Barde Park	Pedestrian		1972	null	null	null	null	null	null	null	2-Year
	Overland Flow	64+25 to 73+00	n/a	S Lafayette St at Barde Park to S Franklin St	n/a	60" RCP runs paralell in E Eastman Avenue.	1972	null	null	null	null	null	null	null	2-Year
	Street	73+00 to 102+15	n/a	S Franklin St to S University Blvd	n/a	Major flow path in E Eastman Ave, a 48" to 54" RCP runs paralell in E Floyd Ave	1972	null	null	null	null	null	null	null	2-Year

River station in feet from confluence with Harvard Gulch

Table 2-2 Drop Structures & Cutoff Walls

Harvard Gulch Major Drainageway Plan Reach	River Station	Structure Type	Height	Condition	Location
Reach 2	47+00	Drop Structure (loose rock)	1’ (±)	Good	Harvard Gulch Park
	48+20	Concrete cutoff wall	n/a	Good	Harvard Gulch Park
	49+70	Concrete cutoff wall	n/a	Good	Harvard Gulch Park
	51+20	Concrete cutoff wall	n/a	Good	Harvard Gulch Park
	52+20	Concrete cutoff wall	n/a	Good	Harvard Gulch Park
	54+30	Baffled concrete chute/drop structure	10.5’	Good	Harvard Gulch Park
Reach 5	109+00	Grouted Boulder Drop Structure	1.7’	Buried	South York Street downstream
	111+30	Drop Structure (boulder)	2.3’	Fair; Need Improvement	South York Street/ S. University Boulevard Alley
	114+50	Concrete cutoff wall with grouted boulders	-1’(±)	Good	South University Boulevard upstream
	117+50	Steel sheet pile cutoff wall	1.6’	Good	South Josephine Street downstream
Reach 6	126+30	Concrete cutoff wall	1.4’	Good	South Clayton Street
	129+45	Concrete cutoff wall	2.6’	Good	South Clayton Street/ South Fillmore Street
	133+30	Concrete cutoff wall	1.1’	Good	South Fillmore Street/ South Milwaukee Street
	134+00	Concrete cutoff wall	1.7’	Good	McWilliams Park
	142+30	Concrete cutoff wall	1.3’	Good	McWilliams Park
	145+45	Concrete cutoff wall	1.45’	Good	McWilliams Park
	152+80	Drop Structure	1.7’	Good	South Cook Street/ South Madison Street Alley
	160+00	Concrete cutoff wall	n/a	Good	South Monroe Street/ South Garfield Street
	166+00	Drop Structure (loose rock)	Unknown	Buried	South Jackson Street/South Colorado Blvd.

River station in feet from confluence with South Platte River

Reach 4 – South Downing Street to South Race Street (Station 71+00 to 97+40)

Reach 4 is a 2,640-foot long concrete trapezoidal channel that has approximately 25-year capacity when flowing full (the design was based upon 10-year capacity with freeboard). Base flows move slowly over the concrete, and the shallow water heats up, which results in poor water quality and algae growth. The concrete trapezoidal channel is nearing the end of its service life. An asphalt or dirt trail runs parallel to the waterway along the north bank. Curbs without handicap access occur at every pedestrian trail road crossing.

The channel condition was classified as "B" condition, good, in the 2009 Denver Parks Gulch Master Plan. There are 8 roadway crossing structures and 4 alley crossing structures as listed in **Table 2-1**.

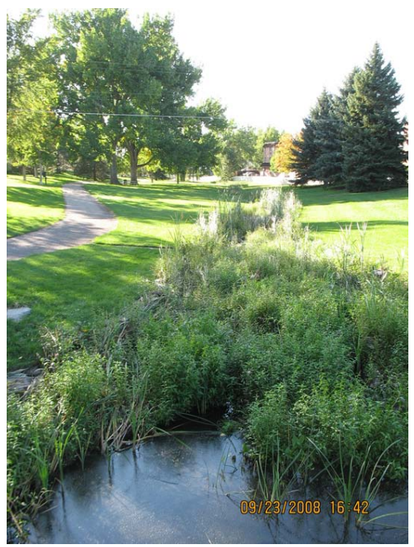


Trapezoidal Concrete Channel
(Station 71+00 to 97+40)



Grass lined channel transition into Trapezoidal Concrete Channel (Station 98+40)

Reach 5 – South Race Street to South Clayton Street (Station 97+40 to 126+00)



Wetland vegetation as a biofilter
DeBoer Park (Station 104+00)

This reach is a 2,860 feet long grass lined natural channel with a well-defined low flow and shallow and wide overbank flow areas. **Figure 2-5** and **Figure 2-6** show the reach boundaries and structure locations.

From South Race Street to South York Street, Harvard Gulch flows through DeBoer Park. Water quality treatment is quite effective through this reach because the existing wetland vegetation is successfully acting as a biofilter.

From South York Street to South Clayton Street, the channel alignment meanders through an 80-foot wide open space corridor. The low flow channel is generally 1.5 feet deep and 5 feet wide. The longitudinal slope is very shallow, resulting in slow moving base flows. In 2004, UDFCD performed sediment removal within this reach. Ponding areas are occurring in the waterway due to new sedimentation in the channel. Between South Clayton Street and South Josephine Street, the low flow channel is narrow and incised in this reach. From South Josephine Street to South York Street, there are low points which occur within the low flow channel causing ponding. The irregularities impede a continuous flow which leads to stagnant water and causes complaints of mosquitos. Eutrophic conditions are present in the ponded areas, leading to poor water quality. Channel irregularities are occurring in the waterway due to sedimentation in the channel from natural sources and roadway traction sands applied during the winter time. Sediment complaints have been repeatedly reported between South Columbine Street and South York Street.



Concrete Cut-off wall downstream of South Steele Street (Station 145+40)

There are two drop structures on this reach to provide longitudinal grade control. However, the channel slope and bank erosion were classified as "C" condition, needs improvement, in the 2009 Denver Parks Gulch Master Plan. Only the reach in DeBoer Park has "B" condition, good, classification on its bank erosion. There are four roadway crossing structures and one pedestrian/bike low flow crossing structures in this reach as listed in **Table 2-1**.



Water ponding downstream of drop structure
South York Street (Station 111+00)



Low flow channel narrow and incised
South Columbine Street (Station 121+00)

Reach 6 – South Clayton Street to South Colorado Boulevard (Station126+00 to 168+00)

This reach is a 4,200 feet long natural channel with well-defined low flow channel. The open channel in Reach 6 ends approximately 400 feet downstream of Colorado Boulevard. The effective FEMA floodplain extends to the outfall of the box culvert west of Colorado Boulevard. Between South Clayton Street and South Steele Street in McWilliams Park, the greenbelt widens. From South Steele Street to South Colorado Boulevard, the channel alignment meanders through an 80-foot wide open space corridor known as Harvard Gulch East Park. In this area, the low flow channel is approximately 1.5 feet deep and 5 feet wide.



Natural Channel downstream of South Madison St (Station 154+00)

In 2004, UDFCD removed accumulated sediment within this reach. Sedimentation has recurred. Sediment accumulation was reported between South Madison Street and South Monroe Streets. Low points occur within the low flow channel causing ponding and impeding a continuous flow which has led to complaints of mosquitos. In general, the low flow channel is stable.

In Reach 6, there are 4 drop structures and 3 concrete cutoff walls which provide longitudinal grade control for this reach. There are 5 roadway crossings, 1 alley crossing structure and 1 pedestrian/bike crossing structures in this reach as listed in **Table 2-1**.



Natural Channel downstream of South Colorado Boulevard (Station 166+00)

Harvard Gulch East Park and McWilliams Park are located within this reach, which are neighborhood-scale parks and provide traditional playgrounds, basketball courts, and soccer fields with some seating areas. Vegetation comprises broad expansive areas of irrigated turf with shade trees. Within this corridor, native, naturalized and invasive vegetation occurs along the waterway. This vegetation is predominantly grasses and shrubs with occasional shade trees on overbank areas.

Reach 7 – South Colorado Boulevard to South Glencoe Street (Station 168+00 to 211+00)

In Reach 7, the waterway is confined to a 14-foot by 9-foot concrete box pipe through the YMCA property along South Colorado Boulevard.

East of Colorado Boulevard, the existing storm drainage system is comprised of 18-inch to 42-inch pipes. Runoff in excess of the pipe capacity is conveyed in East Yale Avenue. On June 3, 2005, news reports described East Yale Avenue "flowing like a river" during a storm event. Street flooding has occurred repeatedly in a low point in South Glencoe Street, south of Yale Avenue. Flood depths have reached the home entry thresholds, causing minor garage flooding and flooding of parked cars along the street.

<u>Dry Gulch</u>

Reach 1 – East Harvard Avenue & South Pearl Street to East Yale Avenue & South Washington Street (Denver City boundary)

The Dry Gulch waterway has been piped and levelled so there is no evidence of a natural waterway. Dry Gulch within Reach 1 comprises 700 feet of parallel twin 68-inch by 43-inch buried elliptical pipes, and 800 feet of 72-inch buried circular pipe extending south from Harvard Gulch Park to the southern City boundary. The 1979 FHAD found that the Dry Gulch drainage improvements carry only 250 cfs of the 1,320 cfs 100-year flood event underground (approximately capacity of 2-year frequency storm event). The remaining flood waters flow overland following the historical flow path through residential single family properties and continue down South Pearl Street to the confluence with Harvard Gulch.

Reach 2 – East Yale Avenue & South Washington Street to South University Blvd & East Floyd Avenue (Englewood City Boundary and upstream study limit)

Reach 2 of Dry Gulch within the City of Englewood is an approximately 9,825-foot long network of underground storm pipes. The natural channel generally does not exist except for pockets of open channel in Clarkson Park, Emerson Park, Barde Park and Packy Romans Park. Existing storm pipes range from 48- to 66-inch diameter and are generally sized for the 2-year storm. Larger floods flow overland with the thalweg generally following the alignment of existing streets, parks and drainage easements. The following describes the overland path starting downstream and progressing upstream. From the city boundary at Yale Avenue, flood waters flow overland following the historical flow path down in South Clarkson Street, through a 60-foot wide City-owned drainage easement between South Washington Street and East Amherst Avenue. Flood waters flow overland in South Washington Street following the historical flow path through single family residential properties, a 135-foot wide City owned parcel (drainage easement), Emerson Park and cross the City Ditch. From East Cornell Avenue to South Downing Street at Barde Park, the thalweg follows the alignment of existing streets in South Downing Street, East Dartmouth Avenue and South Corona Street. From South Downing Street at Barde Park to South Gilpin Street & East Eastman Avenue, flood waters flow overland following the historical flow path through single family properties and an open channel at Barde Park. One split flow occurs at the intersection of East Dartmouth Avenue and South Humboldt Street due to the flat topography. Flood waters will flow in East Dartmouth Avenue and return to the main stream at the intersection of East Dartmouth Avenue & South Downing Street, however, a portion of the flood water will follow the curb and cutter in South Lafayette Street and South Marion Street to return to the main stream at Barde Park. A split flow calculation and floodplain analysis shows that the split flow floodplain depth is less than 1 foot deep during the 100-year event. From South Gilpin Street & East Eastman Avenue to the Englewood city boundary at University (upstream study limit), the thalweg follows the alignment of existing streets in East Floyd Ave and East Eastman Avenue. One split flow occurs at the intersection of East Floyd Avenue and East Eastman Avenue due to the flat topography. A majority of the flood waters flow in East Eastman Avenue, however, a portion of the flood water continues on East Floyd Avenue and flows in South Race Street and South High Street to return to the main stream in East Eastman Avenue. A split flow calculation and floodplain analysis shows that the split flow floodplain depth is less than 1 foot deep during the 100-year event.

2.4 Flood History

The greatest flood of record since 1965 occurred on July 8, 2001 and produced a peak flow rate of 2,120 cfs at Harvard Park according to the USGS stream gage, which is nearly one-half the 1979 FHAD 100-year flow rate of 4,860 cfs at this location. This storm produced little damage to the community; however, this flow rate is at the capacity of the existing underground outfall, and the water was within 6-inches of overtopping South Logan Street.



Harvard Gulch at Logan Street noting levels of high water from the July 8, 2001 flood. (source: UDFCD)

A total of five stream gages have flow records on Harvard Gulch. Four of the gages are active stream peak flow gages; two are operated by USGS and two are operated by UDFCD. One gage owned by USGS is not active; however, it recorded 23 years of peak discharge data. Detailed gage information and flood frequency analysis is provided in **Section 3.1.2.**

Significant flooding locations are noted in the Denver 2014 Storm Drainage Master Plan and are noted on **Figure 2-5**.

- Sump at South Glencoe Street, south of East Yale Avenue (2765 S Glencoe St)
- Parking lot at Schlessman Family YMCA, South Colorado Boulevard at East Yale Avenue
- South Pennsylvania Street & East Harvard Avenue (2508 S Pennsylvania St)



Flooding July 7, 2011 on Colorado Boulevard at Yale (source: YouTube)

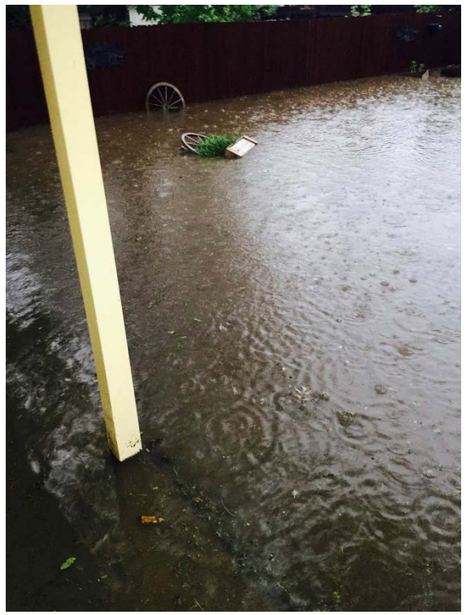
Recent incidents of flooding occurred in Dry Gulch on July 19, 2011, June 6, 2012, August 8, 2013, June 11, 2015 and June 24, 2015, which resulted in heavy flow in the streets when the pipe capacity was exceeded. There are reports of manhole lids popping off at East Bates Avenue & South Emerson Street. Residents noted 2.5 to 3 feet of water in their backyards, alleys and street during these events.



August 8, 2013 flooding on Dry Gulch at 3089 South Downing Street



August 8, 2013 flooding of Dry Gulch at 3182 South Gilpin Street. (Source: Kim Browning)



June 11, 2015 flooding of Dry Gulch on South Ogden Street. (Source: Steve Nelson)

2.5 Environmental Assessment

Parks and Open Space

Figure 2-7 identifies city-owned land. **Figure 2-8** identifies Parks and Open Space.

Wetlands and Riparian Zones

Wetland and riparian zones were identified and provided by the City & County of Denver in a report prepared by ERO Resources Corporation titled, "Existing Habitat Conditions and Restoration Opportunity Report, Weir Gulch and Harvard Gulch." **Appendix E** shows the maps prepared by ERO which include approximate areas of wetland and riparian zones based upon field survey.

Due to the high level of urbanization in this watershed, runoff provides a perennial base flow in Harvard Gulch. Dense and healthy vegetation has developed along the low flow channel. Three vegetation community types exist along the low flow channel, which are turf grass, tufted hairgrass with shrubs, and wetland plants. Remnant Cottonwood patches and willows are thriving in some locations. In upland areas, turf grasses with evergreen and deciduous shade trees are planted in the parks.

The Harvard Gulch corridor is fragmented and areas of dense vegetation exist in McWilliams and DeBoer Parks and Harvard Golf Course, which support a healthy population of birds.

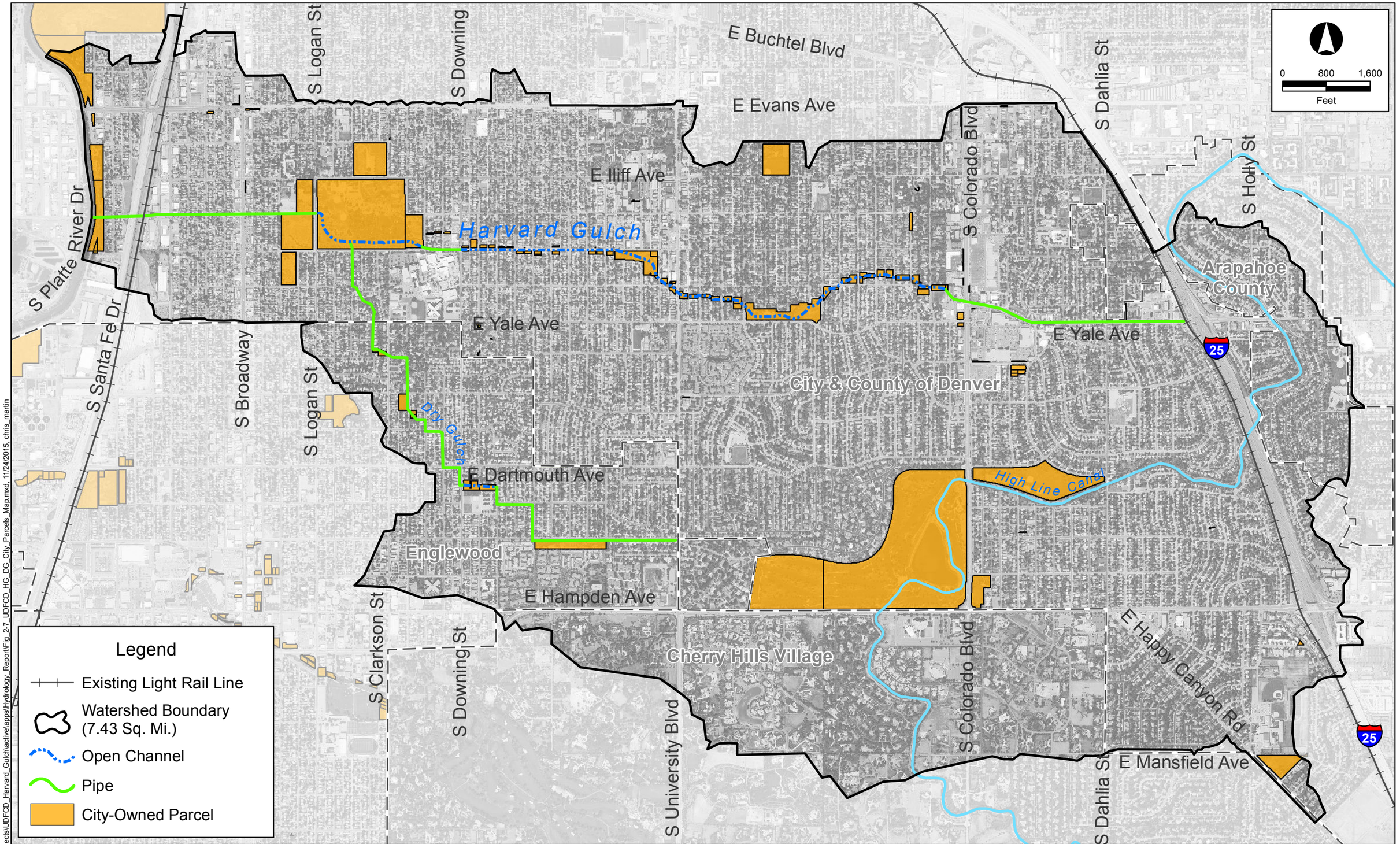
Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS) currently lists the Piping plover, Ute ladies'-tresses orchid and Preble's jumping mouse as threatened, and the Least tern as endangered species for Denver County per the listing on http://www.fws.gov/endangered/.

The entirety of the Harvard Gulch watershed is within the Denver metropolitan Block Clearance Zone for Ute ladies'-tresses orchid, Preble's meadow jumping mouse and the Colorado butterfly plant. These species should not be a concern for projects within the Harvard Gulch watershed. USFWS on-line maps currently indicate that the Canada lynx, Mexican spotted owl and the Pawnee montane skipper are not known or believed to occur within the Denver portion of the watershed. Bird habitat resources for Piping Plover, Least Tern and the Mexican Spotted Owl within the Harvard Gulch watershed and along the Harvard Gulch waterway are currently limited because the watershed is fully urbanized and there is little riparian corridor adjacent to the channels. 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 E-2** in **Appendix E** shows the approximate boundaries of landfill areas. Harvard Gulch Park where future additional detention and water quality treatment could occur is a suspected landfill area.



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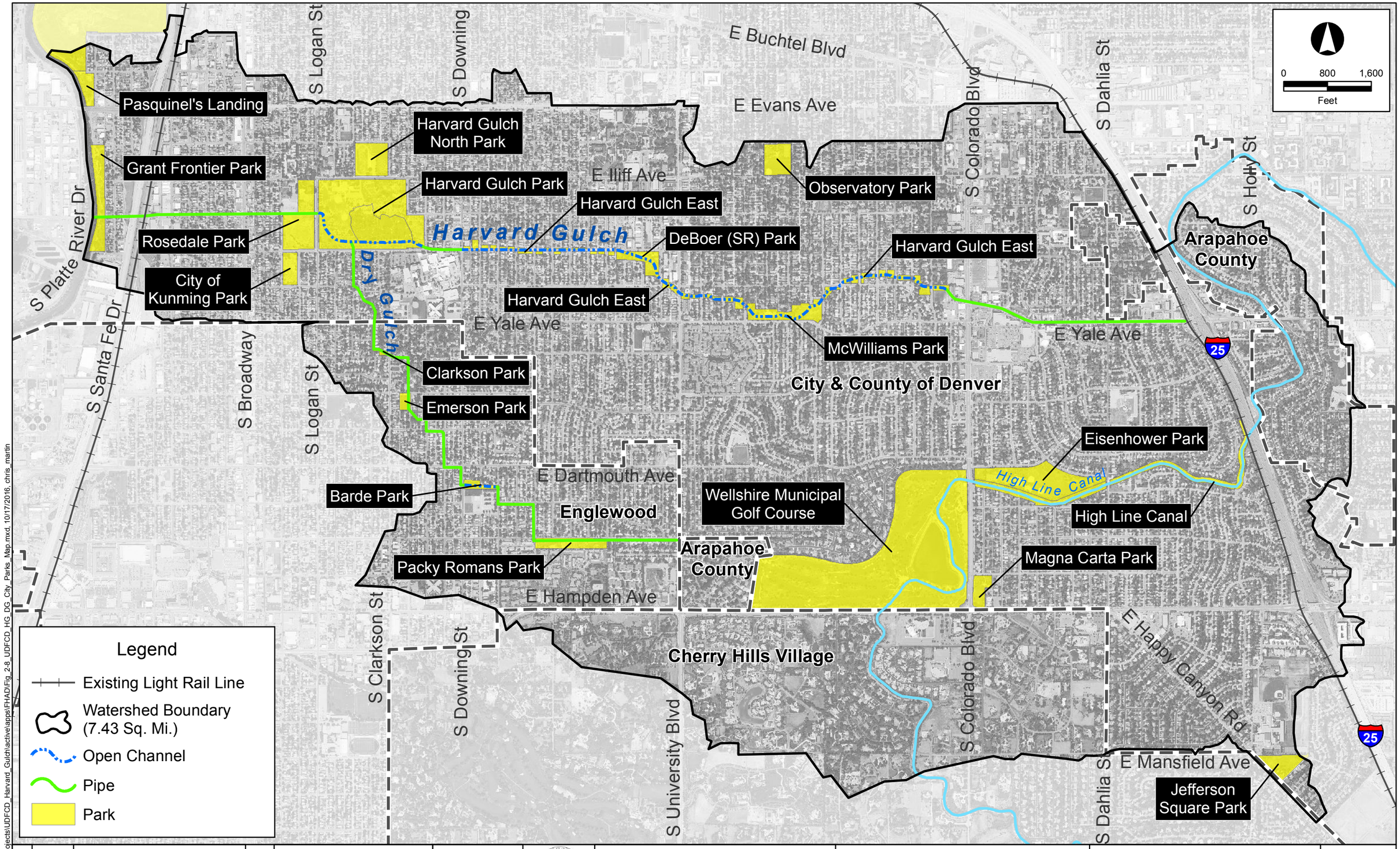
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

CITY-OWNED PARCELS

FIGURE 2-7



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URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

PARKS AND OPEN SPACE

FIGURE 2-8

3.0 HYDROLOGIC ANALYSES

3.1 Overview

In an effort to help engineers and project sponsors to select the best hydrologic modeling approach for the Harvard Gulch FHAD, different flood frequency analyses of gage data and the available hydrologic modeling methodologies were completed for this study. The following sections describe the detailed study and findings.

3.1.1 FHAD Study (Original Hydrologic Modeling)

The FHAD study was completed in 1979 using the Colorado Urban Hydrograph Procedure (CUHP) in accordance with the 1969 UDFCD Drainage Criteria Manual. The total watershed area studied was 7.69 square mile and was composed of 6 sub-basins; 5 sub-basins on Harvard Gulch and 1 sub-basin on Dry Gulch. **Table 3-1** shows the sub-basin delineation. The 2-hour storm duration was used for calculating frequency discharges. The 100-year frequency 1-hour rainfall depth was 2.30 inches and infiltration loss, 0.5 inch/hour, and detention loss, 0.3 inches for pervious areas and 0.1 inches for impervious areas were used for effective runoff adjustment.

The FHAD study concluded that both Harvard Gulch and Dry Gulch have high flood damage potential but may be reduced with structural improvements to outfalls and channels. This 1979 study concluded that the 100-year discharge at South Logan Street was 4,860 cfs.

Table 3-1 1979 FHAD Sub-basin Delineation

Drainageway	Basin Numbers/ Design Points	Sub-basin outfall design points/ Tributary Sub-basins	Area (sq. mi.)	Reference Location
Harvard Gulch	Sub-basin 1	A	1.9	South Colorado Blvd
	Sub-basin 2	B	1.9	South Race Street
	Sub-basin 3	C	0.51	South Downing Street
	Sub-basin 4	E	0.18	South Logan Street
	Sub-basin 5	F	1.4	South Platte River
	A	Sub-basin 1	1.9	South Colorado Blvd
	B	Sub-basin 1,2	3.8	South Race Street
	C	Sub-basin 1,2,3	4.31	South Downing Street
	E	Sub-basin 1,2,3,4,D-1	6.29	South Logan Street
	F	Sub-basin 1,2,3,4,5,D-1	7.69	South Platte River
Dry Gulch	Sub-basin D-1	D	1.8	Confluence with Harvard Gulch

3.1.2 Flood Frequency Analysis of Gage Data

Three stream gages were installed on Harvard Gulch by the USGS in 1981. Two of the USGS gages are still currently in operation and one was removed from service in 2003. An additional two flood warning gages as part of UDFCD's ALERT (Automated Local Evaluation in Real Time) network were installed in 1990. Up to 34 years of actual peak flow stream data is available to rely upon, rather than simulated model results used to determine the regulatory hydrology. The Harvard Gulch basin is a relatively old section of the City of Denver and a majority of the basin was built-out prior to the installation of the stream flow gages. A GIS inventory of the tax assessor's database as shown in **Figure 3-1** identifies the year of construction on each parcel. Most of the basin was developed by 1960, with some infill occurring between 1960 and 1980. Therefore, the basin was fully developed when the gages were installed and gage readings reflect runoff from a fully developed drainage basin.

A flood frequency analysis of annual stream peak flow data was completed using the Army Corps of Engineers' Flood Frequency Analysis (FFA) program as well as a Log-Pearson III distribution statistical analysis for the 3 USGS gages and 2 UDFCD gages as described below:

- Harvard Gulch near South Logan Street (UDFCD Station 603) – 25 years of record (1990-2014)
- Harvard Gulch at Harvard Park (USGS 06711575) – 34 years of record (1981-2014)
- Harvard Gulch Below South University Blvd. (USGS 06711572) – 23 years of record (1981-2003)
- Harvard Gulch at South Colorado Blvd. (UDFCD Station 613) – 25 years of record (1990-2014)
- Harvard Gulch at South Colorado Blvd. (USGS 06711570) – 34 years of record (1981-2014)

The goal of this analysis was to estimate 100-year flows in the Harvard Gulch basin based on actual recorded runoff events to compare with the results of the hydrologic models. Although the period of record is considerable, it is still limited. Additional years of data would improve the confidence the ability of a statistical analysis to predict a 100-year event hydrology. It is very reasonable to expect that a 100-year flow has not been observed in 34 years of record.

It is important to note that 19% of the Harvard Gulch watershed may drain into the High Line Canal, and therefore, the runoff from this area may not be reflected in the gage history. **Figure 3-2** shows the portion of the Harvard Gulch watershed (893 acres) that currently may drain into the High Line Canal, and therefore may not be reflected in the gage history.

The FFA establishes confidence intervals for each of the reoccurrence intervals at each of the gage locations. The results of the FFA for each of the gages are represented in **Figure 3-3** through **Figure 3-7**, where the confidence band for each recurrence interval is shown for the 2-, 5-, 50- and 100-year flood event. The figures also show the 1979 FHAD flow at these same locations for comparison. **Figures 3-3** through **3-8** show that the FHAD flows are consistently higher than the upper 5% confidence limit of a statistical analysis of the gage records for both the 10-year and 100-year flood events. At Logan Street, the gage indicates the 100-year flow upper 5% confidence band is 2,548 cfs per UDFCD Gage 603, whereas the 1979 FHAD at the same location is 4,860 cfs. **Figure 3-8** summarizes the results of the analysis by showing on a bar chart the 100-year flow comparison between the 1979 FHAD and Flood Frequency Analyses. The detailed stream gage data and results of the flood frequency analysis are provided in **Appendix B** – Flood Frequency Analysis.

Gage flows are expected to be lower than model results that do not account for inadvertent detention of stormwater runoff (i.e., ponding in street intersections, clogged and undersized drains, and other factors that slow the discharge of runoff into the waterway). However, the importance of this analysis is to indicate that the 1979 FHAD flows are reasonably conservative based upon the last 34 years of record.

3.1.3 Hydrologic Modeling Methodology

The objective of the existing condition hydrologic analysis is to study the Harvard Gulch basin using several different hydrologic models to recommend a design flow to be used for infrastructure design.

High Line Canal flows across the Harvard Gulch watershed, which 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.

3.1.4 Hydrology Resolution

As further validation that the 1979 FHAD flows are reasonable, the CUHP2005/EPASWMM 5.0 models were also calibrated to the 2-year gage flows. Although 34 years of stream flow gage record may not show a 100-year event, it is sufficient to show a 2-year flood event. Statistical analysis indicates that there is certainty within the 34 years of gage records that a 2-year flow has been observed over that period. Therefore, there is confidence calibrating the CUHP2005/EPASWMM 5.0 models to the FFA gage analysis for the 2-year flow at each of the gages assuming no inflow from the tributary watershed upstream of the High Line Canal. Once calibrated to the 2-year flows, the models were run for the 100-year rainfall with the entire tributary basin. The result was a 100-year discharge within 2% of the 1979 FHAD flows at Logan Street.

The different hydrologic analyses performed for the Harvard Gulch watershed using CUHP2005/EPASWMM 5.0 are shown below for comparison with the previously published 1979 FHAD flows:

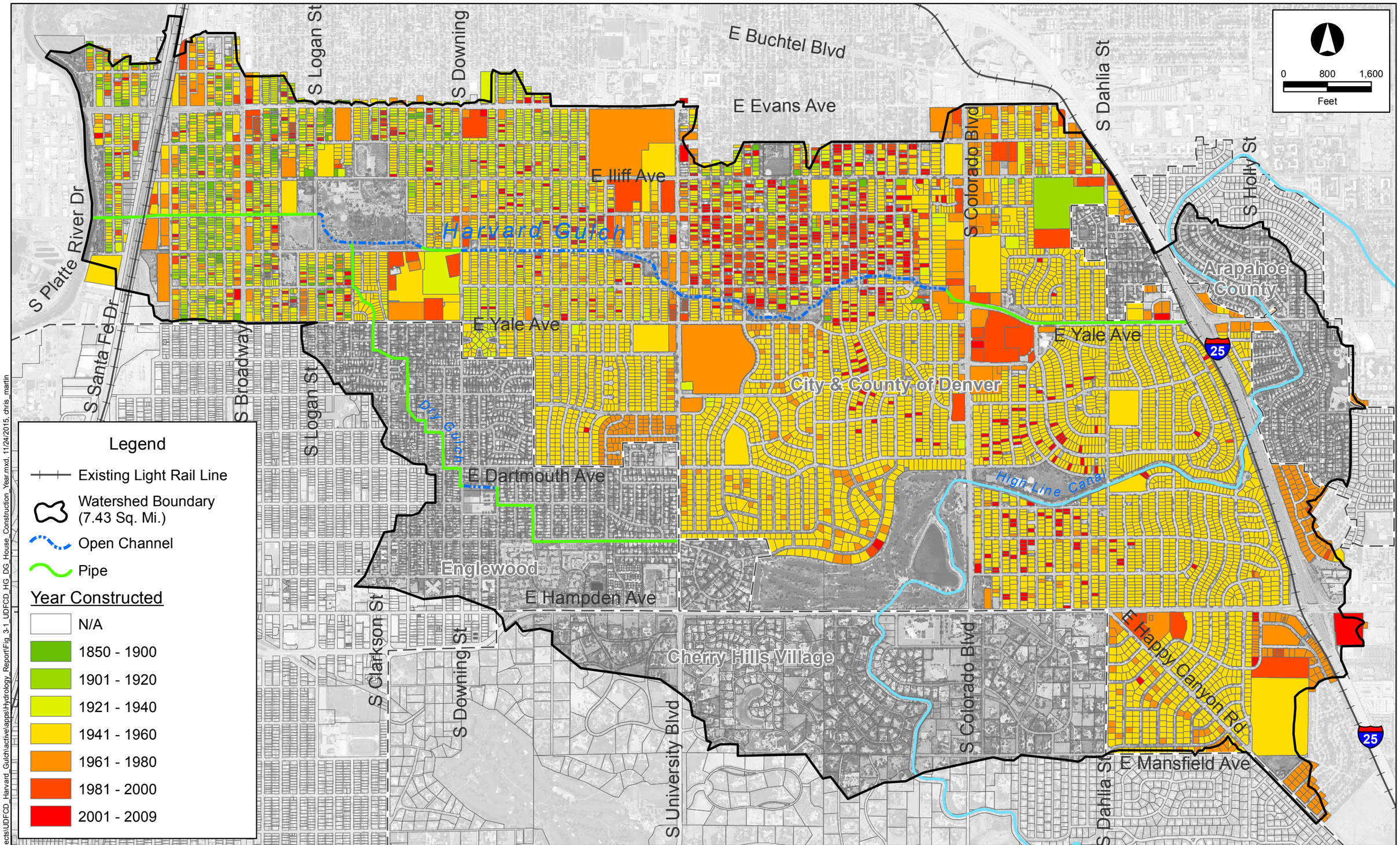
Table 3-2 Hydrologic Methodology Comparison

CUHP2005/EPASWMM 5.0 Model	Q100 Result at Logan (cfs)
1979 FHAD	4,860
Uncalibrated Model	7,849
Calibrate the 100-year discharge to the FHAD	4,952
Calibrate the 2-year discharge to statistical stream gage data	4,949

Table 3-3 summarizes the different hydrologic modeling input parameters used for each model. The analysis included different hydrologic models and statistical analyses of the gages.

The baseline hydrology model was calibrated to reconcile the 1979 FHAD flows for this FHAD study. The flow gages located on Harvard Gulch have a significant amount of data and over the approximate 34 years of data, no event larger than 2,120 cfs has been seen at Logan St. which reinforces that the 100-year flow rate should not be increased from the 1979 FHAD study due to new model results. Furthermore, UDFCD has studied the Harvard Gulch basin and researched rain and stream gage data more than any other basin in Denver, and none of the analyses support a change to the 1979 FHAD flows.

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



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URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DG

HOUSING CONSTRUCTION YEAR

FIGURE 3-1

E Buchtel Blvd
E Evans Ave
E Iliff Ave
E Yale Ave
E Dartmouth Ave
E Hampden Ave
E Mansfield Ave
E Happy Canyon Rd
S Logan St
S Downing
S Dahlia St
S Colorado Blvd
S Holly St
S Platte River Dr
S Santa Fe Dr
S Broadway
S Clarkson St
S University Blvd
Harvard Gulch
City Ditch
High Line Canal
Skeel Res.
Arapahoe County
City & County of Denver
Englewood
Cherry Hills Village
25

0 800 1,600
Feet

893 Acres
19% of Harvard Gulch Area

Legend

- Existing Light Rail Line
- Open Channel
- Pipe
- Watershed Boundary (7.43 Sq. Mi.)
- Secondary basin
- Subbasin
- Tributary Area

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URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION HARVARD GULCH & DRY GULCH

WATERSHED AREA TRIBUTARY TO THE HIGH LINE CANAL

FIGURE 3-2

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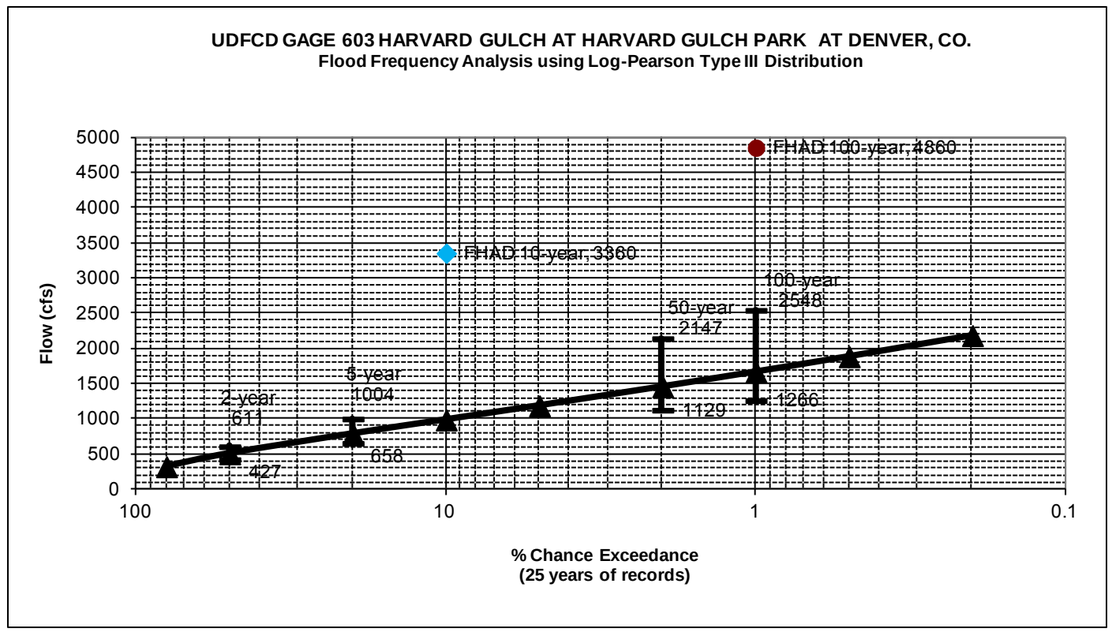


Figure 3-3 UDFCD Gage 603 at South Logan Street

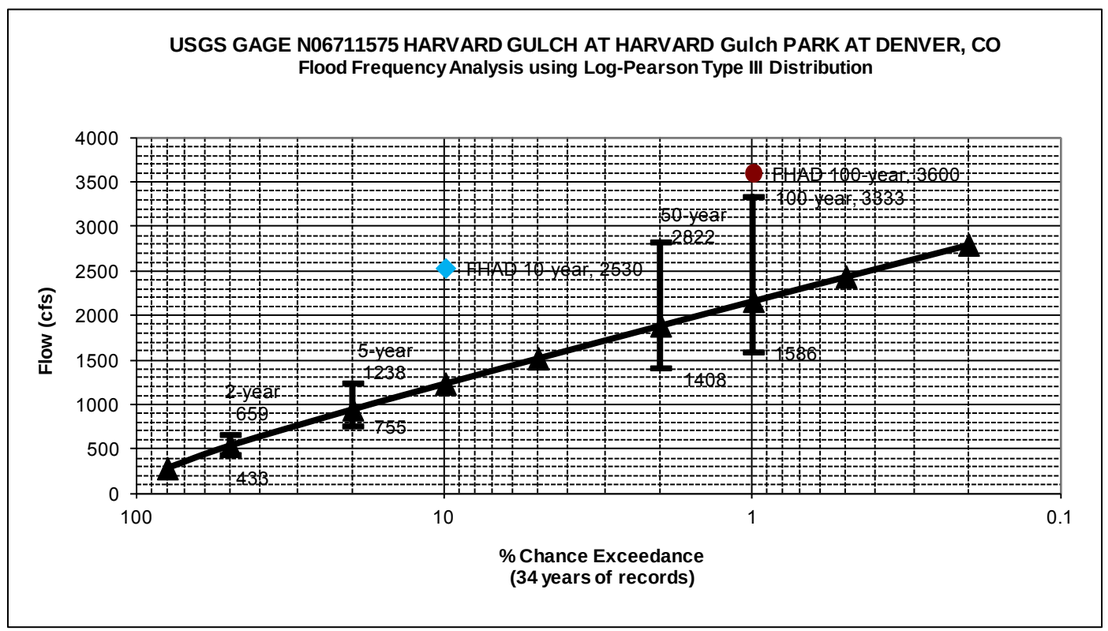


Figure 3-4 USGS Gage N06711575 at Harvard Gulch Park

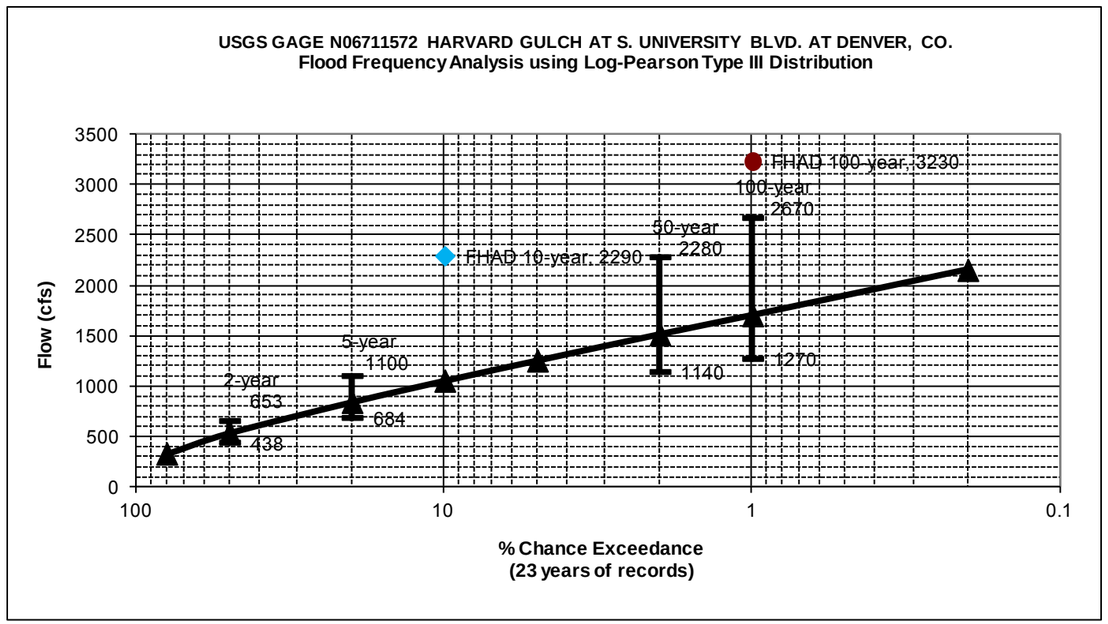


Figure 3-5 USGS Gage N06711572 at South University Blvd

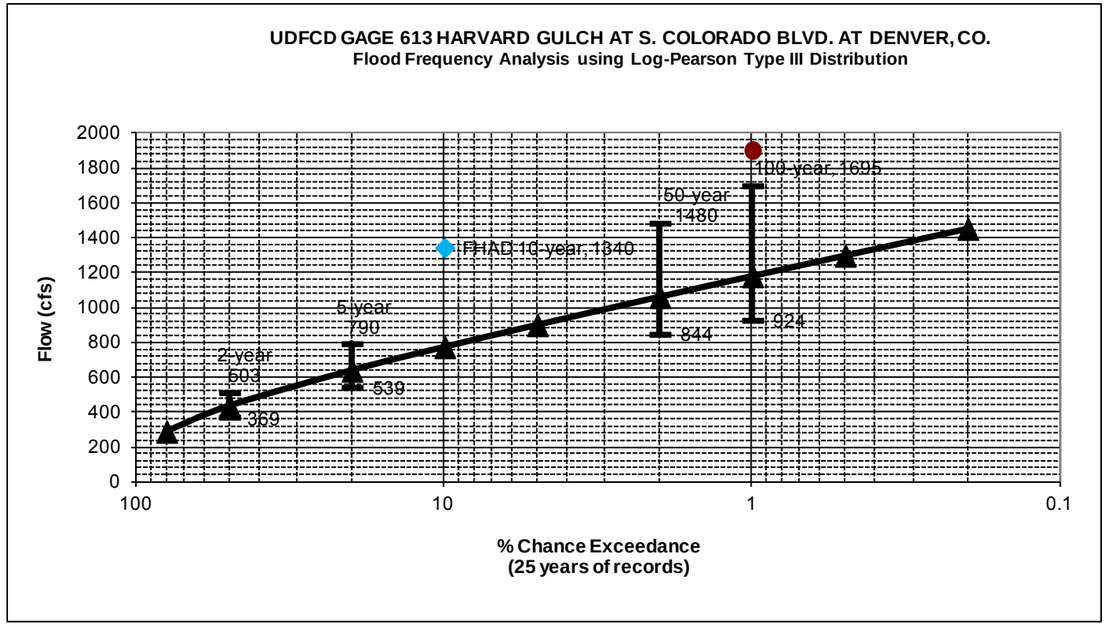


Figure 3-6 UDFCD Gage 613 at South Colorado Blvd

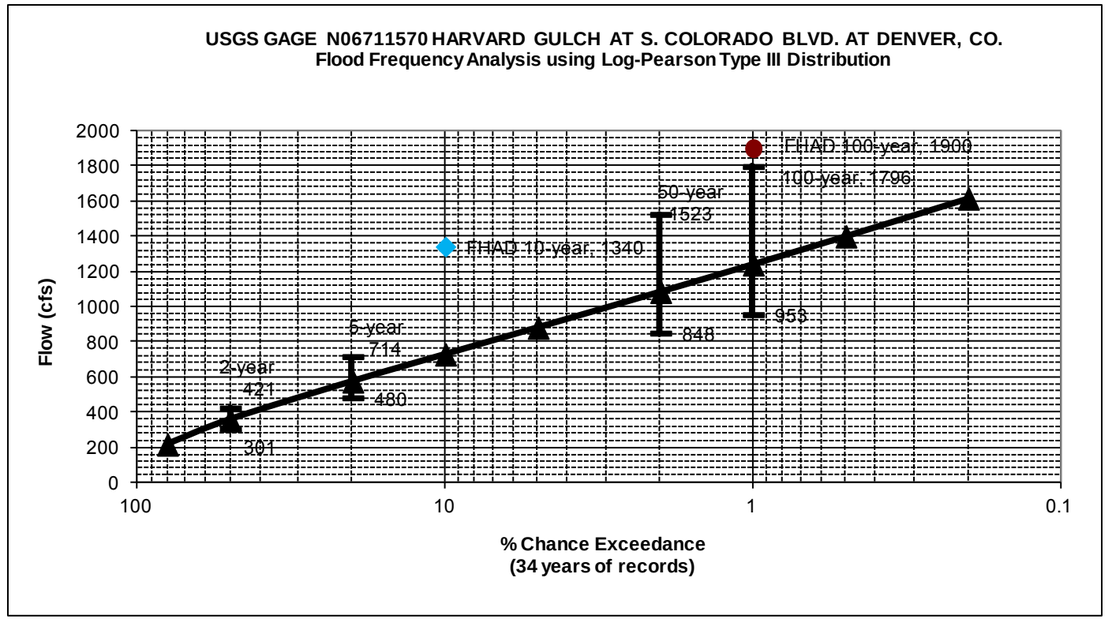


Figure 3-7 USGS Gage N06711570 at South Colorado Blvd

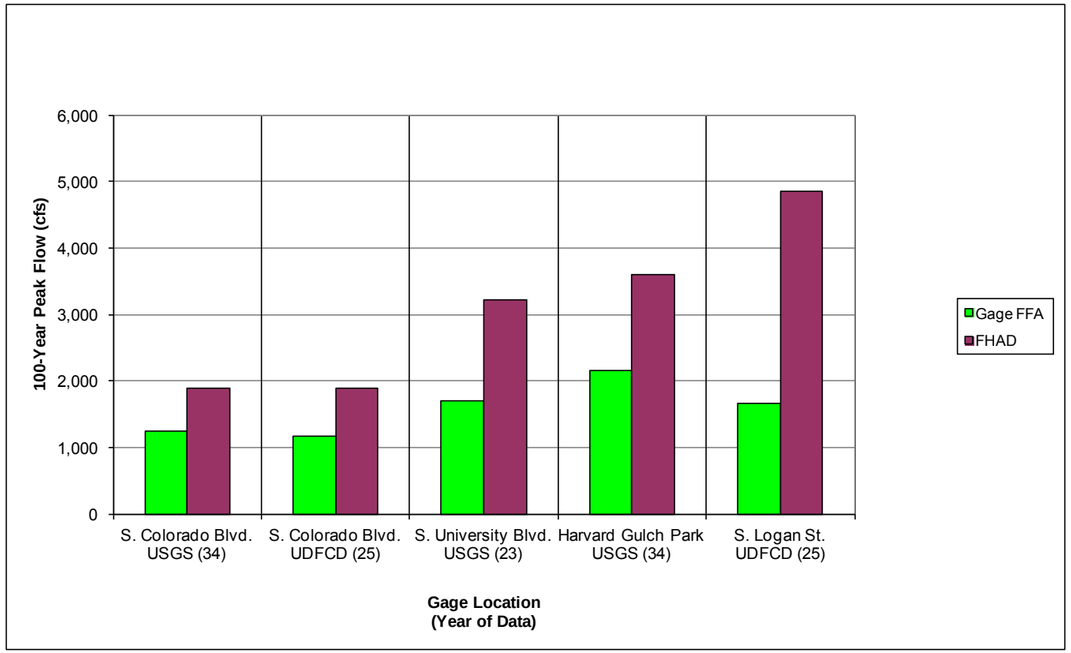


Figure 3-8 100-Year Flow Comparison

Table 3-3 Input Parameters

Study	Hydrology Model	Basin Area (sq mi)[1,2]	Manning's n	100yr Rainfall	Unit Hydrograph Factors Ct/Cp	Routing Method	Cross Section Measurement	Average % Impervious
FHAD Study 1979	CUHP1969	7.69	0.015-0.120	2.30 in. (1hr)	N/A	Kinematic Wave	Digitized from aerial. Surveyed at bridges	40%
Gage Analysis	FFA (Log-Pearson III Statistical Analysis)	3.98	N/A	N/A	N/A	N/A	N/A	N/A
Harvard Gulch Hydrology Study	CUHP2005/EPASWMM 5.0	7.43	0.020-0.052	2.57 in. (1hr)	Unadjusted	Kinematic Wave	Tape surveyed main stem. Adopted all others from CDM.	49.9%
Harvard Gulch Hydrology Study	CUHP2005/EPASWMM 5.0 Calibrated	7.43	0.020-0.052	2.57 in. (1hr)	Adjusted	Kinematic Wave	Tape surveyed main stem. Adopted all others from CDM.	49.9%

Notes: [1] Basin areas for the 1979 FHAD and Harvard Gulch Hydrology Study were computed at the confluence with the South Platte River.

[2] The gage for which data was analyzed is at South Ogden Street, the basin area shown is as provided by the USGS gage record.

Table 3-4 Comparison of 100-Year Model Outputs

Hydrology Model/ Area	Outfall to SPR @ East Wesley Ave. DP 1150	100-year Flow (cfs) @ Gage Location				
		UDFCD Gage 603 - Harvard Gulch Park @ South Logan St. DP 1080	USGS NO6711575 Harvard Gulch Park @ D/S of South Ogden St. DP 1450	USGS NO6711572 Harvard Gulch @ D/S of South University Blvd. DP 1590	UDFCD Gage 613 Harvard Gulch @ D/S of South Colorado Blvd. DP 1700	USGS NO6711570 - Harvard Gulch @ D/S of South Colorado Blvd. DP 1700
Tributary Area (Ac)	**4386.9**	**4213.0**	**2845.1**	**2450.8**	**1462.2**	**1462.2**
CUHP 1969	5,350	4,860	3,600	3,230	N/A	1,900
FFA	N/A	1,672	2,161	1,700	1,177	1,239
CUHP/EPASWMM	7,836	7,849	5,953	5,731	4,158	4,067
CUHP/EPASWMM Calibrated	5,085	4,952	3,623	3,245	1,980	1,980

3.2 Design Rainfall

Rainfall depth and distribution has been updated to current UDFCD-USDCM criteria for use in the baseline hydrologic model. Rainfall duration and 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 Harvard Gulch watershed to the South Platte River is 7.43 square miles. For watersheds less than 10 square miles, the UDFCD-USDCM stipulates that the 1-hour point precipitation depth be used and that no reduction in that depth for area be applied.

The one-hour point rainfall depths for the 2-, 5-, 10-, 50- and 100-year events were read from Table 5.1 One-hour Point Rainfall Depths in the *City & County of Denver Storm Drainage Design and Technical Criteria (Denver SDDTC)*. The one-hour point rainfall depth for the 25-year event was not provided in the *Denver SDDTC* and was read from Figures RA-4 in the UDFCD-USDCM and compared with the interpolated one-hour rainfall depth from the five known frequency-rainfall depth data. Selected point rainfall depths for this and the other design events are given in **Table 3-5** below. **Table B-1** in **Appendix B** shows the detailed rainfall distributions for each event.

Table 3-5: One-Hour Point Rainfall Depths (Inches)

2017 Harvard Gulch FHAD					
2-Year	**5-Year**	**10-Year**	**25-Year**	**50-Year**	**100-Year**
0.95	1.34	1.55	1.98	2.25	2.57

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 and distance to centroid values. The future conditions flow path lengths and distance to centroid values were determined using the approved subdivision drainage studies, where applicable.

3.3.1 Subwatershed Delineation

The subwatersheds within the study area were delineated based on the 2014 Denver Storm Drainage Master Plan and resulted in no single subwatershed exceeding 130-acres in area, and individual subwatersheds averaged no more than 100 acres per standard guidance from UDFCD. A total of 121 subwatersheds were delineated in this Harvard Gulch study area. The minimum, maximum and average sizes of the subwatersheds are summarized in **Table 3-6**.

Table 3-6 Summary of Subwatersheds Delineation

Total Area (sq. mi.)	Sub-basin Area (acre)			Total No. of Sub-basins
	Average	Minimum	Maximum	
7.43	39	9	128	121

3.3.2 Watershed Imperviousness

A GIS-based approach was used to calculate the percent of impervious area within the watershed based upon land use information. The land use data described in the previous section was used in conjunction with Table RO-3 and Figures RO-3 through RO-5, from the UDFCD Drainage Criteria Manual, to create percent impervious values for each land use type. **Table 3-7** lists each land use type and the associated percent impervious values used in the analysis. GIS data representing land use was intersected with sub-basin polygons to calculate area-weighted, or composite, percent impervious values for each sub basin. To more accurately reflect imperviousness for planned developments, the 2009 Evans Station Area Plan was used to supplement the land use data. Percent impervious values for future conditions are shown in **Figure B-1 Interactive Hydrology Map**.

Existing/future development conditions for the composite watershed were calculated to be 49.9 percent imperviousness.

Table 3-7 Summary of Future Land Use (FLU) Imperviousness

Future Land Use	Percent Imperviousness*	Percentage of Watershed Area
Business - Commercial	95	6.3%
Business - Residential	85	3.1%
Industrial	90	0.1%
Industrial - Light	80	0.5%
Park	5	7.8%
Railroad Corridor	40	0.7%
Residential - Multi-Unit Attached	75	7.1%
Residential - Multi-Unit Detached	60	1.9%
Residential - Single Unit	50	58.5%
Residential - Single Unit, Min Lot 0.5 AC	50	0.0%
Residential - Single Unit, Min Lot 1 AC	32	2.4%
Residential - Single Unit, Min Lot 1.25 AC	28	4.3%
Residential - Single Unit, Min Lot 2.5 AC	22	4.6%
Roadway	90	0.1%
School	50	2.5%

* Percent imperviousness were determined using UDFCD USDCM Table RO-3.

3.3.3 Depression Loss

Depression losses were determined using Table RO-6 in the 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, as defined by the NRCS. The soils are generally characterized by moderate (0.15-0.30 in/hr) to low (0.05-0.15 in/hr) infiltration rates.

3.3.5 Detention Basin Facilities

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

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

1. Skeel Reservoir at Wellshire Municipal Golf Course in Denver, 25.9 acre-feet of storage
2. Harvard Gulch Park Irrigation Pond adjacent to waterway at Clarkson in Denver, 11 acre-feet of storage at the spillway crest
3. Packy Romans Park detention facility at East Floyd Avenue & South High Street in Englewood, 1.6 acre-feet storage

Stage-storage-discharge curves were developed for each of the three facilities. EPA SWMM uses a synthetic prismatic volume with base area of one acre and an outlet rating curve of head-discharge to simulate the detention system. However, the stage-storage-discharge curve of the Harvard Gulch Park Irrigation Pond was re-evaluated using the latest topography data as described in Section 1.4 and as-built plans and profiles. The curves are included in **Table B-3** in **Appendix B**.

3.4 Hydrograph Routing

Parameters for the SWMM model conveyance elements were determined using the mapping described in Section 1.4 and GIS layers for the existing storm drainage system provided by Denver. Manning's roughness values were determined based on the 2012 and supplemental 2009 aerial imagery and supplemented by field observation. **Table 3-8** provides the Manning's ***n*** values selected for use in the Corrected (Baseline) Hydrology Model and also provides the 1979 FHAD study values for comparison. In the SWMM routing model, the Manning's ***n*** values were increased by 25 percent, except the Equation RO-10 was used for estimating Manning's ***n*** for natural channel in accordance with the UDFCD-USDCM.

Table 3-8 Manning's Roughness Coefficient & Comparison

Harvard Gulch 2017 FHAD		
Routing Element Description	**Original 'n'**	**Increase 'n' by 25%***
Reinforced Concrete Pipe	0.015	0.019
Asphalt Pavement	0.016	0.020
Open Channel - Paved	0.015	0.019
Open Channel - natural	0.035	N/A
Harvard Gulch 1979 FHAD		
Channel	0.015-0.04	N/A
Overbank	0.035- 0.12	N/A

Major underground storm system facilities were modeled and overflow elements were added parallel to the storm pipes in the model to route surface flows exceeding the capacity of the storm pipes without counting inadvertent detention. At locations where split flows occur, this is the result of the storm system contravening topography where flows in the pipes are routed down streets and do not follow surface flows based upon topography. There are two split flows in the lower basin hydrologic model, which occur in East Evans Avenue at South Delaware Street and South Acoma Street where the Asbury Outfall system was designed with 5-year capacity. Therefore, in the model, only the capacity of the pipe is routed to the West Asbury Avenue Outfall, and the excess storm runoff will flow westerly to follow the surface topography to the Evans Station Area.

There are two split flows in the middle basin hydrologic model, which occur at South Marion Street and the side channel weir at South Ogden Street. The concrete lined trapezoidal channel transitions into a 14'x9' concrete box culvert at South Downing Street which has approximately 2,000 cfs of capacity. Portions of the peak discharge exceeding the capacity of the culvert will overtop the north bank and flow overland following the topographic thalweg within the area north of East Harvard Avenue to East Wesley Avenue into Harvard Gulch Park Golf Course Irrigation Pond via an existing 14'x7' arch pipe underneath South Ogden Street. In Reach 2, Harvard Gulch is designed with a capacity of 1,600 cfs; the high flow will spill over a 174-foot long side channel weir structure during a major flood to a flood control detention facility in Harvard Gulch Park Golf Course Irrigation Pond.

EPA SWMM 5.0 model elements, including subwatersheds, design points and conveyance elements are shown on **Figure B-1 Interactive Hydrology Map** in **Appendix B**.

The highest watershed elevation is 5,638 feet at the neighborhood of Happy Canyon Road and South Hillcrest Drive at the southeast corner of the watershed. The lowest watershed elevation is 5,240 feet on South Platte River at the northwest corner of the watershed. The average watershed slope is 1.28 percent measured following the topographic thalweg.

3.5 Model Calibration

The hydrologic model for this study was converted from the 2014 SDMP model to the latest version of CUHP 2005 1.4.4/EPA SWMM 5.0.022. Denver's SDMP did not model the major drainageway – only tributary inflows. For the purpose of this FHAD, the routing elements representing conveyance of the major drainageway were established in this new model to route the runoff hydrographs through the entire watershed. The raw model creates an un-calibrated flow of 7,849 cfs at South Logan Street. The un-calibrated flow is 62 percent higher than the FHAD flow of 4,860 cfs at South Logan Street.

To reconcile the FHAD flows with the 1979 FHAD flows, the time to peak coefficient (Ct) and the unit hydrograph peaking coefficient (Cp) values were adjusted in the new CUHP model. First, the calibration process was initiated by a global watershed adjustment of the Ct and Cp to attain a 100-year discharge which roughly matched the 100-year flow of the 1979 FHAD at South Logan Street. Secondly, the calibration process was continued from the upper watershed downstream. The model was calibrated at the design points where comparable discharges and/or hydrographs are available from the 1979 FHAD on Harvard Gulch. The calibration was completed at five design points on Harvard Gulch and one design point on Dry Gulch. The discrepancies of 100-year flows are less than ±5 percent between the calibrated flows and the 1979 FHAD flows. **Table 3-9** shows the comparison of calibrated peak discharge. **Table B-4** in **Appendix B** contains

baseline hydrology peak flows at all design points for all events. The runoff hydrographs were compared at five design points on Harvard Gulch and one design point on Dry Gulch. **Figure 3-9** shows the comparison of hydrographs at these design points. The adjusted Ct and Cp values are listed in **Table B-2** in **Appendix B**.

Table 3-9 Comparison of Calibrated Peak Discharges

Location	Harvard Gulch FHAD 1979			Harvard Gulch FHAD 2017			Comparison	
	Design Points	Drainage Area (sq.mi.)	100-Year (cfs)	Design Points	Drainage Area (sq.mi.)	Calibrated 100-Year (cfs)	FHAD 2017 minus FHAD 1979)/ FHAD 1979 Area	100-Year
Harvard Gulch								
Colorado Blvd	NA	1.9	1,900	Junct_1700	2.3	2,003	20%	5.4%
Race Street	NA	3.8	3,230	Junct_1570	3.9	3,188	3%	-1.3%
Downing Street	NA	4.3	3,600	Junct_1550	4.4	3,559	3%	-1.1%
Logan Street	NA	6.3	4,860	Junct_1080	6.6	4,895	4%	0.7%
S. Platte River	NA	7.7	5,350	Root_Junct_1150	6.9	5,030	-11%	-6.0%
Dry Gulch								
Harvard Gulch	NA	1.8	1,332	Junct_1212	1.9	1,320	7%	-0.9%

3.6 Previous Study

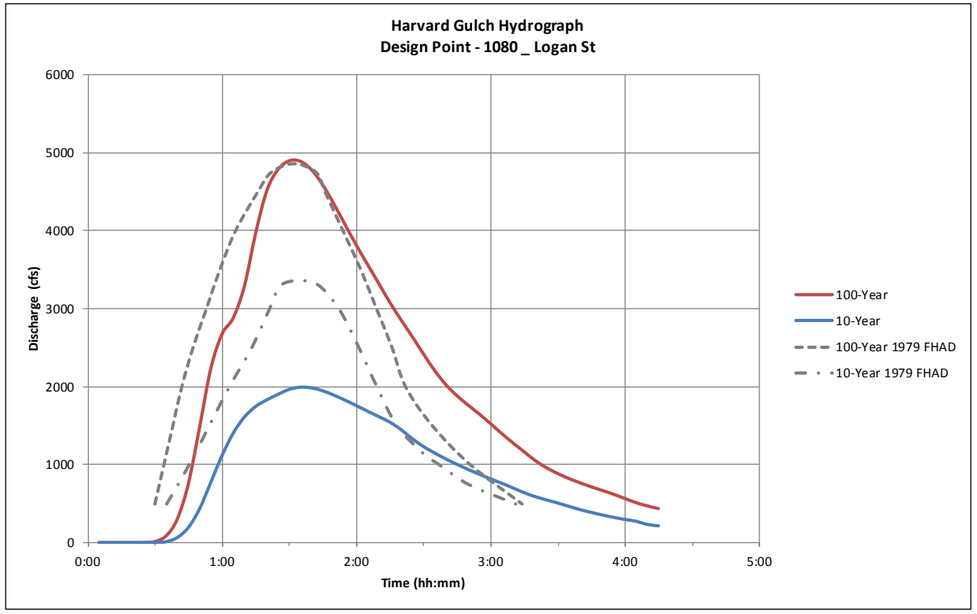
The *Flood Hazard Area Delineation, Harvard Gulch, West Harvard Gulch and Dry Gulch*, December 1979 by Gingery Associates, Inc. documented the hydrology for Harvard Gulch and was adopted by FEMA as the regulatory discharges. Harvard Gulch has a FEMA regulated floodplain, consisting of Zone AE, AO 1 and 2 foot, and a 1-foot rise floodway as shown on the effective FIRM Panel No. 0800460211H, effective date November 20, 2013 and FIRM Panel No. 0800460212G, effective date November 17, 2005.

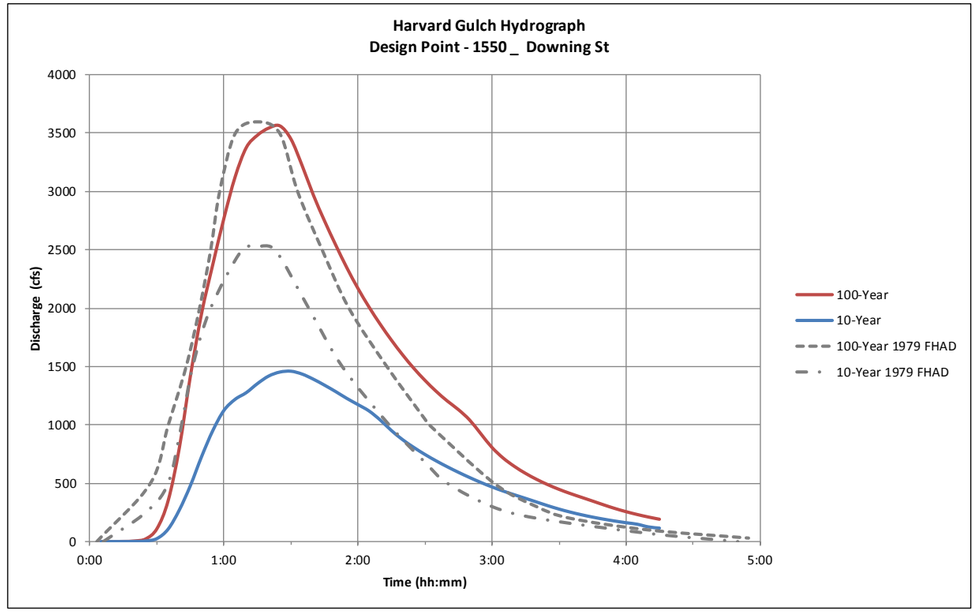
3.7 Result of Analysis

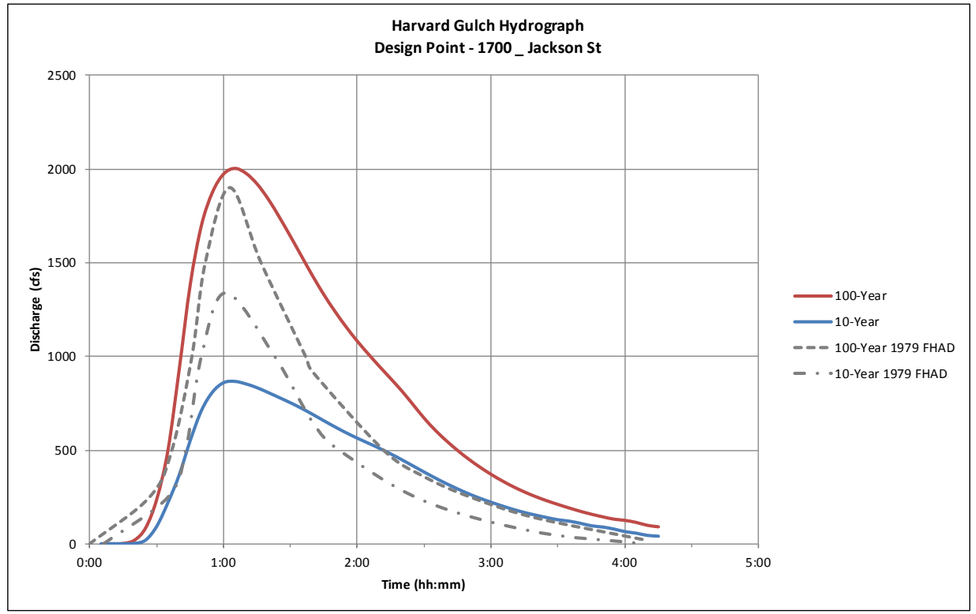
A summary of peak flow rates and runoff volumes at key design points are provided in **Table 3-10**. The computed baseline peak discharges and volumes for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events for all of the EPA SWMM 5.0 design points can be found in **Table B-5** in **Appendix B**.

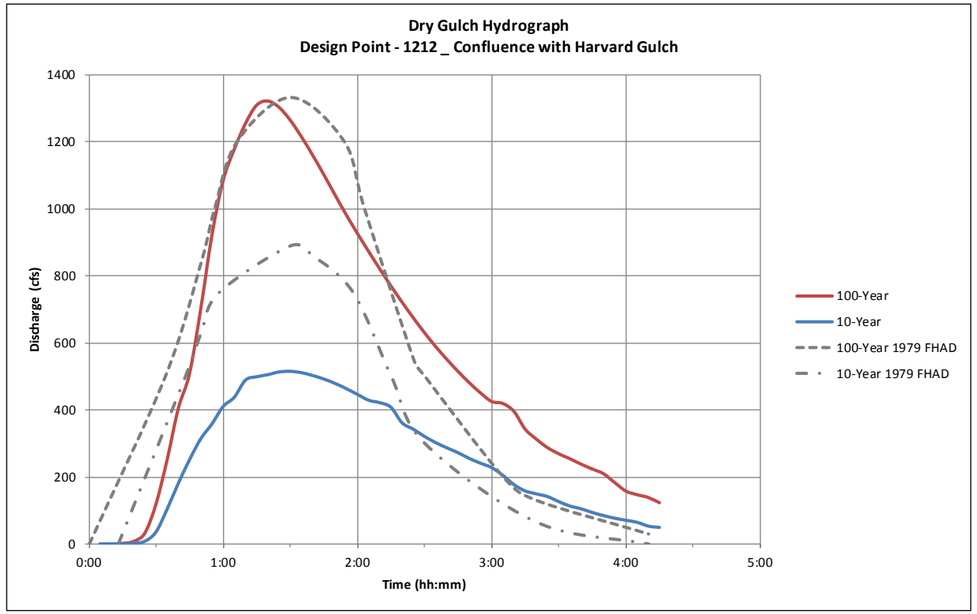
Figure B-2, B-3 in **Appendix B** shows the peak discharge versus location (station) for Harvard Gulch and Dry Gulch for all storm events. **Figure B-4** in **Appendix B** shows hydrographs generated by EPA SWMM 5.0 for the 10-year and 100-year storms at key design points in the study area.

Figure 3-9 Comparison of Calibrated Storm Hydrographs









Note: 10-Year 1979 FHAD and 100-Year 1979 FHAD storm hydrographs were derived from Figure 4, 5, 6 and 7 of the FHAD Harvard Gulch, West Harvard Gulch and Dry Gulch, December 1979 by Gingery Associates, Inc.

Table 3-10 Peak Flow and Runoff Volumes – Future Condition

Locations	Design Points / Conveyance Elements	Total Drainage Area		Station	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
		(acres)	(mi^2)	(ft)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
Harvard Gulch																
Confluence with S Platte River	Root_Junct_1150	4387	6.85	0+00	902	1676	2068	3250	3999	5030	147	265	333	494	589	717
S Delaware St	Junct_1160	4338	6.78	14+00	890	1656	2046	3241	3968	5000	145	262	329	488	582	708
Broadway	Junct_1180	4280	6.69	27+00	874	1628	2025	3219	3933	4956	142	258	324	480	573	697
S Logan St	Junct_1080	4213	6.58	41+00	860	1605	1995	3196	3905	4895	139	253	318	472	564	686
S Pearl St/ Confluence with Dry Gulch	Junct_1200	4169	6.51	50+00	860	1600	1986	3193	3892	4884	141	254	319	472	563	684
S Ogden St	Junct_1450	2845	4.45	64+00	649	1185	1465	2085	2087	2091	103	181	226	322	359	390
E. Havard Ave Culvert	1551	2829	4.42	71+00	645	1178	1457	2072	2072	2072	-	-	-	-	-	-
S Downing St	Junct_1550	2829	4.42	71+00	645	1178	1457	2375	2873	3559	102	180	224	329	391	474
S Franklin St	Junct_1480	2613	4.08	84+00	596	1089	1346	2204	2663	3300	94	165	205	302	359	435
S Race St	Junct_1570	2510	3.92	97+00	577	1052	1302	2134	2567	3188	90	158	197	290	345	418
S University Blvd	Junct_1590	2451	3.83	114+00	570	1039	1281	2101	2537	3190	89	155	194	284	338	408
S Clayton St	Junct_1650	2306	3.60	127+00	537	990	1216	1993	2405	3016	83	145	181	266	316	382
S St. Paul St	Junct_1680	1713	2.68	140+00	458	834	1006	1617	1927	2388	69	119	148	215	255	308
S Cook St	Junct_1690	1614	2.52	151+00	442	795	957	1530	1817	2242	66	113	140	204	241	291
S Monroe St	Junct_1702	1510	2.36	158+00	414	738	887	1414	1677	2068	62	106	131	191	226	273
S Jackson St	Junct_1700	1462	2.28	165+00	403	716	866	1374	1627	2003	60	103	128	186	220	265
S Colorado Blvd	Junct_1730	1418	2.22	172+00	390	694	839	1332	1577	1941	58	100	124	180	213	256
S Clermont Dr	Junct_1740	1104	1.73	186+00	284	516	628	1014	1202	1482	43	74	93	137	162	196
S Dahlia St	Junct_1754	850	1.33	199+00	220	394	481	765	906	1118	34	58	73	106	126	152
S Glencoe St/ I-25	Junct_349	285	0.45	211+00	77	136	164	263	311	375	12	20	25	36	43	52
Dry Gulch																
Confluence with Harvard Gulch	Junct_1212	1234	1.93	0+00	233	410	514	858	1042	1320	37	71	90	137	165	202
E. Yale Ave/S. Washington St	Junct_1210	1182	1.85	19+27	219	380	486	817	989	1253	34	67	85	130	157	192
E. Amherst Ave/S. Clarkson St	Junct_1230	1150	1.80	27+67	213	369	472	796	961	1220	33	65	82	126	152	186
E. Bates Ave/S. Emerson St	Junct_1250	1076	1.68	35+25	192	343	439	741	896	1136	31	60	76	118	141	173
S. Ogden St	Junct_1270	1004	1.57	42+47	175	316	403	684	825	1048	28	55	70	109	131	160
E. Dartmouth Ave/S. Downing St	Junct_1294	925	1.44	55+48	157	288	367	626	755	957	25	50	64	99	119	147
S. Downing St/Barde Park d/s	Junct_1292	901	1.41	59+34	151	280	357	610	735	931	24	48	62	96	116	142
S. Lafayette St/Barde Park u/s	Junct_1300	836	1.31	65+25	127	245	318	542	655	833	21	43	56	88	106	130
E. Eastman Ave/S. Franklin St	Junct_1320	791	1.24	72+53	104	221	287	498	603	768	19	39	51	81	98	121
E. Floyd Ave/S. University Blvd	Junct_1360	637	1.00	101+80	65	155	205	365	446	571	12	28	37	61	74	93

4.0 HYDRAULIC ANALYSIS

Future imperviousness is reasonably similar to existing conditions, since the watershed is essentially fully developed and experiencing redevelopment. Floodplain delineations are based on results from future conditions (fully developed) hydrology. The future peak flows are well within 130% of the existing peak flows.

One-dimensional and two-dimensional hydraulic models were utilized jointly in this study to complete the floodplain analysis and capacity assessment of the culverts and crossing structures. The hydraulic conditions for the Harvard Gulch and Dry Gulch waterways are complex because of the significant development in the 100-year floodplain and floodway as described in Section 2.1. The waterway west of South Logan Street is piped underground; however, this outfall system is only capable of conveying 2,200 cfs and leaves approximately 2,730 cfs flowing overland northwesterly to the South Platte River in a 100-year flood event. Similarly, for all other areas where the 100-year flow exceeds the capacity of the existing underground storm sewer system, surface flow modeling was completed by subtracting out the flow in the pipe/box network. The terrain flattens out east of South Sherman Street with an average ground slope of 0.7 percent toward the South Platte River. The streets, traffic islands, railroads, curbs and gutters and cross pans divert and split flood flow into numerous flow paths which are too complicated to be accurately modeled using the HEC-RAS program, a one-dimensional hydraulic model. The flow centerline and cross sections required for a HEC-RAS model are not easily definable for the urbanized overland flow patterns. A two-dimensional hydraulic analysis works by solving the full dynamic equations and balancing the flow volumes in all directions at each grid cell to define the overland flow direction and flow splits. A two-dimensional model is a more appropriate approach for the lower reach of Harvard Gulch than the one-dimensional hydraulic analysis for urban overland flow because water is not moving in only one direction. The two-dimensional flood routing program FLO-2D of the FLO-2D Software, Inc. was chosen for this study.

FLO-2D Overland Flow Floodplain – Downstream of Logan

FLO-2D computes overland flow in eight directions, reports on mass conservation, utilizes a variable time step incrementing and decrementing scheme, incorporates efficient numerical stability criteria, has unlimited array allocation (unlimited grid elements), includes graphical editing, and has output display processor programs. The data required for FLO-2D modeling are readily available for this basin and include a Digital Terrain Model (DTM), aerial photography, land use data, structure footprint data, street data and hydrology. The mapping information is described in Chapter 1.4 and the land use, structure footprints and streets are in the format of shapefiles which were obtained from the City and County of Denver's GIS database. The grid developer system program (GDS) was utilized to import the DTM, imagery data, set up the grid system, define the calculation boundary and assign hydraulic factors at each grid for the overland flow analysis.

FLO-2D was used to model the overland flow study area generally bounded by the South Platte River on the west, South Logan Street on the east, East Iowa Avenue on the north, and East Harvard Avenue on the south. A grid size of 20 feet by 20 feet was used to calculate and map the overland flow path in FLO-2D. The ground surface was created using GDS by interpolating the elevation points from the DTM (derived from the 2014 LiDAR Digital Elevation Model (DEM)) at each cell and assigned an elevation. Manning's ***n*** for each grid was defined as 0.05 for urbanized areas, 0.025 for parks and golf courses, and 0.02 for streets.

The floodplain element attributes can be modified to add detail to the predicted area of inundation. Area reduction factors (ARFs) and width reduction factors (WRFs) are coefficients that modify the individual grid element surface area storage and flow width. ARFs can be used to reduce the flood volume storage on grid elements due to buildings or topography. Using the ARFs, a grid element can be completely removed from receiving any inflow. WRFs can be assigned to any of the eight flow directions in a grid element and can partially or completely obstruct flow paths in any of the eight directions simulating floodwalls, buildings or berms. Both ARFs and WRFs were used in this model to represent flow obstructions of the buildings in this fully developed area. The surface storage area or flow path on grid elements was adjusted for the buildings footprints.

The FLO-2D levee component confines flow on the floodplain surface by blocking one of the eight flow directions. Levee components were used in this study at South Logan Street to limit the flow direction from flowing upstream because of the low-lying park area in the upstream channel. The levee components prevented the loss of volume by not allowing the inflow to fill back in the upstream channel which is full when water overtops South Logan Street during a 100-year event.

The peak inflow was derived from the weir flow calculation at South Logan Street which can be found in the Hydraulic Appendix. The peak flow of 2,730 cfs (100-year flow minus the flow in the underground box) was used to establish a steady flow hydrograph with a duration of 8.0 hours for input into the FLO-2D model, which was set up to avoid over-attenuation of the peak by minor inadvertent detention within the study area. The total inflow was spread into 20 cells with a total width of 400 feet to simulate overtopping at South Logan Street based on the flow overtopping distribution from the HEC-RAS analysis. Two-thirds of the total inflow was spread evenly into 10 cells centered over the low point in the crossing, however, the other one-third of the total inflow was spread evenly into 10 cells located in the left portion of this crossing where the depth of overtopping is shallower.

HEC-RAS Channel Flow Floodplain – Upstream of South Logan Street

A total of 4.77 miles of waterway were studied with a detailed HEC-RAS hydraulic model for Harvard Gulch upstream of South Logan Street to South Colorado Boulevard, and Dry Gulch from East Harvard Avenue to South University Boulevard at the corporate limits of the City of Englewood. Separate models were developed for Harvard Gulch and Dry Gulch due to the complexity of the confluence area. The HEC-RAS model of Harvard Gulch analyzed 2.4 miles of the Harvard Gulch *Main Stem* and 0.4 miles of the Harvard Gulch *Split Flow Reach* as shown in **Figure 4-1**. The HEC-RAS model of Dry Gulch analyzed 1.93 miles of the waterway.

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 waterway to establish the portion of the channel that must remain free

Limit of Study

FLO-2D Analysis

HEC-RAS Reach HG 01

Split Flow Model 0.4 Miles HEC-RAS Reach HG Split 01

HEC-RAS Analysis: Harvard Gulch Main Stem 2.43 Miles
HEC-RAS Reach HG 02

Limit of Study

HEC-RAS Reach DG 01

HEC-RAS Analysis
Dry Gulch Main Stem 1.93 Miles

Shallow Overland Flow Analysis

Shallow Overland Flow Analysis

Limit of Study

S Logan St
S Downing St
S University Blvd
S Colorado Blvd
S Dahlia St
S Holly St
E Buchtel Blvd
E Evans Ave
E Iliff Ave
S Platte River Dr
S Santa Fe Dr
S Broadway
S Logan St
S Clarkson St
S Downing St
S University Blvd
S Colorado Blvd
E Yale Ave
E Dartmouth Ave
E Hampden Ave
Harvard Gulch
Dry Gulch
High Line Canal
Englewood
City & County of Denver
Arapahoe County
25

0 800 1,600
Feet

Legend
- Inundated Structure
- Existing Light Rail Line
- 100 Year Flood Hazard Area
- 100 Year Shallow Flooding

Overland Flow
- Depth < 1 ft.
- Depth 1 - 2 ft.
- Depth > 2ft.

Study Reach
- Open Channel
- Pipe

No.	DATE	DESCRIPTION	APPR.

Matrix DESIGN GROUP

designed by:
drawn by: CM, AS
checked by: RK
project no.: 15.155.023
date: 11/01/2016

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

FLOOD HAZARD STUDY EXTENTS MAP

FIGURE 4-1

FILE: G:\gis_projects\UDFCD_Harvard_Gulch\active\apps\FHAD\Fig_4-1_UDFCD_HG_DG_Flood_Hazard_Study_Extents_Map.mxd, 11/1/2016, andrea_santoro

from obstructions to preserve conveyance of the 100-year flood. A maximum of 0.5-foot rise in either the hydraulic or energy grade line elevation was utilized in this study to define the floodway, in accordance with the updated Colorado Water Conservation Board, ***Rules and Regulations for Regulatory Floodplains in Colorado***, dated November 17, 2010.

The U.S. Army Corps of Engineer's step backwater program HEC-RAS, Version 4.1.0, was used for the subcritical floodplain analysis of the waterway. Cross sections for use in the HEC-RAS model were developed electronically by cutting the triangulated irregular network (TIN) developed from the 2014 LiDAR DEMs.

Flood profiles for the 10-year, 50-year, 100-year and 500-year events are provided in **Appendix H**. The floodplain mapping and channel profiles show the location of cross-sections for the channel and all hydraulic structures.

A total of 126 cross sections were used in the Harvard Gulch *Main Stem* hydraulic model and 27 cross sections were used in the Harvard Gulch *Split Flow* hydraulic model. The junction option in the HEC-RAS program was used to connect the split flow reach with the main stem reach at Harvard Gulch Park downstream of the concrete baffled chute. A total of 84 cross sections were used in the Dry Gulch hydraulic model. 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 4-1** below:

Table 4-1 Summary of Geometry Input

Drainageway	Reach Length (ft)	Manning's N		Number of Cross Sections	Average Spacing (ft)	Bridge	Culvert	Lateral Structure	Inline Structure	Average Slope
		Overbank	Channel							
Harvard Gulch Main Stem	12,853	0.013 – 0.15	0.013 – 0.045	126	102	21	4	1	1	0.71%
Harvard Gulch Split Flow	2,122	0.015 – 0.15	0.015 – 0.15	27	76	0	1	0	0	1.17%
Dry Gulch	10,215	0.017 – 0.15	0.017 – 0.15	84	122	0	0	0	0	0.91%

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 based upon existing topographic conditions. 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 distribution of 50-, 100-, and 500-year flows between the Harvard Gulch *Main Stem* and the Harvard Gulch *Split Flow* models was determined by balancing the energy grade lines at the adjacent cross sections. Harvard Gulch has the capacity to contain the 10-year flood flow through the split flow reach. However, the 10-year flood flow in the Harvard Gulch Split Flow model was determined by the right overbank on cross section 7289, which is immediately upstream of the flow split. The split flow path begins downstream of this cross section where the overland flow will not return back to Harvard Gulch. The split flow reach encompasses several cross sections and a crossing structure. The lateral weir structure option in HEC-RAS cannot be coded through a roadway crossing structure; therefore, the HEC-RAS hydraulic model could not automatically determine the flow rate for the split flow. **Table C-2a** in **Appendix C** details the location of the flow changes. The capacity of the existing storm drain in Dry Gulch was subtracted from the peak flows derived from the results of the EPA SWMM 5.0 hydrograph routing. **Table C-2b** in **Appendix C** describes the overland flow by subtraction of the capacity of the existing underground storm systems. Pipe capacity was calculated assuming a normal depth analysis using Manning's Equation in a spreadsheet (see the Technical Appendices for details of the spreadsheet calculations). **Table 4-2** summarizes the hardwired hydrology used in the hydraulic model and the model cross sections where the flow change has been applied.

Table 4-2 Steady Flow Input in HEC-RAS Model

Harvard Gulch _ Peak Flows and Flow Change Locations - Future Condition

HEC-RAS Rivers/Reaches/Stations/Reference Locations				Profile Names & Flow Rates			
River	**Reach**	**Station**	**Reference Locations**	**Q_{10}**	**Q_{50}**	**Q_{100}**	**Q_{500}**
Harvard Gulch							
HG	HG_02	167+90	At outlet of 14'x9' CBC d/s of S. Colorado Blvd	866	1,627	2,003	2,619
HG	HG_02	158+89	S. Monroe St upstream	887	1,677	2,068	2,716
HG	HG_02	152+12	S. Cook St upstream	957	1,817	2,242	2,954
HG	HG_02	139+98	S. Saint Paul St/McWilliams Park	1,006	1,927	2,388	3,144
HG	HG_02	126+34	S. Clayton St/Harvard Gulch East Park	1,216	2,405	3,016	4,006
HG	HG_02	114+93	S. University Blvd upstream	1,302	2,567	3,190	4,337
HG	HG_02	84+57	S. Franklin St upstream	1,346	2,663	3,300	4,463
HG	HG_02	72+89	Alley S. Downing St/S. Marion St	1,457	2,873	3,559	4,747
HG	HG_02	72+58	Alley S. Downing St/S. Marion St upstream	1,393	1,170	1,570	2,150
HG	HG_02	72+27	Alley S. Downing St/S. Marion St downstream	1,393	1,780	2,060	2,150
HG	HG_02	71+59	N/A	1,393	1,780	1,823	2,150
HG	HG_02	71+14	S. Downing St upstream	1,393	1,780	1,823	1,920
HG	HG_02	60+27	Downstream of lateral structure in Harvard Gulch Park	1,216	1,380	1,451	1,633
HG	HG_01	52+21	S. Washington St/confluence of Harvard Gulch & split flow	1,995	3,905	4,894	6,385
Harvard Gulch Split Flow							
HG Split	Split_01	21+22	Alley S. Downing St/S. Marion St upstream	64	1,703	1,989	2,597
HG Split	Split_01	20+89	Alley S. Downing St/S. Marion St Upstream	64	1,093	1,499	2,597
HG Split	Split_01	20+16	N/A	64	1,093	1,736	2,597
HG Split	Split_01	19+66	S. Downing St upstream	64	1,093	1,736	2,827
HG Split	Split_01	9+28	Downstream of lateral structure in Harvard Gulch Park	241	1,493	2,108	3,114

Dry Gulch _ Peak Flows and Flow Change Locations - Future Condition

HEC-RAS Rivers/Reaches/Stations/Reference Locations				Profile Names & Flow Rates			
River	**Reach**	**Station**	**Reference Locations**	**Q_{10}**	**Q_{50}**	**Q_{100}**	**Q_{500}**
DG	DG_02	102+15	E. Floyd Ave/S. University Blvd	115	356	481	682
DG	DG_02	72+53	E. Eastman Ave/S. Franklin St	97	413	578	841
DG	DG_02	65+25	S. Lafayette St/Barde Park u/s	318	655	833	1,116
DG	DG_02	59+34	S. Downing St/Barde Park d/s	157	545	747	1,075
DG	DG_02	42+47	S. Ogden St	153	575	798	1,160
DG	DG_02	35+25	E. Bates Ave/S. Emerson St	189	646	886	1,278
DG	DG_02	27+67	E. Amherst Ave/S. Clarkson St	222	711	970	1,393
DG	DG_01	19+27	E. Yale Ave/S. Washington St	264	792	1,070	1,520

The downstream hydraulic control for the HEC-RAS model of Harvard Gulch was set at the known water surface elevations which were calculated using the broad crested weir equation at South Logan Street. **Table C-1a** and **Table C-1b** in **Appendix C** depict the details of the calculations. The downstream hydraulic control for the HEC-RAS model of the Harvard Gulch *Split Flow* was controlled by the junction condition at the confluence with Harvard Gulch. The downstream hydraulic control for the HEC-RAS model of Dry Gulch was set at the known water surface elevation for cross section 4715 on Harvard Gulch. Cross section 0, a duplicated cross section of 4715 of Harvard Gulch, was included at the downstream end of the HEC-RAS model of Dry Gulch to provide a more representative water surface elevation calculation for Dry Gulch. Since the model was run in the subcritical mode, no upstream boundary was specified within the model.

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 healthier stream corridor, and not a regularly mowed turf grass. Refer to **Figure C-1** in the **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. Per discussion with project sponsors, four scenarios for testing overbank roughness were prepared and reviewed for this study. A comparison of flood profiles between the four scenarios can be found on **Figure C-2** in **Appendix C**.

- Scenario 1: Coding in structures in floodplain as blocked obstructions and using lower Manning's n
- Scenario 2: No blocked obstructions and a higher Manning's n=0.25
- Scenario 3: No blocked obstructions and a higher Manning's n=0.15
- Scenario 4: Ineffective flow set at the limits of building structures

A generalized Manning's n of 0.15 was recommended by the project sponsors to be used for residential areas due to the many obstructions such as buildings, fences and landscaping. The option for horizontal varied Manning's n was utilized on cross sections to represent parks and trails where applicable. Manning's ***n*** values in the hydraulic model are listed in **Table 4-1**.

Twenty-five crossing structures were coded in the hydraulic model using field survey data. The majority of these crossing structures are capable of passing 10-year event flow or less. All crossing structures in this study area can be overtopped during major events, which create highly submerged or perched bridge conditions. The *High Flow* method 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.

A concrete baffled chute in Harvard Gulch Park controls the capacity of the main channel and allows flood flow to spill laterally into the Harvard Gulch Park Golf Course as designed through a 174-foot long concrete weir structure along the right overbank downstream of the 14'x9' culvert outlet at South Ogden Street. The *Inline Structure* option was used in the HEC-RAS to model the concrete chute. The concrete weir was modeled as a *Lateral Structure* in the HEC-RAS hydraulic model. 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 for the golf course detention.

Ineffective flow was utilized to account for flow areas with little or no flow conveyance. Blocked obstructions were utilized to account for the masonry wall on Dry Gulch which crosses the waterway, or to block out the non-realistic flow distribution areas in sump condition areas within the overbank.

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 at South Franklin Street and South Gilpin Street on Harvard Gulch and East Floyd Street on Dry Gulch. The calculations for overland shallow flow are provided in **Appendix C**. The areas impacted by the overland shallow flooding are show on the flood maps in **Appendix G**.

The Harvard Gulch Split Flow does not have a distinct flow path once it spills out of Harvard Gulch and begins flowing in the alleys, driveways and streets. There is a small drainage channel and storm drain within City-owned property upstream of South Ogden Street to the alley between South Corona Street and South Downing Street. Floodways were defined along Harvard Gulch from South Logan Street to the upstream study limit at South Colorado Boulevard, and for the Harvard Gulch Split Flow from the confluence with Harvard Gulch to the alley between South Downing Street and South Marion Street. A floodway was defined along Dry Gulch from East Harvard Avenue to the upstream study limit at South University Boulevard based on a 0.5-foot rise in hydraulic or energy grade elevations. There are two areas where portions of the floodway were set coincident with the floodplain. These were within Harvard Gulch Park between South Logan Street and South Ogden Street for both Harvard Gulch and the Harvard Gulch Split Flow to preserve the storage volume of the existing detention basin at the Irrigation Pond. Floodways were delineated 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 those cross sections, the encroachment of the floodway is based upon encroaching more on the milder sloped bank. However, encroachment is limited to the overbank areas only, and is not allowed within the main channel conveyance area. No floodway was defined for the overland flooding area from the South Platte River to South Logan Street because there is not a distinct channel in the overland flow area.

4.1 Evaluation of Existing Facilities

Existing drainage facilities within the project area consist of natural channel sections, nineteen roadway bridges, two pedestrian bridges, and four culverts. An existing infrastructure inventory along the stream corridor was compiled based on the detailed survey information and field measurements provided by UDFCD.

A total of 19 grade control structures exist within the study reach, however, due to the minor drop heights of many of them compared to the flood depths, only three drop structures were modeled in detail using four cross-sections to define the structure hydraulics.

Figure 2-6 identifies the location and type of all existing roadway crossing and hydraulic structures (bridge and culvert) along the channels of Harvard Gulch, Harvard Gulch Split Flow and Dry Gulch within the study area. Pictures of the existing crossing structures are shown in **Figure C-3** in **Appendix C**.

4.2 Flood Hazards

The Harvard Gulch and Dry Gulch waterway corridors are fully developed. On Harvard Gulch, there are 512 insurable structures in the overland flooding area between the South Platte River and South Logan Street, and 217 insurable structures identified in the 100-year floodplain upstream of South Logan Street. On Dry Gulch, there are 33 insurable structures identified in the 100-year floodplain within the City & County of Denver, and 141 insurable structures identified in the 100-year floodplain within the City of Englewood. Overall, this study noted 903 structures that may be inundated in a 100-year flood.

4.3 Previous Analyses

The 2013 FEMA Flood Insurance Study (FIRM) effective mapping was defined by a Zone AO depth 1 foot and Zone AO depth 2 feet designated 100-year floodplain for Harvard Gulch from the South Platte River to South Logan Street. A Zone AE is defined without a floodway from South Logan Street to South Downing Street. A Zone AE is defined with a floodway from S. Downing Street to the upstream study limit at approximately 250 feet upstream of South Jackson Street.

The 2005 and 2013 Flood Insurance Rate Map (FIRM) panels are based on the Urban Drainage & Flood Control District, *Flood Hazard Area Delineation, Harvard Gulch, West Harvard Gulch and Dry Creek*, Gingery Associates, Inc., December 1979. FIRM Panels **0800460211H** effective date November 20, 2013 and **0800460212G** effective date November 17, 2005 for the City & County of Denver, Colorado shows the FEMA FIRM floodplain designation. No LOMR filings were found within the study area since the date FEMA published the FIRM to the date of this study in 2017; however, there are currently a total of 68 valid LOMC determinations (53 approved, and 15 denied) which demonstrated structures are elevated above the 100-year flood elevation. A list of the LOMC validation are included in **Appendix A**. The LOMA cases are shown on the floodplain maps in **Appendix G**.

A comparison was made between the information presented in the FEMA FIRM and this floodplain study to be published in a 2017 FHAD. In general, the 100-year floodplain delineation along Harvard Gulch and Dry Gulch are similar; however, there are some areas where the floodplain is smaller, and some areas where the floodplain is larger compared the effective FIRM regulatory floodplain. The differences between the regulatory and study floodplains were caused by the new topography and new hydraulic model. The 2013 topographic mapping provides a higher resolution of ground information than that used for the 1979 FHAD. 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 difference water surface elevations at hydraulic structures than HEC-2. **Table 4-3** shows a comparison by reach of the building structures inundated by the FEMA regulatory 100-year floodplain and the floodplain defined by this study.

Table 4-4 shows existing hydraulic structures on Harvard Gulch included in the HEC-RAS model, and shows the type of structure, bridge modeling approach, and identifies the hydraulic capacity of the existing crossing structure. **Table 4-5** shows the existing hydraulic structures on Dry Gulch.

Table 4-3 Building Structures in 100-year Floodplain

Reaches	Average Overland Flooding Depth (ft)	Building Structures	
		This Study (FHAD 2017)	FEMA FIS Regulatory Floodplain
HG1	1	460	260
	2	8	12
	3	44	38*
HG2	NA	0**	0**
HG3/HG Split	NA	31	28
HG4	NA	150	177
HG5	NA	22	17
HG6	NA	14	31
DG1	NA	33	27
DG2	NA	141	0
Total	NA	903	590

* Structures in the existing Zone AE floodplain of the South Platte River, where an average overland flooding depth does not apply.

** 100-year floodplain merges with Dry Gulch, inundated structure counted in Dry Gulch floodplain

Table 4-4 Evaluation of Existing Hydraulic Structures - Harvard Gulch

HEC-RAS Hydraulic Reach	Harvard Gulch	Type of Channel	Survey * Structure Number	River ** Station	Location	Crossing Type (FEATURE _CARRIED)	Description / Size (attributes in GIS & other info)	FHAD Report Capacity	Modeled Structure Type	Bridge Modeling		Summary
										Energy Only	Pressure and/ or Weir flow	
FLO-2D Overland Flow	Reach 1	Box culvert	-	1+00 to 41+00	In West Wesley Avenue: S. Platte River to S. Logan Street	n/a	14'W x 9' H RCB	10-Year	NA	NA	NA	Not included in HEC-RAS model
HG Reach 1	Reach 2	Natural	26	40+80	S Logan Street	Roadway	CBC 14' x 9' / Opening is 40' and narrows to 14'	10-Year	NA	NA	NA	Inlet control rating curve was used for developing staring W.S.E. for HEC-RAS model.
HG Reach 2	Reach 3	Box culvert	25	63+70 to 71+10	E Harvard Ave between S Ogden & S Downing	Roadway	CBC 14.1' X 9.6'	10-Year	Culvert	NA	NA	
	Reach 4	Concrete Trapezoidal	24	72+43	S Downing/S Marion Alley	Alley	1 Span, 13" Reinforced Conc. Deck w/WP mbrn and 2"	10-Year	Bridge		X	
		Concrete Trapezoidal	23	74+08	S Marion Street	Roadway	12.5" Conc. Slab w/WP mbrn and 3" overlay	< 10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged
		Concrete Trapezoidal	22	75+72	S Marion/ S Lafayette Alley	Alley	1 Span, 12.5" Conc. Slab w/WP mbrn and 2" overlay	< 10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged
		Concrete Trapezoidal	21	77+38	S Lafayette Street	Roadway	1 Span, 12.5" Conc. Deck w/WP mbrn and 4" overlay	< 10-Year	Bridge	X		Use energy only because the bridge is highly submerged and pressure and/or weir flow method is not returning reasonable result.
		Concrete Trapezoidal	20	79+03	S Lafayette / S Humboldt Alley	Alley	1 Span, 12.5" Conc. Deck w/WP mbrn and 2" overlay	< 10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged
		Concrete Trapezoidal	19	80+68	S Humboldt Street	Roadway	1 Span, 12.5" Conc. Deck w/WP mbrn and 2" overlay	< 10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged
		Concrete Trapezoidal	18	84+00	S Franklin Street	Roadway	1 Span, 13" Conc. Slab w/WP mbrn and 3" overlay	10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged
		Concrete Trapezoidal	17	87+25	S Gilpin Street	Roadway	1 Span, 13" Conc. Slab w/WP mbrn and 2" overlay	10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged
		Concrete Trapezoidal	16	90+55	S Williams Street	Roadway	1 Span, 13" Conc. Deck w/WP mbrn and 3" overlay	10-Year	Bridge		X	100- and 500-year floods are not sensitive to high flow methods and is highly submerged, however 50-year flood is sensitive to high flow methods
		Concrete Trapezoidal	15	92+20	S Williams / S High Alley	Alley	1 Span, 14" Conc. Slab w/WP mbrn and 2" overlay	10-Year	Bridge	X		Not sensitive to high flow methods and is highly submerged , however 10-year is sensitive to high flow method which is decided to use energy only.
		Concrete Trapezoidal	14	93+90	S High Street	Roadway	1 Span, 14" Conc. Slab w/WP mbrn and 4" overlay	< 10-Year	Bridge		X	
		Concrete Trapezoidal	13	97+15	S Race Street	Roadway	1 Span, 14.5" Conc. Slab w/WP mbrn and 3" overlay	10-Year	Bridge		X	
	Reach 5	Natural	12	104+00	S Gaylord Street	Pedestrian/Bike	1 Span, COR10, Conc. Abuts	< 10-Year	Bridge	X		Perched bridge
		Natural	11	109+50	S York Street	Roadway	5 - 5.25' x 9.42 CBC's, 9" Conc. Slab w/6" overlay	10-Year	Culvert	NA	NA	
		Natural	10	113+70	S University Blvd	Roadway	5 - 5.25' x 9.42 CBC's, 9" Conc. Slab w/2" overlay	10-Year	Culvert	NA	NA	
		Natural	9	118+00	S Josephine Street	Roadway	2 Spans, 14" Conc. Slab w/WP mbrn and 3" overlay	< 10-Year	Bridge		X	Energy only calculates WSE is 1.4' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
		Natural	8	122+10	S Columbine Street	Roadway	2 Spans, 14" Conc. Deck w/WP mbrn and 3" overlay	10-Year	Bridge		X	Energy only calculates WSE is 2' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
	Reach 6	Natural	7	132+30	S Fillmore Street-McWilliams Park	Pedestrian/Bike	Steel with Concrete Deck	< 10-Year	Bridge	X		
		Natural	6	145+75	S Steele / S Adams Alley	Alley	2 Spans, 16" Reinforced Conc. Deck w/WP mbrn and 3" overlay	10-Year	Bridge		X	Energy only calculates WSE is 0.9' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
		Natural	5	147+50	S Adams Street / E Vassar Avenue	Roadway	6 - 7' x 3.5' CBC, 9" Conc. Slab w/ 7" overlay	< 10-Year	Culvert	NA	NA	
		Natural	4	151+30	S Cook Street	Roadway	2 Spans, 13" Reinforced Conc. Deck w/WP mbrn and 4" overlay	10-Year	Bridge		X	Energy only calculates WSE is 0.4' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
		Natural	3	154+60	S Madison Street	Roadway	2 Spans, 12" Conc. Slab w/WP mbrn and 3" overlay	10-Year	Bridge		X	Energy only calculates WSE is 1.3' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
		Natural	2	158+00	S Monroe Street	Roadway	2 Spans, 12" Conc. Slab w/WP mbrn and 6" overlay	10-Year	Bridge		X	Energy only calculates WSE is 1.9' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
		Natural	1	165+20	S Jackson Street	Roadway	1 Span, 14.5" Conc. Slab w/WP mbrn and 2" overlay	< 10-Year	Bridge		X	Energy only calculates WSE is 0.6' higher than weir/pressure flow at upstream face. The bridge railing is not fully submerged, so weir and/or pressure flow method is more appropriate.
N/A	Reach 7	Box culvert	-	168+00 to 172+00	S Jackson/Colorado alley to S Colorado	n/a	14'W x 9' H RCB	100-Year	NA	NA	NA	Not included in HEC-RAS model
		Storm Drain	-	172+00 to 211+00	upstream of S Colorado Blvd	n/a	48" CMP at Colorado---> 18" RCP at I-25	2-Year	NA	NA	NA	Not included in HEC-RAS model
HG Split Reach 1	Split Flow Reach 1	Overland/Pipe	27 ***	12+55	S. Ogden Street	Roadway	14'W x7' H Structural plate Arch	10-Year	Culvert	NA	NA	

Note:
* Survey structure numbers are correlated to the survey information which are included in the Technical Appendices.
**River Station in feet from the confluence with South Platte River.
*** Structure size measured on field.

Crossing Counts: Roadway = 20
Alley = 5
Pedestrian/Bike = 2
Total: 27

Table 4-5 Evaluation of Existing Hydraulic Structures - Dry Gulch

Dry Gulch	Type of Channel	River Station	Location	Description / Size (attributes in GIS & other info)	FHAD Report Capacity	Summary
Reach 1	Storm Drain	0+00 to 19+40	East Harvard Avenue/ East Yale Avenue	Twin-68"x43" transitions to 72" RCP at East Vassar Avenue	2-Year	The capacity of existing storm pipe was subtracted from the peak inflow to be used in HEC-RAS.
Reach 2	Storm Drain	19+40 to 59+30	East Yale Avenue to South Downing Street at Barde Park	66" RCP	2-Year	The capacity of existing storm pipe was subtracted from the peak inflow to be used in HEC-RAS.
	Natural	59+30 to 64+25	Barde Park		2-Year	The capacity of existing underdrain storm pipe was subtracted from the peak inflow to be used in HEC-RAS.
	Overland Flow	64+25 to 73+00	South Lafayette Street at Barde Park to South Franklin Street	60" RCP runs parallel in East Eastman Avenue.	2-Year	The capacity of existing storm pipe was subtracted from the peak inflow to be used in HEC-RAS.
	Street	73+00 to 102+15	South Franklin Street to South University Blvd	Major flow path in East Eastman Ave, a 48" to 54" RCP runs parallel in E Floyd Avenue	2-Year	The capacity of existing storm pipe was subtracted from the peak inflow to be used in HEC-RAS.

River station in feet from confluence with Harvard Gulch

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Appendix A – Project Correspondence

Meeting Minutes

Matrix Design Group Inc.
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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Thursday January 29, 2015, 9:30am – 11:00am at UDFCD

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Terri Fead	UDFCD	303-455-6277	tfead@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	Jeremy.Hamer@denvergov.org
Sarah Anderson	Denver Water Quality	720-865-2670	Sarah.Anderson@denvergov.org
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Kevin Lewis	Denver Public Works	303-446-3658	donald.lewis@denvergov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
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Bob Eck	Matrix Design Group	303-572-0200	bob_eck@matrixdesigngroup.com

1. Project Coordination

a. Intend to meet monthly as needed for project updates. No meeting schedule has been established yet.
b. Website to be set up by Matrix ASAP
c. Shea to set up DropBox folder for this project for Sponsor file sharing

2. Data Gathering

a. Aerial and topographic base mapping – Matrix received the data. Data set was thinned to create contours. Jeremy Hamer has 2 files, 30G data so that Matrix does not need to create a new TIN surface.
b. Structure survey information – Shea Thomas to initiate field survey of the channel crossing structures. Mike Anderson has an inventory of all structure crossings.
c. Reference Documents and Data needed for this study:
   i. 1967 Design Report and Construction Drawings for the Logan outfall
   ii. FHAD, 1979
   iii. Rehabilitation of Harvard Gulch, York to Jackson, 1984
   iv. Harvard Gulch Channel Rehabilitation in McWilliams Park, As-Built June 1993
   v. Harvard Gulch Channel Restoration at Garfield, December 1993
   vi. Harvard Gulch Floodplain Restoration , (Steele/Adams alley to Cook/Madison alley), 1995
   vii. Harvard Gulch upstream of Cook Street channel rehabilitation, 2001
   viii. Harvard Gulch at DeBoer Park Channel Improvements Project, 2001
   ix. Harvard Gulch Drainage Rehabilitation Plan Report (Muller 2003) and As-Builts (June 2004) York to Jackson excluding McWilliams Park.
   x. Parks Gulch Master Plan, 2009
   xi. Holly Hills OSP, Phase A-2000, Phase B-2001 and Holly Hills Detention Ponds 2008
   xii. Harvard Gulch Alternatives Analysis and Feasibility Study Preliminary Engineering Report, 2010.
   xiii. Rainfall-Runoff Models from UDFCD using GASSHA
   xiv. Denver FLO-2D study for Broadway area.
   xv. UDFCD gage analysis - looked at confidence bands for recurrence intervals
   xvi. No neighborhood plan updates are planned this area by Denver Community Planning & Development.
   xvii. Evans Station Area Plan by Denver Community Planning & Development
   xviii. Matrix to obtain Denver's latest Land Use and Zoning information
   xix. Matrix to obtain Denver's Environmental layers for known landfills
   xx. Denver to provide Parks BMP guide being developed by Wenk & CH2MHill. Study just started and will be completed in 8 months, with a draft available in June.
   xxi. Matrix to obtain land use data from Englewood and Cherry Hills

3. Stakeholders

a. Corps of Engineers Study – COE initiating a study of Harvard Gulch and the South Platte River. Jennifer Williams attends a monthly conference call for status updates. TetraTech from Fort Collins is the contractor for COE and is completing the CUHP & SWMM hydrology study for Harvard Gulch.
b. High Line Canal Conservancy – "Reach 30" is within the Harvard Gulch watershed and is being studied as a pilot reach. High Line Canal is still owned by Denver Water.
c. RTD FasTracks southwest light rail line passes through the watershed
d. CDOT Sante Fe Drive (Highway 85) and I-25 through Harvard Gulch watershed
e. Englewood and Cherry Hills are stakeholders, but not project sponsors
f. Arapahoe County unincorporated Holly Hills area

4. Project Schedule

a. 50 Weeks by contract (targeting 44 weeks), Concurrent FHAD

HARVARD GULCH MDP & FHAD SCHEDULE

	Draft / First	Comments	Final/Second	Public Meeting	Selected Plan
Baseline Hydrology Report	3/2/2015	3/23/2015	4/13/2015		
Alternatives Analysis	6/22/2015	7/13/2015	8/3/2015	7/1/2015	8/31/2015
Concept Design	10/26/2015	11/16/2015	12/7/2015		
FHAD	6/8/2015	6/29/2015	7/20/2015		

5. Project Goals

a. Reduce the flood hazard area
b. Develop a sustainable corridor
c. Parks actively seeking to expand their land
d. Improve natural areas passive riparian zones with "wild spaces" between programmed activity centers
e. Stable stream channel to reduce sedimentation. Removal of sediment has required significant maintenance.

6. Project Approach

a. Hydrology
   i. Expedite study and hydrologic modeling for delivery of approved model to Corps of Engineers
   ii. Existing Detention
      1. Harvard Gulch Park – 12 acre-foot off-line pond
      2. Skeel Reservoir –. Operates under State restrictions. Saeed Farahmandi, Denver Public Works, is working with Denver Parks as the owner on pond operations. Gregg Blew is the Parks Operations Supervisor
      3. Packy Romans Park in Englewood
   iii. Calibration of models and comparison to gage records – Matrix to examine calibration of 2-year model output to gage records. CUHP & EPA-SWMM model may be calibrated to FHAD flows of 4,860 cfs at Logan if flood frequency analysis of gage records supports the data.
b. Deficiencies
   i. Broad urban floodplain due to limited conveyance capacity of box culvert and concrete channel
   ii. Condition of existing drainage infrastructure
   iii. Channel stabilization, erosion and sedimentation
      1. Maintenance is required every 10 years to remove accumulated sediment. Last sediment removal project was in 2004. 50% to 67% of sediment has re-accumulated.
      2. Sediment deposition from Jackson Street to University.
      3. Sediment removal at Monroe and upstream of McWilliams Park
      4. Complaints of mosquitoes in stagnant water holes created by sediment deposition . Consider steepening channel by removing drops to move water faster. Need to be cautious that steeping low flows will not be unstable at high flows.
   iv. Water quality. Can add filter strips to channel – particularly along the golf course where fertilizers and pesticides are applied. High Line Canal to be used for water quality.
   v. In 2005, there is a video of flooding. Yale Avenue was noted to be flowing like a river; however, no flood damage was noted to structures.

c. Alternatives Analysis - to include these areas with known deficiencies or opportunities:
   i. Underground box outfall to South Platte
   ii. Rosedale Park proposed detention pond site
   iii. Concrete trapezoidal channel section
   iv. Sedimentation issues
   v. Red star flood history
      1. Sump at Glencoe St., south of Yale Ave.
      2. Schlessman Family YMCA – Jeremy Hamer has design drawings
      3. Pennsylvania & Harvard
   vi. High Line Canal pilot project to use Reach 30 for water quality
   vii. Need to consider Park programming and connectivity

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Wednesday April 8, 2015, 2:30pm – 4:00pm at UDFCD

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Terri Fead	UDFCD	303-455-6277	tfead@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	Jeremy.Hamer@denvergov.org
Sarah Anderson	Denver Water Quality	720-865-2670	Sarah.Anderson@denvergov.org
Jennifer Williams	Denver Capital Projects	303-446-3549	Jennifer.L.Williams@denvergov.org
Cincere Eades	Denver Parks Planning	720-913-0655	Cincere.Eades@denvergov.org
David Morrisey	Denver Public Works	720-913-8518	David.morrisey@denvergov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	hungteng_ho@matrixdesigngroup.com
Bob Eck	Matrix Design Group	303-572-0200	bob_eck@matrixdesigngroup.com

1. Project Coordination

a. Update on US Army Corps of Engineers study
   i. Tetra Tech is the Corps' consultant
   ii. Bruce Uhernik and Selena Klosowski are the Denver representative for the coordination meetings
   iii. Mike Anderson gave an overview of the study process to the Corps, current status (Draft Baseline Hydrology study) and noted key design point locations where the study is calibrating to the FHAD, such as Q100 = 4860 cfs at S Logan. Mike described the gage analysis with 34 years of record. The team is also calibrating to the 2 year flow, and extrapolating out to the 100-year, which yielded close to 4860 cfs.
   iv. Jennifer Davis at the Corps has received the draft final CUHP and SWMM models for hydrology. Jennifer noted that the Q100 at Logan from Tetra Tech is 4384 cfs at S Logan.
   v. Coordination is needed between Corps/Tetra Tech efforts and UDFCD/Matrix on Harvard Gulch
   vi. Corps anticipates three public meetings:
      1. Introduction, May 6. Matrix does not need to attend.
      2. Information Gathering, Tentatively early October 2015
      3. Informative to share the results of the study, March/April 2016

b. High Line Canal Reach 30 repurposing through Harvard Gulch
   i. Kelly Crum, Denver Wastewater, is leading the design
   ii. Defining the storage volume and discharge needed on the High Line Canal
   iii. Also noted that the surface area of Skeel Reservoir may be reduced. The entire storage volume is not needed.

2. Project Schedule

	Draft / First	Comments	Final/Second	Public Meeting	Selected Plan
Baseline Hydrology	3/2/2015	3/25/2015	4/27/2015		
Alternatives Analysis	6/22/2015	7/13/2015	8/3/2015	7/1/2015	8/31/2015
Concept Design	10/26/2015	11/16/2015	12/7/2015		
FHAD	6/8/2015	6/29/2015	7/20/2015		

3. Baseline Hydrology

a. Review major comments (see attached table)
b. Hydrology at Jackson is confusing in the 1979 FHAD where it has a big step up from Colorado Blvd. This is due to extrapolating the downstream flow upstream. Additionally, Terri clarified that the Figures in the 1979 FHAD are hydrology while Table 3 is the hydraulics. The new Baseline Hydrology should not have a big step up at Jackson. The only reason hydrology at Jackson is evaluated is for the comparison with the gage at that location, otherwise, note the flow as downstream of Colorado Blvd.
c. Two approaches to model calibration
   i. Calibrate to 100-year FHAD flows published in 1979 by adjusting Cp and Ct
   ii. Calibrate to 2-year gage analysis and run the 100-year
      1. Results show 4949 cfs at Logan which is close to the FHAD of 4860 cfs
      2. Q100 upstream of Logan is higher than the FHAD
      3. Good exercise, but team recommends using the first approach to match FHAD

4. Hydraulics

a. Use FLO 2D to model overland flow from Logan to South Platte to better define floodplain
b. HEC-RAS will be used to model the open channel flow segments
c. There was a brief discussion that Matrix anticipates a split flow model for the reach from Downing to Race where the discharge exceeds capacity of the underground box culvert. More discussion will be needed on the modeling of this reach.

5. Project Goals

a. Reduce flood hazards by providing 100-year protection/conveyance
b. Improve sustainability/resiliency of the drainageway
c. Seek opportunities for additional open spaces and parks
d. Pedestrian connectivity from the South Platte River and Evans Station into Harvard Gulch
e. Improve natural areas and riparian zones with "wild spaces" between activity centers
f. Improve channel stability
g. Improve water quality

6. Alternatives Analysis listed on the Agenda, but did not have time to discuss

a. Team was requested to brainstorm and provide comments and ideas to Matrix in one month
b. Outfall Logan to South Platte. Additional capacity is needed. Consider underground box culvert or open channel
   i. Consider new open channel alignments. Include an open channel alignment along the geologic path.
   ii. Consider new box culvert option in Wesley Avenue
c. Proposed detention at the Rosedale Park site. May consider for water quality in addition.
d. Underground box culvert from Ogden to Downing has limited capacity
e. Concrete trapezoidal channel section: Downing to Race has limited capacity
f. Channel stability / improvements for the low flow channel
g. Water quality: High Line Canal pilot project and other opportunities
h. Detention options upstream of Rosedale Park

7. Action Items

a. Cincere Eades, Bob Eck and Jane Kopperl to review the 2009 Denver Parks Gulch Master Plan and provide updated direction for Harvard Gulch
b. Sarah Anderson, Drew Beck and Robert Krehbiel to investigate water quality needs and opportunities in the Harvard Gulch watershed
c. Matrix to revise and resubmit the Baseline Hydrology Report
d. Matrix to complete the floodplain hydraulic modeling
e. Coordination required between Corps/Tetra Tech efforts and UDFCD/Matrix

Draft Baseline Hydrology Report Review Comments dated March 25, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Baseline Hydrology Report

Page	Reviewer	Comments	Responses
Cover	General Comments	The 1979 FHAD Q's at Colorado & Jackson are confusing, which are referenced in the Draft MDP. The 1979 FHAD lists differing numbers at these 2 locations depending on where in the 1979 FHAD you are looking for flows at S. Colorado Blvd. and S. Jackson St. Table 3 in the 1979 FHAD seems more reliable. In this MDP, Q100 flow rates from the 1979 FHAD at these locations are noted in Figure 3-5 and 3-7, Figure 3-8, Table 3-7, Figure 3-9....ensure consistency.	1. Colorado Blvd. was used as a reference location in this MDP to match the reference location described in the 1979 FHAD and USGS Gage N06711570. Colorado Blvd. is a better name for the design point because it is easier for readers to recognize the location within the watershed. 2. In the 1979 FHAD, **Table 2**, **Figure 1** and **Figure 6** show the results directly from the hydrologic analysis. 3. In the 1979 FHAD, **Table 3** lists the discharges used for floodplain analysis which do not necessarily match the discharges at respective design points. In certain circumstances, the discharges at downstream design points are applied to the reach upstream to account for the accumulation of discharges through the reach, which was a conservative approach.
5	UDFCD	Section 3.1.2 says there is 34 years of data.	Although the gage history only goes back 34 years, the 50-year time frame is counted from the year 1965. The Flood History section of the 1979 FHAD indicates the largest flood since 1965 so it gives us a longer period of record. However, to avoid confusion, the report will only reference the gage history.
11	Denver - PW	When was the nutrient loading evaluated?	2009 Denver Gulch Master Plan, but this will be updated with newer information and monitoring data.
14	Denver - PW	Should the underground pipe/box capacity be noted as between 25 and 100 year?	The report will clarify the design capacity of the underground and trapezoidal channel sections.
16	Denver - DES	Through Reaches 2 and 3, CCD GIS shows small diameter RCP storm sewers along the channel alignment. Should these be mentioned in reach descriptions? Do they serve some purpose ongoing? Please discuss these in terms of purpose, condition, effectiveness/performance and value.	These are underdrains under the concrete trapezoidal channel section. The GIS data is in error in some areas. The underdrains do not need to be included in the hydrologic & hydraulic analyses. Many of the underdrains may be clogged and are no longer effective.
16	UDFCD	Is there a levee through Harvard Park?	This berm provides protection up to the 25-year flood. There is a lateral weir downstream of S. Ogden St. to allow high flows to spill into golf course detention pond. The report will note the weir section.
16	UDFCD	Was the concrete trapezoidal channel section designed for 100-year flows? If so, explain why it no longer has capacity. If not, state the storm event for which it was designed.	Designed for 25-year. (Wright-McLaughlin Engineers, 1967, Harvard Gulch Design Report), although the 1979 FHAD noted that it had 10-year capacity.
17	UDFCD	Reaches 5 and 6 are very similar. Why not just make Reach 5 extend to Colorado?	Reach 5 is 2860 foot section of open channel. Reach 6 is a 4200 foot section of open channel. The report separates the reaches due to the overall length and the specific parks within each reach.
17	Denver - PW	The notation of stability seems to contradict the next sentence. How can the channel be stable if sediment is depositing in the channel. Following the 2004 sediment removal project, complaints or ponding and stagnant smelly water were received in 2006 from residents at 2585 S Monroe Street. (6-8-2006 e-mail form City Council office for the area).	The definition of stability is that sediment inflow equals outflow. If there is deposition, the aggradation is an indication of instability. However, what is unstable at low flows, may be stable at high flows.
21	Denver - PW	If 19% of the Harvard Gulch watershed is above the High Line Canal, what is the actual flow assumed in the model?	To calibrate the model, the model had to be compared to actual runoff events. If the High Line Canal did not overtop, then the tributary basin upstream of the canal had to be ignored. The goal of this analysis was to calculate 100-year flows in the Harvard Gulch basin based on actual recorded runoff events to compare with the results of all of the hydrologic models. The model was calibrated to the watershed below the High Line Canal, and then the area upstream was added back into the model.
21	UDFCD	The detailed stream gage data and results of the flood frequency analysis are provided in Technical Appendix. What are the Conclusions?	Text will be added to describe the results of this analysis.
21	Denver - DES	Please indicate the number and size of basins modeled in the FHAD hydrologic analysis. (Because this is the hydrologic analysis that this study is "calibrated" to, some additional discussion of the modeling approach used in the FHAD would be helpful.)	There were 6 basins in the FHAD model, delineated using USGS topography.

Draft Baseline Hydrology Report Review Comments dated March 25, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Baseline Hydrology Report

Page	Reviewer	Comments	Responses
21	Denver - DES	So that the choice to use this hydrologic methodology is clearly documented and defensible, please discuss how the decision was made to calibrate to earlier CUHP large basin peak flow rates as determined in the FHAD. What decisions were made (when, who, etc.) to proceed with calibration to FHAD flows. Also, please discuss the basic rationale for the use of this methodology, including identification of any background information relevant to the evolution of employing this specific methodology, citing any documentation/studies that are relevant to the adoption of this methodology.	Text will be added to describe the decision to calibrate to the FHAD flows.
21	UDFCD	Please expand on this section, it's really important. Clearly explain the FHAD flows were verified by: 1. Gage analysis 2. Three basin CUHP model 3. Calibration to 2-yr storm model	Text will be added to describe the results of the three analyses and the conclusion to use the FHAD flows.
24	Denver - PW	I think you should add 10-year flow FHAD numbers (shown in Figure 3-9) on these.	Incorporated.
27	Denver - PW	Different values, consistent with UDFCD RA1-RA6 were used for Marston, Sanderson & Weir for 2-year through 50-year. (100-year are the same for Denver and UDFCD). Why using Denver's now for the lesser storms?	Table 5.1 of Denver's Criteria shows the same values on UDFCD Figure RA1-RA6.
28	UDFCD	The increase by 25% is for pipes and concrete channels. Natural channels should use Equation RO-10.	Incorporated.
29	Denver - PW	Add note explaining why additional drainage area was not originally accounted for in the FHAD.	The area discrepancy is a result of this MDP counting Colorado Blvd. as a basin boundary; the 1979 FHAD used only topographic contours to delineate basin boundaries and did not include Colorado Blvd. in the basin delineation. Therefore, the area tributary to Colorado Blvd. varies greatly between this study and the 1979 FHAD, but the overall watershed area is the same.
29	UDFCD	If this area is so much bigger, should we really be calibrating to the flows at Colorado?	The physical location of the both design points for this study and the 1979 FHAD are the same, however, this MDP treated Colorado Blvd as a basin divide whereas the 1979 FHAD delineated the basin by topography using USGS contours. Therefore, this study brings in more area compared to the 1979 FHAD study, but the design points are the same.
30	UDFCD	Any idea why the 10-yr hydrographs are so off?	The program setup of CUHP produces a non-linear frequency-discharge curve, which has a steeper rising slope beyond the 10-year event. The calibration was set to match 100-year runoff, which produced lower runoff for minor events.
39	Denver - PW	The Peak Discharge vs. Channel Stations looks much better upstream of Race Street compared to the 1979 FHAD (1979 FHAD Table 3 vs. Figure 1) and especially at S. Colorado & S. Jackson. Possible solution to my issue with 1979 FHAD Q's at S Colorado & S Jackson: do not discuss S Jackson in this MDP?	This MPD & FHAD will use more frequent flow change locations to avoid the abrupt jump in the discharges. "Downstream of Colorado Blvd" is used in this MDP to refer to the hydrologic design point associated with the gage stations of USGS & UDFCD (rather than Jackson St).
66	Denver - DES	The SWMM file shows the duration of the modeling as 4 hours and 10 minutes. After 4 hours and 10 minutes, the modeled 100-year flood event has not entirely passed through the system. A longer modeling duration is necessary to verify that the entire effective rainfall volume is discharged from the system. Given that there are 3 detention elements in the model, that may have an extended release, it may take as much as 60 hours for the system to have passed the entire storm event. Please execute the model with a duration set of 60 hours or more as necessary, to show that no volume remains "stored" in the system.	Because the Harvard Gulch watershed is over 7 square miles, the modeling duration of 4 hours and 10 minutes is long enough to encompass the peak time of both inflow and outflow hydrographs at all detention basins in the watershed. Figure 3-9 shows the peak time at Logan Street is approximately 1 hour 30 minutes and the recess limb drops below 2000 cfs after 2 hours 45 minutes, which indicates the model duration is sufficient. A longer modeling duration could catch all the runoff volume, but it does not help increase accuracy for the purpose of modeling peak flows for the MDP level of study. The question related to a model check to verify that no storage is occurring in the system.

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Monday April 20, 2015, 9:00am – 10:30am at Denver Parks and Recreation

Attendees:

Cincere Eades	Denver Parks PP	720-913-0655	Cincere.Eades@denvergov.org
Jay Henke	Denver Parks Rec		Jay.Henke@denvergov.org
Kent Sondgerath	Denver Parks Rec		Kent.Sondgerath@denvergov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
Jane Kopperl	Matrix Design Group	303-572-0200	jane_ kopperl@matrixdesigngroup.com
Bob Eck	Matrix Design Group	303-572-0200	bob_eck@matrixdesigngroup.com

1. General Comments

a. Cincere Eades clarified that her affiliation should be listed as Denver Parks – Parks Planning (PP), where she serves as Natural Area coordinator, not Denver Parks - Natural Areas.

b. Cincere reported that she and Gordon Robertson had met to discuss Harvard Gulch and his recommendations were to 'think big', and that property acquisition should be considered, since this Master Drainage Plan is intended to extend for a 30 year period.

2. Basin Overview

a. Upper Basin – Downing to Colorado Blvd

b. Middle Basin – Sherman to Downing (Rosedale and Harvard Gulch Golf Course)

i. Jay Henke stated that Denver Parks and Denver Water have an agreement in place to deepen the irrigation pond in Harvard Gulch Golf Course to provide increased water storage for golf course irrigation.

ii. The current agreement does not include significantly increasing the surface area of the pond; only deepening to increase storage and freeboard.

iii. The City Ditch delivers water to the pond and will now terminate at the golf course, with the reconstruction of the I-25 corridor to the north.

iv. Denver Water is interested in exercising their senior water rights through irrigation use.

v. Denver Parks Golf should be contacted to provide input on the golf course.

vi. Denver Water should be contacted to discuss potential pond enlargement.

c. Lower Basin – South Platte Outfall to Sherman

3. Data Gathering

a. Aerial and topographic base mapping

b. References:

i. Parks Gulch Master Plan, 2009
ii. River South Master Plan
iii. Evans Station Area Plan
iv. South Broadway Corridor
v. Blueprint Denver
vi. South Platte Corridor Study
vii. Overland Neighborhood Plan
viii. Overland Neighborhood Assessment
ix. Other studies

4. Denver Parks 'Wish List' items for incorporation in potential Alternatives

a. Upper Basin – Downing to Colorado Blvd

b. Middle Basin – Sherman to Downing (Rosedale and Harvard Gulch Golf Course)

c. Lower Basin – South Platte Outfall to Sherman

5. Action Items:

a. Cincere to contact Denver Parks – Golf to coordinate a meeting to discuss potential golf course excavation and golf rerouting to accommodate pond enlargement.

b. Matrix to contact Mike Anderson to identify potential contacts for Transportation (potential local street rerouting/ closures), Planning and Community Development (potential lower basin daylighting) and Bridges ("functionally obsolete" status noted in GIS table).

c. Matrix to download "Denver Moves" pedestrian/ bicycle plan for most recent planning information.

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan (MDP) and Flood Hazard Area Delineation (FHAD)
Tuesday May 19, 2015, 10:30am – 12:20pm at UDFCD

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Terri Fead	UDFCD	303-455-6277	tfead@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	jeremy.hamer@denvergov.org
Cincere Eades	Denver Parks Planning	720-913-0655	cincere.eades@denvergov.org
Kevin Lewis	Denver Public Works	303-446-3658	donald.lewis@denvergov.org
David Morrisey	Denver Public Works	720-913-8518	david.morrisey@denvergov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
Drew Beck	Matrix Design Group	303-572-0200	drew_beck@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	hungteng_ho@matrixdesigngroup.com
Bob Eck	Matrix Design Group	303-572-0200	bob_eck@matrixdesigngroup.com

1. Project Coordination

a. The MDP and FHAD are being completed to map the future conditions floodplain and to identify alternative solutions and potential flood hazards which can also be used to inform the Corps Feasibility Study. The Corps study is also for flood control and environmental protection; however, it does not include a FHAD.

b. Update on Corps study: hydrology, progress, schedule, etc.
- Hydrology is complete and in general agreement between the Matrix study and the Corps (Tetra Tech) study. The City and UDFCD have shared the Final Baseline Hydrology Report and models with the Corps, but have not yet seen the hydrology developed by Tetra Tech for the Corps. On April 8, 2015, Denver was informed that the Tetra Tech Q100 at Logan is 4384 cfs; whereas the FHAD Q100 at Logan is 4860 cfs which is within 10%, the generally accepted range of accuracy.
- Introduction Public Meeting was May 6 for Harvard. Public comments (map and summaries) provided to Matrix.
- Alternatives Workshop at PW-WMD on May 28. Matrix will attend.
- Corps 2nd public meeting is September 30. Matrix will attend.

c. Update on Wenk/Zoeller/Greenway Public Outreach for the Corps Feasibility Study. The Corps requires the local sponsor to conduct public outreach and Denver has contracted with Wenk Associates who have the following as sub-consultants: The Greenway Foundation and Capitol Representatives, Urban Interactive Studio, and Ray Fronzyck Consulting, Information is available on the website: http://www.denverwaterways.com/

d. Environmental Analysis by ERO. The Corps Feasibility Study requires Denver to conduct an environmental analysis on the study areas. Denver retained ERO for Harvard Gulch. ERO issued a draft Environmental Report. The GIS files can be used by Matrix for the Environmental and Riparian Zone maps in the report.

e. Coordination with Porter Hospital Master Facility Plan. Redevelopment is proposed that may impact the land use adjacent to Harvard Gulch. Bruce Uhernik will coordinate data sharing.

f. Denver Water and Denver Parks dredging of Harvard Gulch Park Pond. An IGA is being developed to fund the design and construction of the improvements. The park will be irrigated using City Ditch raw water, rather than potable water. Design is expected to occur in early 2016.

g. Lessons learned on other proposed open channels – Weir Gulch, Montclair, Westerly Creek (upstream of Westerly Creek dam), North Dry Gulch in Lakewood, etc.
- The open channel should achieve multi-purpose benefits including transportation, pedestrian, bicycle connectivity, etc.
- It is important to get Parks and other City departments support for an open channel.
- It is best to design the open channel in the historic alignment to avoid split flow situations whereby overflows in major storm events could follow a path different than the drainage improvements.
- A parallel roadway is helpful to maintain circulation, provide increased visibility and night time light for the trail, and improve safety.

2. Project Schedule

	Draft / First	Comments	Final/Second	Public Meeting	Selected Plan
Baseline Hydrology	3/2/2015	3/25/2015	4/27/2015		
Alternatives Analysis	6/22/2015	7/13/2015	10/5/2015	9/30/15	10/26/2015
Concept Design	10/26/2015	11/16/2015	12/7/2015		
FHAD	6/8/2015	6/29/2015	7/20/2015		

A meeting should be held with UDFCD at the first technical submittal to help explain the hydraulic modeling. Denver requested that they be invited to attend.

3. Hydraulics

a. A map was presented which compared the updated DRAFT floodplain to the FIS delineation. The new floodplain generally agrees with the regulatory floodplain, but is larger in some areas.

b. FLO 2D was used to model overland flow Logan to South Platte. Flow greater than 3 inch depth can be shown. This area will be mapped as a Zone AO using the results of the 2D model.

c. Either model structure obstructions or increase the roughness. Due to the large number of structures in the floodplain, it is acceptable to increase the roughness.

d. A Floodway is not needed in overland flow areas noted as Zone AO downstream of Logan.

e. The thalweg will be profiled. The overland flow does not need to be profiled.

f. LOMAs need to be incorporated into this FHAD.

4. Typical Alternatives

a. Flood Control

b. Regional Detention

c. Channel Stability – Harvard Gulch is generally stable, but there are pockets where maintenance is needed due to local scour and smaller flows causing deposition. The latter may be addressed with water quality improvements to capture and remove sediment to reduce the sediment supply to the channel.

d. Water Quality

5. Alternatives Analysis

Bob Eck presented maps showing the different alternatives. It was noted that the base flow is minimal when City Ditch water is not discharged into Harvard Gulch. It is important to understand City Ditch management for the design of a multi-use open channel amenity.

a. Undersized Outfall: Logan to South Platte
    i. Replace Box in Wesley with Open Channel
    ii. Parallel Box in Iliff
    iii. Open Channel adjacent to Iliff
    iv. Open Channel along thalweg to generally follow the geologic path shown by alluvial soil mapping by the USGS.
b. Undersized box culvert: Ogden to Downing
    i. Box in Drainage Easement
    ii. Open Channel in Drainage Easement
    iii. Open Channel along original channel alignment through private and Porter Hospital Property north of E Harvard Avenue.
c. Concrete trapezoidal channel section: Downing to Race
    i. Box
    ii. Open Channel
d. Connectivity
    i. A grade separated trail crossing is desired at University
e. McWilliams Park
    i. It is not likely that there will be public support to alter this community park
f. Proposed Detention – anticipate needing at least 20 acre-feet to be effective:
    i. Rosedale Park
    ii. Harvard Gulch Park Pond enlargement
    iii. Skeel Reservoir-dam safety issues. Likely will not have an impact on downstream main stem hydrology.
g. Water Quality:
    i. High Line Canal pilot project Reach 30
    ii. Rosedale Park Pond
    iii. Watershed Treatment – Green Streets, In-Tract. There needs to be a balanced approach where water is treated within the watershed, not just at the outfalls into the park areas.
    iv. End of pipe – forebays at outfalls, including YMCA
    v. Vegetated buffer strips along open channel
    vi. In-line opportunities for sediment removal?
h. Parks policy regarding use of Park land
    i. Generally, there should not be any land swaps.
    ii. The use of Rosedale Park for drainage (detention and water quality) may be acceptable.

6. Action Items

a. Bruce Uhernik to be the lead contact for the Porter Hospital Master Plan.
b. Shea Thomas to investigate the Urban Waterways website and whether Matrix should also host a website. Mike Anderson to discuss with Bruce Uhernik, project manager of the Corps study. The FHAD needs to be available for public comment, which is separate from the Corps study.
c. Matrix to meet with Teri Fead when the FHAD is submitted. Jeremy Hamer should also be invited.
d. Mike Anderson to set up a meeting with Denver Public Works-Transportation Engineering Services (TES) and Denver Community Planning Development (CPD) to discuss circulation, street realignment and street closures, gather comments/input and note any “fatal flaws” with proposed direction. Mike, Shea, Robert and Bob to be invited.
e. Matrix to review the Grant-Frontier Park design and the Pasquinel’s Landing Park design

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MEETING MINUTES
Harvard Gulch Alternatives Analysis
Major Drainageway Plan (MDP) and Flood Hazard Area Delineation (FHAD)
Wednesday May 27, 2015, 8:00am – 9:00am at Denver Webb Bldg. 6.H.21

Attendees:

Mike Anderson	Denver Capital Projects
Lesley Thomas	Denver City Engineer
David Huntsinger	Denver PWWMD Wastewater
Jennifer Williams	Denver PWWMD Wastewater
Sarah Anderson	Denver Wastewater – Water Quality
Caryn Champine	Denver CPD Planning Services
Steve Chester	Denver Community Planning and Development
Tim Watkins	Denver Community Planning and Development
Sam Suter	Denver CPD Planning Services
Justin Schmitz	Denver PWT Transportation
Brittany Price	Denver PWT Transportation
Shea Thomas	UDFCD
Robert Krehbiel	Matrix Design Group
Bob Eck	Matrix Design Group

1. Project Purpose and Objectives

a. The MDP and FHAD are being completed to map the future conditions floodplain and to identify alternative solutions and potential flood hazards which can also be used to inform the Corps Feasibility Study. The Corps study does not include a FHAD.
b. Building larger open channels improves flood control and provides water quality benefits.
c. Coordination with Porter Hospital Master Facility Plan. Redevelopment is proposed that may impact the land use adjacent to Harvard Gulch. Bruce Uhernik will coordinate data sharing.
d. Open channel design
   - The open channel should achieve multi-purpose benefits including transportation, pedestrian, bicycle connectivity, etc.
   - It is best to design the open channel in the historic alignment to avoid split flow situations whereby overflows could follow a path different than the drainage improvements.
   - A parallel roadway is helpful to maintain circulation, provide increased visibility and night time light for the trail, and improve safety.

2. Alternatives Analysis

Bob Eck presented the broad overland floodplains in Harvard Gulch that result from conveyance facilities sized for the 10-year flood event, where the 100-year flood would spill into the neighborhoods. Bob presented maps showing the different alternatives to provide improved flood control.

a. Existing 10-year capacity concrete trapezoidal channel section ~ 32 feet wide: Downing to Race. Existing bridges over channel for every street and alley.
   i. Proposed wider open channel, 112 feet wide with one-way parallel couplet roadway each side of the open channel. Roadways drawn 20 feet wide (12 foot lane and 8 foot parking), which seems wide, but may be needed for fire access. The need for on-street parking was debated. Opportunities to reduce overall width by adding retaining walls in the upper area. Depth may be fixed by crossing utilities under the channel.

   ii. Need to address traffic circulation. Anticipate bridges approximately every 3rd street (High, Franklin and Downing) at a minimum. Traffic circulation may be an issue. Neighborhood already concerned with too much traffic. The plan would put more traffic on the north-south through streets such as Franklin, but improve east-west connectivity.
b. Existing 10-year capacity box culvert: Ogden to Downing
   i. Open Channel through the city parcel north of Harvard Avenue
   ii. Coordinate with Porter Hospital master plan
c. Existing 10-year capacity box culvert outfall to South Platte River: Logan to South Platte
   i. Box Culvert in Iliff
   ii. Open Channel adjacent to Iliff
      1. Iliff roadway needs remain functional
      2. Historic structure on the south side of Iliff
      3. May conflict with Xcel high voltage power line
   iii. Open Channel following the geologic path along Lincoln and Asbury.
      1. Integrate with redevelopment to be a success.
      2. Timing for redevelopment along Broadway is unknown.
      3. Half block wide seems challenging to integrate with development. Dual fronting properties difficult to integrate into the site.
      4. Need to fit drainage into development. Need to understand how detention and water quality would be accommodated into the redevelopment plan.
      5. It would be good to not remove newly constructed box culvert in Asbury
      6. Rosedale Elementary School – proposed to redevelop for senior housing. May need a structured solution rather than open channel to maintain access into the site. There are steep grades into the site. Developers willing to work with the City on a plan.
d. Detention and Water Quality:
   i. Rosedale Park Pond would reduce the design flow
   ii. Water Quality Treatment by disconnecting impervious surfaces and providing Green Streets. Develop a balanced approach where water is treated within the watershed, not just at the outfalls into the park areas.

3. Action Items

a. Matrix and Bruce Uhernik to meet with Developers for Rosedale School Site
b. Matrix and Bruce Uhernik to meet with Porter Hospital master planners

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Wednesday June 24, 2015, 2:00pm – 4:00pm at UDFCD

Purpose: Will the Alternative Report address Sponsor's expectations?

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	Jeremy.Hamer@denvergov.org
Sarah Anderson	Denver Water Quality	720-865-2670	Sarah.Anderson@denvergov.org
Jennifer Williams	Denver Capital Projects	303-446-3549	Jennifer.L.Williams@denvergov.org
Cincere Eades	Denver Parks Planning	720-913-0655	Cincere.Eades@denvergov.org
Tim Watkins	Denver Community Planning	720-865-2932	Timothy.Watkins@denvergov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	hungteng_ho@matrixdesigngroup.com
Bob Eck	Matrix Design Group	303-572-0200	bob_eck@matrixdesigngroup.com
Wilson Wheeler	Matrix Design Group	303-572-0200	Wilson_wheeler@matrixdesigngroup.com

1. Project Coordination – Corps Study

a. Corps is currently defining the array of alternatives.
b. No economics will be included for the Corps first report.

2. Schedule

a. FHAD 1st Technical Review submittal 6/9/15. Denver would also like to look at the technical models
b. Alternatives report 1st draft delivery estimated 6/30/15. Additional 3-7 days may be needed to evaluate new alternatives discussed in the meeting. 3 week Sponsor review.
c. Sponsors may elect to send the Corps the draft version of the Alternatives report to assist with their evaluation.
d. Matrix website for FHAD only – Wenk team may elect to post Alternatives report on their public information website

3. Floodplain

a. Presented changes to DRAFT floodplain from FIS delineation. Generally a larger floodplain, particularly north of Asbury between Broadway and Santa Fe
b. Approximately 555 structures impacted by the 100-year floodplain. Tables handed out showing the total number of structures by reach.
c. This report will count habitable structures within the floodplain (which is different than the number of parcels in the floodplain)
d. A separate meeting may be necessary to discuss the technical modeling approach.

4. Damages

a. The Assessor's database was updated a month ago which resulted in higher assessed values citywide. Matrix will recalculate the damage assessment using the latest version.
b. Assessor's values for parcel improvements (structures only) appear low, which show structure value generally less than $100 per square foot. Structure value is generally assumed to be approximately $150 per square foot
c. Damages to consider the value of structures and contents (not land)
d. Matrix to review the Weir Gulch report to confirm the BCA analysis is consistent

5. Project Costs

a. Property acquisition:
    i. Needed for 100-year open channels:
        1. Harvard Greenway between Ogden and Race
        2. Iliff Greenway west of Logan
        3. Lincoln Greenway. A table was distributed showing
    ii. Map shown for general locations of acquisitions presented
    iii. Number and value shown on table handout
    iv. Costs could also consider the cost of relocation
b. Assumed no cost for Parks or CDOT land unless project renders land unusable
c. Project Costs completed and shown on handouts

6. Alternatives Analysis

a. Proposed Regional Detention:
    i. Rosedale Park (approx. 20 acre-feet)
    ii. Harvard Gulch Park Pond Enlargement
b. Undersized Outfall: Logan to South Platte (base flows to be put into the open channels, not the underground culverts)
    i. Detention in Harvard Gulch Park (sponsors dismissed option to store 350 acre-feet to alleviate any downstream improvements). Evaluate detention volume using a 3-foot high perimeter berm and excavation of the park that mitigates impacts to programmable areas.
    ii. Parallel Box in Iliff
    iii. Open Channel adjacent to Iliff. Preserve Iliff street and build channel to the north. Build narrow street and pedestrian trail north of the channel for access and circulation connectivity. Consider site-specific multi- use access, mixing low volume vehicular, bike and pedestrian users. Explore and consider opportunities to further narrow the section with increased vertical walls, balanced with habitat and safety issues.
    iv. Open Channel along thalweg to follow geologic path – Lincoln Street. Preserve the newly constructed storm line in Asbury. Concern expressed whether channel is east or west of Lincoln. Exact location of channel alignment may not be necessary during the alternatives analysis phase.
c. Undersized Box Culvert: Ogden to Downing
    i. Open Channel in low point

d. Concrete Trapezoidal Channel: Downing to Race
    i. Open Channel (sponsors dismissed option of underground pipe in this reach).
    ii. Explore and consider opportunities to further narrow the proposed section with increased vertical walls, balanced with habitat and safety issues.
    iii. Consider site-specific methods necessary to meet neighborhood-levels of volume for vehicular, bike and pedestrian users .
e. Culvert Upsizing
    i. All crossings upsized, local streets allow 12” deep at flowline overtopping
    ii. Yale Avenue (arterial classification) flooding along McWilliams Park – consider reshaping channel, constructing a levee, or raising the street
    iii. York Street (close street at the crossing to provide needed capacity to avoid acquisitions)
    iv. Dry Gulch culvert upsize and levee to contain Harvard Gulch floodplain. No options for an open channel were considered since there is no benefit of connectivity.
f. Water Quality
    i. High Line Canal Reach 30
    ii. Rosedale Park Pond
    iii. Watershed Treatment – Green Streets, In-Tract
    iv. End of pipe – forebays at outfalls, including YMCA
    v. Vegetated buffer strips along open channel – no lawn to water’s edge
    vi. In-line opportunities for sediment removal?

7. Action Items

a. Bruce to coordinate Porter Hospital master plan
b. Jennifer to provide Grant-Frontier Park, 30% Design Submittal, proposed improvements
c. Tim to provide updated building cost $/SF information from the I-70 corridor study
d. Shea to post FHAD technical data to Drop Box for Jeremy’s review
e. Matrix to download latest Tax Assessor database
f. Matrix to review the Weir Gulch report to confirm the BCA analysis is consistent
g. Matrix to specifically note in the tables the number of structures removed from the floodplain for the different alternatives
h. Matrix to consider a variety of open channel sections to reduce the need for acquisitions. Currently showing “3 lots deep” for acquisition. Sponsors want to know if the channel width can be reduced so only “2 lots” need to be acquired. Goal is to minimize need for acquisitions.
i. Matrix to define whether Reach 3 improvements can be completed without upstream Reach 4 improvements
j. Matrix to send a PDF showing the floodplain in E. Yale Ave.

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MEETING MINUTES
Dry Gulch Major Drainageway Plan & Flood Hazard Area Delineation
Wednesday August 12, 2015, 11:00am – 12:00pm at UDFCD

Purpose: Kickoff Meeting with Englewood for Dry Gulch

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Dave Henderson	Englewood	303-762-2506	dhenderson@englewoodgov.org
Paul Weller	Englewood	303-762-2505	pweller@englewoodgov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	hungteng_ho@matrixdesigngroup.com

1. Schedule

a. US Army Corps of Engineers using the study which is driving the schedule
b. Kickoff January 29, 2015
c. Baseline Hydrology completed April 27, 2015
d. FHAD 1st Technical Review submittal June 9, 2015
e. Alternatives report 1st draft submitted July 6, 2015
f. Public meeting January 2016
g. Project completion per Corps schedule approx. March 2016

2. Project Approach

a. Data Gathering
   i. Topography 2013 USGS LIDAR – best available
   ii. As-Builts for storm sewer 1972 – provided by Englewood
   iii. Using Parcel data from Arapahoe County
   iv. Land use by Englewood, Zoning Map, adopted as part of the Unified Development Code, February 2004, Amended July 2014.
   v. 1998 OSP for Englewood
   vi. Flood history recent events 6/11/15 and 8/8/13. Pictures shown of significant rivers flowing in the streets.
b. Hydrology
   i. Existing is full build-out.
   ii. Existing Detention - Packy Romans Park, Englewood
   iii. Calibrated CUHP/SWMM to the 1979 FHAD hydrology
   iv. Final Baseline Hydrology Report submitted April 2015
   v. Hand out table of Design Hydrology for Dry Gulch
c. Hydraulics
   i. Channel Centerline and Stationing - HEC-RAS models 10,215 feet long reach with 82 cross sections at average spacing of 125 feet.
   ii. Upstream model limit at City boundary, tributary area 637 acres
   iii. Existing storm sewer capacity subtracted from peak flows
   iv. Overland flow thalweg
   v. Model building blocked obstructions
   vi. Two street split flows at E. Floyd Ave/S. Eastman Ave and E. Dartmouth Ave/S. Humboldt St
   vii. Tie-In – concurrent flood events of Harvard Gulch and Dry Gulch

d. Dry Gulch Reaches (based on the pattern of flow path, mostly in the street)
   i. E. Harvard Street to E. Yale Avenue – 2-68”x43” storm sewer and 72” RCP
   ii. E. Yale Avenue to E. Amherst Place/S. Clarkson Street – 66” RCP
   iii. E. Amherst Place/S. Clarkson Street to E. Cornell Avenue – 66” RCP, a portion of the storm sewer does not follow the topographic thalweg, Emerson Park
   iv. E. Cornell Avenue to S. Downing Street at Barde Park – 66” RCP
   v. S. Downing Street at Barde Park to S. Gilpin Street/E. Eastman Avenue – Barde Park Grass Channel, 60” RCP
   vi. S. Gilpin Street/E. Eastman Avenue to City Boundary (Upstream Study Limit) – 48” to 54” RCP do not follow topographic thalweg, Packy Romans Park
e. Deficiencies
   i. Urban floodplain due to limited conveyance capacity and encroachment in natural/historical flow thalweg.
   ii. 2-year capacity storm sewers, manhole popping at E. Bates Ave/ S. Emerson St (per Jordon Storfa)
f. Alternatives Analysis Issues
   i. Goal is to safely manage 100 year flood event
   ii. Underground pipe
   iii. Open channel with property acquisition
   iv. Detention opportunities
   - Packy Romans Park – area 4.7 acre, Existing V_{100} = 1.61 ac-ft, Q_{100} = 671 cfs. Acceptable to increase the volume.
   - Wellshire Municipal Golf Course (Denver, tributary 394 acres)
   - Barde Park – area 1.78 acres. Acceptable to consider detention.
   - Emerson Park plus 2 city owned lots – area 1.16 acres + lots
   - Clarkson Park – area 0.51 acres
   - Charles Hay School on Downing/Dartmouth

3. Decisions

a. The 1998 OSP hydrology is higher than the new Harvard Gulch Baseline Hydrology which is based upon calibration to gage records. This study will use the newer hydrology.
b. Englewood has a potential flood area along Broadway from Dartmouth to Yale. This study may be expanded to also study this area which is outside of the Harvard Gulch watershed.
c. There may be flooding along University. Matrix to investigate whether the floodplain should be extended upstream.
d. Include the Englewood portion along with the Harvard Gulch study, but a separate public meeting will be held.

4. Action Items

a. Matrix to develop a schedule for completion of Englewood Alternatives
b. Englewood & UDFCD to plan public meeting in October at City Hall
c. Team to develop a Fact Sheet for the public meeting
d. Englewood to review DRAFT map of floodplain to evaluate reasonableness
e. Englewood to see if there was significant flooding July 8, 2001 – highest flow recorded at Harvard Gulch
f. Matrix to review 1998 OSP for Englewood. Understand where Broadway flows go
g. Matrix to update the website with Englewood portion of the study

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Monday August 24, 2015, 10:00am – 12:00pm at UDFCD

Purpose: Review comments on the Alternative Report

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	Jeremy.Hamer@denvergov.org
Sarah Anderson	Denver Water Quality	720-865-2670	Sarah.Anderson@denvergov.org
Jennifer Williams	Denver Capital Projects	303-446-3549	Jennifer.L.Williams@denvergov.org
Cincere Eades	Denver Parks Planning	720-913-0655	Cincere.Eades@denvergov.org
David Morrisey	Denver Public Works	720-913-8518	David.morrisey@denvergov.org
Andy Stewart	Denver Capital Projects	303-446-3510	Andrew.stewart@denvergov.org
Ashlee Grace	Denver CPD Planning	720-865-3131	Ashlee.Grace@denvergov.org
Tim Watkins	Denver Community Planning		Timothy.Watkins@denvergov.org
Katie Ross	Denver Water	303-628-6589	Katie.Ross@denverwater.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
Bob Eck	Matrix Design Group	303-572-0200	bob_eck@matrixdesigngroup.com

1. Project Coordination

a. Update on Corps – Corps is beginning their alternatives analysis and will be requesting files from Matrix to help prepare their separate study
b. There will be a UWR Feasibility Study Technical Session on 8/26/15 with the Corps staff. This meeting is an opportunity to update the Corps on the alternatives being considered under this study.

2. Schedule

a. FHAD 1st Technical Review submittal was made on 6/9/15. Matrix was directed to run some sensitivity analyses for different modeling approaches. Denver is meeting with UDFCD to discuss comments and the additional model analyses requested.
b. Alternatives Analysis report 1st draft was made on 6/30/15. Comments were received 8/13/15. The final Alternatives Analysis report is to be submitted in 3 weeks by contract, although additional time will be needed to explore additional alternatives such as a reconfiguration of detention in Harvard Gulch Park and lowering the existing trapezoidal channel by relocating existing utilities.
c. The public meeting has been moved from September 2015 to January 2016. Matrix will issue a final Alternatives Analysis report which incorporates the comments. The project cannot move forward with a selected plan until the public meeting is held.

3. Englewood as a New Sponsor

a. Englewood has joined this study to evaluate the floodplain and alternatives for Dry Gulch.
b. Englewood has experienced repeated flooding along Dry Gulch
c. Matrix has prepared a draft floodplain model and is working on alternatives
d. Matrix to explore open channel and pipe options for Dry Gulch

4. Alternatives Analysis

a. Existing Detention in Harvard Gulch Park was shown as 6 AF of volume per the Denver master plan model. The design flood control volume is 12 AF. Including the 3 acre-foot permanent pool, the total capacity is designed to be 15 AF. Matrix is changing the Baseline Hydrologic Model to reflect more storage in this pond during a 100-year event.
b. Hydrology at Glencoe – routing of the design points is being changed to more accurately represent hydrology at this point. This change will affect the Baseline Hydrologic Model.
c. Costs regarding contingencies on property acquisition were discussed. Matrix used the tax assessor's value in the report without contingencies. Denver will issue guidance regarding the appropriate contingency based upon their experience. The cost should also include some fee for relocation. The report will explain the basis for the cost estimate.
d. The cost of the levee certification at $450,000 should be explained. Denver Parks is not interested in a certified levee within Harvard Gulch Park. Other options should be explored to avoid a levee.
e. There was a discussion of whether to show the cost of flood insurance in the report.
f. Proposed Regional Detention systems. It was noted that on-line is less efficient than off-line systems.
    i. Rosedale Park (20 AF). Presume off-line detention for peak shaving.
    ii. Harvard Gulch Park Pond (45 AF shows in the alternatives analysis). Parks would like to minimize the disturbance to irrigated areas and ballfields. Presume on-line detention for this area. The ballfields should be elevated at least above a 10-year flood event. Parks would like to minimize disruption to the active areas of the park and mature trees.
    iii. Harvard Gulch Park Irrigation Pond Enlargement. This could be on- or off-line, depending upon routing of flows at Ogden. Denver Water and Denver Parks are currently looking at grading to increase the depth. The project is not currently adding detention, but this could be considered in the final design. There is an opportunity for enlargement of the flood detention at this site.
g. Undersized Box Culvert: Ogden to Downing
    i. Low flows can be routed into the Irrigation Pond or continue in the existing channel. If low flows follow the low point, they can be routed back into the Harvard Gulch channel.
    ii. It may be desirable to keep low flows out of the Irrigation Pond since this is fed by relatively clean City Ditch water and Harvard Gulch flows may bring sediment that could clog the pump and fill the pond.
h. Culvert/Bridge Upsizing
    i. A few roadway bridges are shown over Harvard Gulch. There is no specific reason for the selection of bridges versus culverts at this time since trails do not cross under the bridges.
    ii. Denver's bridge freeboard criteria would require raising roads significantly. If freeboard is difficult to achieve, the study will show box culverts rather than bridges.
i. Water Quality
    i. The alternatives analysis map does not currently show the proposed water quality measures.
    ii. High Line Canal Reach 30 is under study by Denver. Matrix will incorporate this as a water quality measure.

iii. Rosedale Park Pond – There is the option to route base flows into the pond for water quality. It could be a constructed wetland, or just an extended dry detention basin.
iv. Green Streets – recommended by Parks to clean the water before entering Harvard Gulch
v. Parks may accept an on-line sedimentation basin at the Yale outfall.

j. Levee
i. The levee along Harvard Avenue along Harvard Gulch Park where Dry Gulch enters is currently not a certified levee. Costs were shown to certify the levee. Parks may not want this as a certified levee.

5. Action Items

a. Matrix to incorporate comments and re-issue Alternatives Report
b. Matrix to add dummy elements to the model to see if 5 acre feet of on-line storage in McWilliams Park would have an impact on the downstream hydrology. Property could be acquired along McWilliams Park for additional detention if beneficial.
c. Matrix to evaluate what reduction in flow would be necessary to save a row of houses on the design of the outfall along Iliff Avenue.
d. Matrix to look at options to lower the channel along the existing concrete trapezoidal channel section by re-routing a sanitary sewer interceptor along Harvard Avenue. This may provide the additional depth to create grade separated crossings.

Draft Alternatives Analysis Report Review Comments dated August 13, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Alternatives Analysis Report

Items	Page	Reviewer	Comments	Responses
1	15, 33	Denver-CP-Mike Anderson	1965 Report and Plans for Harvard Dam Sheet 1 of 2 show 15 AF.	1. 1976 Report and Plans show 15 ac-ft before the spillway is overtopped. The total volume by design includes 12 ac-ft of flood pool and 3 ac-ft of permanent storage. 2. The existing condition pond volume was re-evaluated using the one-foot, LIDAR-derived topographic contours by USGS in the fall of 2013. The total volume at the crest of spillway is 11 ac-ft which includes 10 ac-ft of flood pool and 1 ac-ft of permanent wet pond. 3. The hydrograph routing for this off-line detention in Harvard Gulch Park Golf Course has been changed to include the split flow from the side channel weir structure and split flow from S. Downing St flows overland and through the culvert underneath S. Ogden St. The revised hydrograph routing calculated 21.7 ac-ft of storage with a surcharged spillway and 2,010 cfs of peak release rate for a 100-year frequency event. 4. This existing off-line detention provides minimal benefit in a 100-year flood event by revising routing to fully utilizing its volume. The same comment was found on page 4 of the 1979 FHAD.
2	31	Denver-CP-Mike Anderson	Table B-4 (pdf pg 95) says 3.8 square miles at S Race Street.	The area shown is from the USGS gage record at the S. Ogden Street gage. This gage is downstream of S. Race and has a slightly larger drainage area.
3	36	Denver-CP-Mike Anderson	revise routing from south of High Line Canal to follow thalweg shown in 2014 Storm Drainage Master Plan which indicates that when the High Line canal is full and overtops, flow will come in at Glencoe, not at Elm. This was also borne out in the FLO-2D rainfall calibration study. This will result in revision to Figure B-2 (pdf pg 84).	1. Instead of routing the hydrograph at Design Point 790 to Design Point 1754 (using a 78” pipe with an overflow element per the model), the hydrograph routing was revised to flow in S. Glencoe St to Design Point 1757 at E. Yale Ave/S. Glencoe St. 2. The Figure B-2 and the other related figures, tables will be updated.
4	39	Denver-PW-Morrisey/Hamer	HEC-RAS model shows modeling as Method 1. Was Method 5 used initially and then converted to M1?	Initially, we started with Method 5 then finished with Method 1.
5	42	Denver-Parks-Cincere Eades	Sentence doesn't make sense.	Sentence revised
6	42	Denver-CP-Jennifer Williams	Is this really structure value? Or is it tax assessor value? Add ** and identify where the data was obtained and a date.	Tax assessor value. The source of the data will be clarified in the report.
7	43	Denver-WQ-Sarah Anderson	This seems confusing. No new development but new water quality ponds? Plus I think the word ‘pond’ is on the way out, please use water quality facilities. Isn't there more possibility for water quality in the regional detention facilities versus new? Also mention retrofit of the High Line Canal for water quality as it will treat 493 acres of the basin.	The word pond changed to facility. Paragraph reworded to indicate that Denver cannot wait for developers to improve water quality in the Harvard Gulch watershed.
8	44	Denver-CP-Jennifer Williams	We know that these values are typically much lower than the actual sale price, plus they do not account for associated relocation costs. Do we need to add a contingency for acquisition so that we are not drastically underestimating costs?	Denver provided guidance to use 2 times the actual value, plus add 30% for relocation costs.
9	44	Denver-CP-Mike Anderson	how long is assumed for establishment irrigation? 3 years?	3 years is the desired goal
10	44	Denver-PW-Morrisey/Hamer	This item to include engineering and permitting for floodplain and stormwater management. Or may be contracted as demolition as part of a bridge construction contract.	Costs were increased from $20,000 to $50,000 to account for incidental items.
11	44	Denver-PW-Morrisey/Hamer	*Some of these cost seem too high or too low. If there is some basis, can these amounts be validated?	Costs modified as directed.
12	45	UDFCD	How was this volume determined? Did you target 45 acres, or did you provide grading per some other plan which resulted in 45 acres?	The 45 acres was graded in assuming the gaps in the existing berm are closed so that the maximum fill at S. Logan Street is 4 feet. This preserves the ball fields and infrequent inundation to the park. The existing grading below elevation 5302 is proposed to be preserved for more frequent flooding of approximate 1,000 cfs which is estimated using the high water marks from recent events in June. The proposed top of grading elevation at S. Logan St is 5308 which matches the top elevation of the existing berm along E. Harvard Avenue.

Draft Alternatives Analysis Report Review Comments dated August 13, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Alternatives Analysis Report

Items	Page	Reviewer	Comments	Responses
13	45	Denver-PW-Morrisey/Hamer	1) Could some additional volume be provided within the downstream portion of HGP by excavating beyond the area shown for the 45 AF alternative, such that the existing ball fields are above 10-yr, but in 100-yr storage area? Are there other opportunities within HGP to accommodate some additional 100-year volume?	Some additional volume could be obtained by relocating the ball fields into the floodplain, but keep them above a 10-year flood. There are a multitude of options to regrade the park to gain additional storage volume. However, the hydrologic model indicates there is no reduction in main stem flows for on-line storage less than 75 acre-feet.
14	45	Denver-Parks-Cincere Eades	Some minor detention could be explored. However, a 4 ft berm will not be supported by DPR. The maximum we would allow is 1 ft.	It is understood that Denver Parks does not want a berm around their park. The goal was to simply fill the gaps in the existing berm.
15	45	Denver-CP-Mike Anderson	4. Reconfiguration of detention at Harvard Gulch Park Golf course? a. If converting it from off-line to on-line in Reach 3 (Figure 5-9). See comments on next page b. Effects of land form change by Parks & Rec/Denver Water for increased permanent pool	The existing Harvard Gulch Park Golf Course Irrigation Pond detention does not provide significant peak shaving benefits in a 100-year flood event.
16	46	Denver-CP-Mike Anderson	At what frequency would this occur? if known	10-year frequency event
17	46	Denver-CP-Mike Anderson	I agree with the elimination of # 3 on page 39 (Skeel Reservoir), but am not sure about Harvard Gulch Park east of Logan I would like to see a table for each of the proposed detention ponds before we select an alternative and finalize a recommended plan. The table should show: Harvard Gulch Park Golf Course, Harvard Gulch Park, Rosedale and list the Name, on-line or off-line, Qin, Qout, Volume, and Peak reduction for each.	A table was added for different detention alternatives within Harvard Gulch Park.
18	46	UDFCD	At this point the detention is schematic so please don't spend time on storage discharge documentation. We can discuss it at the next progress meeting.	Model the effect of detention storage volumes within Harvard Gulch Park.
19	46	UDFCD	5.6.1.1 Is this absolutely necessary? Is there any way to provide the volume with excavation only?	It is not necessary to build a berm around the park. The maximum water surface can be raised, or kept the same by excavating into the Park.
20	46	Denver-Parks-Cincere Eades	5.6.1.1 needs discussion	It is not necessary to build a berm around the park. The maximum water surface can be raised, or kept the same by excavating into the Park.
21	46	Denver-Parks-Cincere Eades	The proposed detention does preclude other park uses at Harvard Gulch Park. The grading plan shown on page 45 eliminates the outfield of the ball fields. The regrading would also remove several large mature trees, which act as a screen between the two uses. This grading plan is not supported by DPR.	The grading will be re-done to not impact the playability of the ball fields. The ball fields will be lowered, but kept above a 10-year flood event. A goal will be to save mature trees.
22	46	Denver-PW-Morrisey/Hamer	There are multiple demands on this area and can be compatible even with more volume provided to improve the flooding conditions downstream. A significant benefit of flood peak reduction must be considered as compared to short-term disruption.	The cost of disturbing the Park will be compared with the cost of a new outfall.
23	46	Denver-PW-Morrisey/Hamer	1) "This amount of storage reduces the 100-year peak flow rate from HGP to ___ cfs. With this additional storage, sizes of downstream improvements can be reduced." 2) How is this facility to be filled/drained, two-way culvert? There are some hydraulic considerations that must be considered in order to properly evaluate the feasibility and value of this proposed feature. Please discuss whether any variant has been modeled and what the results show. 3) Please document the storage discharge relationship for Rosedale Park with 20 acre-feet of volume, and discuss the associated fill/drain concept.	Rosedale Park will essentially act an emergency overflow site to act as off-line peak shaving. It will be designed to capture the peak of the hydrograph and release it back into the Harvard Gulch box culvert in Wesley after the flood has passed.
24	47	UDFCD	I think we're going to need to know what the size of channel/pipe would be and the associated cost if there is no detention in reach 2. Since the detention only reduces the flows a little, we'll need justification for why the ponds are needed and the only way to show that is with $.	A table was added for different detention alternatives within Harvard Gulch Park and the effect on downstream hydrology.
25	47	Denver-Parks-Cincere Eades	Figure 5-3. To fully comply with AASHTO, a railing might be required at top of wall if 5ft clearance from edge of trail cannot be met. Typical for all cross sections.	A railing will be added to retaining walls with a drop height greater than 30 inches.
26	49	Denver-CP-Jennifer Williams	"a sanitary lift station" Is this included in the cost spreadsheet? I didn't see it as a separate item. Would we need a small wet well mounted pump station (S&L style) or a larger dry/wet well? We may need additional property for a larger station, plus we need to add O&M costs to the 50 year cost estimate.	Denver's goal is to avoid lift stations. A sanitary sewer interceptor pipe will be proposed to re-route sanitary sewers so there is not a conflict with the proposed open channel.
27	50	Denver-CP-Mike Anderson	This is the same size as the 2010 draft preliminary report, but that only had off-line detention at Rosedale Park and none at Harvard Gulch Park. I infer from this that the on-line detention at Harvard Gulch park may not be providing much peak-attenuation. See comment on page 40 (Pdf page 46) requesting a table to quantify volumes, peaks and benefits.	On-line detention in Harvard Gulch park is not efficient. The watershed is too large. On-line detention less than 75 acre-feet simply reduced the duration of the hydrograph, but did not reduce the peak flow.
28	50	UDFCD	"Property owners along Harvard Avenue would be less willing to ……" I'm not sure I agree with this as a consideration. Let's discuss.	Put construction in the area of flood reduction. A project in Harvard Avenue is outside of the floodplain. It is better to put the project in Iliff Avenue where there is an existing regulatory floodplain.

Draft Alternatives Analysis Report Review Comments dated August 13, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Alternatives Analysis Report

Items	Page	Reviewer	Comments	Responses
29	50	UDFCD	What is the cost of the Harvard Avenue alignment?	Similar to the Iliff Avenue alignment. It is shorter, but deeper.
30	50	Denver-Parks-Cincere Eades	Need some mention of Grant Frontier Park and the improvements. Also, is this proposed as a 10ft drop structure?	Yes, the proposed open channel option would impact Grant Frontier Park and require a drop structure into the South Platte River. Costs have been included for this work.
31	50	Denver-Parks-Cincere Eades	Shows an open channel under the line.	The figure has a dashed line from the railroad to S Broadway along Harvard Gulch. This dashed line will be removed from the figure.
32	50	Denver-Parks-Cincere Eades	Should we call out assumptions about the neighborhood?	Put construction in the area of flood reduction. A project in Harvard Avenue is outside of the floodplain. It is better to put the project in Iliff Avenue where there is an existing regulatory floodplain.
33	50	Denver-CP-Mike Anderson	No cost summary in Appendix F. This is the same cost estimate from the 2010 Draft preliminary study.	Costs will be used from the 2014 Storm Drain Master Plan and referenced to the study.
34	51	Denver-Parks-Cincere Eades	"…… no additional work is needed on the irrigation pond." Has this fully been ruled out?	Additional detention storage in the Irrigation Pond did not reduce the 100-year discharge in Harvard Gulch. It is more effective for more frequent flood events.
35	51	Denver-Parks-Cincere Eades	Does a 10% reduction warrant the amount of work proposed in Harvard Gulch Park? Please see my comments about this on page 40.	The cost of sufficient detention in Harvard Gulch Park is equivalent to the cost of a new outfall and does not disrupt the park.
36	51	Denver-Parks-Cincere Eades	This design will greatly impact the intent of the park design. The slope and trees provide a separation in park uses currently. DPR would not support the removal of the trees for re-grading. The maximum berm supported is 1 ft.	The hydrologic model and cost estimates do not support disturbing the park.
37	51	Denver-Parks-Cincere Eades Denver-PW-Mike Anderson	Figure 5-8 outfields (approx)No. The detention area shown heavily impacts the ball field outfield area, placing it on a 4:1 slope.	A grading option was explored which lowers the entire ball field area, but keeps it above a 10-year flood event.
38	51	Denver-CP-Mike Anderson	Need to revise these 2 paragraphs: 1. Rosedale Park is in Reach 1 2. See note on page 40 (pdf page 46) regarding effectiveness of each detention basin and my comment on page 44 (pdf page 50) where it appears that Harvard Gulch Park on-line detention may not be providing much benefit. If true, this will need to be revised.	Rosedale Park will be shown in Reach 1. On-line detention in Harvard Gulch Park was not shown to be effective.
39	51	Denver-CP-Mike Anderson	Discuss original design of Harvard Gulch Park golf course as off-line detention (AF of storage), analysis of proposed grading changes by Denver Parks to store more water (ground lowering adds to detention volume?) and change from off-line to on-line detention (Figure 5-9 makes it appear to proposed for on-line)	The Irrigation Pond detention facility was designed to be activated in a 10-year flood event. It all becomes on-line in a 100-year event.
40	51	Denver-WQ-Sarah Anderson	Please add a water quality component to the detention facilities as well as the WQCV provided in each.	Only Rosedale Park is proposed for detention and it is for peak shaving. Low flows could be routed through the site, but the available storage volume is not enough to provide WQCV for the entire watershed.
41	51	UDFCD	We need to talk through how you went about determining this grading plan. It looks as though you held the elevation of the drop and graded downstream. Did you give any consideration to moving the drop upstream? I know it's a massive structure, but if we were able to get more detention volume that looked less like a pit I think it's worth considering. I also just don't think that 4' berm is going to be accepted by parks and the community.	The drop structure could be moved for regrading options to obtain more storage volume.
42	52	Denver-CP-Mike Anderson	It appears that this will make the Harvard Gulch Golf Course detention basin on-line instead of off-line as it is now. Doesn't on-line typically have less peak-reduction capability? Am I missing something? Is there a way to keep it as "off-line" to maximize peak reduction as noted?	The Irrigation Pond detention facility was designed to be activated in a 10-year flood event. It all becomes on-line in a 100-year event.
43	52	Denver-CP-Mike Anderson	It seems a shame to put in an open channel in Reach 3 and not get the WQ benefit; so I would lean towards using the existing box conduit in E Harvard Avenue as the overflow for major storms. However, it appears that the price paid is to convert the current "off-line" detention to "on line". Am I correct? The text notes redesign of the outlet. What is meant by this? Is it possible to reconfigure how the new channel connects to the old channel so that the Harvard Gulch Park Golf Course detention continues to operate as "off-line"?	Low flows will be routed into the proposed open channel. It is better to keep the Irrigation Pond off-line so that it does not fill with sediment and trash which could impact the operation of the pumps. Low flows will be routed back into the Harvard Gulch channel rather than continue to the Irrigation Pond.
44	53	Denver-CP-Mike Anderson	Does the number "62" include the City-owned parcels? If so, please clarify and reduce cost estimate (city parcels would have no cost)	It impacts 62 private parcels. This does not count the existing corridor owned by Denver.
45	53	Denver-WQ-Sarah Anderson	I think it's appropriate to replace GI/green streets/stormwater planters, etc. anywhere that 8' tree lawns are proposed. Given that there are so few opportunities for water quality, please think about the streets as treatment when practical throughout document (I do recognize that green streets are talked about, but should be used consistently throughout document).	Green streets are proposed throughout the report. These can be used in place of tree lawns.

Draft Alternatives Analysis Report Review Comments dated August 13, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Alternatives Analysis Report

Items	Page	Reviewer	Comments	Responses
46	54	Denver-PW-Morrisey/Hamer	1) Please describe what alternatives were considered but that were eliminated and for what reason, i.e., piped alternative. This applies to Reach HG4 and possibly other reaches.	In general, it is not desirable to pipe an open channel for safety, environmental and water quality reasons. A four cell 12' wide by 6' tall box culvert could convey the 100-year flow. However, this MDP focused on ways to restore an open channel.
47	55, 62	Denver-CP-Mike Anderson	Discuss sediment catchment basin upstream of S Jackson Street. Included in cost?	A sediment basin is shown and added to the cost.
48	55	Denver-CP-Mike Anderson	How much are we talking for raising roadway profiles? A few inches, a foot, several feet? What will be the impacts to adjacent private properties? Change access?	Details of proposed structure sizes, roadway profiles and anticipated lowering of water surface elevation are shown in Table 5-6. This is generally 1 to 2 feet.
49	55	Denver-PW-Morrisey/Hamer	Are there any opportunities in this reach for even limited flood storage to achieve even modest peak reduction through downstream reaches? Does the closure of any through-street open up any opportunities to implement detention for peak attenuation or sediment collection? Even a marginal peak reduction could alleviate flooding from HG Park into the Dry Gulch basin. Any alternative that sufficiently improves the conditions at the point where Dry Gulch discharges to HG, such that a levee is not required, would be a positive.	An off-site detention alternative was investigated within the neighborhood of McWilliams Park assuming acquisition of the properties inundated by the 100-year flood event and utilizing these sites as off-line detention. The total lot area for these inundated parcels is approximate 1.59 acres. An estimated off-line detention volume of 5 acre-feet was tested in the hydrologic model. The effectiveness of this minor off-line detention is insignificant for any meaningful hydrologic control. The analysis showed the benefit of reduced main stem flows at S. Logan Street is only 63 cfs (1.3%). Furthermore, these scattered minor off-line detention facilities would increase construction costs, along with maintenance and operation costs.
50	55	UDFCD	Did we rule out analyzing detention in McWilliams Park? If so, explain that it was considered but thrown out and provide the reason.	Existing sanitary sewer crossings limit the opportunity to go deeper.
51	56	Denver-CP-Mike Anderson	Does the 5-year storm conduit proposed in the City's Master Plan collect enough flow that the Q100 on the surface meets street depth criteria (12" in the gutter) or are larger pipes need to achieve street depth criteria. If so, how much larger and what cost? Alternatively, if the City's Q5 in E Yale is close to, or even greater than, the MDP Q100 due to sub-basin discretization in the city's Storm Drainage Master Plan, we should discuss.	Yes, the 2014 Storm Drain Master Plan was intended to provide 5-year conveyance for pipes 80% full. With the calibrated main stem model developed for this study, the pipes flowing full can convey the 100-year event.
52	56, 57	Denver-CP-Mike Anderson	Use City cost from SDMP or use UDFCD?. If using city's, insert this after "is estimated": in the City of Denver's 2014 Storm Drainage Master Plan to be $7,020,081. If use UDFCD costs, include cost table in Appendix F	Costs were used from the 2014 Storm Drain Master Plan and referenced as such.
53	57	Denver-CP-Mike Anderson	List Rosedale Park Detention separately. As I understand from the text on page 41 Section 5.6.2.it is assumed in place for all 3 alternatives: the Iliff culvert and 2 greenway alternatives	Yes, Rosedale Park detention is proposed with all alternatives.
54	57	UDFCD	I would put an asterisk here with a footnote stating that the improvements in this reach help to remove the structures from the floodplain in Reach 1. Also, were these costs included in the BCA for Reach 1?	Detention in Harvard Gulch Park would reduce flooding downstream in Reach 1, however, it is not possible to obtain enough storage in the Park to eliminate the need for a new outfall to place properties outside of the floodplain.
55	59	UDFCD	Let's discuss including flood insurance policies for structures in the floodplain in the BCA.	Reducing the flood hazard area delineation would reduce the number of properties required to purchase flood insurance. However, this benefit was not included in the cost evaluation.
56	60	Denver-CP-Mike Anderson	I'm not sure on-line detention in Harvard Gulch Park at Logan provides much peak reduction benefit for the cost. Continued detention at Harvard Gulch Park Golf Course may be worthwhile if it continues to be off-line. See my general comments on page 40 (pdf pg 46) regarding a table for all considered basins; and on page 46 (pdf page 52) re: golf course pond.	Capital improvements to reduce downstream flood hazards should focus on a new outfall or major detention within the Park, but not both. The cost of building a new outfall is equivalent to building significant detention within the Park. The disruption to the Park makes a new outfall option more appealing. Building additional incremental detention within the Park (not enough to manage the 100-year event) did not significantly downsize the outfall. For the box culvert option, incremental detention only reduced the size of the box by a couple of feet. For the open channel option, incremental detention did not provide enough reduction in the hydrology to reduce the number of property acquisitions.

Draft Alternatives Analysis Report Review Comments dated August 13, 2015 and Responses

Harvard Gulch Major Drainageway Plan _ Alternatives Analysis Report

Items	Page	Reviewer	Comments	Responses
57	61	Denver-CP-Mike Anderson	As noted in the August 2003 Harvard Gulch Drainage Rehabilitation Plan Report prepared by Muller Engineering for the UDFCD, "an underdrain system was constructed several years ago along a large portion of the Harvard Gulch channel invert." (Reaches 2, 3, 4, 5 and 6 of this MDP). "The underdrain system consists of a series of inlets situated flush with the channel bottom, which are connected with concrete pipe. The intent of this system was to drain base flows through the underdrain pipe and allow storm flows to be conveyed through the open channel system above. Continual clogging of the inlet grates has caused the underdrain system to be ineffective. Currently, little to no flow runs through the portions of the underdrain system that still exist and all base flow and storm flow is conveyed through the open channel. Removal or enhancement of the underdrain system should be considered when constructing improvements along the drainageway."	Added to the recommended plan.
58	63	Denver-PW-Morrisey/Hamer	1) Considering the challenges of implementing recommended plan for reaches HG1 and HG2, which are interdependent, the need for so many acquisitions, the significant capital cost ($38M), please recommend how the recommended plan can be phased, identifying incremental benefits associated with incremental improvements. It is unlikely that these combined improvements can be implemented as one large project.	Phasing may include constructing a new outfall from the South Platte River up under Santa Fe Boulevard through the rail lines. A next phase may continue the line upstream to Logan Street. Phasing will be discussed in the Concept Design chapter to be added later.
59	63	UDFCD	Phasing is covered in the conceptual design phase of the study. We can discuss this at the next meeting but you don't need to address it in detail at this point in the report.	Agreed.
60	63	UDFCD	Please include a schematic figure that shows the elements of the recommended plan. I can provide an example if you need one.	Added to the report,
61	65	Denver-WQ-Sarah Anderson	Mike has asked for a detention basin table, can you please add a WQCV column to that table. In this section talks about 'incorporating water quality features into all master drainage projects' including Rosedale and Harvard Gulch, yet it's not talked about in the project descriptions earlier in document. Please add there as well.	The proposed detention basin at Rosedale Park could also include some minor water quality treatment in the bottom. The site could be used to treat base flows and/or minor surcharges of storm flows. However, there is not enough volume to provide the full WQCV. A multi-stage diversion structure could be constructed upstream of Logan Street to divert low flows and/or first flush flows into Rosedale Park for treatment in either a constructed wetland or an extended dry detention basin. Volume must be reserved for peak flow shaving during a 100-year event. Select media on the bottom of the basin coupled with a robust subdrain system could keep the basin mostly dry while providing pure flood attenuation storage in the upper portion of the basin.
62	67	Denver-Parks-Cincere Eades	Other general comments: - DPR needs to discuss the proposed detention at Harvard Gulch Park with the other project sponsors - Are we keeping the sketch out images of the reaches? I have some concern with the quality. The proposed floodplain should be better represented and/or called out in the images.	The analysis did not demonstrate a need for detention in Harvard Gulch Park. The sketch images have been retained in the report.
63	220, 221, 224 225, 227	Denver-CP-Mike Anderson	What is the Special Item for? It's 17% of the total so we should have a "user comment".	The "Special Items" summarize the table of costs above under "Special Items"
64	222	Denver-CP-Mike Anderson	Denver Storm Drainage Master Plan uses $75,000 per AF.	The UDFCD UD-Cost spreadsheet is based upon $48,806 per acre-foot. However, this figure was changed to $75,000 based upon comments from Denver.
65	222	Denver-CP-Mike Anderson	Rosedale, 19.3 AF, is in Reach 1. Do separate cost estimate for Rosedale off-line detention for Reach 1 and include the resultant cost in each of the Alternatives for Reach 1 (2 open channel and 1 box in Harvard)	Done.
66	242	Denver-PW-Morrisey/Hamer	Please identify an alternative to the requirement of an accredited levee.	The levee is no longer proposed since a berm around the Harvard Gulch Park was not supported by Denver Parks.
67	242	Denver-PW-Morrisey/Hamer	Proposed culvert is on private property. Please identify alternative that shows culvert in ROW, or combination of storm sewers in ROW and outside of ROW, and identify needed acquisitions. Please identify alternatives that utilize existing infrastructure, i.e., a system that is a combination of existing and new. Please address the upstream conditions and interception of flows entering CCD, and any issues related to coordination with upstream infrastructure, existing or planned.	The proposed 100-year pipe in Dry Gulch follow the alignment of the existing pipes. Proposed pipe will be kept within the ROW. No property acquisition is proposed for the pipe option.

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MEETING MINUTES
Dry Gulch Major Drainageway Plan & Flood Hazard Area Delineation
Monday October 26, 2015, 1:00pm – 2:30pm at UDFCD

Purpose: Share initial findings with Englewood of the Alternatives Analysis for Dry Gulch

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Dave Henderson	Englewood	303-762-2506	dhenderson@englewoodgov.org
Paul Weller	Englewood	303-762-2505	pweller@englewoodgov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	hungteng_ho@matrixdesigngroup.com

1. To Do Items from the August 12, 2015 meeting

a. Englewood to review DRAFT map of floodplain to evaluate reasonableness
b. Englewood to see if there was significant flooding July 8, 2001 – highest flow recorded at Harvard Gulch
c. Matrix to update the website with Englewood portion of the study

2. Project Approach

a. Issues
   i. 10,215 feet long reach
   ii. Upstream project limit at City boundary, tributary area 637 acres
   iii. Overland flow thalweg different than pipe alignment
   iv. Two street split flows at E. Floyd Ave/S. Eastman Ave and E. Dartmouth Ave/S. Humboldt St
b. Deficiencies
   i. Surface flow due to limited pipe capacity and encroachment into the natural/historical flow thalweg.
   ii. 2-year capacity storm sewers, manhole popping at E. Bates Ave/ S. Emerson St
   iii. Recent incidents of flooding occurred in Dry Gulch on July 19, 2011, June 6, 2012, August 8, 2013, June 11, 2015 and June 24, 2015, which resulted in heavy flow in the streets when the pipe capacity was exceeded. There are reports of manhole lids popping off at E. Bates Avenue & S. Emerson Street. Residents noted 2.5 to 3 feet of water in their backyards, alleys and street during these events.
c. Alternatives Analysis to safely manage the 100 year flood event
   i. Underground pipe option
   ii. Open channel with property acquisition option
   iii. Detention opportunities
      - Packy Romans Park – area 4.7 acre, Existing V_{100} = 1.61 ac-ft, Q_{100} = 671 cfs. Opportunities to increase the volume. If the entire site were used for detention, a 29.9 acre-feet of storage could be achieved 10 feet deep.
      - Wellshire Municipal Golf Course (Denver, tributary 394 acres). The maximum storage in a 100-year flood could be 55 acre-feet.

   iv. Other detention opportunities, but determined to be too small to have a meaningful impact at reducing flows:
      - Barde Park – area 1.78 acres.
      - Emerson Park plus 2 city owned lots – area 1.16 acres + lots
      - Clarkson Park – area 0.51 acres
      - Charles Hay School on Downing/Dartmouth

3. Alternative Exhibits

a. Underground 100-Year pipe, approximate cost $22 million
b. Underground 100-year pipe with maximum detention, $17 million
c. Open channel, approximate cost $47 million with acquisition
d. Open channel with maximum detention, $41 million with acquisition

4. Public Meeting

a. Set meeting November 18, 2015 at the Englewood Civic Center
b. UDFCD to send out postcards 1½ weeks prior to the meeting to notify residents of the meeting. Send to people within a 300 foot buffer from the floodplain
c. Open house format
d. Anticipate 10-50 people, but unknown how many people will show for a planning study

5. Action Items

a. Matrix to update the website to include Englewood as a sponsor and note Dry Gulch
b. Matrix to look at geologic map for Dry Gulch channel alignment
c. Matrix to update costs to include inlets and other incidentals
d. Matrix to bring 4 maps for the 4 alternatives
e. Matrix to bring sign in sheet and comment cards
f. UDFCD to send out postcards for public meeting
g. Englewood to reserve room at the Civic Center for the public meeting

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PUBLIC MEETING
MEETING MINUTES
Dry Gulch Major Drainageway Plan
Wednesday November 18, 2015, 6:30pm – 7:30pm at Englewood Civic Center

Purpose: Gather public input on alternatives for Dry Gulch. Open house format.

Sponsor/Technical Consultant Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Dave Henderson	Englewood	303-762-2506	dhenderson@englewoodgov.org
Paul Weller	Englewood	303-762-2505	pweller@englewoodgov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com

1. Public Meeting Format

a. UDFCD sent out postcards 1½ weeks prior to the meeting to notify residents of the meeting. Send to people within a 300 foot buffer of the 100-year floodplain.
b. 17 residents signed in. Potentially a few more people attended, but did not sign in.
c. 3 public comment cards were filled in

2. Presentation Materials

a. Map #1 – Existing conditions with 100-year areas of inundation delineated
b. Map #2 – USGS Geologic Map showing historic drainageway of Dry Gulch
c. Map #3 – Alternative #1: Proposed 100-Year Pipe
d. Map #4 – Alternative #2: Proposed 100-Year Open Channel
e. Map #5 – Alternative #3: Proposed 100-Year Pipe with Upstream Detention
f. Map #6 – Alternative #4: Proposed 100-Year Open Channel with Upstream Detention

3. General Comments

a. History of flooding in the area, more recurrence of flooding within the last 4 years.
b. Flooding occurred around Ogden Street.
c. General concern about property acquisition to build the open channel alternative.
d. Support to accelerate the construction schedule to reduce flood hazards to the neighborhood

Dry Gulch Tributary to Harvard Gulch
Major Drainageway Plan
Public Information Meeting

Wednesday, November 18, 2015
6:30 to 7:30 p.m.

Englewood Civic Center – Community Room
1000 Englewood Parkway, 2nd Floor

Join project sponsors to learn about a major drainageway planning study for Dry Gulch, a tributary to Harvard Gulch. This is a stormwater drainage master plan.

The study area in northeast Englewood is generally bounded on the north by Harvard Avenue, on the east by University Boulevard, on the south by Hampden Avenue and on the west by Pennsylvania Street.

Project Sponsors
Urban Drainage and Flood Control District, City of Englewood

Learn more online at:
www.matrixdesigngroup.com/UDFCD/HarvardDry/default.html

Dry Gulch, Englewood
Major Drainageway Plan
Public Meeting Comment Card
Wednesday, November 18, 2015

Name	Address	Phone	Email
GEORGE R HOMAN	2720 S WASHINGTON		
Heidi Ebner	2780 S Ogden St		
Doug Cohn	3051 S. MARION		
DAVID & LOREL WESTFALL	2760 S OGDEN ST		
Bruce & Kathleen Weimer	2719 S. Washington St.		
Mark Plunkett	2730 S Washington		
~~Michael Bowers~~ Sonja Strom	2828 S. Washington		
MICHAEL BOWERS	2828 S. WASHINGTON ST.		
Laurett Barrentine	4160 S. Read		com
Shaina & Craig Ferguson	3064 S. Corona St.		
Rita Russell	2216 E. Dorset Cir.		
Jess Gerardi	762 E. Amherst PL		
CJ Cullinan	1501 E Dartmouth Ave 80113		
Archival Sanchez	2970 S. Ogden st Englewood		

Dry Gulch, Englewood
Major Drainageway Plan
Public Meeting Comment Card
Wednesday, November 18, 2015

Comment: We are against any plan that involves taking property & open water channels as it is the most invasive.

Please add our house to all maps as a serious flood area — we had 4ft in June - 3064 S. Corona st

Are there options that really target the areas hardest hit?

We would be in favor of the 100 year, underground pipeline plan. We are against any acquisition of property, as our house would be one taken. We've made a significant investment in our own property, as well as the improvement of Englewood schools to be forced to move.

Please include is in all communication about next steps.

Name and Contact Information:
Shaina & Craig Ferguson
3064 S Corona St

Dry Gulch, Englewood
Major Drainageway Plan
Public Meeting Comment Card
Wednesday, November 18, 2015

Comment: The all pipe option!

Name and Contact Information: Archival Sanchez Ortiz
2970 S. Ogden St. Englewood CO 80113

Dry Gulch, Englewood
Major Drainageway Plan
Public Meeting Comment Card
Wednesday, November 18, 2015

Comment: The "all pipe" option is the only one that makes sense. Don't force residents out of their homes.
Thank you

Name and Contact Information: David & Lorel Westfall
2960 South Ogden Street
Englewood, Co 80113

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Thursday January 28, 2016, 3:00pm – 5:00pm at UDFCD

Purpose: Review comments on the second version of the Draft Alternative Report

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Selena Klosowski	Denver Capital Projects	303-446-3520	Selena.Klosowski@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	Jeremy.Hamer@denvergov.org
Jennifer Williams	Denver Capital Projects	303-446-3549	Jennifer.L.Williams@denvergov.org
Cincere Eades	Denver Parks Planning	720-913-0655	Cincere.Eades@denvergov.org
David Morrisey	Denver Public Works	720-913-8518	David.morrisey@denvergov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	Hungteng_ho@matrixdesigngroup.com

1. Corp of Engineers Study Coordination

a. The Corps recommended plan will not be complete until the fall of 2016. This MDP study can be completed prior to the Corps completing their study.
b. This study will document the City's preferred plan.
c. Regarding potential property acquisitions, if the City does not support acquisitions, then the Corps' recommended plan will not pursue acquisitions.

2. Schedule

a. The public meeting for alternatives was held in January 13, 2016.
b. Matrix will incorporate sponsor comments and issue a final Alternatives Analysis report.
c. UDFCD and Denver will meet to develop a Selected Plan based upon recommendations

3. Alternatives Analysis

a. Matrix to develop a screening criteria chart by weighting factors to use in the decision process.
b. Matrix to recommend alternatives based upon cost and feasibility. Denver to select alternatives based upon other factors such as politics and community desire.
c. Reach 1: Logan to the South Platte River.
    i. There was a discussion of whether to show the cost of flood insurance in the report. There is a real cost to the community for the many flood insurance policies.
    ii. Alternatives are based upon lowered master planned hydrology assuming detention will be constructed in Rosedale Park. Denver Parks is assuming Rosedale Park will be reconstructed to serve as off line detention and potentially some water quality treatment. There is not a need to evaluate Reach 1 options without proposed detention in Rosedale Park. The number of acquisitions remains the same for the open channel option due to the width needed for a road couplet.
    iii. Consider alternatives for a lower level of protection. Discussion regarding having some amount of flooding contained within the streets. Typical street capacity is roughly 100 cfs which is minor compared to the 2,200 cfs shortfall in the existing system.

d. Reach 2: Harvard Gulch Park
    i. Park work is on hold pending the outcome of this study. Parks does not want to spend money on improvements that may be demolished in the recommended plan.
    ii. The Park could be reconstructed to achieve some detention. The cost of the park reconstruction is similar to the cost of a new outfall pipe to the South Platte River. Parks wants to know at what event there is storage in the park. Existing system is 10-year capacity which has not been exceeded in the last 50 years.
    iii. The Corps is showing off-line detention in Harvard Gulch Park. Matrix is concerned that it is not practical to build off-line detention, and that it must be evaluated as on-line detention due to the wide floodplain and flow into the park from multiple directions. Matrix, UDFCD and Denver will meet with the Corps on February 2 to investigate whether off-line detention is achievable.
e. Reach 3: Ogden to Downing
    i. Explanation of the proposed split flow situation. Low flows can be routed to the north to follow the low point and return back into the existing Harvard Gulch channel.
    ii. Address the number of structures impacted by improvements which may include structures upstream and downstream. This would skew the Benefit/Cost ratios.
f. Reach 4: Concrete Trapezoidal Channel
    i. Denver identified potential safety concerns with narrow channel in Reach 4
    ii. The narrow confined channel is shown as an alternative to avoid acquisitions. The open channel is desirable, but Denver needs to address whether they will support acquisitions to build a channel per current criteria.
    iii. To get grade separated crossings would require lowering the channel back into Harvard Gulch Park by lowering the concrete baffled drop.
    iv. Recommend putting the trail along the north side
g. Water Quality
    i. Tap into the new Ultra Urban Guide
    ii. Speak to the bigger initiative of Denver improving water quality
    iii. Define the tools to address water quality
    iv. Harvard Gulch is not a "priority basin". Reference the Water Quality Implementation Plan
    v. Green Streets and Green Infrastructure – recommended by Parks to clean the water before entering Harvard Gulch
    vi. What is the source of sediment flowing into Harvard Gulch? What is the upstream watershed area tributary to the Yale outfall?
    vii. Parks wants more information on an off-line or on-line sedimentation basin near the Yale outfall.
h. Skeel Reservoir
    i. This study should note the decommissioning of Skeel Reservoir and note what detention is needed to maintain existing conditions.

4. Action Items

a. Matrix to incorporate comments and re-issue Alternatives Report
b. Meet with the Corps February 2 to investigate off-line detention options
c. Matrix to add a screening matrix to the report to compare alternatives

Selected Plan for the
Harvard Gulch and Dry Gulch Major Drainageway Plan

April 26, 2016

The *Selected Plan* for Harvard Gulch and Dry Gulch agreed upon by the City and County of Denver (*Denver*), City of Englewood (*Englewood*) and the Urban Drainage and Flood Control District (*UDFCD*) (hereinafter *Denver*, *Englewood* and *UDFCD* shall jointly be referred to as "*Sponsors*") to be shown by Matrix Design Group, Inc. (*Matrix)* in the final *Harvard Gulch and Dry Gulch Major Drainageway Plan* report (hereinafter called "*Final Report*") is described in general and specific terms below.

SELECTED PLAN AND DIRECTLY RELATED ISSUES

Unless specifically directed otherwise below, this *Selected Plan* to be shown in the *Final Report* essentially follows the recommendations made by *Matrix* in the *Harvard Gulch and Dry Gulch Major Drainageway Plan Alternatives Analysis Report* dated February 2016 (hereinafter called "*Alternatives*") based on the following principal elements, goals and objectives:

- Minimize stormwater and flood-related damages to drainageways, public infrastructure and private property. Do this with value engineering and practicalities of implementation in mind.
- Institute an approach that balances the development in the watershed with stormwater management implementation that complements drainageway and stream stability solutions, that as a system, provide multiple benefits that include:
  - Water quality protection and enhancement;
  - Water quantity resources protection;
  - Preservation of natural character of the waterways and their terrestrial and aquatic habitat resource;
  - Wherever possible, provide public use and access and/or trails within the corridors of identified waterways in order to provide maintenance access that will also provide for active and passive recreation of the public.
- Consider the needs for new and upgraded roadway crossings when such improvements are practicable, affordable and add significant value in relation to the cost.

Matrix is asked to address all items that are specified to be addressed in the *Final Report* as described in the agreement between *UDFCD* and *Matrix* for this project, which includes developing, describing and showing a conceptual design based on the Recommended Plan in the *Alternatives*, with the following exceptions:

1. Executive Summary: Include a brief explanation of how the conceptual design relates to the USACE Feasibility Study.
2. Reach HG-1: Include modification of the inlet to the Wesley Avenue box culvert to maximize the existing culvert capacity.

3. Reach HG-1: Size the proposed box culvert in Iliff Avenue for the flow required to remove flooding to structures while allowing street flow (i.e., 100-year flow minus existing culvert capacity with modified inlet minus maximum allowable surface flow that does not inundate structures).
4. Reach HG-4: Proceed with conceptual design of the "Wide Open Channel" section, but minimize section to reduce property acquisition. Remove trail from one side of gulch and determine if reduced cross section width will result in acquisitions on only one side of the gulch or in only partial lot acquisitions.
5. Reach HG-5: Keep the pedestrian trail on the north side of the creek if possible to minimize the number of creek crossings.
6. Revise report to address outstanding comments provided in separate document.

Also show and describe all recommended facilities, costs and actions on a reach-by-reach of the drainageway. In general, the *Final Report* shall provide, show, and recommend the following:

1. Under a section in the *Final Report* titled "General Recommendations", recommend:
   a) That the controlling jurisdictions take steps to stabilize all major waterways when their watershed urbanizes, rehabilitate existing degraded reaches of the waterways and their tributaries, and aggressively control erosion and sediment transport during construction activities.
   b) That Sponsors and any other jurisdiction having land use control powers in this watershed require new land development and significant redevelopment and publicly funded projects to provide to the maximum extent practicable runoff volume control practices (i.e., minimize directly connected impervious areas and employ infiltrating BMPs) whenever site conditions permit.
   c) That the controlling jurisdictions take steps to require that all BMPs for all new development, redevelopment, and publicly funded projects provide to the maximum extent practicable a Water Quality Capture Volume (*WQCV*) as recommended in the Urban Storm Drainage Criteria Manual – Volume 3, after accounting for volume reductions achieved using volume control practices as recommended under Item 1.b above.
   d) That all jurisdiction having land use control powers in this watershed continue to implement their floodplain management regulations, including regulation of the 100-year floodway and floodplain.

      Recommend that these jurisdictions adopt a policy, if not already done so, of preserving the defined floodplains as open spaces to the maximum extent possible and that at least 1-foot freeboard be provided for the lowest floor above the 100-year flood elevation shown on the latest flood hazard area delineation or FIRM maps for all human occupied structures built adjacent to, or within, the defined 100-year floodplains.
   e) That all jurisdiction having land use control powers in this watershed continue to participate in FEMA's flood insurance Community Rating System and public education programs.
2. List on the plan view and profile sheet of the conceptual design, where appropriate, the recommended wetland mitigations that will be needed to implement recommended improvements, if any.

3. Show on appropriate plan and profile sheets facilities to arrest the vertical degradation of the low-flow channel of natural and man-made waterways and to help rehabilitate, as much as possible their stable function and habitat.
4. Recommend rehabilitating eroded and degraded banks where needed and desired to arrest the horizontal erosion along natural waterways using bio-engineered methods that combine buried soil riprap and revegetation with native species of riparian and dryland vegetation.
5. Show on plan view and profile sheet the needed buttressing of critical utilities and other structures that may be endangered by stream erosion.
6. Using the input from stakeholders and the public, work with *Sponsors* and affected other local jurisdictions to prioritize the recommended facilities and actions that are listed in the *Final Report* and clearly articulate them in that document.
7. Describe the recommended type and schedule of maintenance activities for all improved facilities recommended in the *Final Report*.
8. Consider the various functions of all natural waterways in the study watersheds and their floodplain, including flood conveyance, riparian habitat, open space, aesthetics, recreation, urban development, water quality, utility crossing, transportation and other features.
9. Acknowledge in the *Final Report*, that land-use changes to the contributing watersheds affect the flood hazard nature (i.e., runoff rates, volumes and depths), the transport of sediment, and the water quality of the receiving natural waterways. The *Final Report*, under "General Recommendations" shall suggest that Sponsors and any other jurisdiction having land use control powers in these watersheds monitor land-use changes and whenever the land-use changes result in imperviousness ratios that exceed the projections identified in the *Final Report*, these jurisdiction take steps to further limit increases in stormwater runoff through the use of additional on-site detention, infiltrating BMPs and *WQCV* BMPs, thereby reducing the runoff rates, volumes and future damage potentials to the *Final Report* levels.

EXECUTIVE SUMMARY

Include an Executive Summary in the *Final Report* written in plain, non-technical language, which is directed primarily at the general public and elected officials. This summary should, at the minimum, contain the following as well as other items listed in *UDFCD's* checklist for preparation of the final major drainageway plan conceptual design report:

1. A brief summary of the planning process including numbers of progress and public meetings.
2. A brief description of the decisions made by project sponsors during this project.
3. A brief summary of all design criteria specifically developed for this plan.
4. A brief summary of the following sections of the *Final Report*: Purpose and Scope, Study Area Description, Alternative Evaluation, Recommended Plan, and Conceptual Design.
5. A map showing the area and all recommended improvements.
6. Tabular and narrative summaries of costs showing costs for capital improvements, engineering/administrative/contingencies, and land values, all sorted by drainageway, reach, tributary, and by jurisdiction. The reach length (miles), tributary catchment area (square miles), and their totals should also be included in the table.

Incorporate the following notes on each drawing:

"This drawing is for master planning purposes and represents preliminary and conceptual engineering. Alternatives to this outfall system will be considered by local agencies and the Urban Drainage and Flood Control District provided the alternative offers an equivalent intent of the plan, including hydraulic capacity, water quality, stream stability and natural waterway features. The alternative must comply with all requirements of the local jurisdiction and the Urban Drainage and Flood Control District. In addition, there may be State and Federal requirements that will need to be considered and met. This drawing does not provide a final design and shall not be used for construction purposes."

"Local Cities, Towns, and Counties manage and regulate all land use change, development and redevelopment activities within and adjacent to the 100-year floodplains in order to prevent, to a maximum extent possible, future flood damages to buildings and structures from the 100-year flood and to minimize damages from larger floods. The recommendations of this plan provide a set of options subscribed to by Cities, Towns and Counties in carrying out their floodplain management and regulatory responsibilities and obligations."

"Many activities that occur in or affect ditches, drainages, creeks, ponds or wetlands require a Section 404 Permit Authorization from the US Army Corps of Engineers. During preliminary design, and prior to final design or starting work, contact the Corps' Denver Regulatory Office at 303-979-4120 for appropriate permit authority to avoid compromising and delaying the completion of the project."

ADDITIONAL DIRECTION

1. Unit costs should be updated to reflect the most current costs available using the UD-MP Cost worksheet.
2. Include an Acknowledgements section listing all participants and stakeholders in this study. Include in the list their name, organization and function in the planning process.
3. Show all maintenance access routes along all reaches. To the extent feasible, the alignment of these routes shall be coordinated with existing and planned recreational trails identified using input provided by Sponsors, special districts and other local stakeholders.
4. Summarize cost estimates of improvements by jurisdiction where those improvements are located, by the reach in which the improvements are located and overall project totals.
5. Report estimated costs for maintenance of all facilities, including detention ponds, storm sewer outfall points, grade control structures, etc. reported in the *Final Report.*
6. Prepare a GIS shapefile of all proposed improvements using the UDFCD SWIFT tool.

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MEETING MINUTES
Harvard Gulch and Dry Gulch
Major Drainageway Plan and Flood Hazard Area Delineation
Monday May 23, 2016, 2:30pm – 4:00pm at UDFCD

Purpose: Review the Selected Plan and prepare for the Draft Concept Design Report

Attendees:

Shea Thomas	UDFCD	303-455-6277	sthomas@udfcd.org
Mike Anderson	Denver Capital Projects	720-865-3023	mike.anderson@denvergov.org
Selena Klosowski	Denver Capital Projects	303-446-3520	Selena.Klosowski@denvergov.org
Jeremy Hamer	Denver Floodplain	720-913-0720	Jeremy.Hamer@denvergov.org
Sarah Anderson	Denver Water Quality	720-865-2670	Sarah.Anderson@denvergov.org
Jennifer Williams	Denver Capital Projects	303-446-3549	Jennifer.L.Williams@denvergov.org
Cincere Eades	Denver Parks Planning	720-913-0655	Cincere.Eades@denvergov.org
David Morrisey	Denver Public Works	720-913-8518	David.morrisey@denvergov.org
Paul Weller	Englewood	303-762-2505	pweller@englewoodgov.org
Robert Krehbiel	Matrix Design Group	303-572-0200	robertk@matrixdesigngroup.com
HungTeng Ho	Matrix Design Group	303-572-0200	Hungteng_ho@matrixdesigngroup.com
Bob Eck	Matrix Design Group	303-572-0200	Bob_eck@matrixdesigngroup.com

1. Selected Plan

This study will be completed to document CCD and UDFCD's preferred plan. The direction is to develop a conceptual design based on the Recommended Plan in the Alternatives, with the following exceptions:

a. Executive Summary: Include a brief explanation of how the conceptual design relates to the USACE Feasibility Study (Selena can assist in this description).
b. Reach HG-1: Include modification of the inlet to the Wesley Avenue box culvert to maximize the existing culvert capacity. The box culvert would not be built this way under current criteria so it should be modified to meet current design standards.
c. Reach HG-1: Size the proposed box culvert in Iliff Avenue for the flow required to remove flooding to structures. 1,680 cfs.
d. Reach HG-4: Proceed with conceptual design of the "Wide Open Channel" section, but minimize section to reduce property acquisition. Remove trail from one side of gulch and determine if reduced cross section width will result in acquisitions on only one side of the gulch or in only partial lot acquisitions.
e. Reach HG-5: Keep the pedestrian trail on the north side of the creek if possible to minimize the number of creek crossings.
f. Revise report to address outstanding comments provided in separate document.

2. Corp of Engineers Study Coordination

a. The draft BCA values (which determine their Preferred Alternative) was distributed on May 7, 2016. Reach 6 will be excluded from the Corps project. Unofficially, the Corps has demonstrated that the BCA is greater than 1.0.
b. The Tentatively Selected Plan (TSP) will be distributed July 2016
c. The draft *Recommended Plan* (Feasibility Study and EIS) will be completed in November 2016.
d. The 30% Design will be completed by July 2017

3. Project Schedule Summary

a. Progress meeting January 28, 2016 to finalize Alternatives Analysis comments
b. Matrix developed screening criteria with weighting factors to use in the decision process
c. Matrix incorporated comments and issued the Alternatives Analysis report February 16
d. Matrix edited the exhibit for off-line detention in Harvard Gulch Park March 28, 2016
e. Matrix produced a Summary Matrix Table April 24, 2016 and updated it May 2, 2016
f. UDFCD notified Matrix of a Selected Plan April 26, 2016 and transmitted edits to the Alternatives Report from Denver

4. Floodplain FHAD

a. Meeting with UDFCD to discuss technical comments to the hydraulic model

5. Concept Design

a. Reach 1: Logan to the South Platte River.
    i. Rosedale Park off-line detention of 20 acre-feet and water quality. Future preliminary design may achieve more storage volume.
    ii. Inlet modifications to maximize existing culvert capacity.
    iii. Underground outfall in Iliff – 14' x 8' RCBC
b. Reach 2: Harvard Gulch Park
    i. No work proposed, except for water quality
c. Reach 3: Ogden to Downing
    i. Parallel box culvert (14' x 10' RCBC) to work with Porter Hospital master plan
    ii. Update the trail connection
d. Reach 4: Concrete Trapezoidal Channel
    i. Option 1: Reduced acquisitions to 6 parcels. Build 90 foot wide open channel and reconstruct all north-south bridges. It was 104 feet wide in the alternatives analysis, but 90 feet with minor walls will fit better into the available corridor to limit acquisitions. Trail crossings at roadways will be at-grade since clearance will be 7 feet at best if the trail is only 2 feet above the channel bottom, which means the trail would be periodically inundated. Denver's standard of 10 feet of clearance and having the trail above the 5-year flood cannot be achieved.
    ii. Option 2: 24 acquisitions with roadway couplet. Overall cross section shown is 162 feet wide. Only 3 crossings (Franklin, High and Downing). Better east-west connectivity, but limited north-south connectivity. Lengthy discussion about the typical cross section dimensions. Roadway couplet must be at least 23 feet wide for fire access.
    iii. Options are similar in cost at $32 M.
    iv. Denver Parks prefers Option 2 with an improved greenbelt with fewer bridge crossings.
    v. Denver to discuss Option 2 road crossings and trail opportunities.

Review Comments _ 12-10-2015

First Technical Draft Submittal

Appendix A – Project Correspondence

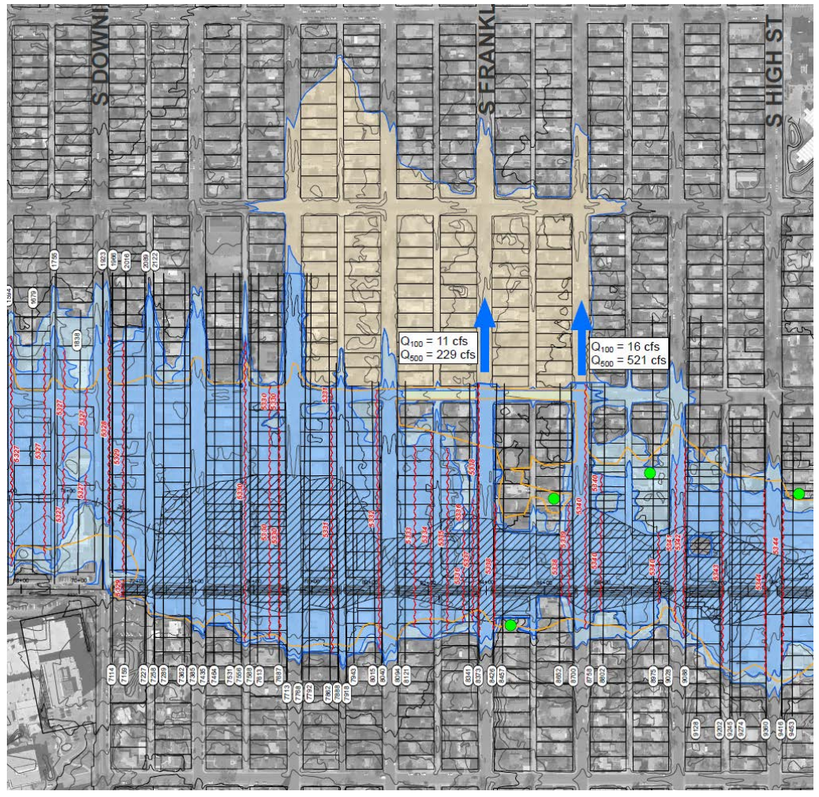
Harvard Gulch FHAD

Matrix Design Group
Submittal Received 10/20/2015
Review 12/10/2015

Products Received:
Harvard Gulch FLO-2D electronic model files & data.

General:
Surface roughness values of 0.04 appear to be slightly high for the golf course area, but low for much of the urban environment.
The inflow hydrograph is uniformly distributed across 10 cells along Logan St. that do not appear to be centered over the low point in the crossing. A different flow distribution (based on RAS) may or may not significantly impact the flow distribution through the grid downstream of Logan.
Please review the duration of the hydrograph, and simulation run time; these may need to be extended to ensure reach steady state throughout system. Currently, the total outflow discharge is less than half the total inflow, and the outflow discharge hasn't quite stabilized.
Several locations are delineated as islands that would likely be inundated. While the building may not allow significant flow through, the floodplain extents would include the structure. Suggest reducing the Width Area Reductions (WRFs) to slightly less than 100% to allow some flow across the cell to better represent floodplain extents.

HARVARD GULCH HEC-RAS MODELING APPROACH



1. Have Matrix prepare a test reach (Downing St. to High St.) using the increase n-value approach in lieu of obstructions along cross sections in the dense urban area. The n-values should be determined using the following publication: Determination of Roughness Coefficients for Streams in Colorado, by Robert Jarrett, USGS, Water-Resources Investigations Report 85-4004, 1985 (WRI 85-4004) (https://pubs.er.usgs.gov/publication/wri854004).

2. The process should consist of determining a range of appropriate average n-values based on several (3 or 4) typical cross sections through the developed area. Average n-values determination is recommended using the procedure for Urban Overbanks (p. 42, WRI 85-4004).

3. Review of the resulting range of n-values should take place, and agreement reached on reasonableness, prior to running a revised HEC-RAS model for the test section.

4. Review of the hydraulic model results for the test section compared to those for the model using blocked obstruction, will provide a basis for a consensus on the preferred modeling approach.

From: Hamer, Jeremy - PWRWS ERA [Jeremy.Hamer@denvergov.org]

Sent: Tuesday, November 10, 2015 1:00 PM

To: Shea Thomas; Robert Krehbiel; Terri Fead; Morrisey, David - PWRWS ERA

Cc: Hung Teng Ho

Subject: RE: Harvard Gulch FHAD - Modeling Methodology

Just to be clear, we aren't dictating what values to use, just suggesting different approaches, and we are certainly open to further discussion as appropriate. Engineering judgement is needed, but everything needs to be technically justifiable especially given the sensitivity surrounding adding many properties to the floodplain and floodway. There's a bit of a balancing act as we have a completely different study that was showing a much different floodplain than the first FHAD submittal, which was a huge red flag. And while the USACE (Tetra Tech) study is not a regulatory product, it is public domain. The studies should be reasonably close especially given that the base data (LiDAR & hydrology) is essentially the same. If significant differences exist we need to be prepared to justify (say, in an appeal) that the FHAD methodology is sound. The USACE study seems to be a little more broad brush approach, and we trust that the FHAD is taking a closer look at certain things that are needed for floodplain delineation purposes that USACE may have glossed over. This is an unintended consequence of having two separate studies on the same drainageway at the same time. Unfortunately we didn't have the opportunity to review the USACE modeling before it was finalized, but we did bring up some issues to the Corps when we saw something out of whack (i.e., Ogden culvert) and tried to coordinate accordingly.

In the end we just want a study that we believe accurately depicts the flood risk so we can regulate appropriately for the next 30 years or so.

Jeremy Hamer, P.E., CFM | Senior Engineer / Floodplain Manager
Public Works Engineering, Regulatory and Analytics | City and County of Denver
720.913.0720 Phone
jeremy.hamer@denvergov.org

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From: Shea Thomas [mailto:sthomas@udfcd.org]
Sent: Tuesday, November 10, 2015 10:54 AM
To: Robert Krehbiel <Robert_Krehbiel@matrixdesigngroup.com>; Terri Fead <tfead@udfcd.org>; Hamer, Jeremy - PWRWS ERA <Jeremy.Hamer@denvergov.org>; Morrisey, David - PWRWS ERA <David.Morrisey@denvergov.org>
Cc: Hung Teng Ho <hungteng_ho@matrixdesigngroup.com>
Subject: RE: Harvard Gulch FHAD - Modeling Methodology

Robert –

Everyone has weighed in and we've opted to move forward with Scenario 3. Denver would like to see the n-values applied more generally, though.

From Jeremy:

> "The cross sections in the test models show varying manning's at cross sections that cut through the houses vs ones that are cut through the front yards. We believe that general land uses (residential areas vs. commercial areas vs. open space/park/trail corridor) in the overbanks should dictate the manning's rather than what is happening exactly where the cross section is cut, which seems overly detailed and creates drastic roughness variations in the overbanks. We think this will help with model stability as well. The more detailed approach might work if there were a lot more cross sections to better define the overbank geometry, but doesn't seem appropriate here.
>
> For example (see attached HEC-RAS sections and workmap):
>
> XS 9453 (cut through houses) has overbank manning's = 0.15
>
> XS 9416 (cut through yards) has overbank manning's = 0.04
>
> Please see attached markup of what we believe is more appropriate usage."

I've attached the figures to which he referred. Having done many FHADs with you, we feel very comfortable with your hydraulic analysis for these types of studies and would not normally dictate with this specificity the roughness values to be used. However, since Denver has requested this methodology and knowing they are trying to coordinate with the USACE study, we support their request. If it requires more work than what you were already anticipating with the fee request you've sent, let me know and I will include it as a separate task in the amendment as well.

Shea Thomas

From: Shea Thomas
Sent: Wednesday, September 09, 2015 10:17 AM
To: 'Robert Krehbiel'; Terri Fead; Jeremy Hamer; Morrisey, David - PWRWS Right-of-Way Services (David.Morrisey@denvergov.org); David Mallory
Cc: Hung Teng Ho
Subject: RE: Harvard Gulch FHAD - Modeling Methodology

Thanks Robert. We'll get you clear direction once we've decided on it.

Shea Thomas

From: Robert Krehbiel [mailto:Robert_Krehbiel@matrixdesigngroup.com]
Sent: Tuesday, September 08, 2015 4:05 PM
To: Terri Fead; Jeremy Hamer; Morrisey, David - PWRWS Right-of-Way Services (David.Morrisey@denvergov.org); David Mallory
Cc: Hung Teng Ho; Shea Thomas
Subject: FW: Harvard Gulch FHAD - Modeling Methodology

We have modeled 4 scenarios per your request:

1. Draft FHAD as submitted with blocked obstructions
2. No blocked obstructions and a higher roughness of n= 0.25
3. No blocked obstructions and a higher roughness of n= 0.15
4. Ineffective flow set at the limits of building structures

The attached flood profile shows the comparison between S Downing St and S. Race St for four scenarios.

Guidance for the increased overbank roughness for urban areas is to increase the Manning's n by 2 to 4 times. The original model estimated overbank roughness at 0.08. We have elected to model the two scenarios of N= 0.15 and 0.25 as a reasonable middle range. The scenarios of higher roughness in overbank area produce higher water surface elevation than the preliminary FHAD, however, the rise is less than 1 foot. The average velocities at overbank areas are generally less than 1 ft/s which also seems reasonable.

A quick test was completed for the floodway encroachment from S. Downing St to S. Humboldt St. using the scenario of no obstruction/overbank Manning's n 0.15. The scenario of ineffective flow area option was setup to not including any habitable structures in the floodway which causes a significant jump on the flood profile. The maximum reduction on top width of the floodway in this reach is approximate 200 feet compared to the top width of floodway of the draft FHAD. The floodway boundary will have a smoother transition for this scenario. Clearly, the ineffective flow option is causing too much of a rise from Franklin to Race. The limits of the encroachment will need to be expanded to include some houses. If you are interested in this option, we need to talk about how the limits should be set.

At this point, we need to understand what direction you would like to continue.

Robert Krehbiel

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303-572-0200 main
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303-226-7818 direct
robertk@matrixdesigngroup.com

From: Robert Krehbiel
Sent: Wednesday, September 02, 2015 9:04 AM
To: Shea Thomas (sthomas@udfcd.org); Terri Fead; Hamer, Jeremy - Public Works <Jeremy.Hamer@denvergov.org> (Jeremy.Hamer@denvergov.org); Morrisey, David - PWRWS Right-of-Way Services (David.Morrisey@denvergov.org); David Mallory <dmallory@udfcd.org> (dmallory@udfcd.org)
Cc: Hung Teng Ho
Subject: FW: Harvard Gulch FHAD - Modeling Methodology

We are nearly complete with the analysis. We removed the blocked obstructions in the overbank and evaluated the options of:

- Higher roughness
- Ineffective flow

Not surprising, the floodplain is higher (but less than 1 foot), and lower than the Corps BFE. The key will be to see the change to the floodway.

Should we set up a meeting to discuss, or just distribute the results?

Robert Krehbiel

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robertk@matrixdesigngroup.com

From: Shea Thomas [mailto:sthomas@udfcd.org]
Sent: Thursday, August 20, 2015 8:55 AM
To: Robert Krehbiel
Subject: Fwd: Harvard Gulch FHAD - Modeling Methodology [Doodle poll]

Robert -

Please see Terri's email and attachment. We would like you to get started on this as soon as you have time. It will be important for resolving our different floodplain mapping results with the Corps.

Let me know if you have any questions.

Sent from my Verizon Wireless 4G LTE smartphone

-------- Original message --------

From: Terri Fead

Date:08/19/2015 8:11 PM (GMT-07:00)

To: Shea Thomas , David Mallory

Cc: Jeremy Hamer , David.Morrisey@denvergov.org

Subject: RE: Harvard Gulch FHAD - Modeling Methodology [Doodle poll]

Hello Shea and David,

I would like to propose having Matrix perform a test run for an urbanized portion of Harvard Gulch using the increase n-values method for comparing results with the blocked obstruction method currently submitted. I don't have a problem with meeting next week to discuss the issue, but don't feel we can come away with a direction forward without additional information. I also think Matrix should not only be aware of the modeling concerns, but believe they need to be included in resolving the issue.

After numerous discussions, and feedback from experienced HEC-RAS users, I have attached a proposed approach to provide results comparison for a test section on Harvard Gulch. I would appreciate your consideration on getting Matrix started on this action as soon as possible. This will allow us to come to a consensus on the modeling approach, and complete the hydraulic analysis.

I would appreciate your input regarding this proposal at your earliest convenience.

Thanks,

Terri

Terri L. Fead, P.E., CFM

Project Manager

Floodplain Management Program

Urban Drainage and Flood Control District

tfead@udfcd.org

303-455-6277

From: Hamer, Jeremy - PWRWS ERA [mailto:Jeremy.Hamer@denvergov.org]
Sent: Thursday, August 13, 2015 4:28 PM
To: Jeremy Hamer; Terri Fead; Shea Thomas; David Mallory
Cc: Morrisey, David - PWRWS Right-of-Way Services
Subject: RE: Harvard Gulch FHAD - Modeling Methodology [Doodle poll]

Shea moved a separate meeting up to convenience Denver folks, so in the same fashion, can you guys all do 2:00-3:30 on the 24th instead of 3:00-4:30? That will allow Davis & I to spend all day with Shea without any gaps ☺

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From: Hamer, Jeremy - PWRWS ERA
Sent: Tuesday, August 11, 2015 1:01 PM
To: Hamer, Jeremy - PWRWS ERA; 'Terri Fead (tfead@udfcd.org)'; 'Shea Thomas'; 'dmallory@udfcd.org'
Cc: Morrisey, David - PWRWS Right-of-Way Services
Subject: RE: Harvard Gulch FHAD - Modeling Methodology [Doodle poll]

Please all update your availability, had to push out to the week of the 24th for schedules. Thanks.

http://doodle.com/qeex58698yr99hri

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From: Hamer, Jeremy - PWRWS ERA
Sent: Thursday, August 06, 2015 4:11 PM
To: Terri Fead (tfead@udfcd.org); 'Shea Thomas'; dmallory@udfcd.org
Cc: Morrisey, David - PWRWS Right-of-Way Services
Subject: Harvard Gulch FHAD - Modeling Methodology [Doodle poll]

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Terri/David & Shea,

I'd like to setup a meeting, prior to the upcoming MDP review meeting on the 24th, to discuss the hydraulic modeling methodology being used for the FHAD (U/S of Harvard Gulch Park). We're a little uncomfortable with the selective use of many blocked obstructions in the densely developed overbank areas to represent the houses. My primary concerns are as follows:

1) Not accurately representing existing conditions
2) Having sections that alternate with blocked obstructions when cut through houses and none when cut U/S & D/S of bridges is possibly creating model stability issues
3) Overly complicated model for regulatory use
4) Creating very wide floodway with significant undulation (bulging) in the floodway boundary

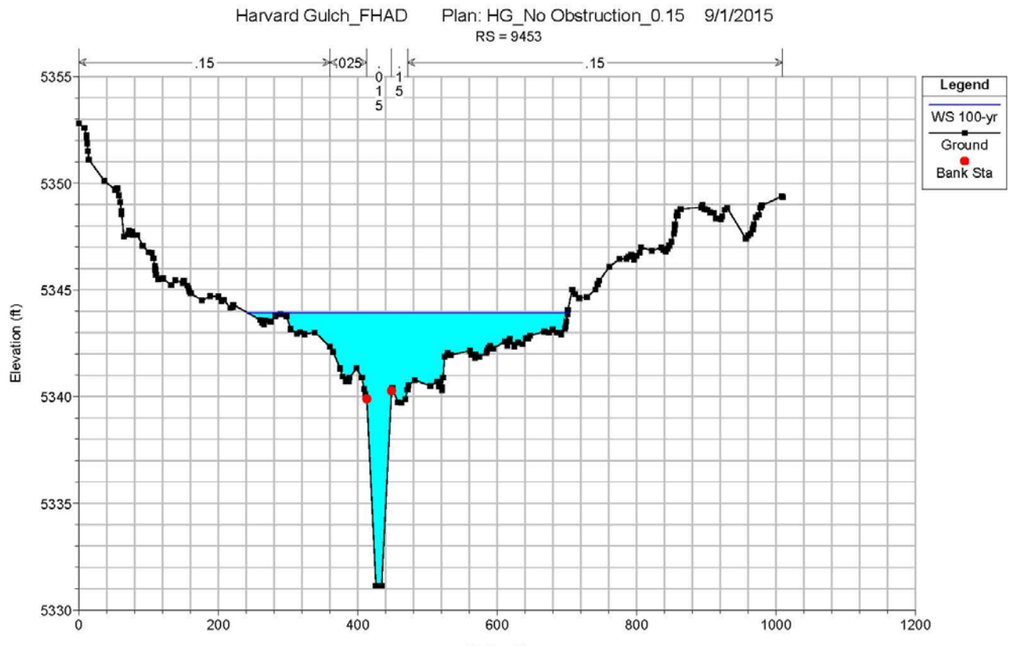
I've discussed with several people internally and externally (Teresa, Justen Hamann & Brian Murphy) all of which have slightly different viewpoints on this. Given the number of primary structures currently shown being added to the floodplain (220) and to floodway (~70), this is going to be very controversial and I want to be extra careful to make sure that the methodology is defendable, fair, and meets mapping standards. Sensitivity analysis may be needed. I'm also trying to find out how USACE (Tetra Tech) did it for the USACE study. I would like to discuss the following options, or combo of options, and look at the pros/cons of each and determine a path forward.

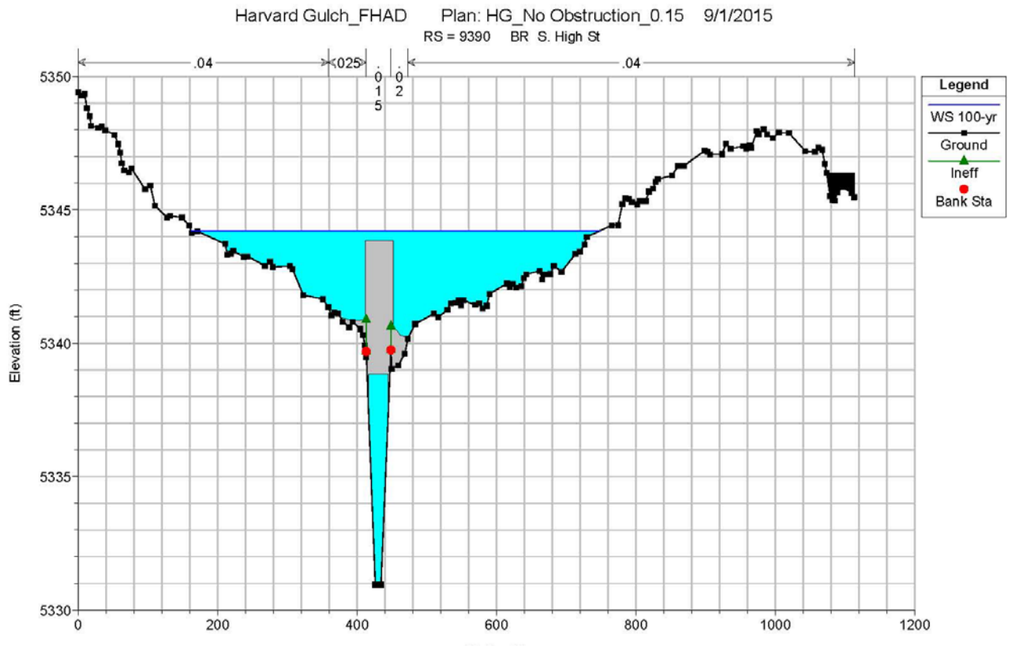
- Utilize a 2-d model (RAS 2d?) to inform the 1-d model and to calibrate to,
- Keep blocked obstructions and increase manning's between houses,
- Shadow blocked obstructions to adjacent section(s),
- Use high manning's n in overbank to represent houses and other stuff (fences, cars, garages, sheds, etc…),
- Fully block the developed overbanks,
- Use bulk ineffective areas in the developed overbanks,
- Other?

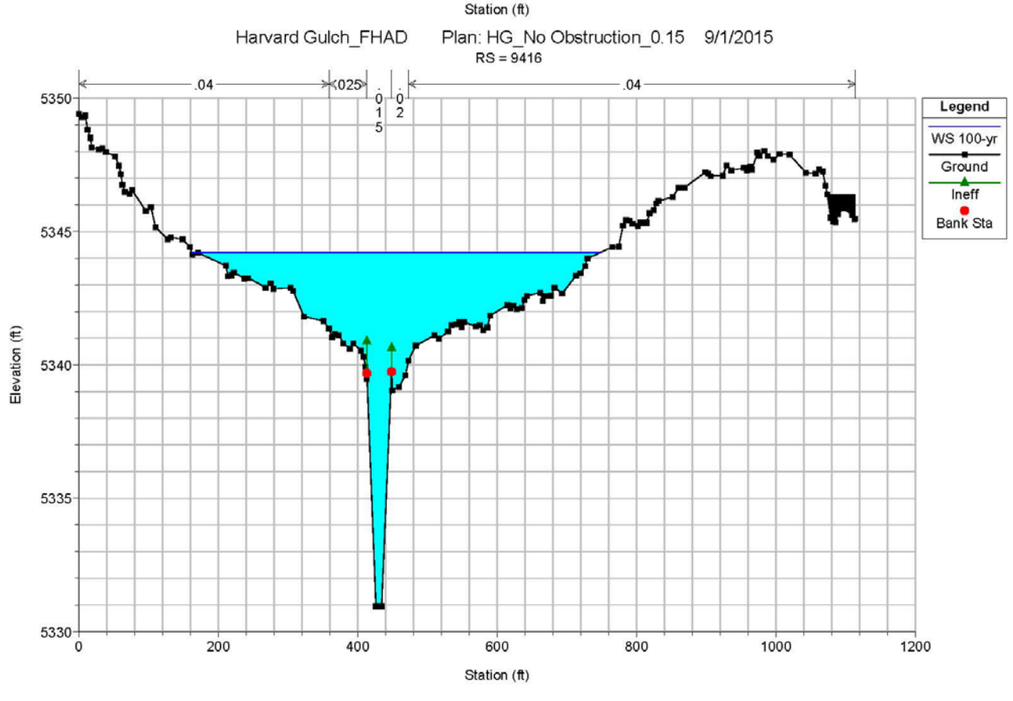
Please fill out the doodle poll with your availability. We will come to UDFCD.

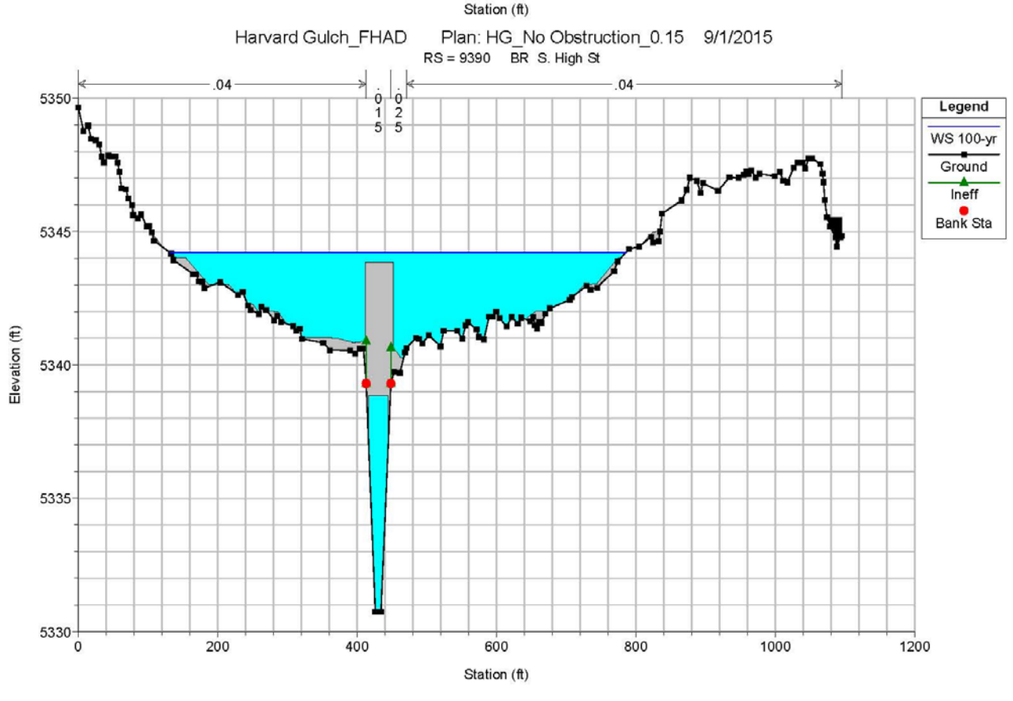
Terri – Please only fill out times that a room is available. Thanks.

http://doodle.com/qeex58698yr99hri


Harvard Gulch_FHAD Plan: HG_No Obstruction_0.15 9/1/2015
RS = 9453
.15
.025
.15
0.15
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Harvard Gulch_FHAD Plan: HG_No Obstruction_0.15 9/1/2015
RS = 9390 BR S. High St
.04
.025
.04
0.15
0.2
Legend
WS 100-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Harvard Gulch_FHAD Plan: HG_No Obstruction_0.15 9/1/2015
RS = 9416
.04
.025
.04
0.15
0.2
Legend
WS 100-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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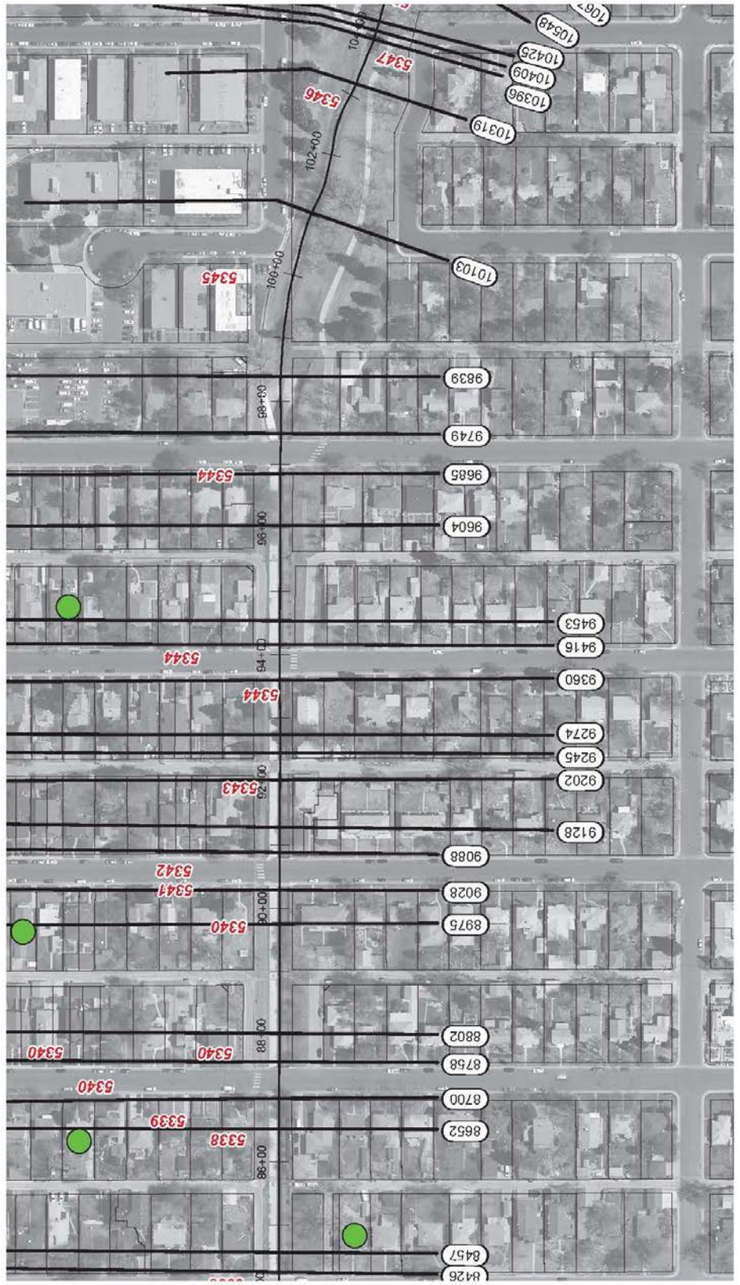
RS = 9390 BR S. High St
.04
.025
.04
0.15
0.25
Legend
WS 100-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


10548
10425
10409
10396
10319
10103
9839
9749
9685
9604
9453
9416
9360
9274
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9202
9128
9088
9028
8975
8802
8758
8700
8652
8457
8426
5347
5346
5345
5344
5343
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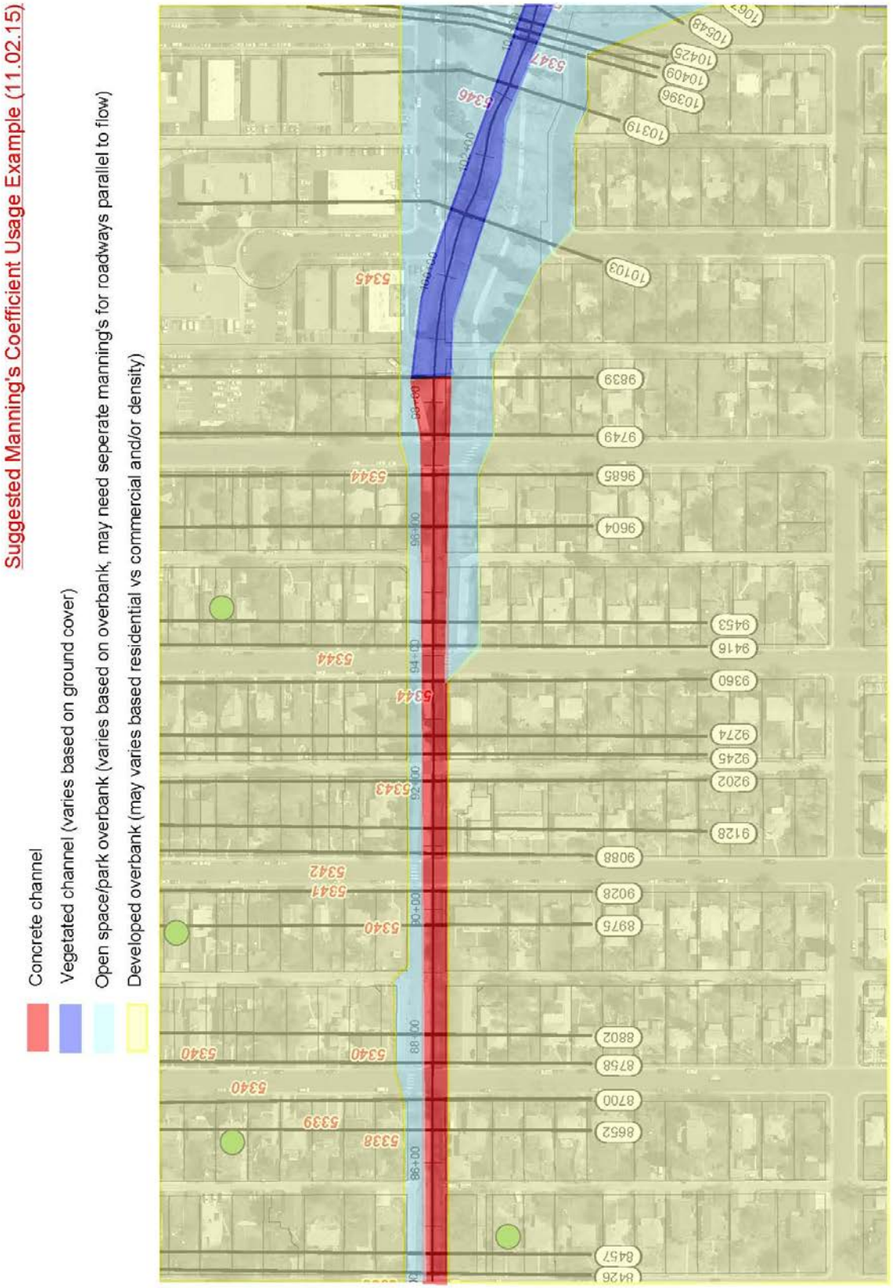
92+00
90+00
88+00


Suggested Manning's Coefficient Usage Example (11.02.15)
Concrete channel
Vegetated channel (varies based on ground cover)
Open space/park overbank (varies based on overbank, may need seperate manning's for roadways parallel to flow)
Developed overbank (may varies based residential vs commercial and/or density)

Review Comments 5-19-2016

Draft Submittal _ Technical Only

Responses to Comments on 05/19/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

Comments			Responses
General:			
	1	There are a number of comments on the red-lined products that do not need to be individually addressed with the resubmittal, but that will need to be addressed in the final products. These include items such as: BFE adjustments for profile replication; floodplains crossing a contour multiple times; adjusting abrupt transitions in the floodplain/floodway delineations; floodway delineations outside the floodplain, the 100-year floodplain outside the 500-year delineation, etc.	All comments have been addressed.
	2	Please provide supporting documentation for storm sewer/culvert capacities where surface flow is reduced (location, capacities of trunk lines how determined). Need more description/documentation in report on what was done in these locations.	The surface flow and storm sewer capacities were calculated in Table C-2b in Appendix C of the FHAD Report. More description/documentation will be added in report on what was done in these locations.
Agreement Table (AT)			
	1	Please include IEFA and high ground (islands) in HEC-RAS top widths (total top width). This can be extracted from HEC-RAS using the difference of the right water surface station and the left water surface station as described in the DFHAD guidelines.	The HEC-RAS top widths have been checked and were calculated as the difference between the right water station and the left water station.
Floodplain and Floodway Data Table (FPFWDT)			
	1	Please ensure 100-year floodplain top widths are based on the work maps. Some values appear to be directly out of the HEC-RAS model where not appropriate.	The 100-year floodplain top widths have been checked and the top widths on the work map were used in the FPFWDT.
HEC-RAS Hydraulic Models			
General	**1**	Please ensure floodway HGL and EGL surcharges are between 0.00 and 0.50. There are negative surcharges at HG 11228 and HG 11325. The EGL surcharge at DG 1879 is greater than 0.50.	The negative surcharges have been reviewed and were removed at cross section HG 11325 and DG 1879, however, the negative surcharge of -0.01 on the HGL and EGL are not able to be removed at cross section HG 11228.
	2	Concerns with modeling of structures compared to survey data. Culverts need to be modeled as culverts. This applies to almost all crossings upstream of Josephine.	The type of structures have been verified on field and were compared with the structure inventory (**Table 2-1** in the report) provided by the City and County of Denver. A total of five culverts are included in the HEC-RAS model. Four culvert crossings, Downing St, York St, University Blvd and Adams St are located on Harvard Gulch and the Ogden St culvert crossing is located on Harvard Gulch Split flow. The rest of the crossing structures are model as bridge in the HEC-RAS model.
Harvard Gulch	**1**	Please revise HG XSs 4715 through 5221 to eliminate the portion of the HG XSs that extend within the Dry Gulch drainage basin. Recommend either trimming these XSs at the high ground between flooding sources, or obstruct the portion of the HG XSs within the Dry Gulch flood hazard areas. The Harvard Gulch parameters (Area, Vel Total, total top width, floodway top width) need to be based on conditions solely from the Harvard Gulch flooding source unless both streams share a common XS with combined flow.	Blocked obstruction was used at the high ground between flooding sources to separate Dry Gulch.
	2	The 100-year WSEL is greater than the 500-year WSEL at cross sections 7159 and 7227. Please adjust the model to ensure water surface profiles do not cross.	The lower 500-year WSEL than the 100-year WSEL was due to the flow distribution between Harvard Gulch and Harvard Gulch split flow. The flow distribution of 500-year has been reviewed and the dip on the 500-year WSEL was removed on the profile.
	3	At cross sections **7362, 7385, 7435, 7464, 7531, 7556, 7588, 7613, 7687, 7713, 7768, 7792, 7862, 7888, 7918**, it appears that portions of cross sections in this area north of Wesley Ave should be IEFA. Please verify and revise as necessary.	Add IEFA
	4	This portion of XSs **9088** and **9128** appears to be IEFA during all events; please verify and revise as necessary. Area appears to be backwater, please remove detached BFE segment.	Add IEFA
	5	This portion of XS **8802 -> 8700** appears to be IEFA for all events; please verify and revise as necessary.	Add IEFA
	6	This portion of XSs **8373** and **8426** appear to be IEFA during all events; please verify and revise as necessary.	Add IEFA

Responses to Comments on 05/19/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

Comments			Responses
HEC-RAS Hydraulic Models			
Harvard Gulch	**7**	This portion of **8700** appears to be IEFA during the 100-year event; please verify and revise as necessary.	Add IEFA
	8	Cross sections **15836**, **15889**, appears to be IEFA during 100-year event; please verify and revise as necessary.	Add IEFA
	9	Area appears to be backwater. Please remove detached BFE segment. Please make LOB of **16153** IEFA for 100-year event.	Add IEFA
	10	Cross section **14699**, area appears to be backwater. Consider making area left of station 325 IEFA during 100-year event.	Add IEFA
	11	Cross sections **10319**, **10409**, **10425**, **10548**, **10671**, **10891**, N-values of 0.03-0.035 in this location may be low due to trees, fences, and playground equipment. Please verify and revise if necessary.	Adjusted Manning's n to 0.035-0.045 in these location.
Harvard Gulch Split	**1**	Banks stations at XSs 139-637, 1755, and 1838 are atypical and often do not contain the cross section low point. Please verify.	Addressed
	2	Floodplain contracts dramatically between XS 411 and 325. Consider increasing contraction and expansion coefficients at 411.	Contraction and expansion coefficients of 0.3 and 0.5 have been used to account for dramatic conveyance changes.
Dry Gulch	**1**	The starting conditions for DG currently use the WSELs from HG XS 4715 even though the most D/S XS for DG (XS 133) has an invert elevation at least 3-ft higher than at XS 4715. The current condition is likely underestimating the WSELs for the DG profile. Please revise the modeling for Dry Gulch to include a duplicate HG XS 4715, so there can be a more representative WSEL calculated for DG XS 133.	A duplicate HG XS 4715 was added to HEC-RAS model of Dry Gulch. The known water surface elevations at HG XS 4715 were used for downstream hydraulic control for backwater calculation.
	2	Please make IEFA in ROB of **9499** permanent or raise IEFA elevation above 500-year WSEL.	Increase IEFA elevation
	3	Cross section **8273**, LOB appears to be IEFA for all events; please verify and revise as necessary.	Increase IEFA elevation
	4	XS 2265 LOB n-value of 0.017 in this location may be low due to impact of houses in floodplain. Please verify and revise as necessary.	Adjusted Manning's n to 0.08 to account the impact of houses in floodplain.
	5	Barde Park lawn in this area is represented with an n-value of 0.025 that may be low. Please verify and revise as necessary.	Adjusted Manning's n to 0.035.
	6	Cross section **6525**, **6559**, with road over-topping, the abrupt contraction of 100-year floodplain between 6559 and 6525 does not appear to be realistic. Please provide a more representative transition downstream of the crossing. This may require the 100-year floodplain being wider on the map than in HEC-RAS; difference to be noted in Comment with FPFWDT.	The abrupt contraction of 100-year floodplain between 6559 and 6525 has been revised to reflect road over-topping which resulted in wider 100-year floodplain top width on the map than in HEC-RAS. The difference has been noted in comment with FPFWDT.

Review Comments 9-28-2016

Draft Submittal _ Report Only

Responses to Comments on 09/28/2016 (Report Only)
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

PDF Page	Comments	Responses/Notes
6	Update as needed. Please provide narrative relative to the USACE involvement/study	Done
6	revise study limits	Done
6	update as appropriate	Done
8	is this properly titled? I don't recall seeing it in the reference listed	Changed to Project REUSE
8	can we establish an approximate date? late 50's?	1920's
13	Please make sure narrative is appropriate for a FHAD study	Done
14	elaborate please	Done
15	Please identify the HEC-RAS hydraulic reaches on Figure 2-5.	Done
20	Probably need a formal citation for this	No citation available. Just provided a general statement
37	Address large storm sewer systems - locations/capacities of trunk lines that justify flow subtraction from surface flow.	Analysis was provided at the column "Full flow Capacity" in Table C-2b. Full flow capacity was based on normal depth analysis using Manning's Equation which was coded in this column in Excel spreadsheet. Please see the Excel spreadsheet in Technical Appendices for details.
37	doesn't read well	Reworded
37	Please update as appropriate, based on past reviews	Done
37	We need a strong statement regarding the difference between the existing and future conditions hydrology, ending with "therefore floodplain delineations are based on future conditions hydrology	Done. Existing conditions = future conditions.
38	The HEC-RAS Model has the following reaches: HG 01, HG 02, HG Split 01 and DG 01, please show the delineation of the HG 01 & 02	Done
40	How are we going to address Englewood's desire to locally regulate the Dry Gulch floodplain?	Not part of the report, just an administrative matter.
40	try to reduce the number of redundant statements	Done
41	can the LOMA locations be added to the floodplain map?	They are on the floodplain map already.
42	Please add structure number to provide correlation of information	Done. Survey structure number was added in Table 4-5 and map. A table shows the corresponding information of structure is added on the floodplain map.
42	A number of structures listed as bridges have become culverts, correct?	No, The type of structures have been verified on field and were compared with the structure inventory (Table 2-1 in the report) provided by the City and County of Denver. A total of five culverts are included in the HEC-RAS model. Four culvert crossings, Downing St, York St, University Blvd and Adams St are located on Harvard Gulch and the Ogden St culvert crossing is located on Harvard Gulch Split flow. The rest of the crossing structures are model as bridge in the HEC-RAS model.

Review Comments 10-27-2016

Draft Submittal _ Technical Only

Responses to Comments on 10/27/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

		Comments	Responses
General:			
	1	Please provide supporting documentation (what was used to determine these values, what (if any) calculations were performed, etc.) for tabular values of storm sewer/culvert capacities where surface flow is reduced (location, capacities of trunk lines how determined) in Table C2-b.	Table C2-b was prepared with Excel spreadsheet. The capacity of existing storm system was estimated by normal depth calculation utilizing Manning's Equation which was coded in the Excel spreadsheet at the column called "Full flow capacity". The Excel spreadsheet can be found in the Technical Appendix.
HEC-RAS Hydraulic Models			
Harvard Gulch	**2**	1. The 100-year WSEL is greater than the 500-year WSEL at cross sections 7159 and 7227. The 500-yr has been manually adjusted on the profile, but not in the model. Please review the modeling in this area. Recommend adding a XS to smooth out transition from culvert hydraulics. The profile shows a drop upstream of the culvert. If there is no drop here, ensuring the invert elevation reflects survey data may resolve this issue. Please adjust the model to ensure water surface profiles do not cross.	1. This issue has been fixed in the model dated 8/30/2016 and the flood profiles are direct outputs from HEC-RAS model without manual adjustment. 2. The invert matched topography and survey, see attached **Exhibit 1**.
	3	Please ensure that the XSs reflect the appropriate floodway encroachments for surcharges. There is a fixed WSEL at HG XS 7114 for the floodway profile, causing HGL surcharges at cross sections 7114-7227, which do not have encroachments. The lack of encroachment results in floodway top widths being wider than 100-year top widths at this location.	Revised. The encroachments at cross sections 7114 to 7227 are coincident with the floodplain top width and are coded in the model at these cross sections.
Harvard Gulch Split	**4**	Please verify that ROB XS 637 is not actually IEFA; and revise as necessary.	Confirmed. No IEFA at cross section 637 in the model dated 8/30/2016.
	5	Please ensure XSs 411 and 637 do not account for area below normal WSEL of pond.	Revised. Add permanent IEFA for normal pond.
Dry Gulch	**6**	Since the starting conditions for DG currently use the WSELs from HG XS 4715 , and there is no floodway on HG XS 4715, the starting WSEL for the floodway needs to be consistent with the starting WSEL for the regulatory floodplain. The current model sets the starting WSEL for the DG floodway 0.5-ft higher than the regulatory floodplain at this location on HG.	Remove the starting WSEL 0.5-ft higher than the regulatory floodplain at HG XS 4715 for the DG floodway model, due to no encroachment in the Harvard Gulch Park is anticipated. Rerun floodway model and made changes to cross sections 133, 237, 409, 595, 4872 and 5367.
	7	HEC-RAS reach lengths all equal for LOB, ROB, and channel for each XS. This is unlikely, but may make little difference in results for this analysis.	Update model with new reach length for LOB and ROB, rerun floodplain and floodway models.
Topographic Work Map			
General	**8**	Please ensure floodway is within 100-year floodplain. There are currently several (32) locations where floodway is outside HG floodplain and 3 along DG.	Done. Checked at final mapping.
Harvard Gulch	**9**	Please label all crossings & associate with structure number. this could be a combination of labels and a corresponding table that provides this information.	Add survey structure number and related table on work map.
	10	Please make sure gutter/separation lines are provided between adjacent flooding sources.	Done, add separation line and label
	11	Please let the delineations show the potential impacts. This notation was previously requested; however, this gives an indication of a level of familiarity with structures that we do not possess. For example, why are we calling out these two, and not others? Please remove the note.	Remove notes.
	12	Please call out average depth of shallow flooding	Add labels
Dry Gulch	**13**	At cross section 7180 LOB, Please check for detached duplicate in GIS shapefile	Done
	14	Please call out average shallow flooding depth.	Add labels
	15	Please verify the transition from the overtopping roadway; this has been modified, but still appears unrealistic. Can eliminate BFEs 5357 and 5358, since no inflection point - might allow more reasonable transition without intermediate BFEs.	Improve the delineation and remove BFEs 5357 and 5358.

Responses to Comments on 10/27/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

Comments			Responses
Dry Gulch	**16**	Please review to ensure there is no potential for a minor split flow in this area.	It is an area with ambiguous floodplain boundary which the 100-year flood is barely contained by the high ground, however, the potential shallow flooding less than one foot is likely to happen at a local lower area. Add shallow floodplain with depth less than one foot to this area.
Flood Profiles			
Harvard Gulch	**17**	Please ensure that invert elevations for bounding XSs are adjusted to reflect survey data. For example, is there a sudden 2-ft jump at the end of this culvert? Please review and revise as necessary.	The survey data does not provide the details of the outlet structure and stilling basin, see attached **Exhibit 2** and **Figure** 1. The information of channel invert was supplemented by the as-built plan "Project No. 9203 - PHASE II, Harvard Gulch Flood Control, August 18,1967", see attached **Exhibit 3 & 4**. However, the details of the outlet structure and stilling basin were not modeled because of the two reasons. • The first, the culvert hydraulics is inlet control for all four flood frequencies, so the backwater condition does not impact the culvert hydraulics. • The second, the floodplain is confined in the outlet structure from the end of the culvert to daylight in the natural channel. So, the culvert was modeled with invert slope derived from the as-built plan and extend the length of culvert to the end of the outlet structure.
	18	At S. University Blvd, Same invert issue concerns as with other locations.	1. The survey data was used to revised the channel invert. 2. There are some local scour which make the channel invert become undulated through these reach. The most significant example is at Madison St. The grouted boulder drop structure at downstream of Madison St at cross section 15281 is in good condition as shown on **Figure 2**, however, local scour happens upstream and develops through Madison Street as shown on **Figure 3**. The survey data of channel invert was used in the hydraulic model to reflect the local scour condition without modification to stream bed profile.
	19	From Monroe St. to Adams St., Same issue with invert elevations reflecting survey data - especially at bounding XSs. Please do not jump back and forth between LiDAR and survey for invert elevations between structures.	
	20	At Jackson St., Same issue with invert elevations and bounding XSs reflecting survey data.	

Topography and Structure Survey
Harvard Gulch

Exhibit 1

S. Downing St

Alley S. Downing/Marion St

TOP OF CURB
5329.111

TOP/ CONC CHANNEL
5326.219

72+00

TOP OF CURB
5328.044

CROWN
5327.27

TOP OF CURB
5328.005

TOP OF CURB
5327.983

TOP OF CURB
5327.932

WING/ -13.0 TO GROUND
5327.762

TOE/ CONC CHANNEL
5316.444

FL/ CONC CHANNEL
5316.47

CROSSING 25/ -13.0 TO GROUND
5327.702

CCD BM 349
5329.46

-11.3 TO GROUND
5327.881

CROSSING 24/ -11.2 TO GROUND
5327.85

TOE/ CONC CHANNEL
5316.295

WING/ -13.0 TO GROUND
5327.619

TOP OF CURB
5327.905

TOP OF CURB
5327.943

CROWN
5327.076

TOP OF CURB
5328.162

TOP OF CURB
5329.363

TOP/ CONC CHANNEL
5326.243

TOP OF CURB
5327.838

5327
5329
5323
5322
5321
5320
5319
5317
5316
5318
5324
5325
5326
5328
5329
5330

N

0 5 10 20

Feet

Exhibit 2


5317
5319
5318
5316
5316
5313
5314
5324
5326
TOP OF CONC
5324.284
CROSSING 25/ -12.6 TO CURB
5324.196
TOP OF CONC
5324.497
5315
TOP OF CONC
5324.353
5323
5321
5322
5320
5324
5325
TOP OF CONC
5324.288
5329
5327
5328
5330
5331
5332
64+00
S OGDEN ST
N
0
5
10
20
Feet
6307

Figure 1



Exhibit 3

500'-15" R.C.P. at .002 FT/FT
See General Plan Sht. No. 3

P.I. 68+02.83
Δ = 20°00'
R = 537.81'
T = 94.83'
L = 187.79'

646'-12" Conc. Pipe at .004 FT/FT

Drop Inlet

℄ Channel

Pipe Inv. 130.45

Pipe Inv. 130.55

295'-12" Conc. Pipe at .004 FT/FT

Pipe Inv. 131.73

P.C. 67+08.00

P.I. 68+04.83

P.T. 68+91.78

66+97

65

PLUG AND ABANDON THIS LATERAL

PROPERTY LINE

M.H.- INV. EL. 135.32

WATER M.H.

EXISTING CURB & GUTTER

Harvard Ave.

PROPERTY LINE

STILLING BASIN

69+89.79

70

NEW M.H.- Inv. El. 138.20

PROPERTY LINE

So. Ogden St.

EXISTING CURB & GUTTER

Drop Inlet

M.H.- INV. EL. 136.62

NEW M.H. INV. EL. 137.12

P.C. 70+58.79

117.02'

285'-15" V.C.P. AT .0085

P.I. 72+10.35

P.I. 72+07.35
Δ = 20°00'
R. = 842.53'
T = 148.56'
L = 294.10'

NEW STORM SEWER LINE
319'-15" R.C.P. AT .002 FT FT/FT.
℄ Pipe placed 1' from outside of new box on curve

NEW M.H. Inv. El 138.84

P.T. 73+52.89

PROPERTY LINE

M.H.- INV. EL. 137.96

Drop MH INV. 137.77

T.H. 24A

23

24

56

57

So. Corona St.

EXISTING CURB & GUTTER

BOX CULVERT
For Details See Sheet No. 11

PROPERTY LINE

NEW STORM SEWER LINE
400'-15" R.C.P. at .002 FT/FT

ABANDONED 15"

M.H.- INV. EL. 139.26

WATER M.H.

M.H.- INV. EL. 140.14

M.H.- INV. EL. 147.93

420'-15" V.C.P. AT .0050 INV. EL. 139.08

PROPERTY LINE

NEW DROP M.H. FOR EXIST. 8" SAN SEWER

#13 inlet @ 0" curb

SLOPE 10%

Sump Inlet Directly Into Box at E. & W. Flow Line Of S. Downing St. See Dwg. 114-7 For Details.

So. Downing St.

EXISTING CURB & GUTTER

8" Sewer Line To Be Removed For Construction

T.H. 24B PLUG

NEW M.H. INV. EL. 139.66

37'-15" V.C.P. AT .0044

INV. EL. 139.50

PROPERTY LINE

M.H.- INV. EL. 141.00

M.H.- INV. EL. 137.7

Harvard Ave.

SEWER LINE ABANDONED

END OF NEW 15" R.C.P. INV EL. 139.64

177+76.51 END OF BOX CULVERT

INV EL 139.40

194'-15" V.C.P AT .0027

SLOPE 1.564%

S. W. 1/4 of the S. W. 1/4 of Sec. 26, T4S, R68W.

8" Sanitary Sewer from Porter Hospital

4

160
155
150
145
140
135
130
125

Existing Ground
℄ Channel

INV. EL. 137.40

66+97 DROP INLET

SLOPE = -.000335 FT/FT

Channel Profile Grade Line

12" Conc. Pipe

INV. EL. 136.45

INV. EL. 136.05

NEW STORM SEWER LINE 800'-15" R.C.P. at .002 FT./FT.

P.I. STA. 69+78.79

P.I. STA. 69+83.79

69+89.79 DROP INLET

INV. EL. 136.20

STA. 70+58.79 BEGIN BOX CULVERT

12" Conc. Pipe

INV. EL. 135.79

STILLING BASIN

40'

40'

NEW M.H.

BOX CULVERT TRANSITION

EXIST. 42" WATER LINE REMOVED BY OTHERS

NEW STORM SEWER LINE 319'-15" R.C.P. at .002 FT./FT.

INV. EL. 136.38

NEW M.H.

EXIST. WATER M.H.

14'X10' BOX CULVERT

SLOPE = -.0064 FT./FT.

Box Culvert Profile Grade Line

STRUCTURE NO. 134-502

8" V.C.P. SAN SEWER ABANDONED

INV. EL. 139.54

STA. 177+27.91 END OF BOX CULVERT

5314.84 (5314.7 survey)

Datum Adjustment

~~5175.0~~

5175.43

Length 719.18

156.31 | 156.34 | 156.37 | 156.41 | 156.44 | 156.47 | 156.50 | 156.79 | 156.83 | 156.94 | 156.38 | 156.22 | 156.86 | 157.50 | 158.14 | 158.78 | 159.27

64+00 | 65+00 | 66+00 | 67+00 | 68+00 | 69+00 | 70+00 | 71+00 | 72+00 | 73+00 | 74+00 | 75+00 | 76+00 | 77+00

~~5175.0~~

Add 5175.2 to transfer the elevation to NAVD88

USED	
	SANITARY SEWER BOOK NO.
	STORM SEWER BOOK NO.
	MAPS NO.
	STREET PROFILE NO.
	FIELD BOOK NO.
	B. M.
	ELEVATION

NOTE: WHEN LOCATIONS OF TEST HOLES AND CONDITIONS ENCOUNTERED THEREIN ARE SHOWN ON THESE PROFILES, THESE ARE NOT GUARANTEED TO REFLECT THE SITUATIONS THAT MAY ACTUALLY BE FOUND. CONTRACTOR SUBMITTING BIDS SHALL MAKE WHATEVER ADDITIONAL TESTS AND INVESTIGATIONS DEEMED NECESSARY. SEWER CONTRACTOR OR HIS AGENT, TO INQUIRE OF OWNERS OR THEIR AGENTS AS TO THE LOCATION OF THEIR PIPE LINES, UNDERGROUND CONDUITS, CABLES, ETC. THAT MAY BE IN LINE OF SEWER CONSTRUCTION, IN ORDER NOT TO DAMAGE THESE UTILITIES.

KENNETH KOSEN MEAD
REG. STEREO
3084
PROFESSIONAL ENGINEER
STATE OF COLORADO

WRIGHT-McLAUGHLIN ENGINEERS
1240 West Bayaud Ave
Denver, Colorado
744-6271

NO.	DATE	NAME
DESCRIPTION OF REVISIONS		
REVISED		

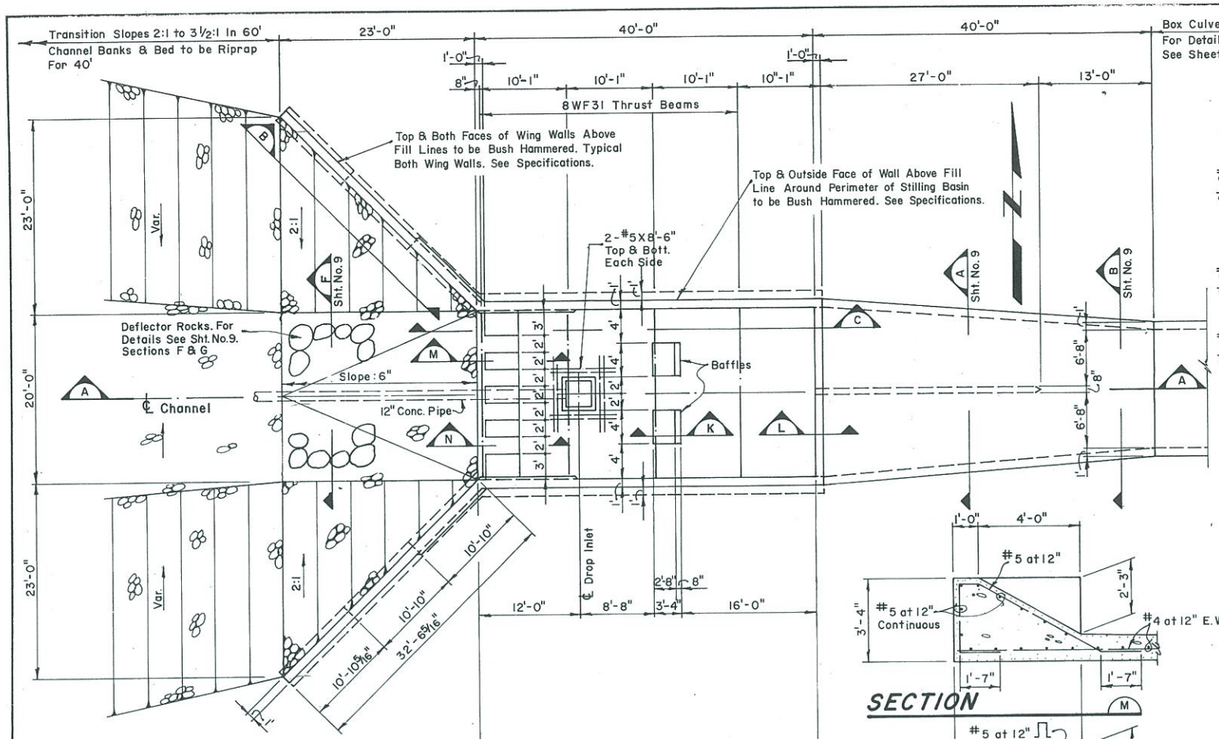
CITY AND COUNTY OF DENVER
DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

HARVARD GULCH FLOOD CONTROL PROJECT
PHASE II - PLAN AND PROFILE

CLARKSON ST. TO DOWNING ST.

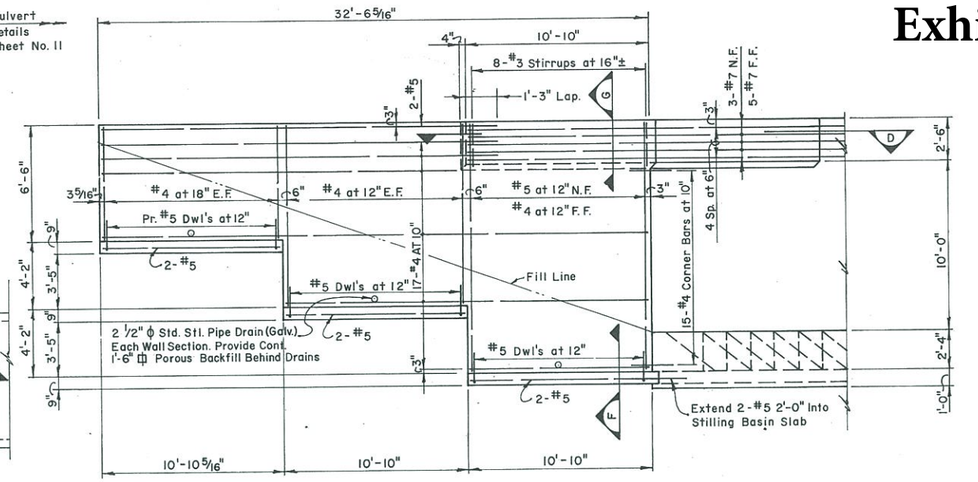
DATE	SCALE	DRAWN BY	TRACED BY	CHECKED BY	SHEET NO. 6 OF 14 SHEETS	DRAWING NO. ~~101-E~~ 134-500
11-26-65	1" = 50'	RK	RK	H.E.M.		

Exhibit 4



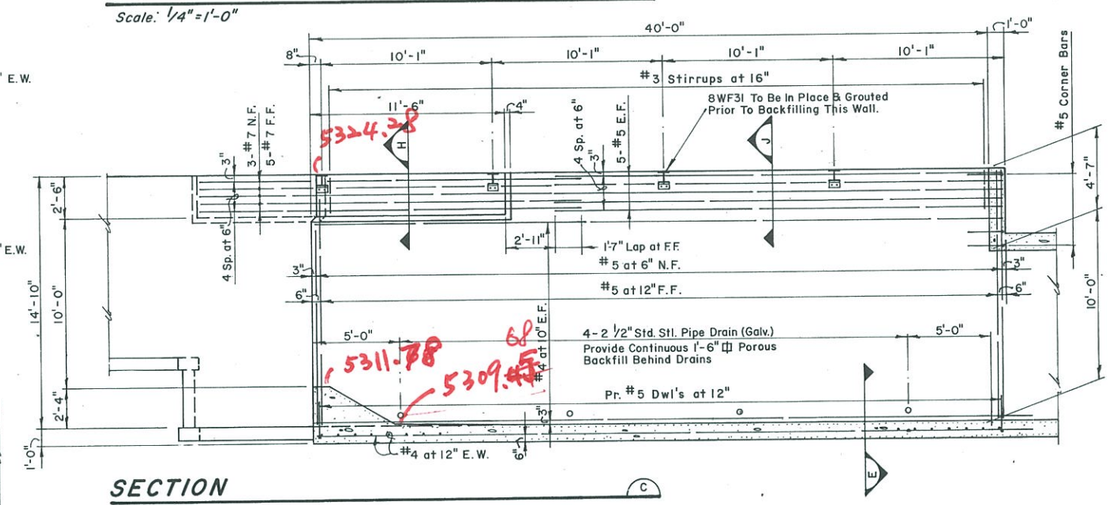
PLAN

Scale: 1/8"=1'-0"



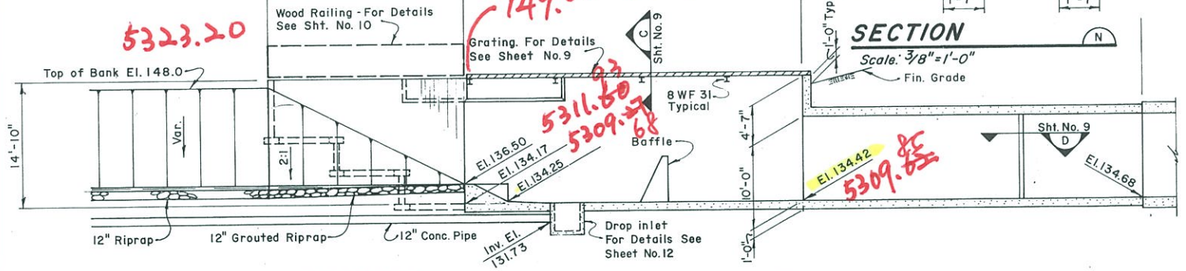
SECTION

Scale: 1/4"=1'-0"



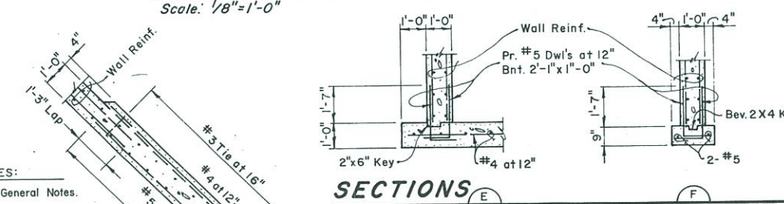
SECTION

Scale: 1/4"=1'-0"



SECTION

Scale: 1/8"=1'-0"



SECTION

Scale: 3/8"=1'-0"

SECTIONS

Scales: 3/8"=1'-0"

STILLING BASIN NOTES:

1. For Design Data and General Notes. See Specifications.
2. All Exposed Concrete Edges to be Chamfered ¾".
3. Grouted Riprap Must be in Place 7 Days Before Backfill is Placed Behind Walls.
4. For Concrete to be Bush Hammered See Plan Above.

5323.20
149.00
5324.20 (survey)
5311.50
5309.34
5309.85
5324.38
5311.78
5309.45
5175.00
Add 5175.45 to transfer the elevation to NAVD 88

WRIGHT-McLAUGHLIN ENGINEERS
1240 West Bayaud Ave
Denver, Colorado
744-6271

DESCRIPTION OF REVISIONS	NO.	DATE	NAME

REVISED

STRUCTURE NO. 134-502

CITY AND COUNTY OF DENVER
DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

HARVARD GULCH FLOOD CONTROL PROJECT
PHASE II

STILLING BASIN DETAILS STRUCTURAL & HYDRAULIC

DATE	SCALE	DRAWN BY	TRACED BY	CHECKED BY	SHEET NO.	DRAWING NO.
11-26-65	AS SHOWN	R.K.	R.K.	[illegible]	8 OF 14 SHEETS	~~181-2~~

134-500



Figure 2

S. Madison St Downstream
Grouted Boulder Drop


Figure 3
S. Madison St
Upstream Face

Review Comments _ 12-29-2017

Pre-final Submittal

Responses to Comments on 12/29/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

		Comments	Responses
HEC-RAS Hydraulic Models			
Harvard Gulch	**1**	We agree with Denver that a floodway needs to be considered between Logan and Downing Streets. In order to preserve the floodplain storage through the Harvard Park area, and adequately reflect the areas of highest risk, we recommend adding a formal floodway along the Harvard Gulch Split, and extending the Harvard Gulch floodway to Logan Street. The hydraulic model already includes these reaches in the HEC-RAS model (that would need to be removed if no floodway were to be defined). The recommendation for the HG Split alignment would be to have floodway equal floodplain from the confluence up to Ogden Street, and have encroachment up to the 0.5-ft floodway from Ogden to upstream of Downing Street. Since the hydrology for the study included the Harvard Park storage, no encroachment would be allowed in this area. This would also eliminate the abrupt (and unrealistic) floodway termination near HG XS 7289 (aka HGS XS 2122).	Floodway analyses were provided for Harvard Gulch and Harvard Gulch Split Flow from S Logan St to S Downing St using recommended approaches by the review comments.
	2	Please ensure that the final HEC-RAS hydraulic model has the hard-wired flows (determined from the optimized model run) specified for both the floodplain and floodway plans. The HEC-RAS model with the optimized lateral structures is necessary documentation for how flows were determined, and needs to be provided, but is not part of the final model.	Both final HEC-RAS floodplain and floodway hydraulic models have the hard-wired flows which were determined from the optimized model run. The plan of optimized model run remains in the HEC-RAS hydraulic project for reference only. Table 4-2 Steady Flow Input in HEC-RAS Model in report text has been updated with hardwired flow.
	3	At HG XS 16425, there is a 0.13 foot WSEL discrepancy between the 100-yr profile in the “normal” plan and the 100-yr profile in the floodway plan. This appears to be due “Calculate Critical Depth at all Cross Sections” being enabled in the normal plan and not in the floodway plan.	Addressed. "Calculate Critical Depth at all Cross Sections" was disabled in both normal plan and floodway plan.
	4	The invert elevation at XS 14544 is 5370.99 in the RAS model. Survey indicates the invert should be 5369.51; please verify and revise as necessary.	Addressed. The channel geometry in the low flow area is controlled by a concrete check structure at cross section 14544. The surveyed crest elevations of this concrete check structure were coded at cross section 14544.
	5	Please verify IE at XS 15352 and revise as necessary. Narrow low flow channel not likely picked up in LiDAR. Recommend straight line between surveyed IEs at XSs 15281 and 15432 to determine IE for XS 15352.	Addressed with recommended approach.
	6	Please revise IE at XS 16736 and revise as necessary. Heavy vegetation results in questionable LiDAR at this XS. Recommend straight line between XSs 16579 and 16790 to determine reasonable IE at XS 16736.	Addressed with recommended approach.
Harvard Gulch	**7**	Please verify the Franklin St bridge (8400) outlet IE, and revise as necessary. The current value does not match survey (5325.92 in RAS vs 5325.54 in survey). This is likely by accident as the inlet elevation is also 5325.92.	The invert at downstream of Franklin St Bridge was revised to 5325.54 to match the survey.
	8	Please verify the IE at XS 6234, and revise as necessary. While the IE at XS 6710 matches existing as-built information, the IE at 6234 represents the downstream end of the stilling basin and is approximately 1.2 feet higher than indicated by either survey or in the as-built plans.	Addressed. For clarification, the mentioned cross section 6234 in the review comments should be cross section 6307 instead. Cross section 6307 was cut at the downstream end of the stilling basin to represent the crest of the stilling basin. The surveyed crest elevation of 5311.6 has been incorporated at cross section 6307. The invert elevation at stilling basin is 5309.68 from the as-built plan was coded in the internal cross section of the culvert at the downstream end to visually represent the drop on the profile. Invert of cross section 6234 has been revised utilizing the inverts at cross section 6027 and 6307.

Responses to Comments on 12/29/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

Comments			Responses
Harvard Gulch Split	**9**	As previously requested, please verify that ROB XS 637 is not actually IEFA; and revise as necessary. Since the ROB of this XS is in the portion of the detention pond where flow would appear to be impacted by the downstream embankment, the area is likely ineffective. There may be little, if any, impact on the model results.	Addressed. Permanent IEFA has been added at the cross section 637 to account the impacts by the downstream embankment. The station of IEFA was determined by assuming the ratio of contraction is 1:1 in the longitudinal direction.
Floodplain Work Map and Flood Profile			
Topographic Work Map 1	**1**	Only show regulatory 100-year limits for South Platte River	Addressed.
	2	Please show limits of South Platte River 100-year floodplain throughout the entire confluence area..... Make sure there is a clear separation provided between flooding sources .....; and clarify that shallow flooding within the limits of the SPR floodplain	Addressed, show only SPR 100-year regulatory floodplain boundary and add note "100-year shallow flooding (based on FLO-2D) within the limits of the South Platte River, however, does not include flooding depths from South Platte River" inside the shallow flooding area on the map.
	3	Please clarify that these are 100-year average depths. For Floodplain Management purposes, please specify the last two shallow flooding categories as Average Depth less than or equal to 2 feet and less than or equal to 3 feet, respectively. If average depths are deeper than 3-ft, will need something besides shallow flooding.	Addressed, clarify with Average Depth ≤ 1 FT, Average Depth ≤ 2 FT and Average Depth ≤ 3 FT.
Topographic Work Map 2	**4**	Please turn off effective floodplain layer for final.	Addressed.
	5	Please extend separation/gutter line across floodplain to clarify hazards from different flooding sources both u/s and d/s split flow path.	Addressed.
	6	Please add duplicate BFE upstream of XS 1426 to replicate the profile within 0.5 feet.	Addressed.
	7	All sheets: please ensure labels do not obscure floodplain and floodway boundaries.	Addressed, use leader to avoid the obscured condition.
	8	Please remove extra BFE 5328.	Removed the extra BFE of 5328 and corrected it to be 5327.
	9	Please use leaders to avoid labels blocking flood hazard data - all locations	Addressed.
	10	PLEASE REMOVE. Previously requested that this note be removed. Comment-response table stated note was removed but it still remains.	Removed.
	11	Cross section id labels are still switched. Please correct.	Corrected.
	12	Please label average depth of shallow flooding as requested.	Labeled as "Shallow flooding average depth less than 1 foot"
	13	Color is fine, but please use a distinctive symbol for shallow flooding areas to avoid confusion between main 100-year floodplain and shallow flooding (i.e., stipple?)	Addressed.
Topographic Work Map3	**14**	Please turn off effective FEMA floodplain for final.	Addressed.
	15	Please remove detached BFE segment.	Detached BFE removed.
	16	Thank you for moving BFE 5328 as requested. Please adjust label positions so that BFE line/label associations are unambiguous.	Addressed, use leader to avoid the ambiguous condition.
	17	Please specify average depth less... For all locations	Addressed.
Flood Profiles	**1**	Please connect survey points here to provide IE at XS 15352	Addressed with recommended approach.
	2	Please straight line between XSs 16579 and 16790. Heavy vegetation at XS 16736 makes LiDAR less reliable.	Addressed with recommended approach.

Responses to Comments on 12/29/2016
Flood Hazard Area Delineation _ Harvard Gulch and Dry Gulch

Comments			Responses
Report Text			
Page	**Item**	**Comments**	**Responses**
37	**1**	As previously requested, please provide a clear statement regarding the use of future conditions hydrology compared to existing conditions hydrology (i.e., same due to fully developed basin, very similar, future peak Qs within 130% of existing peak Qs, etc.)	Narratives have been added to report text.
39	**2**	Please clarify WHY future conditions hydrology is used - recommend addressing at the beginning of this section before you start specifying quantities of flow.	
40	**3**	May need to revise if additional floodways are defined for other reaches.	Narratives have been revised to report text.
40	**4**	See previous note on potential for additional floodway delineation.	
Comments from the City and County of Denver, January 19, 2017			
Page	**Item**	**Comments**	**Responses**
40	**1**	The report should include discussion of LOMC cases for Harvard Gulch and Dry Gulch. Denver requests tabulation of valid cases to include FEMA Case Number, LOMC Type (LOMA, LOMR-F, LOMR_FW, LOMA OAS, LOMA-DEN, etc…), Identifier (address), Lowest Adjacent Grade (from LOMC), BFE (from LOMC) and updated BFE from this FHAD. This information should be used to inform the floodplain delineation at/around these structures/properties. Inclusion of this information is also needed so that the report can be an effective tool for administering the flood hazard areas and will be useful for the eventual PMR. This information can be included as an appendix, but its existence should be noted in the text. The current FHAD report notes that there are 61 LOMCs. The FHAD maps appear to show 59. Our records indicate that there are currently 68 valid LOMC determinations, including denials (see enclosed list). Denied cases still have relevant information that can be used to inform floodplain delineations. Please update map and report text accordingly to show 68 valid determinations (53 approved, 15 denied) using a different color or symbol to distinguish approved vs denied cases.	A table was provided by Denver which includes 68 valid LOMC determinations was included in the Appendix A. The BFE's from this new FHAD study were incorporated on the table for each structure. The narratives for LOMC cases for Harvard Gulch and Dry Gulch were included in the report.
37	**2**	As indicated in our previous FHAD redlines submitted 05/09/16, there is confusion about how the surface used to cut cross sections was created. The text indicates that the surface was created from contour data. However, we provided Matrix the 2014 LiDAR data at the beginning of the MDP/FHAD study (Jan. 2015) and email correspondence in March 2015 (enclosed) indicates that Matrix would use the same, unmodified surface that Tetra Tech derived (for USACE study) from the LiDAR DEM. Clarify in the report text how the surfaces used for Flo-2d modeling and for HEC-RAS modeling were derived. As we have mentioned on other recent FHAD studies, reverse engineering a surface from contour data is unacceptable when the source data exists and is readily available. This is particularly important in relatively flat areas because the margin of error using this methodology could be as much as ±1.5' which is meaningful when mapping property and buildings in/out of the floodplain.	The surface was created from the 2014 LiDAR DEMs which has been incorporated into report text.
8	**3**	It may be useful to show sub-basins on Figure 2-2.	Addressed with secondary basin boundaries were turned on.

LOMC Validation

Appendix A – Project Correspondence

Harvard Gulch LOMC Validation List with BFEs

CASE #:	Project Identifier	Flooding Source	LOMC Type:	BFE from FHAD (NAVD 88)	BFE from LOMA	LAG from LOMA	Lowest Lot Elevation from LOMA	Original Issue Date:	Datum [1]	Original Issue Datum	Issued Panel:	Current Panel:	Latest Revalidation Case #	Notes:
15-08-0216A	2515 S. Pennsylvania	Dry Gulch (Harvard Gulch Trib)	LOMA	5307.3		5310.0		12/18/2014	1988	1988	0211H	0211H		
05-08-0155A	2551 S. Washington	Dry Gulch (Harvard Gulch Trib)	LOMA-DEN	5311.0	5312.7	5310.0		3/28/2005	**1988**	1929	0018C	0211H	N/A	
16-08-0081A	625 E. Martindale	Dry Gulch (Harvard Gulch Trib)	LOMR-FW	5319.8	5318.5	5318.6		11/20/2015	1988	1988	0211H	0211H		Follows 10-08-0472A (CLOMA)
01-08-107A	2395 S. Marion	Harvard Gulch	LOMA-DEN	5329.3	5330.9	5330.0		1/26/2001	**1988**	1929	0018C	0211H	N/A	
14-08-0123A	2444 S. High	Harvard Gulch	LOMA	5344.2		5346.2		11/21/2013	1988	1988	0212G	0212G		
95-08-039A	2453 S. Gilpin	Harvard Gulch	LOMA	5337.9				1/4/1995	NA	NA	0018C	0212G	04-08-0786V	Out as shown
04-08-0559A	2555 S. Monroe	Harvard Gulch	LOMA	5384.4	5384.5	5386.1		10/7/2004	1988	1988	0019E	0212G	04-08-0786V	
98-08-014A	2562 S. Cook	Harvard Gulch	LOMA	5380.8				11/7/1997	NA	NA	0019D	0212G	04-08-0786V	Originally Revalidated on 99-08-038V
08-08-0191A	2580 S. Monroe	Harvard Gulch	LOMA-DEN	5386.3	5388.8		5384.6	1/10/2008	1988	1988	0212G	0212G	N/A	
06-08-B331A	2585 S. Adams	Harvard Gulch	LOMA	5378.2	5379.7	5379.9		6/13/2006	1988	1988	0212G	0212G		
07-08-0601A	2585 S. Madison	Harvard Gulch	LOMA	5381.6	5384.8	5385.3		5/31/2007	1988	1988	0212G	0212G		
06-08-B620A	2585 S. Monroe	Harvard Gulch	LOMA-DEN	5384.4	5387.3	5386.4		11/21/2006	1988	1988	0212G	0211H	N/A	
14-08-0829A	2595 S. Madison	Harvard Gulch	LOMA	5381.6	5385.0	5385.0		5/22/2014	1988	1988	0212G	0212G		
13-08-0654A	2600 S. Cook	Harvard Gulch	LOMA	5380.7	5382.3	5382.6		5/7/2013	1988	1988	0212G	0212G		
97-08-304A	2601 S. Jackson	Harvard Gulch	LOMA-OAS	5389.9				7/31/1997	NA	NA	0019D	0212G	04-08-0786V	Originally Revalidated on 99-08-038V
14-08-0643A	2637 S. Adams	Harvard Gulch	LOMA	5378.1	5379.9	5380.1		3/27/2014	1988	1988	0212G	0212G		
13-08-0146A	2660 S. Josephine	Harvard Gulch	LOMA-OAS	5358.6				12/11/2012	1988	1988	0212G	0212G		Listed on 2013 SOMA, not in revalid letter
11-08-0980A	1961 S. Fox	Harvard Gulch Overflow	LOMA	5257.6	5258.7	5258.7		9/29/2011	1988	1988	0211G	0211H	09-08-0842V	
14-08-0502A	1984 S. Galapago	Harvard Gulch Overflow	LOMA-DEN	5256.3	5255.0	5253.7		3/18/2014	1988	1988	0211H	0211H	N/A	
99-08-388A	2002 S. Fox	Harvard Gulch Overflow	LOMA-OAS	N/A [2]				9/24/1999	NA	NA	0018C	0211H	09-08-0842V	Incorrectly listed as South Platte River on LOMA, still valid determination
04-08-0772A	2019 S. Fox	Harvard Gulch Overflow	LOMA	N/A [2]	5258.1	5258.2		10/20/2004	**1988**	1929	0018C	0211H	09-08-0842V	Incorrectly listed as South Platte River on LOMA, still valid determination
03-08-0359A	2093 S. Acoma	Harvard Gulch Overflow	LOMA-OAS	5282.1				5/7/2003	NA	NA	0018C	0211H	09-08-0842V	
05-08-0164A	2137 S. Cherokee	Harvard Gulch Overflow	LOMA	N/A	5279.0	5279.0		3/4/2005	**1988**	1929	0018C	0211H	09-08-0842V	
14-08-0417A	2140 S. Delaware	Harvard Gulch Overflow	LOMA-DEN	5274.9	5271.5 to 5274.4	5270.1		3/13/2014	1988	1988	0211H	0211H	N/A	
12-08-0769A	2143 S. Bannock	Harvard Gulch Overflow	LOMA	N/A [2]	5281.6	5282.0		8/14/2012	1988	1988	0211G	0211H	09-08-0842V	
99-08-013A	2160 S. Sherman	Harvard Gulch Overflow	LOMA-OAS	N/A [2]				11/2/1998	NA	NA	0018C	0211H	09-08-0842V	
11-08-1076A	2173 S. Lincoln	Harvard Gulch Overflow	LOMA	5287.4	5286.8	5286.9		11/15/2011	1988	1988	0211G	0211H	09-08-0842V	
05-08-0649A	2190 S. Lincoln	Harvard Gulch Overflow	LOMA	5288.4	5286.0	5286.1		11/18/2005	1988	1988	0211G	0211H	09-08-0842V	
14-08-0640A	2207 S. Cherokee	Harvard Gulch Overflow	LOMA	N/A [2]	5280.3 to 5283.2	5282.5 to 5284.6		3/25/2014	1988	1988	0211H	0211H		Supersedes 14-08-0503A
08-08-0267A	2219 S. Bannock	Harvard Gulch Overflow	LOMA-OAS	N/A [2]				2/5/2008	**1988**	1929	0211G	0211H	09-08-0842V	
93-08-005A	2224/2248 S. Cherokee	Harvard Gulch Overflow	LOMA	N/A [2]				11/17/1992	NA	NA	0018C	0211H	04-08-0786V	Out as shown
09-08-0146A	2235 S. Cherokee	Harvard Gulch Overflow	LOMA-DEN	N/A [2]	5280.7	5280.1		4/7/2009	1988	1988	0211G	0211H	N/A	
95-08-054A	2245 S. Bannock	Harvard Gulch Overflow	LOMA-OAS	N/A [2]				1/13/1995	NA	NA	0018C	0211H	04-08-0786V	Not Shown on 09-08-0842V
99-08-241A	2246 S. Bannock	Harvard Gulch Overflow	LOMA-OAS	N/A [2]		5287.8		6/2/1999	**1988**	1929	0018C	0211H	09-08-0842V	
03-08-0657A	2265-2275 S. Acoma	Harvard Gulch Overflow	LOMA	N/A [2]	5287.1	5288.3		10/17/2003	**1988**	1929	0018C	0211H	09-08-0842V	
12-08-0797A	2305 S. Lincoln	Harvard Gulch Overflow	LOMA-DEN	5293.1	5288.8	5288.4		10/11/2012	1988	1988	0211G	0211H	N/A	
15-08-0161A	2305 S. Lincoln	Harvard Gulch Overflow	LOMA-DEN	5294.1	5292.7	5292.2		1/6/2015	1988	1988	0211H	0211H	N/A	
03-08-0665A	2310 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.2	5294.3		5295.2	10/22/2003	**1988**	1929	0018C	0211H	09-08-0842V	
14-08-0968A	2315 S. Bannock	Harvard Gulch Overflow	LOMA-OAS	N/A [2]				6/3/2014	1988	1988	0211H	0211H		
08-08-0859A	2315 S. Lincoln	Harvard Gulch Overflow	LOMA	5293.2	5288.1	5289.00		11/18/2008	1988	1988	0211G	0211H	09-08-0842V	
05-08-0567A	2318 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.3	5291.7	5293.1		8/16/2005	**1988**	1929	0018C	0211H	09-08-0842V	
07-08-0513A	2320 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.3	5291.8	5292.9		4/19/2007	1988	1988	0212G	0212G		
08-08-0774A	2323 S. Lincoln	Harvard Gulch Overflow	LOMA	5293.4	5287.8	5288.8		11/20/2008	1988	1988	0211G	0211H	09-08-0842V	
07-08-0126A	2323 S. Sherman	Harvard Gulch Overflow	LOMA-DEN	5295.5	5293.8	5293.5		12/5/2006	1988	1988	0211G	0211H	N/A	
05-08-0520A	2330 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.5	5292.0	5293.1		7/21/2005	**1988**	1929	0018C	0211H	09-08-0842V	

Harvard Gulch LOMC Validation List with BFEs

CASE #:	Project Identifier	Flooding Source	LOMC Type:	BFE from FHAD (NAVD 88)	BFE from LOMA	LAG from LOMA	Lowest Lot Elevation from LOMA	Original Issue Date:	Datum [1]	Original Issue Datum	Issued Panel:	Current Panel:	Latest Revalidation Case #	Notes:
10-08-0344A	2331 S. Bannock	Harvard Gulch Overflow	LOMA	N/A [2]	5287.2	5290.0		3/9/2010	1988	1988	0211G	0211H	09-08-0842V	
12-08-0998A	2335 S. Bannock	Harvard Gulch Overflow	LOMA	N/A [2]	5287.3	5289.9		10/25/2012	1988	1988	0211G	0211H	09-08-0842V	
14-08-0955A	2337 S. Lincoln (Garage)	Harvard Gulch Overflow	LOMA	5292.9	5291.9	5292.00		6/5/2014	1988	1988	0211H	0211H		
14-08-0586A	2337 S. Lincoln (House)	Harvard Gulch Overflow	LOMA	5293.6	5291.9	5293		3/20/2014	1988	1988	0211H	0211H		Supersedes 05-08-0592A (via 09-08-0842V)
08-08-0777A	2340 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.6	5289.3	5290.2		10/28/2008	1988	1988	0211G	0211H	09-08-0842V	
06-08-B399A	2345 S. Lincoln	Harvard Gulch Overflow	LOMA	5293.8	5289.2	5291.6		6/6/2006	1988	1988	0211G	0211H	09-08-0842V	
12-08-0546A	2352 S. Lincoln	Harvard Gulch Overflow	LOMA	5295.1		5291.4		6/12/2012	1988	1988	0211G	0211H	09-08-0842V	
06-08-0155A	2353-2355 S Lincoln	Harvard Gulch Overflow	LOMA	5290.6	5292.3	5293.4		12/29/2005	**1988**	1929	0211G	0211H	09-08-0842V	Supersedes 05-08-0615A, reissued after 2005 DFIRM became effective
05-08-0689X	2354 S. Lincoln	Harvard Gulch Overflow	LOMA	5295.3	5292.5	5294.1		9/29/2005	**1988**	1929	0018C	0211H	09-08-0842V	Supersedes 05-08-0493A
09-08-0547A	2365 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.1	5289.5	5290.4		4/16/2009	1988	1988	0211G	0211H	09-08-0842V	
05-08-0483A	2366 S. Lincoln	Harvard Gulch Overflow	LOMA	5295.4	5292.7	5294.0		7/1/2005	**1988**	1929	0018C	0211H	09-08-0842V	
05-08-0573A	2370 S. Lincoln	Harvard Gulch Overflow	LOMA	5295.5	5292.8	5294.1		8/16/2005	**1988**	1929	0018C	0211H	09-08-0842V	
14-08-0656A	2371 S. Sherman	Harvard Gulch Overflow	LOMA	5297.2	5295.3	5295.8		4/24/2014	1988	1988	0211H	0211H		
05-08-0544A	2375 S. Lincoln	Harvard Gulch Overflow	LOMA	5294.2	5292.6	5293.0		8/23/2005	**1988**	1929	0018C	0211H	09-08-0842V	
09-08-0610A	2376 S. Lincoln	Harvard Gulch Overflow	LOMA-DEN	5295.3	5294.9	5294.0		6/4/2009	**1988**	1929	0211G	0211H	N/A	
08-08-0878A	2377 S. Lincoln	Harvard Gulch Overflow	LOMA-DEN	5294.2	5289.8	5289.5		11/18/2008	1988	1988	0211G	0211H	N/A	
06-08-B568A	2386 S. Lincoln	Harvard Gulch Overflow	LOMA	5295.9	5293.1	5294.3		8/23/2006	1988	1988	0211G	0211H	09-08-0842V	
16-08-0443A	2417 S. Cherokee	Harvard Gulch Overflow	LOMA-OAS	N/A [2]				3/25/2016	1988	1988	0211H	0211H		
16-08-1265A	2418 S. Lincoln	Harvard Gulch Overflow	LOMA-DEN	5295.8	5294.3	5294.2		9/28/2016	1988	1988	0211H	0211H	N/A	
14-08-0346A	2425 S. Lincoln	Harvard Gulch Overflow	LOMA-DEN	5294.4	5293.8	5293.3		3/6/2014	1988	1988	0211H	0211H	N/A	
06-08-B300A	2465 S. Sherman	Harvard Gulch Overflow	LOMA	5297.6	5296.2	5296.5		6/20/2006	1988	1988	0211G	0211H	09-08-0842V	
03-08-0440A	530 W. Jewell	Harvard Gulch Overflow	LOMA	5259.7	5261.0	5261.2		9/22/2003	**1988**	1929	0018C	0211H	09-08-0842V	
11-08-0417A	606 W. Jewell	Harvard Gulch Overflow	LOMA-DEN	5255.6	5254.9	5254.6		3/29/2011	1988	1988	0211G	0211H	N/A	
~~10-08-0472A~~	~~625 E. Martindale~~	~~Dry Gulch (Harvard Gulch Trib)~~	~~LOMR-FW~~		~~5318.6~~	~~5320.1~~		~~5/6/2010~~	~~1988~~	~~1988~~	~~0211G~~	~~0211H~~	~~09-08-0842V~~	~~For old house, superseded by 16-08-0081A, should not be revalidated~~
~~12-08-0181A~~	~~2600 S. Cook~~	~~Harvard Gulch~~	~~LOMA~~		~~5381.9~~	~~5383.2~~		~~1/12/2012~~	~~1988~~	~~1988~~	~~0212G~~	~~0212G~~		~~For old House, superseded by 13-08-0654A, should not be revalidated~~
~~14-08-0303A~~	~~2437 S. Williams~~	~~Harvard Gulch~~	~~LOMA~~		~~5341.7~~	~~5342.1~~		~~4/17/2014~~	~~1988~~	~~1988~~	~~0212G~~	~~0212G~~		~~Structure Demolished, should not be revalidated~~
~~05-08-0493A~~	~~2354 S. Lincoln~~	~~Harvard Gulch Overflow~~	~~LOMA~~		~~5292.5~~	~~5294.1~~		~~8/2/2005~~	~~**1988**~~	~~1929~~	~~0018G~~	~~0211H~~	~~N/A~~	~~Superseded by 05-08-0689X, processed with wrong panel suffix~~
~~05-08-0592A~~	~~2337 S. Lincoln~~	~~Harvard Gulch Overflow~~	~~LOMA~~		~~5292.0~~	~~5293.0~~		~~8/25/2005~~	~~**1988**~~	~~1929~~	~~0018C~~	~~0211H~~	~~09-08-0842V~~	~~Superseded by 14-08-0586A~~
~~05-08-0615A~~	~~2353-2355 S. Lincoln~~	~~Harvard Gulch Overflow~~	~~LOMA~~		~~5292.3~~	~~5293.4~~		~~11/1/2005~~	~~**1988**~~	~~1929~~	~~0018C~~	~~0211H~~	~~09-08-0842V~~	~~Superseded by 06-08-0155A~~
~~14-08-0503A~~	~~2207 S. Cherokee~~	~~Harvard Gulch Overflow~~	~~LOMA-DEN~~		5283.2	5282.5		~~3/11/2014~~	~~1988~~	~~1988~~	~~0211H~~	~~0211H~~	~~N/A~~	~~Superseded by 14-08-0640A~~

[1] **Bold text** in Datum field indicates conversion from 1929. Assocated elevations converted using 1988 = 1929 + 3.0'.

[2] Structures are not in the 2017 FHAD floodplain.

75 total cases:
7 invalid cases:
- 3 cases invalid due to structure being demolished (625 E. Martindale, 2600 S. Cook & 2437 S. Williams) - strikethrough below
- 4 cases invalid due to case being superseded by newer one (2354 S. Lincoln, 2337 S. Lincoln, 2353-2355 S. Lincoln & 2207 S. Cherokee) - strikethrough below

68 valid determinations:
- 15 valid denied cases (LAG may still valuable info for FHAD mapping purposes)
    - 1 invalid denied case due to case being superseded (already counted as invalid case, 2207 S. Cherokee)
- 53 valid, approved cases

Appendix B – Hydrologic Analysis

Evans Station TOD Area

W EVANS AVE

E JEWELL AVE

S BROADWAY

S LOGAN ST

S DOWNING ST

S UNIVERSITY BLVD

S SAINT PAUL ST

S COLORADO BLVD

INTERSTATE 25

S DAHLIA ST

E EVANS AVE

E ILIFF AVE

S HOLLY ST

High Line Canal

Arapahoe County
City & County of Denver

S PLATTE RIVER DR

UDFCD 603

Harvard Gulch Park Pond

USGS NO6711575

Dry Gulch

USGS NO6711572

UDFCD 613

Harvard Gulch

USGS NO6711570

E YALE AVE

City & County of Denver
City of Englewood

S SANTA FE DR

S BROADWAY

S LOGAN ST

S STEELE ST

E DARTMOUTH AVE

Packy Romans Park Pond

Steel Reservoir

E HAMPDEN AVE

City of Englewood
Cherry Hills Village

Unincorporated
Arapahoe County

City & County of Denver
Cherry Hills Village

S DOWNING ST

S UNIVERSITY BLVD

COLORADO BLVD

S DAHLIA ST

INTERSTATE 25

S MONACO STREET PKWY

Legend

- City Boundary
- Existing Light Rail Line
- Watershed Boundary (7.4 Sq. Mi.)
- Subbasin
- UDFCD Gage
- USGS Gage

Study Reach
- Open Channel
- Pipe

- Basin ID
  Area, %Imp

SWMM Routing Elements
- Outfall
- Design Point
- Detention
- Split Flow
- Conveyance

Future Land Use, % Impervious
- Park, 5%
- Residential - Single Unit, Min Lot 2.5 AC, 22%
- Residential - Single Unit, Min Lot 1.25 AC, 28%
- Residential - Single Unit, Min Lot 1 AC, 32%
- Residential - Single Unit, 50%
- Residential - Single Unit, Min Lot 0.5 AC, 50%
- Residential - Multi-Unit Detached, 60%
- Residential - Multi-Unit Attached, 75%
- Railroad Corridor, 40%
- School, 50%
- Industrial - Light, 80%
- Industrial, 90%
- Business - Residential, 85%
- Business - Commercial, 95%
- Roadway, 90%

DENVER PUBLIC WORKS

Matrix DESIGN GROUP

0 200 400 800 Feet

Layer Control Instructions

The Map Controls above set the visibility of the layers automatically for the selected map. Additional layer control is available through the "Layers" Navigation Panel which can be accessed from the View Menu under Navigation Panels. In the Panel, the visibility of layers and layer groups can be changed by clicking the square left of the layer/group. An eye in the square indicates that the layer is on. An empty square indicates that the layer is off. Layer groups can be expanded and reduced by clicking the +/- symbol left of the layer/group.

Interactive Figures (Select from Below)

Study Area Map
Future Land Use Map
Subwatershed Boundaries Map
Baseline Hydrology SWMM Routing Map

Figure B-1
Hydrology Map
Harvard Gulch & Dry Gulch Major Drainageway Plan

Figure B-2 Harvard Gulch _ Peak Discharges vs. Channel Stations - Future Conditions

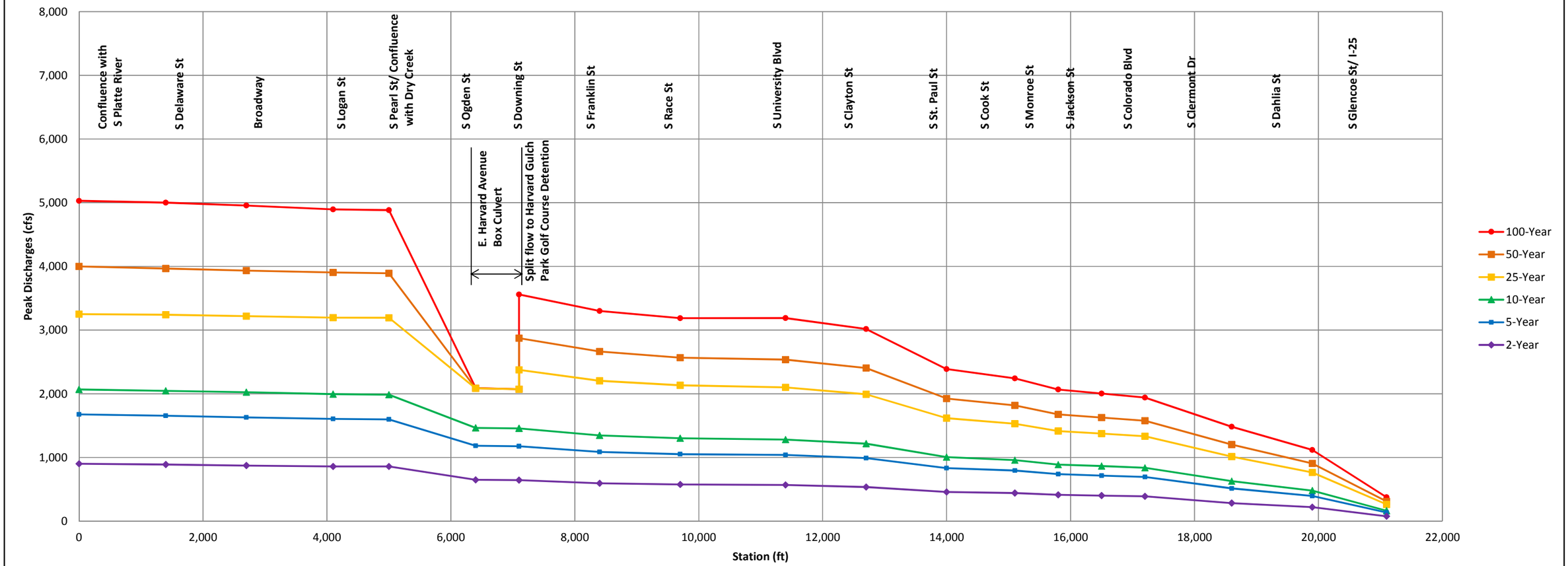


Figure B-3 Dry Gulch _ Peak Discharges vs. Channel Stations - Future Conditions

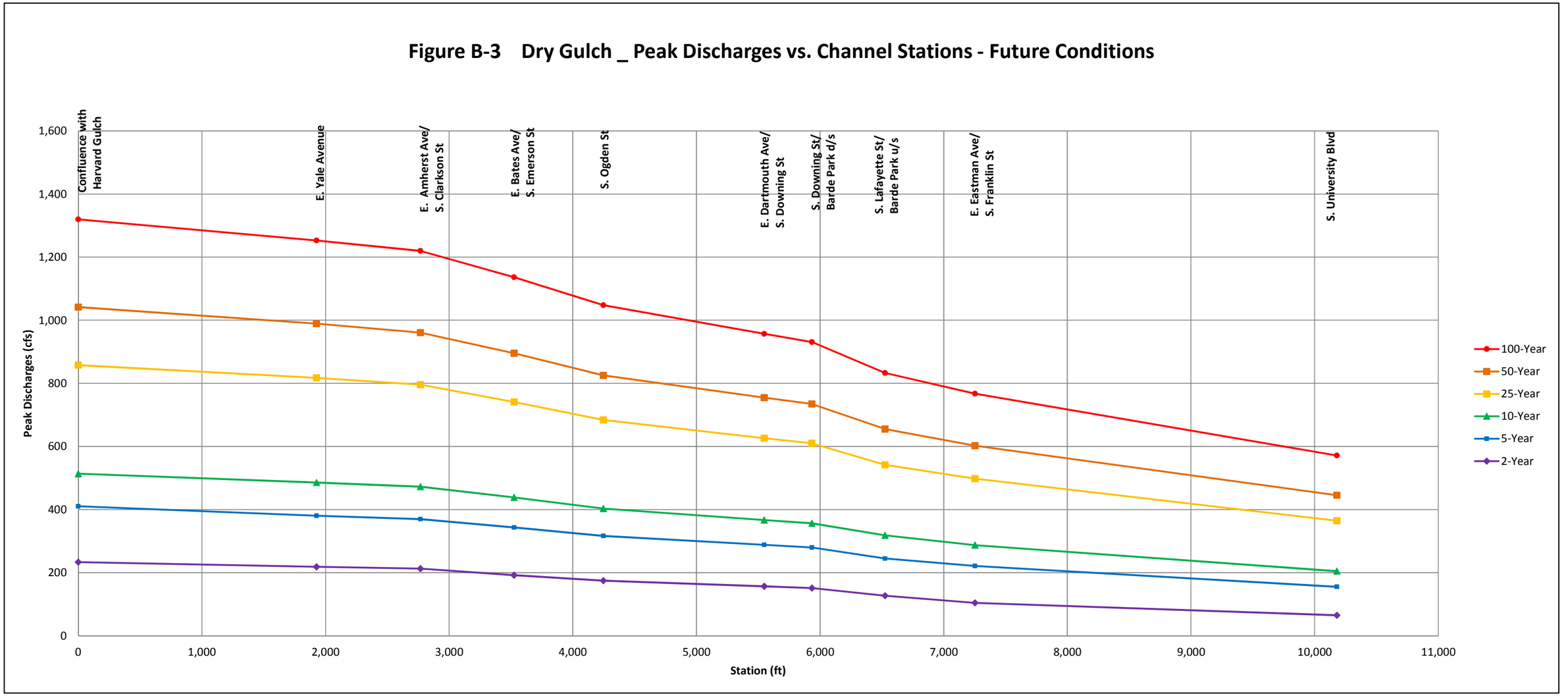
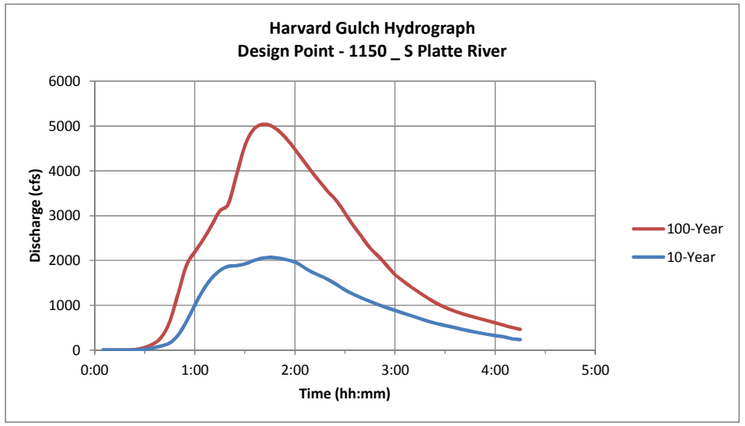
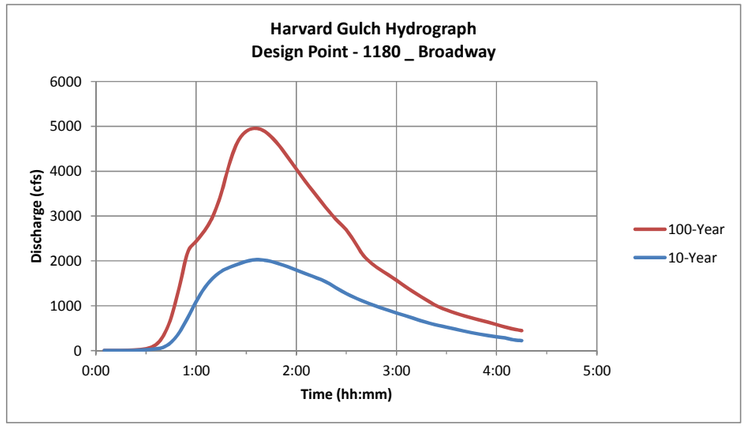
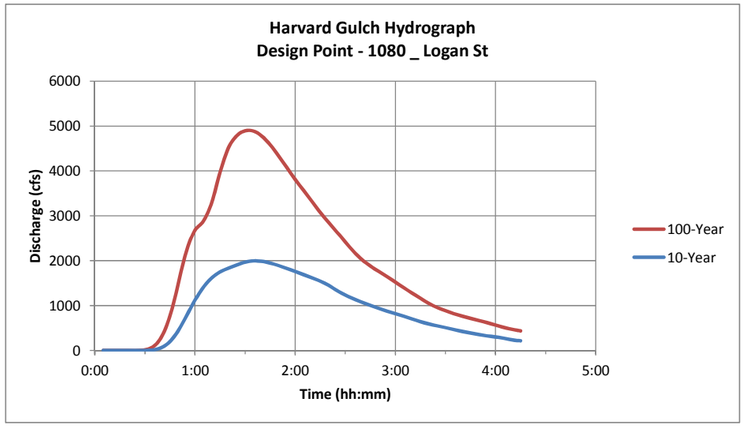
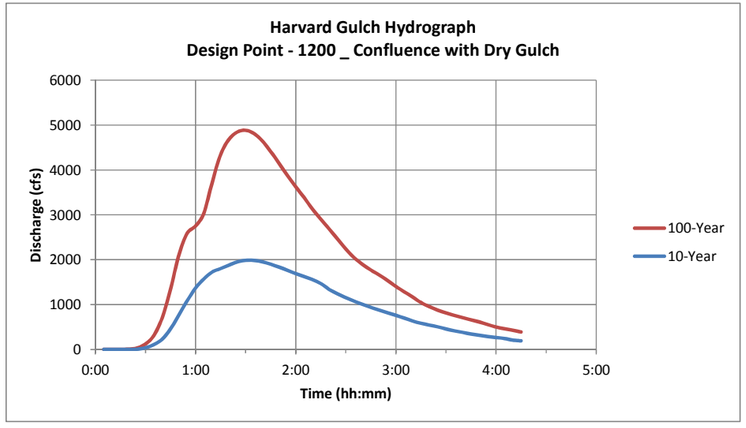


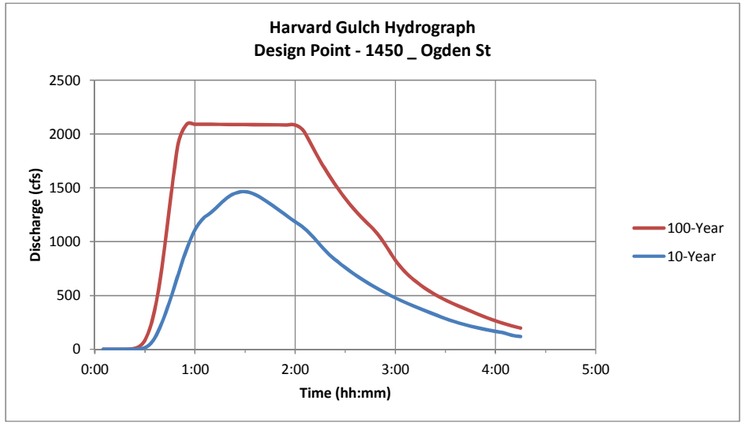
Figure B-4 Harvard Gulch _ Storm Hydrographs at Key Design Points











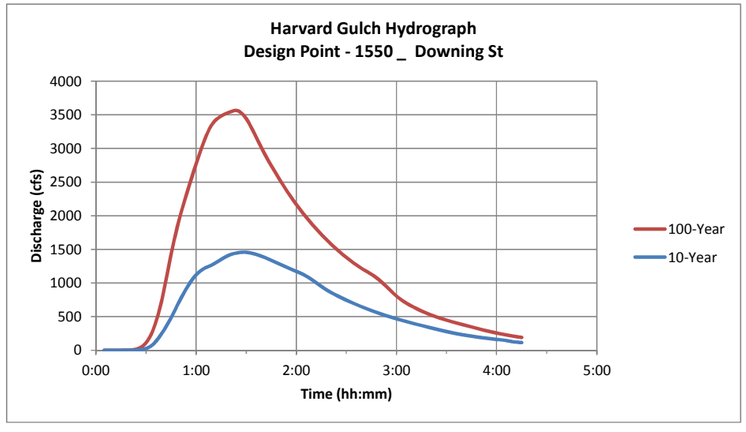
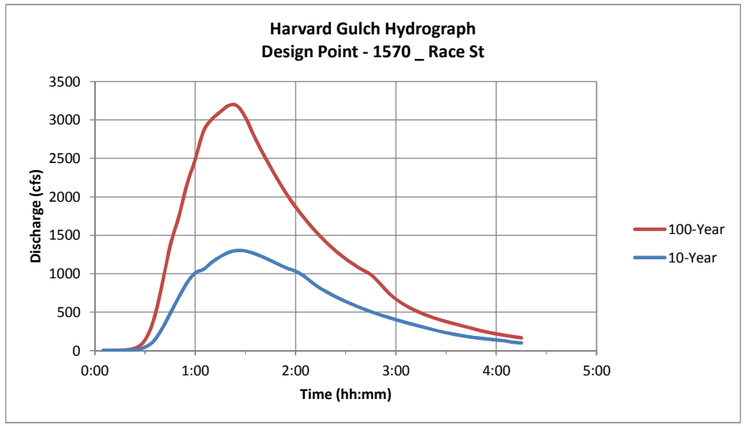
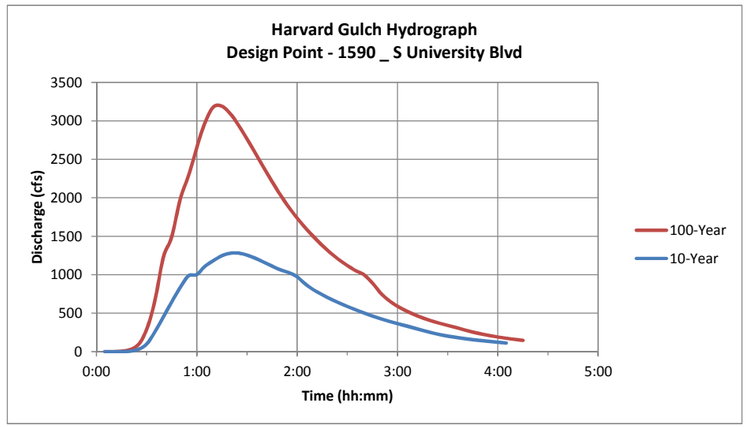
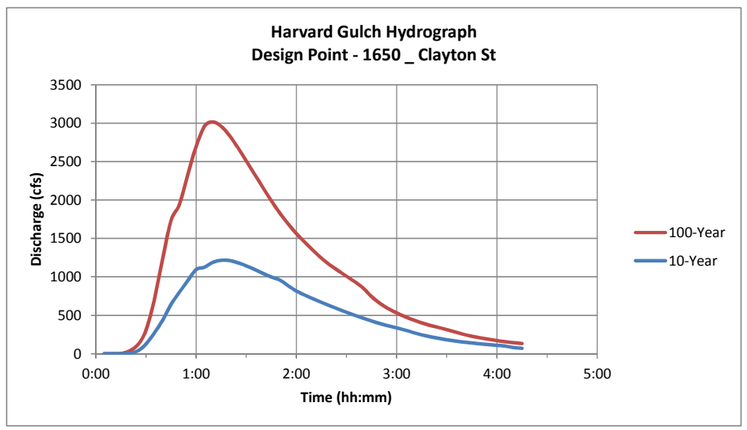
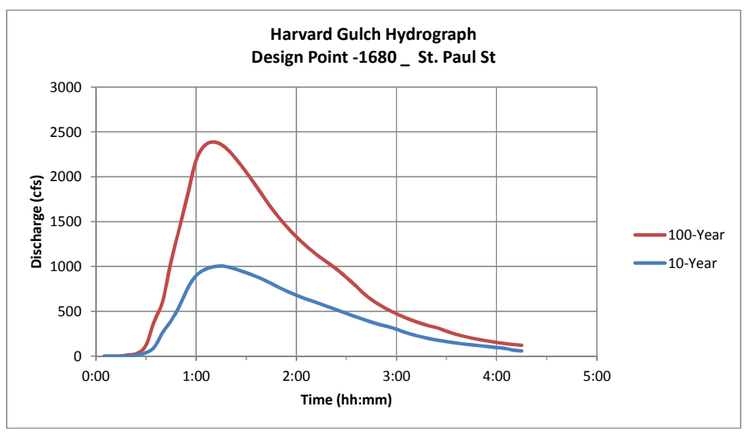


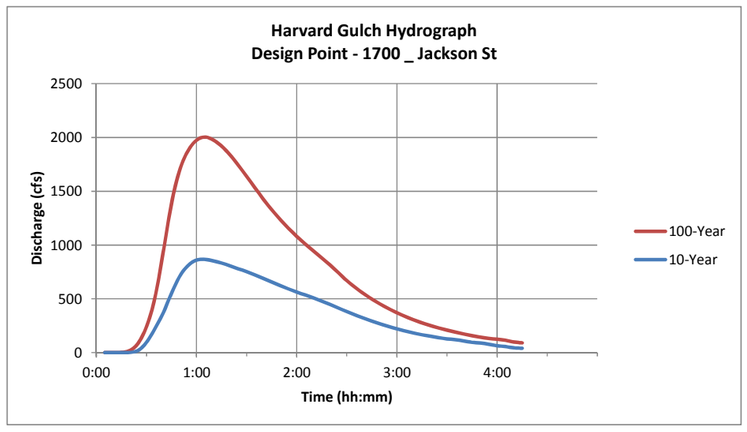
Figure B-4 Harvard Gulch _ Storm Hydrographs at Key Design Points











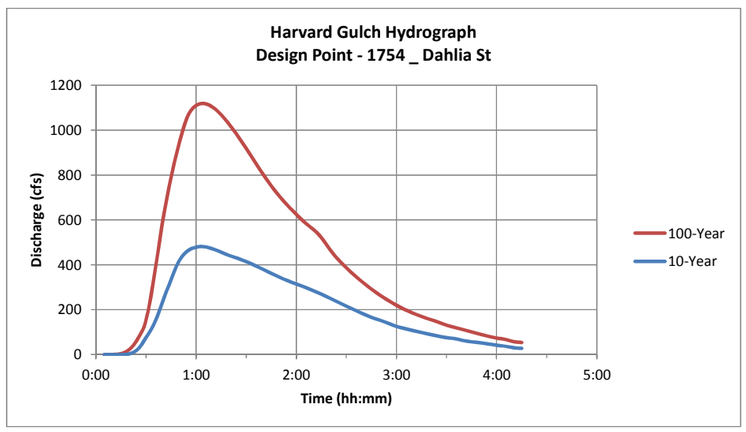
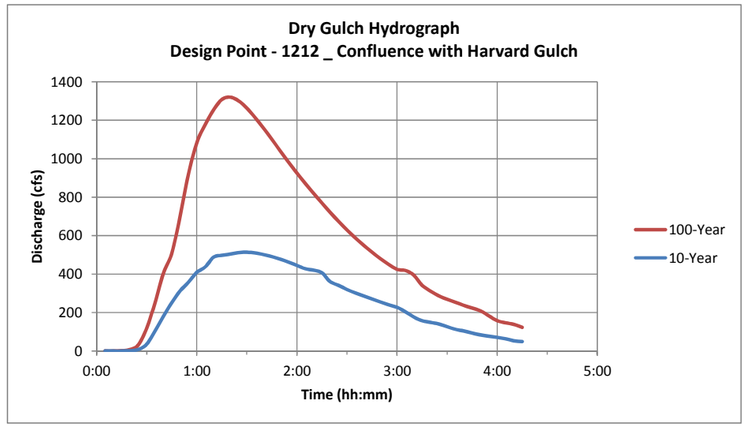
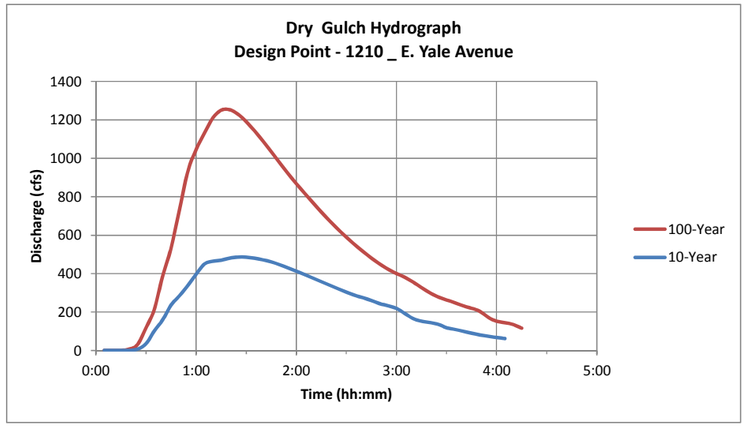
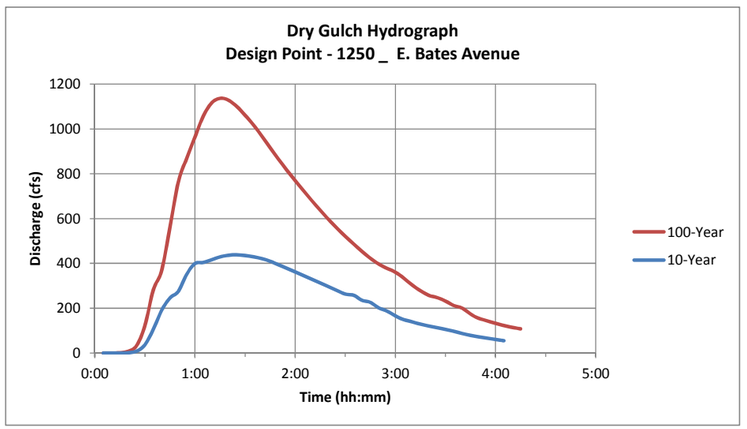
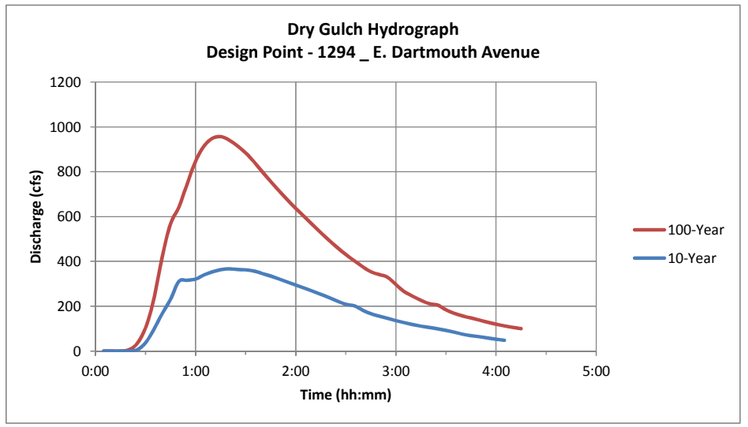


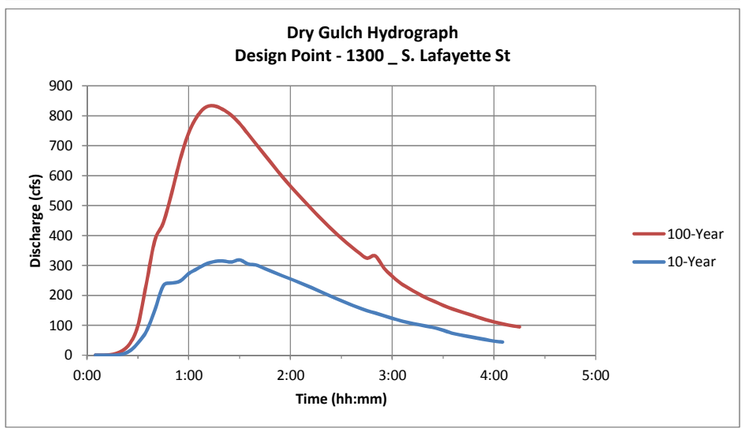
Figure B-4 Dry Gulch _ Storm Hydrographs at Key Design Points











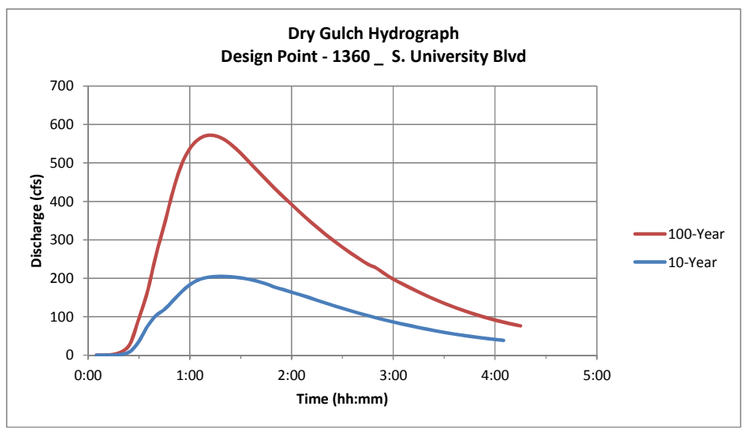


Table B-1 Rainfall Distribution (2-hour Distribution)

1Hr Depth	0.95 Inches
Return Period	2-Year
Time	Depth
0:05	0.02
0:15	0.08
0:20	0.15
0:25	0.24
0:30	0.13
0:35	0.06
0:40	0.05
0:45	0.03
0:50	0.03
0:55	0.03
1:00	0.03
1:05	0.03
1:10	0.02
1:15	0.02
1:20	0.02
1:25	0.02
1:30	0.02
1:35	0.02
1:40	0.02
1:45	0.02
1:50	0.02
1:55	0.01
2:00	0.01
2:05	0.00

1Hr Depth	1.34 Inches
Return Period	5-Year
Time	Depth
0:05	0.03
0:15	0.12
0:20	0.21
0:25	0.34
0:30	0.17
0:35	0.08
0:40	0.06
0:45	0.05
0:50	0.05
0:55	0.04
1:00	0.04
1:05	0.04
1:10	0.04
1:15	0.03
1:20	0.03
1:25	0.03
1:30	0.03
1:35	0.03
1:40	0.02
1:45	0.02
1:50	0.02
1:55	0.02
2:00	0.02
2:05	0.00

1Hr Depth	1.55 Inches
Return Period	10-Year
Time	Depth
0:05	0.03
0:15	0.13
0:20	0.23
0:25	0.39
0:30	0.19
0:35	0.09
0:40	0.07
0:45	0.06
0:50	0.05
0:55	0.05
1:00	0.05
1:05	0.05
1:10	0.05
1:15	0.05
1:20	0.04
1:25	0.03
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.03
2:00	0.02
2:05	0.00

1Hr Depth	1.98 Inches
Return Period	25-Year
Time	Depth
0:05	0.03
0:15	0.10
0:20	0.16
0:25	0.30
0:30	0.50
0:35	0.24
0:40	0.16
0:45	0.10
0:50	0.10
0:55	0.06
1:00	0.06
1:05	0.06
1:10	0.05
1:15	0.05
1:20	0.04
1:25	0.04
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.03
2:00	0.03
2:05	0.00

1Hr Depth	2.25 Inches
Return Period	50-Year
Time	Depth
0:05	0.03
0:15	0.11
0:20	0.18
0:25	0.34
0:30	0.56
0:35	0.27
0:40	0.18
0:45	0.11
0:50	0.11
0:55	0.07
1:00	0.07
1:05	0.07
1:10	0.05
1:15	0.05
1:20	0.04
1:25	0.04
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.03
2:00	0.03
2:05	0.00

1Hr Depth	2.57 Inches
Return Period	100-Year
Time	Depth
0:05	0.03
0:15	0.12
0:20	0.21
0:25	0.36
0:30	0.64
0:35	0.36
0:40	0.21
0:45	0.16
0:50	0.13
0:55	0.10
1:00	0.10
1:05	0.10
1:10	0.05
1:15	0.05
1:20	0.03
1:25	0.03
1:30	0.03
1:35	0.03
1:40	0.03
1:45	0.03
1:50	0.03
1:55	0.03
2:00	0.03
2:05	0.00

Table B-2 CUHP Input Parameters

Catchment Name	Area	Area	Distance to Centroid	Length	Slope	Future Percent Imperviousness	Future Depression Storage on Pervious	Future Depression Storage on Impervious	Initial Infiltration Rate	Horton's Decay Coefficient	Final Infiltration Rate	Ct	Cp
	acres	mi2	mi	mi	ft/ft	%	in	in	in/hr	1/seconds	in/hr	Override	Override
10	19	0.0295	0.0568	0.1610	0.0118	33	0.35	0.10	3.00	0.0018	0.50	0.30	0.10
20	15	0.0233	0.1326	0.2462	0.0123	64	0.35	0.10	3.00	0.0018	0.50	0.27	0.16
30	10	0.0159	0.1136	0.2462	0.0123	42	0.35	0.10	3.00	0.0018	0.50	0.34	0.11
40	32	0.0503	0.1231	0.3409	0.0078	86	0.35	0.10	3.00	0.0018	0.50	0.20	0.21
50	13	0.0200	0.1326	0.2652	0.0100	62	0.35	0.10	3.00	0.0018	0.50	0.29	0.16
60	81	0.1259	0.6250	0.8712	0.0135	63	0.35	0.10	3.00	0.0018	0.50	0.16	0.21
71	24	0.0376	0.2025	0.3648	0.0205	74	0.35	0.10	3.00	0.0018	0.50	0.22	0.19
72	36	0.0562	0.1901	0.4965	0.0122	34	0.35	0.10	3.00	0.0018	0.50	0.24	0.11
73	22	0.0345	0.1894	0.3542	0.0222	63	0.35	0.10	3.00	0.0018	0.50	0.24	0.17
80	34	0.0537	0.1420	0.2557	0.0341	5	0.35	0.10	3.00	0.0018	0.50	0.37	0.08
90	24	0.0382	0.1515	0.3314	0.0149	20	0.35	0.10	3.00	0.0018	0.50	0.32	0.08
95	11	0.0179	0.1932	0.2519	0.0105	76	0.35	0.10	3.00	0.0018	0.50	0.28	0.17
100	12	0.0186	0.1515	0.2557	0.0074	76	0.35	0.10	3.00	0.0018	0.50	0.28	0.17
110	42	0.0652	0.2936	0.5152	0.0059	55	0.35	0.10	3.00	0.0018	0.50	0.21	0.17
120	39	0.0605	0.1515	0.3977	0.0143	51	0.35	0.10	3.00	0.0018	0.50	0.22	0.16
130	10	0.0151	0.1799	0.3598	0.0063	41	0.35	0.10	3.00	0.0018	0.50	0.35	0.11
140	70	0.1096	0.2652	0.5492	0.0069	73	0.35	0.10	3.00	0.0018	0.50	0.16	0.22
150	48	0.0757	0.3030	0.5303	0.0150	63	0.35	0.10	3.00	0.0018	0.50	0.19	0.19
160	20	0.0306	0.1705	0.3598	0.0063	69	0.35	0.10	3.00	0.0018	0.50	0.24	0.18
170	39	0.0614	0.2367	0.4356	0.0052	78	0.35	0.10	3.00	0.0018	0.50	0.19	0.21
180	67	0.1041	0.2462	0.5398	0.0121	57	0.35	0.10	3.00	0.0018	0.50	0.18	0.19
190	10	0.0149	0.1326	0.2652	0.0230	50	0.35	0.10	3.00	0.0018	0.50	0.33	0.13
200	52	0.0815	0.2462	0.4924	0.0169	61	0.35	0.10	3.00	0.0018	0.50	0.19	0.20
210	22	0.0336	0.1894	0.3409	0.0100	50	0.35	0.10	3.00	0.0018	0.50	0.26	0.15
220	11	0.0168	0.1326	0.2462	0.0169	50	0.35	0.10	3.00	0.0018	0.50	0.32	0.14
230	29	0.0448	0.0568	0.2083	0.0127	50	0.35	0.10	3.00	0.0018	0.50	0.24	0.16
240	45	0.0705	0.2083	0.4545	0.0108	50	0.35	0.10	3.00	0.0018	0.50	0.21	0.17
250	30	0.0473	0.1420	0.2273	0.0250	49	0.35	0.10	3.00	0.0018	0.50	0.23	0.16
255	21	0.0334	0.1894	0.4451	0.0136	50	0.35	0.10	3.00	0.0018	0.50	0.26	0.16
260	21	0.0327	0.1705	0.3220	0.0259	50	0.35	0.10	3.00	0.0018	0.50	0.26	0.15
270	79	0.1234	0.3125	0.5303	0.0143	49	0.35	0.10	3.00	0.0018	0.50	0.17	0.19
280	47	0.0740	0.1515	0.3788	0.0120	68	0.35	0.10	3.00	0.0018	0.50	0.19	0.21
290	18	0.0280	0.1799	0.3030	0.0213	67	0.35	0.10	3.00	0.0018	0.50	0.25	0.18
300	45	0.0710	0.2083	0.4830	0.0212	69	0.35	0.10	3.00	0.0018	0.50	0.19	0.21
310	23	0.0362	0.2273	0.4640	0.0163	50	0.35	0.10	3.00	0.0018	0.50	0.25	0.16
320	78	0.1222	0.2367	0.6250	0.0139	50	0.35	0.10	3.00	0.0018	0.50	0.17	0.19
330	75	0.1179	0.3977	0.6061	0.0125	73	0.35	0.10	3.00	0.0018	0.50	0.16	0.23
340	58	0.0903	0.1326	0.3030	0.0150	23	0.35	0.10	3.00	0.0018	0.50	0.23	0.10
350	58	0.0913	0.2652	0.5966	0.0197	50	0.35	0.10	3.00	0.0018	0.50	0.19	0.18
360	58	0.0911	0.2083	0.6439	0.0200	50	0.35	0.10	3.00	0.0018	0.50	0.19	0.18
370	69	0.1074	0.2273	0.3977	0.0181	29	0.35	0.10	3.00	0.0018	0.50	0.21	0.11

Table B-2 CUHP Input Parameters

Catchment Name	Area	Area	Distance to Centroid	Length	Slope	Future Percent Imperviousness	Future Depression Storage on Pervious	Future Depression Storage on Impervious	Initial Infiltration Rate	Horton's Decay Coefficient	Final Infiltration Rate	Ct	Cp
	acres	mi2	mi	mi	ft/ft	%	in	in	in/hr	1/seconds	in/hr	Override	Override
380	56	0.0871	0.1705	0.4167	0.0145	21	0.35	0.10	3.00	0.0018	0.50	0.24	0.09
390	60	0.0939	0.2462	0.4545	0.0300	8	0.35	0.10	3.00	0.0018	0.50	0.29	0.09
400	128	0.2002	0.3788	0.6629	0.0154	26	0.35	0.10	3.00	0.0018	0.50	0.18	0.12
410	86	0.1348	0.3314	0.8144	0.0256	33	0.35	0.10	3.00	0.0018	0.50	0.19	0.31
420	79	0.1236	0.2273	0.4072	0.0251	23	0.35	0.10	3.00	0.0018	0.50	0.21	0.24
430	46	0.0720	0.0947	0.2746	0.0207	25	0.35	0.10	3.00	0.0018	0.50	0.24	0.10
440	104	0.1621	0.2178	1.0220	0.0163	34	0.35	0.10	3.00	0.0018	0.50	0.18	0.14
450	16	0.0246	0.2557	0.4924	0.0115	72	0.35	0.10	3.00	0.0018	0.50	0.26	0.18
460	10	0.0152	0.1326	0.2273	0.0117	50	0.35	0.10	3.00	0.0018	0.50	0.33	0.14
470	30	0.0464	0.2462	0.4830	0.0141	51	0.35	0.10	3.00	0.0018	0.50	0.23	0.17
480	38	0.0586	0.2652	0.4830	0.0173	51	0.35	0.10	3.00	0.0018	0.50	0.22	0.17
490	27	0.0427	0.2273	0.4811	0.0189	49	0.35	0.10	3.00	0.0018	0.50	0.24	0.16
500	38	0.0600	0.2311	0.4886	0.0124	50	0.35	0.10	3.00	0.0018	0.50	0.22	0.17
510	28	0.0441	0.1420	0.3220	0.0200	46	0.35	0.10	3.00	0.0018	0.50	0.24	0.36
520	47	0.0731	0.2462	0.4830	0.0149	51	0.35	0.10	3.00	0.0018	0.50	0.20	0.42
531	11	0.0170	0.1610	0.3047	0.0162	72	0.35	0.10	3.00	0.0018	0.50	0.29	0.41
532	24	0.0374	0.2593	0.0374	0.0162	50	0.35	0.10	3.00	0.0018	0.50	0.25	0.38
533	29	0.0460	0.1517	0.3570	0.0203	65	0.35	0.10	3.00	0.0018	0.50	0.22	0.46
540	68	0.1066	0.2746	0.5303	0.0071	53	0.35	0.10	3.00	0.0018	0.50	0.18	0.19
550	49	0.0766	0.3409	0.8144	0.0140	66	0.35	0.10	3.00	0.0018	0.50	0.19	0.21
560	59	0.0928	0.2652	0.4072	0.0233	52	0.35	0.10	3.00	0.0018	0.50	0.19	0.19
570	31	0.0485	0.1894	0.4640	0.0196	56	0.35	0.10	3.00	0.0018	0.50	0.22	0.42
580	40	0.0628	0.3125	0.5682	0.0133	65	0.35	0.10	3.00	0.0018	0.50	0.20	0.48
590	17	0.0269	0.1705	0.3314	0.0137	48	0.35	0.10	3.00	0.0018	0.50	0.28	0.34
600	45	0.0710	0.1227	0.2479	0.0138	50	0.35	0.10	3.00	0.0018	0.50	0.21	0.41
605	25	0.0390	0.2941	0.2896	0.0052	36	0.35	0.10	3.00	0.0018	0.50	0.27	0.28
610	22	0.0338	0.1894	0.3314	0.0069	50	0.35	0.10	3.00	0.0018	0.50	0.26	0.37
620	17	0.0270	0.2352	0.3655	0.0104	50	0.35	0.10	3.00	0.0018	0.50	0.28	0.36
625	49	0.0769	0.3335	0.5903	0.0077	50	0.35	0.10	3.00	0.0018	0.50	0.20	0.42
631	12	0.0195	0.0800	0.1580	0.0222	36	0.35	0.10	3.00	0.0018	0.50	0.33	0.25
632	36	0.0561	0.2448	0.4833	0.0124	48	0.35	0.10	3.00	0.0018	0.50	0.22	0.39
633	31	0.0488	0.1203	0.3275	0.0175	47	0.35	0.10	3.00	0.0018	0.50	0.23	0.38
640	25	0.0393	0.1799	0.3977	0.0114	61	0.35	0.10	3.00	0.0018	0.50	0.23	0.17
651	47	0.0742	0.2489	0.4590	0.0183	52	0.35	0.10	3.00	0.0018	0.50	0.20	0.43
652	17	0.0261	0.1395	0.2951	0.0325	50	0.35	0.10	3.00	0.0018	0.50	0.28	0.36
661	44	0.0692	0.2367	0.5036	0.0203	50	0.35	0.10	3.00	0.0018	0.50	0.21	0.41
662	39	0.0608	0.2075	0.5100	0.0213	50	0.35	0.10	3.00	0.0018	0.50	0.22	0.40
663	27	0.0423	0.1032	0.2894	0.0251	50	0.35	0.10	3.00	0.0018	0.50	0.24	0.38
670	59	0.0916	0.1042	0.2273	0.0333	12	0.35	0.10	3.00	0.0018	0.50	0.27	0.20
681	37	0.0574	0.2481	0.4413	0.0280	50	0.35	0.10	3.00	0.0018	0.50	0.22	0.40
682	27	0.0418	0.1932	0.4754	0.0140	43	0.35	0.10	3.00	0.0018	0.50	0.25	0.34

Table B-2 CUHP Input Parameters

Catchment Name	Area	Area	Distance to Centroid	Length	Slope	Future Percent Imperviousness	Future Depression Storage on Pervious	Future Depression Storage on Impervious	Initial Infiltration Rate	Horton's Decay Coefficient	Final Infiltration Rate	Ct	Cp
	acres	mi2	mi	mi	ft/ft	%	in	in	in/hr	1/seconds	in/hr	Override	Override
691	28	0.0432	0.1970	0.3796	0.0325	50	0.35	0.10	3.00	0.0018	0.50	0.24	0.38
692	40	0.0622	0.2574	0.5115	0.0316	48	0.35	0.10	3.00	0.0018	0.50	0.22	0.39
693	21	0.0329	0.1555	0.3208	0.0240	55	0.35	0.10	3.00	0.0018	0.50	0.25	0.39
694	16	0.0252	0.1229	0.2710	0.0306	46	0.35	0.10	3.00	0.0018	0.50	0.29	0.33
695	15	0.0241	0.1269	0.3617	0.0178	50	0.35	0.10	3.00	0.0018	0.50	0.29	0.35
700	19	0.0301	0.2083	0.3314	0.0217	63	0.35	0.10	3.00	0.0018	0.50	0.25	0.17
711	37	0.0580	0.2652	0.3542	0.0203	41	0.35	0.10	3.00	0.0018	0.50	0.23	0.14
712	40	0.0623	0.2215	0.4170	0.0183	81	0.35	0.10	3.00	0.0018	0.50	0.19	0.21
721	23	0.0355	0.1288	0.4394	0.0086	91	0.35	0.10	3.00	0.0018	0.50	0.21	0.20
722	32	0.0500	0.0966	0.4299	0.0088	71	0.35	0.10	3.00	0.0018	0.50	0.21	0.19
723	41	0.0646	0.2102	0.5455	0.0120	81	0.35	0.10	3.00	0.0018	0.50	0.18	0.21
724	35	0.0548	0.1761	0.4867	0.0130	67	0.35	0.10	3.00	0.0018	0.50	0.21	0.19
731	72	0.1118	0.3421	0.7347	0.0117	67	0.35	0.10	3.00	0.0018	0.50	0.16	0.21
732	30	0.0468	0.1149	0.3581	0.0190	50	0.35	0.10	3.00	0.0018	0.50	0.23	0.16
733	52	0.0819	0.2085	0.4251	0.0175	56	0.35	0.10	3.00	0.0018	0.50	0.19	0.18
741	25	0.0397	0.1910	0.3284	0.0173	62	0.35	0.10	3.00	0.0018	0.50	0.23	0.17
742	38	0.0590	0.1907	0.4059	0.0189	50	0.35	0.10	3.00	0.0018	0.50	0.22	0.16
743	36	0.0559	0.2112	0.4454	0.0185	50	0.35	0.10	3.00	0.0018	0.50	0.22	0.16
744	37	0.0579	0.2914	0.5248	0.0204	49	0.35	0.10	3.00	0.0018	0.50	0.22	0.16
751	28	0.0436	0.2471	0.4995	0.0199	49	0.35	0.10	3.00	0.0018	0.50	0.24	0.15
752	66	0.1030	0.3683	0.6552	0.0122	48	0.35	0.10	3.00	0.0018	0.50	0.19	0.17
760	20	0.0316	0.1402	0.2500	0.0167	7	0.35	0.10	3.00	0.0018	0.50	0.41	0.07
771	34	0.0528	0.1136	0.4167	0.0136	27	0.35	0.10	3.00	0.0018	0.50	0.26	0.09
772	54	0.0846	0.1559	0.4215	0.0397	48	0.35	0.10	3.00	0.0018	0.50	0.20	0.16
780	51	0.0799	0.1705	0.4167	0.0373	49	0.35	0.10	3.00	0.0018	0.50	0.20	0.17
790	59	0.0926	0.2652	0.6155	0.0197	49	0.35	0.10	3.00	0.0018	0.50	0.19	0.17
800	60	0.0931	0.3883	1.0130	0.0191	58	0.35	0.10	3.00	0.0018	0.50	0.18	0.19
810	66	0.1025	0.2557	0.5208	0.0204	50	0.35	0.10	3.00	0.0018	0.50	0.18	0.17
820	44	0.0688	0.1610	0.4299	0.0282	60	0.35	0.10	3.00	0.0018	0.50	0.20	0.19
821	18	0.0286	0.2311	0.3977	0.0152	76	0.35	0.10	3.00	0.0018	0.50	0.24	0.18
831	34	0.0526	0.1427	0.3617	0.0297	50	0.35	0.10	3.00	0.0018	0.50	0.23	0.16
832	42	0.0664	0.2123	0.5429	0.0317	49	0.35	0.10	3.00	0.0018	0.50	0.21	0.16
840	59	0.0915	0.2652	0.5019	0.0234	46	0.35	0.10	3.00	0.0018	0.50	0.19	0.16
860	78	0.1217	0.2273	0.5114	0.0104	60	0.35	0.10	3.00	0.0018	0.50	0.17	0.20
870	40	0.0623	0.0947	0.3636	0.0063	50	0.35	0.10	3.00	0.0018	0.50	0.22	0.16
871	25	0.0393	0.1799	0.3598	0.0153	50	0.35	0.10	3.00	0.0018	0.50	0.25	0.15
872	9	0.0138	0.1042	0.2367	0.0264	50	0.35	0.10	3.00	0.0018	0.50	0.34	0.13
880	94	0.1462	0.4735	0.7576	0.0170	51	0.35	0.10	3.00	0.0018	0.50	0.16	0.19
881	40	0.0623	0.5379	0.7112	0.0272	62	0.35	0.10	3.00	0.0018	0.50	0.20	0.19

Table B-3 Detention Pond Rating Curves

Harvard Gulch Park Design Point 1090		SKEEL RESERVOIR Design Point 671		Packy Romans Park Design Point 1330	
Discharge (cfs)	Storage (Ac-ft)	Discharge (cfs)	Storage (Ac-ft)	Discharge (cfs)	Storage (Ac-ft)
0	0.0	0	0	0	0
12	1.3	0	23.8	14.9	0.4
43	2.9	0	89.11	20.9	0.6
46	5.3	76.84	100.9	1438.4	2.8
48	8.9	293.68	117.93	-	-
654	13.6	614.75	136.27	-	-
1,797	19.5	-	-	-	-
3,329	26.2	-	-	-	-
*Rating curve of Harvard Gulch Park Pond at Harvard Gulch Park Golf Course was recalculated using the 2014 topography and as-built plans. See Technical Appendices for details of calculation.					

Table B-4 - Comparison of Calibrated Peak Flows

Calibration to 1979 FHAD Flows

Location	Harvard Gulch FHAD 1979					Harvard Gulch MDP 2015					Comparison			
	Design Points	Drainage Area	Peak Discharges (cfs)			Design Points	Drainage Area	Calibrated Peak Discharges (cfs)			(MDP 2015 minus FHAD 1979)/ FHAD 1979			
		(sq.mi.)	10-Year	50-Year	100-Year		(sq.mi.)	10-Year	50-Year	100-Year	Area	10-Year	50-Year	100-Year
Harvard Gulch														
Colorado Blvd	NA	1.9	1,340	1,750	1,900	Junct_1700	2.3	866	1,627	2,003	20%	-35%	-7%	**5.4%**
Race Street	NA	3.8	2,290	2,950	3,230	Junct_1570	3.9	1,302	2,567	3,188	3%	-43%	-13%	**-1.3%**
Downing Street	NA	4.3	2,530	3,300	3,600	Junct_1550	4.4	1,457	2,873	3,559	3%	-42%	-13%	**-1.1%**
Logan Street	NA	6.3	3,360	4,400	4,860	Junct_1080	6.6	1,995	3,905	4,894	4%	-41%	-11%	**0.7%**
S. Platte River	NA	7.7	3,600	4,800	5,350	Root_Junct_1150	6.9	2,068	3,999	5,030	-11%	-43%	-17%	**-6.0%**
Dry Creek														
Harvard Gulch	NA	1.8	900	1,200	1,332	Junct_1212	1.9	514	1,042	1,320	7%	-43%	-13%	**-0.9%**

Table B-5 Peak Discharges and Runoff Volumes (All Design Points)

Design Point		Drainage Area	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
Number	Type	(acres)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
JUNCT_10	JUNCTION	19	4	8	11	18	22	27	0.4	0.9	1.3	2.0	2.4	3.0
JUNCT_100	JUNCTION	12	5	7	9	13	15	18	0.7	1.1	1.3	1.8	2.1	2.4
JUNCT_1010	JUNCTION	252	58	124	156	266	325	390	6.5	14.3	19.1	30.8	38.2	47.4
JUNCT_1073	JUNCTION	36	4	9	11	19	23	30	0.8	1.7	2.2	3.5	4.3	5.3
JUNCT_110	JUNCTION	42	9	16	19	30	36	44	1.7	2.9	3.5	5.1	6.1	7.3
JUNCT_1110	JUNCTION	54	14	23	27	316	822	1520	2.4	3.9	4.8	15.8	43.3	97.1
JUNCT_1120	JUNCTION	119	60	69	74	91	99	111	10.2	13.4	14.8	17.4	19.0	20.8
JUNCT_1150	JUNCTION	4387	902	1676	2068	3250	3999	5030	146.6	265.5	333.4	493.9	589.1	716.5
JUNCT_120	JUNCTION	39	12	21	26	42	49	60	1.5	2.6	3.3	4.8	5.7	6.9
JUNCT_1212	JUNCTION	1234	233	410	514	858	1042	1320	36.8	71.2	90.1	137.2	164.8	201.5
JUNCT_130	JUNCTION	10	1	2	2	4	5	6	0.2	0.4	0.6	0.9	1.0	1.3
JUNCT_1385	JUNCTION	56	4	10	14	26	32	41	0.7	2.0	2.8	4.8	5.9	7.5
JUNCT_1390	JUNCTION	394	31	79	107	196	242	313	5.8	14.8	20.3	34.4	42.4	53.7
JUNCT_1400	JUNCTION	334	30	73	97	177	217	280	5.7	13.7	18.6	30.8	37.8	47.6
JUNCT_1430	JUNCTION	150	19	43	56	99	120	152	3.2	7.0	9.3	15.1	18.5	23.1
JUNCT_150	JUNCTION	48	17	27	32	50	59	71	2.3	3.8	4.7	6.6	7.8	9.3
JUNCT_1593	JUNCTION	58	32	57	69	105	125	149	2.4	4.1	5.1	7.4	8.7	10.5
JUNCT_160	JUNCTION	20	7	11	13	19	23	27	1.0	1.6	2.0	2.8	3.2	3.8
JUNCT_1675	JUNCTION	165	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
JUNCT_1686	JUNCTION	37	20	36	44	69	82	98	1.4	2.4	3.1	4.5	5.4	6.5
JUNCT_1692	JUNCTION	89	48	88	107	170	202	239	3.4	6.0	7.5	11.0	13.1	15.9
JUNCT_1694	JUNCTION	61	33	60	74	115	137	164	2.3	4.1	5.1	7.5	9.0	10.9
JUNCT_1696	JUNCTION	21	14	25	30	45	53	64	0.9	1.5	1.9	2.7	3.2	3.9
JUNCT_1733	JUNCTION	108	51	79	93	139	162	193	6.2	9.7	11.7	15.9	18.6	21.9
JUNCT_1735	JUNCTION	76	35	55	64	96	111	133	4.4	6.9	8.3	11.3	13.1	15.5
JUNCT_1737	JUNCTION	35	14	23	27	41	48	58	1.8	2.9	3.5	4.9	5.8	6.8
JUNCT_1743	JUNCTION	163	48	89	109	175	209	256	5.3	9.8	12.5	18.9	22.6	27.7
JUNCT_1762	JUNCTION	71	10	21	26	46	55	69	1.7	3.5	4.6	7.3	8.9	11.1
JUNCT_180	JUNCTION	67	22	38	45	72	84	102	2.9	4.9	6.1	8.7	10.3	12.3
JUNCT_190	JUNCTION	10	2	4	5	8	10	12	0.4	0.6	0.8	1.2	1.4	1.7
JUNCT_20	JUNCTION	15	6	10	11	17	20	25	0.7	1.2	1.5	2.0	2.4	2.9
JUNCT_200	JUNCTION	52	20	34	40	62	73	88	2.4	4.0	4.9	7.0	8.2	9.8
JUNCT_210	JUNCTION	22	5	9	11	17	21	25	0.8	1.4	1.8	2.6	3.1	3.8
JUNCT_220	JUNCTION	11	3	5	6	10	12	14	0.4	0.7	0.9	1.3	1.6	1.9
JUNCT_230	JUNCTION	29	14	25	30	48	57	68	1.1	1.9	2.4	3.5	4.2	5.1
JUNCT_240	JUNCTION	45	12	21	26	42	50	61	1.7	3.0	3.8	5.6	6.6	8.0
JUNCT_250	JUNCTION	30	11	21	26	41	48	58	1.1	2.0	2.5	3.7	4.4	5.4
JUNCT_255	JUNCTION	21	5	8	10	17	20	24	0.8	1.4	1.8	2.6	3.1	3.7
JUNCT_260	JUNCTION	21	6	11	13	21	25	31	0.8	1.4	1.7	2.6	3.1	3.7
JUNCT_270	JUNCTION	79	21	38	47	76	90	110	2.9	5.2	6.5	9.7	11.5	14.0
JUNCT_290	JUNCTION	18	8	13	15	22	26	31	0.9	1.5	1.8	2.5	3.0	3.5

Table B-5 Peak Discharges and Runoff Volumes (All Design Points)

Design Point		Drainage Area	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
Number	Type	(acres)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
JUNCT_30	JUNCTION	10	2	3	4	7	8	11	0.3	0.6	0.7	1.1	1.4	1.7
JUNCT_300	JUNCTION	45	23	36	43	64	75	89	2.4	3.9	4.7	6.5	7.6	8.9
JUNCT_320	JUNCTION	78	22	40	49	79	94	114	2.9	5.2	6.5	9.6	11.5	13.9
JUNCT_330	JUNCTION	75	33	52	60	91	106	126	4.3	6.7	8.1	11.1	12.9	15.2
JUNCT_340	JUNCTION	58	6	16	20	38	47	59	0.9	2.3	3.2	5.5	6.8	8.7
JUNCT_350	JUNCTION	58	15	28	34	55	66	80	2.2	3.9	4.9	7.2	8.6	10.4
JUNCT_360	JUNCTION	58	17	30	37	59	70	86	2.2	3.9	4.9	7.2	8.6	10.4
JUNCT_370	JUNCTION	69	8	19	25	45	54	69	1.4	3.1	4.2	6.9	8.4	10.6
JUNCT_390	JUNCTION	60	1	7	10	21	26	34	0.2	1.4	2.1	4.1	5.2	6.8
JUNCT_40	JUNCTION	32	22	33	38	54	62	72	2.2	3.3	3.9	5.1	5.9	6.9
JUNCT_400	JUNCTION	128	10	26	34	61	75	97	2.0	5.0	6.8	11.4	14.0	17.6
JUNCT_410	JUNCTION	86	21	46	58	100	120	149	2.0	4.4	5.8	9.2	11.2	14.0
JUNCT_420	JUNCTION	79	14	40	52	93	114	142	1.2	3.2	4.5	7.6	9.5	12.0
JUNCT_430	JUNCTION	46	6	16	20	37	46	57	0.8	2.0	2.7	4.5	5.6	7.1
JUNCT_440	JUNCTION	104	13	29	37	65	78	99	2.4	5.1	6.7	10.7	13.0	16.1
JUNCT_450	JUNCTION	16	5	7	9	13	15	18	0.8	1.3	1.6	2.2	2.6	3.0
JUNCT_470	JUNCTION	30	7	12	15	24	28	35	1.1	2.0	2.5	3.7	4.3	5.3
JUNCT_480	JUNCTION	38	9	17	20	33	39	48	1.4	2.5	3.1	4.6	5.5	6.7
JUNCT_490	JUNCTION	27	6	11	14	22	26	32	1.0	1.8	2.2	3.3	4.0	4.8
JUNCT_50	JUNCTION	13	4	7	8	13	15	19	0.6	1.0	1.2	1.7	2.0	2.4
JUNCT_510	JUNCTION	28	15	29	35	56	66	80	1.0	1.8	2.2	3.4	4.0	4.9
JUNCT_520	JUNCTION	47	24	44	53	83	98	119	1.8	3.1	3.9	5.8	6.9	8.4
JUNCT_531	JUNCTION	11	8	13	16	23	27	31	0.6	1.0	1.1	1.6	1.8	2.2
JUNCT_532	JUNCTION	24	21	39	47	70	83	101	0.9	1.6	2.0	2.9	3.5	4.2
JUNCT_533	JUNCTION	29	26	42	50	72	85	102	1.5	2.4	2.9	4.0	4.7	5.6
JUNCT_540	JUNCTION	68	18	32	39	62	74	90	2.7	4.7	5.8	8.6	10.2	12.3
JUNCT_550	JUNCTION	49	15	25	29	45	53	64	2.5	4.0	4.9	6.8	8.0	9.5
JUNCT_570	JUNCTION	31	20	34	41	62	74	88	1.3	2.3	2.8	4.0	4.8	5.7
JUNCT_580	JUNCTION	40	26	43	50	75	88	105	2.0	3.3	4.0	5.6	6.5	7.7
JUNCT_590	JUNCTION	17	7	14	17	26	31	38	0.6	1.1	1.4	2.1	2.5	3.0
JUNCT_60	JUNCTION	81	20	33	39	61	72	88	3.7	6.1	7.4	10.5	12.3	14.7
JUNCT_600	JUNCTION	45	34	62	77	118	141	167	1.7	3.0	3.8	5.6	6.7	8.1
JUNCT_631	JUNCTION	12	5	11	13	22	26	32	0.3	0.7	0.9	1.4	1.6	2.0
JUNCT_632	JUNCTION	36	15	28	34	55	65	79	1.3	2.3	2.9	4.3	5.2	6.3
JUNCT_633	JUNCTION	31	18	35	42	65	77	94	1.1	2.0	2.5	3.7	4.5	5.4
JUNCT_640	JUNCTION	25	8	14	16	25	30	36	1.2	1.9	2.4	3.4	4.0	4.7
JUNCT_651	JUNCTION	47	27	49	60	92	109	130	1.9	3.3	4.1	5.9	7.1	8.5
JUNCT_652	JUNCTION	17	10	18	22	34	40	48	0.6	1.1	1.4	2.1	2.5	3.0
JUNCT_661	JUNCTION	44	23	42	52	80	96	114	1.7	2.9	3.7	5.5	6.5	7.9
JUNCT_662	JUNCTION	39	20	38	46	71	85	102	1.5	2.6	3.2	4.8	5.7	6.9
JUNCT_663	JUNCTION	27	19	35	44	67	79	95	1.0	1.8	2.3	3.3	4.0	4.8

Table B-5 Peak Discharges and Runoff Volumes (All Design Points)

Design Point		Drainage Area	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
Number	Type	(acres)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
JUNCT_681	JUNCTION	28	20	36	44	69	82	98	1.4	2.4	3.1	4.5	5.4	6.5
JUNCT_682	JUNCTION	40	9	19	23	37	44	54	0.9	1.6	2.1	3.1	3.7	4.6
JUNCT_691	JUNCTION	21	16	29	35	55	65	79	1.0	1.8	2.3	3.4	4.1	4.9
JUNCT_692	JUNCTION	16	19	36	45	70	83	100	1.4	2.6	3.2	4.8	5.8	7.0
JUNCT_693	JUNCTION	15	14	25	30	45	53	64	0.9	1.5	1.9	2.7	3.2	3.9
JUNCT_694	JUNCTION	19	8	16	20	31	37	45	0.6	1.0	1.3	1.9	2.3	2.8
JUNCT_695	JUNCTION	37	8	14	17	27	32	38	0.6	1.0	1.3	1.9	2.3	2.7
JUNCT_700	JUNCTION	40	7	11	13	21	24	29	0.9	1.5	1.9	2.6	3.1	3.7
JUNCT_71	JUNCTION	24	12	18	21	31	37	43	1.4	2.2	2.6	3.6	4.1	4.9
JUNCT_711	JUNCTION	37	7	13	17	28	34	42	1.1	2.1	2.7	4.2	5.1	6.2
JUNCT_712	JUNCTION	40	24	36	41	60	70	83	2.5	3.9	4.6	6.2	7.1	8.3
JUNCT_72	JUNCTION	36	4	9	11	19	23	30	0.8	1.7	2.2	3.5	4.3	5.3
JUNCT_721	JUNCTION	23	14	20	23	33	37	44	1.6	2.4	2.8	3.7	4.3	5.0
JUNCT_722	JUNCTION	32	17	27	31	46	54	65	1.8	2.8	3.4	4.6	5.4	6.4
JUNCT_723	JUNCTION	41	21	32	37	54	63	74	2.6	4.0	4.7	6.4	7.4	8.6
JUNCT_724	JUNCTION	35	14	23	27	41	48	58	1.8	2.9	3.5	4.9	5.8	6.8
JUNCT_73	JUNCTION	22	8	14	16	25	29	35	1.1	1.7	2.1	3.0	3.5	4.2
JUNCT_731	JUNCTION	72	25	40	47	73	85	103	3.7	5.9	7.2	10.0	11.7	13.9
JUNCT_732	JUNCTION	30	10	18	22	35	41	50	1.1	2.0	2.5	3.7	4.4	5.3
JUNCT_733	JUNCTION	52	19	33	40	62	73	89	2.2	3.8	4.7	6.8	8.0	9.7
JUNCT_741	JUNCTION	25	9	16	19	29	34	41	1.2	2.0	2.4	3.4	4.0	4.8
JUNCT_742	JUNCTION	38	10	19	23	38	45	55	1.4	2.5	3.1	4.6	5.5	6.7
JUNCT_743	JUNCTION	36	9	17	20	33	39	47	1.3	2.4	3.0	4.4	5.2	6.4
JUNCT_744	JUNCTION	37	8	14	17	29	34	42	1.3	2.4	3.0	4.5	5.3	6.5
JUNCT_751	JUNCTION	28	6	11	13	21	25	31	1.0	1.8	2.3	3.3	4.0	4.8
JUNCT_752	JUNCTION	66	13	23	29	47	56	69	2.3	4.1	5.2	7.7	9.2	11.2
JUNCT_760	JUNCTION	74	20	38	47	75	90	110	2.0	3.9	5.1	7.9	9.5	11.8
JUNCT_769	JUNCTION	34	3	8	10	18	22	29	0.6	1.4	1.9	3.2	3.9	4.9
JUNCT_771	JUNCTION	34	3	8	10	18	22	29	0.6	1.4	1.9	3.2	3.9	4.9
JUNCT_772	JUNCTION	54	19	36	44	70	84	102	2.0	3.5	4.4	6.6	7.9	9.5
JUNCT_80	JUNCTION	34	1	5	7	14	18	24	0.1	0.8	1.2	2.5	3.2	4.2
JUNCT_820	JUNCTION	121	40	68	82	130	153	187	5.1	8.7	10.8	15.6	18.5	22.3
JUNCT_831	JUNCTION	59	12	21	25	41	48	59	1.3	2.2	2.8	4.2	5.0	6.0
JUNCT_832	JUNCTION	78	11	21	25	41	49	60	1.6	2.8	3.5	5.2	6.2	7.5
JUNCT_860	JUNCTION	78	30	50	60	93	109	132	3.5	5.9	7.3	10.3	12.2	14.6
JUNCT_870	JUNCTION	40	12	23	28	44	53	64	1.5	2.6	3.3	4.9	5.9	7.1
JUNCT_871	JUNCTION	25	6	11	14	22	27	33	0.9	1.7	2.1	3.1	3.7	4.5
JUNCT_872	JUNCTION	9	2	4	5	9	10	12	0.3	0.6	0.7	1.1	1.3	1.6
JUNCT_880	JUNCTION	94	21	37	45	74	88	108	3.5	6.2	7.8	11.4	13.6	16.5
JUNCT_90	JUNCTION	24	1	4	5	9	11	15	0.3	0.8	1.1	1.9	2.3	3.0
JUNCT_95	JUNCTION	11	5	7	8	12	14	17	0.7	1.0	1.2	1.7	2.0	2.3

Table B-5 Peak Discharges and Runoff Volumes (All Design Points)

Design Point		Drainage Area	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
Number	Type	(acres)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
JUNCT_1551	JUNCTION	0	0	0	0	303	801	1487	0.0	0.0	0.0	8.7	35.0	87.2
JUNCT_790	JUNCTION	382	108	192	234	368	436	534	15.0	26.3	32.7	48.2	57.2	68.9
ROOT_JUNCT_1010	OUTFALL	252	58	124	156	266	325	390	6.5	14.3	19.1	30.8	38.2	47.4
ROOT_JUNCT_1120	OUTFALL	119	60	69	74	91	99	111	10.2	13.4	14.8	17.4	19.0	20.8
ROOT_JUNCT_1150	OUTFALL	4387	902	1676	2068	3250	3999	5030	146.6	265.5	333.4	493.9	589.1	716.5
JUNCT_1020	DIVIDER	233	56	116	146	250	305	364	6.1	13.4	17.9	28.8	35.8	44.4
JUNCT_1030	DIVIDER	218	50	108	136	233	287	340	5.4	12.2	16.5	26.8	33.5	41.6
JUNCT_1060	DIVIDER	176	46	77	92	145	183	209	7.5	12.6	15.5	22.2	26.5	31.6
JUNCT_1061	DIVIDER/Split Flow	0	31	51	60	93	115	130	5.2	8.5	10.4	14.6	17.2	20.3
JUNCT_1065	DIVIDER	176	15	26	31	52	68	79	2.3	4.1	5.1	7.6	9.3	11.3
JUNCT_1070	DIVIDER	176	46	77	92	144	170	209	7.5	12.6	15.5	22.2	26.2	31.5
JUNCT_1077	DIVIDER	22	8	14	16	25	29	35	1.1	1.7	2.1	3.0	3.5	4.2
JUNCT_1080	DIVIDER	4213	860	1605	1995	3196	3905	4894	139.4	253.4	318.3	472.0	563.7	686.0
JUNCT_1091	DIVIDER	78	6	13	20	781	1284	2010	1.0	2.6	3.6	44.6	84.1	148.9
JUNCT_1095	DIVIDER	2857	650	1189	1469	1619	1637	1630	103.2	181.1	225.9	291.0	315.1	335.1
JUNCT_1130	DIVIDER	80	47	48	48	50	51	52	8.7	10.8	11.6	12.6	13.3	13.9
JUNCT_1140	DIVIDER/Split Flow	0	14	51	68	129	162	195	0.6	4.3	6.8	13.0	16.9	21.7
JUNCT_1160	DIVIDER	4338	890	1656	2046	3241	3968	5000	144.7	262.2	329.3	488.0	582.0	708.0
JUNCT_1180	DIVIDER	4280	874	1628	2025	3219	3933	4956	141.9	257.6	323.6	479.8	573.2	697.0
JUNCT_1190	DIVIDER	4179	861	1604	1992	3184	3898	4892	140.5	254.2	318.9	472.1	563.3	684.9
JUNCT_1200	DIVIDER	4169	860	1600	1986	3193	3892	4884	140.5	254.2	318.8	471.8	562.9	684.4
JUNCT_1210	DIVIDER	1182	219	380	486	817	989	1253	34.5	67.0	85.1	130.3	156.6	191.8
JUNCT_1230	DIVIDER	1150	213	369	472	796	961	1220	33.3	64.9	82.5	126.5	152.1	186.3
JUNCT_1250	DIVIDER	1076	192	343	439	741	896	1136	30.5	60.0	76.4	117.6	141.2	173.3
JUNCT_1260	DIVIDER	42	10	19	23	37	44	54	1.6	2.8	3.5	5.2	6.2	7.5
JUNCT_1270	DIVIDER	1004	175	316	403	684	825	1048	27.9	55.1	70.4	108.6	130.6	160.5
JUNCT_1290	DIVIDER	65	34	54	64	95	111	133	3.4	5.5	6.6	9.2	10.8	12.8
JUNCT_1292	DIVIDER	901	151	280	357	610	735	931	24.3	48.3	62.1	96.4	115.9	142.5
JUNCT_1294	DIVIDER	925	157	288	367	626	755	957	25.1	49.9	64.0	99.2	119.3	146.6
JUNCT_1300	DIVIDER	836	127	245	318	542	655	833	21.1	43.0	55.7	87.6	105.5	130.2
JUNCT_1320	DIVIDER	791	104	221	287	498	603	768	18.7	39.2	51.1	81.0	97.9	121.1
JUNCT_1331	DIVIDER	713	89	191	250	435	526	671	15.8	34.1	44.7	71.3	86.4	107.1
JUNCT_1360	DIVIDER	637	65	155	205	365	446	571	12.3	27.9	37.3	60.9	74.5	93.3
JUNCT_1370	DIVIDER	127	14	35	45	83	101	127	2.2	5.5	7.4	12.4	15.3	19.3
JUNCT_140	DIVIDER	70	60	97	114	175	208	241	9.1	14.7	17.8	24.8	29.1	34.3
JUNCT_1450	DIVIDER	2845	649	1185	1465	2085	2087	2091	103.1	180.8	225.5	322.5	358.7	389.6
JUNCT_1480	DIVIDER	2613	596	1089	1346	2204	2663	3300	93.8	164.7	205.5	302.1	359.2	435.3
JUNCT_1490	DIVIDER	2537	581	1061	1314	2151	2593	3214	91.1	160.0	199.5	293.2	348.6	422.3
JUNCT_1540	DIVIDER	128	38	68	83	132	160	188	5.0	8.8	11.0	16.0	19.1	23.2
JUNCT_1550	DIVIDER	2829	645	1178	1457	2375	2873	3559	102.4	179.7	224.2	329.3	391.4	474.2
JUNCT_1570	DIVIDER	2510	577	1052	1302	2134	2567	3188	90.2	158.3	197.5	290.1	344.8	417.7

Table B-5 Peak Discharges and Runoff Volumes (All Design Points)

Design Point		Drainage Area	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
Number	Type	(acres)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
JUNCT_1590	DIVIDER	2451	570	1039	1281	2101	2537	3190	88.7	155.4	193.8	284.4	337.9	408.5
JUNCT_1600	DIVIDER	137	50	94	114	177	205	245	4.9	8.8	11.1	16.7	19.9	24.2
JUNCT_1650	DIVIDER	2306	537	990	1216	1993	2405	3016	82.8	145.0	180.8	265.8	315.6	381.7
JUNCT_1660	DIVIDER	290	44	97	122	207	249	308	2.9	6.3	8.3	13.3	16.2	20.1
JUNCT_1662	DIVIDER	375	86	171	217	361	432	534	6.1	12.1	15.4	23.8	28.7	35.2
JUNCT_1671	DIVIDER	251	25	63	81	141	171	213	1.4	3.6	5.0	8.4	10.3	13.1
JUNCT_1680	DIVIDER	1713	458	834	1006	1617	1927	2388	69.2	118.9	147.9	215.4	255.4	307.9
JUNCT_1688	DIVIDER	104	55	101	124	193	228	275	4.0	7.0	8.8	13.0	15.5	18.7
JUNCT_1690	DIVIDER	1614	442	795	957	1530	1817	2242	65.7	112.6	139.8	203.8	241.3	290.6
JUNCT_170	DIVIDER	39	17	26	30	44	51	61	2.4	3.7	4.4	5.9	6.9	8.1
JUNCT_1700	DIVIDER	1462	403	716	866	1374	1627	2003	60.5	103.1	127.9	185.8	219.9	264.6
JUNCT_1702	DIVIDER	1510	414	738	887	1414	1677	2068	62.0	105.9	131.4	191.2	226.2	272.7
JUNCT_1730	DIVIDER	1418	390	694	839	1332	1577	1941	58.5	99.8	123.8	179.9	213.0	256.3
JUNCT_1740	DIVIDER	1104	284	516	628	1014	1202	1482	42.8	74.3	93.0	136.7	162.4	196.3
JUNCT_1752	DIVIDER	916	234	424	517	826	979	1207	36.2	62.6	78.1	114.4	135.9	163.9
JUNCT_1754	DIVIDER	850	220	394	481	765	906	1118	33.6	58.2	72.6	106.4	126.3	152.3
JUNCT_1756	DIVIDER	431	213	380	463	737	873	1077	32.2	55.8	69.5	101.9	120.9	145.8
JUNCT_1757	DIVIDER	351	190	342	416	663	785	967	29.0	50.2	62.5	91.7	108.9	131.3
JUNCT_1822	DIVIDER	155	51	89	107	169	199	243	6.4	11.0	13.6	19.8	23.5	28.3
JUNCT_280	DIVIDER	47	26	42	49	73	85	102	2.5	4.0	4.8	6.7	7.8	9.3
JUNCT_310	DIVIDER	23	5	9	11	18	21	26	0.9	1.5	1.9	2.8	3.3	4.0
JUNCT_347	DIVIDER	167	41	74	90	147	174	213	6.3	11.1	13.9	20.5	24.4	29.6
JUNCT_349	DIVIDER	285	77	136	164	263	311	375	11.6	20.0	24.8	36.1	42.7	51.5
JUNCT_380	DIVIDER	56	4	11	14	27	33	43	0.7	2.0	2.8	4.8	6.0	7.6
JUNCT_460	DIVIDER	10	2	4	5	8	10	12	0.4	0.6	0.8	1.2	1.4	1.7
JUNCT_500	DIVIDER	38	9	17	20	33	39	48	1.4	2.5	3.2	4.7	5.6	6.8
JUNCT_560	DIVIDER	59	21	37	45	71	84	101	2.4	4.1	5.1	7.5	8.9	10.7
JUNCT_605	DIVIDER	74	24	46	56	90	107	132	2.5	4.6	5.9	8.9	10.6	12.9
JUNCT_610	DIVIDER	159	59	110	134	211	244	288	5.7	10.3	13.0	19.4	23.2	28.2
JUNCT_620	DIVIDER	17	7	12	15	23	28	33	0.6	1.2	1.4	2.1	2.5	3.1
JUNCT_625	DIVIDER	49	19	35	43	68	81	98	1.9	3.3	4.1	6.1	7.2	8.8
JUNCT_670	DIVIDER	224	7	31	42	80	99	124	0.4	1.8	2.7	5.0	6.4	8.3
JUNCT_770	DIVIDER	54	19	36	44	70	84	102	2.0	3.5	4.4	6.6	7.9	9.5
JUNCT_780	DIVIDER	51	18	33	40	64	76	93	1.9	3.4	4.2	6.3	7.5	9.1
JUNCT_800	DIVIDER	322	94	165	203	318	376	459	12.9	22.4	27.9	40.9	48.6	58.4
JUNCT_810	DIVIDER	66	19	34	41	67	79	97	2.5	4.4	5.5	8.1	9.6	11.7
JUNCT_821	DIVIDER	18	7	11	13	19	23	27	1.1	1.7	2.0	2.7	3.2	3.7
JUNCT_830	DIVIDER	197	62	109	132	209	247	302	7.9	13.8	17.2	25.2	29.8	35.8
JUNCT_840	DIVIDER	59	14	26	32	53	64	78	2.0	3.7	4.6	7.0	8.3	10.2
JUNCT_881	DIVIDER	40	10	16	19	30	36	44	1.8	3.0	3.6	5.2	6.1	7.3
JUNCT_1075	DIVIDER	82	22	38	46	72	85	103	3.2	5.6	6.9	10.0	11.9	14.3

Table B-5 Peak Discharges and Runoff Volumes (All Design Points)

Design Point		Drainage Area	Future Conditions Peak Flow (cfs)						Future Conditions Runoff Volume (acre-feet)					
Number	Type	(acres)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	V_2	V_5	V_{10}	V_{25}	V_{50}	V_{100}
JUNCT_1148	DIVIDER	70	46	46	46	46	46	46	8.5	10.3	11.0	11.8	12.2	12.6
JUNCT_1040	DIVIDER	208	34	53	63	98	118	138	4.5	7.3	9.0	12.7	15.1	18.2
JUNCT_1141	DIVIDER/Split Flow	0	14	51	69	128	162	195	0.6	4.3	6.8	13.0	17.0	21.8
JUNCT_1451	DIVIDER/Split Flow	0	649	1185	1465	1600	1600	1600	103.1	180.8	225.5	290.3	314.3	334.1
JUNCT_671	STORAGE	165	35	86	110	192	233	288	3.3	7.6	10.2	16.9	20.7	26.0
JUNCT_1090	STORAGE	78	15	26	32	805	1308	2019	2.6	4.7	5.9	49.8	90.0	155.6
JUNCT_1330	STORAGE	713	89	192	251	434	528	673	16.4	34.5	45.3	71.8	86.9	107.7

EPA SWMM 5.0 Input Parameters

```
[TITLE]
Harvard Gulch Major Drainageway Plan and Flood Hazard Area Delineation
Matrix Design Group, Inc., February 2015
Based on CUHP/UDSWM 2000 model from 2014 Denver SDMP Update by Olsson Assoicates
DENVER STORMWATER MASTERPLAN, BASIN 5200-01 5200-02 5200-03
2-, 5-, & 100 YEAR, MATRIX DESIGN GROUP, INC. October 2008

[OPTIONS]
FLOW_UNITS           CFS
INFILTRATION         HORTON
FLOW_ROUTING         KINWAVE
START_DATE           01/01/2005
START_TIME           00:00:00
REPORT_START_DATE    01/01/2005
REPORT_START_TIME    00:00:00
END_DATE             01/01/2005
END_TIME             04:10:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:05:00
WET_STEP             00:05:00
DRY_STEP             00:05:00
ROUTING_STEP         0:05:00
ALLOW_PONDING        NO
INERTIAL_DAMPING     PARTIAL
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
NORMAL_FLOW_LIMITED  BOTH
SKIP_STEADY_STATE    NO
FORCE_MAIN_EQUATION  H-W
LINK_OFFSETS         DEPTH
MIN_SLOPE            0

[FILES]
USE INFLOWS "R:\15.155.023 (Harvard Gulch MDP FHAD)\Hydrology\CUHP-SWMM\2015_Calibration_FHAD
Flow\SWMM\Input Hydrographs\Harvard_Calibrated_CUHP_Output_FU.txt"

[EVAPORATION]
;;Type       Parameters
;;---------- ----------
CONSTANT     0.0
DRY_ONLY     NO

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
JUNCT_10         5240.1     0          0          0          0
JUNCT_100        5304.99    0          0          0          0
JUNCT_1010       5240.05    0          0          0          0
JUNCT_1073       5289.121   0          0          0          0
JUNCT_110        5304.99    0          0          0          0
JUNCT_1110       5304.987   0          0          0          0
JUNCT_1120       5242.05    0          0          0          0
JUNCT_1150       5246.05    0          0          0          0
JUNCT_120        5242.1     0          0          0          0
JUNCT_1212       5294.45    0          0          0          0
JUNCT_130        5260.78    0          0          0          0
JUNCT_1385       5437.816   0          0          0          0
JUNCT_1390       5416.236   0          0          0          0
JUNCT_1400       5431.216   0          0          0          0
JUNCT_1430       5480.716   0          0          0          0
JUNCT_150        5246.1     0          0          0          0
JUNCT_1593       5368.245   0          0          0          0
JUNCT_160        5268.36    0          0          0          0
JUNCT_1675       5458.045   0          0          0          0
JUNCT_1686       5370.045   0          0          0          0
JUNCT_1692       5384.65    0          0          0          0
JUNCT_1694       5390.65    0          0          0          0
JUNCT_1696       5397.65    0          0          0          0
JUNCT_1733       5403.535   0          0          0          0
JUNCT_1735       5407.815   0          0          0          0
JUNCT_1737       5411.535   0          0          0          0
JUNCT_1743       5427.352   0          0          0          0
JUNCT_1762       5442.635   0          0          0          0
JUNCT_180        5276.34    0          0          0          0
JUNCT_190        5292.4     0          0          0          0
JUNCT_20         5243.94    0          0          0          0
JUNCT_200        5294.44    0          0          0          0
JUNCT_210        5319.11    0          0          0          0
JUNCT_220        5319.11    0          0          0          0
JUNCT_230        5320.99    0          0          0          0
JUNCT_240        5333.343   0          0          0          0
JUNCT_250        5328.5     0          0          0          0
JUNCT_255        5372.13    0          0          0          0
JUNCT_260        5336.58    0          0          0          0
JUNCT_270        5334.53    0          0          0          0
JUNCT_290        5361.96    0          0          0          0
JUNCT_30         5247.79    0          0          0          0
JUNCT_300        5348.7     0          0          0          0
JUNCT_320        5373.3     0          0          0          0
JUNCT_330        5386.33    0          0          0          0
JUNCT_340        5424.7     0          0          0          0
JUNCT_350        5399.35    0          0          0          0
JUNCT_360        5399.35    0          0          0          0
JUNCT_370        5424.7     0          0          0          0
JUNCT_390        5416.24    0          0          0          0
JUNCT_40         5248.83    0          0          0          0
JUNCT_400        5431.22    0          0          0          0
JUNCT_410        5458.05    0          0          0          0
JUNCT_420        5458.05    0          0          0          0
JUNCT_430        5480.72    0          0          0          0
JUNCT_440        5498.86    0          0          0          0
JUNCT_450        5308.3     0          0          0          0
JUNCT_470        5312.4     0          0          0          0
JUNCT_480        5320.2     0          0          0          0
JUNCT_490        5326.1     0          0          0          0
JUNCT_50         5258.62    0          0          0          0
JUNCT_510        5331.85    0          0          0          0
JUNCT_520        5368.25    0          0          0          0
JUNCT_531        5368.25    0          0          0          0
JUNCT_532        5371.51    0          0          0          0
JUNCT_533        5344.25    0          0          0          0
JUNCT_540        5316.29    0          0          0          0
JUNCT_550        5312.4     0          0          0          0
JUNCT_570        5331.85    0          0          0          0
JUNCT_580        5344.25    0          0          0          0
JUNCT_590        5344.25    0          0          0          0
JUNCT_60         5258.62    0          0          0          0
JUNCT_600        5357.38    0          0          0          0
JUNCT_631        5350.45    0          0          0          0
JUNCT_632        5363.05    0          0          0          0
JUNCT_633        5372.65    0          0          0          0
JUNCT_640        5380.35    0          0          0          0
JUNCT_651        5350.45    0          0          0          0
JUNCT_652        5371.55    0          0          0          0
JUNCT_661        5371.55    0          0          0          0
JUNCT_662        5387.65    0          0          0          0
JUNCT_663        5407.37    0          0          0          0
JUNCT_681        5370.05    0          0          0          0
JUNCT_682        5363.05    0          0          0          0
JUNCT_691        5384.7     0          0          0          0
JUNCT_692        5390.7     0          0          0          0
JUNCT_693        5397.7     0          0          0          0
JUNCT_694        5372.65    0          0          0          0
JUNCT_695        5372.7     0          0          0          0
JUNCT_700        5380.35    0          0          0          0
JUNCT_71         5261.2     0          0          0          0
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JUNCT_711        5442.65    0          0          0          0
JUNCT_712        5396.1     0          0          0          0
JUNCT_72         5289.15    0          0          0          0
JUNCT_721        5396.1     0          0          0          0
JUNCT_722        5403.55    0          0          0          0
JUNCT_723        5407.85    0          0          0          0
JUNCT_724        5411.55    0          0          0          0
JUNCT_73         5264.15    0          0          0          0
JUNCT_731        5396.1     0          0          0          0
JUNCT_732        5411.76    0          0          0          0
JUNCT_733        5420.65    0          0          0          0
JUNCT_741        5404.2     0          0          0          0
JUNCT_742        5427.4     0          0          0          0
JUNCT_743        5411.8     0          0          0          0
JUNCT_744        5419.2     0          0          0          0
JUNCT_751        5420.65    0          0          0          0
JUNCT_752        5430.55    0          0          0          0
JUNCT_760        5448.592   0          0          0          0
JUNCT_769        5479.51    0          0          0          0
JUNCT_771        5479.55    0          0          0          0
JUNCT_772        5462.1     0          0          0          0
JUNCT_80         5290.34    0          0          0          0
JUNCT_820        5511.241   0          0          0          0
JUNCT_831        5484.85    0          0          0          0
JUNCT_832        5464.35    0          0          0          0
JUNCT_860        5438.15    0          0          0          0
JUNCT_870        5450.75    0          0          0          0
JUNCT_871        5450.75    0          0          0          0
JUNCT_872        5450.75    0          0          0          0
JUNCT_880        5450.75    0          0          0          0
JUNCT_90         5300.79    0          0          0          0
JUNCT_95         5306.28    0          0          0          0

[OUTFALLS]
;;               Invert     Outfall    Stage/Table      Tide
;;Name           Elev.      Type       Time Series      Gate
;;-------------- ---------- ---------- ---------------- ----
;The names are derived from the swmm element IDs with ROOT_JUNCT_ appended to the front.
ROOT_JUNCT_1010  5240       NORMAL                      NO
ROOT_JUNCT_1120  5242       NORMAL                      NO
ROOT_JUNCT_1150  5246       NORMAL                      NO

[DIVIDERS]
;;               Invert     Diverted         Divider
;;Name           Elev.      Link             Type       Parameters
;;-------------- ---------- ---------------- ---------- ----------
JUNCT_1020       5243.933   1021-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1030       5247.78    1031-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1060       5257.05    1060-DIV         TABULAR    DIVCURVE_1060    0          0          0
0
JUNCT_1061       5278.449   1061-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1065       5257.043   1065-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1070       5258.609   1071-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1077       5264.143   1076-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1080       5290.335   1081-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1091       5300.781   1091-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1095       5306.27    1096-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1130       5260.774   1131-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1140       5253.546   1140-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1160       5268.355   1161-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1180       5276.335   1181-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1190       5292.39    1191-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1200       5294.43    1201-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1210       5319.102   1211-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1230       5320.983   1231-OVERFLOW    OVERFLOW   0          0          0          0
;The names are derived from the swmm element IDs
JUNCT_1250       5328.495   1251-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1260       5336.571   1261-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1270       5334.525   1271-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1290       5361.951   1291-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1292       5344.365   1293-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1294       5342.205   1295-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1300       5348.67    1301-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1320       5373.24    1321-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1331       5386.32    1331-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1360       5399.346   1361-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1370       5424.69    1371-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_140        5266.35    140-DIV          TABULAR    DIVCURVE_140     0          0          0
0
JUNCT_1450       5308.25    1451-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1480       5320.13    1481-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1490       5326.07    1491-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1540       5316.284   1541-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1550       5312.33    1551-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1570       5331.845   1571-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1590       5344.245   1591-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1600       5357.375   1602-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1650       5350.445   1651-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1660       5387.625   1663-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1662       5371.505   1661-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1671       5407.365   1670-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1680       5363.045   1681-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1688       5372.61    1687-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1690       5368.77    1691-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_170        5271.68    1170-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1700       5380.345   1703-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1702       5372.645   1701-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1730       5396.095   1731-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1740       5404.151   1741-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1752       5411.751   1751-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1754       5419.111   1753-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1756       5420.631   1755-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1757       5430.521   1349-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1822       5484.841   1821-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_280        5363.359   1280-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_310        5361.539   1310-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_347        5450.711   348-OVERFLOW     OVERFLOW   0          0          0          0
JUNCT_349        5438.111   1758-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_380        5440.572   1380-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_460        5331.83    1460-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_500        5349.476   1500-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_560        5332.195   1560-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_605        5366.53    1601-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_610        5352.825   1610-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_620        5371.727   1620-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_625        5372.26    1625-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_670        5422.345   1672-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_770        5462.092   1770-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_780        5468.751   1780-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_790        5456.621   1790-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_800        5461.471   1800-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_810        5526.172   1810-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_821        5542.261   1820-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_830        5464.321   1830-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_840        5532.597   1841-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_881        5450.961   1881-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1075       5261.121   1074-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1148       5266.341   1148-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1040       5248.828   1041-OVERFLOW    OVERFLOW   0          0          0          0
JUNCT_1141       5250.558   1142-OVERFLOW    OVERFLOW   0          0          0          0

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                    Ponded   Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                   Area     Frac.
Infiltration Parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -------- ----
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;Because SWMM uses Stage-Area and Stage-Discharge, a sythetic
;rectangular basin has been generated to substitute for the
;volume of the system. The artificial pond is a rectangular
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;prism with a cross-section of 1 acre. This creates a pond such
;that every 1 foot of stage equals 1 acre foot of volume. This
;is particularlly handy in the sense that it allows us to equate
;volume directly to stage. Also, the rectangular shape allows for
;the proper use of linier interpolation on the pond stage (and
;consequently volume), and as such, the results should reasonably
;mimic those of UDSWMM. Please note that CUHP objects will not
;appear on the map, as it is impossible to determine their placement.
JUNCT_671        5458.046 13627    0        FUNCTIONAL 0        0        43560    0        0
JUNCT_1090       5300.782 2080     0        FUNCTIONAL 0        0        43560    0        0
JUNCT_1330       5386.321 280      0        FUNCTIONAL 0        0        43560    0        0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.
Max.
;;Name           Node             Node             Length     N          Offset     Offset     Flow
Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------
- ----------
10               JUNCT_10         JUNCT_1010       1          .01        0          0          0
0
100              JUNCT_100        JUNCT_1110       1          .01        0          0          0
0
1010             JUNCT_1010       ROOT_JUNCT_1010  1          .01        0          0          0
0
1021             JUNCT_1020       JUNCT_1010       715        0.019      0          0          0
0
1021-OVERFLOW    JUNCT_1020       JUNCT_1010       715        0.02       0          0          0
0
1031             JUNCT_1030       JUNCT_1020       675        0.019      0          0          0
0
1031-OVERFLOW    JUNCT_1030       JUNCT_1020       675        0.02       0          0          0
0
110              JUNCT_110        JUNCT_1110       1          .01        0          0          0
0
1041             JUNCT_1040       JUNCT_1030       262        0.019      0          0          0
0
1041-OVERFLOW    JUNCT_1040       JUNCT_1030       262        0.02       0          0          0
0
1060             JUNCT_1060       JUNCT_1065       1          0.01       0          0          0
0
1060-DIV         JUNCT_1060       JUNCT_1061       1          0.01       21         0          0
0
1061             JUNCT_1061       JUNCT_140        1009       0.019      0          0          0
0
1061-OVERFLOW    JUNCT_1061       JUNCT_140        1009       0.02       0          0          0
0
1065             JUNCT_1065       JUNCT_1040       1643       0.019      0          0          0
0
1065-OVERFLOW    JUNCT_1065       JUNCT_1040       1643       0.02       0          0          0
0
1071             JUNCT_1070       JUNCT_1060       348        0.019      0          0          0
0
1071-OVERFLOW    JUNCT_1070       JUNCT_1060       348        0.02       0          0          0
0
1072             JUNCT_1073       JUNCT_1075       2000       0.019      0          0          0
0
1074             JUNCT_1075       JUNCT_1070       628        0.019      0          0          0
0
1074-OVERFLOW    JUNCT_1075       JUNCT_1070       628        0.02       0          0          0
0
1076             JUNCT_1077       JUNCT_1075       657        0.019      0          0          0
0
1076-OVERFLOW    JUNCT_1077       JUNCT_1075       657        0.02       0          0          0
0
1081             JUNCT_1080       JUNCT_1180       1400       0.02       0          0          0
0
1081-OVERFLOW    JUNCT_1080       JUNCT_1180       1400       0.052      0          0          0
0
1091             JUNCT_1091       JUNCT_1200       438        0.019      0          0          0
0
1091-OVERFLOW    JUNCT_1091       JUNCT_1200       438        0.052      0          0          0
0
1096             JUNCT_1095       JUNCT_1200       740        0.052      0          0          0
0
1096-OVERFLOW    JUNCT_1095       JUNCT_1200       740        0.052      0          0          0
0
1111             JUNCT_1110       JUNCT_1090       841        0.02       0          0          0
0
1120             JUNCT_1120       ROOT_JUNCT_1120  1          .01        0          0          0
0
1131             JUNCT_1130       JUNCT_1120       1043       0.019      0          0          0
0
1131-OVERFLOW    JUNCT_1130       JUNCT_1120       1043       0.02       0          0          0
0
1140             JUNCT_1140       JUNCT_1141       498        0.019      0          0          0
0
1140-OVERFLOW    JUNCT_1140       JUNCT_1141       498        0.02       0          0          0
0
1142             JUNCT_1141       JUNCT_1030       448        0.019      0          0          0
0
1142-OVERFLOW    JUNCT_1141       JUNCT_1030       448        0.02       0          0          0
0
1148             JUNCT_1148       JUNCT_1130       293        0.019      0          0          0
0
1148-OVERFLOW    JUNCT_1148       JUNCT_1130       293        0.02       0          0          0
0
1150             JUNCT_1150       ROOT_JUNCT_1150  1          .01        0          0          0
0
1161             JUNCT_1160       JUNCT_1150       1315       0.02       0          0          0
0
1161-OVERFLOW    JUNCT_1160       JUNCT_1150       1315       0.052      0          0          0
0
1170             JUNCT_170        JUNCT_1160       665        0.019      0          0          0
0
1170-OVERFLOW    JUNCT_170        JUNCT_1160       665        0.02       0          0          0
0
1181             JUNCT_1180       JUNCT_1160       1330       0.02       0          0          0
0
1181-OVERFLOW    JUNCT_1180       JUNCT_1160       1330       0.052      0          0          0
0
1191             JUNCT_1190       JUNCT_1080       685        0.052      0          0          0
0
1191-OVERFLOW    JUNCT_1190       JUNCT_1080       685        0.052      0          0          0
0
20               JUNCT_20         JUNCT_1020       1          .01        0          0          0
0
30               JUNCT_30         JUNCT_1030       1          .01        0          0          0
0
40               JUNCT_40         JUNCT_1040       1          .01        0          0          0
0
50               JUNCT_50         JUNCT_1070       1          .01        0          0          0
0
60               JUNCT_60         JUNCT_1070       1          .01        0          0          0
0
71               JUNCT_71         JUNCT_1075       1          .01        0          0          0
0
72               JUNCT_72         JUNCT_1073       1          0.01       0          0          0
0
73               JUNCT_73         JUNCT_1077       1          0.01       0          0          0
0
80               JUNCT_80         JUNCT_1080       1          .01        0          0          0
0
90               JUNCT_90         JUNCT_1090       1          .01        0          0          0
0
95               JUNCT_95         JUNCT_1095       1          .01        0          0          0
0
120              JUNCT_120        JUNCT_1120       1          .01        0          0          0
0
```

1201-OVERFLOW	JUNCT_1200	JUNCT_1190	340	0.052	0	0	0	420	JUNCT_420	JUNCT_671	1	.01	0	0	0	0
1211-OVERFLOW	JUNCT_1210	JUNCT_1212	1542	0.02	0	0	0	430	JUNCT_430	JUNCT_1430	1	.01	0	0	0	0
1231-OVERFLOW	JUNCT_1230	JUNCT_1210	627	0.02	0	0	0	450	JUNCT_450	JUNCT_1450	1	.01	0	0	0	0
1251-OVERFLOW	JUNCT_1250	JUNCT_1230	1252	0.02	0	0	0	470	JUNCT_470	JUNCT_1550	1	.01	0	0	0	0
1261-OVERFLOW	JUNCT_1260	JUNCT_1250	1346	0.02	0	0	0	480	JUNCT_480	JUNCT_1480	1	.01	0	0	0	0
1271-OVERFLOW	JUNCT_1270	JUNCT_1250	670	0.02	0	0	0	490	JUNCT_490	JUNCT_1490	1	.01	0	0	0	0
1280-OVERFLOW	JUNCT_280	JUNCT_1290	352	0.02	0	0	0	510	JUNCT_510	JUNCT_1570	1	.01	0	0	0	0
1291-OVERFLOW	JUNCT_1290	JUNCT_1292	977	0.02	0	0	0	520	JUNCT_520	JUNCT_1593	1	.01	0	0	0	0
1293-OVERFLOW	JUNCT_1292	JUNCT_1294	360	0.02	0	0	0	531	JUNCT_531	JUNCT_1593	1	.01	0	0	0	0
1295-OVERFLOW	JUNCT_1294	JUNCT_1270	1536	0.02	0	0	0	532	JUNCT_532	JUNCT_1662	1	.01	0	0	0	0
130	JUNCT_130	JUNCT_1130	1	.01	0	0	0	533	JUNCT_533	JUNCT_1590	1	.01	0	0	0	0
140	JUNCT_140	JUNCT_1148	1	0.01	0	0	0	540	JUNCT_540	JUNCT_1540	1	.01	0	0	0	0
150	JUNCT_150	JUNCT_1150	1	.01	0	0	0	550	JUNCT_550	JUNCT_1550	1	.01	0	0	0	0
160	JUNCT_160	JUNCT_1160	1	.01	0	0	0	570	JUNCT_570	JUNCT_1570	1	.01	0	0	0	0
180	JUNCT_180	JUNCT_1180	1	.01	0	0	0	580	JUNCT_580	JUNCT_1590	1	.01	0	0	0	0
190	JUNCT_190	JUNCT_1190	1	.01	0	0	0	590	JUNCT_590	JUNCT_1590	1	.01	0	0	0	0
200	JUNCT_200	JUNCT_1212	1	.01	0	0	0	600	JUNCT_600	JUNCT_1600	1	.01	0	0	0	0
210	JUNCT_210	JUNCT_1210	1	.01	0	0	0	631	JUNCT_631	JUNCT_1650	1	.01	0	0	0	0
220	JUNCT_220	JUNCT_1210	1	.01	0	0	0	632	JUNCT_632	JUNCT_1680	1	.01	0	0	0	0
230	JUNCT_230	JUNCT_1230	1	.01	0	0	0	633	JUNCT_633	JUNCT_1702	1	.01	0	0	0	0
250	JUNCT_250	JUNCT_1250	1	.01	0	0	0	640	JUNCT_640	JUNCT_1700	1	.01	0	0	0	0
260	JUNCT_260	JUNCT_1260	1	.01	0	0	0	651	JUNCT_651	JUNCT_1650	1	.01	0	0	0	0
270	JUNCT_270	JUNCT_1270	1	.01	0	0	0	652	JUNCT_652	JUNCT_1662	1	.01	0	0	0	0
290	JUNCT_290	JUNCT_1290	1	.01	0	0	0	661	JUNCT_661	JUNCT_1662	1	.01	0	0	0	0
300	JUNCT_300	JUNCT_1300	1	.01	0	0	0	662	JUNCT_662	JUNCT_1660	1	.01	0	0	0	0
320	JUNCT_320	JUNCT_1320	1	.01	0	0	0	663	JUNCT_663	JUNCT_1671	1	.01	0	0	0	0
330	JUNCT_330	JUNCT_1330	1	.01	0	0	0	681	JUNCT_681	JUNCT_1686	1	.01	0	0	0	0
340	JUNCT_340	JUNCT_1370	1	.01	0	0	0	682	JUNCT_682	JUNCT_1680	1	.01	0	0	0	0
348	JUNCT_347	JUNCT_349	840	0.019	0	0	0	691	JUNCT_691	JUNCT_1692	1	.01	0	0	0	0
350	JUNCT_350	JUNCT_1360	1	.01	0	0	0	692	JUNCT_692	JUNCT_1694	1	.01	0	0	0	0
360	JUNCT_360	JUNCT_1360	1	.01	0	0	0	693	JUNCT_693	JUNCT_1696	1	.01	0	0	0	0
370	JUNCT_370	JUNCT_1370	1	.01	0	0	0	694	JUNCT_694	JUNCT_1702	1	.01	0	0	0	0
390	JUNCT_390	JUNCT_1390	1	.01	0	0	0	695	JUNCT_695	JUNCT_1688	1	.01	0	0	0	0
400	JUNCT_400	JUNCT_1400	1	.01	0	0	0	700	JUNCT_700	JUNCT_1700	1	.01	0	0	0	0
410	JUNCT_410	JUNCT_671	1	.01	0	0	0	711	JUNCT_711	JUNCT_1762	1	.01	0	0	0	0

712	JUNCT_712	JUNCT_1730	1	.01	0	0	0	1295	JUNCT_1294	JUNCT_1270	1536	0.019	0	0	0	0
721	JUNCT_721	JUNCT_1730	1	.01	0	0	0	1301	JUNCT_1300	JUNCT_1292	615	0.052	0	0	0	0
722	JUNCT_722	JUNCT_1733	1	.01	0	0	0	1301-OVERFLOW	JUNCT_1300	JUNCT_1292	615	0.052	0	0	0	0
723	JUNCT_723	JUNCT_1735	1	.01	0	0	0	1310	JUNCT_310	JUNCT_1294	1381	0.019	0	0	0	0
724	JUNCT_724	JUNCT_1737	1	.01	0	0	0	1310-OVERFLOW	JUNCT_310	JUNCT_1294	1381	0.02	0	0	0	0
731	JUNCT_731	JUNCT_1730	1	.01	0	0	0	1321	JUNCT_1320	JUNCT_1300	945	0.019	0	0	0	0
732	JUNCT_732	JUNCT_1752	1	.01	0	0	0	1321-OVERFLOW	JUNCT_1320	JUNCT_1300	945	0.02	0	0	0	0
733	JUNCT_733	JUNCT_1756	1	.01	0	0	0	1331	JUNCT_1331	JUNCT_1320	654	0.019	0	0	0	0
741	JUNCT_741	JUNCT_1740	1	.01	0	0	0	1331-OVERFLOW	JUNCT_1331	JUNCT_1320	654	0.02	0	0	0	0
742	JUNCT_742	JUNCT_1743	1	.01	0	0	0	1349	JUNCT_1757	JUNCT_1756	430	0.019	0	0	0	0
743	JUNCT_743	JUNCT_1752	1	.01	0	0	0	1349-OVERFLOW	JUNCT_1757	JUNCT_1756	430	0.02	0	0	0	0
744	JUNCT_744	JUNCT_1754	1	.01	0	0	0	1361	JUNCT_1360	JUNCT_1330	2605	0.019	0	0	0	0
751	JUNCT_751	JUNCT_1756	1	.01	0	0	0	1361-OVERFLOW	JUNCT_1360	JUNCT_1330	2605	0.02	0	0	0	0
752	JUNCT_752	JUNCT_1757	1	.01	0	0	0	1371	JUNCT_1370	JUNCT_1360	1584	0.019	0	0	0	0
771	JUNCT_771	JUNCT_769	1	.01	0	0	0	1371-OVERFLOW	JUNCT_1370	JUNCT_1360	1584	0.02	0	0	0	0
772	JUNCT_772	JUNCT_770	1	.01	0	0	0	1380	JUNCT_380	JUNCT_1385	1378	0.052	0	0	0	0
831	JUNCT_831	JUNCT_1822	1	.01	0	0	0	1380-OVERFLOW	JUNCT_380	JUNCT_1385	1378	0.052	0	0	0	0
832	JUNCT_832	JUNCT_830	1	.01	0	0	0	1385	JUNCT_1385	JUNCT_1400	1100	0.052	0	0	0	0
860	JUNCT_860	JUNCT_349	1	.01	0	0	0	1391	JUNCT_1390	JUNCT_1360	1689	0.02	0	0	0	0
870	JUNCT_870	JUNCT_347	1	.01	0	0	0	1401	JUNCT_1400	JUNCT_1390	1070	0.052	0	0	0	0
871	JUNCT_871	JUNCT_347	1	.01	0	0	0	140-DIV	JUNCT_140	JUNCT_1140	1	.01	0	12	0	0
872	JUNCT_872	JUNCT_347	1	.01	0	0	0	1431	JUNCT_1430	JUNCT_1400	3300	0.02	0	0	0	0
880	JUNCT_880	JUNCT_347	1	.01	0	0	0	1440	JUNCT_440	JUNCT_1430	864	0.02	0	0	0	0
1201	JUNCT_1200	JUNCT_1190	340	0.052	0	0	0	1451	JUNCT_1450	JUNCT_1095	660	0.052	0	0	0	0
1211	JUNCT_1210	JUNCT_1212	1542	0.019	0	0	0	1451-OVERFLOW	JUNCT_1450	JUNCT_1095	660	0.052	0	0	0	0
1212	JUNCT_1212	JUNCT_1200	1	0.01	0	0	0	1460	JUNCT_460	JUNCT_1550	1300	0.019	0	0	0	0
1231	JUNCT_1230	JUNCT_1210	627	0.019	0	0	0	1460-OVERFLOW	JUNCT_460	JUNCT_1550	1300	0.02	0	0	0	0
1240	JUNCT_240	JUNCT_1230	1030	0.02	0	0	0	1481	JUNCT_1480	JUNCT_1550	1300	0.02	0	0	0	0
1251	JUNCT_1250	JUNCT_1230	1252	0.019	0	0	0	1481-OVERFLOW	JUNCT_1480	JUNCT_1550	1300	0.052	0	0	0	0
1255	JUNCT_255	JUNCT_1260	1317	0.02	0	0	0	1491	JUNCT_1490	JUNCT_1480	990	0.02	0	0	0	0
1261	JUNCT_1260	JUNCT_1250	1346	0.019	0	0	0	1491-OVERFLOW	JUNCT_1490	JUNCT_1480	990	0.052	0	0	0	0
1271	JUNCT_1270	JUNCT_1250	670	0.019	0	0	0	1500	JUNCT_500	JUNCT_1480	2190	0.019	0	0	0	0
1280	JUNCT_280	JUNCT_1290	352	0.019	0	0	0	1500-OVERFLOW	JUNCT_500	JUNCT_1480	2190	0.02	0	0	0	0
1291	JUNCT_1290	JUNCT_1292	977	0.019	0	0	0	1541	JUNCT_1540	JUNCT_1550	1318	0.02	0	0	0	0
1293	JUNCT_1292	JUNCT_1294	360	0.019	0	0	0	1541-OVERFLOW	JUNCT_1540	JUNCT_1550	1318	0.02	0	0	0	0

1551	JUNCT_1550	JUNCT_1450	680	0.02	0	0	0	1689	JUNCT_1692	JUNCT_1688	860	0.02	0	0	0	0
1551-OVERFLOW	JUNCT_1550	JUNCT_1450	680	0.052	0	0	0	1691	JUNCT_1690	JUNCT_1680	1145	0.052	0	0	0	0
1560	JUNCT_560	JUNCT_1540	2273	0.019	0	0	0	1691-OVERFLOW	JUNCT_1690	JUNCT_1680	1145	0.052	0	0	0	0
1560-OVERFLOW	JUNCT_560	JUNCT_1540	2273	0.02	0	0	0	1693	JUNCT_1694	JUNCT_1692	300	0.02	0	0	0	0
1571	JUNCT_1570	JUNCT_1490	525	0.02	0	0	0	1695	JUNCT_1696	JUNCT_1694	280	0.02	0	0	0	0
1571-OVERFLOW	JUNCT_1570	JUNCT_1490	525	0.052	0	0	0	1701	JUNCT_1702	JUNCT_1690	775	0.052	0	0	0	0
1591	JUNCT_1590	JUNCT_1570	1550	0.052	0	0	0	1701-OVERFLOW	JUNCT_1702	JUNCT_1690	775	0.052	0	0	0	0
1591-OVERFLOW	JUNCT_1590	JUNCT_1570	1550	0.052	0	0	0	1703	JUNCT_1700	JUNCT_1702	770	0.052	0	0	0	0
1592	JUNCT_1593	JUNCT_1590	600	0.02	0	0	0	1703-OVERFLOW	JUNCT_1700	JUNCT_1702	770	0.052	0	0	0	0
1601	JUNCT_605	JUNCT_1600	1308	0.019	0	0	0	1731	JUNCT_1730	JUNCT_1700	750	0.02	0	0	0	0
1601-OVERFLOW	JUNCT_605	JUNCT_1600	1308	0.02	0	0	0	1731-OVERFLOW	JUNCT_1730	JUNCT_1700	750	0.052	0	0	0	0
1602	JUNCT_1600	JUNCT_610	650	0.019	0	0	0	1732	JUNCT_1733	JUNCT_1730	1240	0.02	0	0	0	0
1602-OVERFLOW	JUNCT_1600	JUNCT_610	650	0.02	0	0	0	1734	JUNCT_1735	JUNCT_1733	1070	0.02	0	0	0	0
1610	JUNCT_610	JUNCT_1650	340	0.019	0	0	0	1736	JUNCT_1737	JUNCT_1735	310	0.02	0	0	0	0
1610-OVERFLOW	JUNCT_610	JUNCT_1650	340	0.02	0	0	0	1741	JUNCT_1740	JUNCT_1730	1007	0.019	0	0	0	0
1620	JUNCT_620	JUNCT_1600	1794	0.019	0	0	0	1741-OVERFLOW	JUNCT_1740	JUNCT_1730	1007	0.02	0	0	0	0
1620-OVERFLOW	JUNCT_620	JUNCT_1600	1794	0.02	0	0	0	1742	JUNCT_1743	JUNCT_1740	1450	0.02	0	0	0	0
1625	JUNCT_625	JUNCT_605	1146	0.019	0	0	0	1751	JUNCT_1752	JUNCT_1740	950	0.019	0	0	0	0
1625-OVERFLOW	JUNCT_625	JUNCT_605	1146	0.02	0	0	0	1751-OVERFLOW	JUNCT_1752	JUNCT_1740	950	0.02	0	0	0	0
1651	JUNCT_1650	JUNCT_1590	1240	0.052	0	0	0	1753	JUNCT_1754	JUNCT_1752	920	0.019	0	0	0	0
1651-OVERFLOW	JUNCT_1650	JUNCT_1590	1240	0.052	0	0	0	1753-OVERFLOW	JUNCT_1754	JUNCT_1752	920	0.02	0	0	0	0
1661	JUNCT_1662	JUNCT_1650	1620	0.019	0	0	0	1755	JUNCT_1756	JUNCT_1754	190	0.019	0	0	0	0
1661-OVERFLOW	JUNCT_1662	JUNCT_1650	1620	0.02	0	0	0	1755-OVERFLOW	JUNCT_1756	JUNCT_1754	190	0.02	0	0	0	0
1663	JUNCT_1660	JUNCT_1662	1240	0.019	0	0	0	1758	JUNCT_349	JUNCT_1757	330	0.019	0	0	0	0
1663-OVERFLOW	JUNCT_1660	JUNCT_1662	1240	0.02	0	0	0	1758-OVERFLOW	JUNCT_349	JUNCT_1757	330	0.02	0	0	0	0
1670	JUNCT_1671	JUNCT_1660	1410	0.019	0	0	0	1761	JUNCT_1762	JUNCT_1730	1790	0.02	0	0	0	0
1670-OVERFLOW	JUNCT_1671	JUNCT_1660	1410	0.02	0	0	0	1763	JUNCT_760	JUNCT_1743	1180	0.02	0	0	0	0
1672	JUNCT_670	JUNCT_1671	1070	0.019	0	0	0	1769	JUNCT_769	JUNCT_1762	1475	0.02	0	0	0	0
1672-OVERFLOW	JUNCT_670	JUNCT_1671	1070	0.02	0	0	0	1770	JUNCT_770	JUNCT_760	900	0.019	0	0	0	0
1675	JUNCT_1675	JUNCT_670	1050	0.02	0	0	0	1770-OVERFLOW	JUNCT_770	JUNCT_760	900	0.02	0	0	0	0
1681	JUNCT_1680	JUNCT_1650	1260	0.052	0	0	0	1780	JUNCT_780	JUNCT_1743	2300	0.019	0	0	0	0
1681-OVERFLOW	JUNCT_1680	JUNCT_1650	1260	0.052	0	0	0	1780-OVERFLOW	JUNCT_780	JUNCT_1743	2300	0.02	0	0	0	0
1685	JUNCT_1686	JUNCT_1680	280	0.02	0	0	0	1790	JUNCT_790	JUNCT_1754	3410	0.019	0	0	0	0
1687	JUNCT_1688	JUNCT_1690	960	0.019	0	0	0	1790-OVERFLOW	JUNCT_790	JUNCT_1754	3410	0.02	0	0	0	0
1687-OVERFLOW	JUNCT_1688	JUNCT_1690	960	0.02	0	0	0	1800	JUNCT_800	JUNCT_790	970	0.019	0	0	0	0

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1800-OVERFLOW    JUNCT_800       JUNCT_790       970       0.02      0          0          0
0
1810             JUNCT_810       JUNCT_800       3081      0.019     0          0          0
0
1810-OVERFLOW    JUNCT_810       JUNCT_800       3081      0.02      0          0          0
0
1820             JUNCT_821       JUNCT_820       1410      0.019     0          0          0
0
1820-OVERFLOW    JUNCT_821       JUNCT_820       1410      0.02      0          0          0
0
1821             JUNCT_1822      JUNCT_830       1140      0.019     0          0          0
0
1821-OVERFLOW    JUNCT_1822      JUNCT_830       1140      0.02      0          0          0
0
1823             JUNCT_820       JUNCT_1822      1100      0.019     0          0          0
0
1830             JUNCT_830       JUNCT_800       570       0.019     0          0          0
0
1830-OVERFLOW    JUNCT_830       JUNCT_800       570       0.02      0          0          0
0
1841             JUNCT_840       JUNCT_820       1124      0.019     0          0          0
0
1841-OVERFLOW    JUNCT_840       JUNCT_820       1124      0.02      0          0          0
0
1881             JUNCT_881       JUNCT_349       2570      0.019     0          0          0
0
1881-OVERFLOW    JUNCT_881       JUNCT_349       2570      0.02      0          0          0
0
348-OVERFLOW     JUNCT_347       JUNCT_349       840       0.02      0          0          0
0

[OUTLETS]
;;               Inlet           Outlet          Outflow    Outlet          Qcoeff/
Flap
;;Name            Node            Node            Height     Type            QTable          Qexpon
;;--------------- --------------- --------------- ---------- --------------- --------------- ---------
- ----
;These define our stage/discharge curves for the system.
;Note that 1 ft of stage exactly equals 1 acre-ft of
;volume. Thus this curve is the exact curve from the original
;UDSWMM input file.
OUTLET_671       JUNCT_671       JUNCT_1675      0          TABULAR/DEPTH   RATINGCURVE_671
NO
OUTLET_1090      JUNCT_1090      JUNCT_1091      0          TABULAR/DEPTH   RATINGCURVE_1090
NO
OUTLET_1330      JUNCT_1330      JUNCT_1331      0          TABULAR/DEPTH   RATINGCURVE_1330
NO

[XSECTIONS]
;;Link           Shape        Geom1           Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ --------------- ---------- ---------- ---------- ----------
10               DUMMY        0               0          0          0          1
100              DUMMY        0               0          0          0          1
1010             DUMMY        0               0          0          0          1
1021             CIRCULAR     10              0          0          0          1
1021-OVERFLOW    TRAPEZOIDAL  20              11         20         20         1
1031             CIRCULAR     10              0          0          0          1
1031-OVERFLOW    TRAPEZOIDAL  20              11         20         20         1
110              DUMMY        0               0          0          0          1
1041             CIRCULAR     6               0          0          0          1
1041-OVERFLOW    TRAPEZOIDAL  20              4          20         20         1
1060             DUMMY        0               0          0          0          1
1060-DIV         DUMMY        0               0          0          0          1
1061             CIRCULAR     4.5             0          0          0          1
1061-OVERFLOW    TRAPEZOIDAL  20              5.5        20         20         1
1065             CIRCULAR     4               0          0          0          1
1065-OVERFLOW    TRAPEZOIDAL  20              5          20         20         1
1071             CIRCULAR     5.5             0          0          0          1
1071-OVERFLOW    TRAPEZOIDAL  20              6.5        20         20         1
1072             TRAPEZOIDAL  20              1          20         20         1
1074             CIRCULAR     4.5             0          0          0          1
1074-OVERFLOW    TRAPEZOIDAL  20              5.5        20         20         1
1076             CIRCULAR     3               0          0          0          1
1076-OVERFLOW    TRAPEZOIDAL  20              4          20         20         1
1081             TRAPEZOIDAL  9               14         0.001      0.001      1
1081-OVERFLOW    TRAPEZOIDAL  20              20         20         20         1
1091             CIRCULAR     2.5             0          0          0          1
1091-OVERFLOW    TRAPEZOIDAL  20              20         20         20         1
1096             TRAPEZOIDAL  10              14         20         20         1
1096-OVERFLOW    TRAPEZOIDAL  20              400        40         40         1
1111             TRAPEZOIDAL  20              19.1       20         20         1
1120             DUMMY        0               0          0          0          1
1131             CIRCULAR     3               0          0          0          1
1131-OVERFLOW    TRAPEZOIDAL  20              4          20         20         1
1140             CIRCULAR     5               0          0          0          1
1140-OVERFLOW    TRAPEZOIDAL  20              6          20         20         1
1142             CIRCULAR     6.4             0          0          0          1
1142-OVERFLOW    TRAPEZOIDAL  20              4          20         20         1
1148             CIRCULAR     3               0          0          0          1
1148-OVERFLOW    TRAPEZOIDAL  20              4          20         20         1
1150             DUMMY        0               0          0          0          1
1161             TRAPEZOIDAL  9               14         0.001      0.001      1
1161-OVERFLOW    TRAPEZOIDAL  20              20         20         20         1
1170             CIRCULAR     2.5             0          0          0          1
1170-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1181             TRAPEZOIDAL  9               14         0.001      0.001      1
1181-OVERFLOW    TRAPEZOIDAL  20              20         20         20         1
1191             TRAPEZOIDAL  10              15         20         20         1
1191-OVERFLOW    TRAPEZOIDAL  20              400        40         40         1
20               DUMMY        0               0          0          0          1
30               DUMMY        0               0          0          0          1
40               DUMMY        0               0          0          0          1
50               DUMMY        0               0          0          0          1
60               DUMMY        0               0          0          0          1
71               DUMMY        0               0          0          0          1
72               DUMMY        0               0          0          0          1
73               DUMMY        0               0          0          0          1
80               DUMMY        0               0          0          0          1
90               DUMMY        0               0          0          0          1
95               DUMMY        0               0          0          0          1
120              DUMMY        0               0          0          0          1
1201-OVERFLOW    TRAPEZOIDAL  20              400        40         40         1
1211-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1231-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1251-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1261-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1271-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1280-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1291-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1293-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1295-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
130              DUMMY        0               0          0          0          1
140              DUMMY        0               0          0          0          1
150              DUMMY        0               0          0          0          1
160              DUMMY        0               0          0          0          1
180              DUMMY        0               0          0          0          1
190              DUMMY        0               0          0          0          1
200              DUMMY        0               0          0          0          1
210              DUMMY        0               0          0          0          1
220              DUMMY        0               0          0          0          1
230              DUMMY        0               0          0          0          1
250              DUMMY        0               0          0          0          1
260              DUMMY        0               0          0          0          1
270              DUMMY        0               0          0          0          1
290              DUMMY        0               0          0          0          1
300              DUMMY        0               0          0          0          1
320              DUMMY        0               0          0          0          1
330              DUMMY        0               0          0          0          1
340              DUMMY        0               0          0          0          1
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348	CIRCULAR	2	0	0	0	1
350	DUMMY	0	0	0	0	1
360	DUMMY	0	0	0	0	1
370	DUMMY	0	0	0	0	1
390	DUMMY	0	0	0	0	1
400	DUMMY	0	0	0	0	1
410	DUMMY	0	0	0	0	1
420	DUMMY	0	0	0	0	1
430	DUMMY	0	0	0	0	1
450	DUMMY	0	0	0	0	1
470	DUMMY	0	0	0	0	1
480	DUMMY	0	0	0	0	1
490	DUMMY	0	0	0	0	1
510	DUMMY	0	0	0	0	1
520	DUMMY	0	0	0	0	1
531	DUMMY	0	0	0	0	1
532	DUMMY	0	0	0	0	1
533	DUMMY	0	0	0	0	1
540	DUMMY	0	0	0	0	1
550	DUMMY	0	0	0	0	1
570	DUMMY	0	0	0	0	1
580	DUMMY	0	0	0	0	1
590	DUMMY	0	0	0	0	1
600	DUMMY	0	0	0	0	1
631	DUMMY	0	0	0	0	1
632	DUMMY	0	0	0	0	1
633	DUMMY	0	0	0	0	1
640	DUMMY	0	0	0	0	1
651	DUMMY	0	0	0	0	1
652	DUMMY	0	0	0	0	1
661	DUMMY	0	0	0	0	1
662	DUMMY	0	0	0	0	1
663	DUMMY	0	0	0	0	1
681	DUMMY	0	0	0	0	1
682	DUMMY	0	0	0	0	1
691	DUMMY	0	0	0	0	1
692	DUMMY	0	0	0	0	1
693	DUMMY	0	0	0	0	1
694	DUMMY	0	0	0	0	1
695	DUMMY	0	0	0	0	1
700	DUMMY	0	0	0	0	1
711	DUMMY	0	0	0	0	1
712	DUMMY	0	0	0	0	1
721	DUMMY	0	0	0	0	1
722	DUMMY	0	0	0	0	1
723	DUMMY	0	0	0	0	1
724	DUMMY	0	0	0	0	1
731	DUMMY	0	0	0	0	1
732	DUMMY	0	0	0	0	1
733	DUMMY	0	0	0	0	1
741	DUMMY	0	0	0	0	1
742	DUMMY	0	0	0	0	1
743	DUMMY	0	0	0	0	1
744	DUMMY	0	0	0	0	1
751	DUMMY	0	0	0	0	1
752	DUMMY	0	0	0	0	1
771	DUMMY	0	0	0	0	1
772	DUMMY	0	0	0	0	1
831	DUMMY	0	0	0	0	1
832	DUMMY	0	0	0	0	1
860	DUMMY	0	0	0	0	1
870	DUMMY	0	0	0	0	1
871	DUMMY	0	0	0	0	1
872	DUMMY	0	0	0	0	1
880	DUMMY	0	0	0	0	1
1201	TRAPEZOIDAL	10	14	20	20	1
1211	CIRCULAR	6	0	0	0	1
1212	DUMMY	0	0	0	0	1
1231	CIRCULAR	5.5	0	0	0	1
1240	TRAPEZOIDAL	20	1	20	20	1
1251	CIRCULAR	5.5	0	0	0	1
1255	TRAPEZOIDAL	20	1	20	20	1
1261	CIRCULAR	2.3	0	0	0	1
1271	CIRCULAR	5.5	0	0	0	1
1280	CIRCULAR	3.5	0	0	0	1
1291	CIRCULAR	4	0	0	0	1
1293	CIRCULAR	5.5	0	0	0	1
1295	CIRCULAR	5.5	0	0	0	1
1301	TRAPEZOIDAL	7	1	5.5	5.5	1
1301-OVERFLOW	TRAPEZOIDAL	20	32	20	20	1
1310	TRAPEZOIDAL	0.5	0.5	20	20	1
1310-OVERFLOW	TRAPEZOIDAL	20	10	20	20	1
1321	CIRCULAR	5	0	0	0	1
1321-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1331	CIRCULAR	5	0	0	0	1
1331-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1349	CIRCULAR	2.5	0	0	0	1
1349-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1361	CIRCULAR	4	0	0	0	1
1361-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1371	CIRCULAR	2.5	0	0	0	1
1371-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1380	CIRCULAR	2.5	0	0	0	1
1380-OVERFLOW	TRAPEZOIDAL	20	20	20	20	1
1385	TRAPEZOIDAL	20	58	3	4	1
1391	TRAPEZOIDAL	20	1	20	20	1
1401	TRAPEZOIDAL	20	50	19	19	1
140-DIV	DUMMY	0	0	0	0	1
1431	TRAPEZOIDAL	8	30	20	20	1
1440	TRAPEZOIDAL	20	195	20	20	1
1451	TRAPEZOIDAL	10	13	5	5	1
1451-OVERFLOW	TRAPEZOIDAL	20	120	20	20	1
1460	CIRCULAR	2.25	0	0	0	1
1460-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1481	TRAPEZOIDAL	9	9	1.5	1.5	1
1481-OVERFLOW	TRAPEZOIDAL	20	36	20	20	1
1491	TRAPEZOIDAL	9	9	1.5	1.5	1
1491-OVERFLOW	TRAPEZOIDAL	20	36	20	20	1
1500	CIRCULAR	3	0	0	0	1
1500-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1541	CIRCULAR	4	0	0	0	1
1541-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1551	TRAPEZOIDAL	10	14	0.001	0.001	1
1551-OVERFLOW	TRAPEZOIDAL	20	20	20	20	1
1560	CIRCULAR	4	0	0	0	1
1560-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1571	TRAPEZOIDAL	9	9	1.5	1.5	1
1571-OVERFLOW	TRAPEZOIDAL	20	36	20	20	1
1591	TRAPEZOIDAL	6	8	20	7	1
1591-OVERFLOW	TRAPEZOIDAL	20	125	20	20	1
1592	TRAPEZOIDAL	20	1	20	20	1
1601	CIRCULAR	4	0	0	0	1
1601-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1602	CIRCULAR	4	0	0	0	1
1602-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1610	CIRCULAR	4	0	0	0	1
1610-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1620	CIRCULAR	2	0	0	0	1
1620-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1625	CIRCULAR	3.5	0	0	0	1
1625-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1651	TRAPEZOIDAL	6	3	5	5	1
1651-OVERFLOW	TRAPEZOIDAL	20	70	20	20	1
1661	CIRCULAR	2.75	0	0	0	1
1661-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1663	CIRCULAR	2.75	0	0	0	1
1663-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1670	CIRCULAR	1.75	0	0	0	1
1670-OVERFLOW	TRAPEZOIDAL	20	1	20	20	1
1672	CIRCULAR	1.75	0	0	0	1

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1672-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1675             TRAPEZOIDAL  8               40         20         20         1
1681             TRAPEZOIDAL  3               6          20         20         1
1681-OVERFLOW    TRAPEZOIDAL  20              68         20         20         1
1685             TRAPEZOIDAL  20              1          20         20         1
1687             CIRCULAR     4.5             0          0          0          1
1687-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1689             TRAPEZOIDAL  20              1          20         20         1
1691             TRAPEZOIDAL  3               7          8          8          1
1691-OVERFLOW    TRAPEZOIDAL  20              57         20         20         1
1693             TRAPEZOIDAL  20              1          20         20         1
1695             TRAPEZOIDAL  20              1          20         20         1
1701             TRAPEZOIDAL  5               10         7          7          1
1701-OVERFLOW    TRAPEZOIDAL  20              60         20         20         1
1703             TRAPEZOIDAL  4               15         5          5          1
1703-OVERFLOW    TRAPEZOIDAL  20              60         20         20         1
1731             TRAPEZOIDAL  9               14         0.001      0.001      1
1731-OVERFLOW    TRAPEZOIDAL  20              20         20         20         1
1732             TRAPEZOIDAL  20              1          20         20         1
1734             TRAPEZOIDAL  20              1          20         20         1
1736             TRAPEZOIDAL  20              1          20         20         1
1741             CIRCULAR     4               0          0          0          1
1741-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1742             TRAPEZOIDAL  20              1          20         20         1
1751             CIRCULAR     3.5             0          0          0          1
1751-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1753             CIRCULAR     3.5             0          0          0          1
1753-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1755             CIRCULAR     3.5             0          0          0          1
1755-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1758             CIRCULAR     2.5             0          0          0          1
1758-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1761             TRAPEZOIDAL  20              1          20         20         1
1763             TRAPEZOIDAL  20              1          20         20         1
1769             TRAPEZOIDAL  20              1          20         20         1
1770             CIRCULAR     3               0          0          0          1
1770-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1780             CIRCULAR     2.5             0          0          0          1
1780-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1790             CIRCULAR     6.5             0          0          0          1
1790-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1800             CIRCULAR     6               0          0          0          1
1800-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1810             CIRCULAR     2.5             0          0          0          1
1810-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1820             CIRCULAR     1.75            0          0          0          1
1820-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1821             CIRCULAR     1.75            0          0          0          1
1821-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1823             TRAPEZOIDAL  20              1          20         20         1
1830             CIRCULAR     5               0          0          0          1
1830-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1841             CIRCULAR     1.75            0          0          0          1
1841-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
1881             CIRCULAR     3               0          0          0          1
1881-OVERFLOW    TRAPEZOIDAL  20              1          20         20         1
348-OVERFLOW     TRAPEZOIDAL  20              1          20         20         1

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate
;;-------------- ---------- ---------- ---------- ----------

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
DIVCURVE_140     Diversion  0          0
DIVCURVE_140                46         0
DIVCURVE_140                47         1
DIVCURVE_140                1000       954
DIVCURVE_1060    Diversion  0          0
DIVCURVE_1060               3.4        3.3
DIVCURVE_1060               115.8      75.8
DIVCURVE_1060               319        194.3

;Curves are named using RATINGCURVE_ for rating (outflow) curves
;and DIVCURVE_ for diversion curves.
RATINGCURVE_671  RATING     0          0
RATINGCURVE_671             23.8       0
RATINGCURVE_671             89.11      0
RATINGCURVE_671             100.9      76.84
RATINGCURVE_671             117.93     293.68
RATINGCURVE_671             136.27     614.75

RATINGCURVE_1090 RATING     0          0
RATINGCURVE_1090            3.5        0
RATINGCURVE_1090            6.6        53.4
RATINGCURVE_1090            11.2       53.4
RATINGCURVE_1090            16.4       1077.3
RATINGCURVE_1090            20.8       3531.4

RATINGCURVE_1330 RATING     0          0
RATINGCURVE_1330            0.4        14.9
RATINGCURVE_1330            0.6        20.9
RATINGCURVE_1330            2.8        1438.4

[REPORT]
INPUT      NO
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]

[MAP]
DIMENSIONS 3140029.776 1662392.197 3168666.890 1676285.001
Units      None

[COORDINATES]
;;Node           X-Coord            Y-Coord
;;-------------- ------------------ ------------------
JUNCT_10         3142011.909        1672983.374
JUNCT_100        3149015.163        1671677.458
JUNCT_1010       3141702.179        1673285.512
JUNCT_1073       3146221.769        1672746.077
JUNCT_110        3148942.998        1672475.100
JUNCT_1110       3148387.296        1671495.037
JUNCT_1120       3142012.150        1672618.163
JUNCT_1150       3142495.777        1670836.379
JUNCT_120        3142733.348        1671901.207
JUNCT_1212       3147164.184        1670927.502
JUNCT_130        3143190.504        1672120.865
JUNCT_1385       3156517.865        1664899.990
JUNCT_1390       3155361.707        1666637.555
JUNCT_1400       3156047.247        1665874.693
JUNCT_1430       3158847.823        1664946.502
JUNCT_150        3143187.279        1670110.939
JUNCT_1593       3153182.744        1670687.859
JUNCT_160        3144763.701        1670751.500
JUNCT_1675       3157998.197        1667573.352
JUNCT_1686       3155711.464        1671037.544
JUNCT_1692       3156971.348        1670821.152
JUNCT_1694       3157259.871        1670768.256
JUNCT_1696       3157630.143        1670720.169
JUNCT_1733       3157998.368        1673200.065
JUNCT_1735       3157790.933        1674216.070
JUNCT_1737       3158129.602        1674288.037
JUNCT_1743       3160131.977        1670422.987
JUNCT_1762       3158749.331        1670230.661
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JUNCT_180	3145858.477	1670401.780
JUNCT_190	3146784.785	1670454.569
JUNCT_20	3142789.166	1673091.712
JUNCT_200	3147900.521	1670450.326
JUNCT_210	3147145.384	1669338.833
JUNCT_220	3148679.598	1669811.250
JUNCT_230	3147671.390	1668648.344
JUNCT_240	3148863.533	1669088.534
JUNCT_250	3148423.545	1668280.268
JUNCT_255	3151218.787	1668824.380
JUNCT_260	3150402.103	1668657.544
JUNCT_270	3150114.560	1668056.222
JUNCT_290	3150253.255	1665650.394
JUNCT_30	3143237.384	1673230.372
JUNCT_300	3150920.059	1666322.532
JUNCT_320	3152248.332	1667448.097
JUNCT_330	3152664.417	1666050.476
JUNCT_340	3152636.864	1664773.383
JUNCT_350	3154135.670	1667600.567
JUNCT_360	3154594.408	1666414.408
JUNCT_370	3155115.446	1664953.554
JUNCT_390	3156595.777	1666594.580
JUNCT_40	3143971.846	1673394.454
JUNCT_400	3157150.902	1664447.125
JUNCT_410	3159084.098	1666950.054
JUNCT_420	3159006.185	1666784.491
JUNCT_430	3159410.355	1664549.385
JUNCT_440	3159722.004	1665197.030
JUNCT_450	3148968.497	1671019.895
JUNCT_470	3150198.986	1670888.193
JUNCT_480	3151190.214	1670510.349
JUNCT_490	3151610.090	1671292.791
JUNCT_50	3145018.845	1673550.722
JUNCT_510	3152275.058	1671170.983
JUNCT_520	3152836.262	1669384.891
JUNCT_531	3153485.306	1670004.655
JUNCT_532	3153907.807	1668936.815
JUNCT_533	3153880.588	1670526.818
JUNCT_540	3149518.237	1673270.101
JUNCT_550	3150663.669	1672035.579
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JUNCT_580	3152963.142	1672996.114
JUNCT_590	3153592.666	1671668.746
JUNCT_60	3147011.269	1673238.185
JUNCT_600	3154134.350	1673220.596
JUNCT_631	3154864.656	1671441.309
JUNCT_632	3155769.724	1672437.419
JUNCT_633	3156647.112	1672907.613
JUNCT_640	3157614.223	1673010.375
JUNCT_651	3154963.955	1670497.538
JUNCT_652	3155278.951	1669486.319
JUNCT_661	3155120.315	1668552.124
JUNCT_662	3156201.347	1668493.689
JUNCT_663	3156937.706	1667920.894
JUNCT_681	3156153.866	1670633.612
JUNCT_682	3156043.265	1671503.990
JUNCT_691	3157036.700	1669855.050
JUNCT_692	3158079.758	1669570.885
JUNCT_693	3158098.993	1670542.246
JUNCT_694	3157119.591	1671727.423
JUNCT_695	3156865.556	1671338.089
JUNCT_700	3157938.825	1671503.293
JUNCT_71	3145500.571	1672279.419
JUNCT_711	3159171.330	1669808.662
JUNCT_712	3158956.194	1671161.540
JUNCT_72	3147375.686	1672720.623
JUNCT_721	3158271.156	1672716.687
JUNCT_722	3158324.336	1673911.268
JUNCT_723	3157515.766	1675223.607
JUNCT_724	3158794.238	1674711.372
JUNCT_73	3145517.540	1671795.792
JUNCT_731	3159353.163	1673667.308
JUNCT_732	3160182.457	1672829.592
JUNCT_733	3161069.317	1673238.243
JUNCT_741	3159979.576	1671388.191
JUNCT_742	3160506.452	1669905.882
JUNCT_743	3160669.613	1671180.757
JUNCT_744	3161287.682	1671049.523
JUNCT_751	3161859.184	1671413.591
JUNCT_752	3162590.890	1670847.200
JUNCT_760	3159949.991	1669358.116
JUNCT_769	3158972.743	1668803.312
JUNCT_771	3158989.291	1668153.765
JUNCT_772	3160365.046	1668125.759
JUNCT_80	3147005.387	1671892.723
JUNCT_820	3164145.977	1667370.240
JUNCT_831	3163744.831	1667757.747
JUNCT_832	3163950.627	1669062.310
JUNCT_860	3162956.067	1672255.742
JUNCT_870	3163338.634	1673038.265
JUNCT_871	3163008.235	1673151.296
JUNCT_872	3161790.977	1673620.810
JUNCT_880	3164374.294	1671667.884
JUNCT_90	3147844.938	1672056.635
JUNCT_95	3148056.394	1670850.201
ROOT_JUNCT_1010	3141235.801	1672991.489
ROOT_JUNCT_1120	3141520.038	1672308.472
ROOT_JUNCT_1150	3141944.272	1670700.625
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JUNCT_1030	3143065.598	1673528.438
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JUNCT_1061	3144160.695	1673043.840
JUNCT_1065	3144352.183	1673745.163
JUNCT_1070	3144776.629	1673214.745
JUNCT_1077	3144838.765	1671969.728
JUNCT_1080	3146475.094	1671616.970
JUNCT_1091	3147481.083	1671439.816
JUNCT_1095	3147857.003	1671215.042
JUNCT_1130	3143097.940	1672689.588
JUNCT_1140	3143653.253	1672857.140
JUNCT_1160	3143752.553	1670994.784
JUNCT_1180	3145044.997	1671245.670
JUNCT_1190	3146619.334	1671052.739
JUNCT_1200	3147118.669	1671113.512
JUNCT_1210	3147609.375	1669788.604
JUNCT_1230	3147730.069	1669107.105
JUNCT_1250	3148578.244	1668701.688
JUNCT_1260	3149934.542	1668840.007
JUNCT_1270	3149015.667	1668210.920
JUNCT_1290	3150007.871	1666173.168
JUNCT_1292	3149833.066	1667160.599
JUNCT_1294	3149787.886	1667620.616
JUNCT_1300	3150450.629	1667245.388
JUNCT_1320	3151176.857	1667101.966
JUNCT_1331	3151300.175	1666641.893
JUNCT_1360	3153863.981	1666872.142
JUNCT_1370	3154029.545	1665562.243
JUNCT_140	3143722.668	1672699.163
JUNCT_1450	3148459.416	1671270.193
JUNCT_1480	3150522.853	1671624.253
JUNCT_1490	3151322.704	1671746.930
JUNCT_1540	3149632.780	1672137.396
JUNCT_1550	3149150.259	1671348.686
JUNCT_1570	3151801.695	1671820.027
JUNCT_1590	3153124.183	1671288.103
JUNCT_1600	3154153.870	1672249.470
JUNCT_1650	3154299.447	1671166.154
JUNCT_1660	3155325.616	1668956.026
JUNCT_1662	3154531.104	1669628.286
JUNCT_1671	3156639.603	1668683.600

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JUNCT_1680       3155295.567       1671295.188
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JUNCT_1690       3156134.787       1672029.196
JUNCT_170        3143938.173       1670229.724
JUNCT_1700       3157560.123       1672090.669
JUNCT_1702       3156856.818       1672191.141
JUNCT_1730       3158269.623       1671916.649
JUNCT_1740       3159323.407       1671849.626
JUNCT_1752       3160153.144       1671959.693
JUNCT_1754       3161037.914       1672090.927
JUNCT_1756       3161382.326       1672151.405
JUNCT_1757       3161808.366       1672247.047
JUNCT_1822       3163846.203       1668460.064
JUNCT_280        3149125.464       1665890.903
JUNCT_310        3151158.640       1667781.893
JUNCT_347        3162851.731       1672629.614
JUNCT_349        3162138.765       1672333.994
JUNCT_380        3155900.485       1664533.353
JUNCT_460        3149363.035       1670035.671
JUNCT_500        3151186.411       1669608.026
JUNCT_560        3151155.781       1673015.560
JUNCT_605        3153847.885       1673533.936
JUNCT_610        3154240.971       1671571.449
JUNCT_620        3155147.196       1673094.592
JUNCT_625        3155100.530       1673781.851
JUNCT_670        3157447.942       1667943.435
JUNCT_770        3160537.575       1668698.790
JUNCT_780        3161622.648       1669345.852
JUNCT_790        3162531.854       1669803.773
JUNCT_800        3162965.648       1669506.273
JUNCT_810        3163313.986       1666534.737
JUNCT_821        3165356.309       1667219.619
JUNCT_830        3163574.301       1669528.207
JUNCT_840        3164650.694       1666540.971
JUNCT_881        3163751.821       1670590.391
JUNCT_1075       3144766.646       1672640.018
JUNCT_1148       3143477.677       1672728.480
JUNCT_1040       3143426.950       1673573.986
JUNCT_1141       3143449.798       1673402.879
JUNCT_671        3158334.193       1667329.876
JUNCT_1090       3147668.209       1671599.218
JUNCT_1330       3151368.151       1666439.889

[VERTICES]
;;Link            X-Coord           Y-Coord
;;--------------- ----------------- ------------------
1021-OVERFLOW     3142075.875       1673457.932
1031-OVERFLOW     3142834.644       1673599.154
1041-OVERFLOW     3143247.824       1673645.529
1061-OVERFLOW     3143907.390       1673032.519
1065-OVERFLOW     3143988.357       1673805.003
1071-OVERFLOW     3144601.998       1673298.888
1074-OVERFLOW     3144613.921       1672792.743
1076-OVERFLOW     3144643.618       1672292.146
1081-OVERFLOW     3145881.166       1671638.182
1091-OVERFLOW     3147203.683       1671414.432
1096-OVERFLOW     3147670.340       1671338.070
1131-OVERFLOW     3142741.833       1672876.946
1140-OVERFLOW     3143634.105       1673110.861
1142-OVERFLOW     3143388.956       1673499.987
1148-OVERFLOW     3143313.864       1672816.687
1161-OVERFLOW     3143475.758       1671218.190
1170-OVERFLOW     3143734.541       1670458.811
1181-OVERFLOW     3144672.099       1671336.976
1191-OVERFLOW     3146672.126       1671457.006
1201-OVERFLOW     3146883.130       1671196.932
1211-OVERFLOW     3147230.231       1670263.663
1231-OVERFLOW     3147785.978       1669406.710
1251-OVERFLOW     3148121.319       1668760.179
1261-OVERFLOW     3149542.308       1668948.537
1271-OVERFLOW     3148935.653       1668469.152
1280-OVERFLOW     3149520.002       1666179.382
1291-OVERFLOW     3149769.403       1666792.996
1293-OVERFLOW     3149685.204       1667298.194
1295-OVERFLOW     3149175.700       1667842.845
1255              3150789.556       1668982.476
1301-OVERFLOW     3150260.225       1667331.052
1310-OVERFLOW     3150789.556       1667913.406
1321-OVERFLOW     3150792.704       1667019.366
1331-OVERFLOW     3151089.668       1666803.006
1349-OVERFLOW     3161596.717       1672264.495
1361-OVERFLOW     3153013.601       1667072.399
1371-OVERFLOW     3153812.121       1666269.441
1380-OVERFLOW     3156026.044       1664807.469
1431              3158186.028       1664550.979
1451-OVERFLOW     3148268.511       1671401.705
1460-OVERFLOW     3149392.731       1670485.359
1481-OVERFLOW     3150262.412       1671435.644
1491-OVERFLOW     3150936.844       1671813.527
1500-OVERFLOW     3150808.843       1670320.739
1541-OVERFLOW     3149666.719       1671823.462
1551-OVERFLOW     3148862.439       1671452.613
1560-OVERFLOW     3150264.889       1672875.563
1571-OVERFLOW     3151523.660       1671920.210
1591-OVERFLOW     3152686.879       1671730.518
1601-OVERFLOW     3153861.068       1672971.714
1602-OVERFLOW     3154301.463       1672045.301
1610-OVERFLOW     3154446.176       1671404.875
1620-OVERFLOW     3154964.775       1672687.327
1625-OVERFLOW     3154436.264       1673835.480
1651-OVERFLOW     3153568.266       1671419.864
1661-OVERFLOW     3154582.478       1670435.010
1663-OVERFLOW     3155173.880       1669321.506
1670-OVERFLOW     3156084.748       1669085.548
1672-OVERFLOW     3157304.967       1668378.505
1681-OVERFLOW     3154997.857       1671093.919
1687-OVERFLOW     3156372.663       1671554.481
1691-OVERFLOW     3155733.129       1671911.376
1701-OVERFLOW     3156434.691       1672323.744
1703-OVERFLOW     3157142.777       1672446.185
1731-OVERFLOW     3157938.825       1672214.327
1741-OVERFLOW     3158784.901       1672157.810
1751-OVERFLOW     3159573.175       1672002.027
1753-OVERFLOW     3160593.412       1672171.361
1755-OVERFLOW     3161169.148       1672289.895
1758-OVERFLOW     3161877.924       1672360.078
1770-OVERFLOW     3160402.115       1669062.496
1780-OVERFLOW     3161008.769       1669999.551
1790-OVERFLOW     3161748.743       1670769.389
1800-OVERFLOW     3162630.973       1669550.785
1810-OVERFLOW     3163264.732       1668488.564
1820-OVERFLOW     3165001.254       1667376.922
1821-OVERFLOW     3163805.754       1668931.972
1830-OVERFLOW     3163433.592       1669646.153
1841-OVERFLOW     3164560.807       1666927.486
1881-OVERFLOW     3163014.746       1671637.578
348-OVERFLOW      3162356.133       1672577.446


[BACKDROP]
FILE       "R:\15.155.023 (Harvard Gulch MDP FHAD)\Hydrology\CUHP-SWMM\2015_Calibration_FHAD
Flow\SWMM\Backdrops\Harvard Gulch_2014_WM_5200-01_02_03.jpg"
DIMENSIONS 3140371.658 1662392.197 3168666.890 1676285.001
```

EPA SWMM 5.0 100-year, Future Conditions Output

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------

Harvard Gulch Major Drainageway Plan and Flood Hazard Area Delineation
Matrix Design Group, Inc., February 2015
Based on CUHP/UDSWM 2000 model from 2014 Denver SDMP Update by Olsson Assoicates

*****************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*****************************************************

***************
Analysis Options
***************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Flow Routing Method ...... KINWAVE
Starting Date ............ JAN-01-2005 00:00:00
Ending Date .............. JAN-01-2005 04:10:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Routing Time Step ........ 300.00 sec


*************************       Volume        Volume
Flow Routing Continuity       acre-feet      10^6 gal
*************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.000         0.000
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........       833.290       271.540
External Outflow .........       787.186       256.516
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......        58.944        19.208
Continuity Error (%) .....        -1.541


*******************************
Highest Flow Instability Indexes
*******************************
Link 1148 (34)
Link 1881 (12)
Link 1602-OVERFLOW (9)
Link 1610-OVERFLOW (9)
Link 1131 (9)


************************
Routing Time Step Summary
************************
Minimum Time Step           :   300.00 sec
Average Time Step           :   300.00 sec
Maximum Time Step           :   300.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     1.08


*****************
Node Depth Summary
*****************

                                      Average  Maximum  Maximum  Time of Max
                                        Depth    Depth      HGL   Occurrence
Node                 Type               Feet     Feet     Feet  days hr:min
-------------------------------------------------------------------------
JUNCT_10             JUNCTION           0.00     0.00  5240.10     0  00:00
JUNCT_100            JUNCTION           0.00     0.00  5304.99     0  00:00
JUNCT_1010           JUNCTION           2.24     4.63  5244.68     0  01:00
JUNCT_1073           JUNCTION           0.41     0.58  5289.70     0  01:10
JUNCT_110            JUNCTION           0.00     0.00  5304.99     0  00:00
JUNCT_1110           JUNCTION           0.38     0.63  5305.62     0  01:05
JUNCT_1120           JUNCTION           1.72     2.13  5244.18     0  01:20
JUNCT_1150           JUNCTION           5.43     9.00  5255.05     0  01:10
JUNCT_120            JUNCTION           0.00     0.00  5242.10     0  00:00
JUNCT_1212           JUNCTION           4.57     6.00  5300.45     0  00:45
JUNCT_130            JUNCTION           0.00     0.00  5260.78     0  00:00
JUNCT_1385           JUNCTION           2.23     2.50  5440.32     0  00:35
JUNCT_1390           JUNCTION           1.07     1.55  5417.78     0  01:20
JUNCT_1400           JUNCTION           0.75     1.20  5432.42     0  01:15
JUNCT_1430           JUNCTION           0.36     0.63  5481.35     0  01:05
JUNCT_150            JUNCTION           0.00     0.00  5246.10     0  00:00
JUNCT_1593           JUNCTION           0.32     0.89  5369.14     0  00:45
JUNCT_160            JUNCTION           0.00     0.00  5268.36     0  00:00
JUNCT_1675           JUNCTION           0.00     0.00  5458.05     0  00:00
JUNCT_1686           JUNCTION           0.28     0.83  5370.88     0  00:40
JUNCT_1692           JUNCTION           0.44     1.31  5385.96     0  00:40
JUNCT_1694           JUNCTION           0.36     1.06  5391.71     0  00:40
JUNCT_1696           JUNCTION           0.22     0.71  5398.36     0  00:40
JUNCT_1733           JUNCTION           0.76     1.42  5404.96     0  00:50
JUNCT_1735           JUNCTION           0.71     1.33  5409.14     0  00:50
JUNCT_1737           JUNCTION           0.42     0.78  5412.32     0  00:50
JUNCT_1743           JUNCTION           1.21     2.50  5429.85     0  00:35
JUNCT_1762           JUNCTION           0.49     0.72  5443.36     0  01:05
JUNCT_180            JUNCTION           0.00     0.00  5276.34     0  00:00
JUNCT_190            JUNCTION           0.00     0.00  5292.40     0  00:00
JUNCT_20             JUNCTION           0.00     0.00  5243.94     0  00:00
JUNCT_200            JUNCTION           0.00     0.00  5294.44     0  00:00
JUNCT_210            JUNCTION           0.00     0.00  5319.11     0  00:00
JUNCT_220            JUNCTION           0.00     0.00  5319.11     0  00:00
JUNCT_230            JUNCTION           0.00     0.00  5320.99     0  00:00
JUNCT_240            JUNCTION           0.47     0.80  5334.14     0  00:55
JUNCT_250            JUNCTION           0.00     0.00  5328.50     0  00:00
JUNCT_255            JUNCTION           0.32     0.48  5372.61     0  01:00
JUNCT_260            JUNCTION           0.00     0.00  5336.58     0  00:00
JUNCT_270            JUNCTION           0.00     0.00  5334.53     0  00:00
JUNCT_290            JUNCTION           0.00     0.00  5361.96     0  00:00
JUNCT_30             JUNCTION           0.00     0.00  5247.79     0  00:00
JUNCT_300            JUNCTION           0.00     0.00  5348.70     0  00:00
JUNCT_320            JUNCTION           0.00     0.00  5373.30     0  00:00
JUNCT_330            JUNCTION           0.00     0.00  5386.33     0  00:00
JUNCT_340            JUNCTION           0.00     0.00  5424.70     0  00:00
JUNCT_350            JUNCTION           0.00     0.00  5399.35     0  00:00
JUNCT_360            JUNCTION           0.00     0.00  5399.35     0  00:00
JUNCT_370            JUNCTION           0.00     0.00  5424.70     0  00:00
JUNCT_390            JUNCTION           0.00     0.00  5416.24     0  00:00
JUNCT_40             JUNCTION           0.00     0.00  5248.83     0  00:00
JUNCT_400            JUNCTION           0.00     0.00  5431.22     0  00:00
JUNCT_410            JUNCTION           0.00     0.00  5458.05     0  00:00
JUNCT_420            JUNCTION           0.00     0.00  5458.05     0  00:00
JUNCT_430            JUNCTION           0.00     0.00  5480.72     0  00:00
JUNCT_440            JUNCTION           0.09     0.16  5499.02     0  01:05
JUNCT_450            JUNCTION           0.00     0.00  5308.30     0  00:00
JUNCT_470            JUNCTION           0.00     0.00  5312.40     0  00:00
JUNCT_480            JUNCTION           0.00     0.00  5320.20     0  00:00
JUNCT_490            JUNCTION           0.00     0.00  5326.10     0  00:00
JUNCT_50             JUNCTION           0.00     0.00  5258.62     0  00:00
JUNCT_510            JUNCTION           0.00     0.00  5331.85     0  00:00
JUNCT_520            JUNCTION           0.00     0.00  5368.25     0  00:00
JUNCT_531            JUNCTION           0.00     0.00  5368.25     0  00:00
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JUNCT_532	JUNCTION	0.00	0.00	5371.51	0	00:00
JUNCT_533	JUNCTION	0.00	0.00	5344.25	0	00:00
JUNCT_540	JUNCTION	0.00	0.00	5316.29	0	00:00
JUNCT_550	JUNCTION	0.00	0.00	5312.40	0	00:00
JUNCT_570	JUNCTION	0.00	0.00	5331.85	0	00:00
JUNCT_580	JUNCTION	0.00	0.00	5344.25	0	00:00
JUNCT_590	JUNCTION	0.00	0.00	5344.25	0	00:00
JUNCT_60	JUNCTION	0.00	0.00	5258.62	0	00:00
JUNCT_600	JUNCTION	0.00	0.00	5357.38	0	00:00
JUNCT_631	JUNCTION	0.00	0.00	5350.45	0	00:00
JUNCT_632	JUNCTION	0.00	0.00	5363.05	0	00:00
JUNCT_633	JUNCTION	0.00	0.00	5372.65	0	00:00
JUNCT_640	JUNCTION	0.00	0.00	5380.35	0	00:00
JUNCT_651	JUNCTION	0.00	0.00	5350.45	0	00:00
JUNCT_652	JUNCTION	0.00	0.00	5371.55	0	00:00
JUNCT_661	JUNCTION	0.00	0.00	5371.55	0	00:00
JUNCT_662	JUNCTION	0.00	0.00	5387.65	0	00:00
JUNCT_663	JUNCTION	0.00	0.00	5407.37	0	00:00
JUNCT_681	JUNCTION	0.00	0.00	5370.05	0	00:00
JUNCT_682	JUNCTION	0.00	0.00	5363.05	0	00:00
JUNCT_691	JUNCTION	0.00	0.00	5384.70	0	00:00
JUNCT_692	JUNCTION	0.00	0.00	5390.70	0	00:00
JUNCT_693	JUNCTION	0.00	0.00	5397.70	0	00:00
JUNCT_694	JUNCTION	0.00	0.00	5372.65	0	00:00
JUNCT_695	JUNCTION	0.00	0.00	5372.70	0	00:00
JUNCT_700	JUNCTION	0.00	0.00	5380.35	0	00:00
JUNCT_71	JUNCTION	0.00	0.00	5261.20	0	00:00
JUNCT_711	JUNCTION	0.00	0.00	5442.65	0	00:00
JUNCT_712	JUNCTION	0.00	0.00	5396.10	0	00:00
JUNCT_72	JUNCTION	0.00	0.00	5289.15	0	00:00
JUNCT_721	JUNCTION	0.00	0.00	5396.10	0	00:00
JUNCT_722	JUNCTION	0.00	0.00	5403.55	0	00:00
JUNCT_723	JUNCTION	0.00	0.00	5407.85	0	00:00
JUNCT_724	JUNCTION	0.00	0.00	5411.55	0	00:00
JUNCT_73	JUNCTION	0.00	0.00	5264.15	0	00:00
JUNCT_731	JUNCTION	0.00	0.00	5396.10	0	00:00
JUNCT_732	JUNCTION	0.00	0.00	5411.76	0	00:00
JUNCT_733	JUNCTION	0.00	0.00	5420.65	0	00:00
JUNCT_741	JUNCTION	0.00	0.00	5404.20	0	00:00
JUNCT_742	JUNCTION	0.00	0.00	5427.40	0	00:00
JUNCT_743	JUNCTION	0.00	0.00	5411.80	0	00:00
JUNCT_744	JUNCTION	0.00	0.00	5419.20	0	00:00
JUNCT_751	JUNCTION	0.00	0.00	5420.65	0	00:00
JUNCT_752	JUNCTION	0.00	0.00	5430.55	0	00:00
JUNCT_760	JUNCTION	1.24	3.00	5451.59	0	00:35
JUNCT_769	JUNCTION	0.36	0.52	5480.03	0	01:05
JUNCT_771	JUNCTION	0.00	0.00	5479.55	0	00:00
JUNCT_772	JUNCTION	0.00	0.00	5462.10	0	00:00
JUNCT_80	JUNCTION	0.00	0.00	5290.34	0	00:00
JUNCT_820	JUNCTION	1.29	1.75	5512.99	0	00:30
JUNCT_831	JUNCTION	0.00	0.00	5484.85	0	00:00
JUNCT_832	JUNCTION	0.00	0.00	5464.35	0	00:00
JUNCT_860	JUNCTION	0.00	0.00	5438.15	0	00:00
JUNCT_870	JUNCTION	0.00	0.00	5450.75	0	00:00
JUNCT_871	JUNCTION	0.00	0.00	5450.75	0	00:00
JUNCT_872	JUNCTION	0.00	0.00	5450.75	0	00:00
JUNCT_880	JUNCTION	0.00	0.00	5450.75	0	00:00
JUNCT_90	JUNCTION	0.00	0.00	5300.79	0	00:00
JUNCT_95	JUNCTION	0.00	0.00	5306.28	0	00:00
ROOT_JUNCT_1010	OUTFALL	0.00	0.00	5240.00	0	00:00
ROOT_JUNCT_1120	OUTFALL	0.00	0.00	5242.00	0	00:00
ROOT_JUNCT_1150	OUTFALL	0.00	0.00	5246.00	0	00:00
JUNCT_1020	DIVIDER	2.25	4.62	5248.56	0	01:00
JUNCT_1030	DIVIDER	2.20	4.39	5252.17	0	01:00
JUNCT_1060	DIVIDER	21.00	21.00	5278.05	0	00:05
JUNCT_1061	DIVIDER	1.85	3.28	5281.73	0	01:05
JUNCT_1065	DIVIDER	1.89	4.00	5261.04	0	00:50
JUNCT_1070	DIVIDER	2.98	5.50	5264.11	0	00:45
JUNCT_1077	DIVIDER	1.22	3.00	5267.14	0	00:40
JUNCT_1080	DIVIDER	5.87	9.00	5299.34	0	00:55
JUNCT_1091	DIVIDER	1.47	2.50	5303.28	0	01:45
JUNCT_1095	DIVIDER	6.00	10.00	5316.27	0	01:10
JUNCT_1130	DIVIDER	1.73	2.13	5262.90	0	01:15
JUNCT_1140	DIVIDER	12.00	12.00	5265.55	0	00:05
JUNCT_1160	DIVIDER	6.41	9.00	5277.35	0	00:55
JUNCT_1180	DIVIDER	6.34	9.00	5285.34	0	00:55
JUNCT_1190	DIVIDER	4.58	7.57	5299.96	0	01:25
JUNCT_1200	DIVIDER	4.02	6.62	5301.05	0	01:25
JUNCT_1210	DIVIDER	5.23	6.00	5325.10	0	00:40
JUNCT_1230	DIVIDER	4.98	5.50	5326.48	0	00:30
JUNCT_1250	DIVIDER	4.72	5.50	5333.99	0	00:35
JUNCT_1260	DIVIDER	1.59	2.30	5338.87	0	00:30
JUNCT_1270	DIVIDER	4.68	5.50	5340.02	0	00:35
JUNCT_1290	DIVIDER	1.52	4.00	5365.95	0	00:45
JUNCT_1292	DIVIDER	4.59	5.57	5349.93	0	01:15
JUNCT_1294	DIVIDER	4.68	5.50	5347.70	0	00:35
JUNCT_1300	DIVIDER	3.90	5.57	5354.24	0	01:15
JUNCT_1320	DIVIDER	3.73	5.00	5378.24	0	00:40
JUNCT_1331	DIVIDER	3.66	5.00	5391.32	0	00:45
JUNCT_1360	DIVIDER	3.68	4.00	5403.35	0	00:30
JUNCT_1370	DIVIDER	1.91	2.50	5427.19	0	00:30
JUNCT_140	DIVIDER	1.83	3.28	5269.63	0	01:05
JUNCT_1450	DIVIDER	6.25	10.00	5318.25	0	01:10
JUNCT_1480	DIVIDER	4.82	9.00	5329.13	0	01:20
JUNCT_1490	DIVIDER	4.75	8.90	5334.97	0	01:20
JUNCT_1540	DIVIDER	2.60	4.00	5320.28	0	00:30
JUNCT_1550	DIVIDER	5.90	10.00	5322.33	0	00:55
JUNCT_1570	DIVIDER	4.10	7.67	5339.52	0	01:20
JUNCT_1590	DIVIDER	4.69	6.00	5350.24	0	00:40
JUNCT_1600	DIVIDER	1.98	4.00	5361.38	0	00:30
JUNCT_1650	DIVIDER	4.73	6.00	5356.44	0	00:40
JUNCT_1660	DIVIDER	1.20	2.75	5390.38	0	00:30
JUNCT_1662	DIVIDER	1.37	2.75	5374.26	0	00:25
JUNCT_1671	DIVIDER	0.83	1.75	5409.11	0	00:25
JUNCT_1680	DIVIDER	2.75	3.92	5366.96	0	01:10
JUNCT_1688	DIVIDER	1.66	4.50	5377.11	0	00:30
JUNCT_1690	DIVIDER	3.66	5.00	5373.77	0	00:45
JUNCT_170	DIVIDER	1.63	2.50	5274.18	0	00:30
JUNCT_1700	DIVIDER	3.25	5.87	5386.21	0	01:05
JUNCT_1702	DIVIDER	3.61	5.00	5377.65	0	00:40
JUNCT_1730	DIVIDER	3.94	5.87	5401.96	0	01:05
JUNCT_1740	DIVIDER	3.62	4.00	5408.15	0	00:30
JUNCT_1752	DIVIDER	3.22	3.50	5415.25	0	00:25
JUNCT_1754	DIVIDER	4.00	6.50	5425.61	0	00:50
JUNCT_1756	DIVIDER	3.01	3.50	5424.13	0	00:25
JUNCT_1757	DIVIDER	2.23	2.50	5433.02	0	00:25
JUNCT_1822	DIVIDER	1.43	1.75	5486.59	0	00:25
JUNCT_280	DIVIDER	1.50	3.50	5366.86	0	00:30
JUNCT_310	DIVIDER	0.36	0.50	5362.04	0	00:40
JUNCT_347	DIVIDER	1.77	2.00	5452.71	0	00:25
JUNCT_349	DIVIDER	2.25	3.00	5441.11	0	00:55
JUNCT_380	DIVIDER	2.30	2.50	5443.07	0	00:30
JUNCT_460	DIVIDER	0.60	1.07	5332.90	0	00:55
JUNCT_500	DIVIDER	1.17	2.24	5351.71	0	00:55
JUNCT_560	DIVIDER	1.52	4.00	5336.19	0	00:40
JUNCT_605	DIVIDER	1.64	4.00	5370.53	0	00:45
JUNCT_610	DIVIDER	2.04	4.00	5356.82	0	00:30
JUNCT_620	DIVIDER	0.88	2.00	5373.73	0	00:35
JUNCT_625	DIVIDER	1.43	3.50	5375.76	0	00:35
JUNCT_670	DIVIDER	0.74	1.75	5424.10	0	00:25
JUNCT_770	DIVIDER	1.20	3.00	5465.09	0	00:30
JUNCT_780	DIVIDER	1.16	2.50	5471.25	0	00:30
JUNCT_790	DIVIDER	3.59	6.50	5463.12	0	00:45
JUNCT_800	DIVIDER	3.51	6.00	5467.47	0	00:35
JUNCT_810	DIVIDER	1.41	2.50	5528.67	0	00:30
JUNCT_821	DIVIDER	0.97	1.75	5544.01	0	00:35
JUNCT_830	DIVIDER	2.83	5.00	5469.32	0	00:35
JUNCT_840	DIVIDER	1.28	1.75	5534.35	0	00:30
JUNCT_881	DIVIDER	1.76	3.00	5453.96	0	00:45
JUNCT_1075	DIVIDER	2.16	4.50	5265.62	0	00:45
JUNCT_1148	DIVIDER	1.59	1.91	5268.25	0	00:30
JUNCT_1040	DIVIDER	2.06	4.00	5252.83	0	01:05

JUNCT_1141	DIVIDER	1.95	5.00	5255.56	0	00:45
JUNCT_671	STORAGE	18.80	25.90	5483.95	0	04:15
JUNCT_1090	STORAGE	4.14	6.01	5306.79	0	02:15
JUNCT_1330	STORAGE	0.99	1.61	5387.93	0	01:15

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
JUNCT_10	JUNCTION	27.14	27.14	0	00:45	0.990	0.990
JUNCT_100	JUNCTION	18.01	18.01	0	00:50	0.785	0.785
JUNCT_1010	JUNCTION	0.00	390.08	0	01:00	0.000	15.414
JUNCT_1073	JUNCTION	0.00	29.81	0	01:10	0.000	1.733
JUNCT_110	JUNCTION	44.28	44.28	0	01:05	2.388	2.382
JUNCT_1110	JUNCTION	0.00	61.46	0	01:05	0.000	3.167
JUNCT_1120	JUNCTION	0.00	111.03	0	00:50	0.000	6.757
JUNCT_1150	JUNCTION	0.00	5085.13	0	01:40	0.000	234.327
JUNCT_120	JUNCTION	60.13	60.13	0	00:50	2.256	2.256
JUNCT_1212	JUNCTION	0.00	1319.74	0	01:20	0.000	65.505
JUNCT_130	JUNCTION	6.06	6.06	0	01:15	0.420	0.418
JUNCT_1385	JUNCTION	0.00	41.45	0	01:25	0.000	2.429
JUNCT_1390	JUNCTION	0.00	312.67	0	01:20	0.000	17.467
JUNCT_1400	JUNCTION	0.00	279.84	0	01:15	0.000	15.464
JUNCT_1430	JUNCTION	0.00	152.49	0	01:05	0.000	7.515
JUNCT_150	JUNCTION	70.53	70.53	0	00:55	3.009	3.008
JUNCT_1593	JUNCTION	0.00	149.22	0	00:45	0.000	3.422
JUNCT_160	JUNCTION	27.11	27.11	0	00:55	1.248	1.248
JUNCT_1675	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
JUNCT_1686	JUNCTION	0.00	97.88	0	00:40	0.000	2.125
JUNCT_1692	JUNCTION	0.00	239.31	0	00:40	0.000	5.162
JUNCT_1694	JUNCTION	0.00	164.27	0	00:40	0.000	3.539
JUNCT_1696	JUNCTION	0.00	63.83	0	00:40	0.000	1.254
JUNCT_1733	JUNCTION	0.00	193.45	0	00:50	0.000	7.105
JUNCT_1735	JUNCTION	0.00	132.60	0	00:50	0.000	5.023
JUNCT_1737	JUNCTION	0.00	58.15	0	00:50	0.000	2.220
JUNCT_1743	JUNCTION	0.00	255.86	0	00:50	0.000	8.992
JUNCT_1762	JUNCTION	0.00	69.41	0	01:05	0.000	3.602
JUNCT_180	JUNCTION	102.20	102.20	0	00:50	4.014	4.014
JUNCT_190	JUNCTION	11.91	11.91	0	00:55	0.551	0.551
JUNCT_20	JUNCTION	24.61	24.61	0	00:50	0.930	0.930
JUNCT_200	JUNCTION	87.73	87.73	0	00:50	3.200	3.200
JUNCT_210	JUNCTION	25.24	25.24	0	01:00	1.232	1.230
JUNCT_220	JUNCTION	14.06	14.06	0	00:55	0.622	0.622
JUNCT_230	JUNCTION	68.35	68.35	0	00:40	1.654	1.654
JUNCT_240	JUNCTION	61.04	61.04	0	00:55	2.610	2.609
JUNCT_250	JUNCTION	58.36	58.36	0	00:45	1.742	1.742
JUNCT_255	JUNCTION	24.34	24.34	0	01:00	1.221	1.219
JUNCT_260	JUNCTION	30.82	30.82	0	00:50	1.212	1.212
JUNCT_270	JUNCTION	109.73	109.73	0	00:55	4.549	4.548
JUNCT_290	JUNCTION	31.25	31.25	0	00:45	1.137	1.137
JUNCT_30	JUNCTION	10.54	10.54	0	01:00	0.549	0.548
JUNCT_300	JUNCTION	89.46	89.46	0	00:45	2.904	2.904
JUNCT_320	JUNCTION	114.26	114.26	0	00:50	4.528	4.527
JUNCT_330	JUNCTION	126.04	126.04	0	00:50	4.935	4.935
JUNCT_340	JUNCTION	58.86	58.86	0	00:55	2.827	2.823
JUNCT_350	JUNCTION	80.08	80.08	0	00:55	3.379	3.379
JUNCT_360	JUNCTION	85.68	85.68	0	00:50	3.383	3.383
JUNCT_370	JUNCTION	68.55	68.55	0	01:00	3.453	3.446
JUNCT_390	JUNCTION	34.49	34.49	0	01:10	2.220	2.209
JUNCT_40	JUNCTION	72.35	72.35	0	00:45	2.237	2.237
JUNCT_400	JUNCTION	96.90	96.90	0	01:10	5.753	5.731
JUNCT_410	JUNCTION	149.22	149.22	0	00:50	4.540	4.540
JUNCT_420	JUNCTION	141.67	141.67	0	00:45	3.901	3.901
JUNCT_430	JUNCTION	57.08	57.08	0	00:50	2.304	2.303
JUNCT_440	JUNCTION	99.05	99.05	0	01:05	5.261	5.246
JUNCT_450	JUNCTION	18.25	18.25	0	01:05	0.992	0.989
JUNCT_470	JUNCTION	34.82	34.82	0	01:00	1.714	1.711
JUNCT_480	JUNCTION	47.87	47.87	0	00:55	2.176	2.175
JUNCT_490	JUNCTION	32.45	32.45	0	01:00	1.565	1.563
JUNCT_50	JUNCTION	18.53	18.53	0	00:50	0.791	0.791
JUNCT_510	JUNCTION	79.93	79.93	0	00:40	1.596	1.596
JUNCT_520	JUNCTION	118.93	118.93	0	00:45	2.717	2.717
JUNCT_531	JUNCTION	31.29	31.29	0	00:40	0.705	0.705
JUNCT_532	JUNCTION	100.74	100.74	0	00:35	1.375	1.375
JUNCT_533	JUNCTION	101.74	101.74	0	00:40	1.826	1.826
JUNCT_540	JUNCTION	90.15	90.15	0	00:55	3.999	3.997
JUNCT_550	JUNCTION	63.96	63.96	0	01:00	3.076	3.073
JUNCT_570	JUNCTION	87.94	87.94	0	00:40	1.860	1.860
JUNCT_580	JUNCTION	105.05	105.05	0	00:45	2.519	2.519
JUNCT_590	JUNCTION	38.18	38.18	0	00:45	0.984	0.984
JUNCT_60	JUNCTION	88.22	88.22	0	01:05	4.795	4.782
JUNCT_600	JUNCTION	167.28	167.28	0	00:35	2.627	2.627
JUNCT_631	JUNCTION	32.23	32.23	0	00:40	0.662	0.662
JUNCT_632	JUNCTION	79.08	79.08	0	00:45	2.050	2.050
JUNCT_633	JUNCTION	93.90	93.90	0	00:40	1.770	1.770
JUNCT_640	JUNCTION	35.68	35.68	0	00:55	1.540	1.540
JUNCT_651	JUNCTION	130.06	130.06	0	00:40	2.779	2.779
JUNCT_652	JUNCTION	48.42	48.42	0	00:40	0.968	0.968
JUNCT_661	JUNCTION	114.40	114.40	0	00:40	2.560	2.560
JUNCT_662	JUNCTION	101.57	101.57	0	00:40	2.248	2.248
JUNCT_663	JUNCTION	94.63	94.63	0	00:35	1.565	1.565
JUNCT_681	JUNCTION	97.88	97.88	0	00:40	2.125	2.125
JUNCT_682	JUNCTION	53.85	53.85	0	00:45	1.490	1.490
JUNCT_691	JUNCTION	78.56	78.56	0	00:40	1.602	1.602
JUNCT_692	JUNCTION	99.85	99.85	0	00:40	2.275	2.275
JUNCT_693	JUNCTION	63.83	63.83	0	00:40	1.254	1.254
JUNCT_694	JUNCTION	44.92	44.92	0	00:40	0.911	0.911
JUNCT_695	JUNCTION	38.46	38.46	0	00:40	0.892	0.892
JUNCT_700	JUNCTION	29.38	29.38	0	00:50	1.197	1.197
JUNCT_71	JUNCTION	43.33	43.33	0	00:45	1.582	1.582
JUNCT_711	JUNCTION	41.51	41.51	0	00:55	2.024	2.021
JUNCT_712	JUNCTION	82.52	82.52	0	00:45	2.708	2.708
JUNCT_72	JUNCTION	29.81	29.81	0	01:10	1.740	1.733
JUNCT_721	JUNCTION	43.85	43.85	0	00:45	1.615	1.615
JUNCT_722	JUNCTION	64.60	64.60	0	00:45	2.073	2.073
JUNCT_723	JUNCTION	74.43	74.43	0	00:50	2.796	2.796
JUNCT_724	JUNCTION	58.15	58.15	0	00:50	2.220	2.220
JUNCT_73	JUNCTION	35.45	35.45	0	00:50	1.368	1.368
JUNCT_731	JUNCTION	102.72	102.72	0	00:55	4.527	4.526
JUNCT_732	JUNCTION	50.17	50.17	0	00:45	1.737	1.737
JUNCT_733	JUNCTION	88.52	88.52	0	00:45	3.139	3.139
JUNCT_741	JUNCTION	41.20	41.20	0	00:50	1.565	1.565
JUNCT_742	JUNCTION	54.65	54.65	0	00:50	2.183	2.183
JUNCT_743	JUNCTION	47.45	47.45	0	00:55	2.068	2.068
JUNCT_744	JUNCTION	41.91	41.91	0	01:00	2.103	2.100
JUNCT_751	JUNCTION	30.80	30.80	0	01:00	1.577	1.574
JUNCT_752	JUNCTION	69.40	69.40	0	01:05	3.657	3.648
JUNCT_760	JUNCTION	10.20	109.95	0	00:45	0.698	3.822
JUNCT_769	JUNCTION	0.00	28.67	0	01:05	0.000	1.593
JUNCT_771	JUNCTION	28.67	28.67	0	01:05	1.599	1.593
JUNCT_772	JUNCTION	102.15	102.15	0	00:45	3.102	3.102
JUNCT_80	JUNCTION	23.95	23.95	0	01:05	1.365	1.360
JUNCT_820	JUNCTION	88.00	186.53	0	00:50	2.695	7.233
JUNCT_831	JUNCTION	58.54	58.54	0	00:45	1.951	1.951
JUNCT_832	JUNCTION	59.75	59.75	0	00:50	2.442	2.441
JUNCT_860	JUNCTION	132.02	132.02	0	00:50	4.746	4.746
JUNCT_870	JUNCTION	63.89	63.89	0	00:50	2.307	2.307
JUNCT_871	JUNCTION	32.65	32.65	0	00:55	1.454	1.453
JUNCT_872	JUNCTION	12.42	12.42	0	00:50	0.512	0.511
JUNCT_880	JUNCTION	108.01	108.01	0	01:00	5.370	5.361
JUNCT_90	JUNCTION	14.66	14.66	0	01:10	0.969	0.964
JUNCT_95	JUNCTION	16.86	16.86	0	00:55	0.756	0.756
ROOT_JUNCT_1010	OUTFALL	0.00	390.08	0	01:00	0.000	15.414
ROOT_JUNCT_1120	OUTFALL	0.00	111.03	0	00:50	0.000	6.757
ROOT_JUNCT_1150	OUTFALL	0.00	5085.13	0	01:40	0.000	234.327

JUNCT_1020	DIVIDER	0.00	364.10	0	01:00	0.000	14.446
JUNCT_1030	DIVIDER	0.00	340.02	0	01:00	0.000	13.530
JUNCT_1060	DIVIDER	0.00	208.59	0	01:05	0.000	10.259
JUNCT_1061	DIVIDER	0.00	129.91	0	01:05	0.000	6.598
JUNCT_1065	DIVIDER	0.00	78.68	0	01:05	0.000	3.660
JUNCT_1070	DIVIDER	0.00	208.70	0	01:05	0.000	10.253
JUNCT_1077	DIVIDER	0.00	35.45	0	00:50	0.000	1.368
JUNCT_1080	DIVIDER	0.00	4951.91	0	01:30	0.000	224.275
JUNCT_1091	DIVIDER	0.00	43.23	0	02:15	0.000	2.617
JUNCT_1095	DIVIDER	0.00	3612.01	0	01:25	0.000	155.909
JUNCT_1130	DIVIDER	0.00	52.07	0	01:15	0.000	4.519
JUNCT_1140	DIVIDER	0.00	195.02	0	00:55	0.000	7.049
JUNCT_1160	DIVIDER	0.00	5044.16	0	01:35	0.000	231.541
JUNCT_1180	DIVIDER	0.00	4993.94	0	01:35	0.000	227.981
JUNCT_1190	DIVIDER	0.00	4927.90	0	01:25	0.000	223.873
JUNCT_1200	DIVIDER	0.00	4922.73	0	01:25	0.000	223.675
JUNCT_1210	DIVIDER	0.00	1253.03	0	01:20	0.000	62.346
JUNCT_1230	DIVIDER	0.00	1219.72	0	01:15	0.000	60.552
JUNCT_1250	DIVIDER	0.00	1136.29	0	01:15	0.000	56.332
JUNCT_1260	DIVIDER	0.00	53.93	0	00:55	0.000	2.427
JUNCT_1270	DIVIDER	0.00	1047.61	0	01:15	0.000	52.162
JUNCT_1290	DIVIDER	0.00	132.87	0	00:45	0.000	4.166
JUNCT_1292	DIVIDER	0.00	931.05	0	01:15	0.000	46.314
JUNCT_1294	DIVIDER	0.00	956.88	0	01:15	0.000	47.640
JUNCT_1300	DIVIDER	0.00	833.15	0	01:15	0.000	42.310
JUNCT_1320	DIVIDER	0.00	767.56	0	01:15	0.000	39.376
JUNCT_1331	DIVIDER	0.00	671.12	0	01:15	0.000	34.831
JUNCT_1360	DIVIDER	0.00	571.42	0	01:10	0.000	30.332
JUNCT_1370	DIVIDER	0.00	127.18	0	01:00	0.000	6.269
JUNCT_140	DIVIDER	117.67	241.02	0	00:55	4.575	11.154
JUNCT_1450	DIVIDER	0.00	3623.13	0	01:25	0.000	155.596
JUNCT_1480	DIVIDER	0.00	3353.47	0	01:20	0.000	142.073
JUNCT_1490	DIVIDER	0.00	3273.95	0	01:20	0.000	137.861
JUNCT_1540	DIVIDER	0.00	187.57	0	00:55	0.000	7.537
JUNCT_1550	DIVIDER	0.00	3608.84	0	01:20	0.000	154.744
JUNCT_1570	DIVIDER	0.00	3238.17	0	01:20	0.000	136.369
JUNCT_1590	DIVIDER	0.00	3245.44	0	01:10	0.000	133.143
JUNCT_1600	DIVIDER	0.00	244.56	0	00:55	0.000	7.879
JUNCT_1650	DIVIDER	0.00	3035.38	0	01:05	0.000	124.429
JUNCT_1660	DIVIDER	0.00	308.08	0	00:45	0.000	6.522
JUNCT_1662	DIVIDER	0.00	533.87	0	00:45	0.000	11.450
JUNCT_1671	DIVIDER	0.00	212.52	0	00:40	0.000	4.261
JUNCT_1680	DIVIDER	0.00	2380.21	0	01:10	0.000	100.421
JUNCT_1688	DIVIDER	0.00	275.04	0	00:45	0.000	6.077
JUNCT_1690	DIVIDER	0.00	2233.08	0	01:05	0.000	94.798
JUNCT_170	DIVIDER	61.07	61.07	0	00:55	2.623	2.623
JUNCT_1700	DIVIDER	0.00	1980.47	0	01:05	0.000	86.293
JUNCT_1702	DIVIDER	0.00	2047.88	0	01:05	0.000	88.942
JUNCT_1730	DIVIDER	0.00	1919.04	0	01:05	0.000	83.612
JUNCT_1740	DIVIDER	0.00	1464.51	0	01:05	0.000	64.088
JUNCT_1752	DIVIDER	0.00	1195.41	0	01:05	0.000	53.551
JUNCT_1754	DIVIDER	0.00	1108.90	0	01:05	0.000	49.754
JUNCT_1756	DIVIDER	0.00	559.23	0	00:55	0.000	25.132
JUNCT_1757	DIVIDER	0.00	443.37	0	00:55	0.000	20.404
JUNCT_1822	DIVIDER	0.00	243.25	0	00:50	0.000	9.205
JUNCT_280	DIVIDER	101.62	101.62	0	00:45	3.014	3.014
JUNCT_310	DIVIDER	25.87	25.87	0	01:00	1.318	1.315
JUNCT_347	DIVIDER	0.00	213.40	0	00:55	0.000	9.632
JUNCT_349	DIVIDER	0.00	374.85	0	00:55	0.000	16.746
JUNCT_380	DIVIDER	43.33	43.33	0	01:05	2.487	2.478
JUNCT_460	DIVIDER	11.92	11.92	0	00:55	0.560	0.560
JUNCT_500	DIVIDER	47.86	47.86	0	00:55	2.215	2.213
JUNCT_560	DIVIDER	101.15	101.15	0	00:45	3.488	3.488
JUNCT_605	DIVIDER	35.41	131.63	0	00:55	1.339	4.206
JUNCT_610	DIVIDER	46.98	288.41	0	00:45	1.251	9.163
JUNCT_620	DIVIDER	33.41	33.41	0	00:50	1.001	1.001
JUNCT_625	DIVIDER	97.88	97.88	0	00:50	2.849	2.849
JUNCT_670	DIVIDER	124.12	124.12	0	00:40	2.690	2.690
JUNCT_770	DIVIDER	0.00	102.15	0	00:45	0.000	3.102
JUNCT_780	DIVIDER	92.94	92.94	0	00:45	2.942	2.942
JUNCT_790	DIVIDER	76.51	534.41	0	01:00	3.406	22.397
JUNCT_800	DIVIDER	65.50	458.75	0	00:55	3.480	18.983
JUNCT_810	DIVIDER	96.56	96.56	0	00:50	3.799	3.798
JUNCT_821	DIVIDER	26.94	26.94	0	00:55	1.207	1.206
JUNCT_830	DIVIDER	0.00	301.96	0	00:55	0.000	11.653
JUNCT_840	DIVIDER	77.78	77.78	0	00:55	3.309	3.308
JUNCT_881	DIVIDER	43.72	43.72	0	01:05	2.368	2.361
JUNCT_1075	DIVIDER	0.00	103.18	0	01:05	0.000	4.662
JUNCT_1148	DIVIDER	0.00	46.00	0	00:30	0.000	4.105
JUNCT_1040	DIVIDER	0.00	137.73	0	00:55	0.000	5.905
JUNCT_1141	DIVIDER	0.00	195.45	0	01:00	0.000	7.082
JUNCT_671	STORAGE	0.00	288.12	0	00:45	0.000	8.440
JUNCT_1090	STORAGE	0.00	75.86	0	01:05	0.000	4.115
JUNCT_1330	STORAGE	0.00	672.82	0	01:15	0.000	35.024

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Node Surcharge Summary
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Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
JUNCT_10	JUNCTION	4.25	0.000	0.000
JUNCT_100	JUNCTION	4.25	0.000	0.000
JUNCT_110	JUNCTION	4.25	0.000	0.000
JUNCT_120	JUNCTION	4.25	0.000	0.000
JUNCT_130	JUNCTION	4.25	0.000	0.000
JUNCT_150	JUNCTION	4.25	0.000	0.000
JUNCT_160	JUNCTION	4.25	0.000	0.000
JUNCT_180	JUNCTION	4.25	0.000	0.000
JUNCT_190	JUNCTION	4.25	0.000	0.000
JUNCT_20	JUNCTION	4.25	0.000	0.000
JUNCT_200	JUNCTION	4.25	0.000	0.000
JUNCT_210	JUNCTION	4.25	0.000	0.000
JUNCT_220	JUNCTION	4.25	0.000	0.000
JUNCT_230	JUNCTION	4.25	0.000	0.000
JUNCT_250	JUNCTION	4.25	0.000	0.000
JUNCT_260	JUNCTION	4.25	0.000	0.000
JUNCT_270	JUNCTION	4.25	0.000	0.000
JUNCT_290	JUNCTION	4.25	0.000	0.000
JUNCT_30	JUNCTION	4.25	0.000	0.000
JUNCT_300	JUNCTION	4.25	0.000	0.000
JUNCT_320	JUNCTION	4.25	0.000	0.000
JUNCT_330	JUNCTION	4.25	0.000	0.000
JUNCT_340	JUNCTION	4.25	0.000	0.000
JUNCT_350	JUNCTION	4.25	0.000	0.000
JUNCT_360	JUNCTION	4.25	0.000	0.000
JUNCT_370	JUNCTION	4.25	0.000	0.000
JUNCT_390	JUNCTION	4.25	0.000	0.000
JUNCT_40	JUNCTION	4.25	0.000	0.000
JUNCT_400	JUNCTION	4.25	0.000	0.000
JUNCT_410	JUNCTION	4.25	0.000	0.000
JUNCT_420	JUNCTION	4.25	0.000	0.000
JUNCT_430	JUNCTION	4.25	0.000	0.000
JUNCT_450	JUNCTION	4.25	0.000	0.000
JUNCT_470	JUNCTION	4.25	0.000	0.000
JUNCT_480	JUNCTION	4.25	0.000	0.000
JUNCT_490	JUNCTION	4.25	0.000	0.000
JUNCT_50	JUNCTION	4.25	0.000	0.000
JUNCT_510	JUNCTION	4.25	0.000	0.000
JUNCT_520	JUNCTION	4.25	0.000	0.000
JUNCT_531	JUNCTION	4.25	0.000	0.000
JUNCT_532	JUNCTION	4.25	0.000	0.000
JUNCT_533	JUNCTION	4.25	0.000	0.000
JUNCT_540	JUNCTION	4.25	0.000	0.000
JUNCT_550	JUNCTION	4.25	0.000	0.000
JUNCT_570	JUNCTION	4.25	0.000	0.000
JUNCT_580	JUNCTION	4.25	0.000	0.000

JUNCT_590	JUNCTION	4.25	0.000	0.000
JUNCT_60	JUNCTION	4.25	0.000	0.000
JUNCT_600	JUNCTION	4.25	0.000	0.000
JUNCT_631	JUNCTION	4.25	0.000	0.000
JUNCT_632	JUNCTION	4.25	0.000	0.000
JUNCT_633	JUNCTION	4.25	0.000	0.000
JUNCT_640	JUNCTION	4.25	0.000	0.000
JUNCT_651	JUNCTION	4.25	0.000	0.000
JUNCT_652	JUNCTION	4.25	0.000	0.000
JUNCT_661	JUNCTION	4.25	0.000	0.000
JUNCT_662	JUNCTION	4.25	0.000	0.000
JUNCT_663	JUNCTION	4.25	0.000	0.000
JUNCT_681	JUNCTION	4.25	0.000	0.000
JUNCT_682	JUNCTION	4.25	0.000	0.000
JUNCT_691	JUNCTION	4.25	0.000	0.000
JUNCT_692	JUNCTION	4.25	0.000	0.000
JUNCT_693	JUNCTION	4.25	0.000	0.000
JUNCT_694	JUNCTION	4.25	0.000	0.000
JUNCT_695	JUNCTION	4.25	0.000	0.000
JUNCT_700	JUNCTION	4.25	0.000	0.000
JUNCT_71	JUNCTION	4.25	0.000	0.000
JUNCT_711	JUNCTION	4.25	0.000	0.000
JUNCT_712	JUNCTION	4.25	0.000	0.000
JUNCT_72	JUNCTION	4.25	0.000	0.000
JUNCT_721	JUNCTION	4.25	0.000	0.000
JUNCT_722	JUNCTION	4.25	0.000	0.000
JUNCT_723	JUNCTION	4.25	0.000	0.000
JUNCT_724	JUNCTION	4.25	0.000	0.000
JUNCT_73	JUNCTION	4.25	0.000	0.000
JUNCT_731	JUNCTION	4.25	0.000	0.000
JUNCT_732	JUNCTION	4.25	0.000	0.000
JUNCT_733	JUNCTION	4.25	0.000	0.000
JUNCT_741	JUNCTION	4.25	0.000	0.000
JUNCT_742	JUNCTION	4.25	0.000	0.000
JUNCT_743	JUNCTION	4.25	0.000	0.000
JUNCT_744	JUNCTION	4.25	0.000	0.000
JUNCT_751	JUNCTION	4.25	0.000	0.000
JUNCT_752	JUNCTION	4.25	0.000	0.000
JUNCT_771	JUNCTION	4.25	0.000	0.000
JUNCT_772	JUNCTION	4.25	0.000	0.000
JUNCT_80	JUNCTION	4.25	0.000	0.000
JUNCT_831	JUNCTION	4.25	0.000	0.000
JUNCT_832	JUNCTION	4.25	0.000	0.000
JUNCT_860	JUNCTION	4.25	0.000	0.000
JUNCT_870	JUNCTION	4.25	0.000	0.000
JUNCT_871	JUNCTION	4.25	0.000	0.000
JUNCT_872	JUNCTION	4.25	0.000	0.000
JUNCT_880	JUNCTION	4.25	0.000	0.000
JUNCT_90	JUNCTION	4.25	0.000	0.000
JUNCT_95	JUNCTION	4.25	0.000	0.000
JUNCT_1060	DIVIDER	4.25	0.000	0.000
JUNCT_671	STORAGE	4.25	25.904	13601.096

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Node Flooding Summary
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No nodes were flooded.

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Storage Volume Summary
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Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	E&I Pcnt Loss	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
JUNCT_671	819.183	0	0	1128.404	0	0 04:15	0.00
JUNCT_1090	180.211	0	0	261.924	0	0 02:15	43.23
JUNCT_1330	43.011	0	0	69.955	1	0 01:15	671.12

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Outfall Loading Summary
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Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
ROOT_JUNCT_1010	98.04	137.46	390.08	15.414
ROOT_JUNCT_1120	98.04	60.39	111.03	6.757
ROOT_JUNCT_1150	98.04	2092.81	5085.13	234.327
System	98.04	2290.65	5438.11	256.497

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Link Flow Summary
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Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
10	DUMMY	27.14	0 00:45			
100	DUMMY	18.01	0 00:50			
1010	DUMMY	390.08	0 01:00			
1021	CONDUIT	364.64	0 01:00	10.27	0.44	0.46
1021-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1031	CONDUIT	340.95	0 01:00	10.27	0.40	0.44
1031-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
110	DUMMY	44.28	0 01:05			
1041	CONDUIT	136.34	0 00:55	7.12	0.74	0.64
1041-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1060	DUMMY	78.68	0 01:05			
1060-DIV	DUMMY	129.91	0 01:05			
1061	CONDUIT	129.86	0 01:05	10.45	0.88	0.73
1061-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1065	CONDUIT	72.11	0 00:55	6.52	1.04	1.00
1065-OVERFLOW	CONDUIT	8.25	0 01:15	4.73	0.00	0.02
1071	CONDUIT	161.35	0 01:35	7.39	1.05	1.00
1071-OVERFLOW	CONDUIT	54.80	0 01:05	4.00	0.00	0.04
1072	CONDUIT	29.70	0 01:15	4.18	0.00	0.03
1074	CONDUIT	89.89	0 01:20	6.19	1.06	1.00
1074-OVERFLOW	CONDUIT	17.90	0 01:00	4.17	0.00	0.03
1076	CONDUIT	32.74	0 01:05	5.12	1.06	1.00
1076-OVERFLOW	CONDUIT	4.19	0 00:55	2.56	0.00	0.01
1081	CONDUIT	2336.95	0 01:00	18.54	1.00	1.00
1081-OVERFLOW	CONDUIT	2592.79	0 01:35	7.78	0.02	0.23
1091	CONDUIT	35.19	0 03:05	7.94	1.04	1.00
1091-OVERFLOW	CONDUIT	9.43	0 02:20	1.38	0.00	0.01
1096	CONDUIT	3613.84	0 01:30	6.79	0.16	0.48
1096-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1111	CONDUIT	61.41	0 01:05	3.09	0.00	0.03
1120	DUMMY	111.03	0 00:50			
1131	CONDUIT	52.06	0 01:20	9.71	0.85	0.71
1131-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1140	CONDUIT	147.91	0 01:30	8.07	1.07	1.00
1140-OVERFLOW	CONDUIT	57.42	0 01:00	5.11	0.00	0.04
1142	CONDUIT	194.43	0 01:00	9.17	0.72	0.63
1142-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1148	CONDUIT	46.41	0 00:35	9.77	0.74	0.64
1148-OVERFLOW	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
1150	DUMMY	5085.13	0 01:40			
1161	CONDUIT	3043.74	0 01:10	24.14	1.00	1.00
1161-OVERFLOW	CONDUIT	1996.38	0 01:40	8.13	0.01	0.18

1170	CONDUIT	20.68	0	02:25	4.74	1.04	1.00
1170-OVERFLOW	CONDUIT	41.25	0	00:55	4.82	0.00	0.04
1181	CONDUIT	1810.16	0	00:55	14.36	1.00	1.00
1181-OVERFLOW	CONDUIT	3170.76	0	01:35	6.56	0.04	0.27
1191	CONDUIT	4931.45	0	01:30	3.92	0.49	0.76
1191-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
20	DUMMY	24.61	0	00:50			
30	DUMMY	10.54	0	01:00			
40	DUMMY	72.35	0	00:45			
50	DUMMY	18.53	0	00:50			
60	DUMMY	88.22	0	01:05			
71	DUMMY	43.33	0	00:45			
72	DUMMY	29.81	0	01:10			
73	DUMMY	35.45	0	00:50			
80	DUMMY	23.95	0	01:05			
90	DUMMY	14.66	0	01:10			
95	DUMMY	16.86	0	00:55			
120	DUMMY	60.13	0	00:50			
1201-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1211-OVERFLOW	CONDUIT	887.87	0	01:20	13.37	0.00	0.11
1231-OVERFLOW	CONDUIT	1093.07	0	01:20	5.51	0.01	0.16
1251-OVERFLOW	CONDUIT	955.56	0	01:20	10.44	0.00	0.13
1261-OVERFLOW	CONDUIT	36.13	0	01:00	5.14	0.00	0.04
1271-OVERFLOW	CONDUIT	827.19	0	01:15	7.78	0.00	0.11
1280-OVERFLOW	CONDUIT	58.08	0	00:45	4.40	0.00	0.05
1291-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1293-OVERFLOW	CONDUIT	753.61	0	01:15	6.51	0.00	0.12
1295-OVERFLOW	CONDUIT	789.51	0	01:15	8.68	0.00	0.13
130	DUMMY	6.06	0	01:15			
140	DUMMY	46.00	0	00:30			
150	DUMMY	70.53	0	00:55			
160	DUMMY	27.11	0	00:55			
180	DUMMY	102.20	0	00:50			
190	DUMMY	11.91	0	00:55			
200	DUMMY	87.73	0	00:50			
210	DUMMY	25.24	0	01:00			
220	DUMMY	14.06	0	00:55			
230	DUMMY	68.35	0	00:40			
250	DUMMY	58.36	0	00:45			
260	DUMMY	30.82	0	00:50			
270	DUMMY	109.73	0	00:55			
290	DUMMY	31.25	0	00:45			
300	DUMMY	89.46	0	00:45			
320	DUMMY	114.26	0	00:50			
330	DUMMY	126.04	0	00:50			
340	DUMMY	58.86	0	00:55			
348	CONDUIT	20.25	0	03:40	7.04	1.07	1.00
350	DUMMY	80.08	0	00:55			
360	DUMMY	85.68	0	00:50			
370	DUMMY	68.55	0	01:00			
390	DUMMY	34.49	0	01:10			
400	DUMMY	96.90	0	01:10			
410	DUMMY	149.22	0	00:50			
420	DUMMY	141.67	0	00:45			
430	DUMMY	57.08	0	00:50			
450	DUMMY	18.25	0	01:05			
470	DUMMY	34.82	0	01:00			
480	DUMMY	47.87	0	00:55			
490	DUMMY	32.45	0	01:00			
510	DUMMY	79.93	0	00:40			
520	DUMMY	118.93	0	00:45			
531	DUMMY	31.29	0	00:40			
532	DUMMY	100.74	0	00:35			
533	DUMMY	101.74	0	00:40			
540	DUMMY	90.15	0	00:55			
550	DUMMY	63.96	0	01:00			
570	DUMMY	87.94	0	00:40			
580	DUMMY	105.05	0	00:45			
590	DUMMY	38.18	0	00:45			
600	DUMMY	167.28	0	00:35			
631	DUMMY	32.23	0	00:40			
632	DUMMY	79.08	0	00:45			
633	DUMMY	93.90	0	00:40			
640	DUMMY	35.68	0	00:55			
651	DUMMY	130.06	0	00:40			
652	DUMMY	48.42	0	00:40			
661	DUMMY	114.40	0	00:40			
662	DUMMY	101.57	0	00:40			
663	DUMMY	94.63	0	00:35			
681	DUMMY	97.88	0	00:40			
682	DUMMY	53.85	0	00:45			
691	DUMMY	78.56	0	00:40			
692	DUMMY	99.85	0	00:40			
693	DUMMY	63.83	0	00:40			
694	DUMMY	44.92	0	00:40			
695	DUMMY	38.46	0	00:40			
700	DUMMY	29.38	0	00:50			
711	DUMMY	41.51	0	00:55			
712	DUMMY	82.52	0	00:45			
721	DUMMY	43.85	0	00:45			
722	DUMMY	64.60	0	00:45			
723	DUMMY	74.43	0	00:50			
724	DUMMY	58.15	0	00:50			
731	DUMMY	102.72	0	00:55			
732	DUMMY	50.17	0	00:45			
733	DUMMY	88.52	0	00:45			
741	DUMMY	41.20	0	00:50			
742	DUMMY	54.65	0	00:50			
743	DUMMY	47.45	0	00:55			
744	DUMMY	41.91	0	01:00			
751	DUMMY	30.80	0	01:00			
752	DUMMY	69.40	0	01:05			
771	DUMMY	28.67	0	01:05			
772	DUMMY	102.15	0	00:45			
831	DUMMY	58.54	0	00:45			
832	DUMMY	59.75	0	00:50			
860	DUMMY	132.02	0	00:50			
870	DUMMY	63.89	0	00:50			
871	DUMMY	32.65	0	00:55			
872	DUMMY	12.42	0	00:50			
880	DUMMY	108.01	0	01:00			
1201	CONDUIT	4918.35	0	01:25	5.08	0.35	0.66
1211	CONDUIT	381.31	0	03:05	15.11	1.04	1.00
1212	DUMMY	1319.74	0	01:20			
1231	CONDUIT	128.90	0	04:05	6.23	1.02	1.00
1240	CONDUIT	60.97	0	00:55	4.51	0.00	0.04
1251	CONDUIT	184.53	0	03:45	8.84	1.04	1.00
1255	CONDUIT	24.28	0	01:05	4.86	0.00	0.02
1261	CONDUIT	18.26	0	02:35	5.03	1.05	1.00
1271	CONDUIT	224.40	0	03:25	10.59	1.03	1.00
1280	CONDUIT	46.38	0	01:30	5.20	1.07	1.00
1291	CONDUIT	133.74	0	00:50	12.11	1.01	0.91
1293	CONDUIT	186.40	0	03:25	8.55	1.05	1.00
1295	CONDUIT	171.00	0	03:40	8.08	1.05	1.00
1301	CONDUIT	833.48	0	01:15	4.73	0.55	0.80
1301-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1310	CONDUIT	19.58	0	00:45	3.76	1.00	1.00
1310-OVERFLOW	CONDUIT	6.12	0	01:10	3.51	0.00	0.01
1321	CONDUIT	307.63	0	02:50	16.70	1.07	1.00
1321-OVERFLOW	CONDUIT	480.14	0	01:15	14.51	0.00	0.08
1331	CONDUIT	266.43	0	02:50	14.70	1.06	1.00
1331-OVERFLOW	CONDUIT	418.68	0	01:15	11.47	0.00	0.08
1349	CONDUIT	44.15	0	00:25	10.00	1.04	1.00
1349-OVERFLOW	CONDUIT	400.69	0	00:55	9.19	0.00	0.07
1361	CONDUIT	69.50	0	00:35	5.53	1.00	1.00
1361-OVERFLOW	CONDUIT	499.48	0	01:20	5.53	0.00	0.11
1371	CONDUIT	37.96	0	02:50	8.46	1.07	1.00
1371-OVERFLOW	CONDUIT	91.48	0	01:00	8.98	0.00	0.04
1380	CONDUIT	4.59	0	00:35	0.93	1.00	1.00
1380-OVERFLOW	CONDUIT	36.86	0	01:25	0.99	0.00	0.05
1385	CONDUIT	40.96	0	01:35	1.38	0.00	0.03
1391	CONDUIT	312.24	0	01:20	6.34	0.00	0.08

1401	CONDUIT	278.83	0	01:20	3.19	0.00	0.06
140-DIV	DUMMY	195.02	0	00:55			
1431	CONDUIT	151.80	0	01:10	5.69	0.00	0.08
1440	CONDUIT	98.70	0	01:05	3.13	0.00	0.01
1451	CONDUIT	3064.75	0	01:10	4.87	1.00	1.00
1451-OVERFLOW	CONDUIT	533.90	0	01:25	2.54	0.01	0.09
1460	CONDUIT	11.88	0	01:00	6.40	0.46	0.48
1460-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1481	CONDUIT	3338.18	0	01:25	16.58	0.99	1.00
1481-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1491	CONDUIT	3269.31	0	01:20	16.45	0.97	0.99
1491-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1500	CONDUIT	47.73	0	01:00	8.50	0.90	0.74
1500-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1541	CONDUIT	53.62	0	02:30	4.90	1.05	1.00
1541-OVERFLOW	CONDUIT	135.24	0	01:05	5.60	0.00	0.07
1551	CONDUIT	2072.43	0	00:55	14.79	1.00	1.00
1551-OVERFLOW	CONDUIT	1534.34	0	01:25	5.24	0.02	0.20
1560	CONDUIT	87.64	0	01:15	7.83	1.07	1.00
1560-OVERFLOW	CONDUIT	15.72	0	01:00	8.11	0.00	0.03
1571	CONDUIT	3245.27	0	01:20	20.61	0.71	0.85
1571-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1591	CONDUIT	2920.95	0	01:10	5.53	1.00	1.00
1591-OVERFLOW	CONDUIT	257.34	0	01:20	3.76	0.00	0.04
1592	CONDUIT	150.36	0	00:45	8.88	0.00	0.04
1601	CONDUIT	87.13	0	01:30	7.74	1.06	1.00
1601-OVERFLOW	CONDUIT	47.47	0	01:00	7.91	0.00	0.04
1602	CONDUIT	86.17	0	01:45	7.64	1.05	1.00
1602-OVERFLOW	CONDUIT	160.21	0	00:40	6.65	0.00	0.06
1610	CONDUIT	83.44	0	01:55	7.58	1.01	1.00
1610-OVERFLOW	CONDUIT	209.51	0	00:45	7.49	0.00	0.07
1620	CONDUIT	14.28	0	01:45	5.39	1.03	1.00
1620-OVERFLOW	CONDUIT	18.24	0	00:55	6.85	0.00	0.03
1625	CONDUIT	50.43	0	01:35	6.13	1.04	1.00
1625-OVERFLOW	CONDUIT	47.55	0	00:55	6.33	0.00	0.04
1651	CONDUIT	847.83	0	00:40	4.38	1.00	1.00
1651-OVERFLOW	CONDUIT	2171.36	0	01:10	3.89	0.02	0.20
1661	CONDUIT	42.61	0	02:05	8.65	1.03	1.00
1661-OVERFLOW	CONDUIT	479.80	0	00:45	11.00	0.00	0.09
1663	CONDUIT	41.93	0	01:50	8.28	1.02	1.00
1663-OVERFLOW	CONDUIT	270.02	0	00:45	9.97	0.00	0.07
1670	CONDUIT	13.60	0	02:00	6.60	1.06	1.00
1670-OVERFLOW	CONDUIT	195.76	0	00:45	9.58	0.00	0.06
1672	CONDUIT	13.32	0	01:50	6.60	1.04	1.00
1672-OVERFLOW	CONDUIT	109.29	0	00:45	8.97	0.00	0.05
1675	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1681	CONDUIT	764.21	0	00:45	3.96	1.00	1.00
1681-OVERFLOW	CONDUIT	1612.98	0	01:10	4.50	0.01	0.14
1685	CONDUIT	97.80	0	00:40	6.66	0.00	0.04
1687	CONDUIT	85.73	0	01:30	6.45	1.01	1.00
1687-OVERFLOW	CONDUIT	190.19	0	00:45	8.06	0.00	0.08
1689	CONDUIT	237.67	0	00:45	6.73	0.00	0.07
1691	CONDUIT	265.53	0	00:40	2.91	1.00	1.00
1691-OVERFLOW	CONDUIT	1963.16	0	01:10	3.71	0.02	0.20
1693	CONDUIT	160.98	0	00:45	6.99	0.00	0.05
1695	CONDUIT	64.42	0	00:40	6.03	0.00	0.04
1701	CONDUIT	900.58	0	00:45	4.02	1.00	1.00
1701-OVERFLOW	CONDUIT	1144.24	0	01:10	3.21	0.01	0.15
1703	CONDUIT	738.80	0	00:40	5.28	1.00	1.00
1703-OVERFLOW	CONDUIT	1235.81	0	01:10	4.21	0.01	0.13
1731	CONDUIT	1918.77	0	01:05	23.35	0.57	0.65
1731-OVERFLOW	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
1732	CONDUIT	192.76	0	00:55	4.65	0.00	0.07
1734	CONDUIT	131.59	0	00:55	3.63	0.00	0.07
1736	CONDUIT	58.17	0	00:50	4.45	0.00	0.04
1741	CONDUIT	90.85	0	04:05	8.34	1.03	1.00
1741-OVERFLOW	CONDUIT	1373.72	0	01:10	8.43	0.01	0.14
1742	CONDUIT	254.42	0	00:55	7.19	0.00	0.07
1751	CONDUIT	63.46	0	04:10	7.65	1.03	1.00
1751-OVERFLOW	CONDUIT	1132.24	0	01:10	8.31	0.00	0.13
1753	CONDUIT	66.17	0	04:00	7.47	1.07	1.00
1753-OVERFLOW	CONDUIT	1043.99	0	01:05	7.87	0.00	0.13
1755	CONDUIT	61.79	0	03:30	7.34	1.00	1.00
1755-OVERFLOW	CONDUIT	497.60	0	00:55	6.53	0.00	0.10
1758	CONDUIT	45.13	0	03:20	9.91	1.06	1.00
1758-OVERFLOW	CONDUIT	333.34	0	00:55	8.79	0.00	0.07
1761	CONDUIT	69.36	0	01:05	6.23	0.00	0.04
1763	CONDUIT	110.04	0	00:50	6.08	0.00	0.05
1769	CONDUIT	28.56	0	01:10	4.92	0.00	0.03
1770	CONDUIT	57.40	0	01:25	9.26	1.03	1.00
1770-OVERFLOW	CONDUIT	46.02	0	00:45	9.82	0.00	0.03
1780	CONDUIT	39.56	0	01:45	9.15	1.05	1.00
1780-OVERFLOW	CONDUIT	53.51	0	00:50	9.36	0.00	0.03
1790	CONDUIT	391.03	0	01:40	13.52	1.04	1.00
1790-OVERFLOW	CONDUIT	148.68	0	01:10	14.95	0.00	0.06
1800	CONDUIT	217.55	0	02:05	8.53	1.06	1.00
1800-OVERFLOW	CONDUIT	253.99	0	01:00	8.27	0.00	0.08
1810	CONDUIT	42.41	0	02:05	10.03	1.04	1.00
1810-OVERFLOW	CONDUIT	54.00	0	01:00	12.00	0.00	0.03
1820	CONDUIT	17.12	0	01:45	7.81	1.06	1.00
1820-OVERFLOW	CONDUIT	10.72	0	01:00	7.42	0.00	0.02
1821	CONDUIT	15.27	0	03:20	7.23	1.05	1.00
1821-OVERFLOW	CONDUIT	228.15	0	00:55	7.30	0.00	0.06
1823	CONDUIT	185.86	0	00:55	8.03	0.00	0.05
1830	CONDUIT	129.12	0	02:00	7.50	1.02	1.00
1830-OVERFLOW	CONDUIT	175.97	0	00:55	5.58	0.00	0.07
1841	CONDUIT	15.60	0	02:55	7.31	1.04	1.00
1841-OVERFLOW	CONDUIT	62.94	0	00:55	7.05	0.00	0.04
1881	CONDUIT	34.27	0	01:55	5.48	1.06	1.00
1881-OVERFLOW	CONDUIT	10.27	0	01:20	6.10	0.00	0.02
348-OVERFLOW	CONDUIT	194.18	0	00:55	6.54	0.00	0.06
OUTLET_671	DUMMY	0.00	0	00:00			
OUTLET_1090	DUMMY	43.23	0	02:15			
OUTLET_1330	DUMMY	671.12	0	01:15			

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Conduit Surcharge Summary
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Conduit	Hours Full: Both Ends	Hours Full: Upstream	Hours Full: Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
10	0.01	0.01	0.01	4.25	0.01
100	0.01	0.01	0.01	4.25	0.01
1010	0.01	0.01	0.01	4.25	0.01
110	0.01	0.01	0.01	4.25	0.01
1060	0.01	0.01	0.01	4.25	0.01
1060-DIV	0.01	0.01	0.01	4.25	0.01
1065	0.33	0.67	0.33	0.33	0.67
1071	0.83	0.92	0.83	0.92	0.92
1074	0.50	0.67	0.50	0.75	0.67
1076	0.33	0.58	0.33	0.50	0.58
1081	1.50	1.58	1.50	0.01	1.58
1091	1.25	1.50	1.25	0.17	1.50
1120	0.01	0.01	0.01	4.25	0.01
1140	0.75	0.92	0.75	0.83	0.92
1150	0.01	0.01	0.01	4.25	0.01
1161	1.25	1.25	1.25	0.01	1.25
1170	1.83	1.92	1.83	1.92	1.92
1181	1.92	1.92	1.92	0.01	1.92
20	0.01	0.01	0.01	4.25	0.01
30	0.01	0.01	0.01	4.25	0.01
40	0.01	0.01	0.01	4.25	0.01
50	0.01	0.01	0.01	4.25	0.01
60	0.01	0.01	0.01	4.25	0.01
71	0.01	0.01	0.01	4.25	0.01
72	0.01	0.01	0.01	4.25	0.01
73	0.01	0.01	0.01	4.25	0.01
80	0.01	0.01	0.01	4.25	0.01

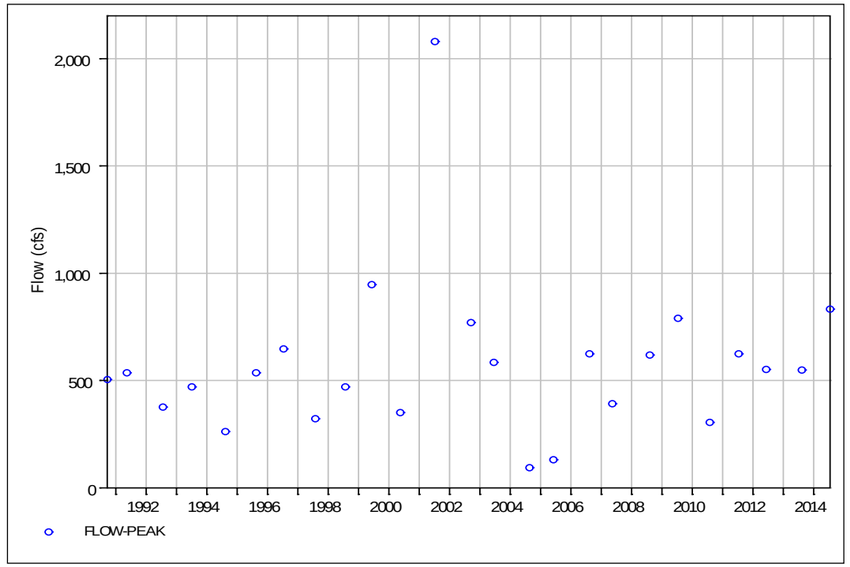
90	0.01	0.01	0.01	4.25	0.01	741	0.01	0.01	0.01	4.25	0.01
95	0.01	0.01	0.01	4.25	0.01	742	0.01	0.01	0.01	4.25	0.01
120	0.01	0.01	0.01	4.25	0.01	743	0.01	0.01	0.01	4.25	0.01
130	0.01	0.01	0.01	4.25	0.01	744	0.01	0.01	0.01	4.25	0.01
140	0.01	0.01	0.01	4.25	0.01	751	0.01	0.01	0.01	4.25	0.01
150	0.01	0.01	0.01	4.25	0.01	752	0.01	0.01	0.01	4.25	0.01
160	0.01	0.01	0.01	4.25	0.01	771	0.01	0.01	0.01	4.25	0.01
180	0.01	0.01	0.01	4.25	0.01	772	0.01	0.01	0.01	4.25	0.01
190	0.01	0.01	0.01	4.25	0.01	831	0.01	0.01	0.01	4.25	0.01
200	0.01	0.01	0.01	4.25	0.01	832	0.01	0.01	0.01	4.25	0.01
210	0.01	0.01	0.01	4.25	0.01	860	0.01	0.01	0.01	4.25	0.01
220	0.01	0.01	0.01	4.25	0.01	870	0.01	0.01	0.01	4.25	0.01
230	0.01	0.01	0.01	4.25	0.01	871	0.01	0.01	0.01	4.25	0.01
250	0.01	0.01	0.01	4.25	0.01	872	0.01	0.01	0.01	4.25	0.01
260	0.01	0.01	0.01	4.25	0.01	880	0.01	0.01	0.01	4.25	0.01
270	0.01	0.01	0.01	4.25	0.01	1211	2.33	2.50	2.33	0.17	2.50
290	0.01	0.01	0.01	4.25	0.01	1212	0.01	0.01	0.01	4.25	0.01
300	0.01	0.01	0.01	4.25	0.01	1231	3.50	3.67	3.50	3.67	3.67
320	0.01	0.01	0.01	4.25	0.01	1251	3.17	3.17	3.17	3.25	3.17
330	0.01	0.01	0.01	4.25	0.01	1261	1.92	2.08	1.92	0.17	2.08
340	0.01	0.01	0.01	4.25	0.01	1271	2.75	2.92	2.75	0.17	2.92
348	3.25	3.33	3.25	0.17	3.33	1280	1.00	1.08	1.00	0.08	1.08
350	0.01	0.01	0.01	4.25	0.01	1291	0.01	0.08	0.01	0.08	0.08
360	0.01	0.01	0.01	4.25	0.01	1293	2.83	2.92	2.83	2.92	2.92
370	0.01	0.01	0.01	4.25	0.01	1295	2.92	3.08	2.92	3.17	3.08
390	0.01	0.01	0.01	4.25	0.01	1310	0.92	1.00	0.92	0.92	1.00
400	0.01	0.01	0.01	4.25	0.01	1321	2.08	2.25	2.08	2.25	2.25
410	0.01	0.01	0.01	4.25	0.01	1331	2.08	2.17	2.08	2.17	2.17
420	0.01	0.01	0.01	4.25	0.01	1349	3.25	3.42	3.25	0.17	3.42
430	0.01	0.01	0.01	4.25	0.01	1361	3.75	3.83	3.75	3.75	3.83
450	0.01	0.01	0.01	4.25	0.01	1371	2.25	2.33	2.25	2.33	2.33
470	0.01	0.01	0.01	4.25	0.01	1380	3.75	3.83	3.75	0.01	3.83
480	0.01	0.01	0.01	4.25	0.01	140-DIV	0.01	0.01	0.01	4.25	0.01
490	0.01	0.01	0.01	4.25	0.01	1451	0.58	0.58	0.58	0.01	0.58
510	0.01	0.01	0.01	4.25	0.01	1541	1.83	2.00	1.83	2.00	2.00
520	0.01	0.01	0.01	4.25	0.01	1551	0.01	1.17	0.01	1.17	1.17
531	0.01	0.01	0.01	4.25	0.01	1560	0.42	0.58	0.42	0.58	0.58
532	0.01	0.01	0.01	4.25	0.01	1591	0.33	0.42	0.33	0.33	0.42
533	0.01	0.01	0.01	4.25	0.01	1601	0.75	0.83	0.75	0.17	0.83
540	0.01	0.01	0.01	4.25	0.01	1602	1.25	1.33	1.25	1.33	1.33
550	0.01	0.01	0.01	4.25	0.01	1610	1.42	1.42	1.42	0.08	1.42
570	0.01	0.01	0.01	4.25	0.01	1620	1.00	1.08	1.08	0.08	1.08
580	0.01	0.01	0.01	4.25	0.01	1625	0.83	1.00	0.83	1.00	1.00
590	0.01	0.01	0.01	4.25	0.01	1651	2.00	2.00	2.00	2.00	2.00
600	0.01	0.01	0.01	4.25	0.01	1661	1.67	1.67	1.67	0.08	1.67
631	0.01	0.01	0.01	4.25	0.01	1663	1.33	1.33	1.33	1.42	1.33
632	0.01	0.01	0.01	4.25	0.01	1670	1.58	1.58	1.58	0.08	1.58
633	0.01	0.01	0.01	4.25	0.01	1672	1.33	1.42	1.33	1.42	1.42
640	0.01	0.01	0.01	4.25	0.01	1681	1.92	1.92	1.92	1.92	1.92
651	0.01	0.01	0.01	4.25	0.01	1687	0.92	1.00	0.92	1.00	1.00
652	0.01	0.01	0.01	4.25	0.01	1691	2.75	2.83	2.75	2.75	2.83
661	0.01	0.01	0.01	4.25	0.01	1701	1.58	1.67	1.58	1.58	1.67
662	0.01	0.01	0.01	4.25	0.01	1703	1.75	1.75	1.75	1.75	1.75
663	0.01	0.01	0.01	4.25	0.01	1741	3.50	3.58	3.50	0.17	3.58
681	0.01	0.01	0.01	4.25	0.01	1751	3.67	3.75	3.67	0.08	3.75
682	0.01	0.01	0.01	4.25	0.01	1753	3.50	3.67	3.50	0.17	3.67
691	0.01	0.01	0.01	4.25	0.01	1755	3.00	3.08	3.00	0.17	3.08
692	0.01	0.01	0.01	4.25	0.01	1758	2.83	3.00	2.83	2.92	3.00
693	0.01	0.01	0.01	4.25	0.01	1770	0.83	0.92	0.83	0.92	0.92
694	0.01	0.01	0.01	4.25	0.01	1780	1.08	1.25	1.08	1.25	1.25
695	0.01	0.01	0.01	4.25	0.01	1790	0.75	0.92	0.75	0.92	0.92
700	0.01	0.01	0.01	4.25	0.01	1800	1.42	1.58	1.42	1.50	1.58
711	0.01	0.01	0.01	4.25	0.01	1810	1.42	1.50	1.50	0.08	1.50
712	0.01	0.01	0.01	4.25	0.01	1820	1.08	1.25	1.08	1.25	1.25
721	0.01	0.01	0.01	4.25	0.01	1821	2.92	3.00	2.92	3.08	3.00
722	0.01	0.01	0.01	4.25	0.01	1830	1.42	1.50	1.42	0.08	1.50
723	0.01	0.01	0.01	4.25	0.01	1841	2.42	2.42	2.42	2.50	2.42
724	0.01	0.01	0.01	4.25	0.01	1881	0.83	1.08	0.92	1.17	1.08
731	0.01	0.01	0.01	4.25	0.01						
732	0.01	0.01	0.01	4.25	0.01						
733	0.01	0.01	0.01	4.25	0.01						

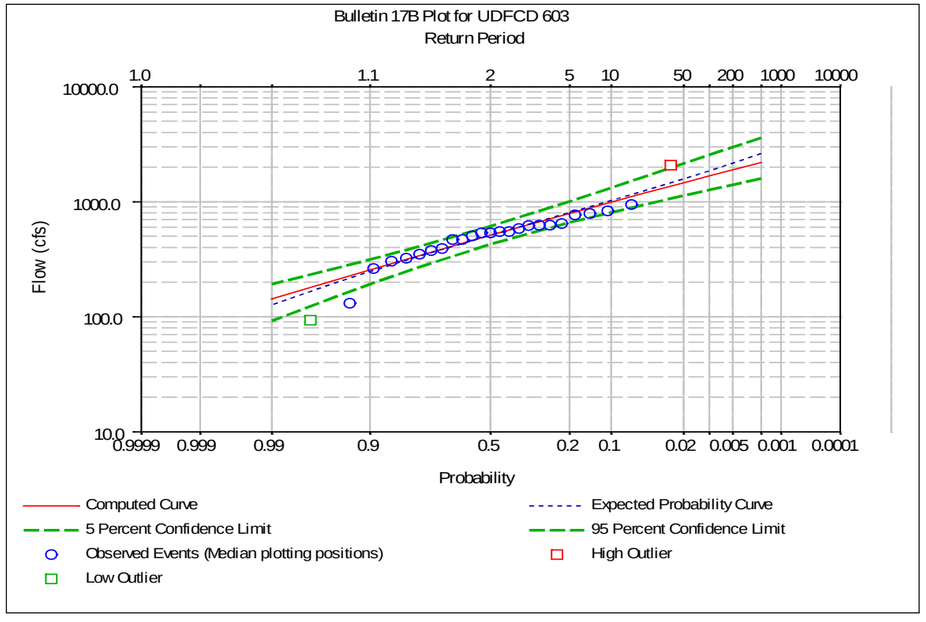
Analysis begun on: Fri Apr 24 15:48:25 2015
Analysis ended on: Fri Apr 24 15:48:25 2015
Total elapsed time: < 1 sec

Flood Frequency Analysis

UDFCD Gage 603 at Harvard Park near S. Logan Street at Denver, CO

DATE	PEAK FLOW
18-Sep-1990	504
16-May-1991	536
20-Jul-1992	376
5-Jul-1993	470
13-Aug-1994	262
18-Aug-1995	536
12-Jul-1996	647
28-Jul-1997	322
25-Jul-1998	470
10-Jun-1999	947
17-May-2000	350
8-Jul-2001	2080
13-Sep-2002	770
18-Jun-2003	584
18-Aug-2004	93
3-Jun-2005	131
13-Aug-2006	624
14-May-2007	392
8-Aug-2008	619
10-Jul-2009	790
30-Jul-2010	304
14-Jul-2011	624
7-Jun-2012	552
8-Aug-2013	549
14-Jul-2014	833



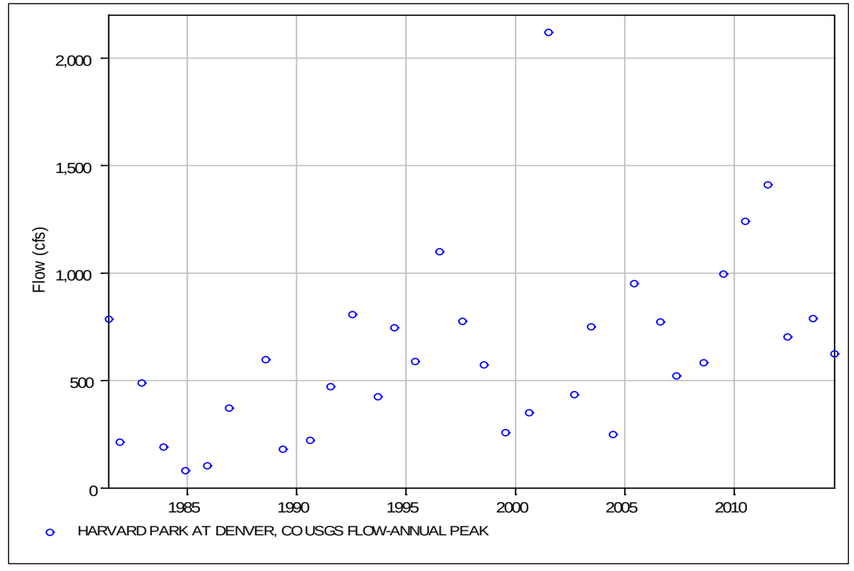


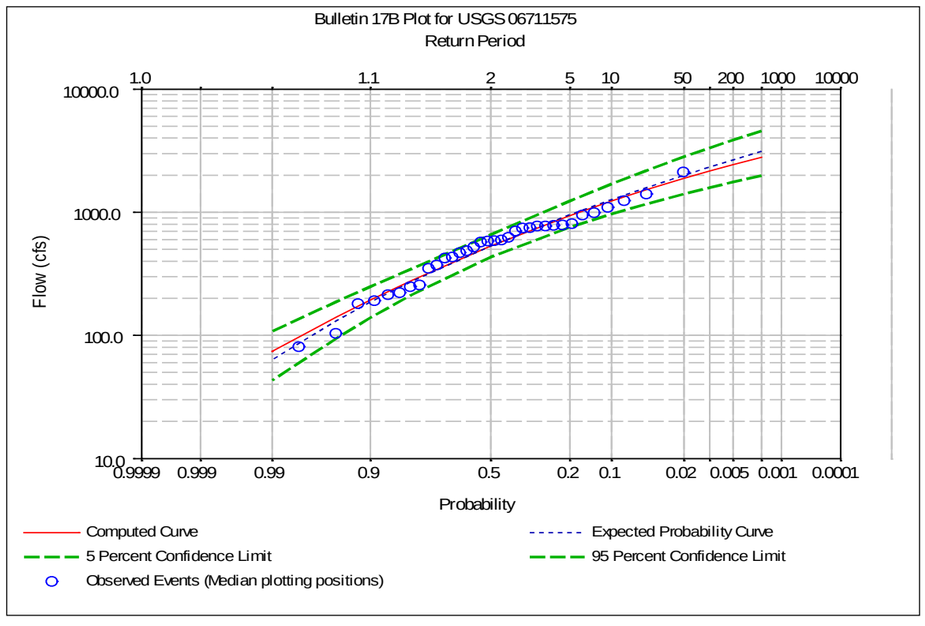
CURVE PROBABILITY FLOW IN CFS		PECENT CHANCE OF	CONFIDENCE LIMITS FLOW IN CFS	
COMPUTED	EXPECTED	EXCEEDANCE	0.05	0.95
2190	2615	0.2	3600	1587
1890	2163	0.5	2980	1403
1672	1859	1	2548	1266
1461	1582	2	2147	1129
1191	1253	5	1659	948
991	1023	10	1320	807
791	805	20	1004	658
510	510	50	611	427
325	320	80	391	257
256	247	90	315	192
210	198	95	264	150
143	127	99	191	92

SYNTHETIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
Mean	2.704	HISTORIC EVENTS	0
Standard Dev	0.229	HIGH OUTLIERS	1
Station Skew	-0.052	LOW OUTLIERS	1
Regional Skew	-0.14	ZERO OR MISSING	0
Weighted Skew	-0.088	SYSTEMATIC EVENTS	25
Adopted Skew	-0.088	HISTORIC PERIOD	25

USGS Gage N06711575 at Harvard Gulch Park at Denver, CO

Date	Peak Flow	Date	Peak Flow
28-May-81	785	25-Jul-98	573
30-Nov-81	214	19-Jul-99	257
30-Nov-82	488	17-Aug-00	350
30-Nov-83	191	8-Jul-01	2120
30-Nov-84	81	12-Sep-02	434
30-Nov-85	104	18-Jun-03	750
30-Nov-86	372	18-Jun-04	249
4-Aug-88	597	3-Jun-05	951
15-May-89	181	13-Aug-06	772
15-Aug-90	222	14-May-07	522
20-Jul-91	471	9-Aug-08	583
20-Jul-92	807	3-Jul-09	995
18-Sep-93	424	5-Jul-10	1240
21-Jun-94	746	14-Jul-11	1410
4-Jun-95	589	7-Jun-12	703
12-Jul-96	1100	8-Aug-13	788
31-Jul-97	776	29-Jul-14	624



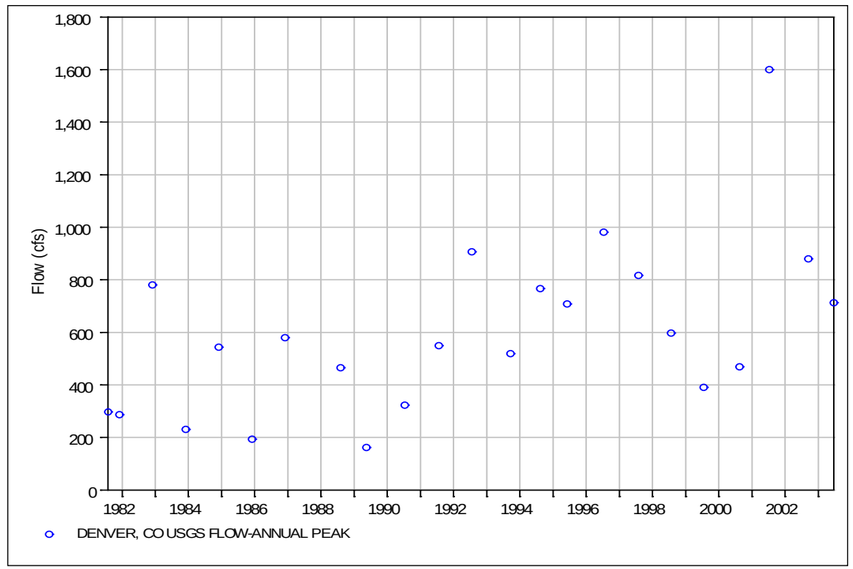


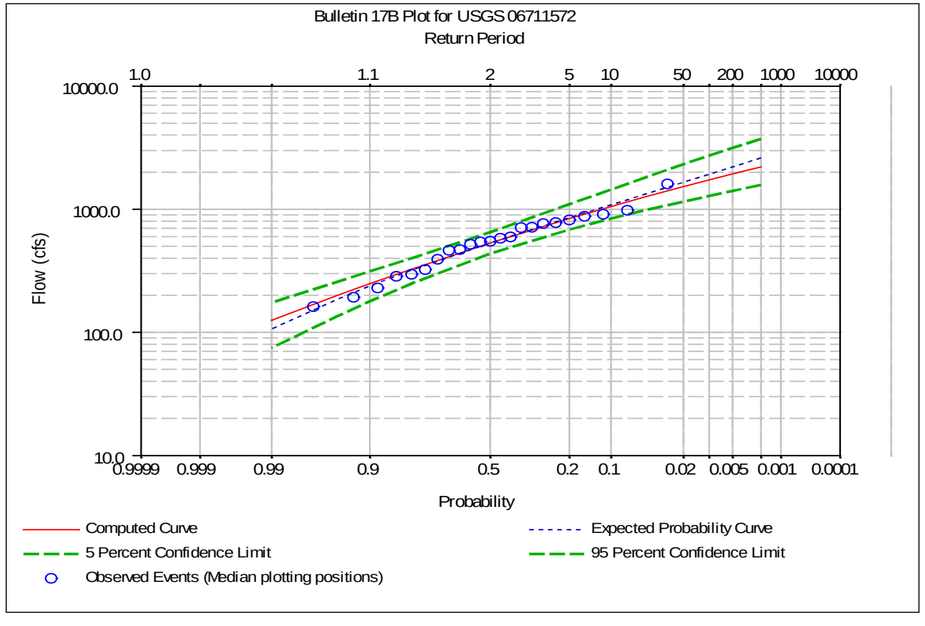
CURVE PROBABILITY FLOW IN CFS		PECENT CHANCE OF	CONFIDENCE LIMITS FLOW IN CFS	
COMPUTED	EXPECTED	EXCEEDANCE	0.05	0.95
2793	3125	0.2	4561	1980
2435	2663	0.5	3855	1759
2161	2326	1	3333	1586
1884	1997	2	2822	1408
1515	1576	5	2169	1162
1231	1263	10	1694	965
941	955	20	1238	755
533	533	50	659	433
280	275	80	348	214
194	186	90	249	139
141	132	95	188	95
74	64	99	108	43

SYNTHETIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
Mean	2.704	HISTORIC EVENTS	0
Standard Dev	0.316	HIGH OUTLIERS	0
Station Skew	-0.643	LOW OUTLIERS	0
Regional Skew	-0.14	ZERO OR MISSING	0
Weighted Skew	-0.44	SYSTEMATIC EVENTS	34
Adopted Skew	-0.44	HISTORIC PERIOD	0

USGS Gage N06711572 at S. University Blvd at Denver, CO

Date	Peak Flow (cfs)
26-Jul-81	297
30-Nov-81	286
30-Nov-82	780
30-Nov-83	230
30-Nov-84	543
30-Nov-85	193
30-Nov-86	579
4-Aug-88	465
15-May-89	162
10-Jul-90	323
20-Jul-91	549
20-Jul-92	907
18-Sep-93	519
13-Aug-94	766
4-Jun-95	708
12-Jul-96	981
28-Jul-97	817
25-Jul-98	597
19-Jul-99	391
17-Aug-00	469
8-Jul-01	1,600
12-Sep-02	879
18-Jun-03	713



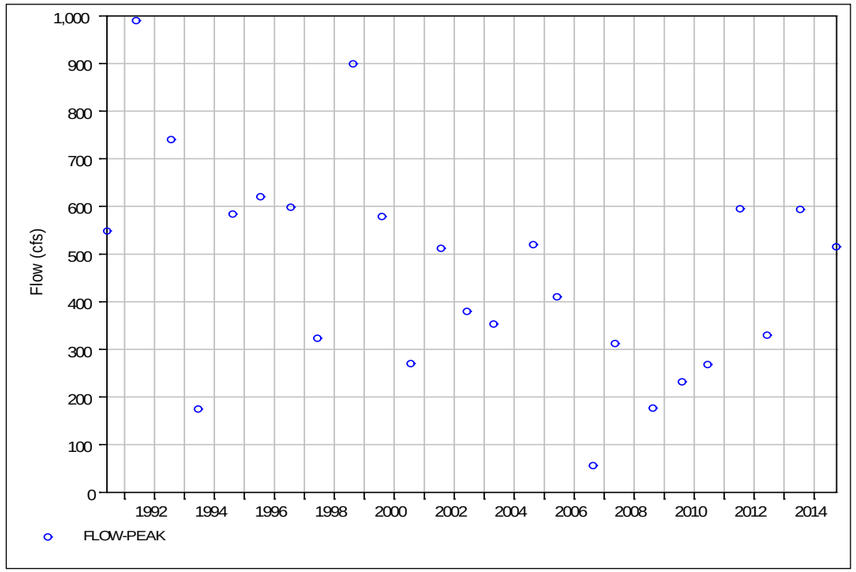


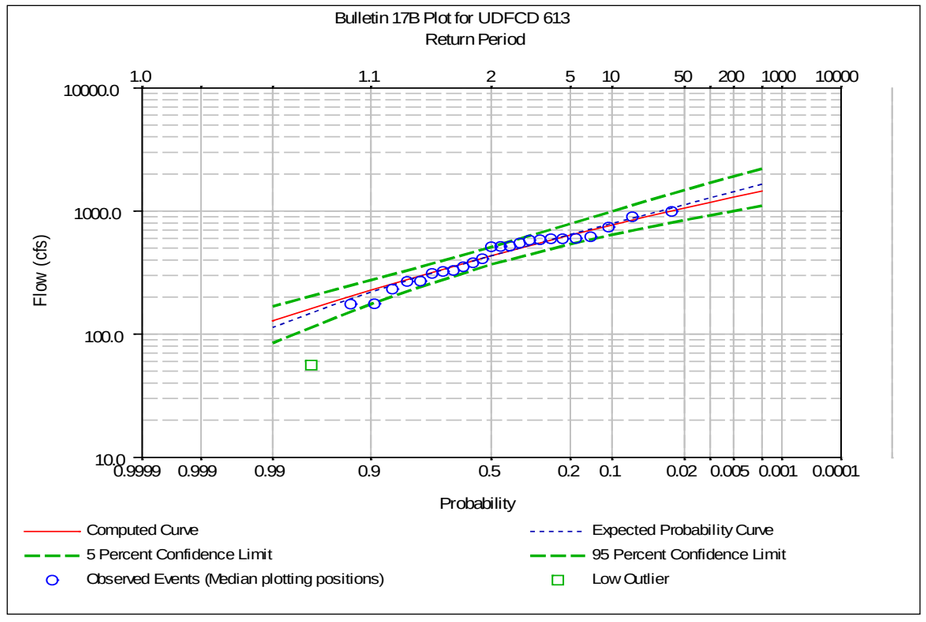
CURVE PROBABILITY FLOW IN CFS		PECENT CHANCE OF	CONFIDENCE LIMITS FLOW IN CFS	
COMPUTED	EXPECTED	EXCEEDANCE	0.05	0.95
2150	2520	0.2	3610	1540
1700	1880	1	2670	1270
1510	1630	2	2280	1140
1250	1310	5	1800	973
1050	1080	10	1440	835
839	854	20	1100	684
534	534	50	653	438
326	319	80	400	250
248	237	90	312	178
196	182	95	254	133
123	104	99	172	73

SYNTHETIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.7149	HISTORIC EVENTS	0
STANDARD DEV	0.2452	HIGH OUTLIERS	0
COMPUTED SKEW	-0.3595	LOW OUTLIERS	0
REGIONAL SKEW	-0.14	ZERO OR MISSING	0
ADOPTED SKEW	-0.3	SYSTEMATIC EVENTS	23

UDFCD Gage 613 at S. Colorado Blvd. at Denver, CO

DATE	PEAK FLOW
30-May-1990	548
23-May-1991	990
20-Jul-1992	740
17-Jun-1993	175
13-Aug-1994	584
15-Jul-1995	620
19-Jul-1996	598
6-Jun-1997	323
15-Aug-1998	899
4-Aug-1999	579
17-Jul-2000	270
23-Jul-2001	512
3-Jun-2002	380
23-Apr-2003	353
18-Aug-2004	520
3-Jun-2005	410
19-Aug-2006	56
14-May-2007	312
16-Aug-2008	177
6-Aug-2009	232
12-Jun-2010	268
14-Jul-2011	595
7-Jun-2012	330
13-Jul-2013	594
29-Sep-2014	515



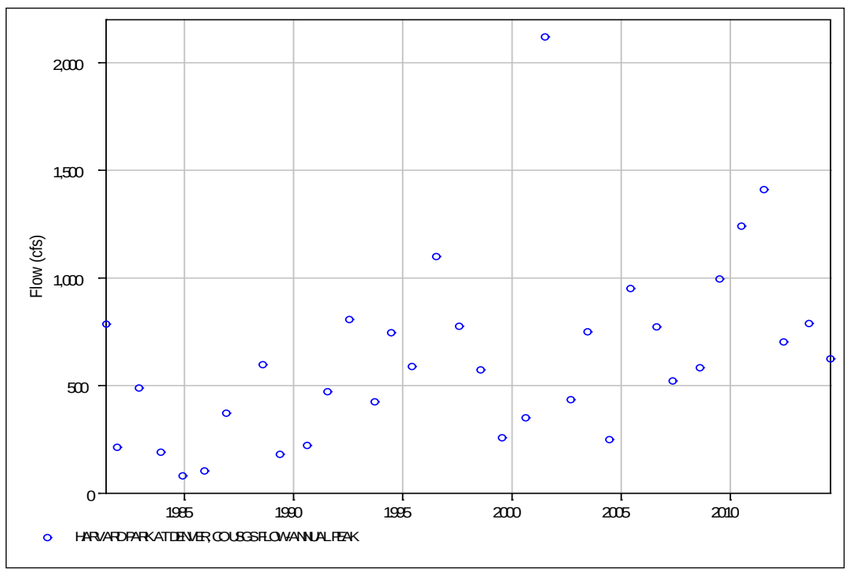


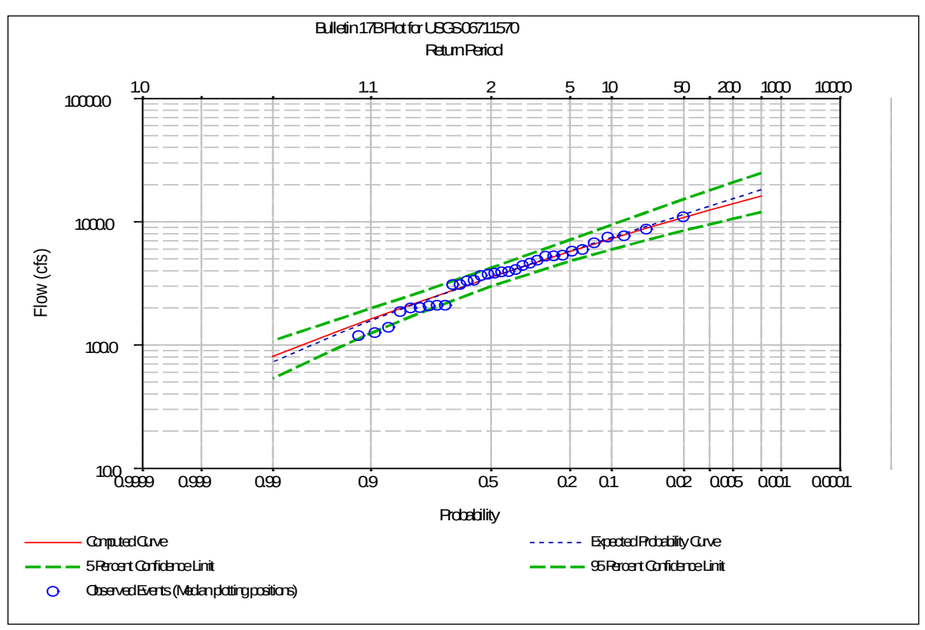
CURVE PROBABILITY FLOW IN CFS		PECENT CHANCE OF EXCEEDANCE	CONFIDENCE LIMITS FLOW IN CFS	
COMPUTED	EXPECTED		0.05	0.95
1449	1654	0.2	2210	1100
1295	1435	0.5	1914	1001
1177	1278	1	1695	924
1058	1127	2	1480	844
897	935	5	1202	732
771	791	10	996	641
637	646	20	790	539
433	433	50	509	369
286	281	80	338	231
228	220	90	275	175
187	178	95	232	137
128	113	99	168	85

SYNTHETIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
Mean	2.628	ISTORIC EVENTS	0
Standard Dev	0.207	HIGH OUTLIERS	0
Station Skew	-0.335	LOW OUTLIERS	1
Regional Skew	-0.14	ZERO OR MISSING	0
Weighted Skew	-0.251	SYSTEMATIC EVENTS	25
Adopted Skew	-0.251	HISTORIC PERIOD	

USGS Gage N06711570 at S. Colorado Blvd at Denver, CO

Date	Peak Flow	Date	Peak Flow
28-May-81	395	25-Jul-98	462
30-Nov-81	210	20-May-99	529
30-Nov-82	410	17-May-00	441
30-Nov-83	200	8-Jul-01	1100
30-Nov-84	392	12-Sep-02	870
30-Nov-85	139	18-Jun-03	578
30-Nov-86	335	30-Nov-03	
4-Aug-88	597	3-Jun-05	210
15-May-89	187	7-Jul-06	201
15-Aug-90		4-Jul-07	119
20-Jul-91	309	9-Aug-08	126
20-Jul-92	750	3-Jul-09	309
18-Sep-93	332	12-Jun-10	208
13-Aug-94	382	14-Jul-11	525
4-Jun-95	367	7-Jun-12	375
12-Jul-96	673	13-Jul-13	534
4-Sep-97	488	14-Jul-14	767





CURVE PROBABILITY FLOW IN CFS		PECENT CHANCE OF	CONFIDENCE LIMITS FLOW IN CFS	
COMPUTED	EXPECTED	EXCEEDANCE	0.05	0.95
1614	1822	0.2	2483	1196
1398	1536	0.5	2082	1058
1239	1335	1	1796	953
1083	1146	2	1523	848
879	913	5	1185	707
727	744	10	944	596
573	580	20	714	480
356	356	50	421	301
214	211	80	256	172
162	158	90	198	124
128	122	95	161	94
81	73	99	108	54

SYNTHETIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
Mean	2.542	HISTORIC EVENTS	0
Standard Dev	0.254	HIGH OUTLIERS	0
Station Skew	-0.259	LOW OUTLIERS	0
Regional Skew	-0.14	ZERO OR MISSING	2
Weighted Skew	-0.216	SYSTEMATIC EVENTS	34
Adopted Skew	-0.216	HISTORIC PERIOD	

Appendix C – Hydraulic Analysis

Figure C-1 Recommended Manning's Roughness



Manning's Roughness

n = 0.035 – Channel, n = 0.04 to 0.08 – Overbank Area, n = 0.025 – Park



Manning's Roughness

n = 0.035 to 0.04 – Channel, n = 0.04 to 0.05 – Overbank Area, n = 0.025 – Park



Manning's Roughness

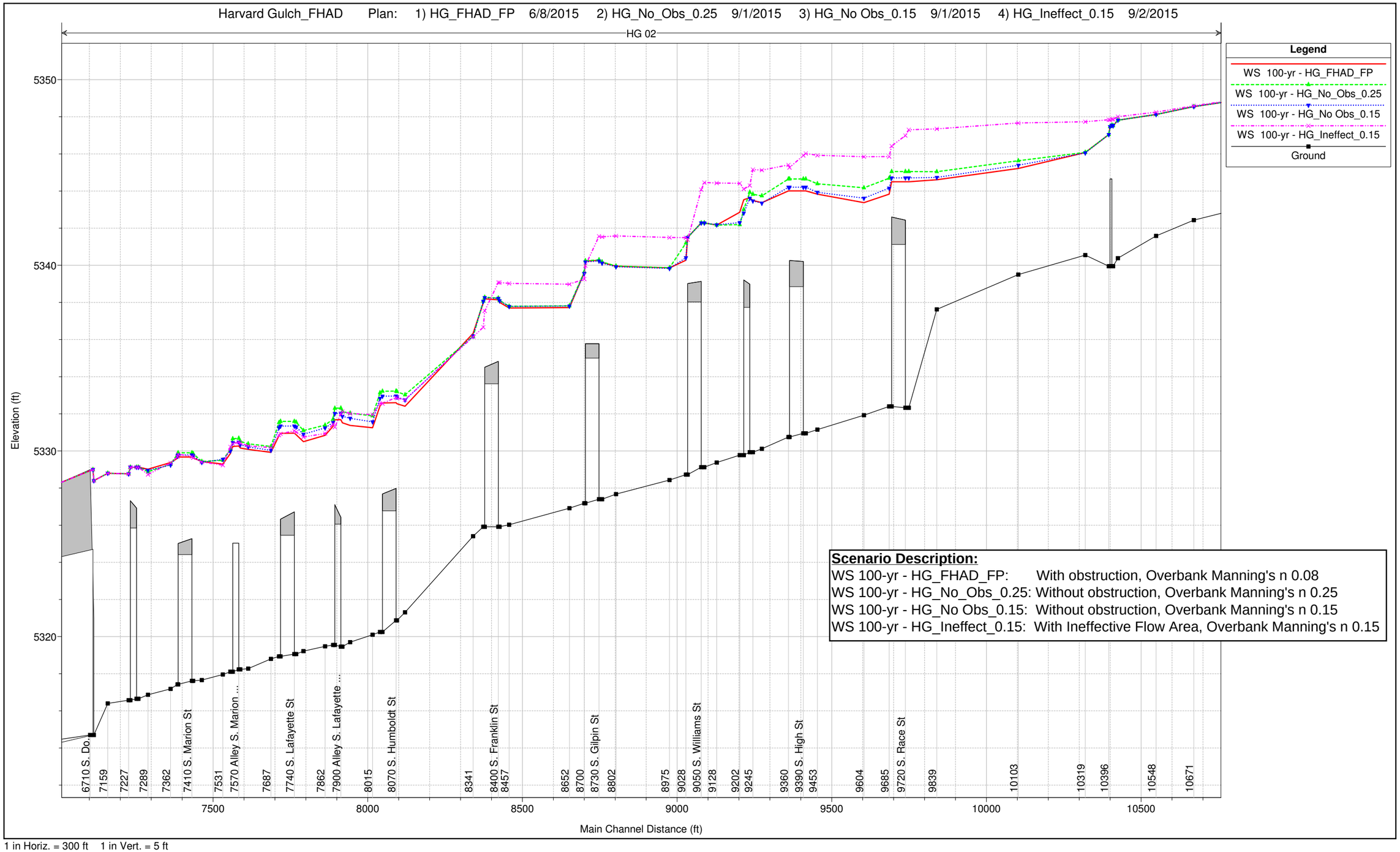
n = 0.015 – Channel, n = 0.035 to 0.08 – Overbank Area



Manning's Roughness

n = 0.04 – Channel, n = 0.025 to 0.08 – Overbank Area, n = 0.025 – Park

Figure C-2 Comparison of Flood Profiles of Four Scenarios



1 in Horiz. = 300 ft 1 in Vert. = 5 ft

Figure C-3 - Existing Roadway/ Pedestrian Crossing Inventory



S. Logan Street (Station 40+80)



S. Marion Street (Station 74+08)



S. Lafayette / S. Humboldt Alley (Station 79+03)



S. Downing Street (Station 71+00)



S. Marion/ S. Lafayette Alley (Station 75+72)



S. Humboldt Street (Station 80+68)



S. Downing/ S. Marion Alley (Station 72+43)



S. Lafayette Street (Station 77+38)



S. Franklin Street (Station 84+00)



S. Gilpin Street (Station 87+25)



S. High Street (Station 93+90)



S. York Street (Station 109+50)



S. Williams Street (Station 90+55)



S. Race Street (Station 97+15)



S. University Boulevard (Station 113+70)



S. Williams/ S. High Alley (Station 92+20)



Pedestrian/ Bike at S. Gaylord Street (Station 104+00)



S. Josephine Street (Station 118+00)



S. Columbine Street (Station 122+10)



S. Adams Street/ E. Vassar Avenue (Station 147+50)



S. Monroe Street (Station 158+00)



Pedestrian/ bike S. Fillmore St.-McWilliams Park (Station 132+30)



S. Cook Street (Station 151+30)



S. Jackson Street (Station 165+20)



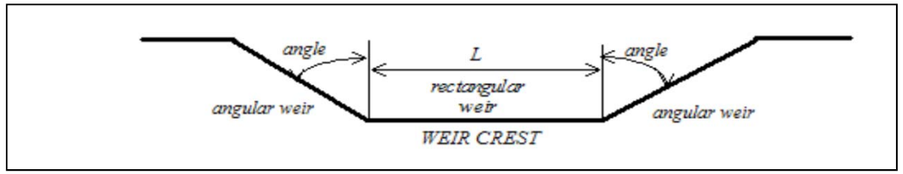
S. Steele/ S. Adams Alley (Station 145+75)



S. Madison Street (Station 154+60)

Table C-1a Starting Water Surface Elevation at S. Logan Street

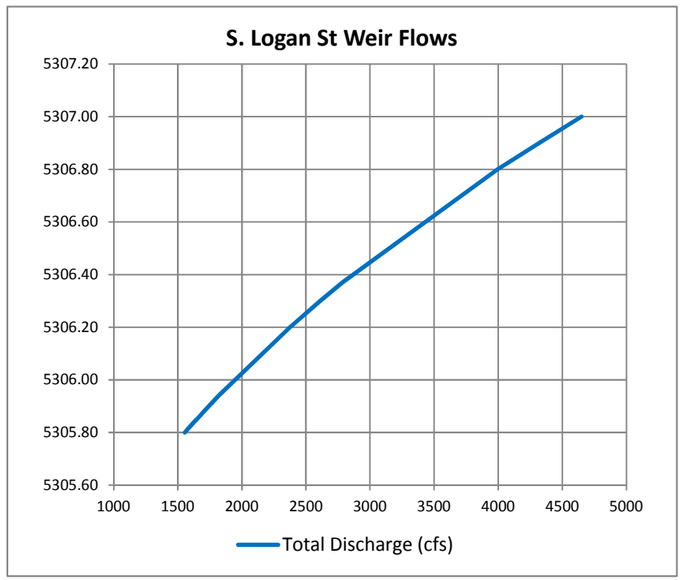
WEIR STRUCTURE: S. Logan Street _ Broad Crested Weir



Bottom Length of Weir	L =	92.00
Angle of Side Slope Weir (Left)	Left Angle =	89.27
Angle of Side Slope Weir (Right)	Right Angle =	89.05
Elev. for Weir Crest	EL. Crest =	5,304.01
Coefficient for Rectangular Weir	C_w =	3.00
Coefficient for Trapezoidal Weir	C_t =	3.00

H:V = 79.00
H:V = 60.00

W.S.E.	Rectangular Weir (cfs)	Left Triangular Weir (cfs)	Right Triangular Weir (cfs)	Total Discharge (cfs)
5305.80	661	386	508	1555
5305.82	672	397	522	1591
5305.84	683	408	537	1628
5305.86	694	419	552	1665
5305.88	706	430	567	1703
5305.94	740	466	613	1819
5306.20	894	639	841	2374
5306.30	956	714	940	2611
5306.37	1001	770	1014	2785
5306.80	1286	1170	1541	3997
5306.85	1321	1223	1611	4155
5306.90	1356	1278	1683	4316
5307.00	1427	1391	1832	4650



INLET STRUCTURE: S. Logan Street _ Inlet structure

Discharge (cfs)	Head El (ft)	Head El (NAVD 88)		Search Discharge (cfs)	Head El (ft)
2300	134.5	5309.85			
2240	131.8	5307.15			
2100	128.5	5303.85		2170	5305.50
2000	128.2	5303.55		2039	5303.67
1900	127.6	5302.95			
1750	126.8	5302.15			
1500	126.1	5301.45			
1200	125.5	5300.85			
930	125.1	5300.45			
600	124.3	5299.65			
300	123.4	5298.75			
Sill El	122.0	5297.35	(survey)		

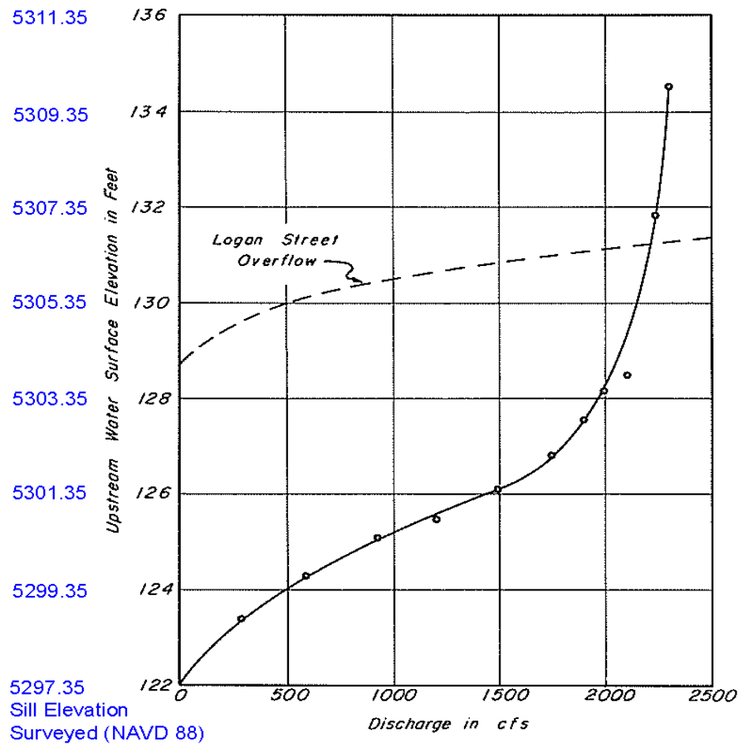


FIGURE 12 RECOMMENDED DISCHARGE RATING CURVE

Source: City & County of Denver, Harvard Gulch Flood Control Design Report, Wright-McLaughlin Water Engineers, 1967

2015 FHAD _ Starting Water Surface Elevation at S. Logan Street

Strom Events	Inflows (cfs)	Culvert* (cfs)	Weir** (cfs)	W.S.EL. (ft)
10-year	2,039	2,039	0	5303.67
50-year	3,988	2,200	1,788	5305.92
100-year	4,952	2,200	**2,752**	5306.36
500-year	6,486	2,200	4,286	5306.89

*The rising slope of the inlet discharge rating curve from 1967 Design Report is too steep to determine an accurate discharge off the curve between 2,100 cfs and 2,300 cfs. The mean discharge was used for flow entering the culvert.

****The 100-year weir flow of 2,752 cfs was used for overland flooding analysis from S. Logan St to S. Platte River in FLO-2D model.**

Table C-1b Starting Water Surface Elevation at S. Logan Street

Geometry of Broad Crested Weir at S. Logan Street

2014 LiDAR TOPO	
Station	Elevation
0.0	5309.77
35.8	5309.02
74.3	5309.00
86.0	5308.73
87.0	5308.72
118.7	5308.01
147.0	5308.00
192.0	5307.01
222.1	5307.00
224.6	5306.95
225.3	5306.95
283.7	5306.01
309.0	5306.00
351.5	5305.08
366.0	5305.05
367.0	5305.06
382.2	5305.00
383.9	5304.97
384.5	5304.97
445.1	5304.32
457.2	5304.01
472.5	5304.03
473.3	5304.02
549.3	5304.09
595.8	5304.92
597.8	5304.93
598.9	5305.00
622.6	5305.02
664.9	5306.00
686.2	5306.05
692.2	5306.40
696.4	5306.39
727.0	5306.98

Weir Geometry

Station	Elevation	Delta Station (H)	Delta Elevation (V)
0	5309.77	N/A	N/A
457	5304.01	457	5.76
549	5304.01	92	0.00
727	5306.98	178	2.97

Summary			
Parameters		Units	H/V
Left side Slope	0.0126	ft/ft	79
Weir Length	92	ft	N/A
Right side Slope	0.0167	ft/ft	60

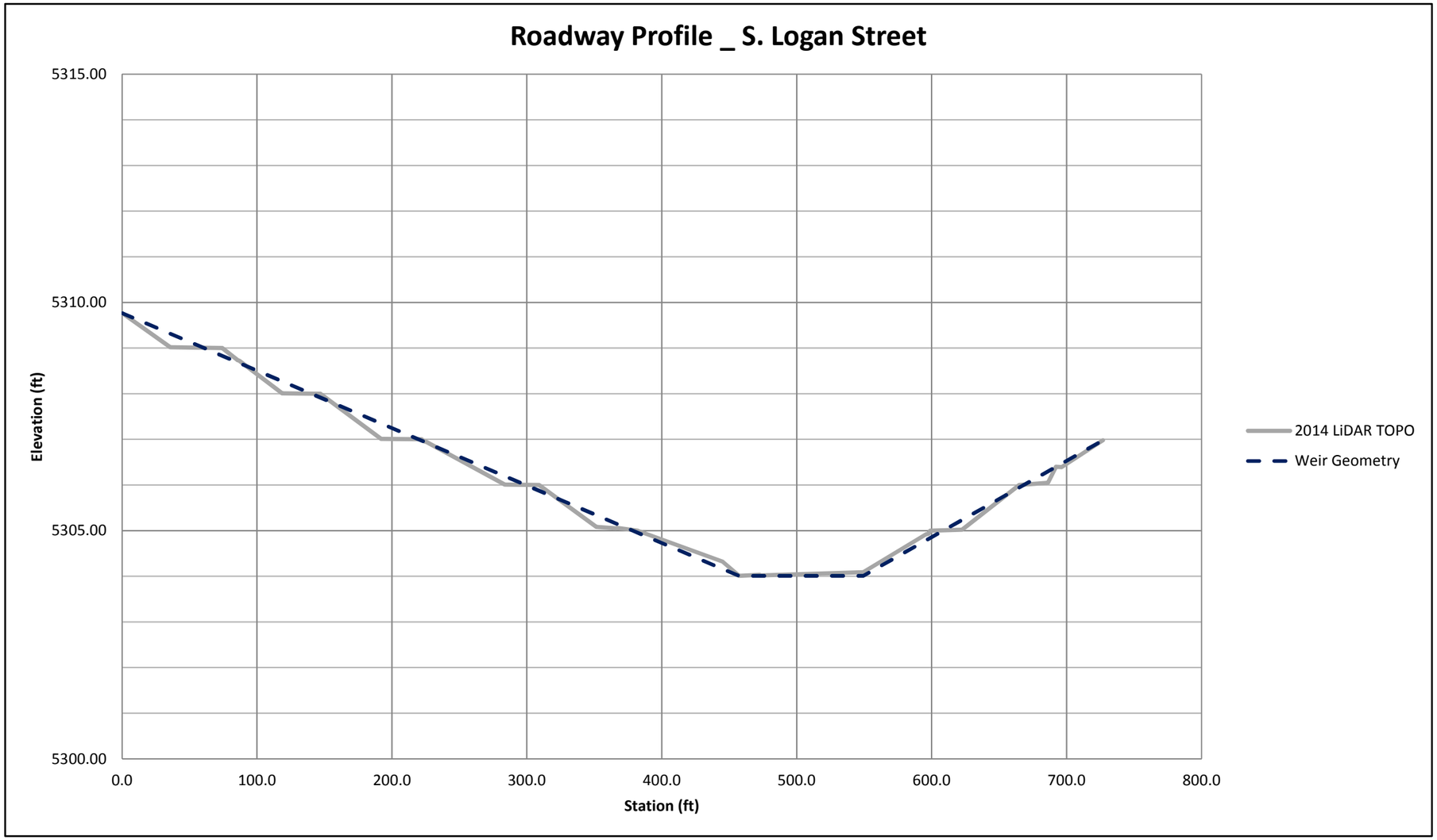


Table C-2a Harvard Gulch _ Flood Hazard Area Delineation Peak Flows and Flow Change Locations - Future Condition

Reference Locations	Design Points / Conveyance Elements	Total Drainage Area		HEC-RAS Rivers/Reaches/Stations/Reference Locations				Profile Names & Flow Rates			
		(acres)	(mi^2)	River	Reach	Station	Reference Locations	Q_{10}	Q_{50}	Q_{100}	Q_{500}
Harvard Gulch											
S. Jackson St	Junct_1700	1462	2.28	HG	HG_02	167+90	At outlet of 14'x9' CBC d/s of S. Colorado Blvd	866	1627	2003	2619
S. Monroe St	Junct_1702	1510	2.36	HG	HG_02	158+89	S. Monroe St upstream	887	1677	2068	2716
S. Cook St	Junct_1690	1614	2.52	HG	HG_02	152+12	S. Cook St upstream	957	1817	2242	2954
S. Saint Paul St/McWilliams Park	Junct_1680	1713	2.68	HG	HG_02	139+98	S. Saint Paul St/McWilliams Park	1006	1927	2388	3144
S. Clayton St/Harvard Gulch East Park	Junct_1650	2306	3.60	HG	HG_02	126+34	S. Clayton St/Harvard Gulch East Park	1216	2405	3016	4006
S. University Blvd	Junct_1590	2451	3.83	HG	HG_02	114+93	S. University Blvd upstream	1302	2567	3190	4337
S. Franklin St	Junct_1480	2613	4.08	HG	HG_02	84+57	S. Franklin St upstream	1346	2663	3300	4463
S. Downing St	Junct_1550	2829	4.42	HG	HG_02	72+89	Alley S. Downing St/S. Marion St (***See split flow table for details***)	1457	2873	3559	4747
S. Pearl St/ Confluence with Dry Gulch	Junct_1200	4169	6.51	HG	HG_01	52+21	S. Washington St/confluence of Harvard Gulch & split flow	1,995	3,905	4,894	6,385
N/A	N/A	N/A	N/A	HG Split	Split_01	19+66	S. Downing St (***See split flow table for details***)	64	1,093	1,736	2,827

Harvard Gulch & Harvard Gulch Split Flow - Peak Flows and Flow Change Locations - Future Condition

Reference Locations	Design Points / Conveyance Elements	Total Drainage Area		HEC-RAS Rivers/Reaches/Stations/Reference Locations				Profile Names & Flow Rates			
		(acres)	(mi^2)	River	Reach	Station	Reference Locations	Q_{10}	Q_{50}	Q_{100}	Q_{500}
Harvard Gulch											
S. Downing St	Junct_1550	2829	4.42	HG	HG_02	72+58	Alley S. Downing St/S. Marion St upstream	1,393	1,170	1,570	2,150
				HG	HG_02	72+27	Alley S. Downing St/S. Marion St downstream	1,393	1,780	2,060	2,150
				HG	HG_02	71+59	N/A	1,393	1,780	1,823	2,150
				HG	HG_02	71+14	S. Downing St upstream	1,393	1,780	1,823	1,920
N/A	N/A	N/A	N/A	HG Split	Split_01	21+22	Alley S. Downing St/S. Marion St upstream	64	1,703	1,989	2,597
				HG Split	Split_01	20+89	Alley S. Downing St/S. Marion St Upstream	64	1,093	1,499	2,597
				HG Split	Split_01	20+16	N/A	64	1,093	1,736	2,597
				HG Split	Split_01	19+66	S. Downing St upstream	64	1,093	1,736	2,827

Table C-2b Dry Gulch _ Flood Hazard Area Delineation Peak Flows and Flow Change Locations - Future Condition

Overland Peak Flows and Flow Change Locations - Future Condition

Design Point	Location	HEC-RAS Station	Overland Flow Rates*			
			Q_{10}	Q_{50}	Q_{100}	Q_{500}
1360	E. Floyd Ave/S. University Blvd	***10215***	***115***	***356***	***481***	***682***
1320	E. Eastman Ave/S. Franklin St	***7253***	***97***	***413***	***578***	***841***
1300	S. Lafayette St/Barde Park u/s	***6525***	***318***	***655***	***833***	***1,116***
1292*	S. Downing St/Barde Park d/s	***5934***	***157***	***545***	***747***	***1,075***
1270	S. Ogden St	***4247***	***153***	***575***	***798***	***1,160***
1250	E. Bates Ave/S. Emerson St	***3525***	***189***	***646***	***886***	***1,278***
1230	E. Amherst Ave/S. Clarkson St	***2767***	***222***	***711***	***970***	***1,393***
1212	E. Yale Ave/S. Washington St	***1927***	***264***	***792***	***1,070***	***1,520***

*The existing storm drain capacities were subtracted from the peak flows of Baseline Hydrology.

Capacity Estimates of the Existing Storm Sewer System

Design Point	Location	River Station	Flow Rates for HEC-RAS Model (Storm Sewer Capacity Subtracted from 2015 MDP) (cfs)				Flow Rates from 2015 MDP (cfs)				Existing Storm Sewer Size (inch)	Manning's n	Pipe Slope/ Weighted Slope (ft/ft)	Full Flow Capacity (cfs)	Estimated Capacity of Storm Sewer System (cfs)	Note
			Q_{10}	Q_{50}	Q_{100}	Q_{500}	Q_{10}	Q_{50}	Q_{100}	Q_{500}						
1360	E. Floyd Ave/S. University Blvd	**10215**	**115**	**356**	**481**	**682**	205	446	571	772	54	0.013	0.002	88	**90**	Existing storm sewer system is comprised of 48" RCP/slope 0.56% to 1.67% and 54' RCP/slope 0.2% to 0.8%.
1320	E. Eastman Ave/S. Franklin St	**7253**	**97**	**413**	**578**	**841**	287	603	768	1,031	60	0.013	0.0052	188	**190**	Existing storm sewer system is comprised of 60" RCP/slope 0.52% to 1.76%.
1300	S. Lafayette St/Barde Park u/s	**6525**	**318**	**655**	**833**	**1116**	318	655	833	1,116	-	-	-	-		Open channel
1292*	S. Downing St/Barde Park d/s	**5934**	**141**	**525**	**721**	**1041**	351	735	931	1,251	66	0.013	0.00374	206	**210**	Existing storm sewer system is comprised of 66" RCP/slope 0.374%.
1294*	E. Dartmouth Ave/S. Downing St	**5548**	**157**	**545**	**747**	**1075**	367	755	957	1,285	66	0.013	0.00374	206	**210**	Existing storm sewer system is comprised of 66" RCP/slope 0.374% to 0.64%.
1270	S. Ogden St	**4247**	**153**	**575**	**798**	**1160**	403	825	1,048	1,410	66	0.013	0.0051	240	**250**	Existing storm sewer system is comprised of 66" RCP/slope 0.2% to 1.88%. Weighted pipe slope used for capacity calculation.
1250	E. Bates Ave/S. Emerson St	**3525**	**189**	**646**	**886**	**1278**	439	896	1,136	1,528	66	0.013	0.0056	252	**250**	Existing storm sewer system is comprised of 66" RCP/slope 0.56% to 1.2%.
1230	E. Amherst Ave/S. Clarkson St	**2767**	**222**	**711**	**970**	**1393**	472	961	1,220	1,643	66	0.013	0.0107	348	**250**	Existing storm sewer system is comprised of 66" RCP/slope 0.32% to 2.24%. Weighted pipe slope used for capacity calculation.
1212	E. Yale Ave/S. Washington St	**1927**	**264**	**792**	**1070**	**1520**	514	1,042	1,320	1,770	72	0.013	0.00346	250	**250**	Existing storm sewer system is comprised of 2-68"x43"/slope 0.2% to 1.88% and 72" RCP/slope 0.14% to 0.48%. Weighted pipe slope used for capacity calculation.

*Flow rates are very close at design point 1292 and 1294. The flow rates at design point 1294 were selected and applied at design point 1292 to reduce the numbers of flow change location in HEC-RAS model.

Table C3 - Spill Flow Calculation at S. Gilpin Street & E. Wesley Avenue

Ground_Gilpin St north of Wesley Ave

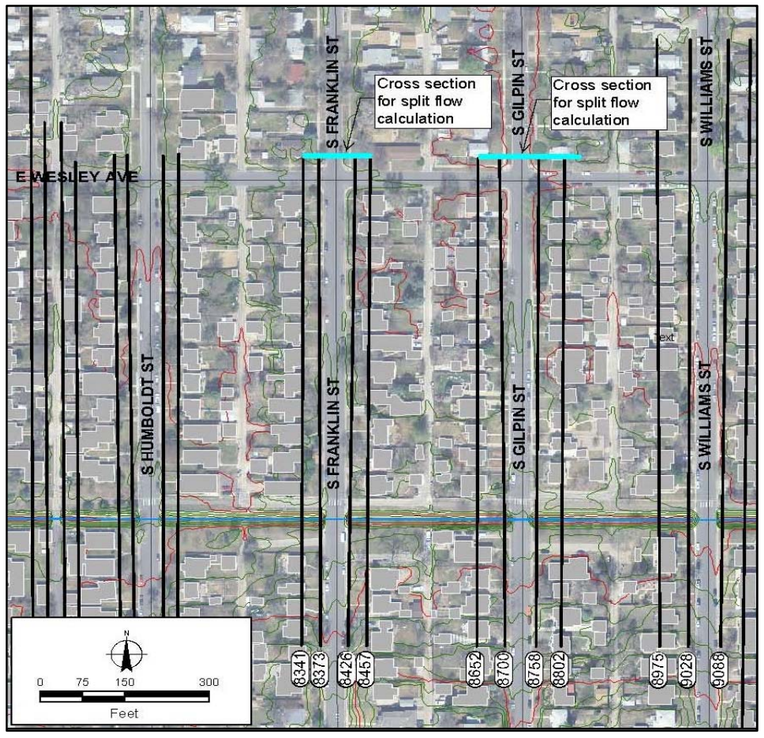
PVI Station	PVI Elevation
0.0	5341.00
20.1	5341.00
25.8	5340.86
27.4	5340.84
50.7	5340.00
92.2	5340.00
107.0	5341.00
153.1	5341.44
172.4	5342.00
173.4	5342.00

100yr W.S. Elevation

Reach	River Station	Profile	W.S. Elevation	Graphical Station	
			(ft)		
2	8652	100-yr	5337.94	0.0	
2	8700	100-yr	5338.21	48.0	
2	8730 BR D	100-yr	5339.54	51.9	
2	8730 BR U	100-yr	5340.85	96.0	
2	8758	100-yr	5340.76	106.0	
2	8802	100-yr	5340.71	150.0	
Flow Area		**Width**	**Depth**	**Discharge**	**Total Flow**
a	Triangular	24	0.7	21	**34**
b	Triangular	12	0.8	13	
c					
d					
e					
f					
g					
h					
i					
j					

500yr W.S. Elevation

Reach	River Station	Profile	W.S. Elevation	Graphical Station	
			(ft)		
2	8652	500-yr	5339.2	0.0	
2	8700	500-yr	5340.32	48.0	
2	8730 BR D	500-yr	5341.45	51.9	
2	8730 BR U	500-yr	5341.74	96.0	
2	8758	500-yr	5341.62	106.0	
2	8802	500-yr	5341.56	150.0	
Flow Area		**Width**	**Depth**	**Discharge**	**Total Flow**
1	Triangular	6	1.5	17	**308**
2	Triangular	40	0.2	5	
3	Rectangular	40	1.45	210	
4	Rectangular	16	0.6	22	
5	Triangular	16	1	24	
6	Triangular	44	0.6	31	
7					
8					
9					
10					



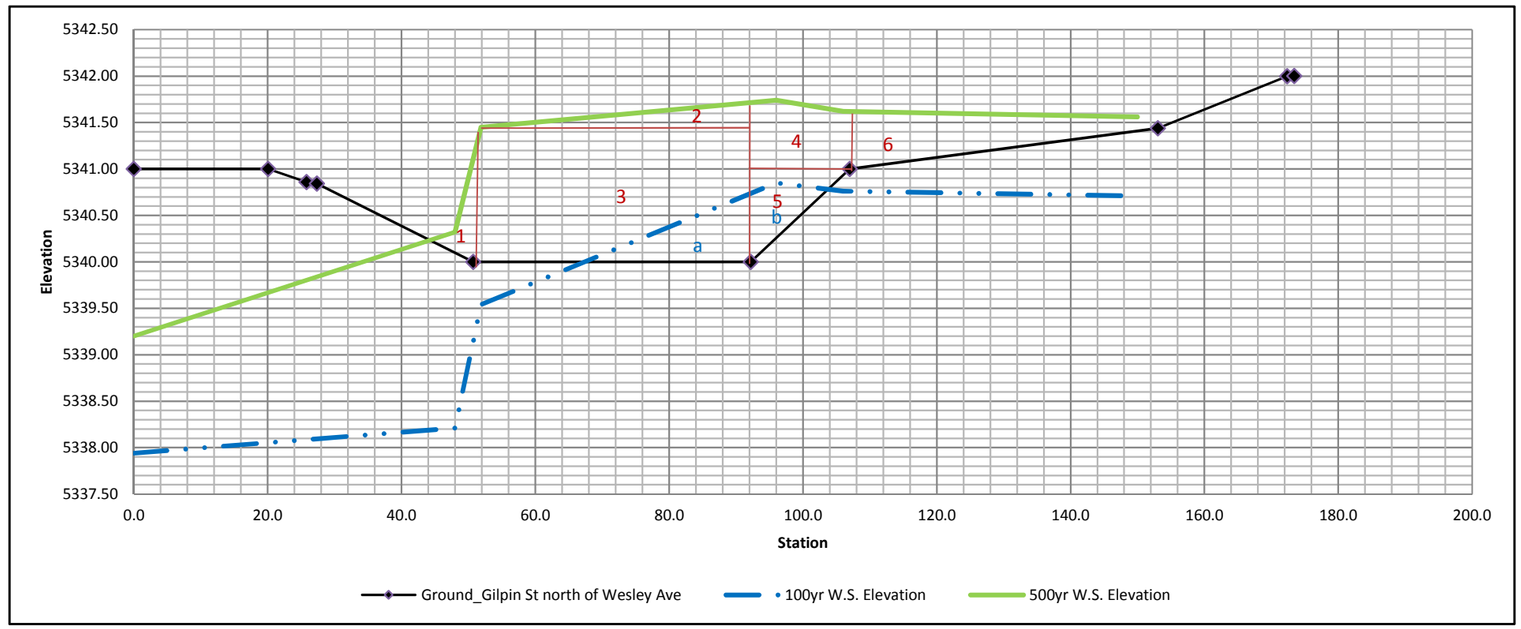
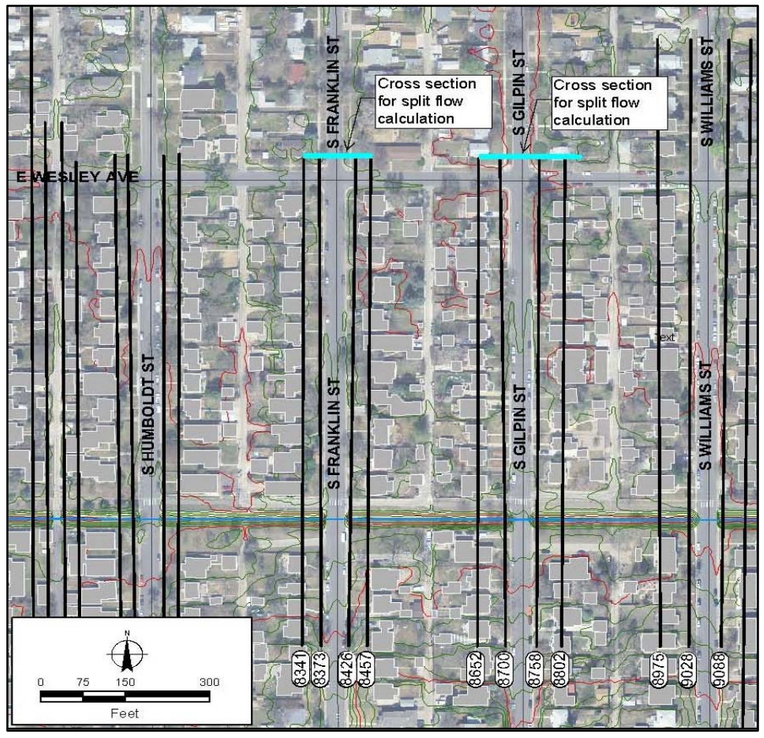


Table C4 - Split Flow Calculation at S. Franklin Street & E. Wesley Avenue

Ground _ Franklin St north of Wesley Ave

PVI Station	PVI Elevation
0.0	5338.00
71.6	5338.00
84.6	5338.53
96.4	5339.00
119.2	5339.55

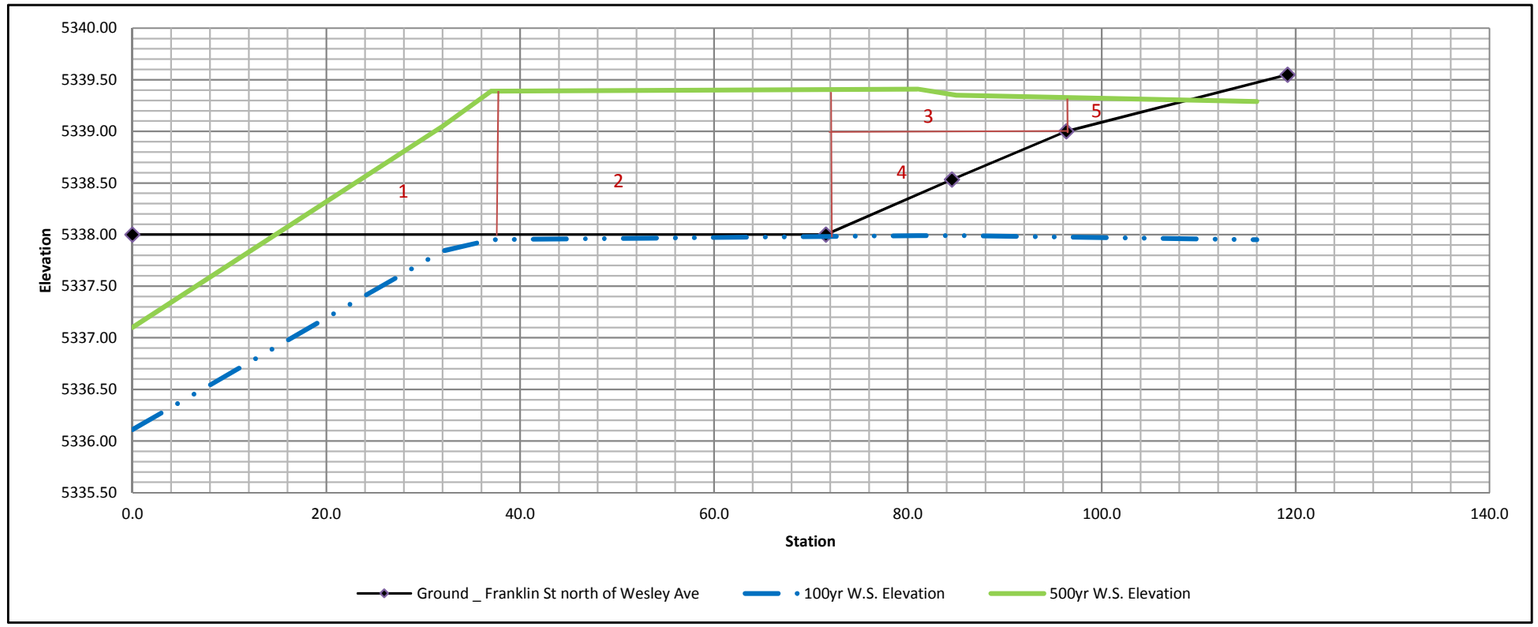


100yr W.S. Elevation

Reach	River Station	Profile	W.S. Elevation	Graphical Station	
			(ft)		
2	8341	100-yr	5336.11	0	
2	8373	100-yr	5337.84	32	
2	8400 BR D	100-yr	5337.95	37	
2	8400 BR U	100-yr	5337.99	81	
2	8426	100-yr	5337.99	85	
2	8457	100-yr	5337.95	116	
Flow Area		Width	Depth	Discharge	Total Flow
a					0
b					
c					
d					
e					
f					
g					
h					
i					
j					

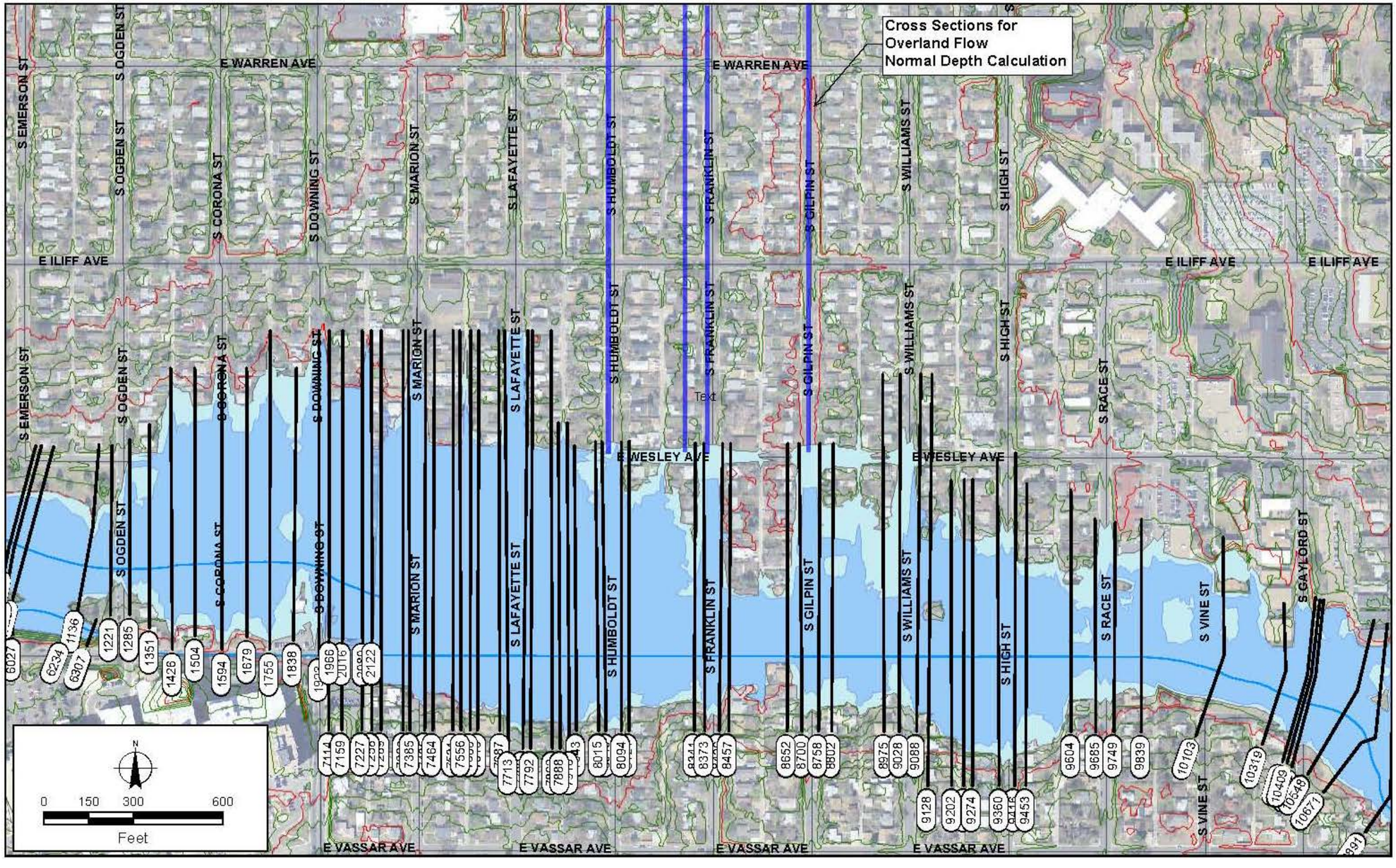
500yr W.S. Elevation

Reach	River Station	Profile	W.S. Elevation	Graphical Station	
			(ft)		
2	8341	500-yr	5337.1	0	
2	8373	500-yr	5339.05	32	
2	8400 BR D	500-yr	5339.39	37	
2	8400 BR U	500-yr	5339.41	81	
2	8426	500-yr	5339.35	85	
2	8457	500-yr	5339.29	116	
Flow Area		Width	Depth	Discharge	Total Flow
1	Triangular	22	1.4	55	283
2	Rectangular	35	1.4	174	
3	Rectangular	24	0.35	15	
4	Triangular	24	1	36	
5	Triangular	13	0.3	3	
6					
7					
8					
9					
10					



Overland Flow _ Normal Depth Calculation _ Cross Sections

Harvard Gulch



FlowMaster Cross Section for Overland Flow at S. Gilpin St

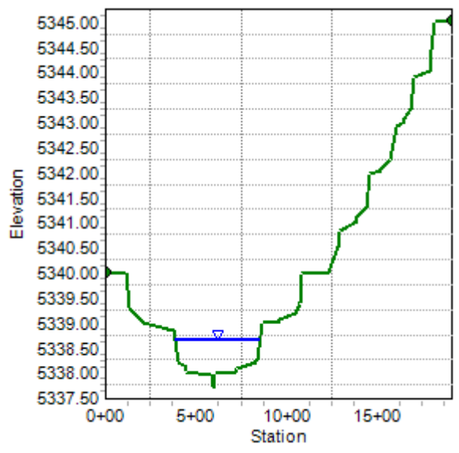
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Normal Depth	0.93	ft
Discharge	310.00	ft³/s

Cross Section Image



FlowMaster Cross Section for Overland Flow at S. Gilpin St

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Discharge	310.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5339.99
1+15	5339.97
1+38	5339.29
2+15	5339.00
3+79	5338.84
4+01	5338.21
4+46	5338.11
4+51	5338.01
5+86	5337.95
5+99	5337.71
6+06	5337.97
7+20	5338.01
7+23	5338.07
8+25	5338.21
8+27	5338.23
8+40	5338.28
8+63	5338.99
9+62	5339.01
9+63	5339.06
10+48	5339.19
10+71	5339.37
10+72	5339.41
10+83	5339.97
12+26	5340.01
12+85	5340.51
12+94	5340.81
13+85	5341.01

FlowMaster Cross Section for Overland Flow at S. Gilpin St

Input Data

Station (ft)	Elevation (ft)
13+88	5341.12
14+35	5341.30
14+55	5341.95
15+16	5342.01
15+18	5342.06
15+68	5342.25
15+99	5342.90
16+44	5343.00
16+45	5343.05
16+79	5343.26
17+02	5343.88
17+85	5344.01
17+92	5344.45
18+13	5345.00
19+11	5345.01

Start Station	Ending Station	Roughness Coefficient
(0+00, 5339.99)	(19+11, 5345.01)	0.080

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.93	ft
Elevation Range	5337.71 to 5345.01 ft	
Flow Area	267.08	ft²

FlowMaster Cross Section for Overland Flow at S. Gilpin St

Results

Wetted Perimeter	466.04	ft
Hydraulic Radius	0.57	ft
Top Width	466.01	ft
Normal Depth	0.93	ft
Critical Depth	0.58	ft
Critical Slope	0.14844	ft/ft
Velocity	1.16	ft/s
Velocity Head	0.02	ft
Specific Energy	0.95	ft
Froude Number	0.27	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.93	ft
Critical Depth	0.58	ft
Channel Slope	0.00820	ft/ft
Critical Slope	0.14844	ft/ft

FlowMaster Cross Section for Overland Flow at S. Franklin St

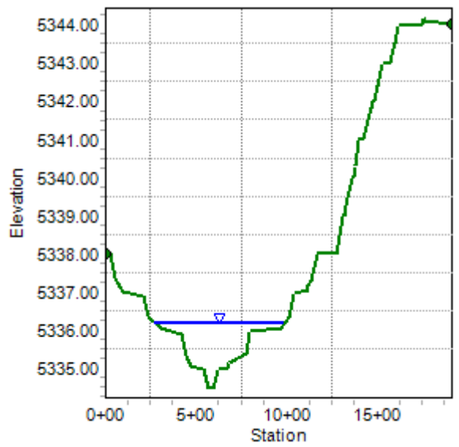
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Normal Depth	1.73	ft
Discharge	590.00	ft³/s

Cross Section Image



FlowMaster Worksheet for Overland Flow at S. Franklin St

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Discharge	590.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5337.99
0+30	5337.98
0+57	5337.35
0+98	5337.01
2+13	5336.89
2+35	5336.34
3+04	5336.05
4+25	5335.90
4+45	5335.32
4+48	5335.32
4+50	5335.29
4+71	5335.05
5+47	5334.99
5+65	5334.48
5+96	5334.46
6+20	5334.97
6+75	5335.01
6+80	5335.13
7+73	5335.38
7+75	5335.40
7+93	5335.98
9+65	5336.05
10+14	5336.34
10+38	5336.98
11+12	5337.03
11+17	5337.17
11+35	5337.30

FlowMaster Worksheet for Overland Flow at S. Franklin St

Input Data

Station (ft)	Elevation (ft)
11+66	5338.00
12+64	5338.01
12+66	5338.03
12+74	5338.00
13+07	5338.98
13+14	5339.01
13+26	5339.30
13+27	5339.30
13+57	5340.00
13+67	5340.02
13+75	5340.27
13+78	5340.33
13+93	5340.97
14+18	5341.01
14+68	5341.99
14+83	5342.01
15+25	5342.99
15+69	5343.01
15+85	5343.39
15+86	5343.39
15+91	5343.49
15+92	5343.49
16+07	5343.98
17+39	5344.01
17+50	5344.19
17+56	5344.07
19+11	5344.00

Start Station	Ending Station	Roughness Coefficient

FlowMaster Worksheet for Overland Flow at S. Franklin St

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+00, 5337.99)	(19+11, 5344.00)	0.080

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		1.73	ft
Elevation Range	5334.46 to 5344.19 ft		
Flow Area		466.74	ft²
Wetted Perimeter		716.32	ft
Hydraulic Radius		0.65	ft
Top Width		716.29	ft
Normal Depth		1.73	ft
Critical Depth		1.02	ft
Critical Slope		0.12120	ft/ft
Velocity		1.26	ft/s
Velocity Head		0.02	ft
Specific Energy		1.75	ft
Froude Number		0.28	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.73	ft
Critical Depth	1.02	ft

FlowMaster Worksheet for Overland Flow at S. Franklin St

GVF Output Data

Channel Slope	0.00820	ft/ft
Critical Slope	0.12120	ft/ft

FlowMaster Cross Section for Overland Flow at S. Humboldt St

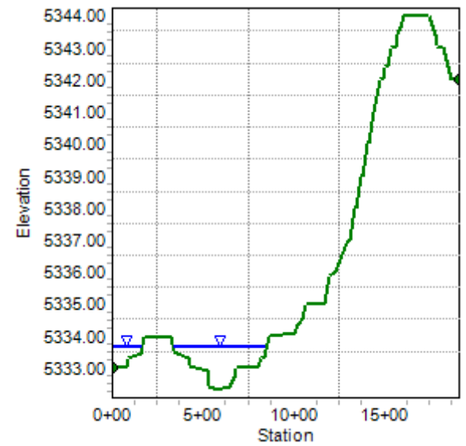
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Normal Depth	1.38	ft
Discharge	590.00	ft³/s

Cross Section Image



FlowMaster Worksheet for Overland Flow at S. Humboldt St

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Discharge	590.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5332.98
0+78	5333.02
0+88	5333.30
1+57	5333.46
1+79	5334.00
3+29	5333.94
3+47	5333.50
3+59	5333.45
4+23	5333.27
4+33	5333.05
5+23	5332.88
5+37	5332.42
5+64	5332.35
5+68	5332.28
6+51	5332.38
6+70	5332.69
6+79	5332.98
8+05	5333.06
8+19	5333.31
8+37	5333.35
8+62	5333.97
10+05	5334.07
10+18	5334.32
10+50	5334.53
10+68	5334.98
11+68	5335.02
11+98	5335.85

FlowMaster Worksheet for Overland Flow at S. Humboldt St

Input Data

Station (ft)	Elevation (ft)
12+30	5335.99
12+90	5336.91
13+07	5337.01
13+32	5337.99
13+42	5338.01
13+71	5338.96
13+74	5339.00
14+05	5340.00
14+08	5340.02
14+37	5341.00
14+41	5341.02
14+71	5342.00
14+92	5342.03
15+01	5342.39
15+12	5342.44
15+29	5343.00
15+62	5343.02
15+72	5343.42
15+88	5343.64
15+99	5343.96
17+45	5343.99
17+73	5343.38
17+83	5343.36
17+88	5343.05
18+23	5343.00
18+64	5342.00
19+11	5342.01

Start Station	Ending Station	Roughness Coefficient

FlowMaster Worksheet for Overland Flow at S. Humboldt St

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+00, 5332.98)	(19+11, 5342.01)	0.080

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		1.38	ft
Elevation Range	5332.28 to 5343.99 ft		
Flow Area		455.81	ft²
Wetted Perimeter		675.20	ft
Hydraulic Radius		0.68	ft
Top Width		674.48	ft
Normal Depth		1.38	ft
Critical Depth		0.90	ft
Critical Slope		0.13036	ft/ft
Velocity		1.29	ft/s
Velocity Head		0.03	ft
Specific Energy		1.41	ft
Froude Number		0.28	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.38	ft
Critical Depth	0.90	ft

FlowMaster Worksheet for Overland Flow at S. Humboldt St

GVF Output Data

Channel Slope	0.00820	ft/ft
Critical Slope	0.13036	ft/ft

FlowMaster Cross Section for Overland flow at Residential

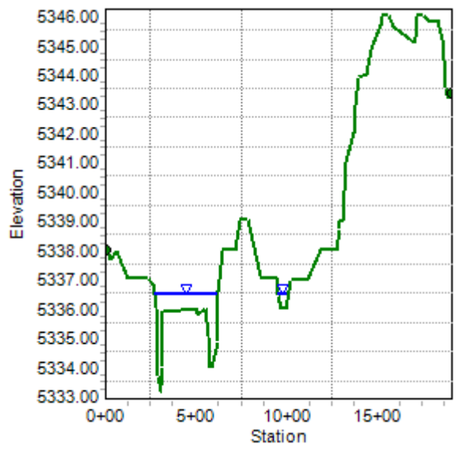
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Normal Depth	3.36	ft
Discharge	590.00	ft³/s

Cross Section Image



FlowMaster Cross Section for Overland flow at Residential

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00820	ft/ft
Discharge	590.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5338.00
0+09	5338.00
0+27	5337.65
0+65	5337.95
1+29	5337.00
2+39	5336.99
2+64	5336.81
2+75	5336.40
2+82	5336.00
2+90	5334.20
2+94	5333.66
2+97	5333.39
3+07	5333.12
3+12	5333.41
3+15	5334.00
3+15	5334.21
3+17	5335.00
3+20	5335.86
5+09	5336.00
5+12	5335.79
5+50	5336.00
5+66	5335.00
5+74	5334.00
5+85	5334.00
6+17	5334.84
6+25	5336.59
6+27	5337.00

FlowMaster Cross Section for Overland flow at Residential

Input Data

Station (ft)	Elevation (ft)
6+48	5338.00
7+20	5338.00
7+40	5339.00
7+89	5339.00
8+52	5337.07
9+48	5337.00
9+54	5336.43
9+68	5336.00
9+90	5336.00
10+16	5336.98
11+15	5337.00
11+83	5337.98
12+72	5338.00
12+86	5338.68
12+90	5338.99
13+04	5339.00
13+25	5341.00
13+67	5342.00
13+74	5342.97
13+94	5343.89
14+36	5344.00
14+60	5344.88
15+14	5345.70
15+24	5346.00
15+60	5346.00
15+84	5345.64
16+97	5345.08
17+03	5345.29
17+16	5346.00
17+54	5346.00
17+88	5345.79
18+24	5345.87
18+54	5345.14
18+64	5344.43
18+68	5344.00
18+74	5343.52
18+77	5343.31

FlowMaster Cross Section for Overland flow at Residential

Input Data

Station (ft)	Elevation (ft)
18+89	5343.20
19+11	5343.36

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5338.00)	(19+11, 5343.36)	0.080

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		3.36	ft
Elevation Range	5333.12 to 5346.00 ft		
Flow Area		370.38	ft²
Wetted Perimeter		402.09	ft
Hydraulic Radius		0.92	ft
Top Width		401.10	ft
Normal Depth		3.36	ft
Critical Depth		2.17	ft
Critical Slope		0.09120	ft/ft
Velocity		1.59	ft/s
Velocity Head		0.04	ft
Specific Energy		3.40	ft
Froude Number		0.29	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft

Appendix C – Hydraulics Analysis

FlowMaster Cross Section for Overland flow at Residential

GVF Input Data

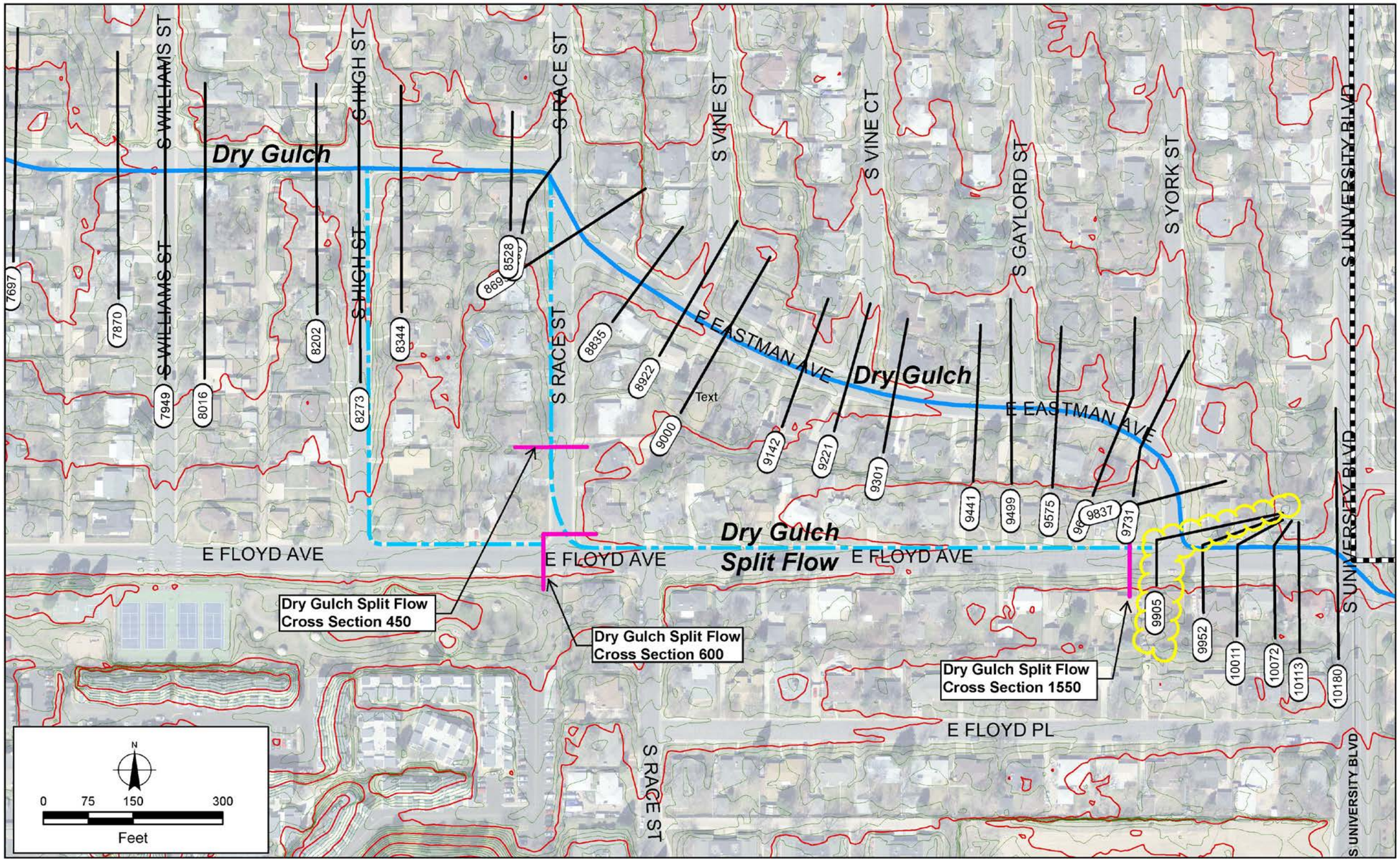
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.36	ft
Critical Depth	2.17	ft
Channel Slope	0.00820	ft/ft
Critical Slope	0.09120	ft/ft

Split Flow & Shallow Overland Floodplain Analysis @ E. Eastman Ave/E. Floyd Ave

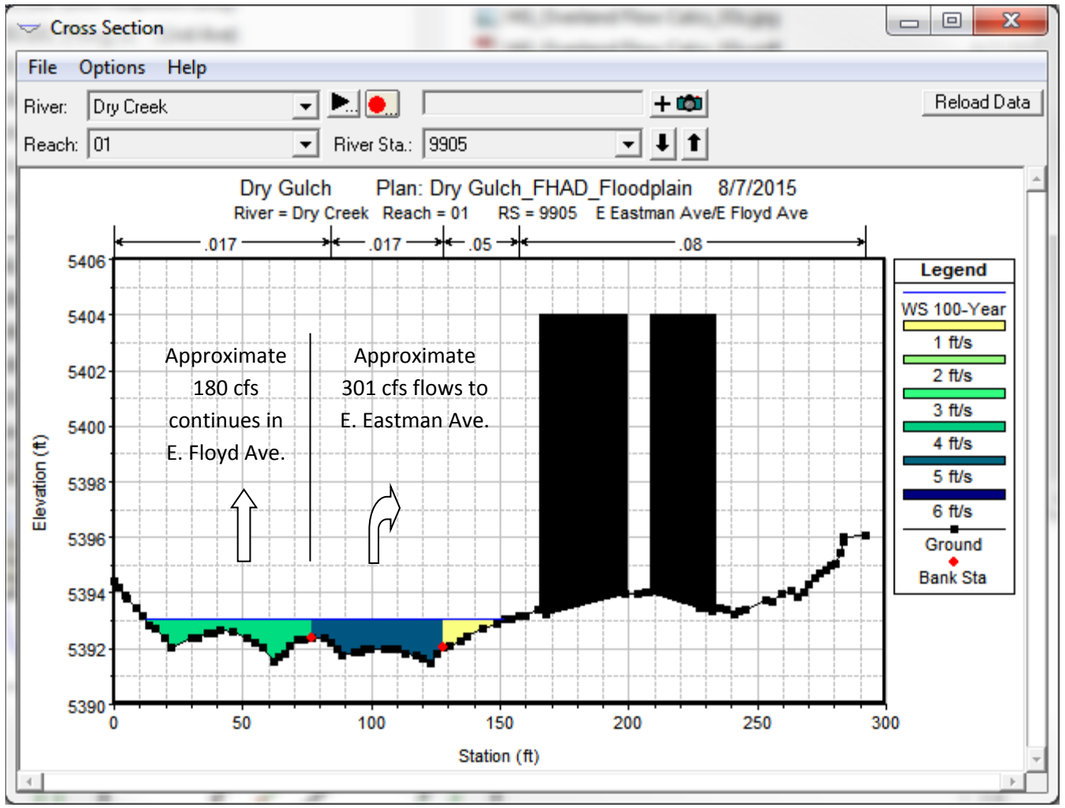
Dry Gulch

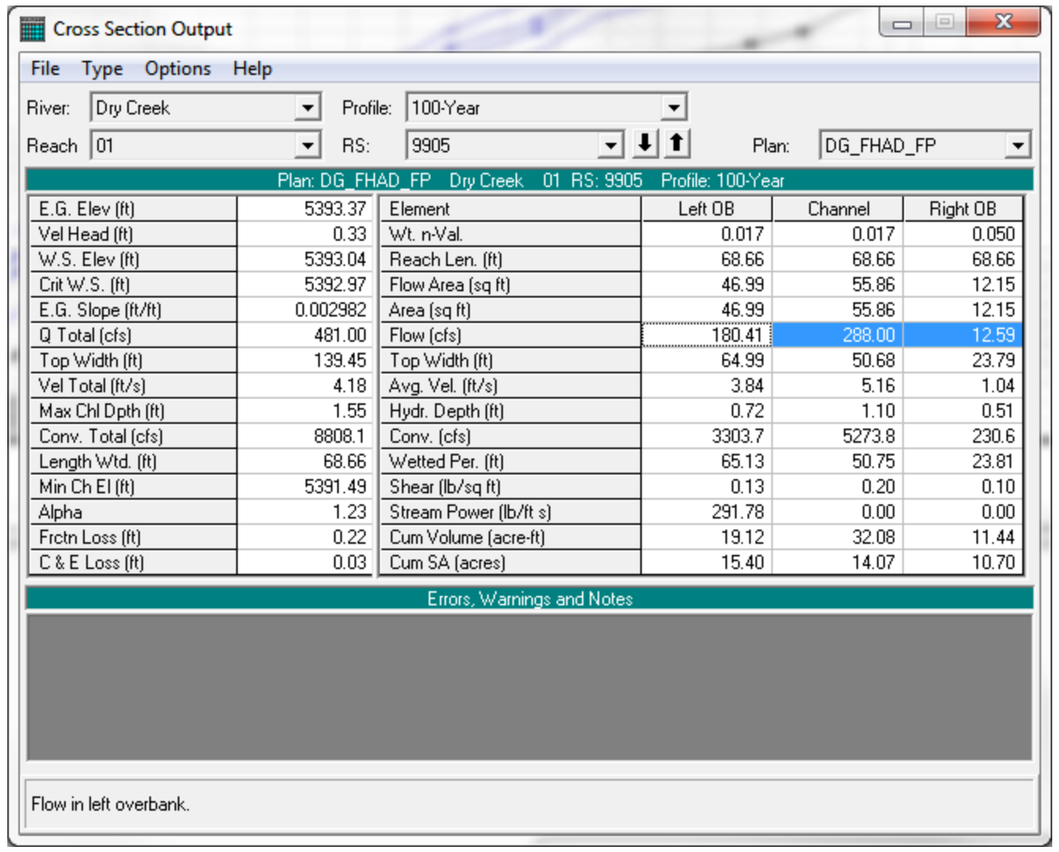


100-year Split Flow Analysis @ E. Eastman Ave/E. Floyd Ave

HEC-RAS Cross Section/River Station 9905

Dry Gulch





Cross Section 1550 _ Dry Gulch 100-year Split Flow Normal Depth Calculation

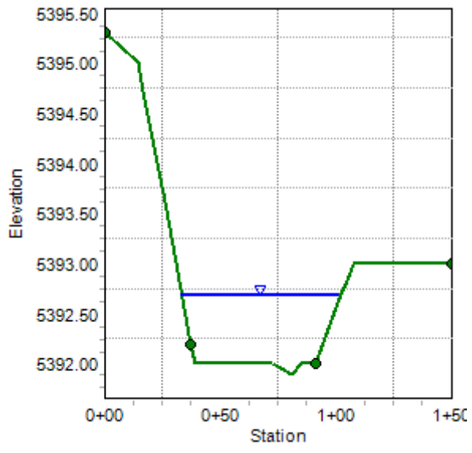
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00580	ft/ft
Normal Depth	0.78	ft
Discharge	180.00	ft³/s

Cross Section Image



Worksheet for Dry Gulch_100-year Split Flow Normal Depth Calculation_1550

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00580	ft/ft
Discharge	180.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5395.30
0+14	5395.00
0+17	5394.70
0+23	5394.00
0+25	5393.70
0+31	5393.00
0+37	5392.20
0+39	5392.00
0+72	5392.00
0+81	5391.90
0+85	5392.00
0+91	5392.00
1+02	5392.70
1+04	5392.80
1+08	5393.00
1+50	5393.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5395.30)	(0+37, 5392.20)	0.025
(0+37, 5392.20)	(0+91, 5392.00)	0.017
(0+91, 5392.00)	(1+50, 5393.00)	0.025

Worksheet for Dry Gulch_100-year Split Flow Normal Depth Calculation_1550

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.78	ft
Elevation Range	5391.90 to 5395.30 ft		
Flow Area		41.83	ft²
Wetted Perimeter		68.33	ft
Hydraulic Radius		0.61	ft
Top Width		68.26	ft
Normal Depth		0.78	ft
Critical Depth		0.77	ft
Critical Slope		0.00621	ft/ft
Velocity		4.30	ft/s
Velocity Head		0.29	ft
Specific Energy		1.07	ft
Froude Number		0.97	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.78	ft
Critical Depth	0.77	ft
Channel Slope	0.00580	ft/ft
Critical Slope	0.00621	ft/ft

Cross Section 600 _ Dry Gulch 100-year Split Flow Normal Depth Calculation

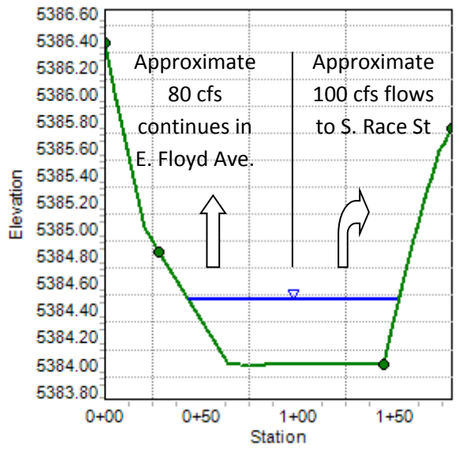
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Normal Depth	0.49	ft
Discharge	180.00	ft³/s

Cross Section Image



Split flow analysis at E. Floyd Ave and S. Race St

Worksheet for Dry Gulch _ 100-year Split Flow Normal Depth Calculation _ 600

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Discharge	180.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5386.38
0+05	5386.07
0+05	5386.00
0+06	5385.91
0+21	5385.00
0+24	5384.93
0+28	5384.83
0+51	5384.30
0+53	5384.24
0+55	5384.21
0+64	5384.00
0+71	5383.99
0+75	5383.98
0+83	5384.00
1+05	5384.00
1+17	5383.99
1+21	5383.99
1+37	5384.00
1+45	5384.00
1+47	5384.16
1+52	5384.45
1+59	5384.89
1+61	5385.00
1+64	5385.15
1+68	5385.31
1+69	5385.37
1+74	5385.58

Worksheet for Dry Gulch _ 100-year Split Flow Normal Depth Calculation _ 600

Input Data

Station (ft)	Elevation (ft)
1+75	5385.61
1+76	5385.63
1+79	5385.73
1+80	5385.74

Start Station	Ending Station	Roughness Coefficient
(0+00, 5386.38)	(0+28, 5384.83)	0.025
(0+28, 5384.83)	(1+45, 5384.00)	0.017
(1+45, 5384.00)	(1+80, 5385.74)	0.025

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.49	ft
Elevation Range	5383.98 to 5386.38 ft	
Flow Area	44.31	ft²
Wetted Perimeter	108.57	ft
Hydraulic Radius	0.41	ft
Top Width	108.55	ft
Normal Depth	0.49	ft
Critical Depth	0.52	ft
Critical Slope	0.00601	ft/ft
Velocity	4.06	ft/s
Velocity Head	0.26	ft
Specific Energy	0.74	ft

Worksheet for Dry Gulch _ 100-year Split Flow Normal Depth Calculation _ 600

Results

Froude Number	1.12	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.49	ft
Critical Depth	0.52	ft
Channel Slope	0.00770	ft/ft
Critical Slope	0.00601	ft/ft

Cross Section 450 _ Dry Gulch _ 100-year Split Flow Normal Depth Calculation

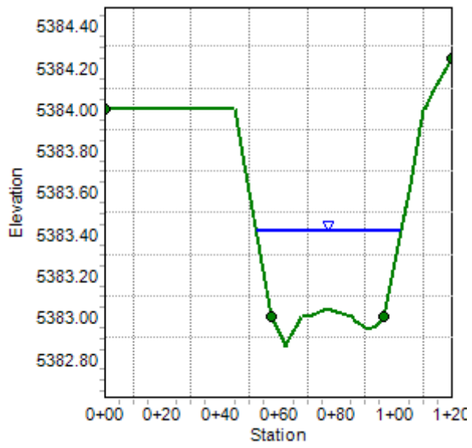
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01690	ft/ft
Normal Depth	0.55	ft
Discharge	100.00	ft³/s

Cross Section Image



Worksheet for Dry Gulch _ 100-year Split Flow Normal Depth Calculation _ 450

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01690	ft/ft
Discharge	100.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5384.00
0+45	5384.00
0+47	5383.86
0+49	5383.69
0+57	5383.00
0+62	5382.88
0+62	5382.86
0+63	5382.88
0+67	5382.97
0+68	5383.00
0+72	5383.01
0+77	5383.04
0+79	5383.03
0+86	5383.00
0+87	5382.98
0+88	5382.97
0+91	5382.94
0+94	5382.96
0+97	5383.00
1+05	5383.64
1+10	5384.00
1+11	5384.00
1+14	5384.08
1+20	5384.24

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient

Worksheet for Dry Gulch _ 100-year Split Flow Normal Depth Calculation _ 450

Input Data

(0+00, 5384.00)	(0+57, 5383.00)	0.025
(0+57, 5383.00)	(0+97, 5383.00)	0.017
(0+97, 5383.00)	(1+20, 5384.24)	0.025

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.55	ft
Elevation Range	5382.86 to 5384.24 ft		
Flow Area		18.84	ft²
Wetted Perimeter		49.94	ft
Hydraulic Radius		0.38	ft
Top Width		49.90	ft
Normal Depth		0.55	ft
Critical Depth		0.67	ft
Critical Slope		0.00674	ft/ft
Velocity		5.31	ft/s
Velocity Head		0.44	ft
Specific Energy		0.98	ft
Froude Number		1.52	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s

Worksheet for Dry Gulch _ 100-year Split Flow Normal Depth Calculation _ 450

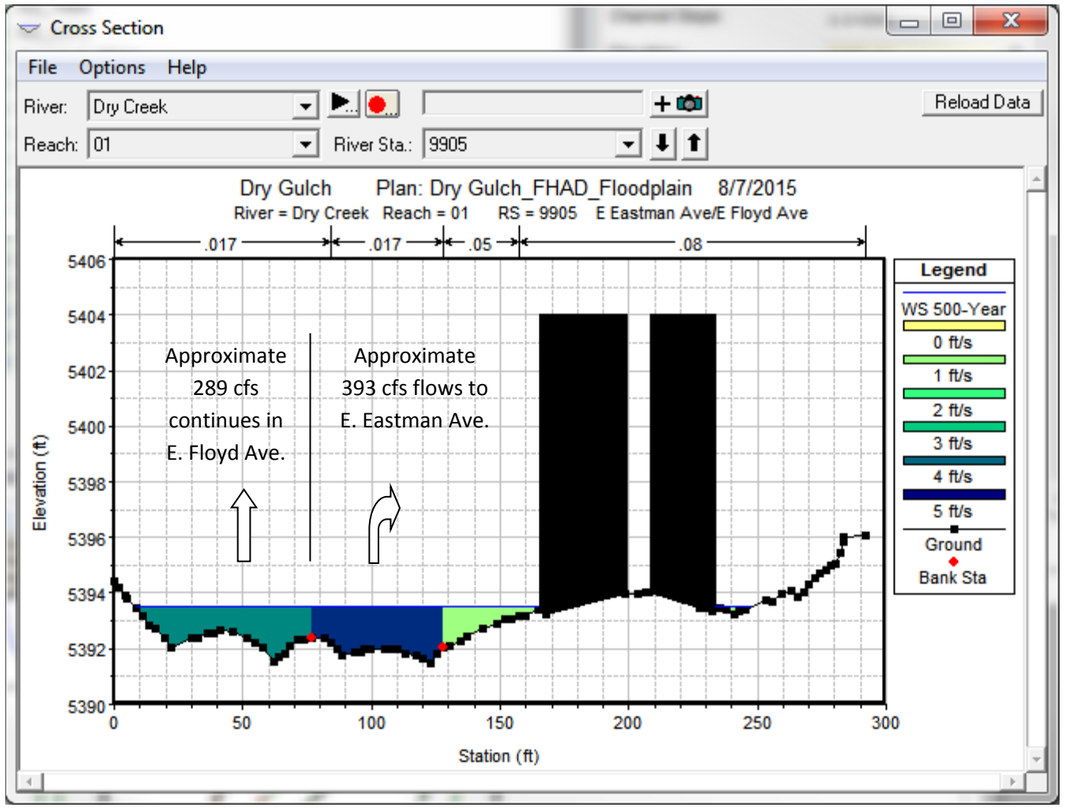
GVF Output Data

Normal Depth	0.55	ft
Critical Depth	0.67	ft
Channel Slope	0.01690	ft/ft
Critical Slope	0.00674	ft/ft

500-year Split Flow Analysis @ E. Eastman Ave/E. Floyd Ave

HEC-RAS Cross Section/River Station 9905

Dry Gulch



Cross Section Output

File Type Options Help

River: Dry Creek Profile: 500-Year

Reach 01 RS: 9905 Plan: DG_FHAD_FP

Plan: DG_FHAD_FP Dry Creek 01 RS: 9905 Profile: 500-Year

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	5393.77	Wt. n-Val.	0.017	0.017	0.053
Vel Head (ft)	0.26	Reach Len. (ft)	68.66	68.66	68.66
W.S. Elev (ft)	5393.51	Flow Area (sq ft)	78.79	80.01	32.38
Crit W.S. (ft)		Area (sq ft)	78.79	80.01	32.38
E.G. Slope (ft/ft)	0.001470	Flow (cfs)	288.61	365.57	27.82
Q Total (cfs)	682.00	Top Width (ft)	68.78	50.68	73.13
Top Width (ft)	192.59	Avg. Vel. (ft/s)	3.66	4.57	0.86
Vel Total (ft/s)	3.57	Hydr. Depth (ft)	1.15	1.58	0.44
Max Chl Dpth (ft)	2.02	Conv. (cfs)	7526.8	9533.6	725.5
Conv. Total (cfs)	17786.0	Wetted Per. (ft)	68.95	50.75	73.20
Length Wtd. (ft)	68.66	Shear (lb/sq ft)	0.10	0.14	0.04
Min Ch El (ft)	5391.49	Stream Power (lb/ft s)	291.78	0.00	0.00
Alpha	1.33	Cum Volume (acre-ft)	32.32	36.11	23.94
Frctn Loss (ft)	0.14	Cum SA (acres)	22.89	13.46	18.76
C & E Loss (ft)	0.05				

Errors, Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Flow in left overbank.

Cross Section 1550 _ Dry Gulch 500-year Split Flow Normal Depth Calculation

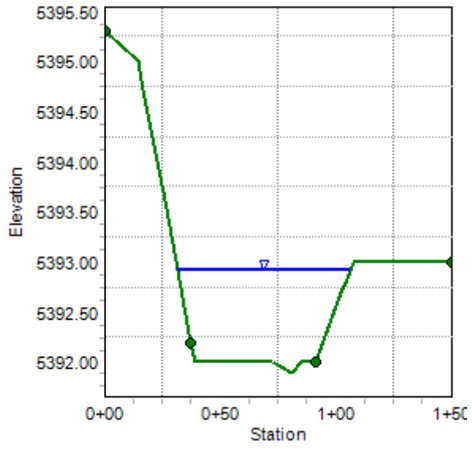
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00580	ft/ft
Normal Depth	1.02	ft
Discharge	289.00	ft³/s

Cross Section Image



Worksheet for Dry Gulch_500-year Split Flow Normal Depth Calculation_1550

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00580	ft/ft
Discharge	289.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5395.30
0+14	5395.00
0+17	5394.70
0+23	5394.00
0+25	5393.70
0+31	5393.00
0+37	5392.20
0+39	5392.00
0+72	5392.00
0+81	5391.90
0+85	5392.00
0+91	5392.00
1+02	5392.70
1+04	5392.80
1+08	5393.00
1+50	5393.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5395.30)	(0+37, 5392.20)	0.025
(0+37, 5392.20)	(0+91, 5392.00)	0.017
(0+91, 5392.00)	(1+50, 5393.00)	0.025

Worksheet for Dry Gulch_500-year Split Flow Normal Depth Calculation_1550

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		1.02	ft
Elevation Range	5391.90 to 5395.30 ft		
Flow Area		58.87	ft²
Wetted Perimeter		75.17	ft
Hydraulic Radius		0.78	ft
Top Width		75.08	ft
Normal Depth		1.02	ft
Critical Depth		1.01	ft
Critical Slope		0.00610	ft/ft
Velocity		4.91	ft/s
Velocity Head		0.37	ft
Specific Energy		1.39	ft
Froude Number		0.98	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.02	ft
Critical Depth	1.01	ft
Channel Slope	0.00580	ft/ft
Critical Slope	0.00610	ft/ft

Cross Section 600 _ Dry Gulch 500-year Split Flow Normal Depth Calculation

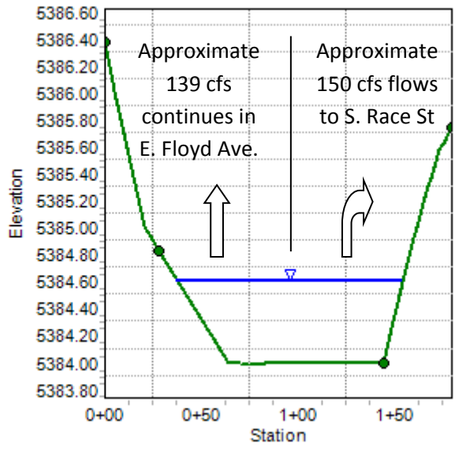
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Normal Depth	0.63	ft
Discharge	289.00	ft³/s

Cross Section Image



Split flow analysis at E. Floyd Ave and S. Race St

Worksheet for Dry Gulch_500-year Split Flow Normal Depth Calculation_600

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00770	ft/ft
Discharge	289.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5386.38
0+05	5386.07
0+05	5386.00
0+06	5385.91
0+21	5385.00
0+24	5384.93
0+28	5384.83
0+51	5384.30
0+53	5384.24
0+55	5384.21
0+64	5384.00
0+71	5383.99
0+75	5383.98
0+83	5384.00
1+05	5384.00
1+17	5383.99
1+21	5383.99
1+37	5384.00
1+45	5384.00
1+47	5384.16
1+52	5384.45
1+59	5384.89
1+61	5385.00
1+64	5385.15
1+68	5385.31
1+69	5385.37
1+74	5385.58

Worksheet for Dry Gulch_500-year Split Flow Normal Depth Calculation_600

Input Data

Station (ft)	Elevation (ft)
1+75	5385.61
1+76	5385.63
1+79	5385.73
1+80	5385.74

Start Station	Ending Station	Roughness Coefficient
(0+00, 5386.38)	(0+28, 5384.83)	0.025
(0+28, 5384.83)	(1+45, 5384.00)	0.017
(1+45, 5384.00)	(1+80, 5385.74)	0.025

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.63	ft
Elevation Range	5383.98 to 5386.38 ft	
Flow Area	61.05	ft²
Wetted Perimeter	117.37	ft
Hydraulic Radius	0.52	ft
Top Width	117.35	ft
Normal Depth	0.63	ft
Critical Depth	0.69	ft
Critical Slope	0.00560	ft/ft
Velocity	4.73	ft/s
Velocity Head	0.35	ft
Specific Energy	0.98	ft

Worksheet for Dry Gulch_500-year Split Flow Normal Depth Calculation_600

Results

Froude Number	1.16	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.63	ft
Critical Depth	0.69	ft
Channel Slope	0.00770	ft/ft
Critical Slope	0.00560	ft/ft

Cross Section 450 _ Dry Gulch _ 500-year Split Flow Normal Depth Calculation

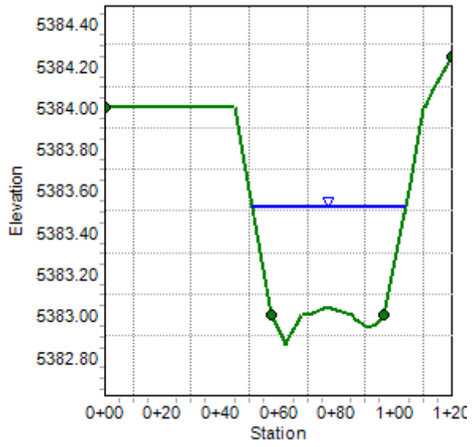
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01690	ft/ft
Normal Depth	0.66	ft
Discharge	150.00	ft³/s

Cross Section Image



Worksheet for Dry Gulch _ 500-year Split Flow Normal Depth Calculation _ 450

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01690	ft/ft
Discharge	150.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	5384.00
0+45	5384.00
0+47	5383.86
0+49	5383.69
0+57	5383.00
0+62	5382.88
0+62	5382.86
0+63	5382.88
0+67	5382.97
0+68	5383.00
0+72	5383.01
0+77	5383.04
0+79	5383.03
0+86	5383.00
0+87	5382.98
0+88	5382.97
0+91	5382.94
0+94	5382.96
0+97	5383.00
1+05	5383.64
1+10	5384.00
1+11	5384.00
1+14	5384.08
1+20	5384.24

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient

Worksheet for Dry Gulch _ 500-year Split Flow Normal Depth Calculation _ 450

Input Data

(0+00, 5384.00)	(0+57, 5383.00)	0.025
(0+57, 5383.00)	(0+97, 5383.00)	0.017
(0+97, 5383.00)	(1+20, 5384.24)	0.025

Options

Current Roughness Weighted	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.66	ft
Elevation Range	5382.86 to 5384.24 ft		
Flow Area		24.93	ft²
Wetted Perimeter		53.06	ft
Hydraulic Radius		0.47	ft
Top Width		53.02	ft
Normal Depth		0.66	ft
Critical Depth		0.83	ft
Critical Slope		0.00653	ft/ft
Velocity		6.02	ft/s
Velocity Head		0.56	ft
Specific Energy		1.23	ft
Froude Number		1.55	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

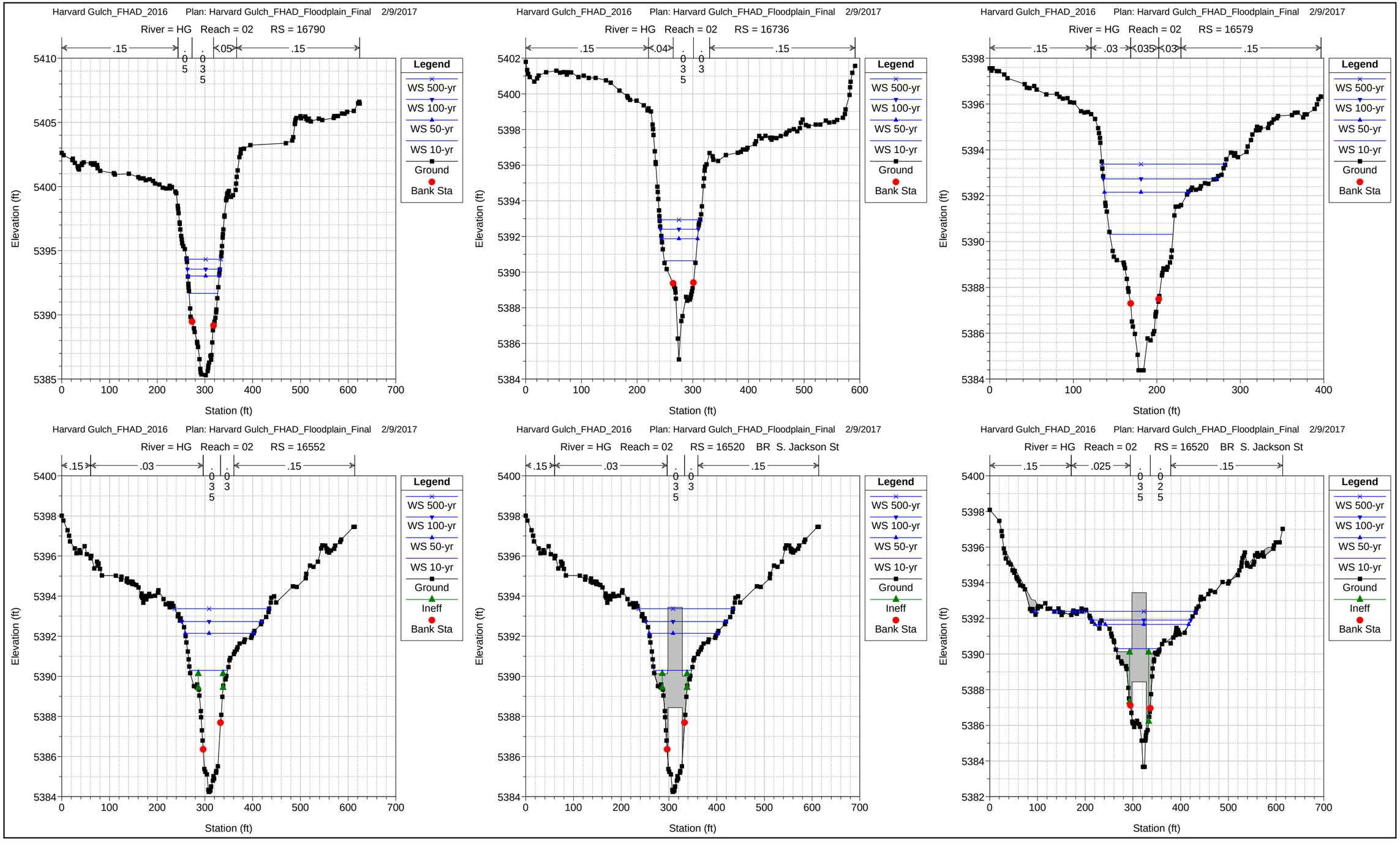
GVF Output Data

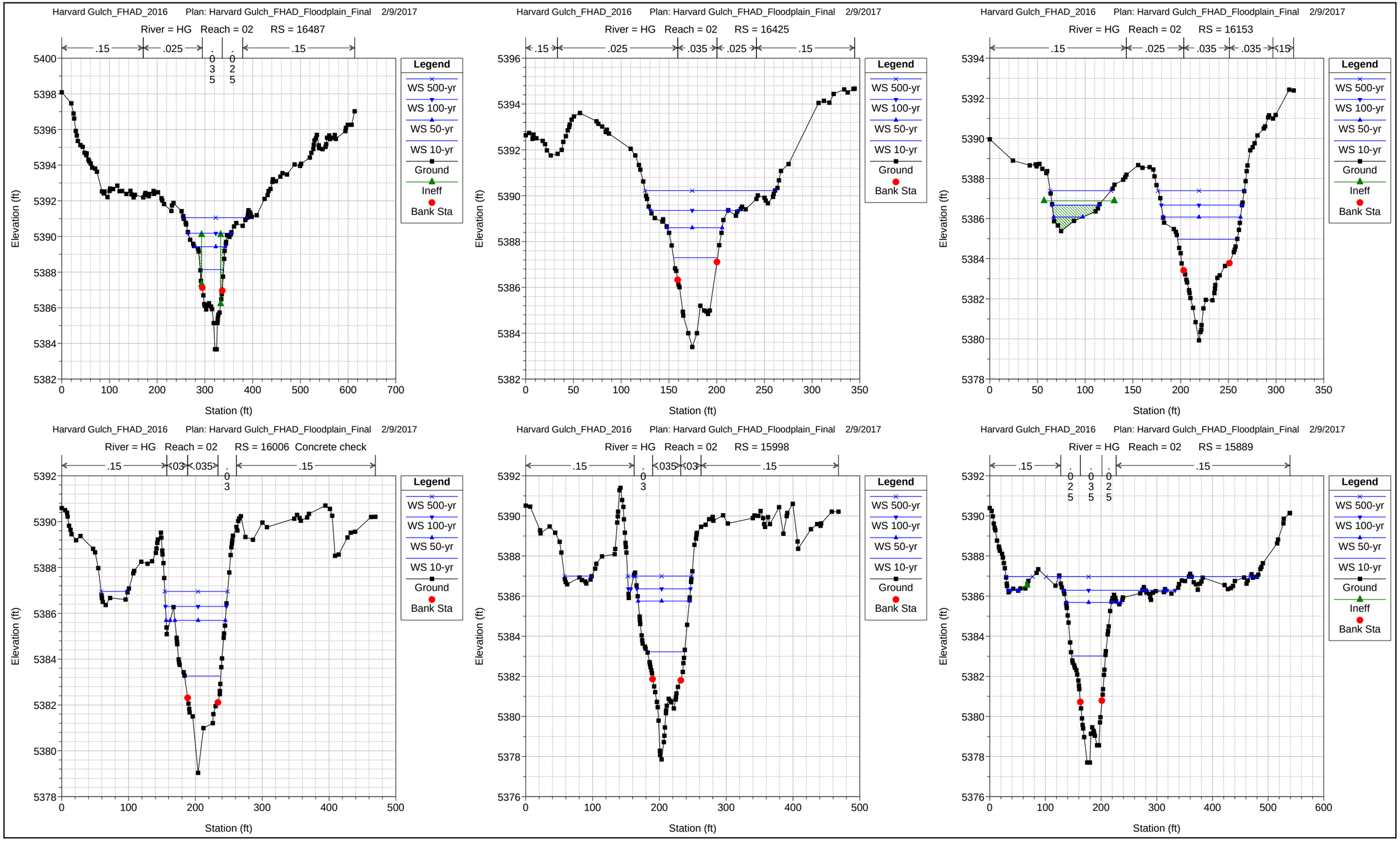
Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s

Worksheet for Dry Gulch _ 500-year Split Flow Normal Depth Calculation _ 450

GVF Output Data

Normal Depth	0.66	ft
Critical Depth	0.83	ft
Channel Slope	0.01690	ft/ft
Critical Slope	0.00653	ft/ft


Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16790
.15 .05 .15
.05 .035
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16736
.15 .04 .15
.035 .03
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16579
.15 .03 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16552
.15 .03 .15
.035 .03
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16520 BR S. Jackson St
.15 .03 .15
.035 .03
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16520 BR S. Jackson St
.15 .025 .15
.035 .025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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River = HG Reach = 02 RS = 16487
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Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16425
.15 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16153
.15 .025 .035 .035 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 16006 Concrete check
.15 .03 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15998
.15 .03 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15889
.15 .025 .035 .025 .15
Legend
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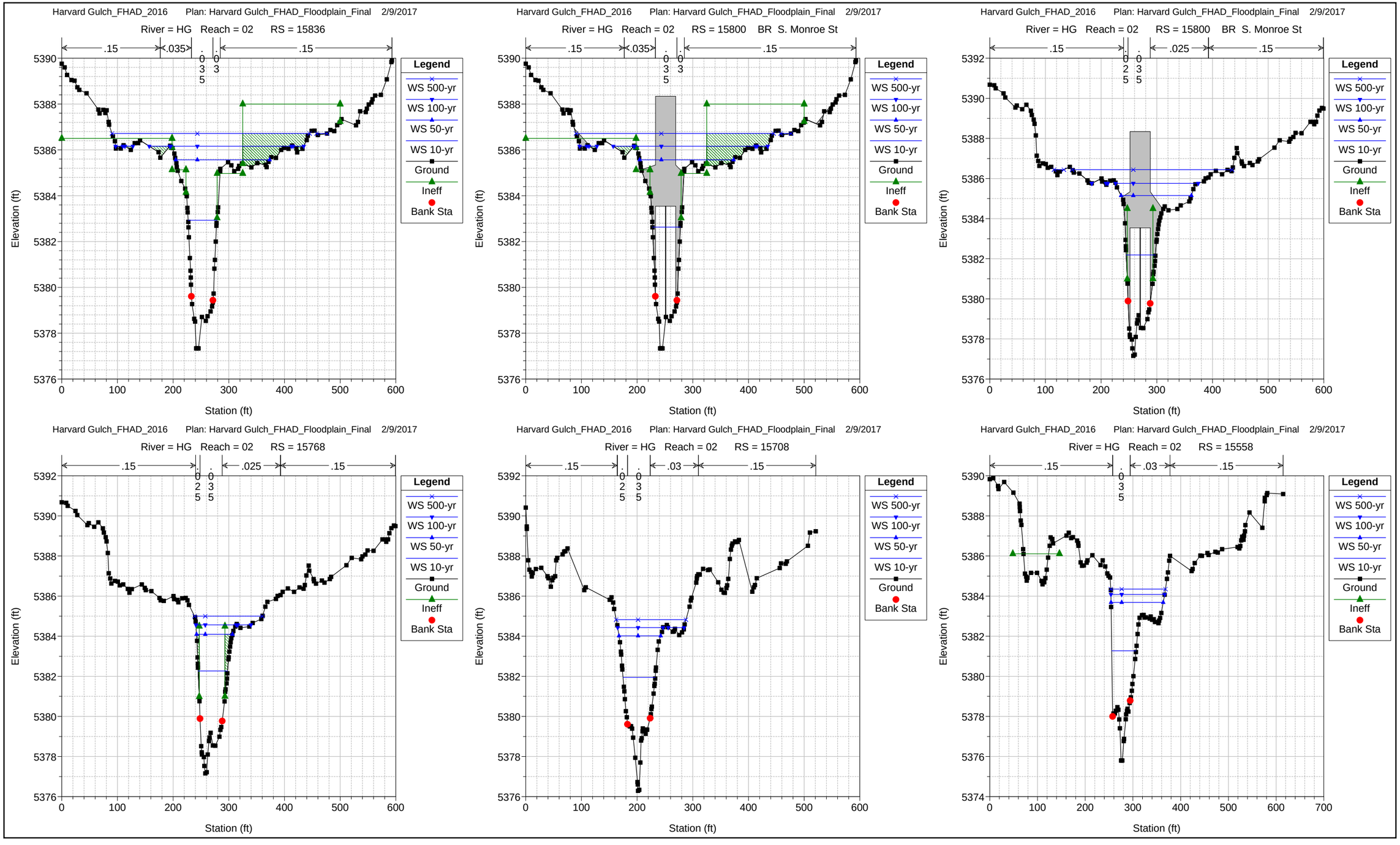
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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River = HG Reach = 02 RS = 15836
.15 .035 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15800 BR S. Monroe St
.15 .035 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15800 BR S. Monroe St
.15 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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River = HG Reach = 02 RS = 15768
.15 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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River = HG Reach = 02 RS = 15708
.15 .025 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15558
.15 .035 .03 .15
Legend
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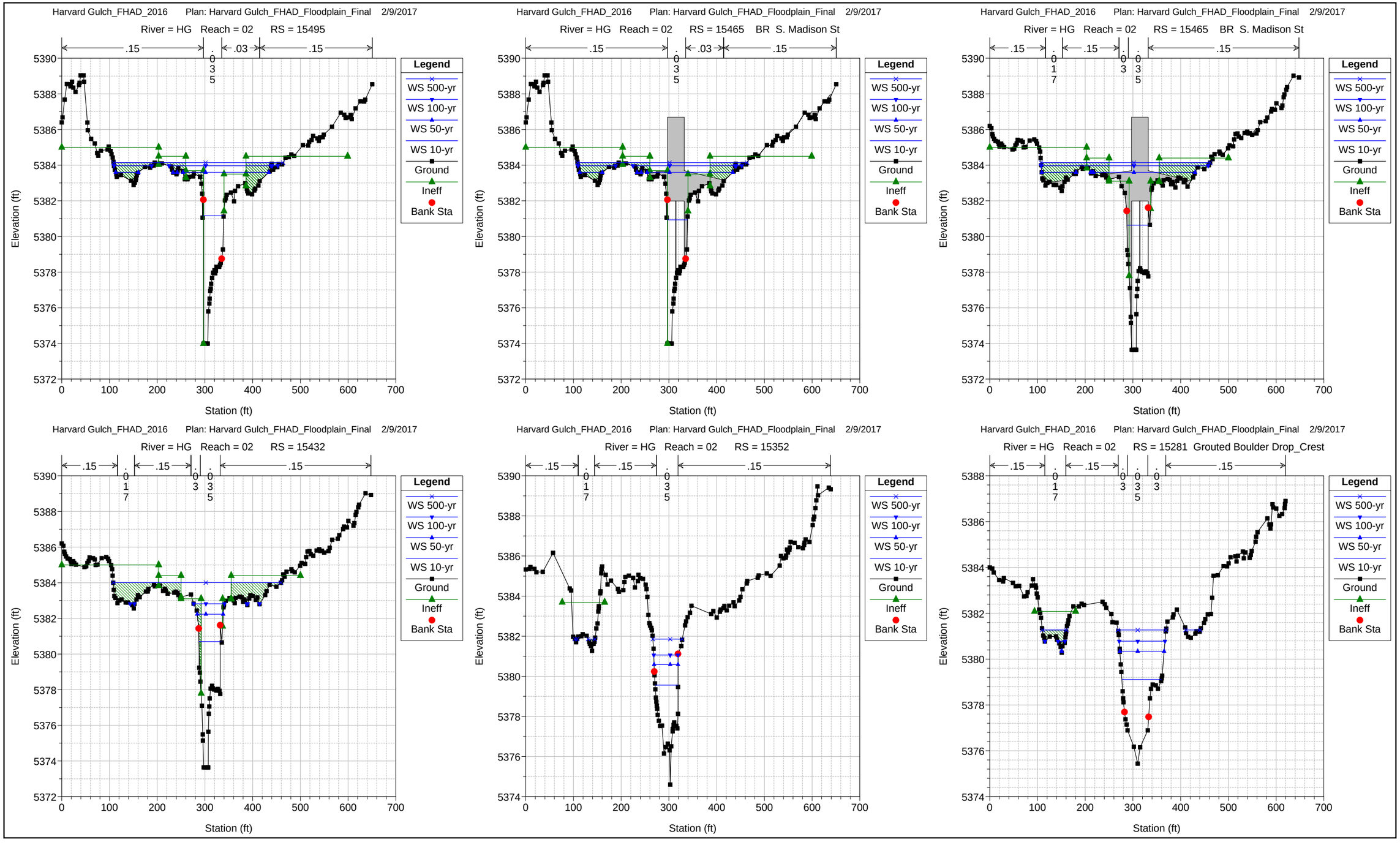
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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River = HG Reach = 02 RS = 15495
River = HG Reach = 02 RS = 15465 BR S. Madison St
River = HG Reach = 02 RS = 15432
River = HG Reach = 02 RS = 15352
River = HG Reach = 02 RS = 15281 Grouted Boulder Drop_Crest
Legend
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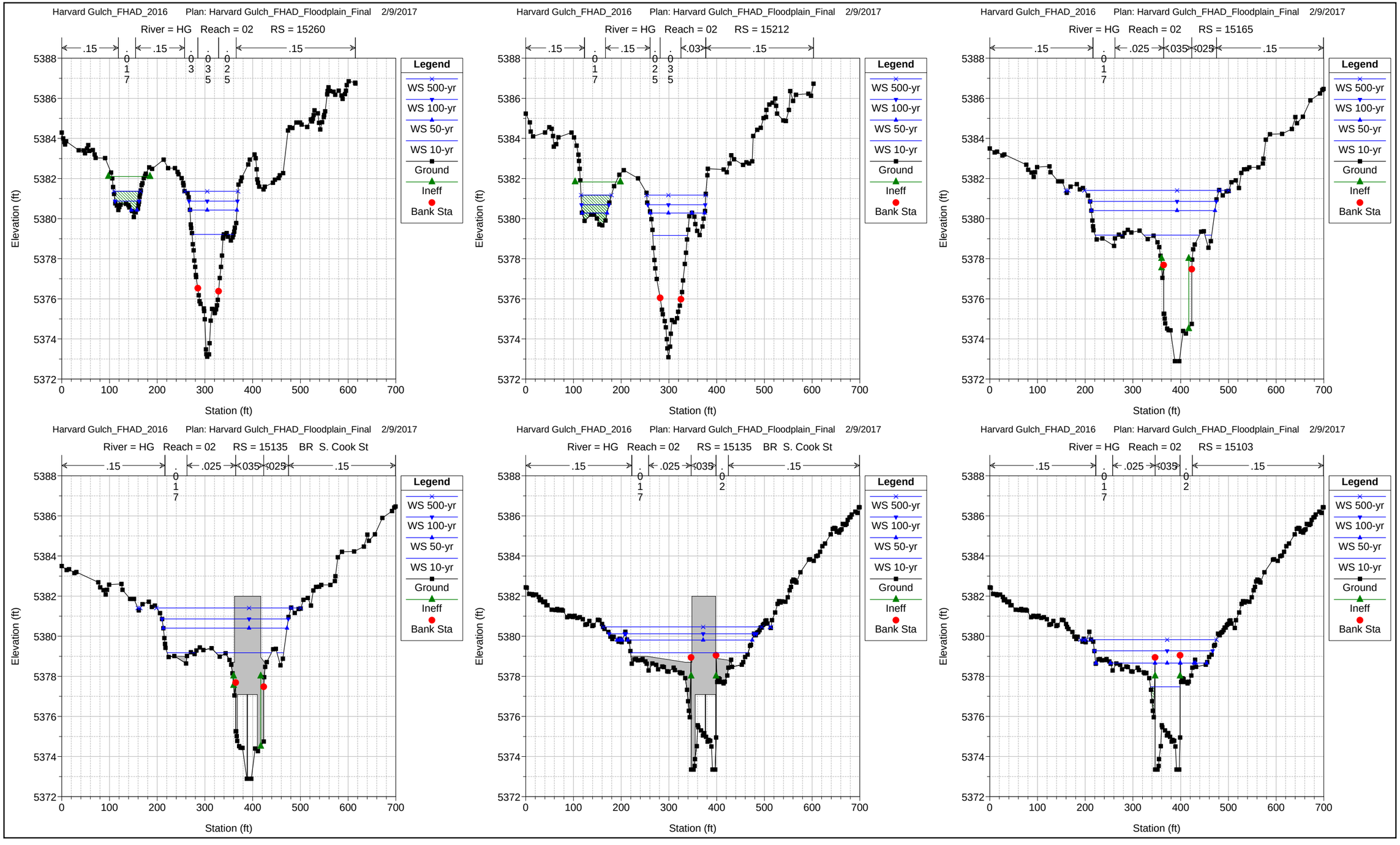
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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River = HG Reach = 02 RS = 15260
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Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15212
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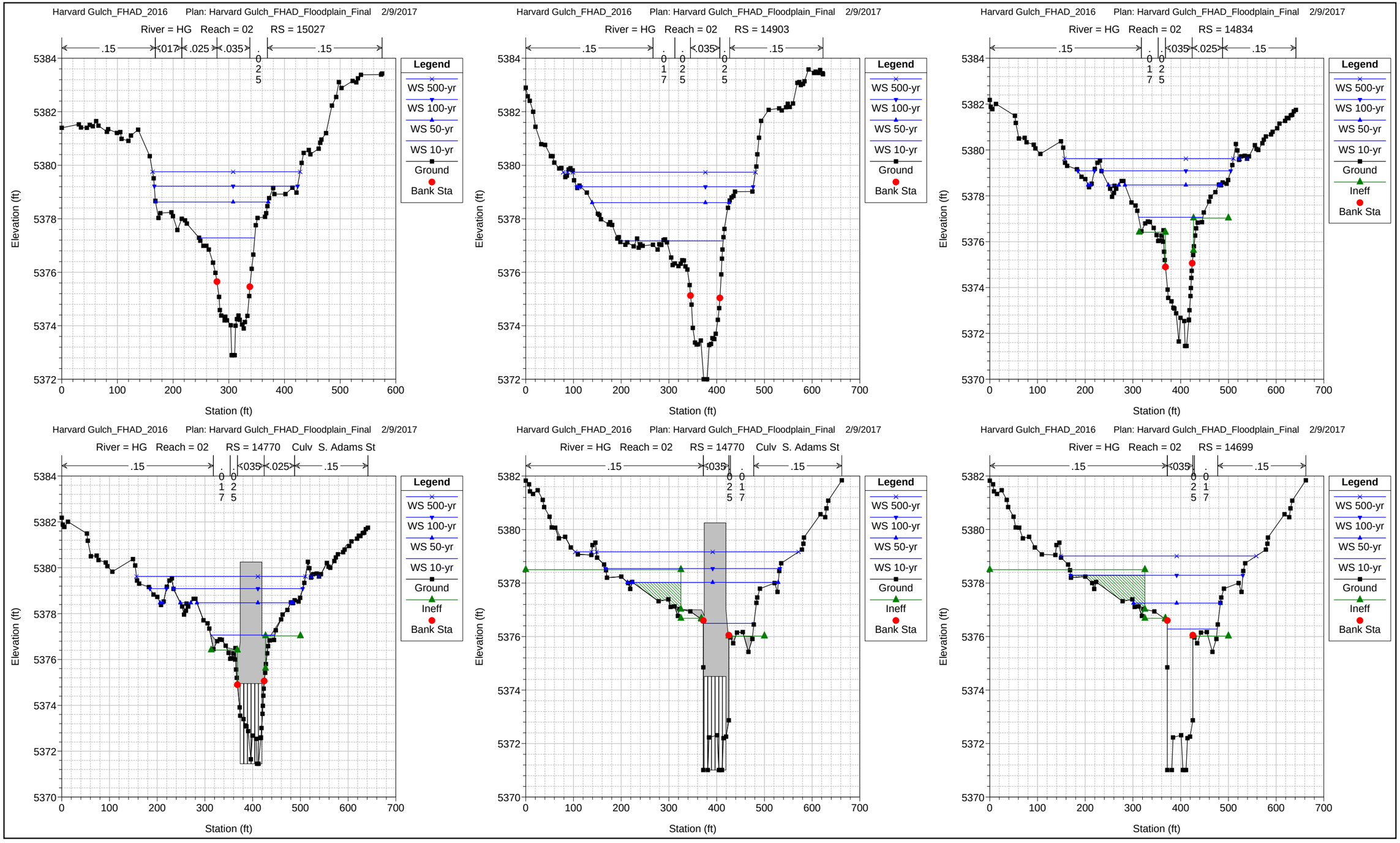
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15165
.15 .017 .025 .035 .025 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15135 BR S. Cook St
.15 .017 .025 .035 .025 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15135 BR S. Cook St
.15 .017 .025 .035 .02 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 15103
.15 .017 .025 .035 .02 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
5372
5374
5376
5378
5380
5382
5384
5386
5388
0
100
200
300
400
500
600
700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River = HG Reach = 02 RS = 15027
.15 .017 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 14903
.15 .017 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 14834
.15 .017 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 14770 Culv S. Adams St
.15 .017 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 14770 Culv S. Adams St
.15 .035 .025 .017 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 14699
.15 .035 .025 .017 .15
Legend
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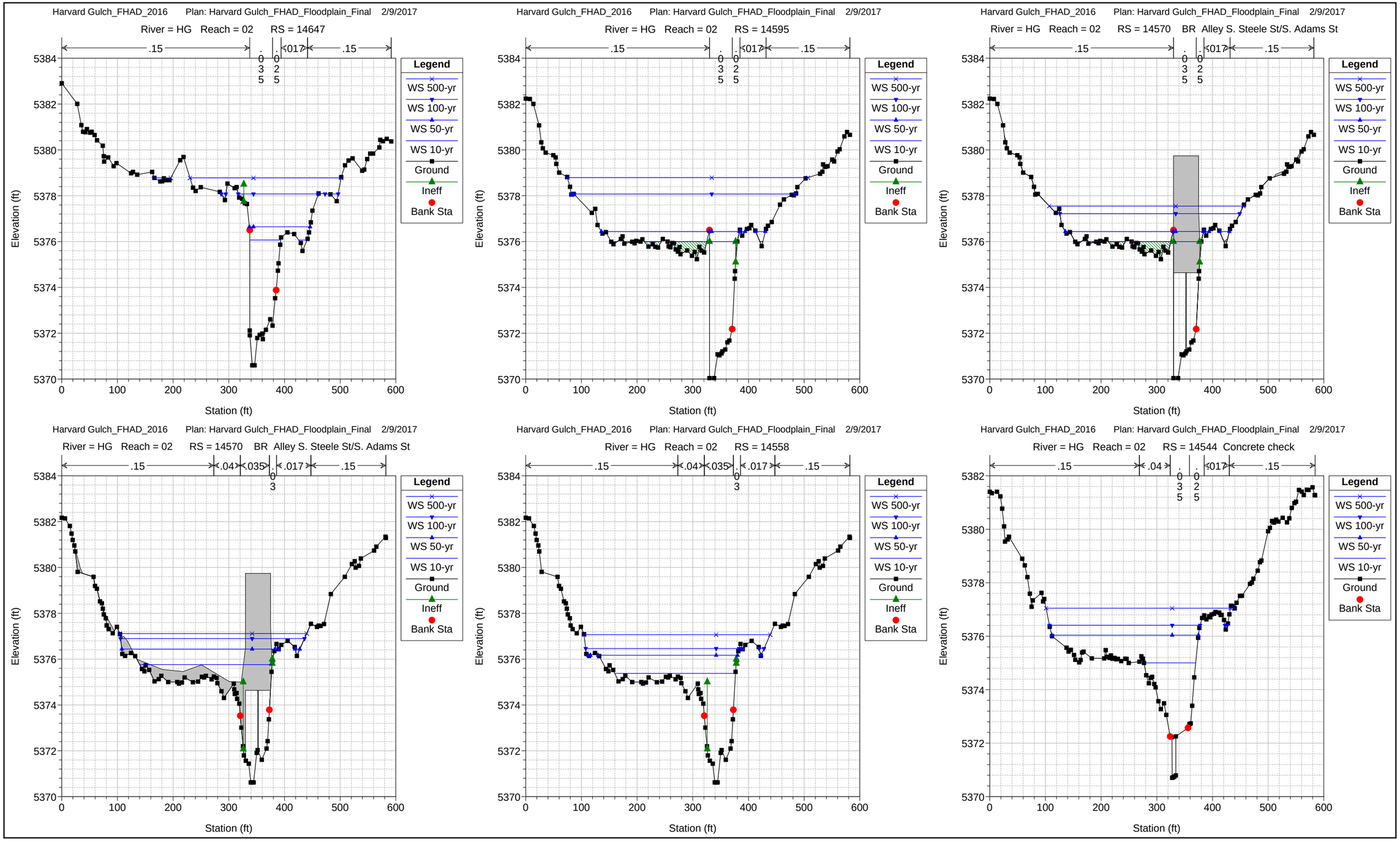
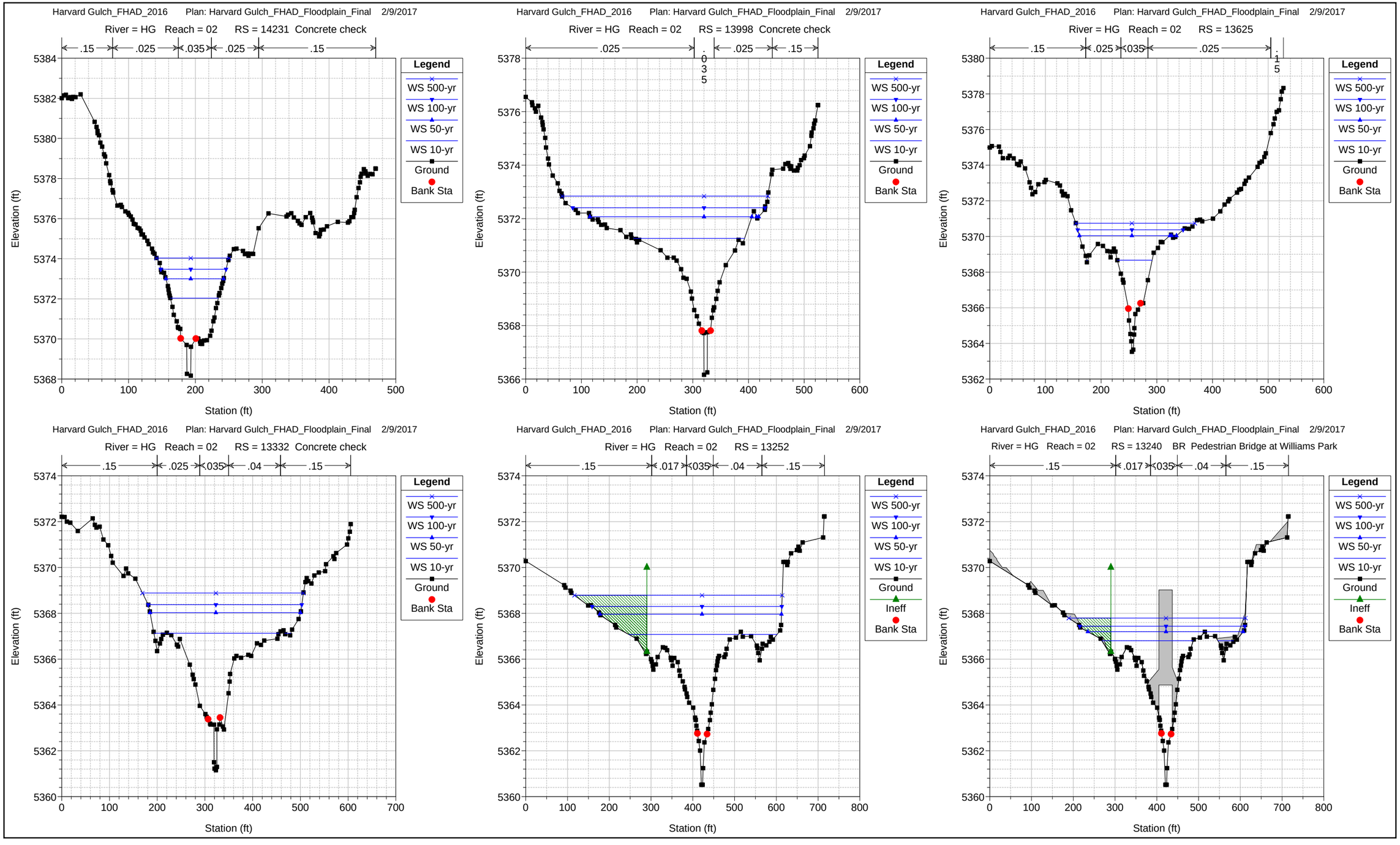
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



Appendix C - Hydraulic Analysis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River = HG Reach = 02 RS = 14231 Concrete check
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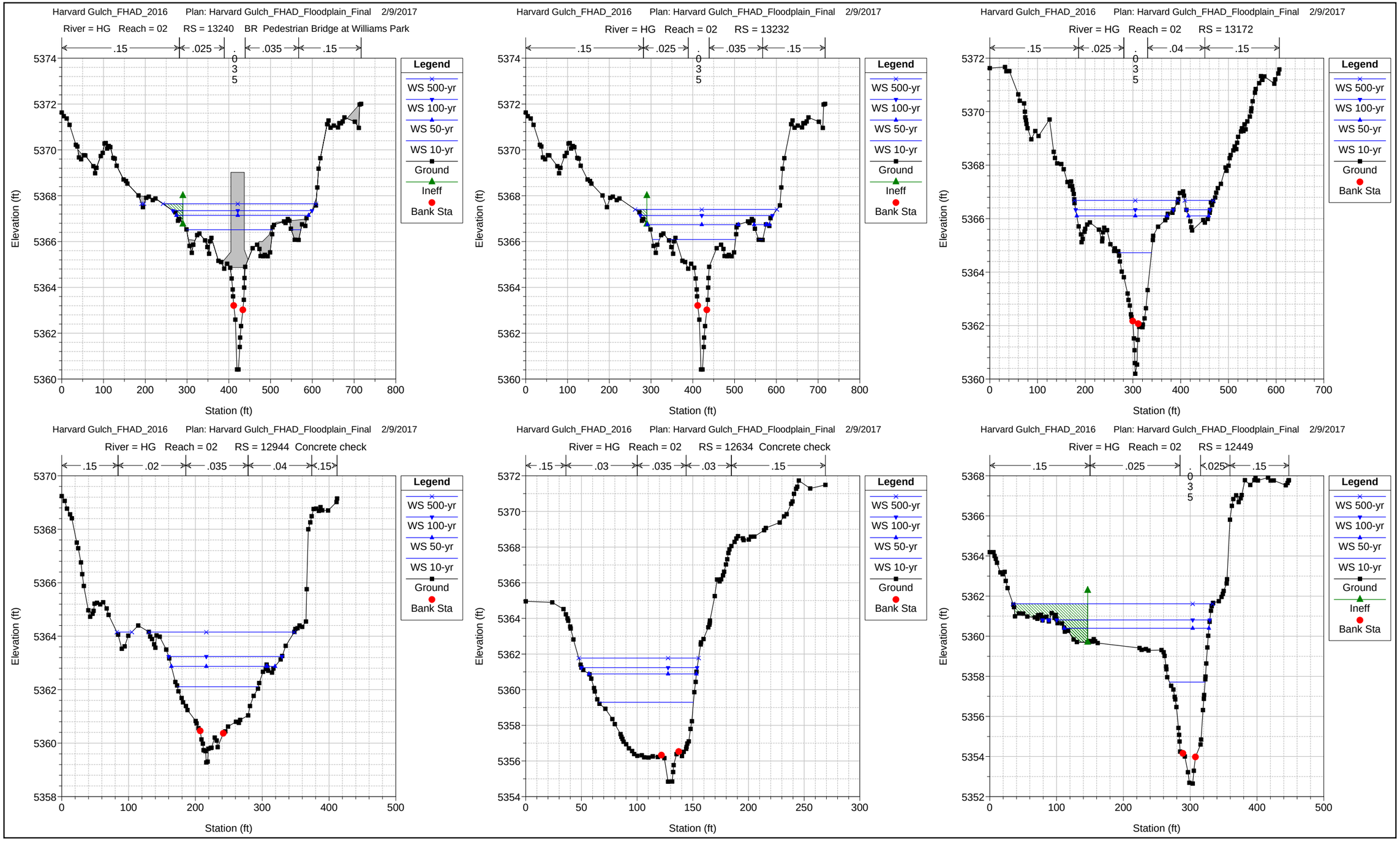
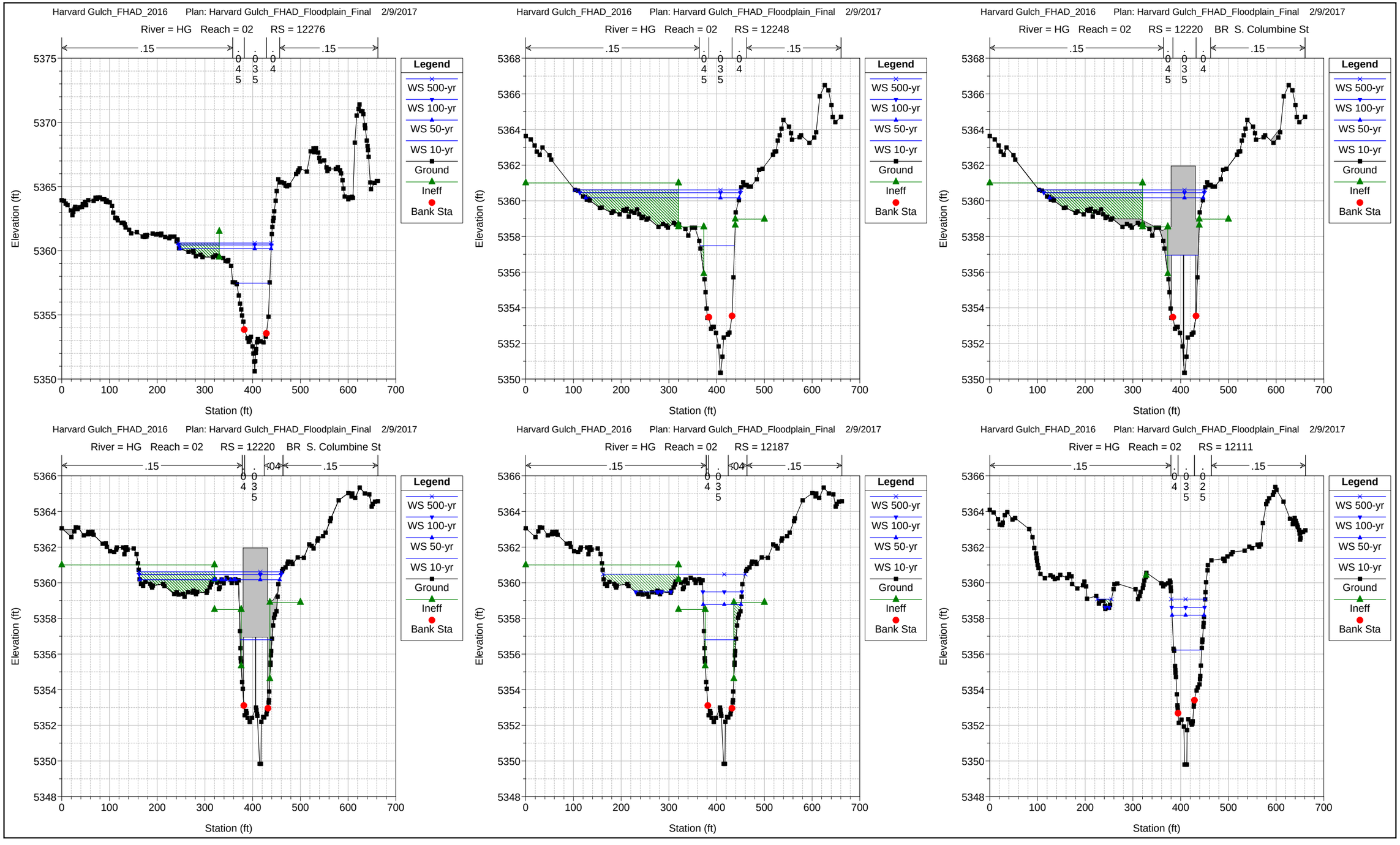
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13998 Concrete check
.025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13625
.15 .025 .035 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13332 Concrete check
.15 .025 .035 .04 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13252
.15 .017 .035 .04 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13240 BR Pedestrian Bridge at Williams Park
.15 .017 .035 .04 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13240 BR Pedestrian Bridge at Williams Park
.15 .025 .035 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13232
.15 .025 .035 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 13172
.15 .025 .04 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 12944 Concrete check
.15 .02 .035 .04 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 12634 Concrete check
.15 .03 .035 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 12449
.15 .025 .025 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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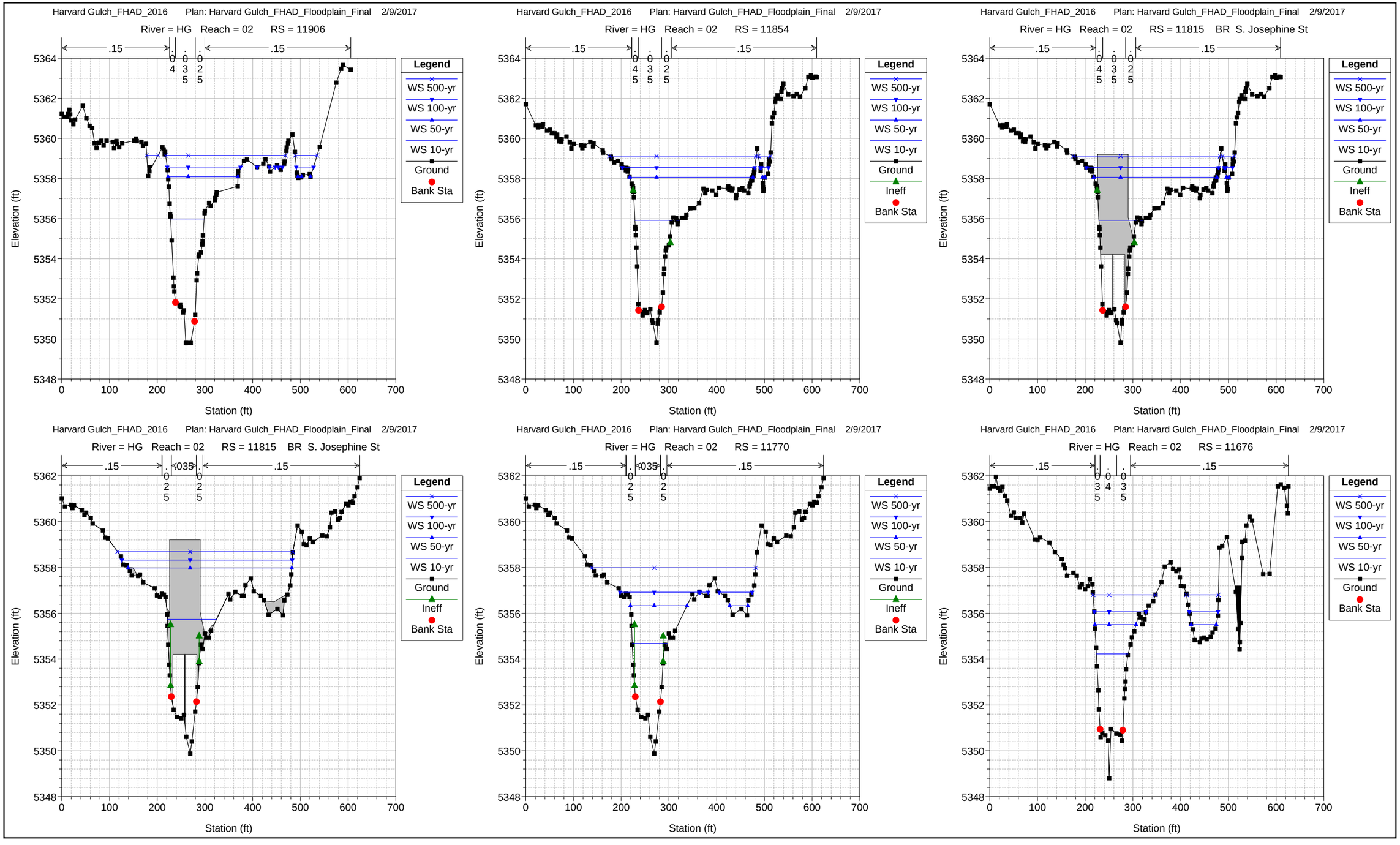
River = HG Reach = 02 RS = 12276
River = HG Reach = 02 RS = 12248
River = HG Reach = 02 RS = 12220 BR S. Columbine St
River = HG Reach = 02 RS = 12187
River = HG Reach = 02 RS = 12111
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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River = HG Reach = 02 RS = 11906
River = HG Reach = 02 RS = 11854
River = HG Reach = 02 RS = 11815 BR S. Josephine St
River = HG Reach = 02 RS = 11770
River = HG Reach = 02 RS = 11676
.15
.045
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
5364
5362
5360
5358
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5354
5352
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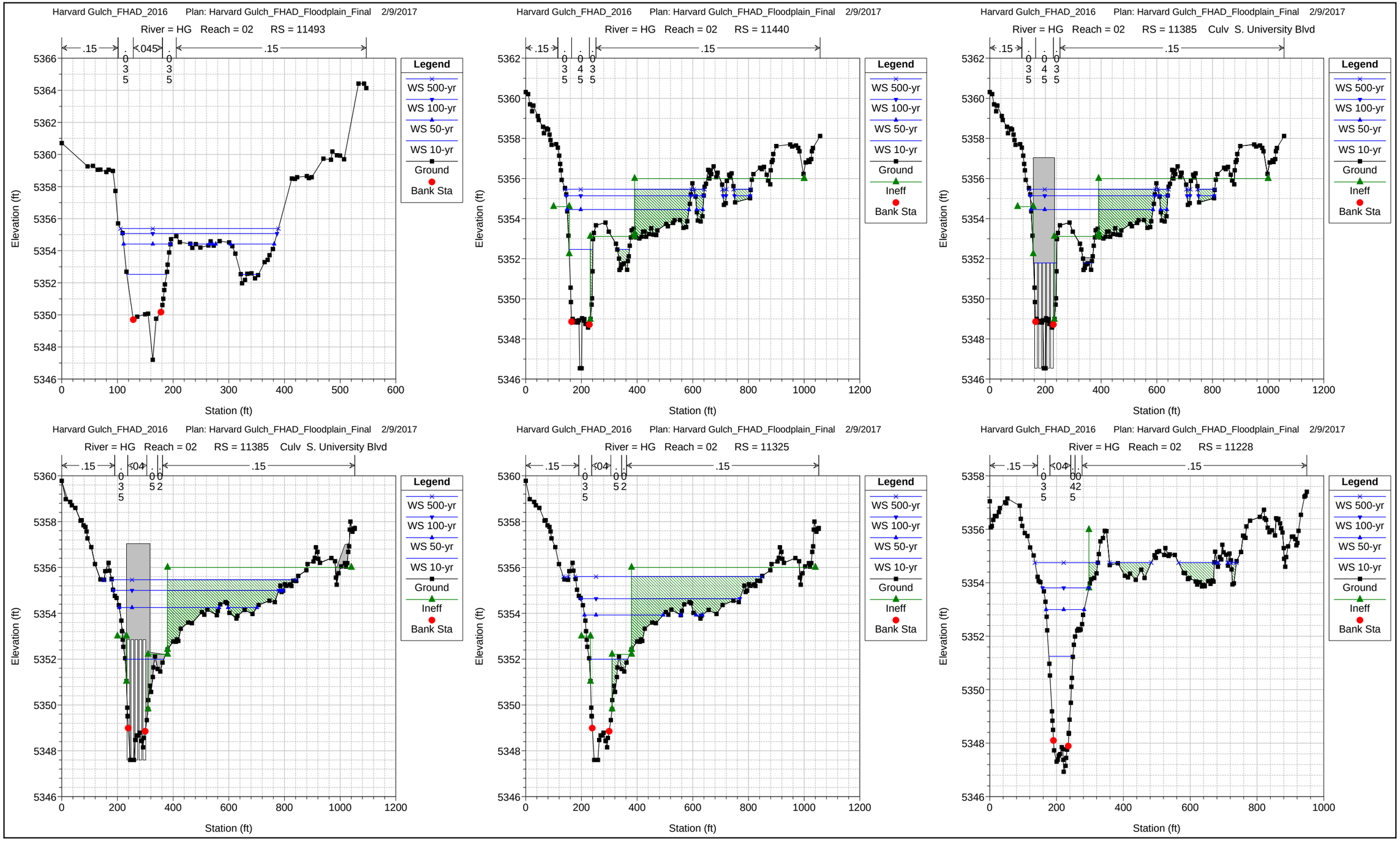
200
300
400
500
600
700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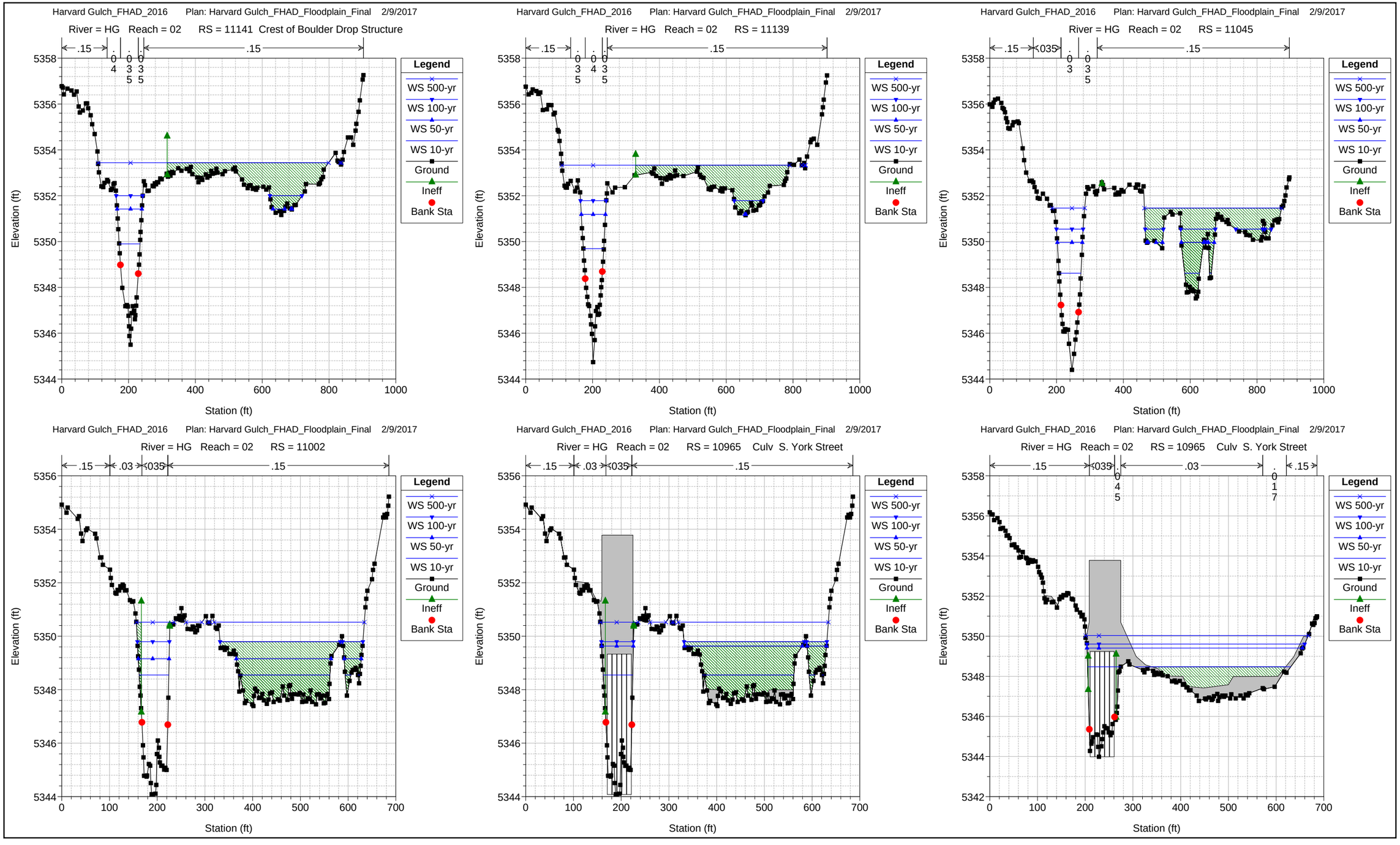
River = HG Reach = 02 RS = 11493
River = HG Reach = 02 RS = 11440
River = HG Reach = 02 RS = 11385 Culv S. University Blvd
River = HG Reach = 02 RS = 11325
River = HG Reach = 02 RS = 11228
.15
.045
.035
.042
.052
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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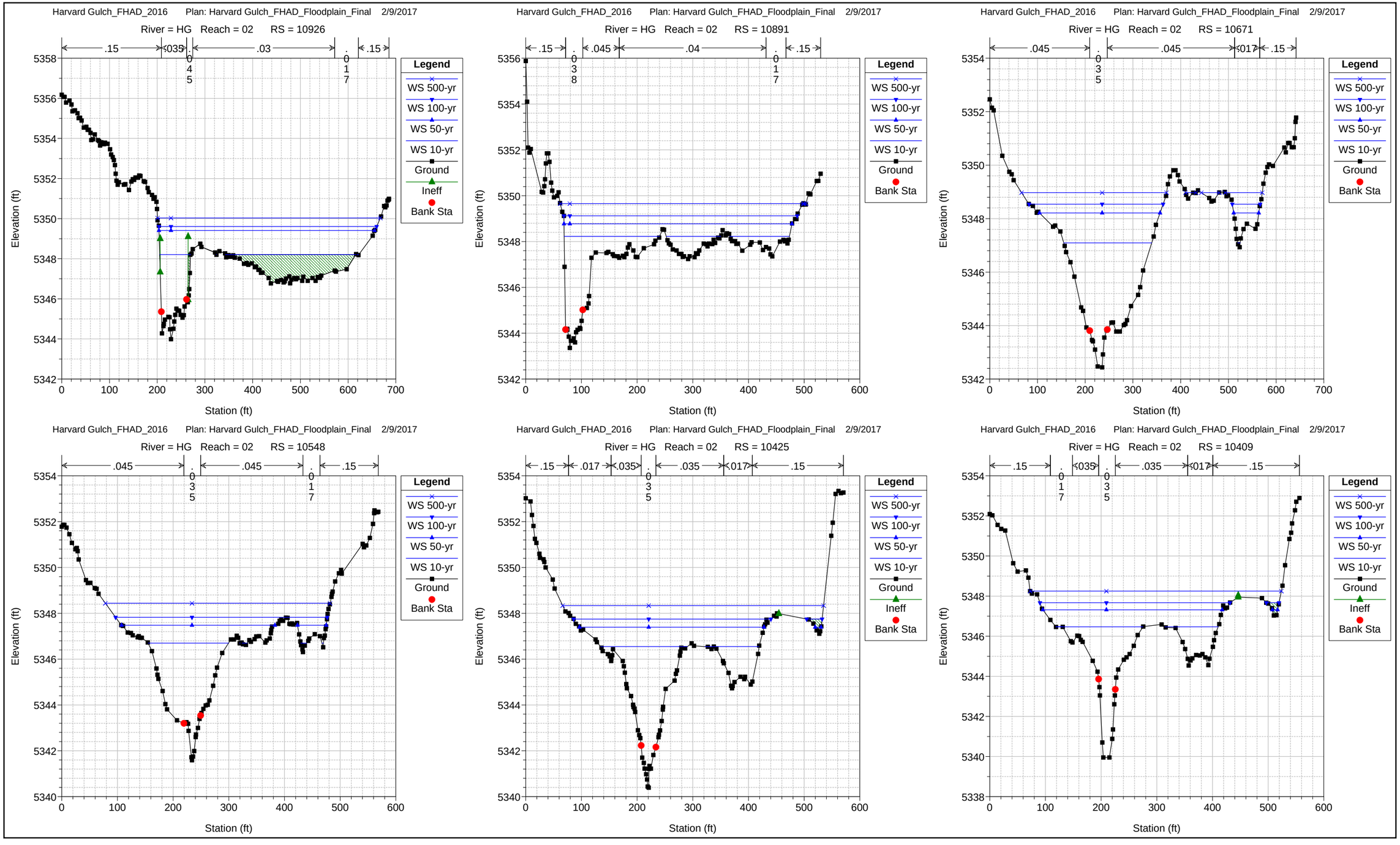
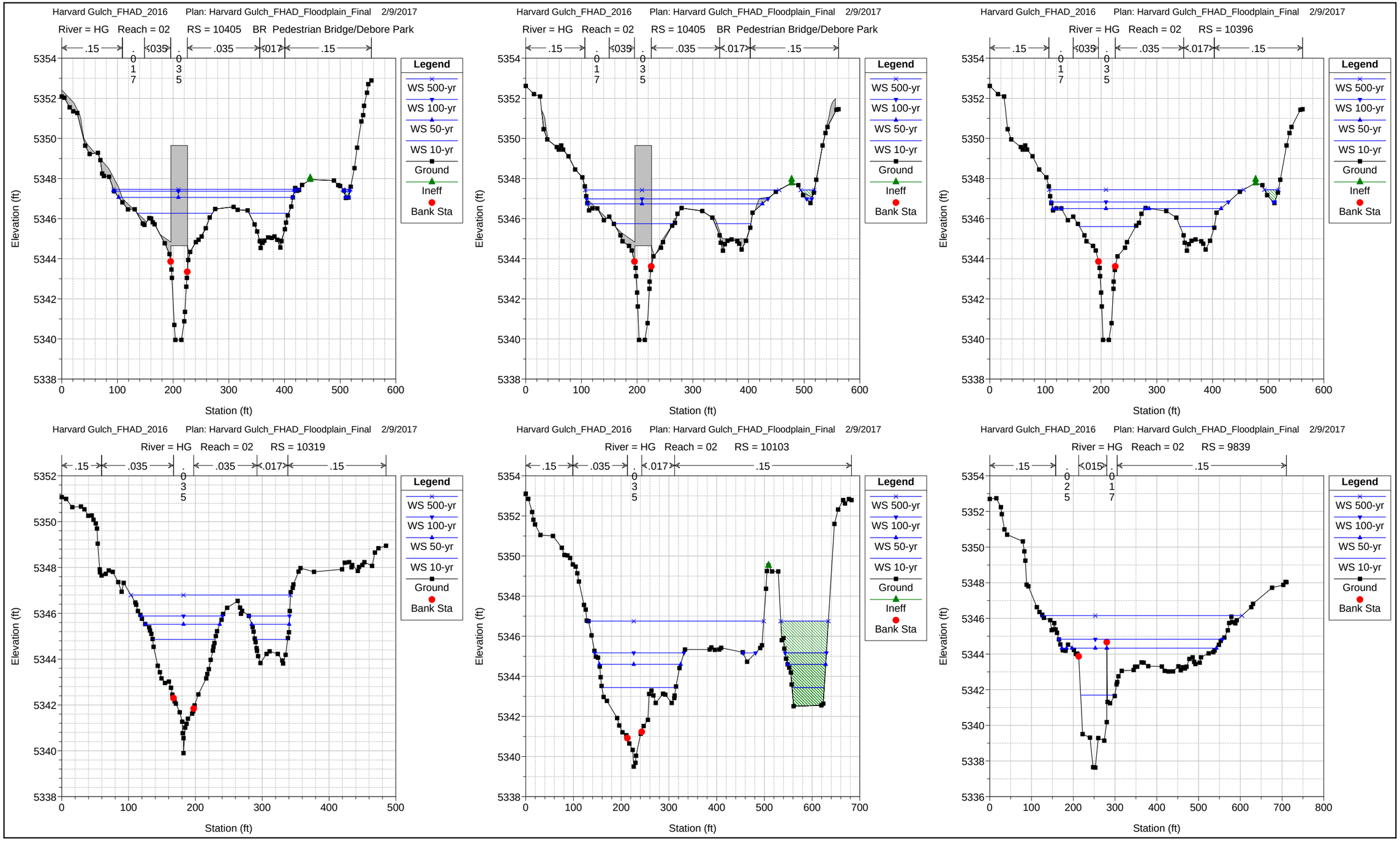
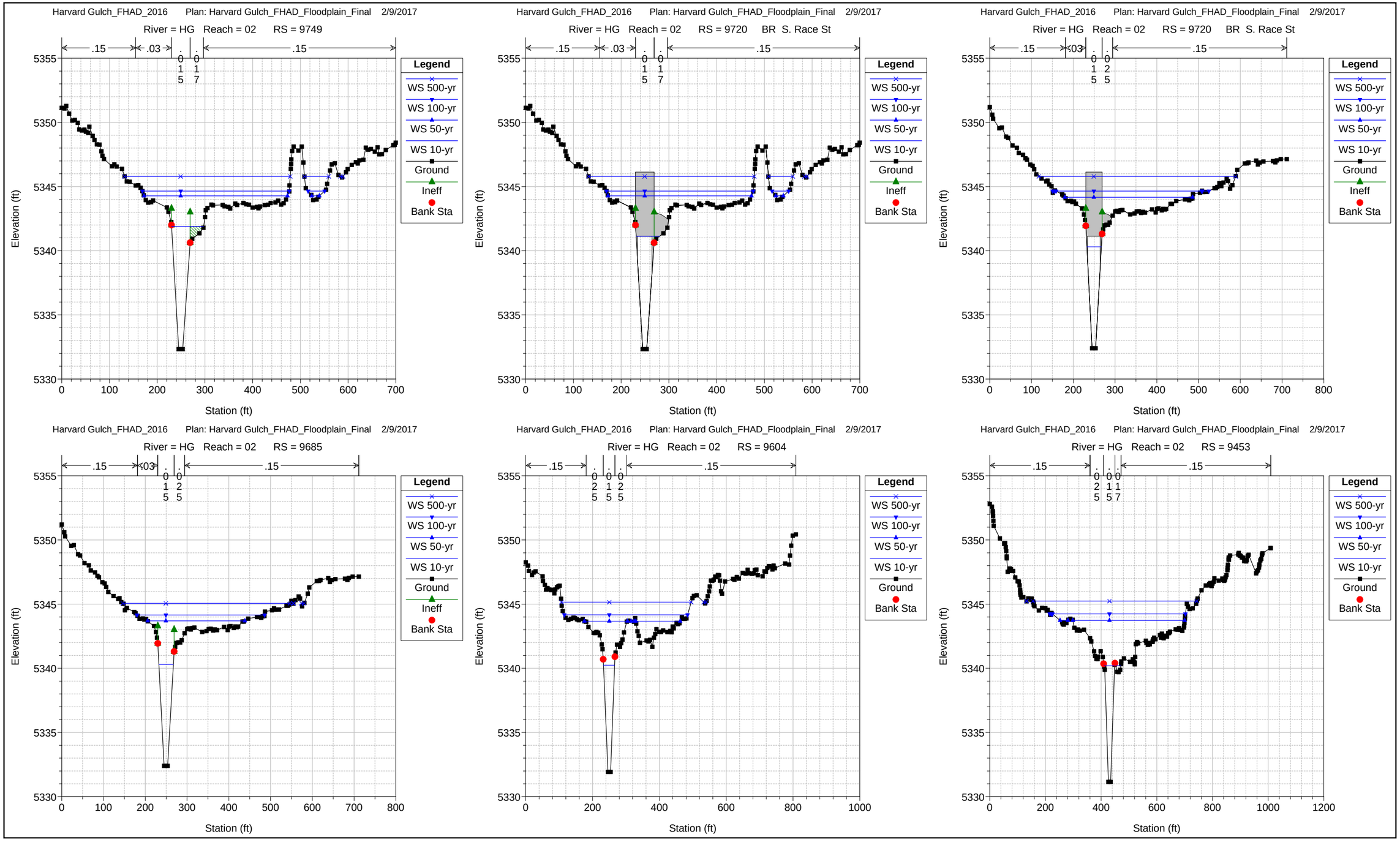
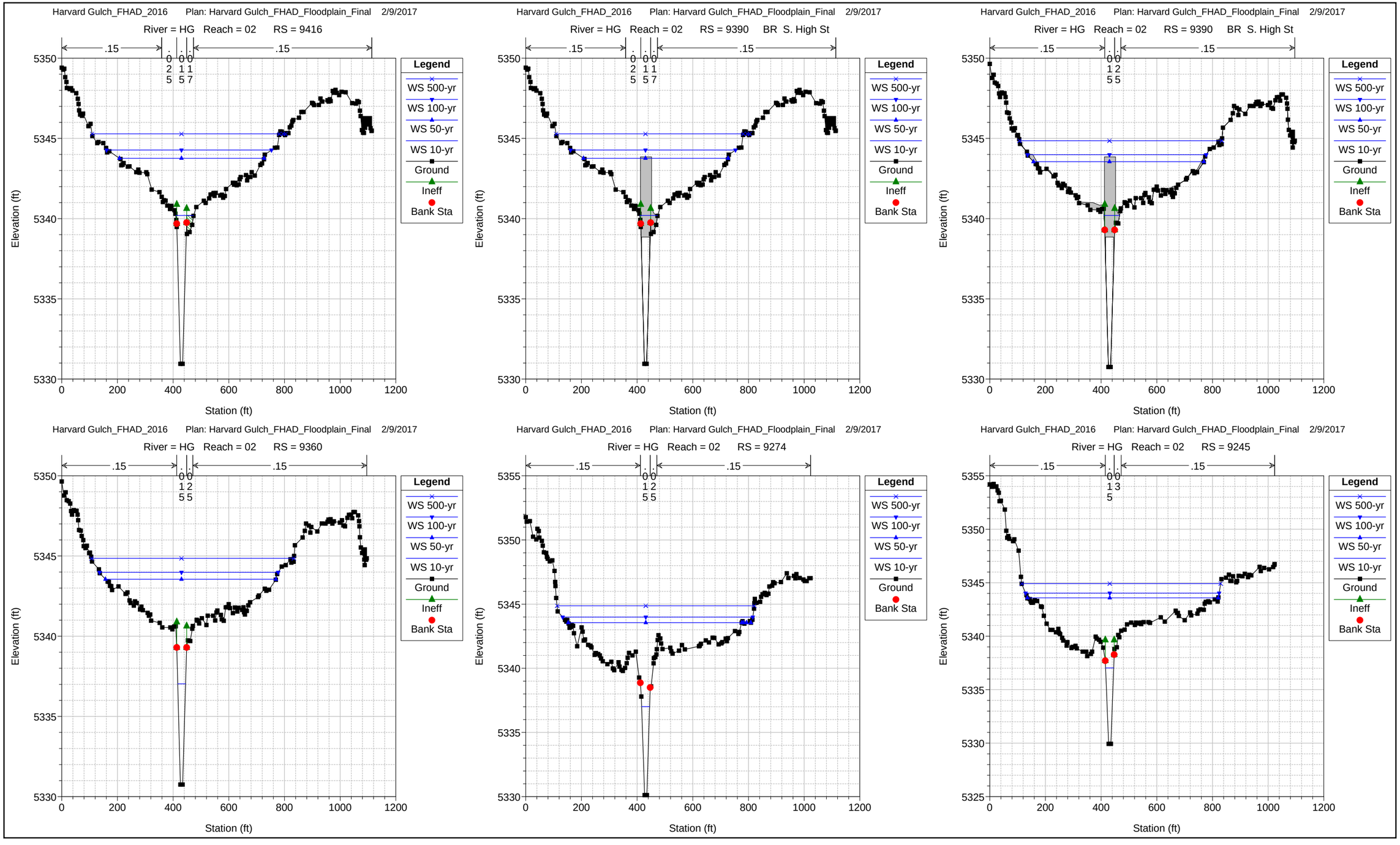
River = HG Reach = 02 RS = 11141 Crest of Boulder Drop Structure
.15 .04 .035 .035 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 11139
.15 .035 .04 .035 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 11045
.15 .035 .03 .035 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 11002
.15 .03 .035 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10965 Culv S. York Street
.15 .03 .035 .15
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10965 Culv S. York Street
.15 .035 .045 .03 .017 .15

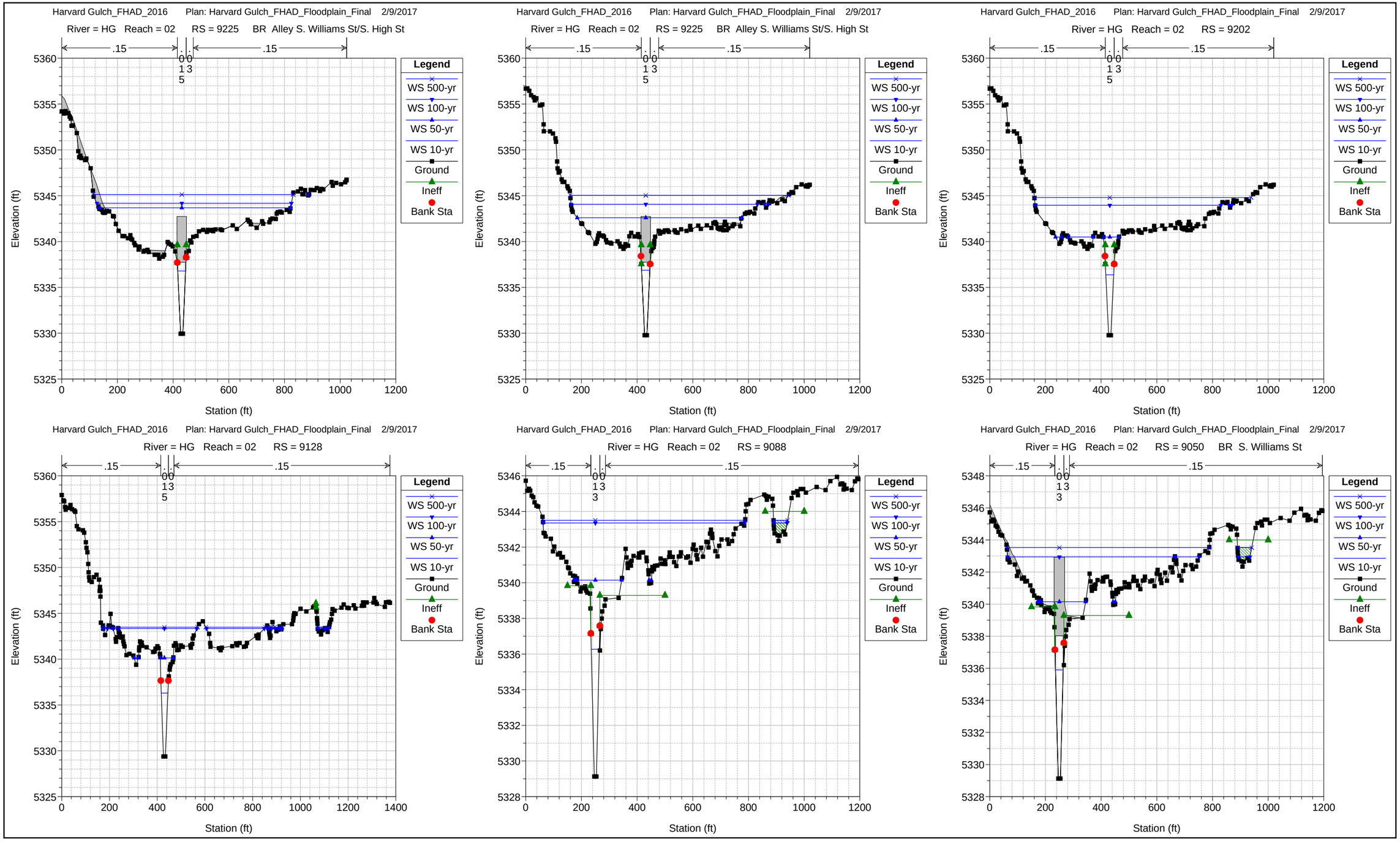

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10926
.15
.035
.045
.03
.017
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10891
.15
.038
.045
.04
.017
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10671
.045
.035
.045
.017
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10548
.045
.035
.045
.017
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10425
.15
.017
.035
.035
.017
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10409
.15
.017
.035
.035
.017
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10405 BR Pedestrian Bridge/Debore Park
.15 .017 .035 .035 .035 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10396
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10319
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 10103
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 9839

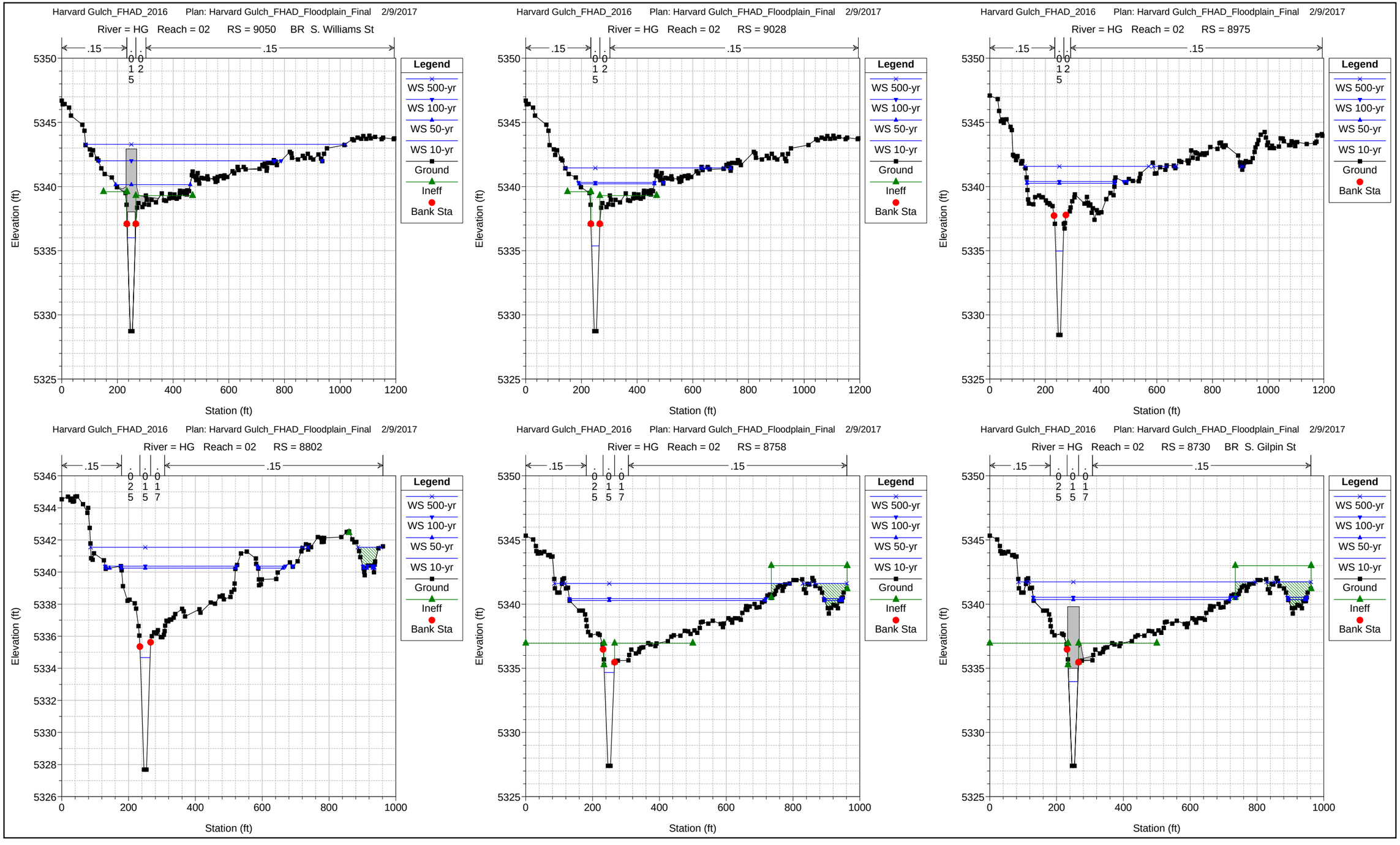


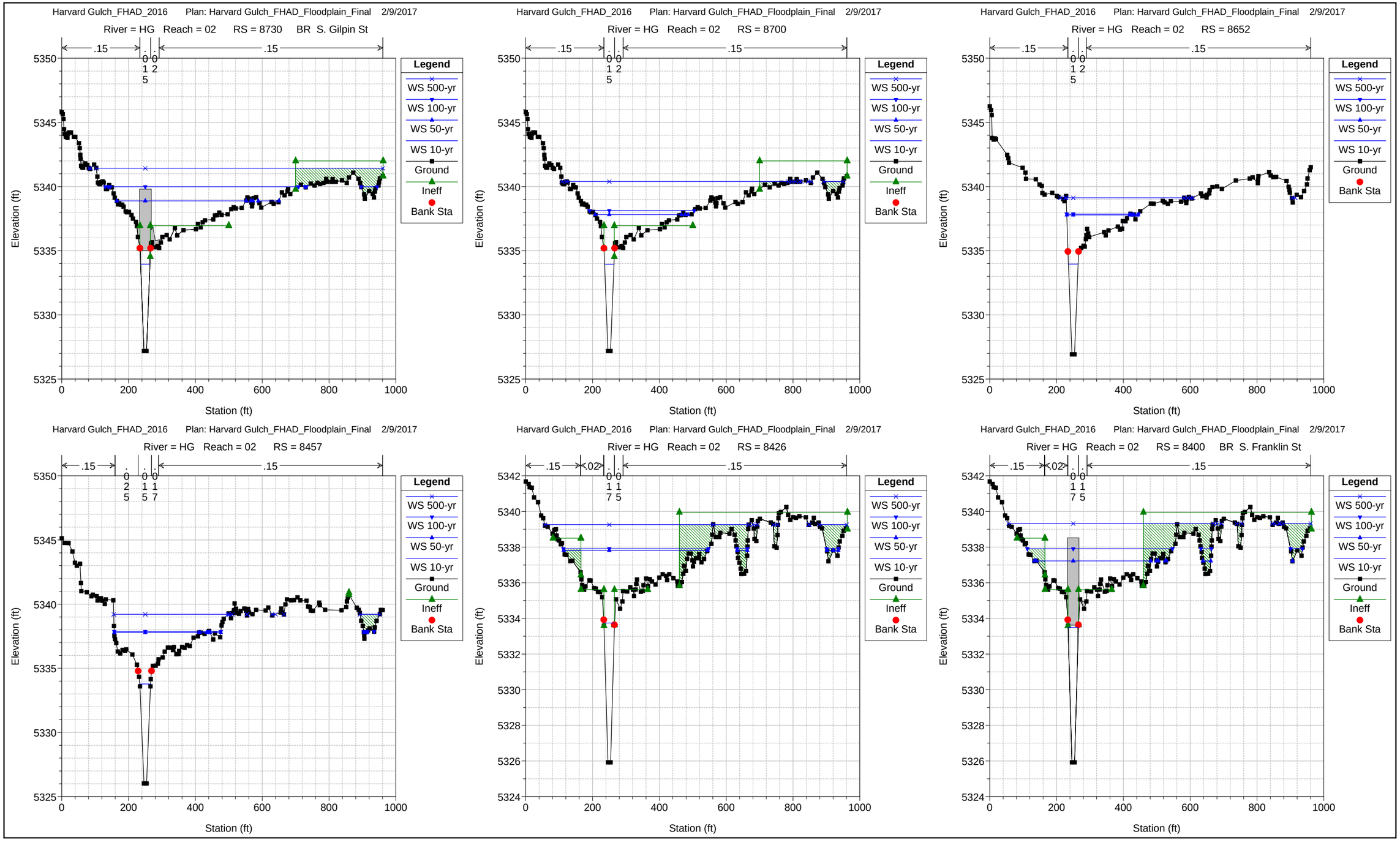
Appendix C - Hydraulic Analysis

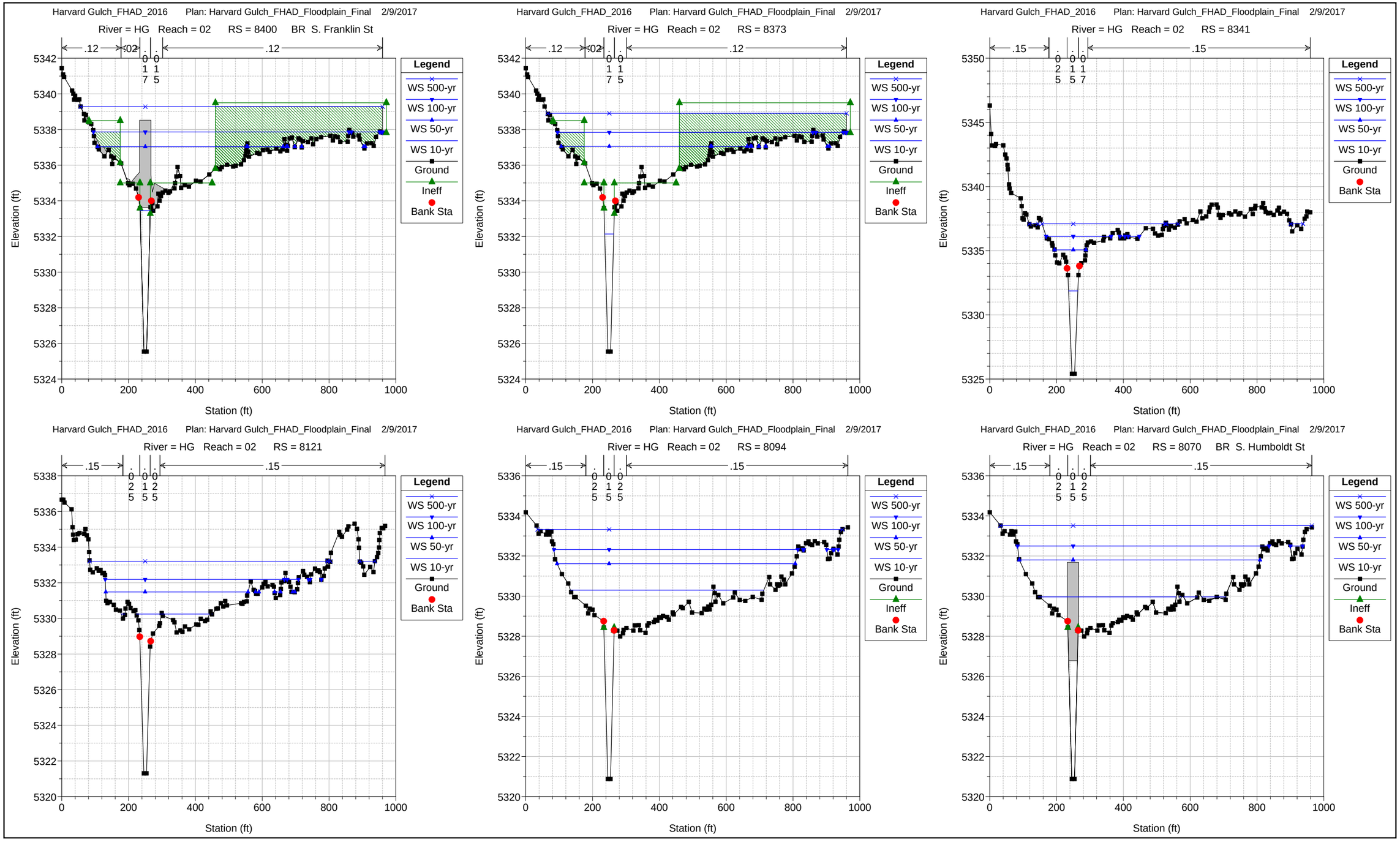

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 9416
River = HG Reach = 02 RS = 9390 BR S. High St
River = HG Reach = 02 RS = 9360
River = HG Reach = 02 RS = 9274
River = HG Reach = 02 RS = 9245
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

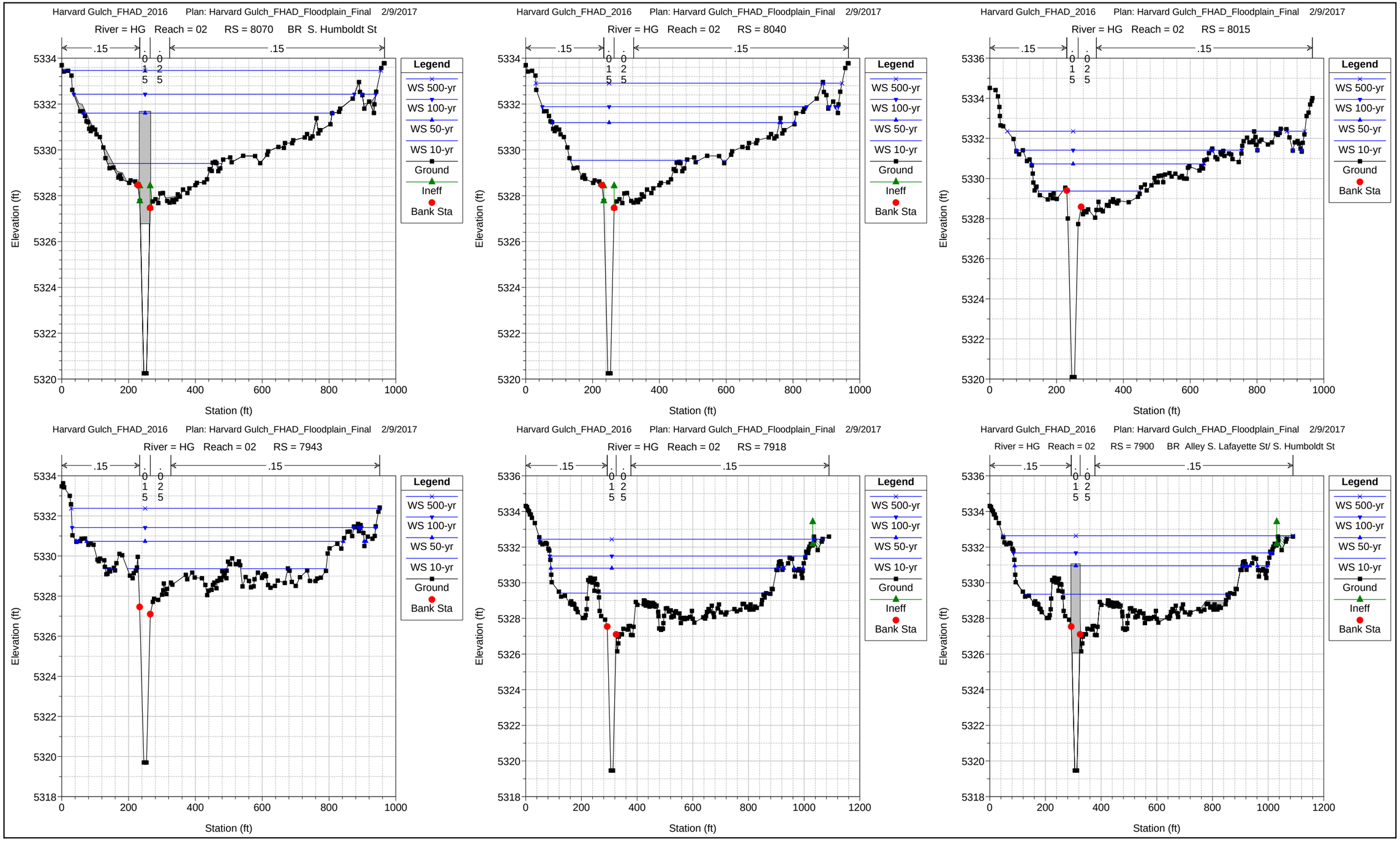


Appendix C - Hydraulic Analysis

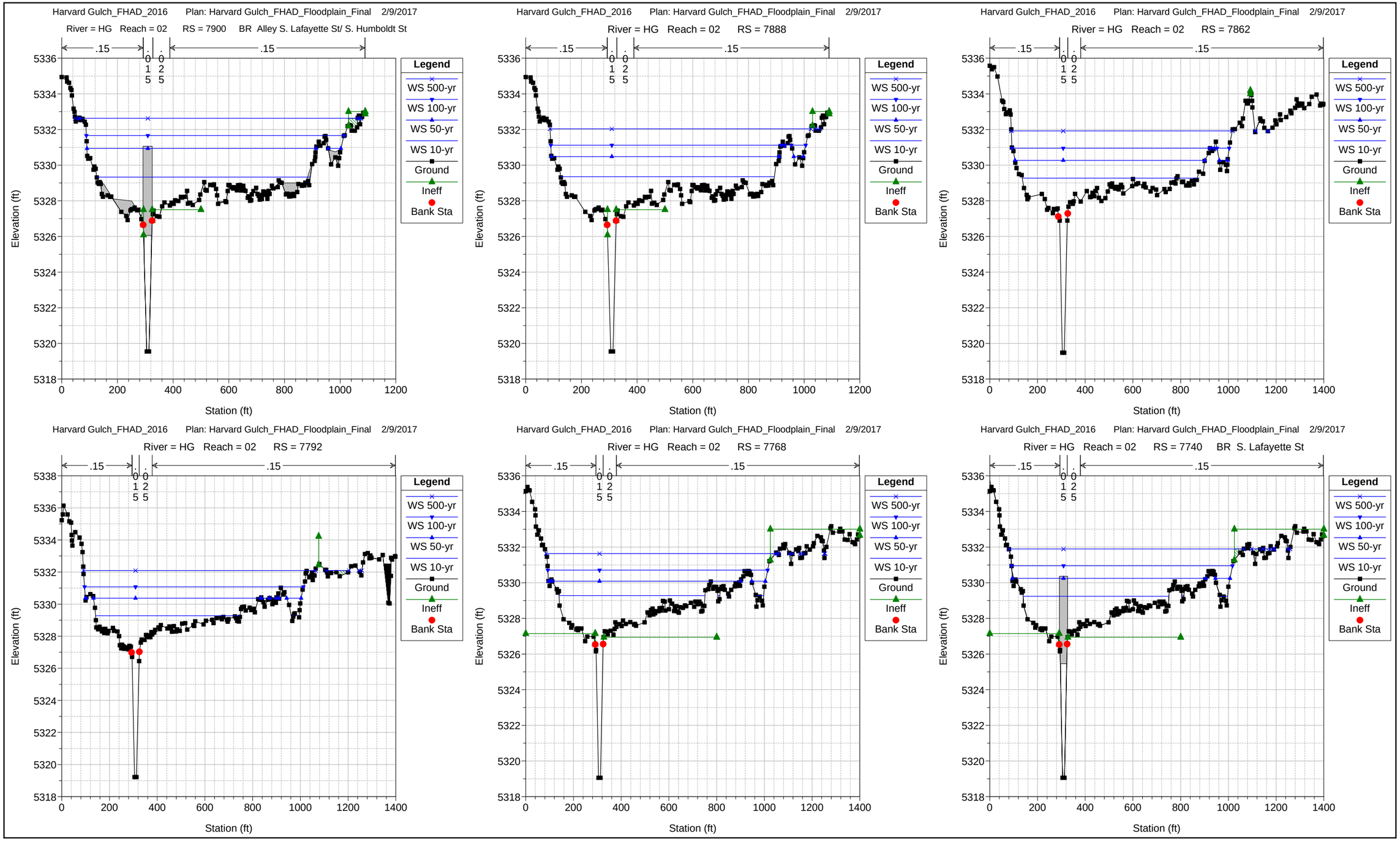

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 9050 BR S. Williams St
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 9028
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8975
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8802
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8758
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8730 BR S. Gilpin St
.15
.025
.015
.017
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

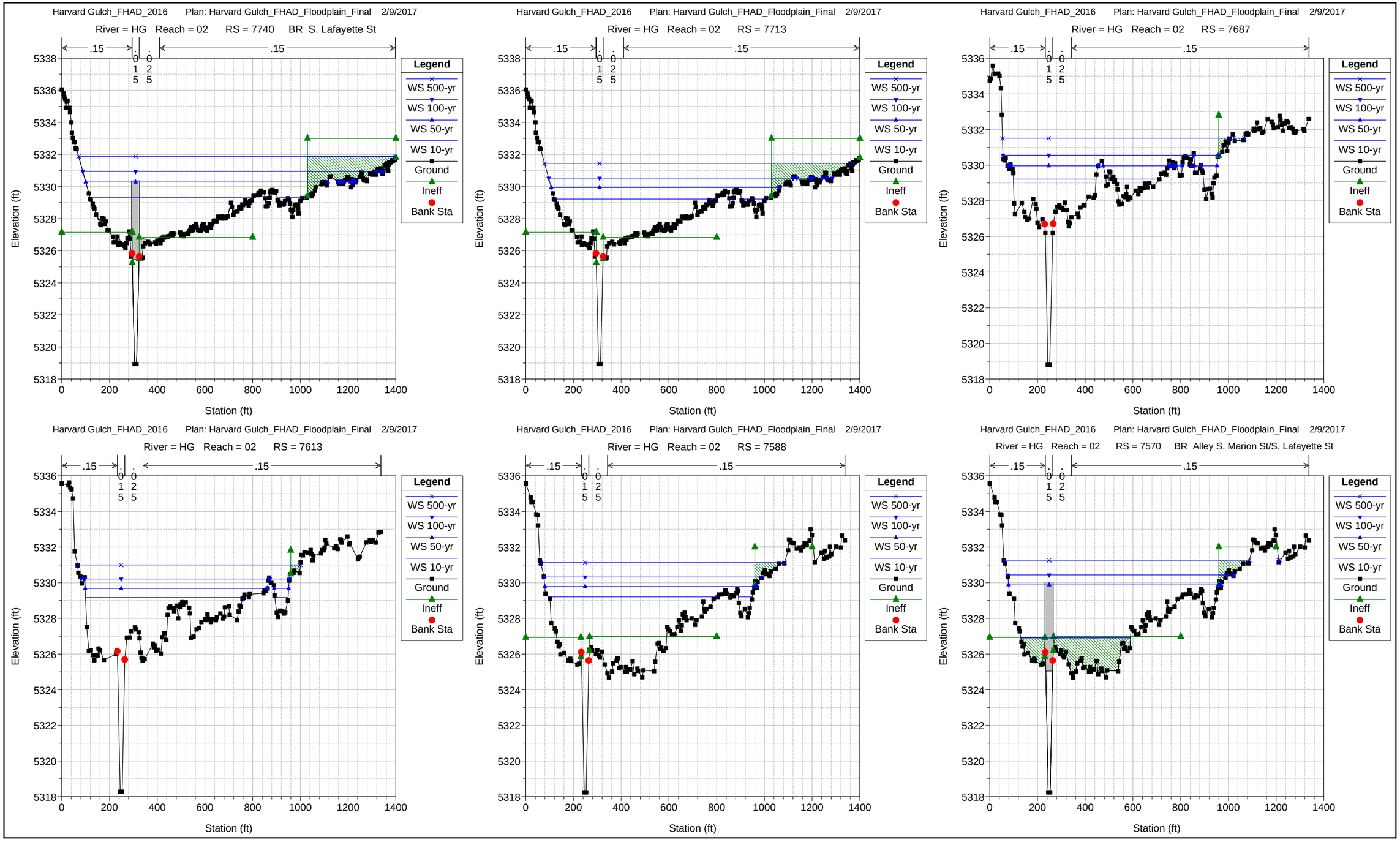

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8730 BR S. Gilpin St
River = HG Reach = 02 RS = 8700
River = HG Reach = 02 RS = 8652
River = HG Reach = 02 RS = 8457
River = HG Reach = 02 RS = 8426
River = HG Reach = 02 RS = 8400 BR S. Franklin St
.15
.02
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

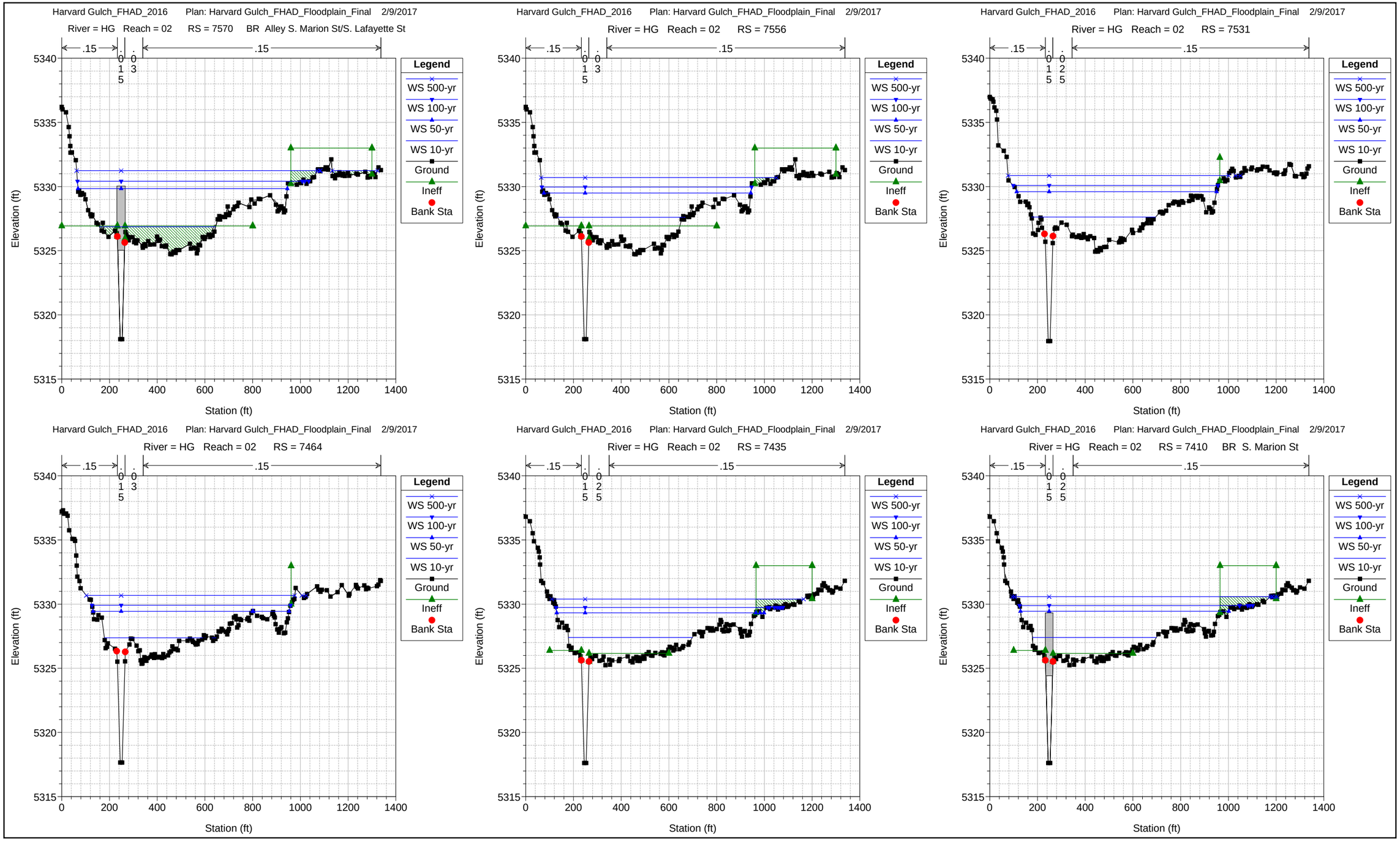

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8400 BR S. Franklin St
.12 .02 .12
0.17 0.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8373
.12 .02 .12
0.17 0.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8341
.15 .15
0.25 0.15 0.17
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8121
.15 .15
0.25 0.15 0.25
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8094
.15 .15
0.25 0.15 0.25
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 8070 BR S. Humboldt St
.15 .15
0.25 0.15 0.25
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

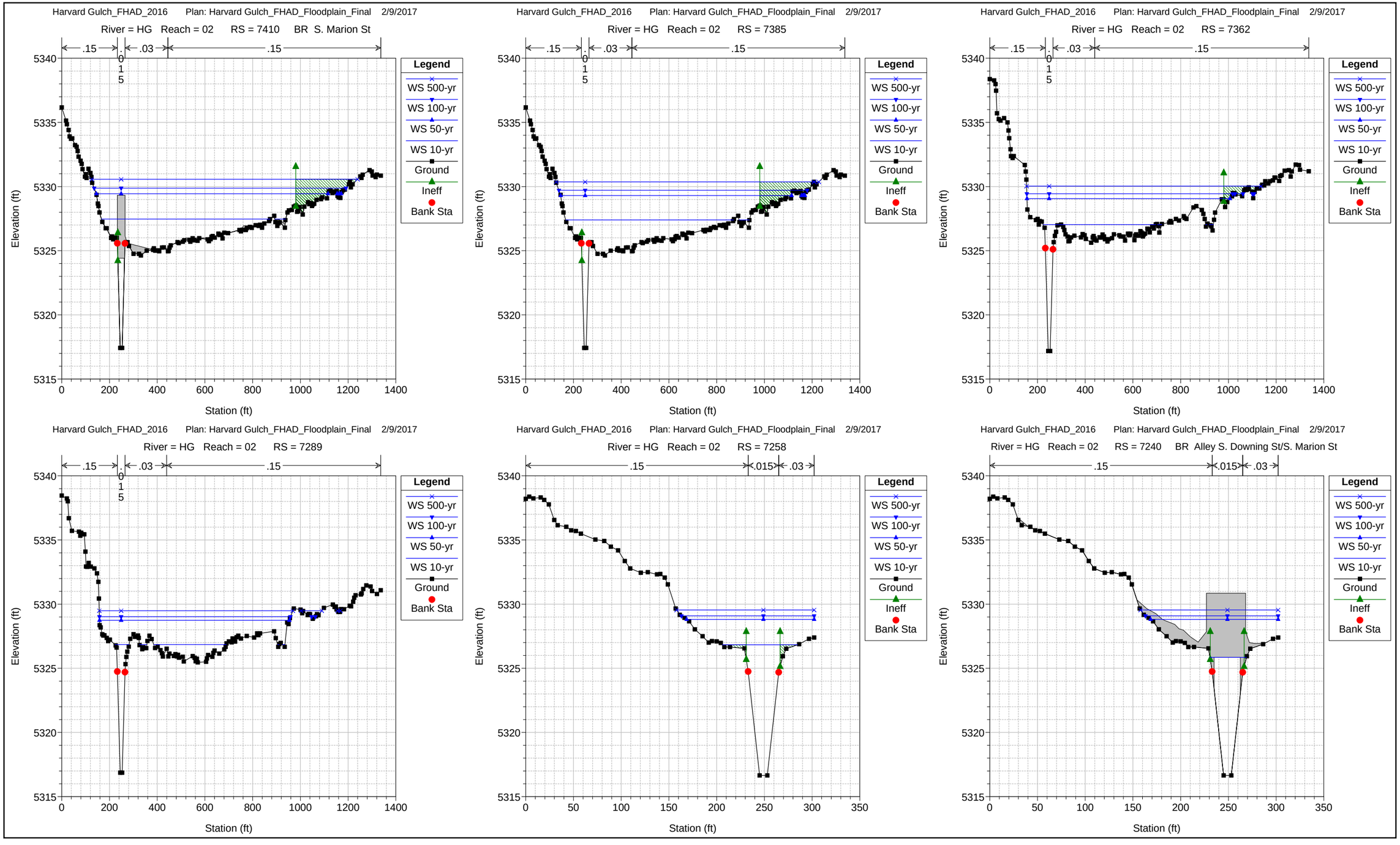


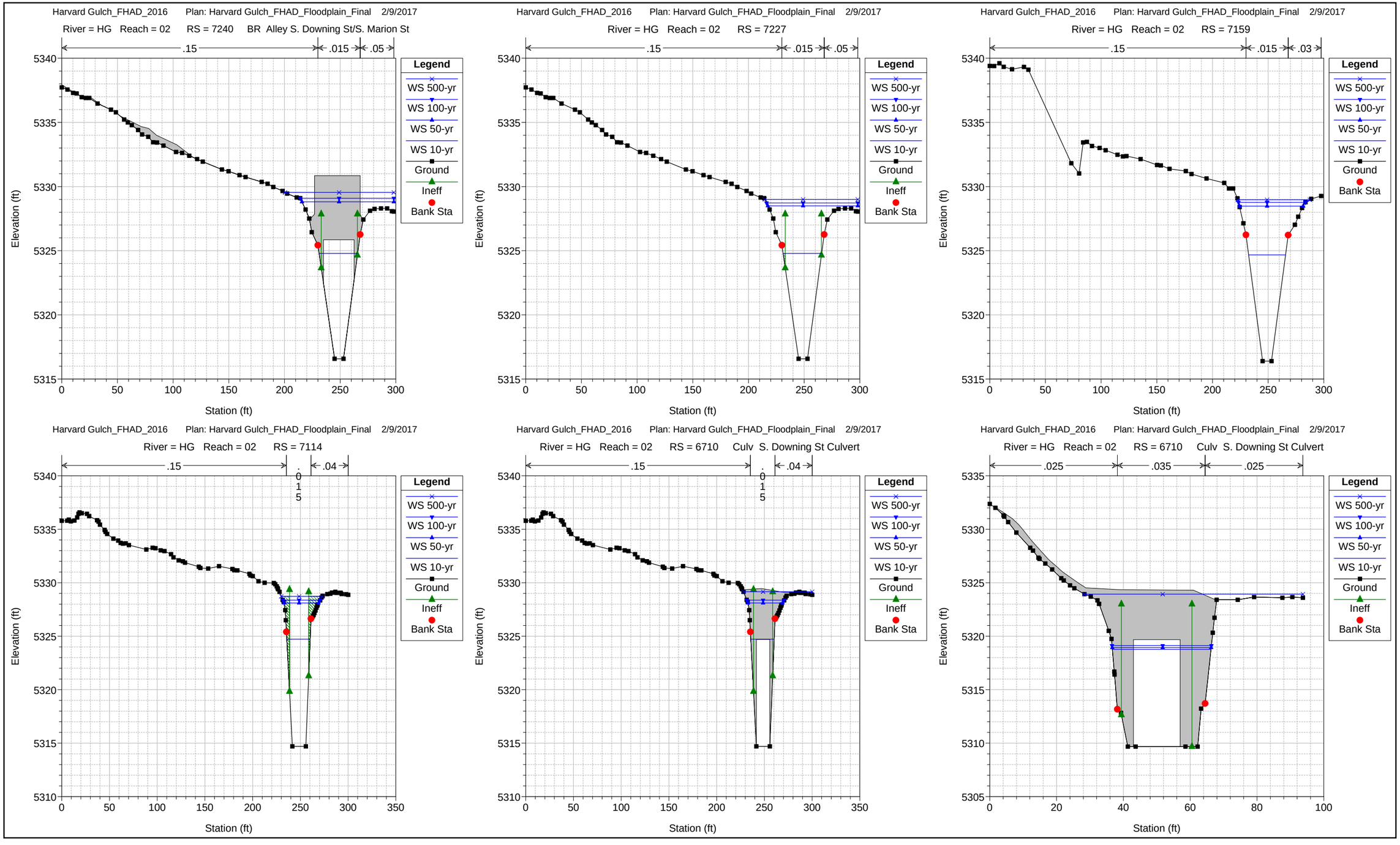
Appendix C - Hydraulic Analysis

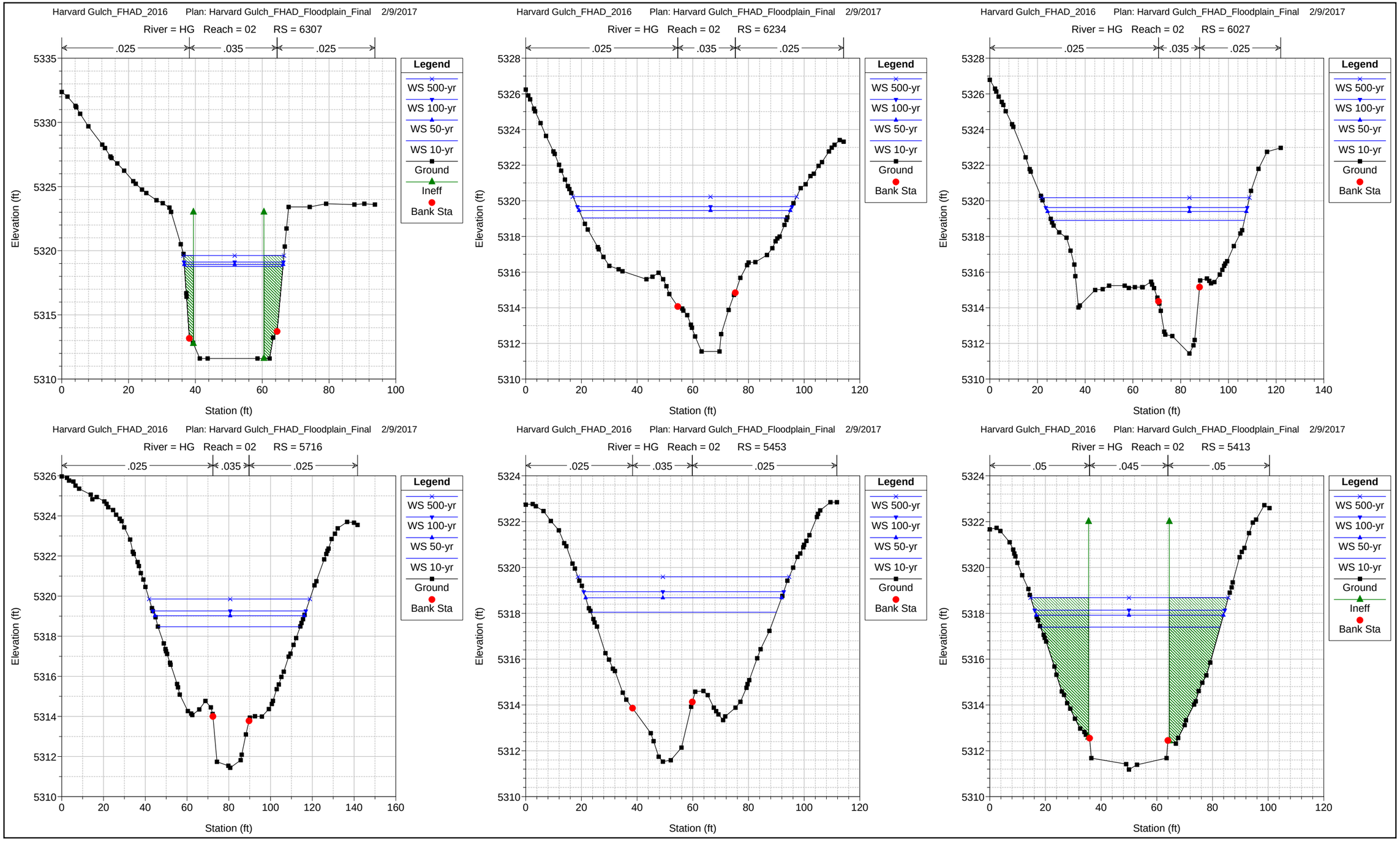

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7900 BR Alley S. Lafayette St/ S. Humboldt St
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7888
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7862
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7792
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7768
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7740 BR S. Lafayette St
.15
.015
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

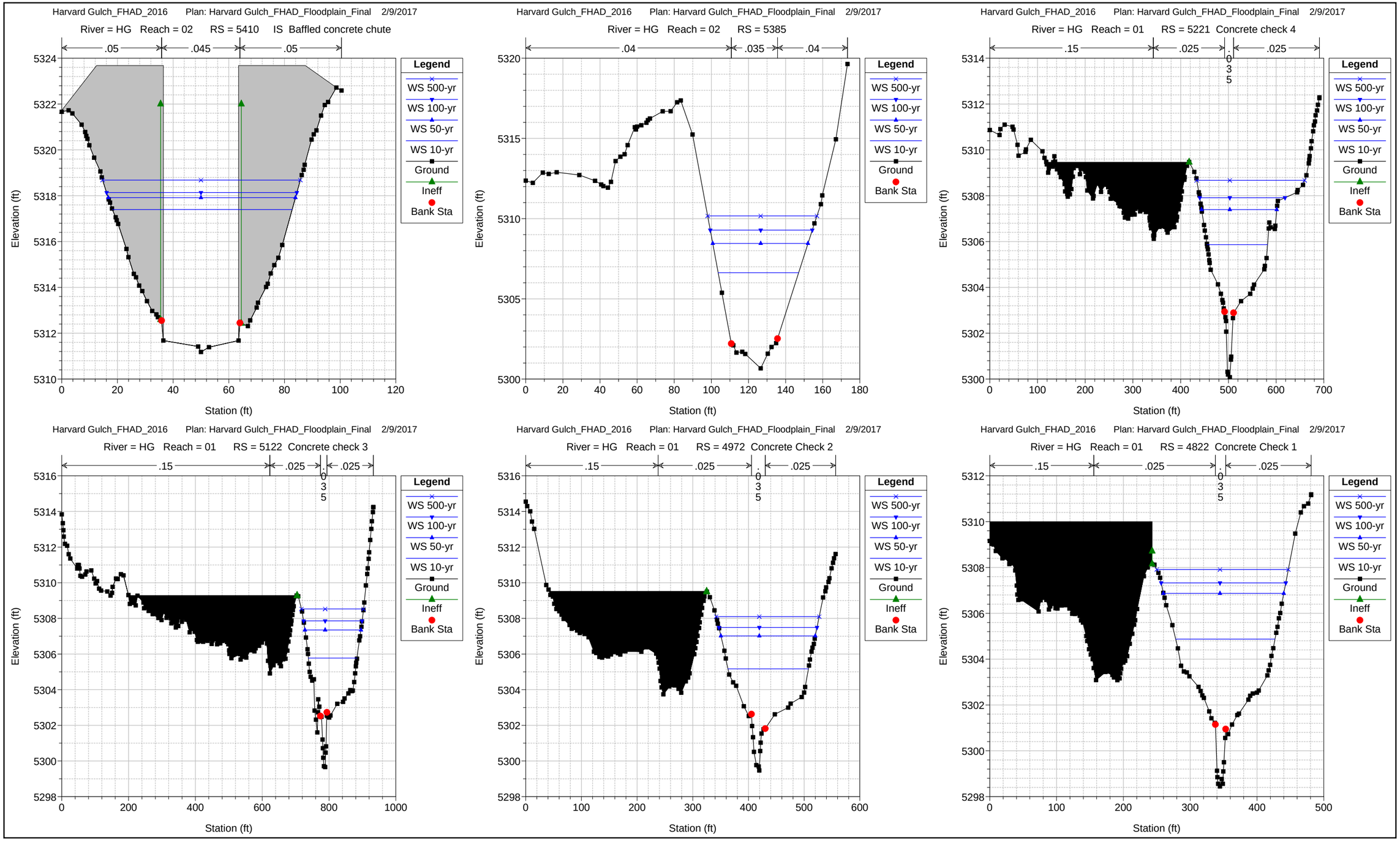

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7740 BR S. Lafayette St
River = HG Reach = 02 RS = 7713
River = HG Reach = 02 RS = 7687
River = HG Reach = 02 RS = 7613
River = HG Reach = 02 RS = 7588
River = HG Reach = 02 RS = 7570 BR Alley S. Marion St/S. Lafayette St
.15
.015
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

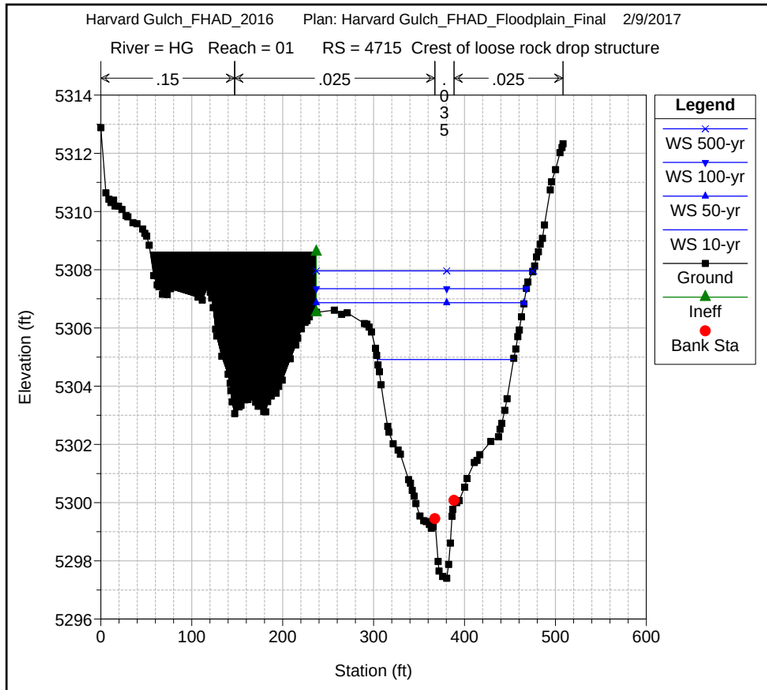

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7570 BR Alley S. Marion St/S. Lafayette St
River = HG Reach = 02 RS = 7556
River = HG Reach = 02 RS = 7531
River = HG Reach = 02 RS = 7464
River = HG Reach = 02 RS = 7435
River = HG Reach = 02 RS = 7410 BR S. Marion St
.15
.015
.03
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
5340
5335
5330
5325
5320
5315
0
200
400
600
800
1000
1200
1400

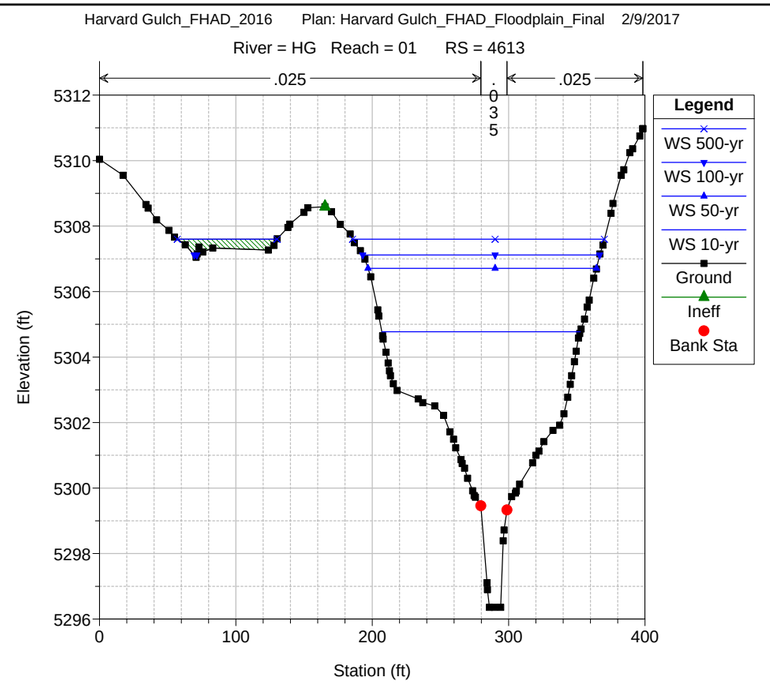

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7410 BR S. Marion St
.15 .015 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7385
.15 .015 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7362
.15 .015 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7289
.15 .015 .03 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7258
.15 .015 .03
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7240 BR Alley S. Downing St/S. Marion St
.15 .015 .03
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

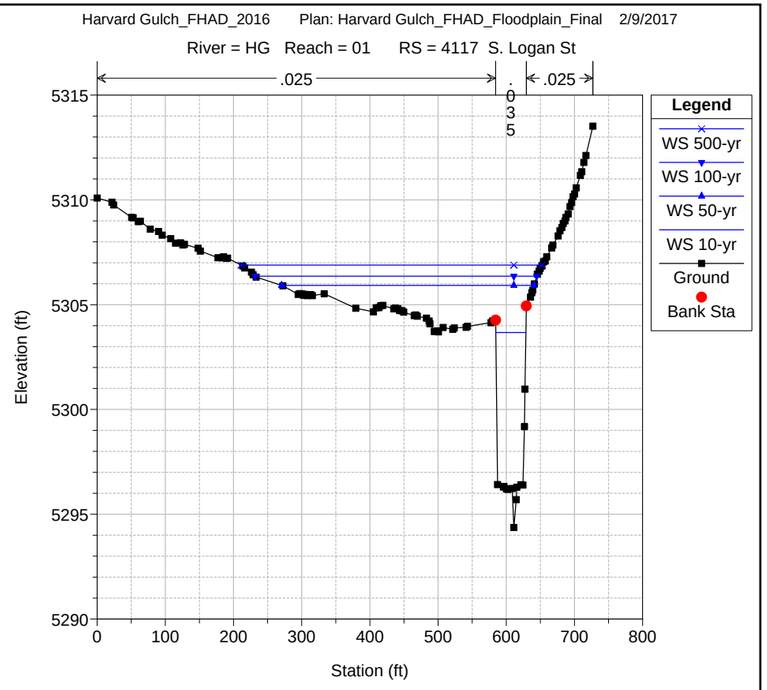

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7240 BR Alley S. Downing St/S. Marion St
.15
.015
.05
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7227
.15
.015
.05
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7159
.15
.015
.03
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 7114
.15
.015
.04
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 6710 Culv S. Downing St Culvert
.15
.015
.04
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 6710 Culv S. Downing St Culvert
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

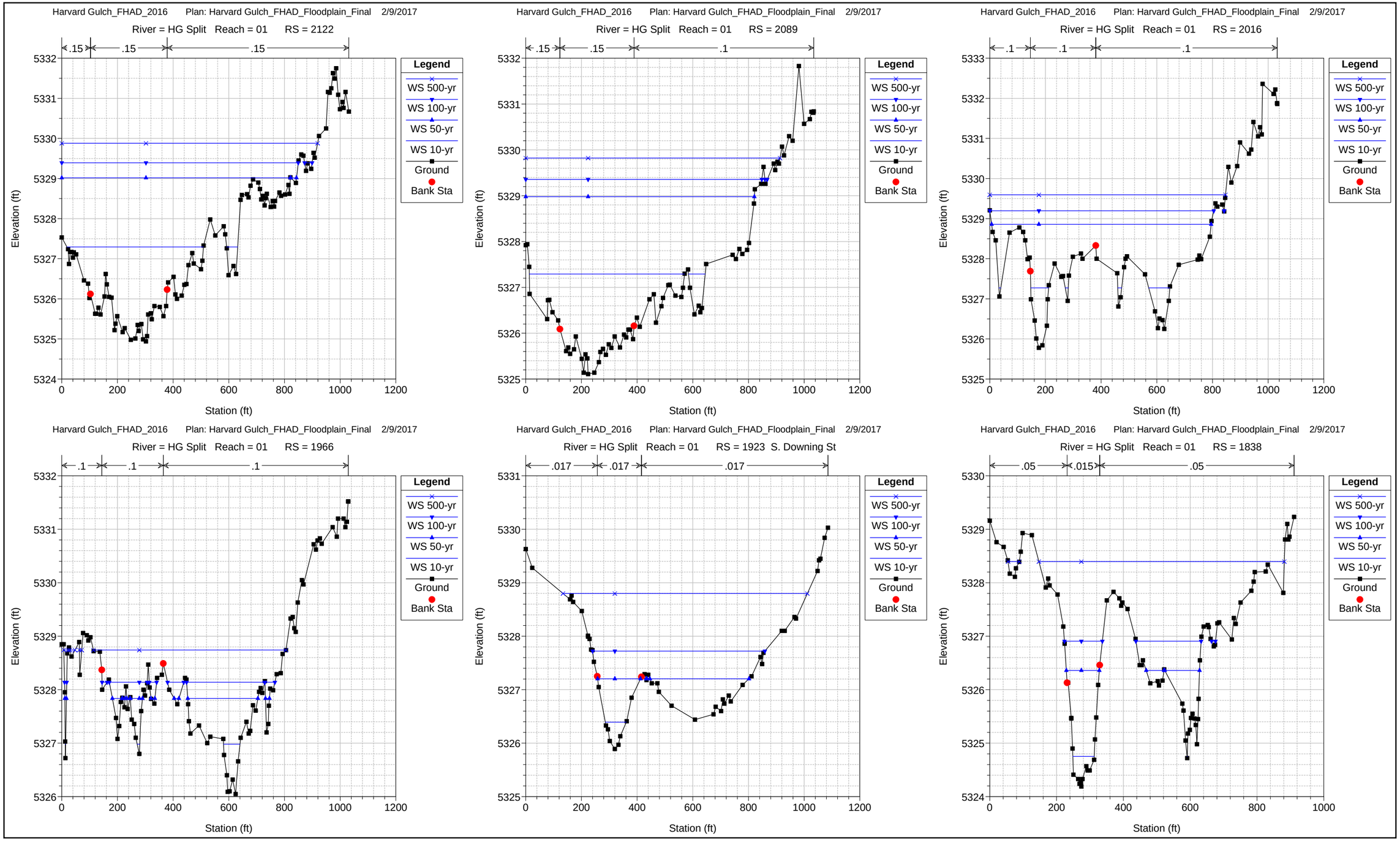

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 6307
.025 .035 .025
Elevation (ft)
Station (ft)
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 6234
.025 .035 .025
Elevation (ft)
Station (ft)
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 6027
.025 .035 .025
Elevation (ft)
Station (ft)
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 5716
.025 .035 .025
Elevation (ft)
Station (ft)
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 5453
.025 .035 .025
Elevation (ft)
Station (ft)
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 5413
.05 .045 .05
Elevation (ft)
Station (ft)
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta

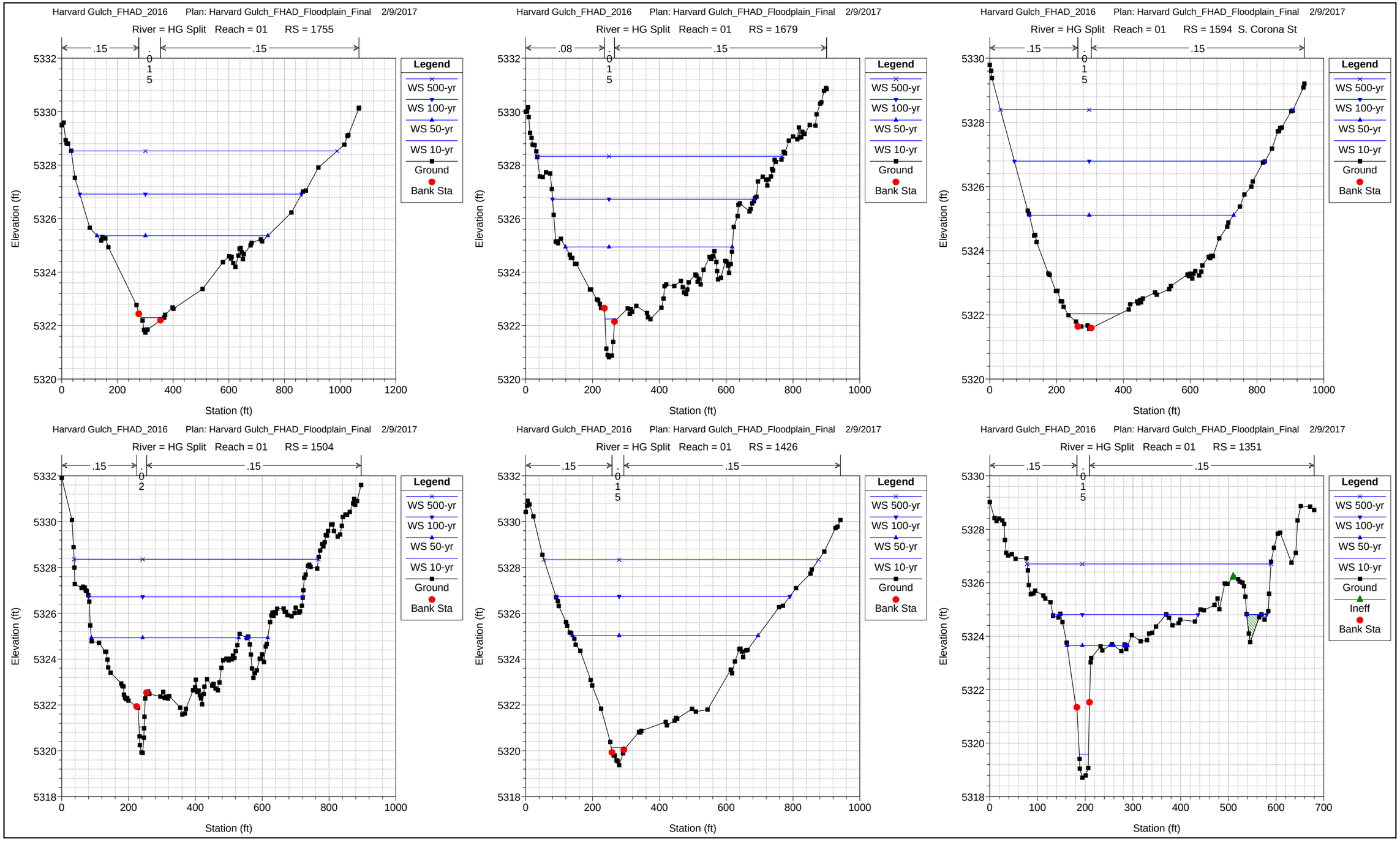

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 5410 IS Baffled concrete chute
.05
.045
.05
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 02 RS = 5385
.04
.035
.04
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 5221 Concrete check 4
.15
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 5122 Concrete check 3
.15
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 4972 Concrete Check 2
.15
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 4822 Concrete Check 1
.15
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

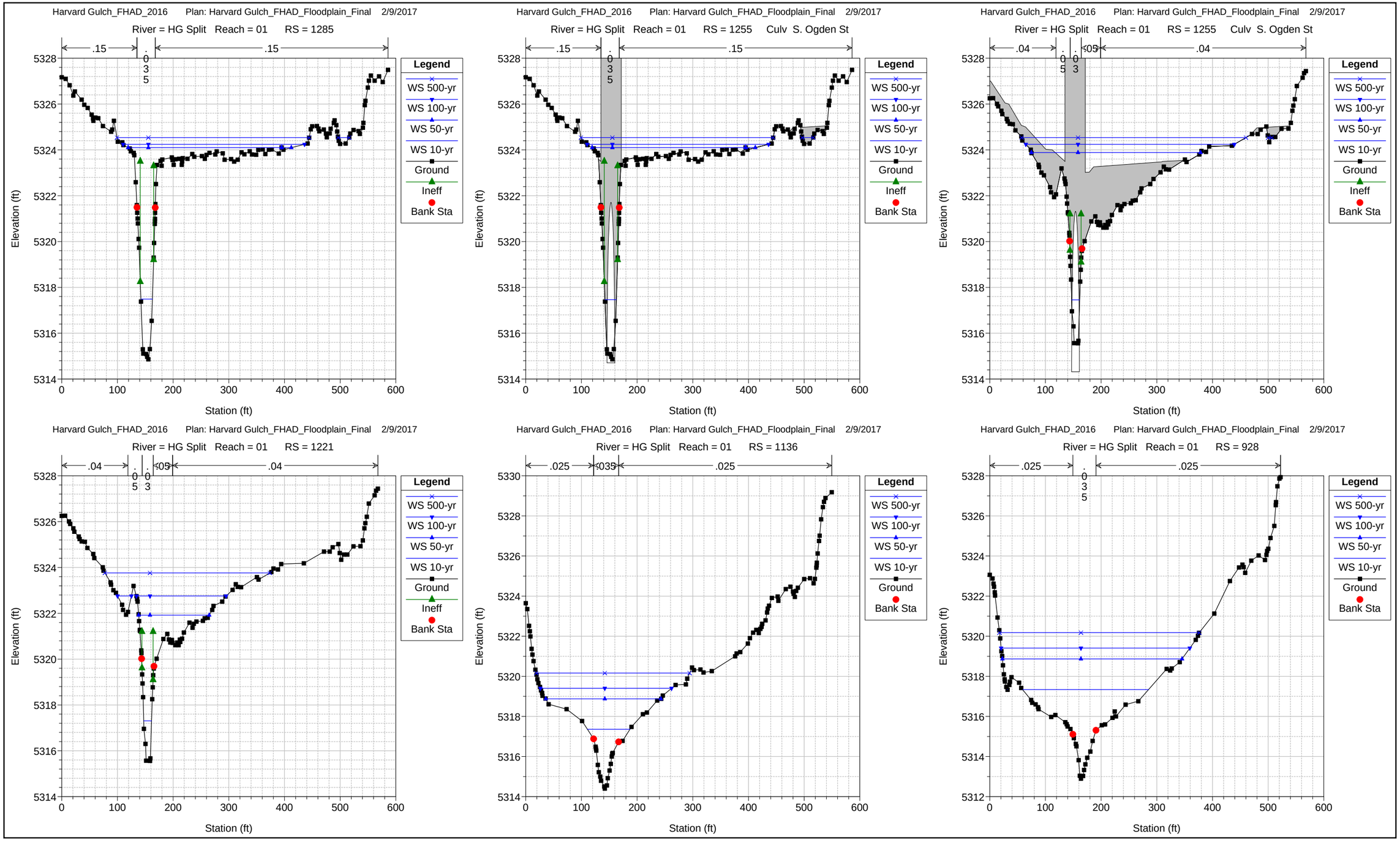

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 4715 Crest of loose rock drop structure
.15
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

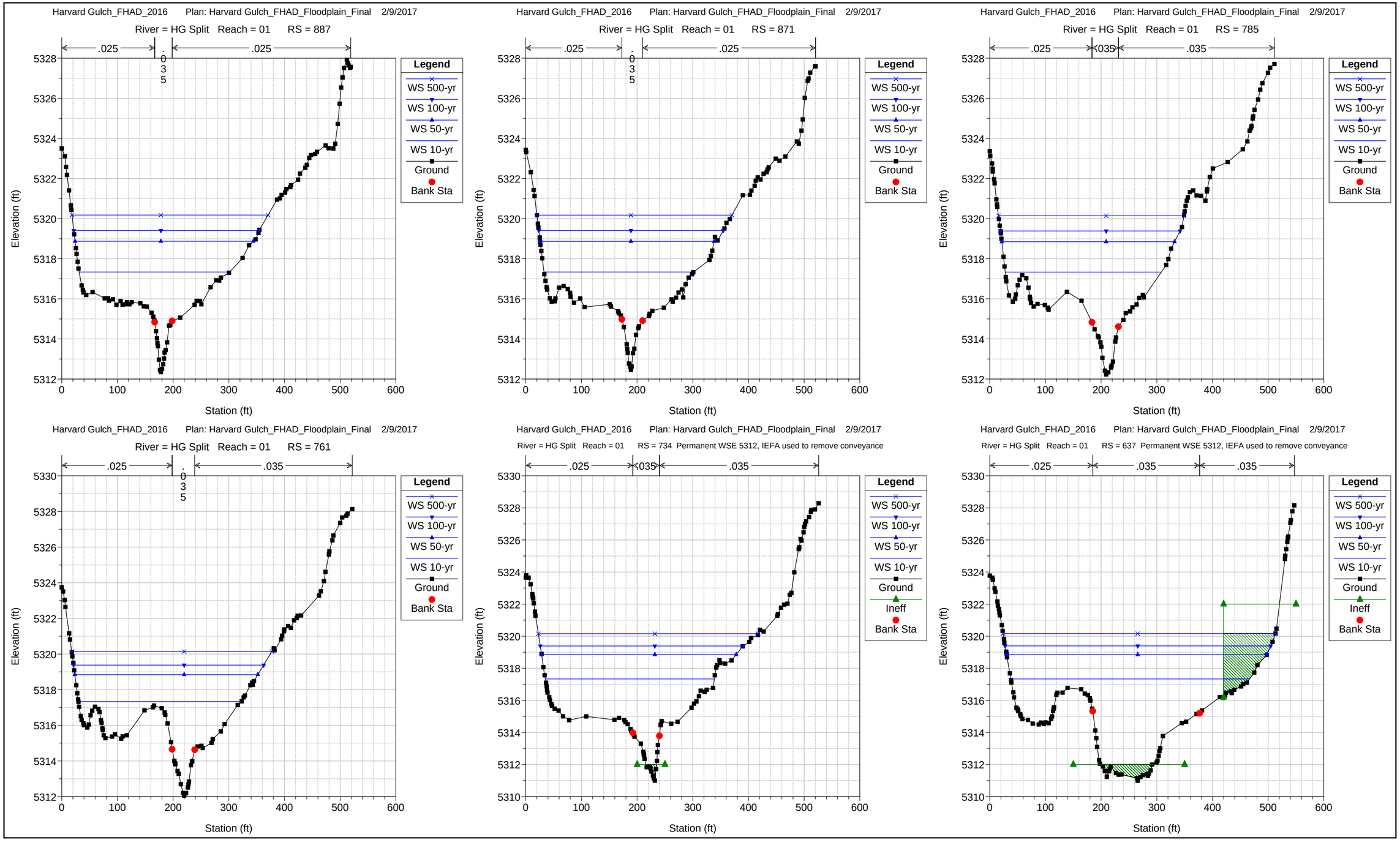

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 4613
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

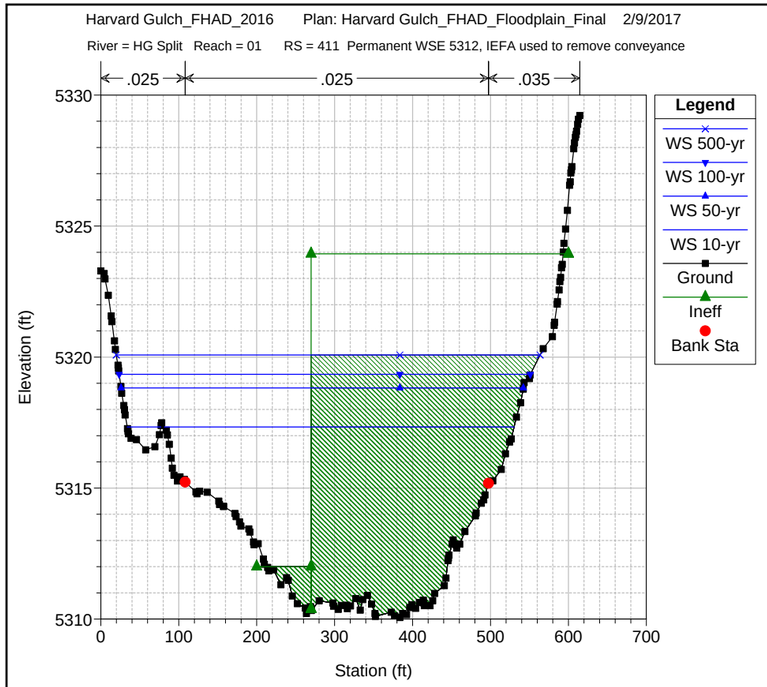

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Reach = 01 RS = 4117 S. Logan St
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

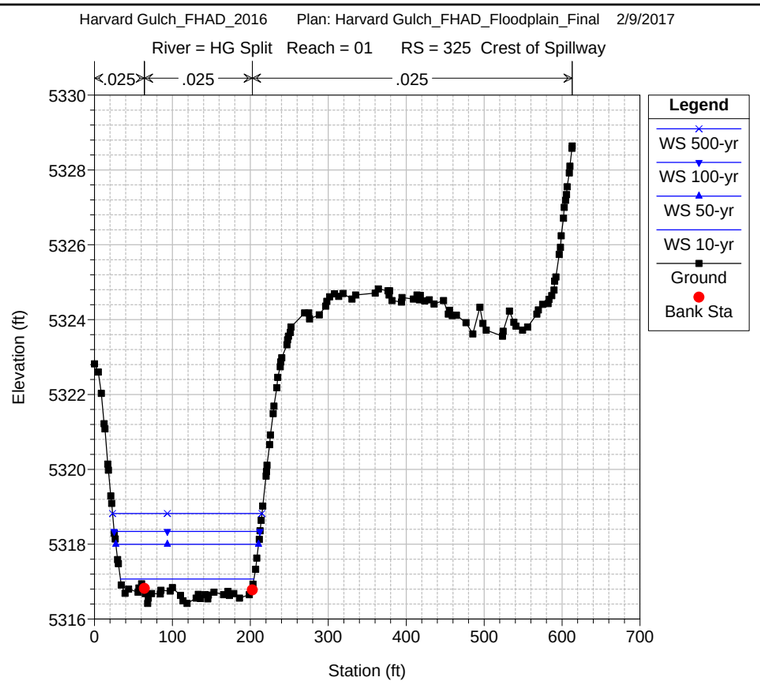

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 2122
.15 .15 .15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 2089
.15 .15 .1
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 2016
.1 .1 .1
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1966
.1 .1 .1
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1923 S. Downing St
.017 .017 .017
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1838
.05 .015 .05
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

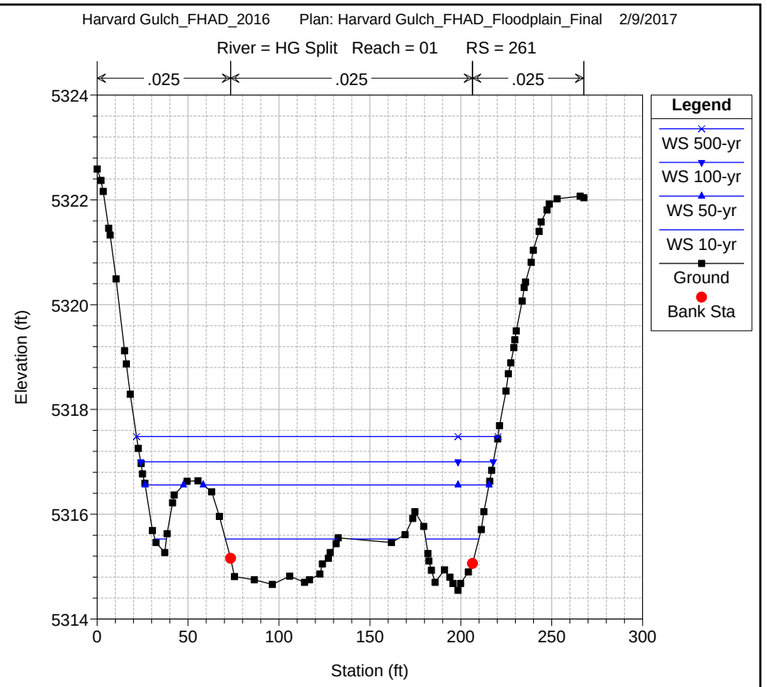

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1755
.15
.015
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1679
.08
.015
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1594 S. Corona St
.15
.015
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1504
.15
.02
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1426
.15
.015
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1351
.15
.015
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

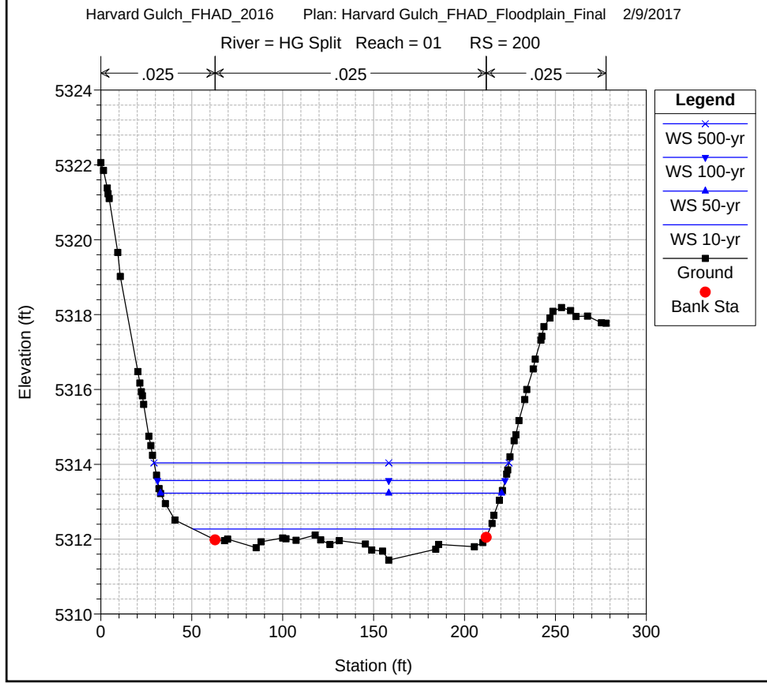

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1285
.15
.035
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1255 Culv S. Ogden St
.15
.035
.15
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1255 Culv S. Ogden St
.04
.05
.03
.04
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1221
.04
.05
.03
.05
.04
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 1136
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 928
.025
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

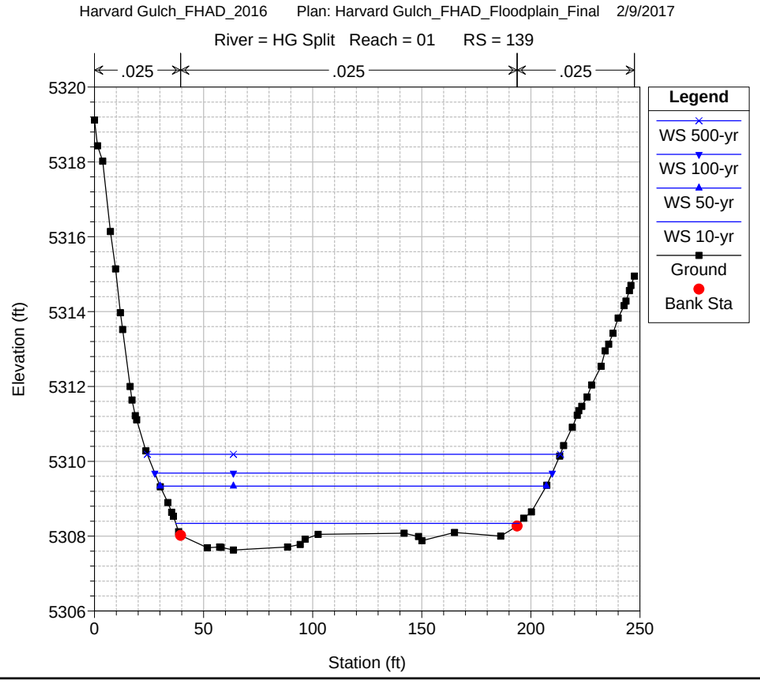

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 887
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 871
.025
.035
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 785
.025
.035
.035
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 761
.025
.035
.035
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 734 Permanent WSE 5312, IEFA used to remove conveyance
.025
.035
.035
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 637 Permanent WSE 5312, IEFA used to remove conveyance
.025
.035
.035
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

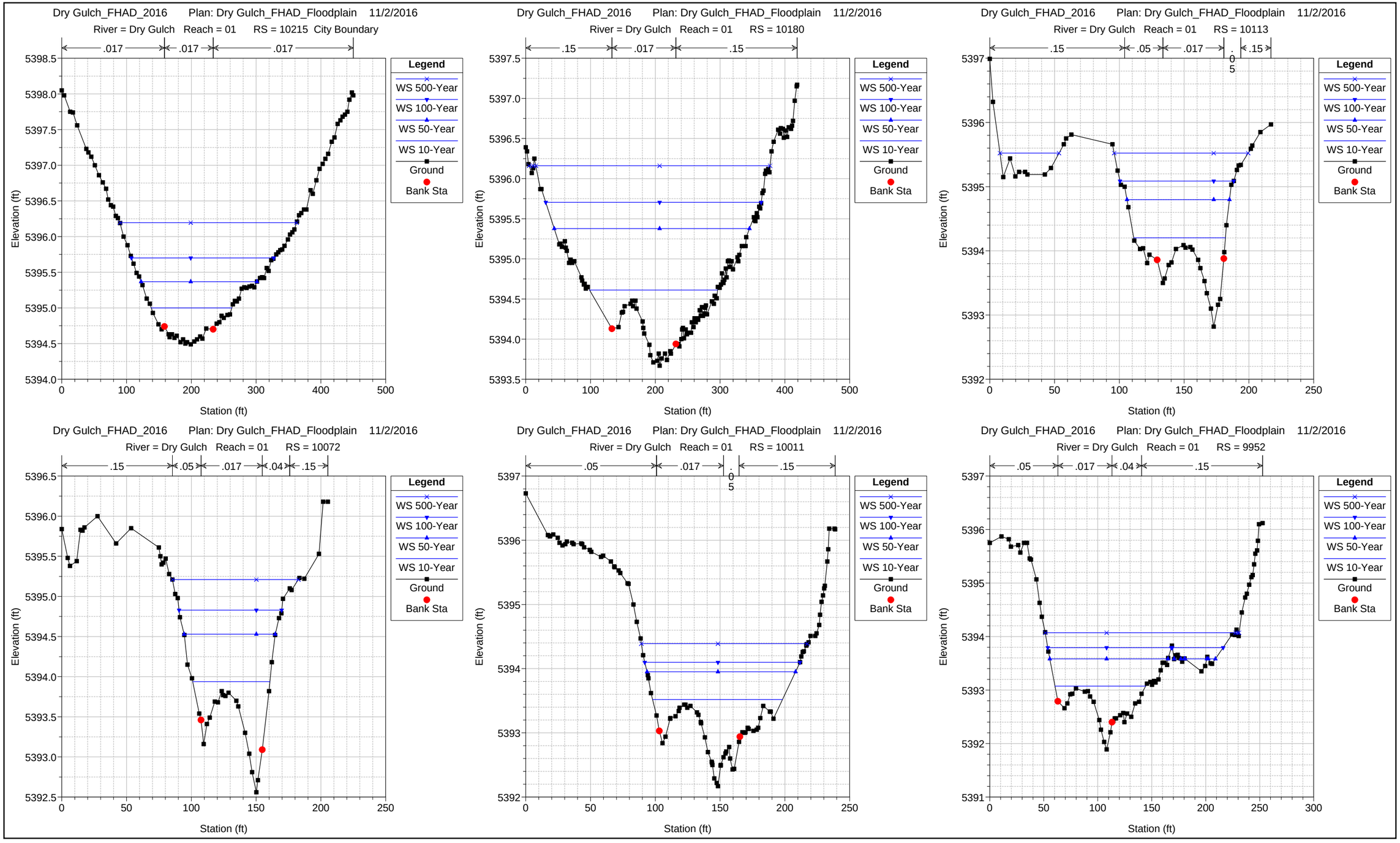

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 411 Permanent WSE 5312, IEFA used to remove conveyance
.025
.025
.035
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

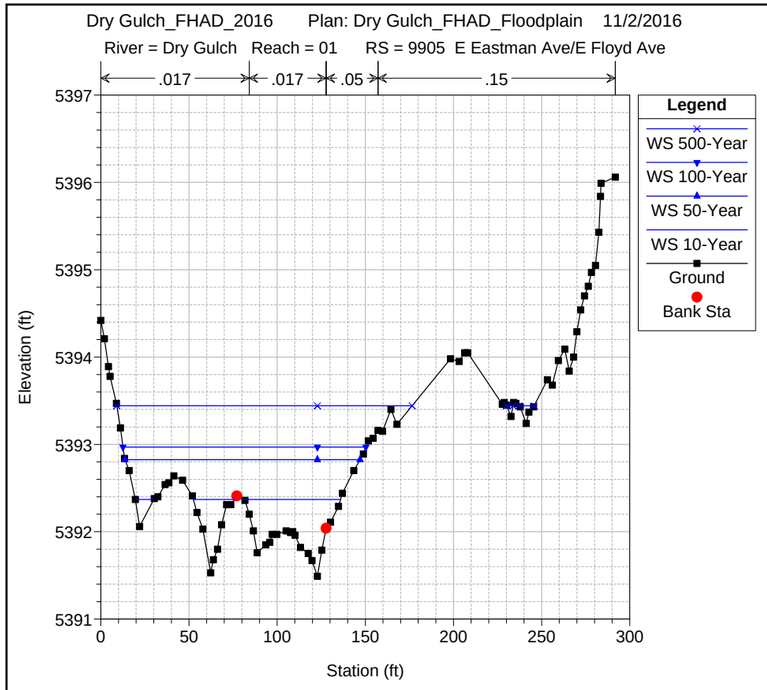

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 325 Crest of Spillway
.025
.025
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

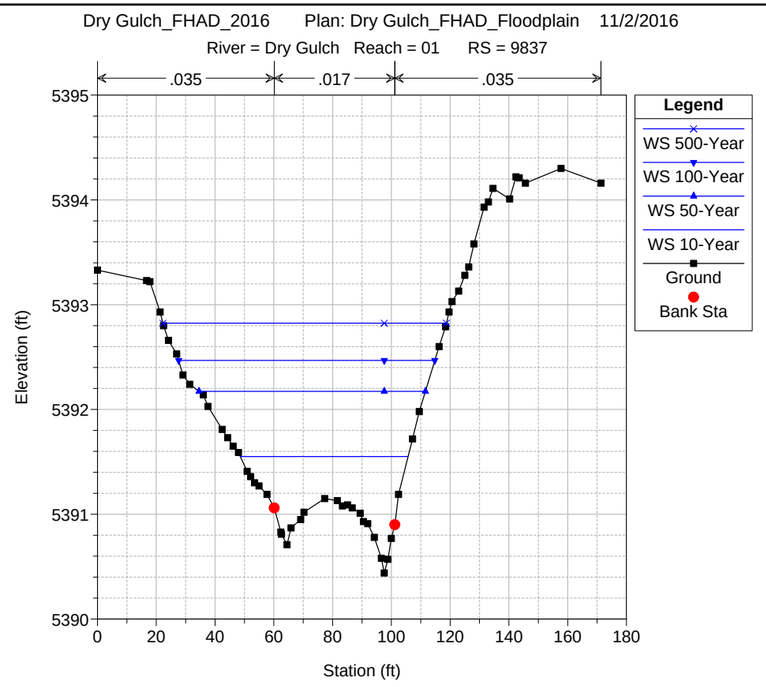

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 261
.025
.025
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

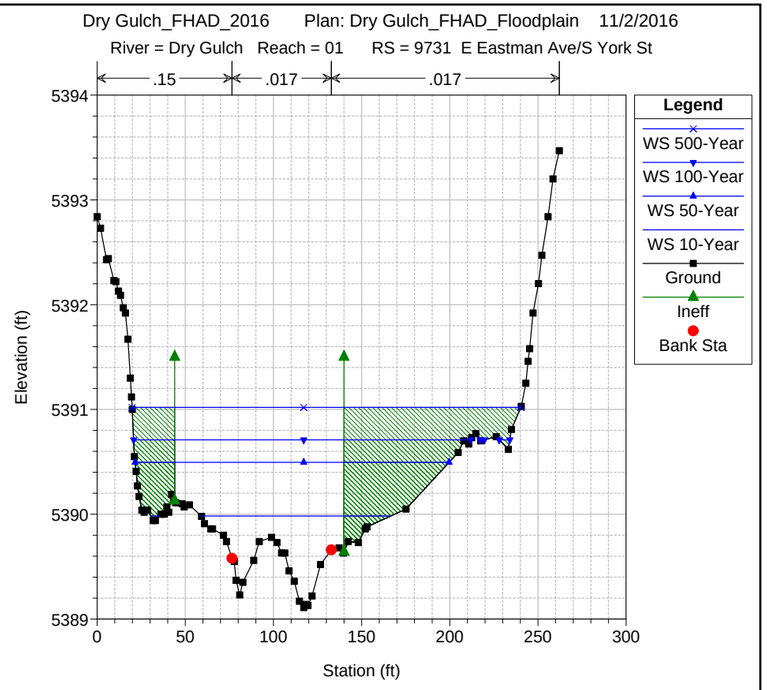

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 200
.025
.025
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

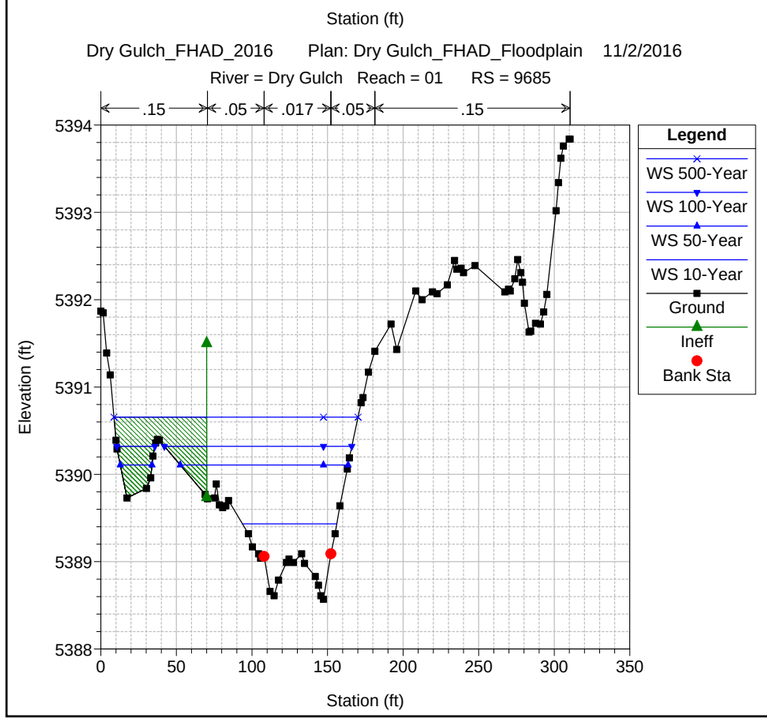

Harvard Gulch_FHAD_2016 Plan: Harvard Gulch_FHAD_Floodplain_Final 2/9/2017
River = HG Split Reach = 01 RS = 139
.025
.025
.025
Legend
WS 500-yr
WS 100-yr
WS 50-yr
WS 10-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

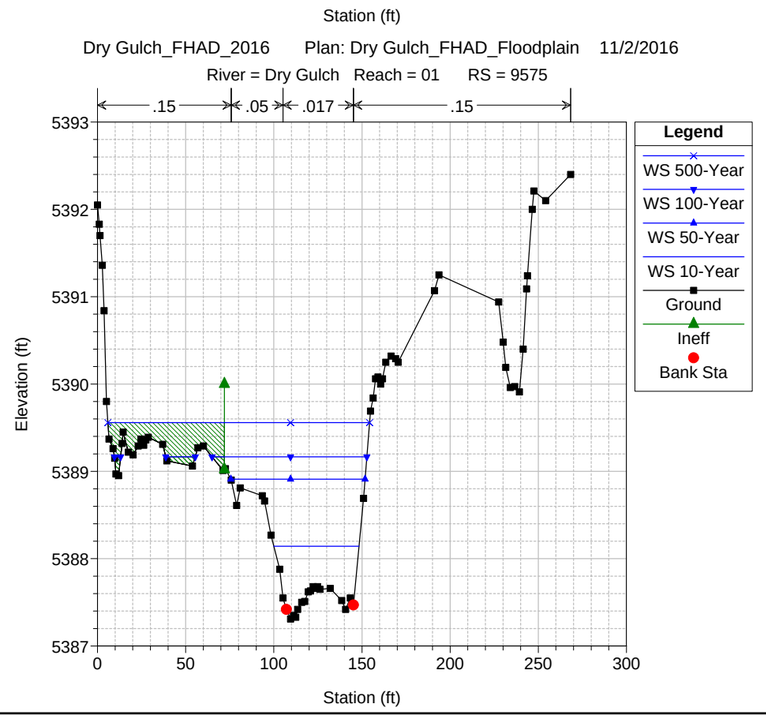

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 10215 City Boundary
.017 .017 .017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 10180
.15 .017 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 10113
.15 .05 .017 .05 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 10072
.15 .05 .017 .04 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 10011
.05 .017 .05 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9952
.05 .017 .04 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

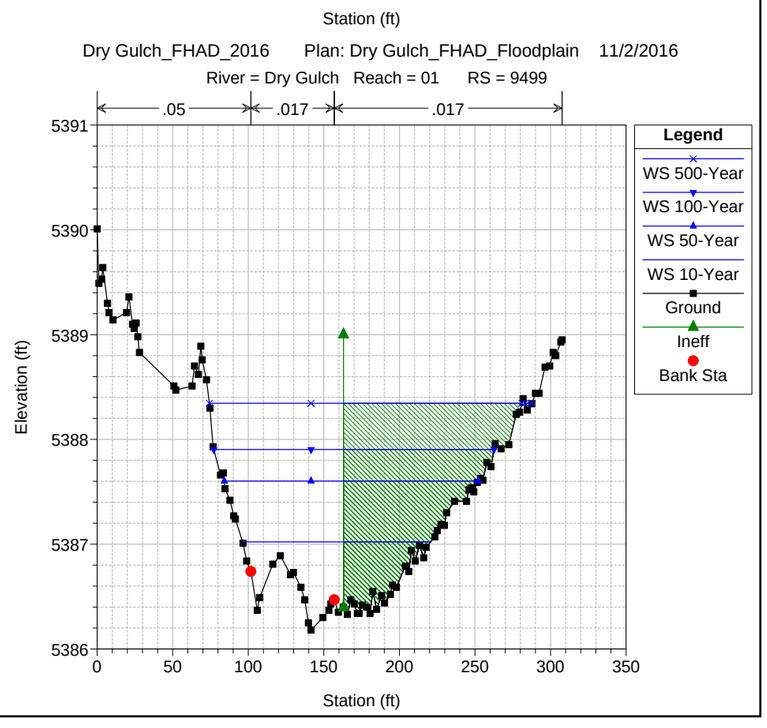

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9905 E Eastman Ave/E Floyd Ave
.017
.017
.05
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

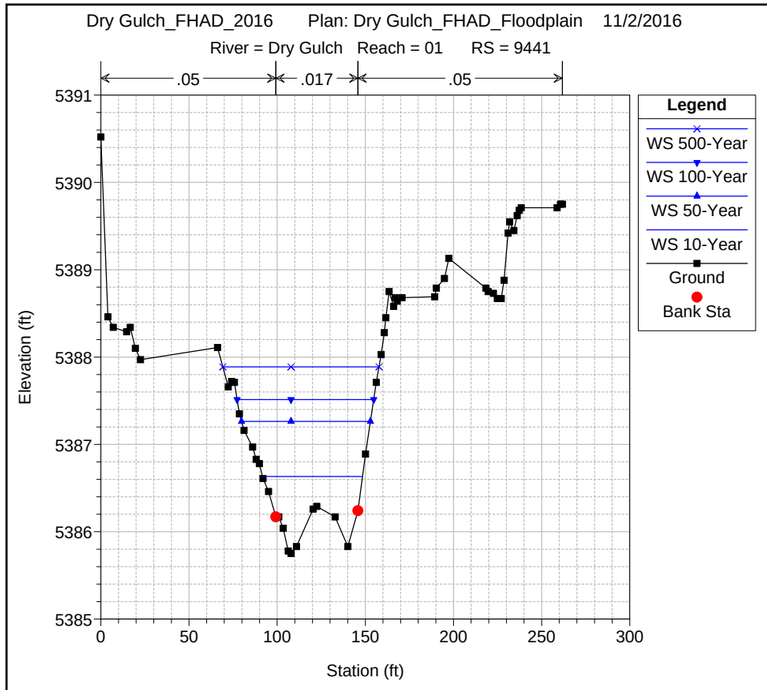

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9837
.035
.017
.035
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

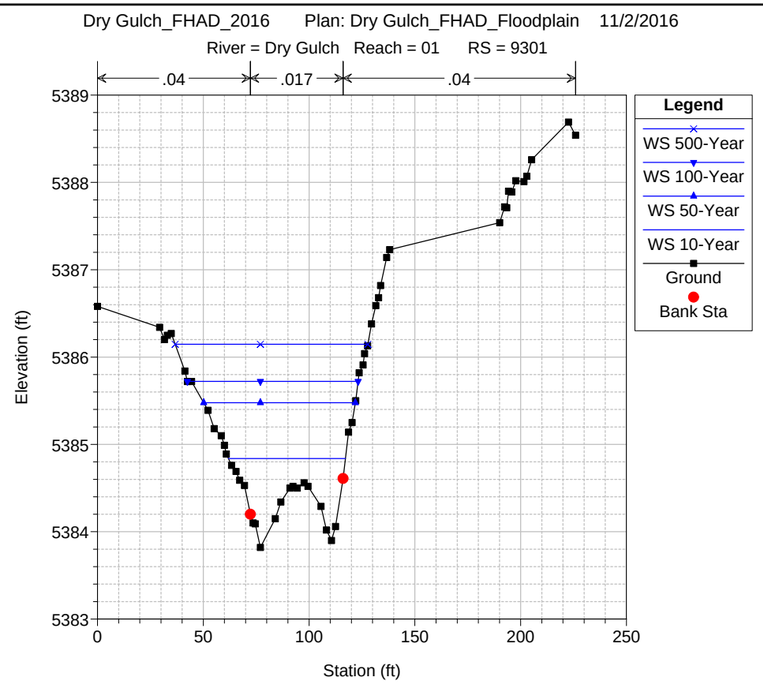

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9731 E Eastman Ave/S York St
.15
.017
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

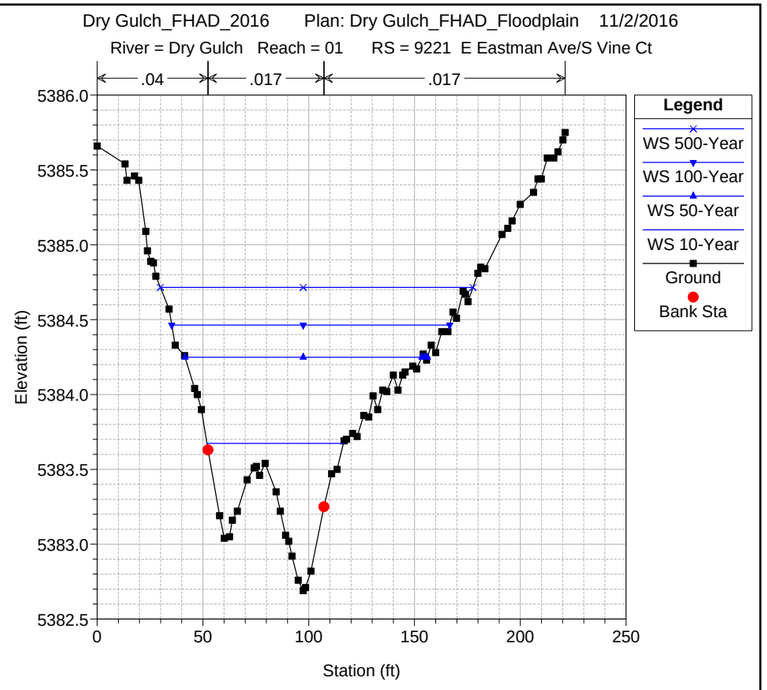

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9685
.15
.05
.017
.05
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

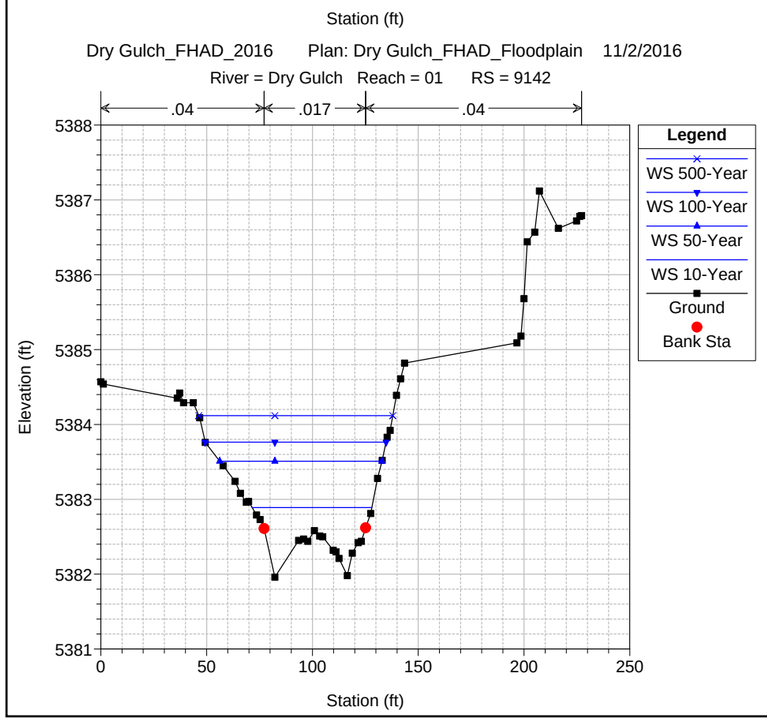

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9575
.15
.05
.017
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

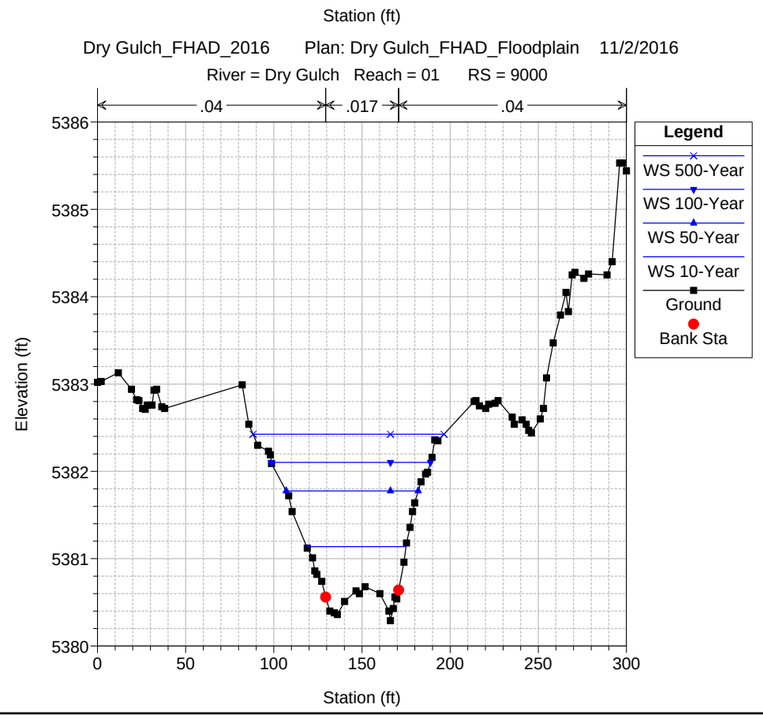

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9499
.05
.017
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

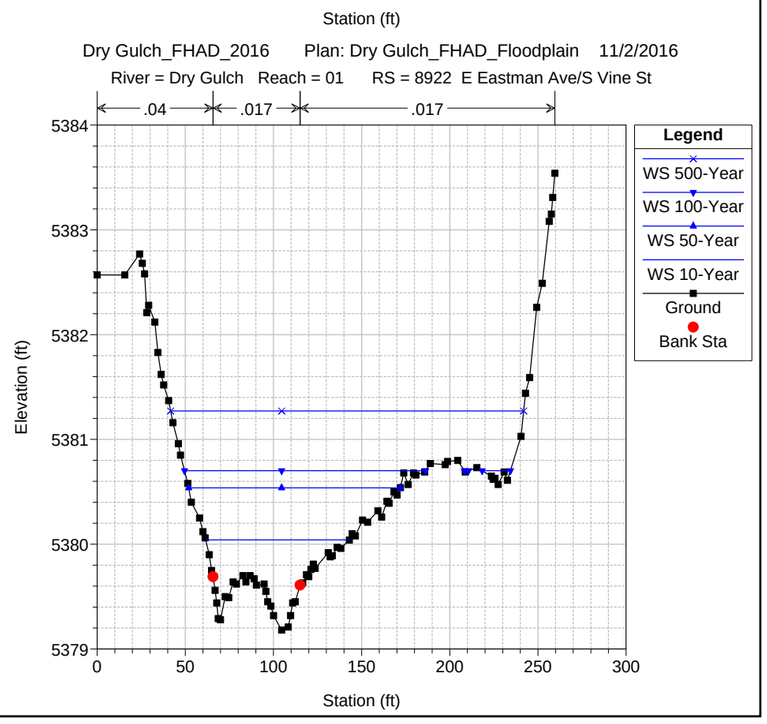

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9441
.05
.017
.05
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

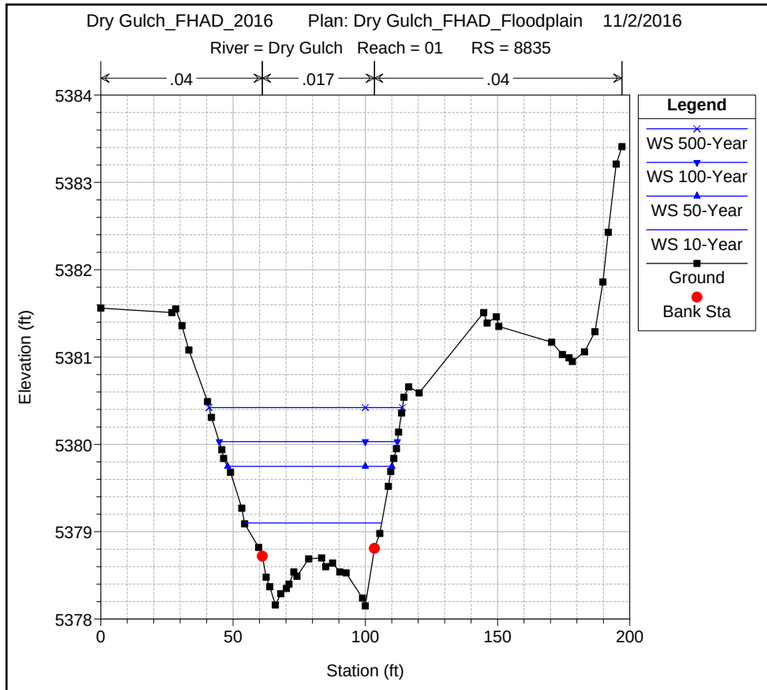

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9301
.04
.017
.04
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

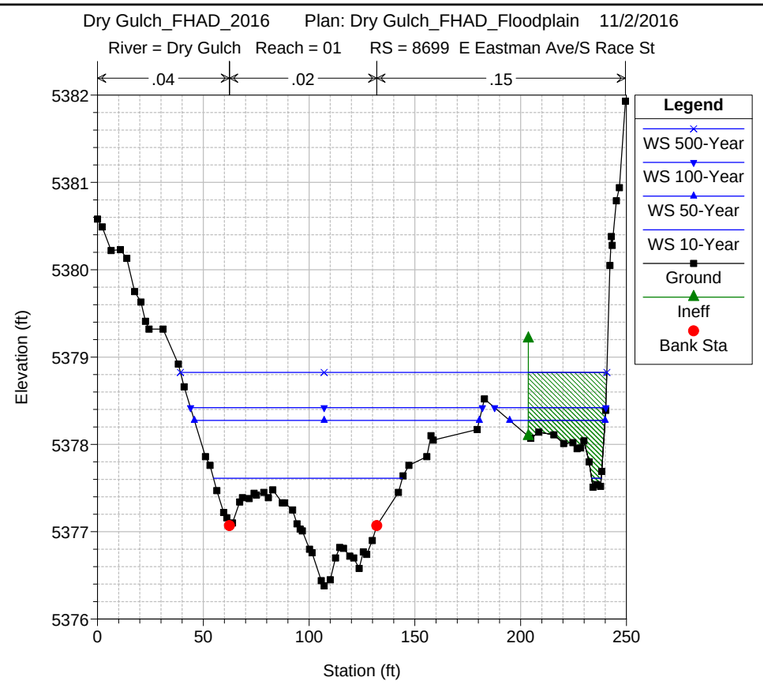

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9221 E Eastman Ave/S Vine Ct
.04
.017
.017
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

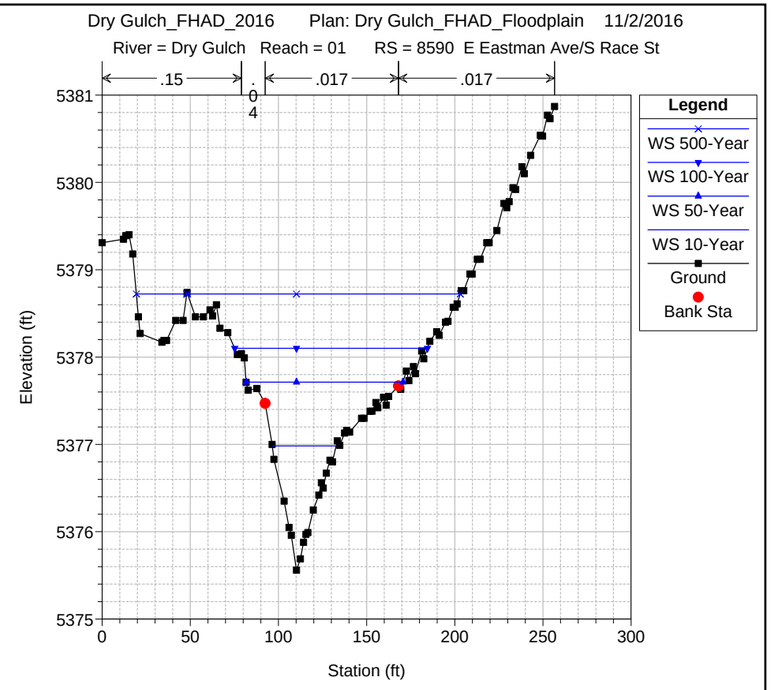

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9142
.04
.017
.04
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

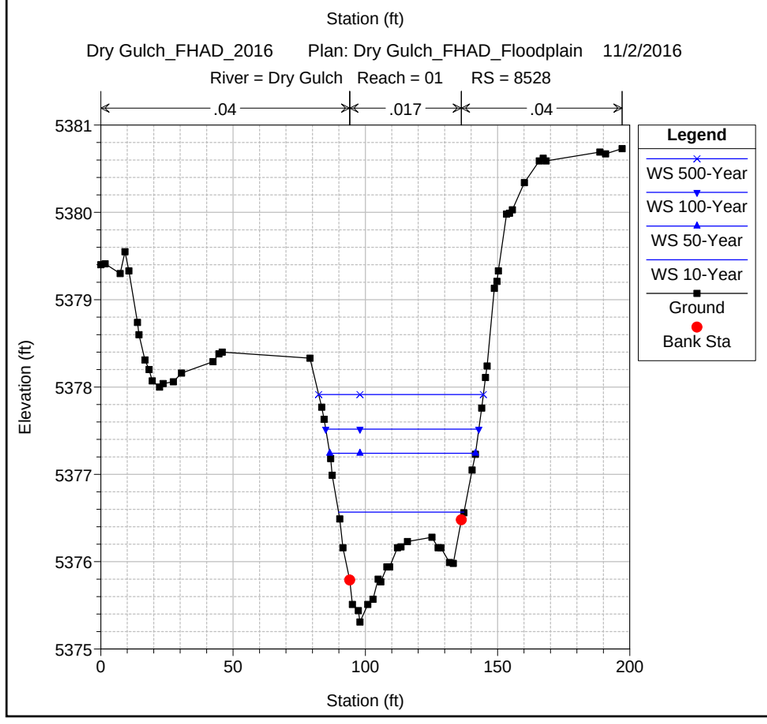

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 9000
.04
.017
.04
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

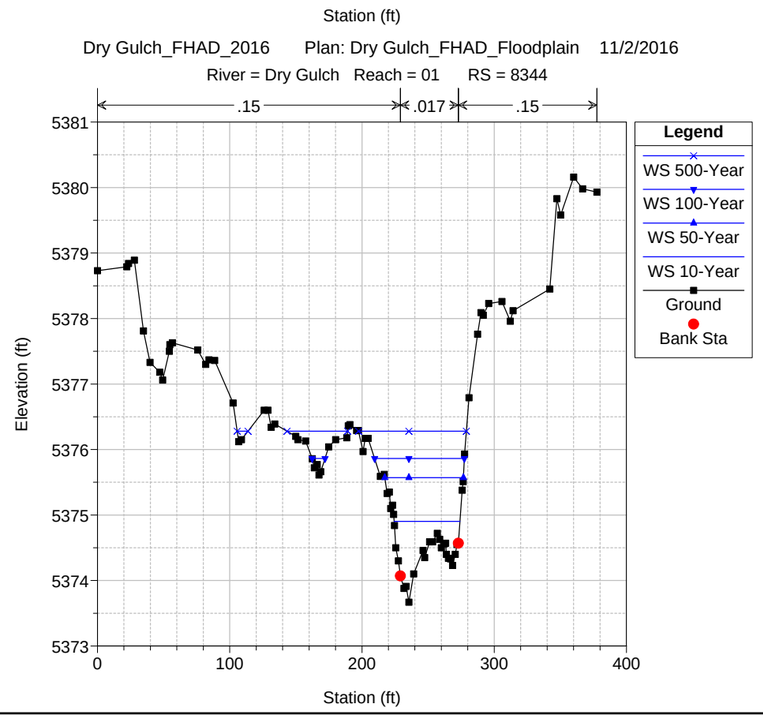

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8922 E Eastman Ave/S Vine St
.04
.017
.017
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

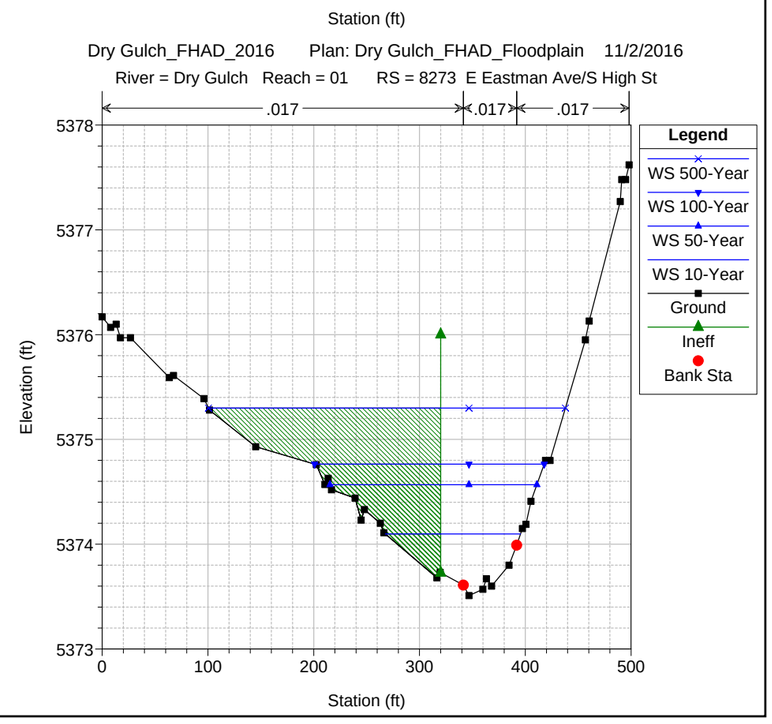

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8835
.04
.017
.04
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

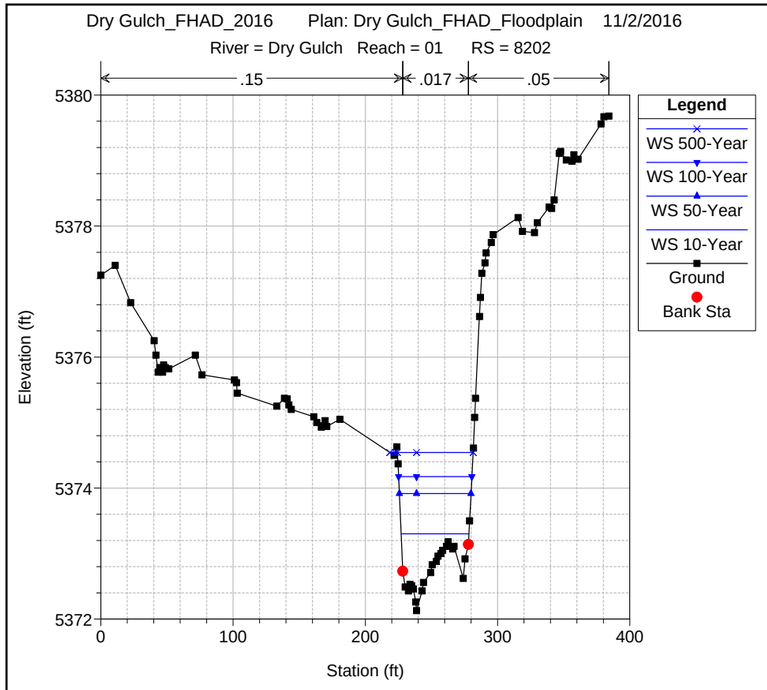

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8699 E Eastman Ave/S Race St
.04
.02
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

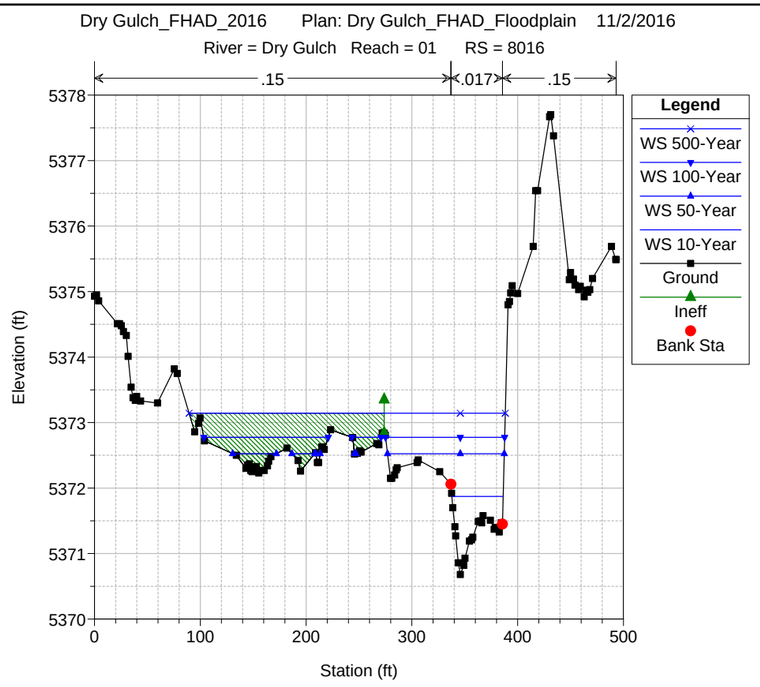

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8590 E Eastman Ave/S Race St
.15
.04
.017
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

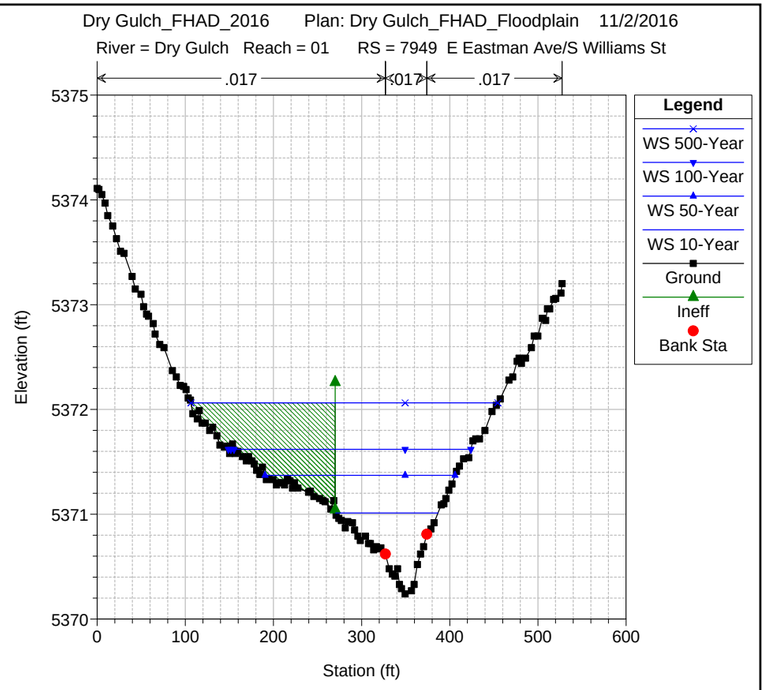

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8528
.04
.017
.04
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

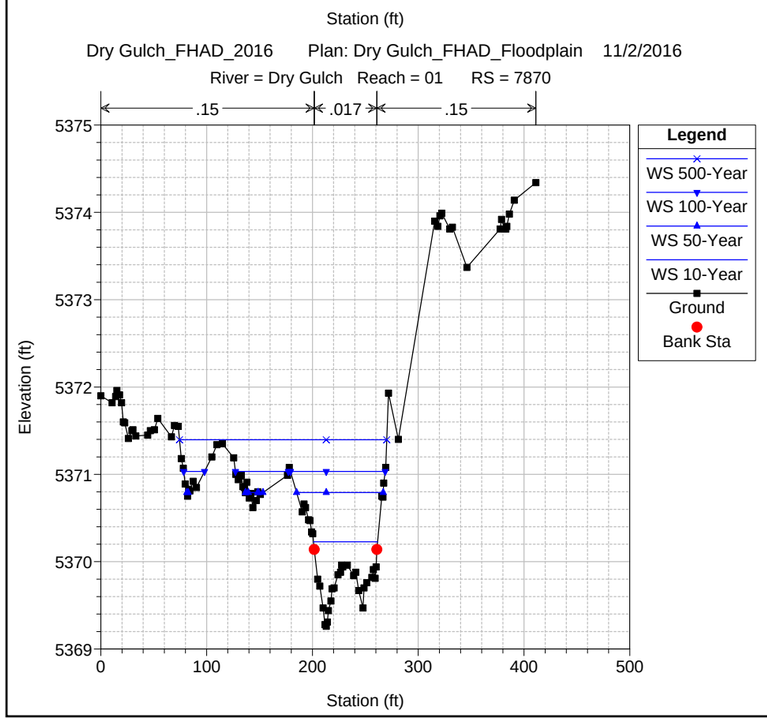

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8344
.15
.017
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

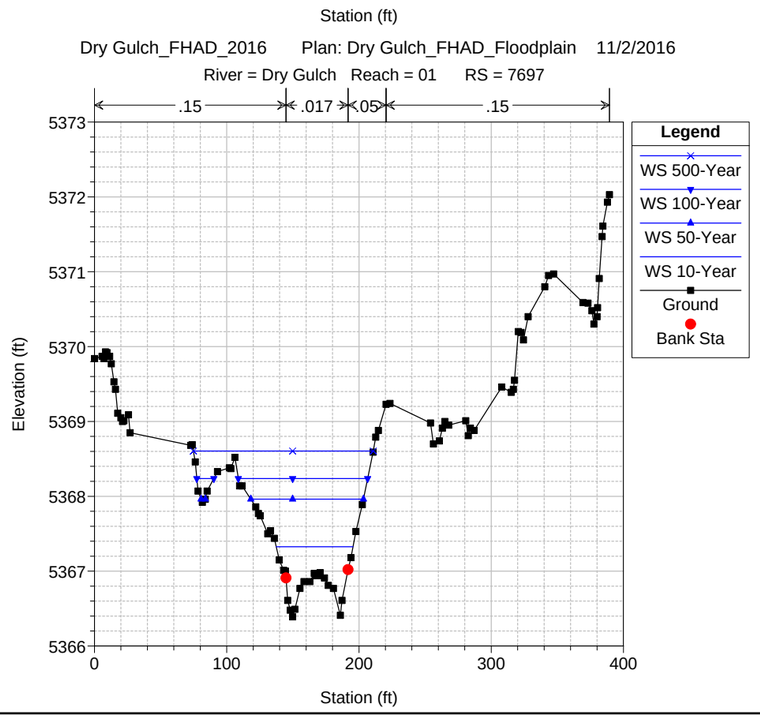

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8273 E Eastman Ave/S High St
.017
.017
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

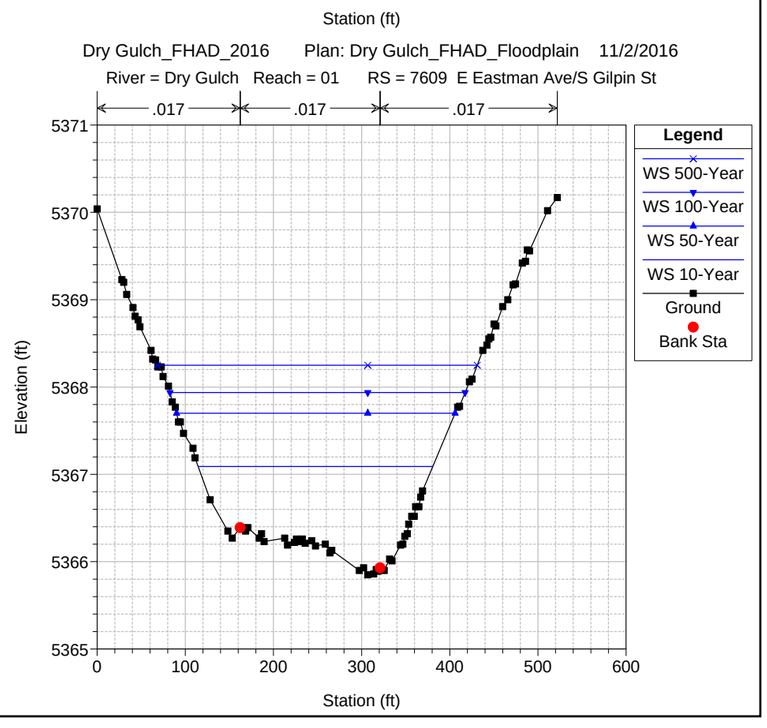

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8202
.15
.017
.05
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

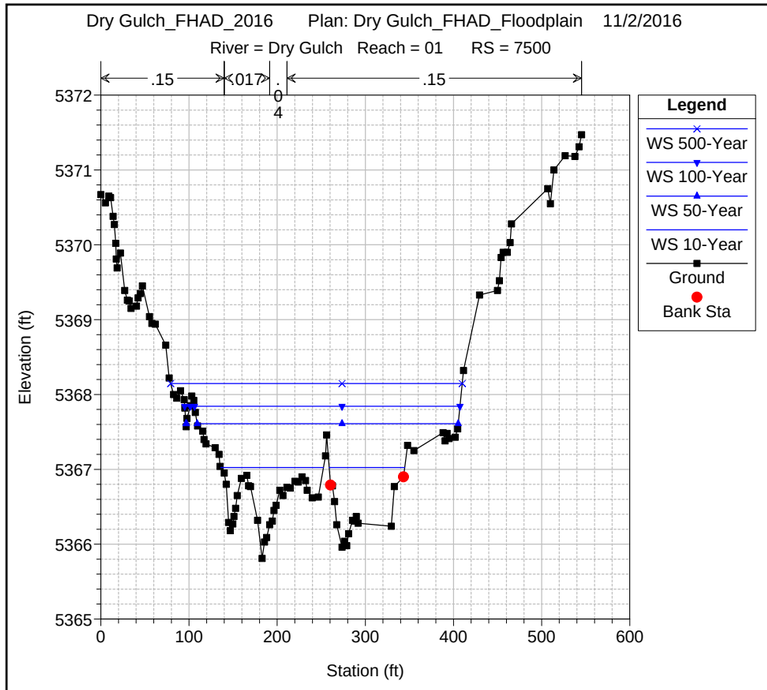

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 8016
.15
.017
.15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta

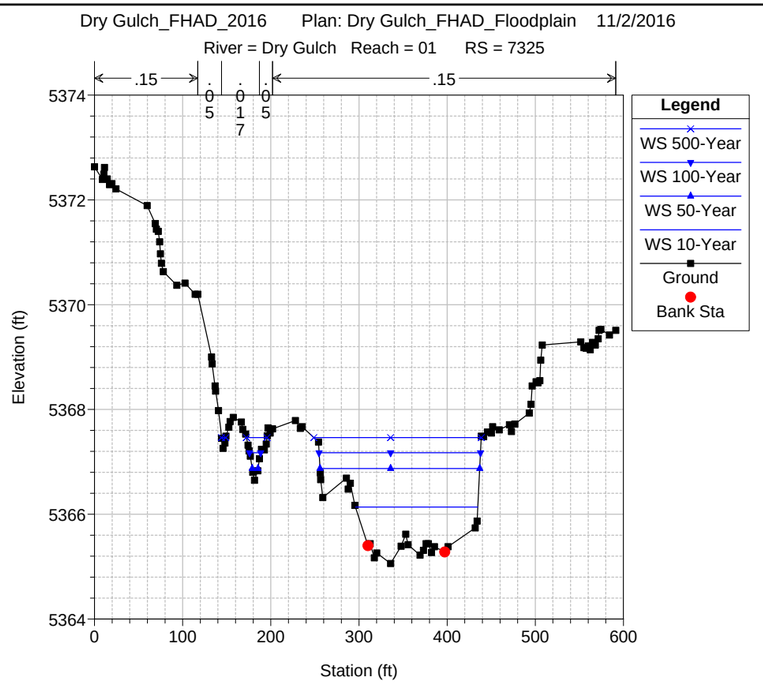

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7949 E Eastman Ave/S Williams St
.017
.017
.017
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta

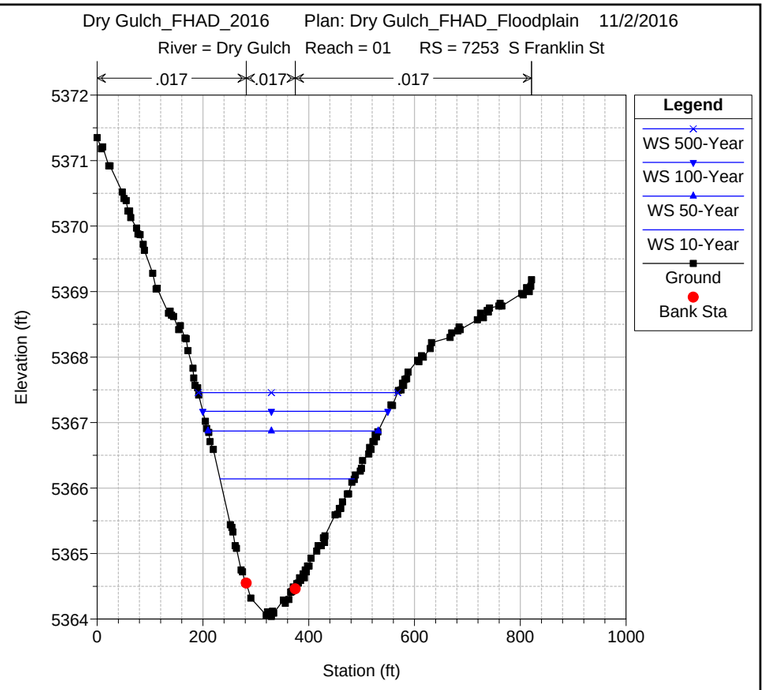

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7870
.15
.017
.15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

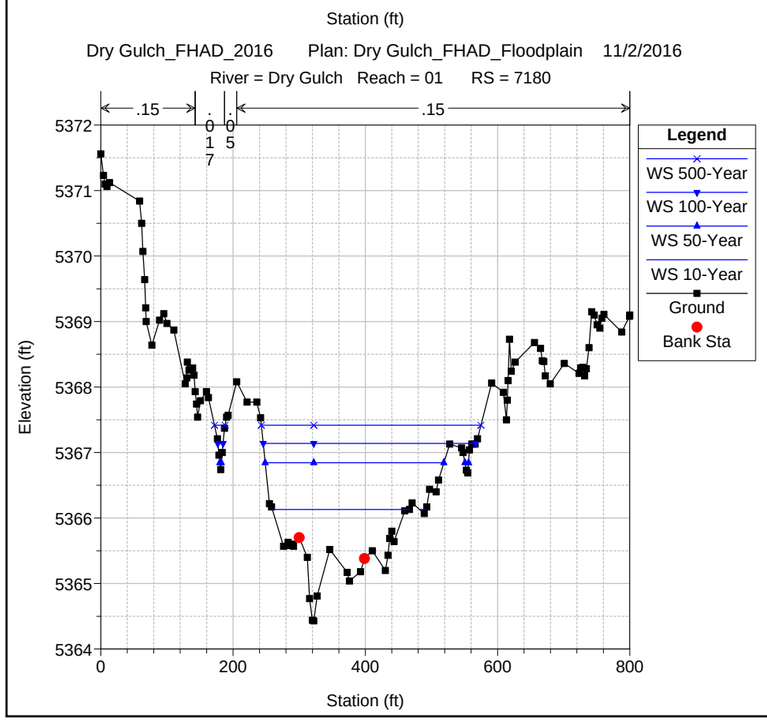

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7697
.15
.017
.05
.15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

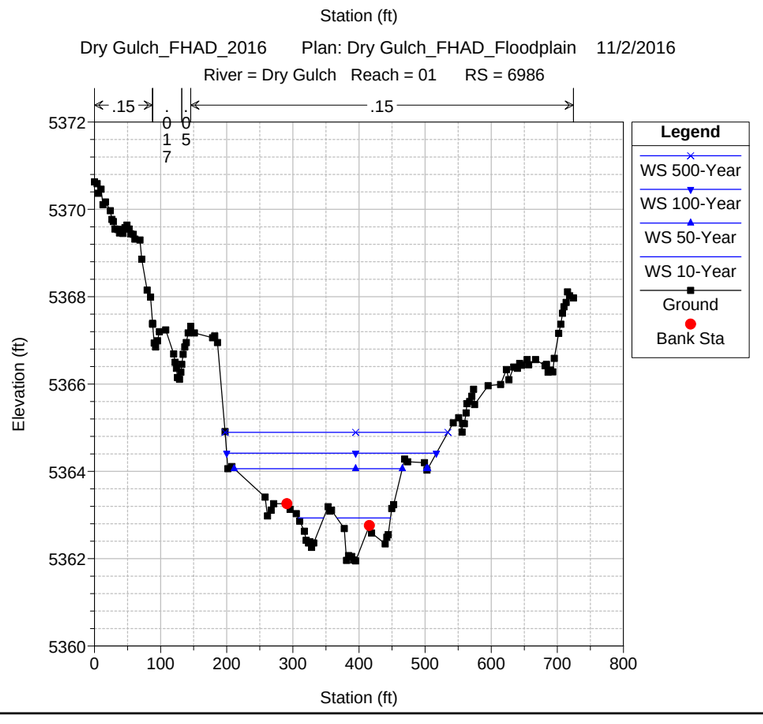

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7609 E Eastman Ave/S Gilpin St
.017
.017
.017
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

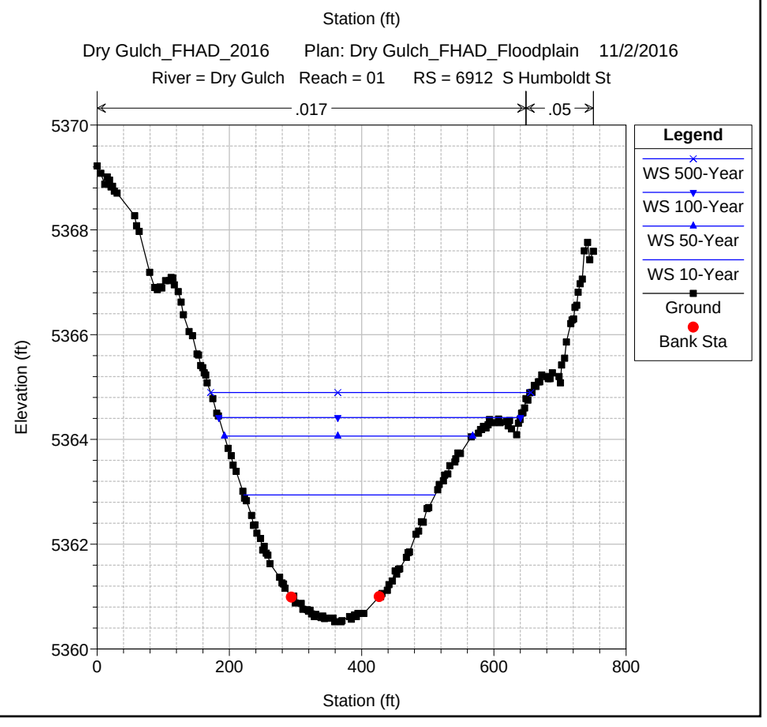

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7500
.15
.017
.04
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

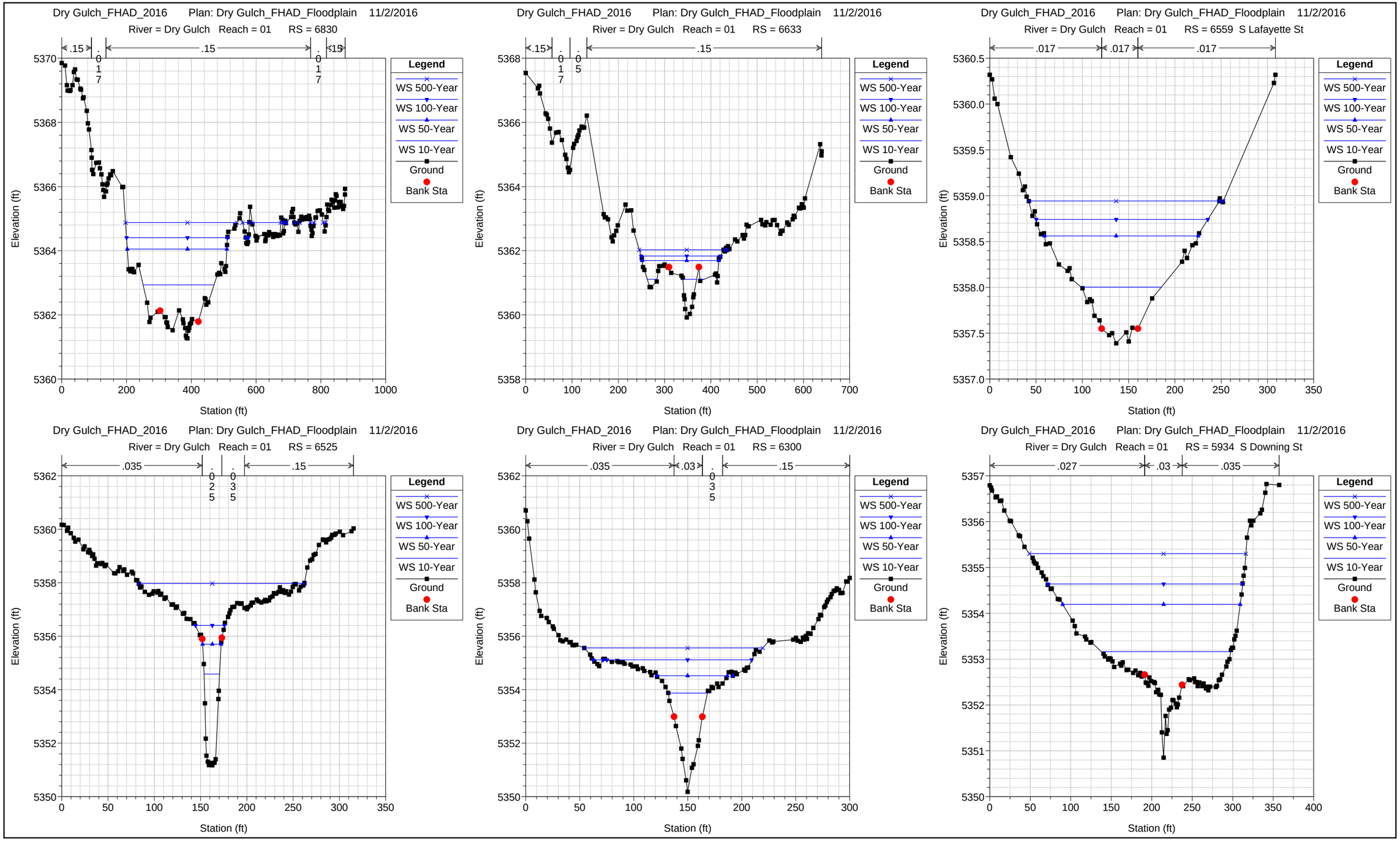

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7325
.15
.05
.017
.05
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

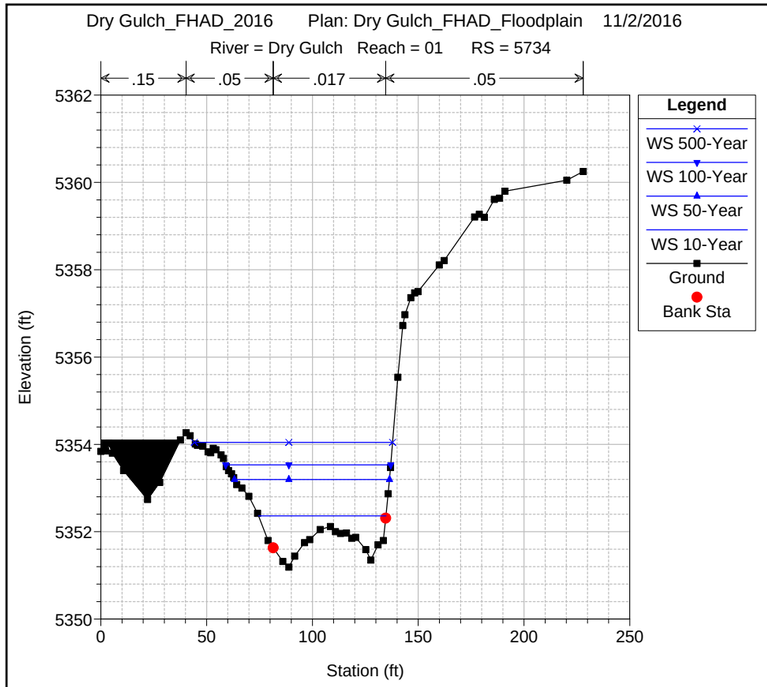

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7253 S Franklin St
.017
.017
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

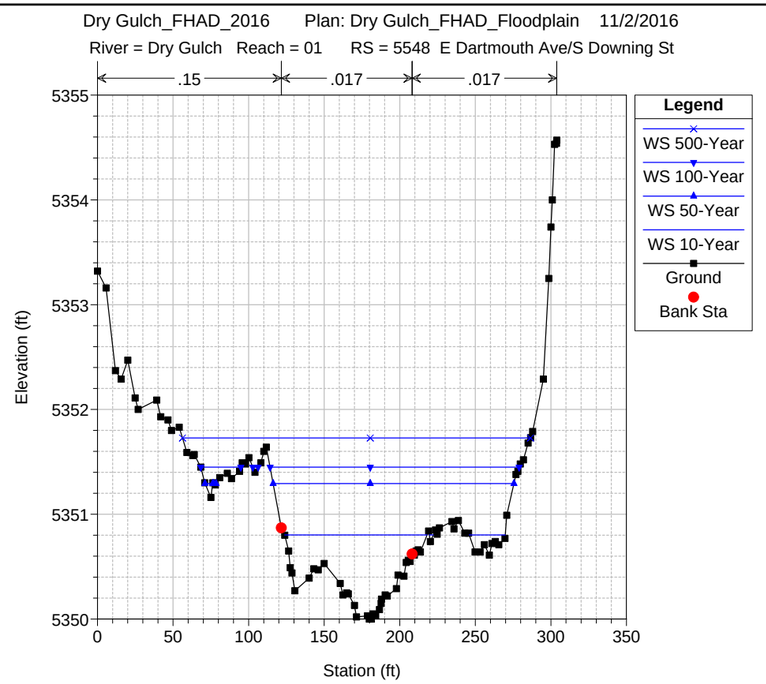

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 7180
.15
.017
.05
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

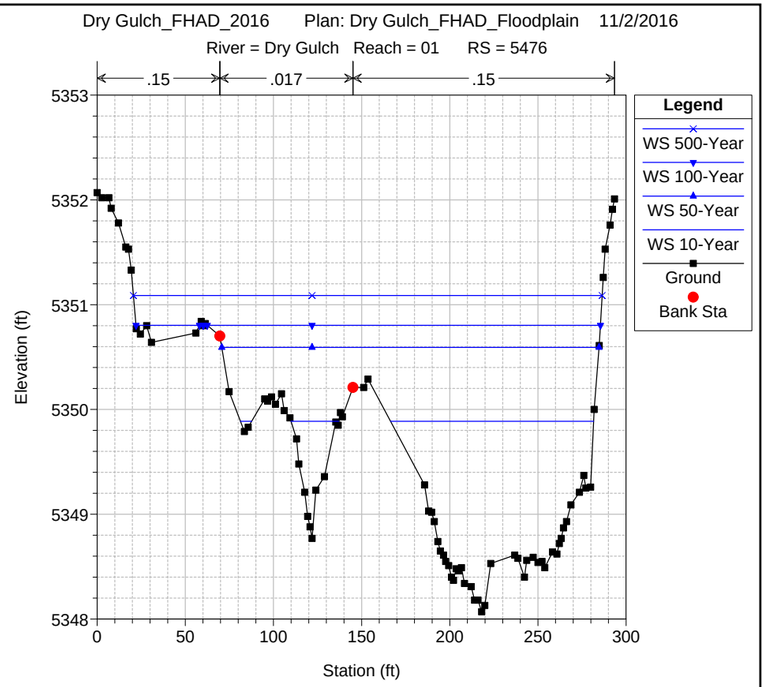

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6986
.15
.017
.05
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

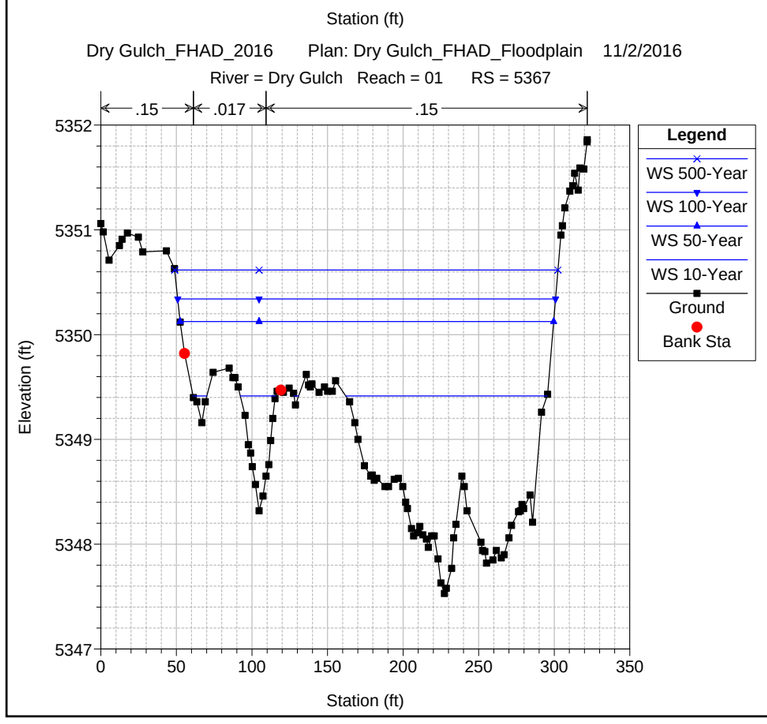

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6912 S Humboldt St
.017
.05
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

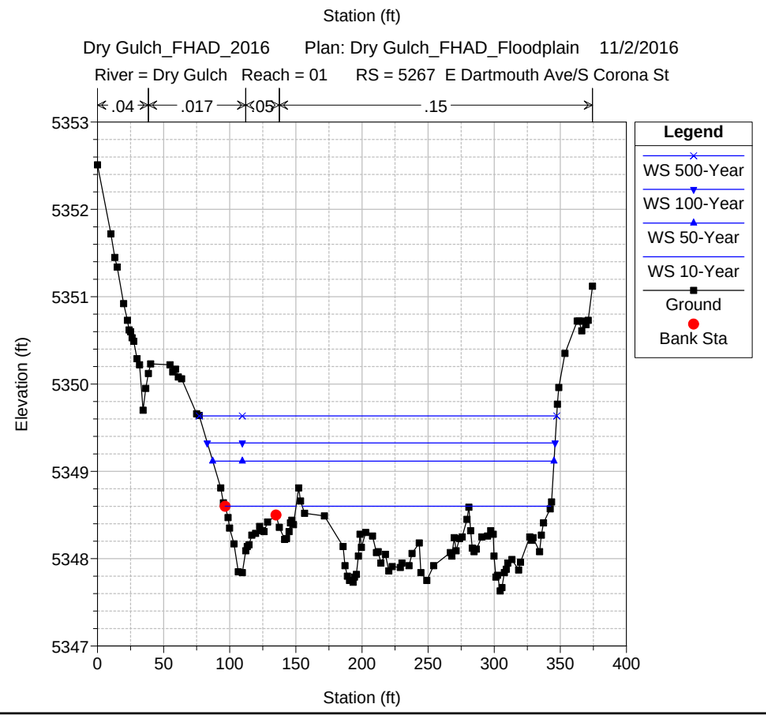

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6830
.15 .017 .15 .017 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6633
.15 .017 .015 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6559 S Lafayette St
.017 .017 .017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6525
.035 .025 .035 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 6300
.035 .03 .035 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5934 S Downing St
.027 .03 .035
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

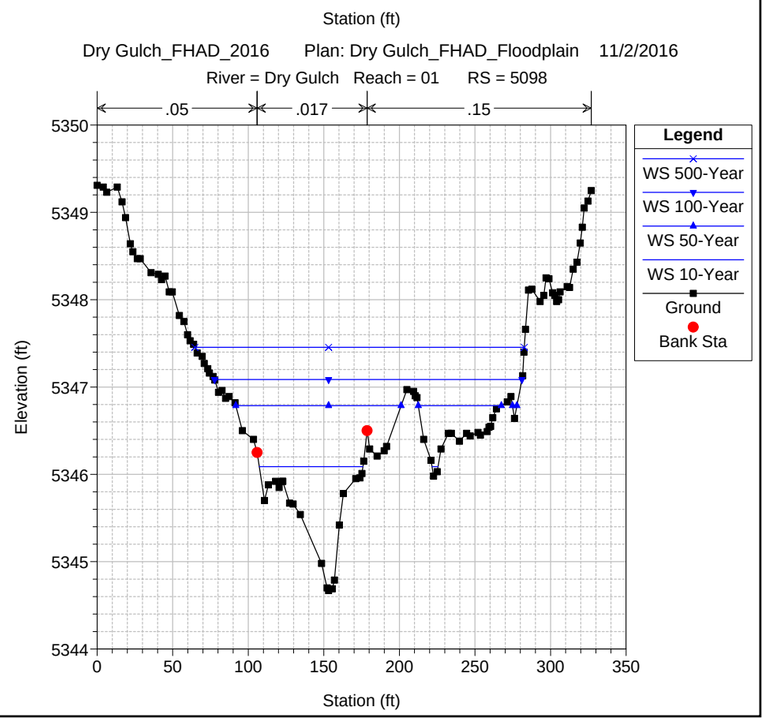

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5734
.15 .05 .017 .05
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

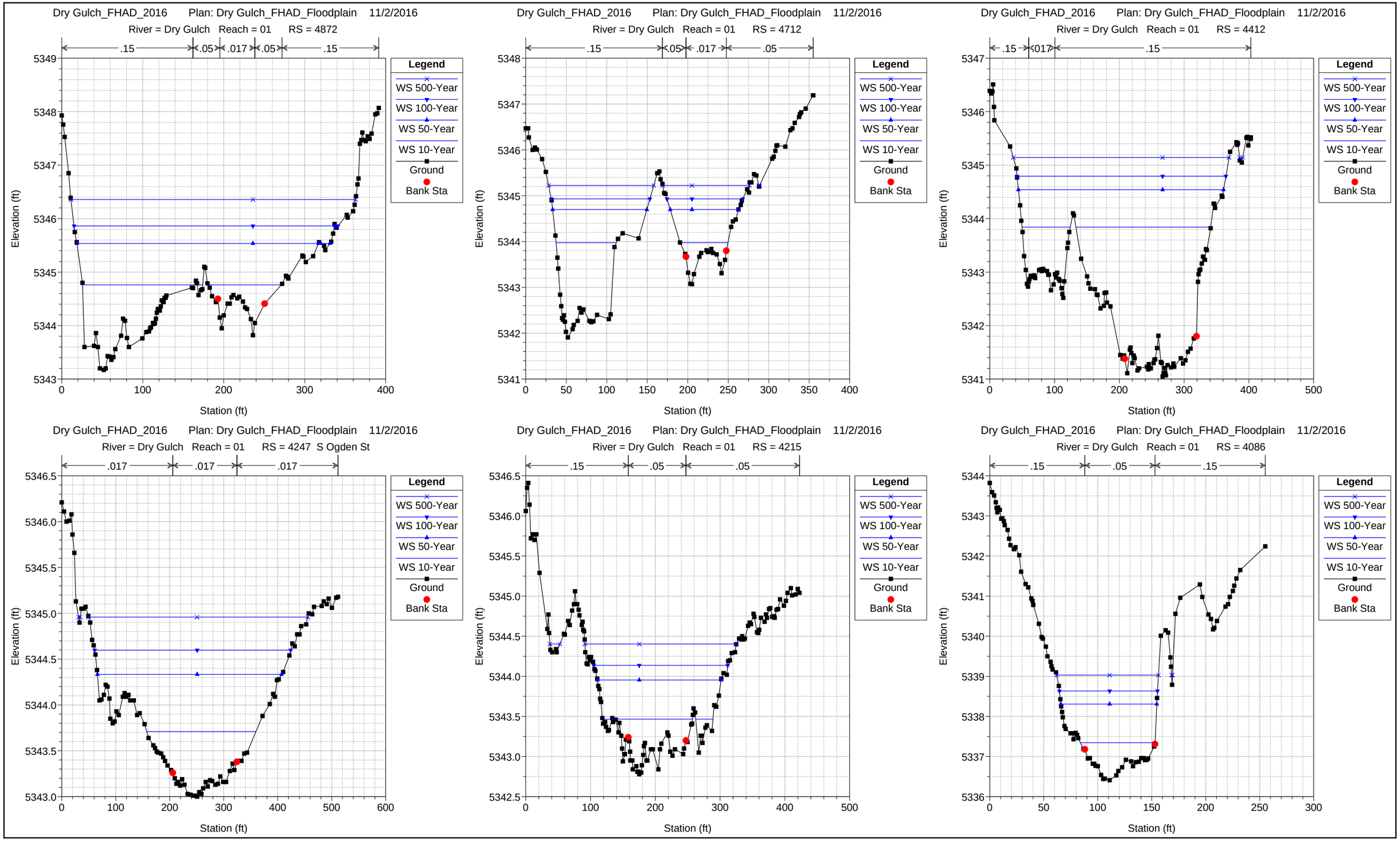

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5548 E Dartmouth Ave/S Downing St
.15 .017 .017
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

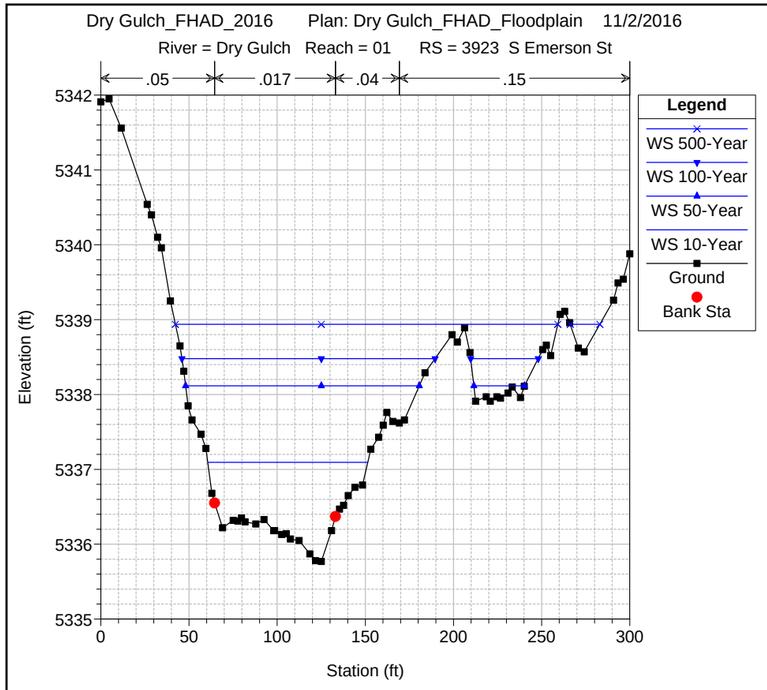

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5476
.15 .017 .15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

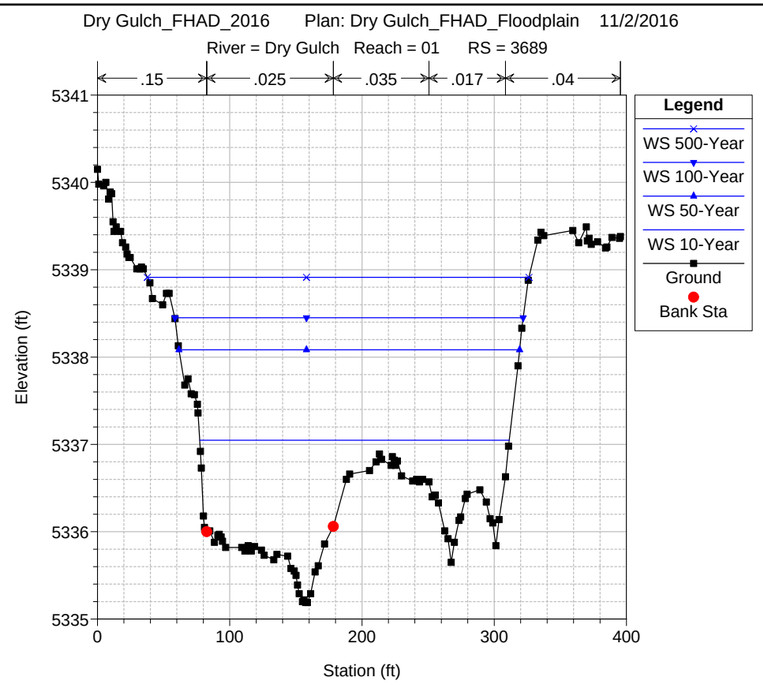

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5367
.15 .017 .15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

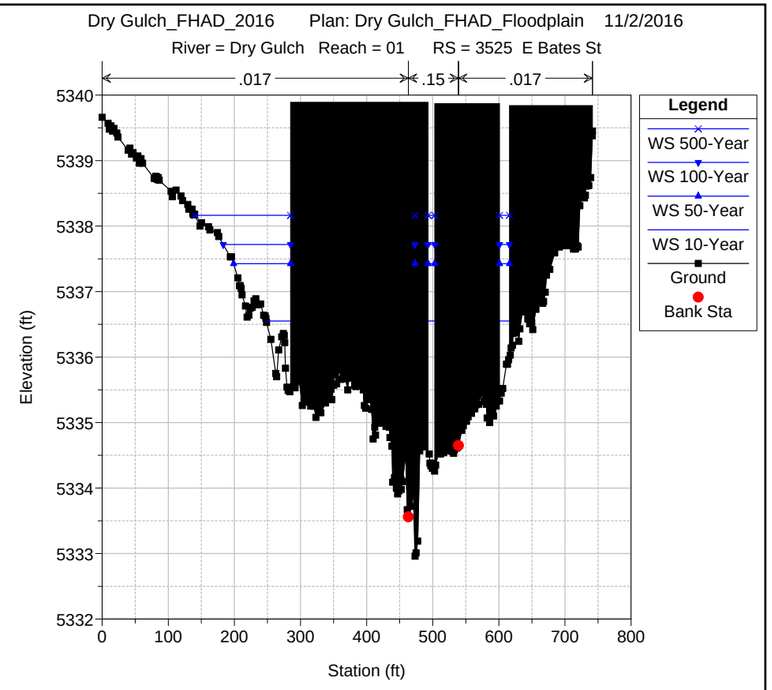

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5267 E Dartmouth Ave/S Corona St
.04 .017 .05 .15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

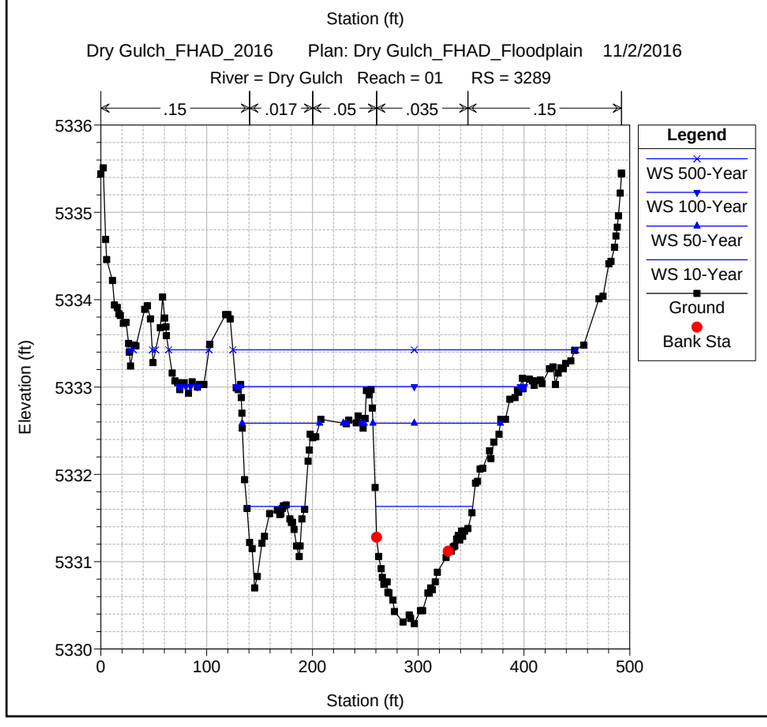

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 5098
.05 .017 .15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

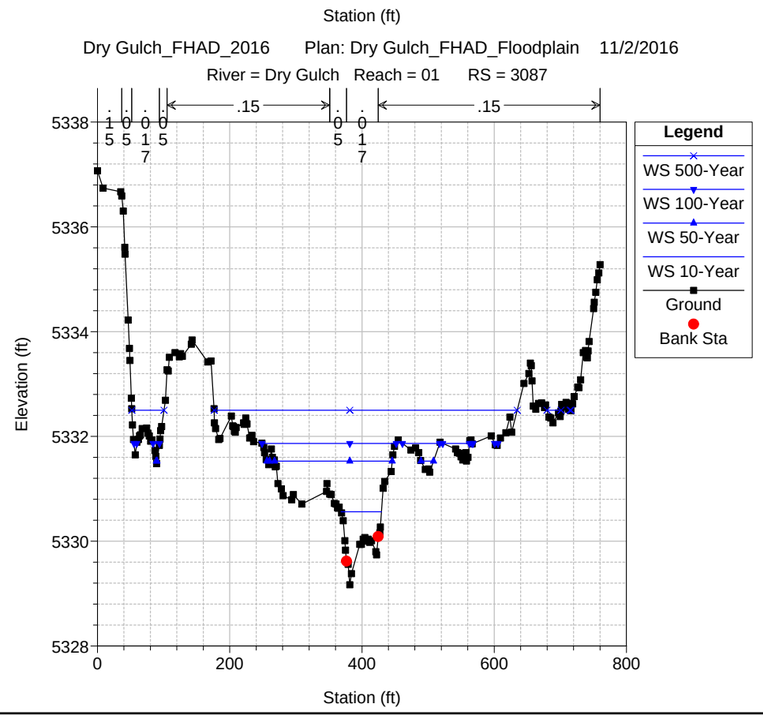

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 4872
.15 .05 .017 .05 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 4712
.15 .05 .017 .05
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 4412
.15 .017 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 4247 S Ogden St
.017 .017 .017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 4215
.15 .05 .05
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 4086
.15 .05 .15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

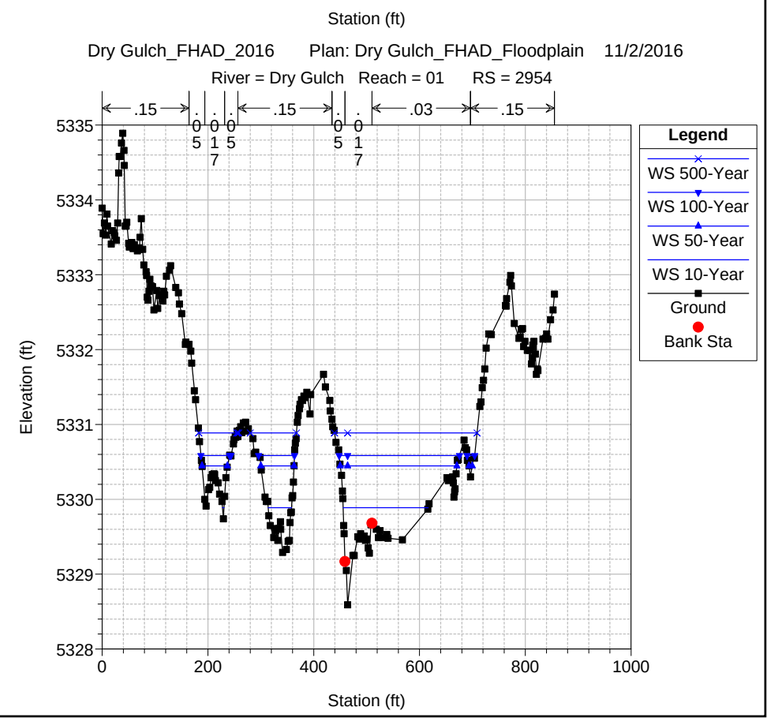

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 3923 S Emerson St
.05
.017
.04
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

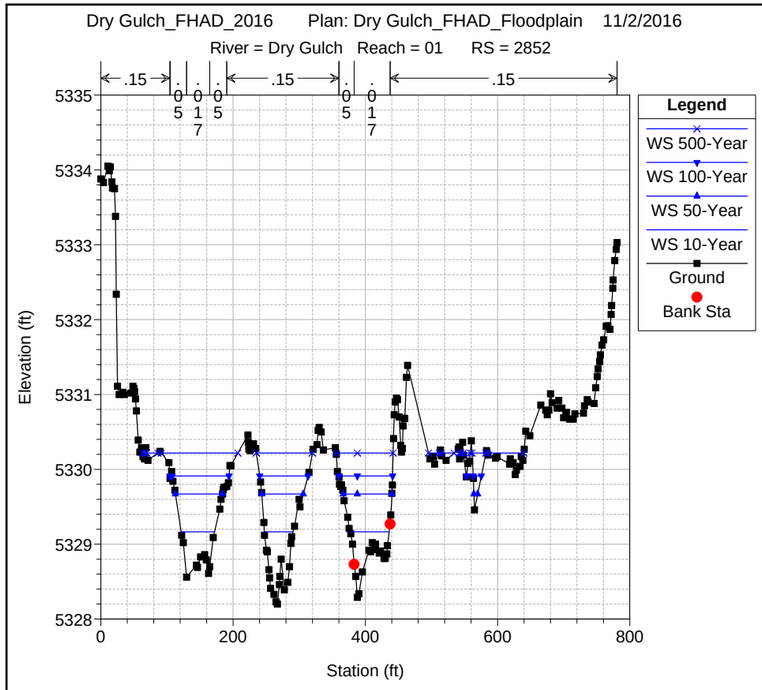

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 3689
.15
.025
.035
.017
.04
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

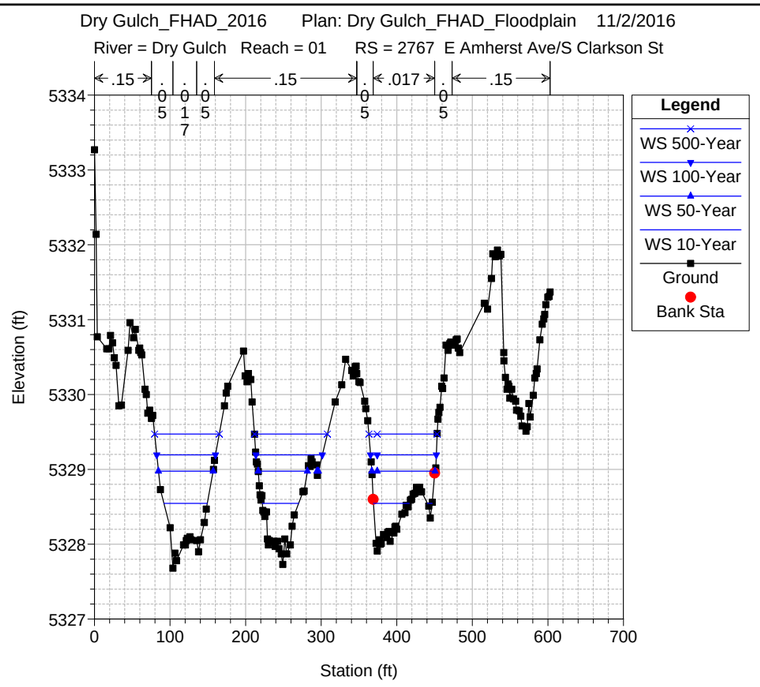

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 3525 E Bates St
.017
.15
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

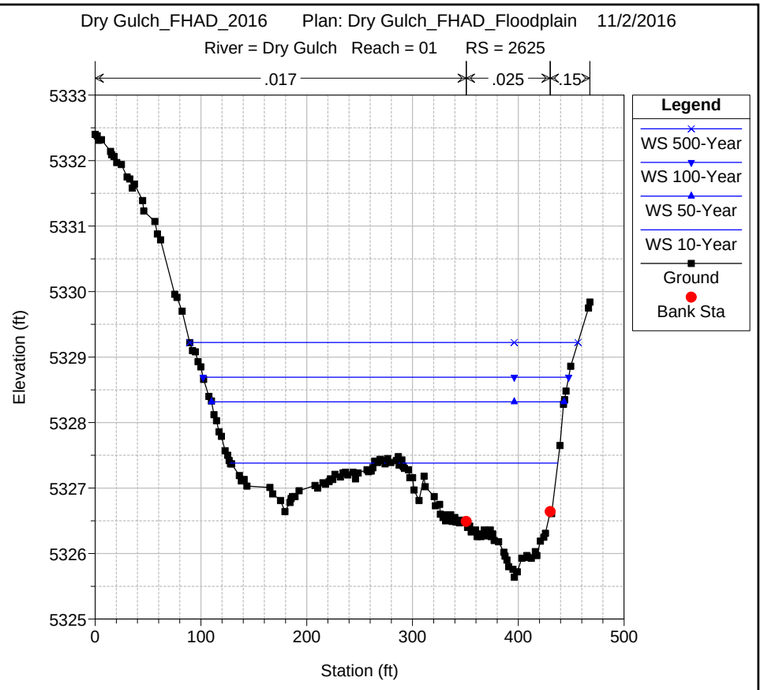

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 3289
.15
.017
.05
.035
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

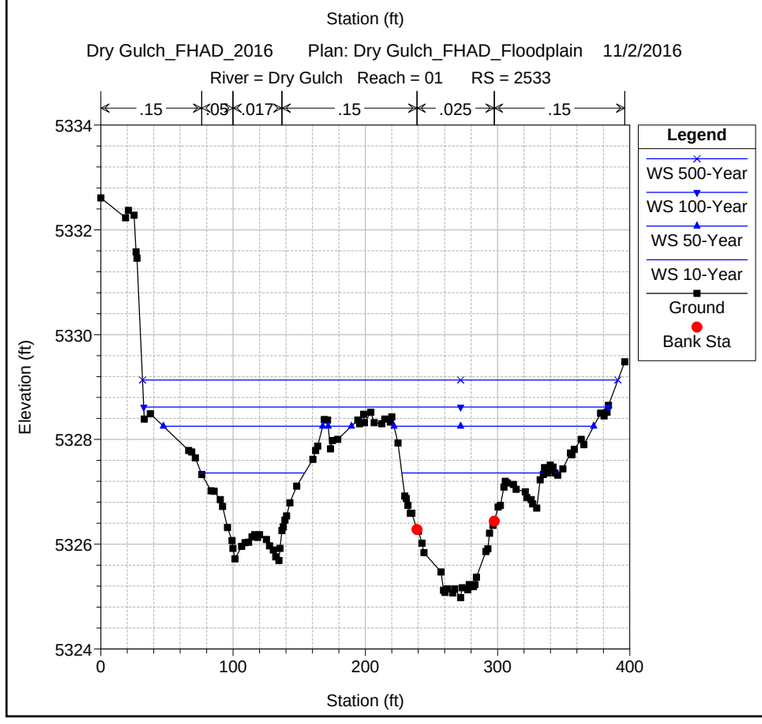

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 3087
.15
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

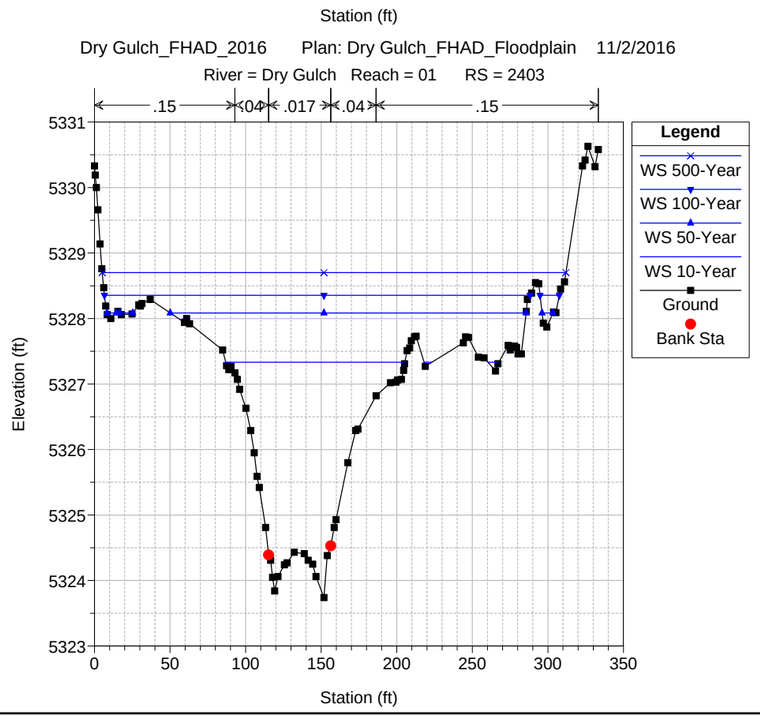

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2954
.15
.15
.03
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

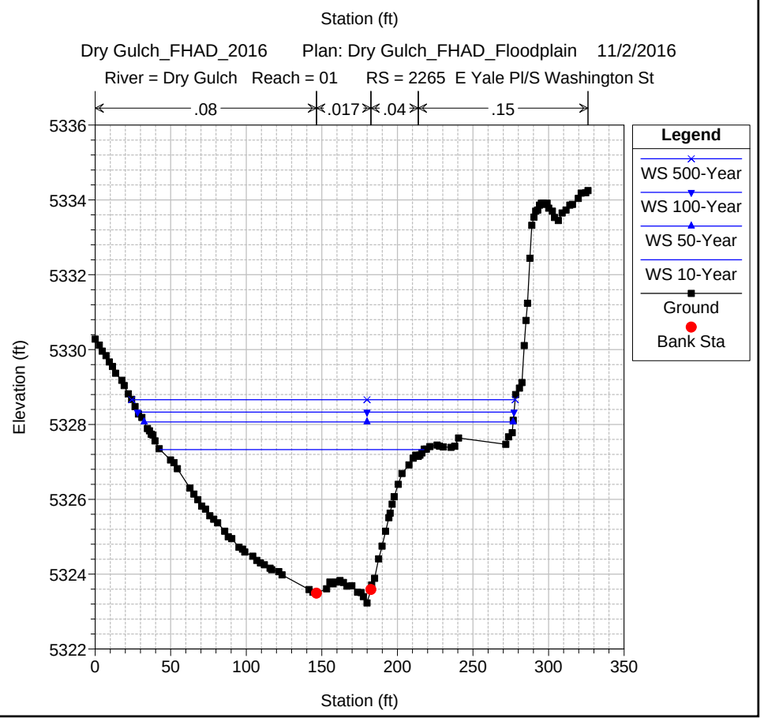

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2852
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

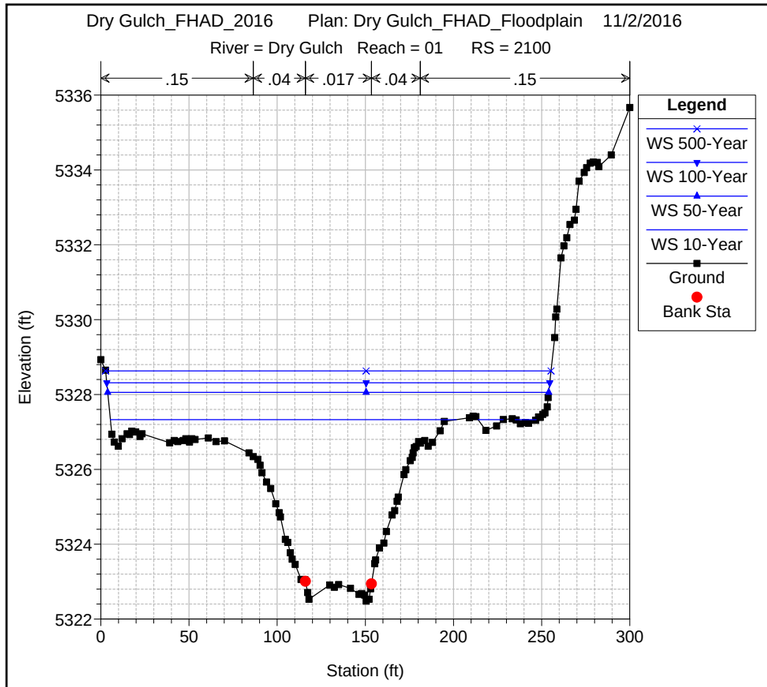

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2767 E Amherst Ave/S Clarkson St
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

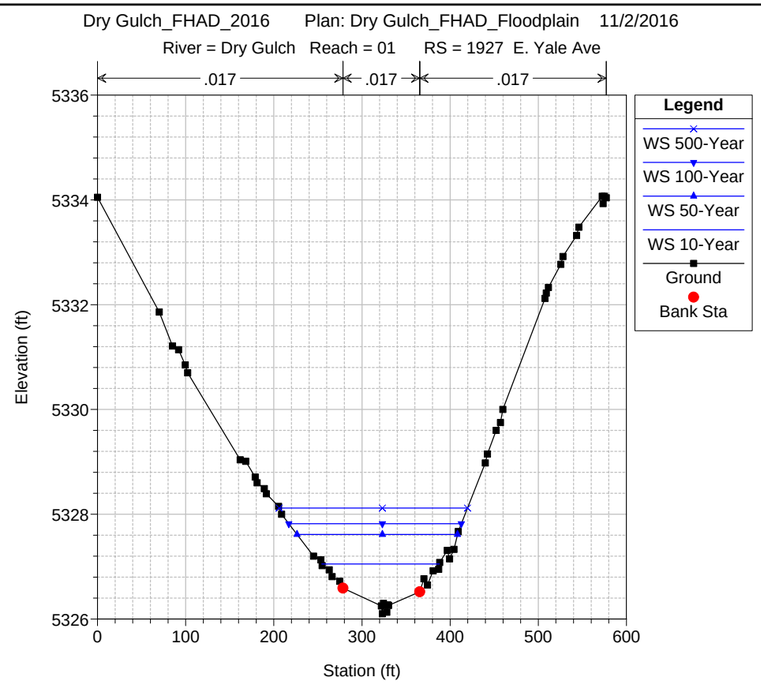

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2625
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

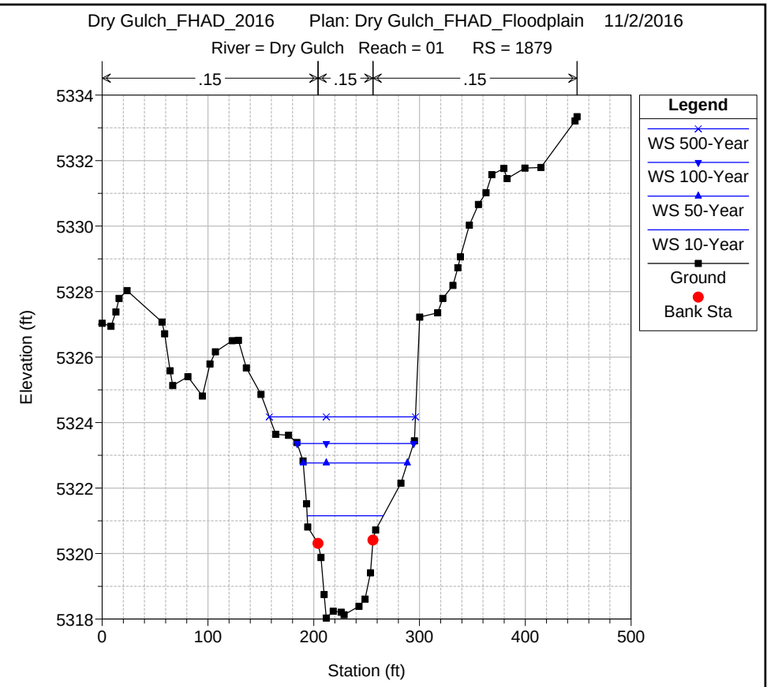

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2533
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

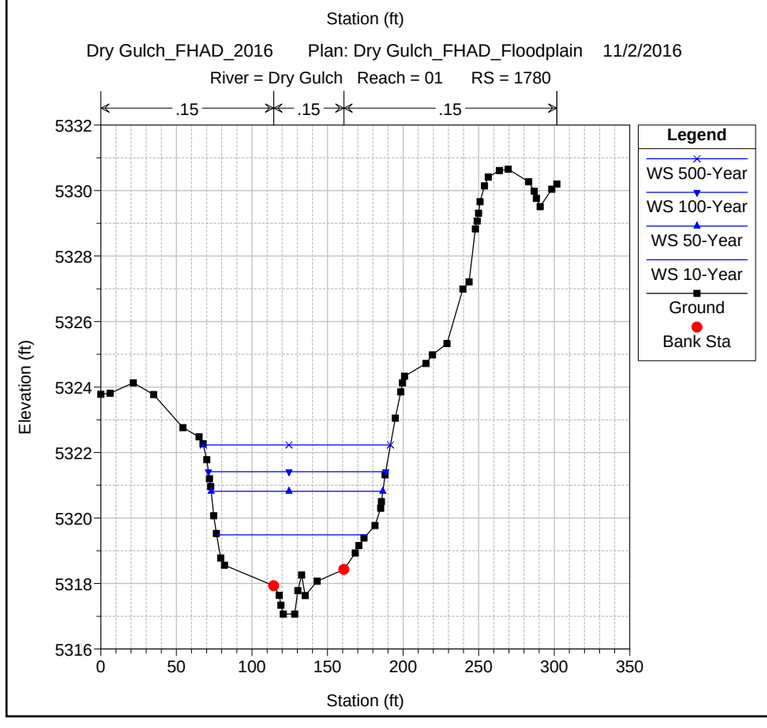

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2403
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

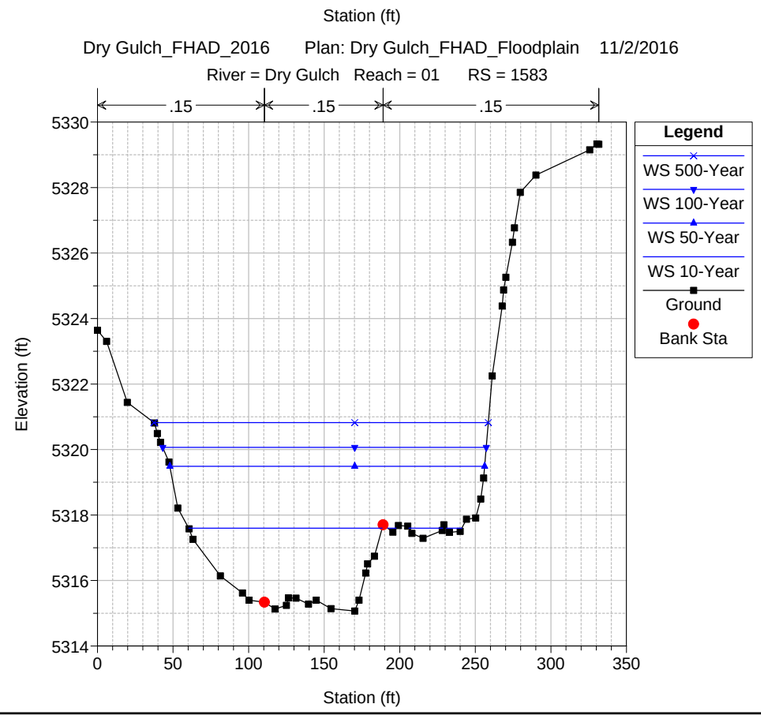

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2265 E Yale Pl/S Washington St
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta

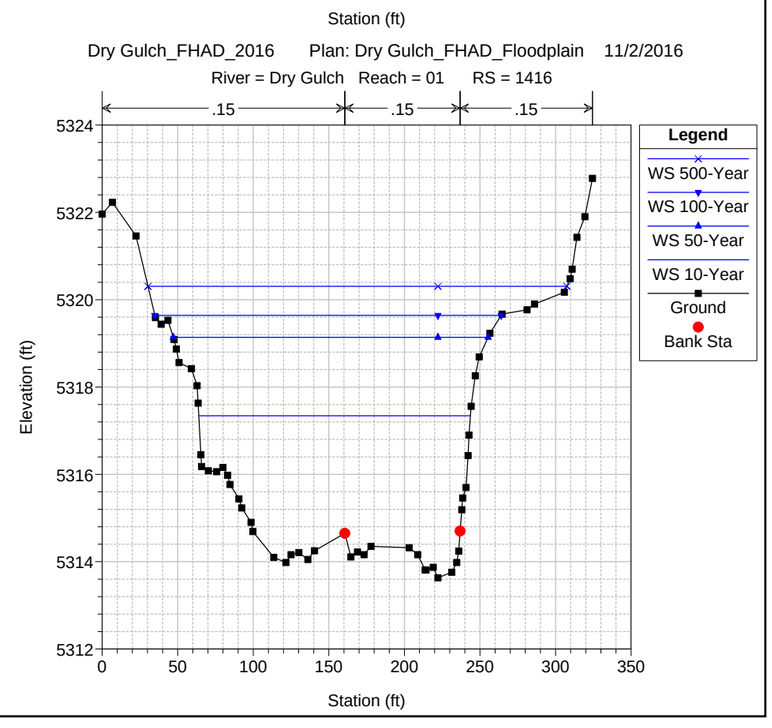

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 2100
.15
.04
.017
.04
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

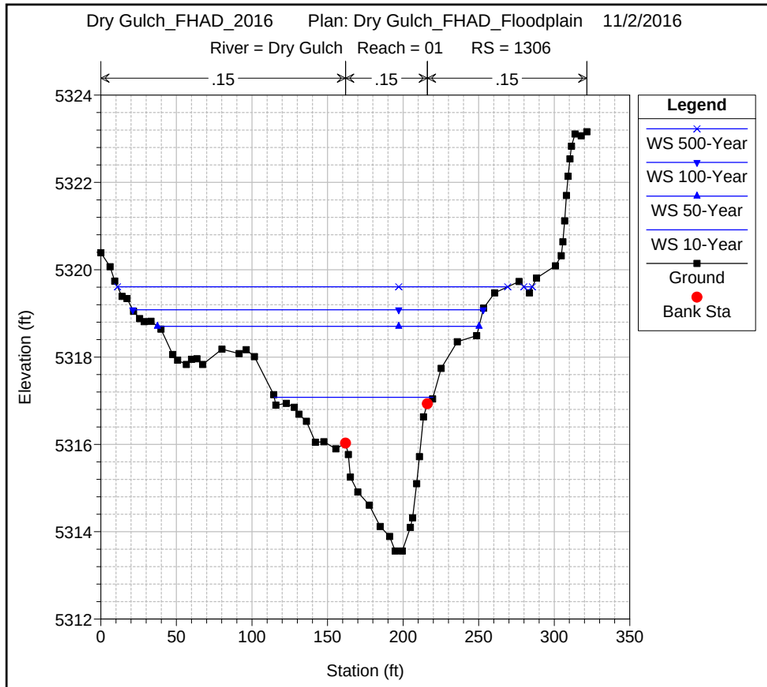

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1927 E. Yale Ave
.017
.017
.017
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

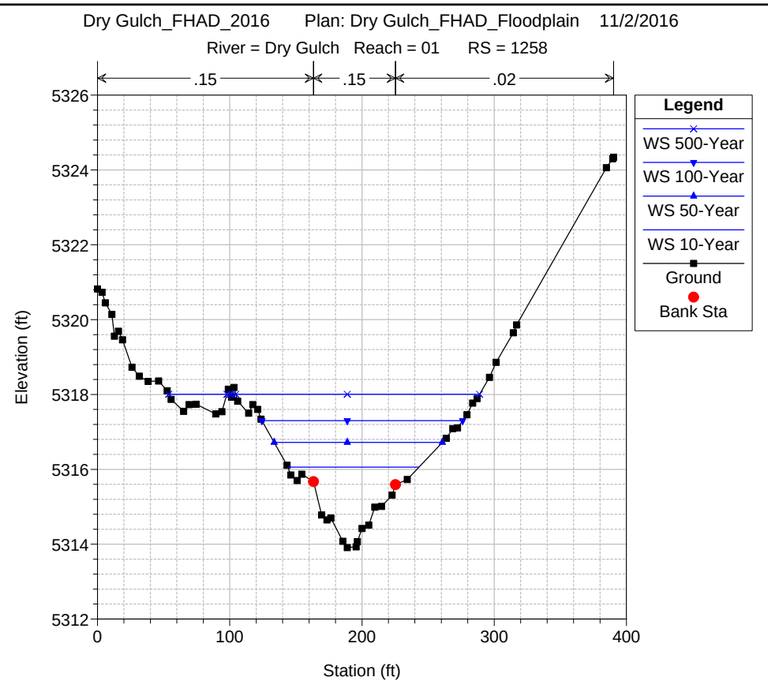

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1879
.15
.15
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

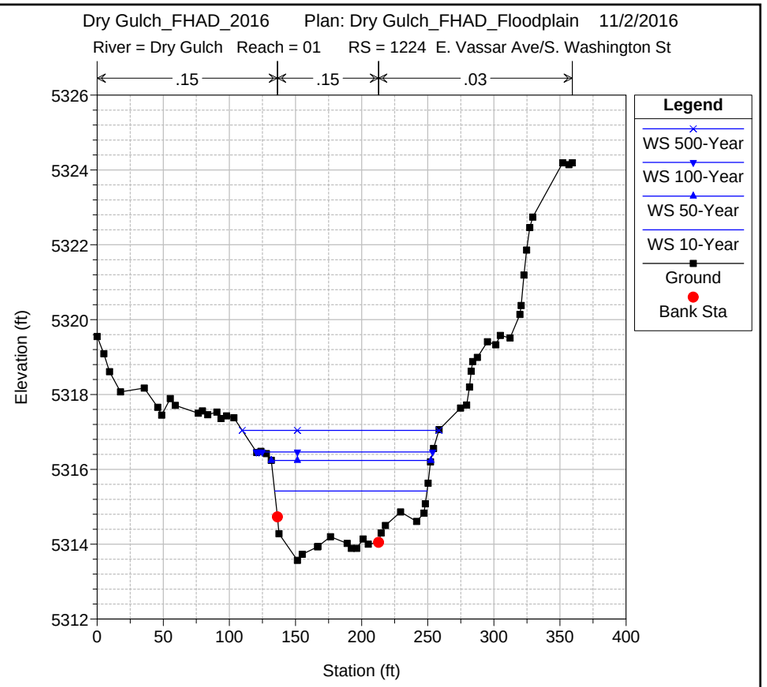

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1780
.15
.15
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

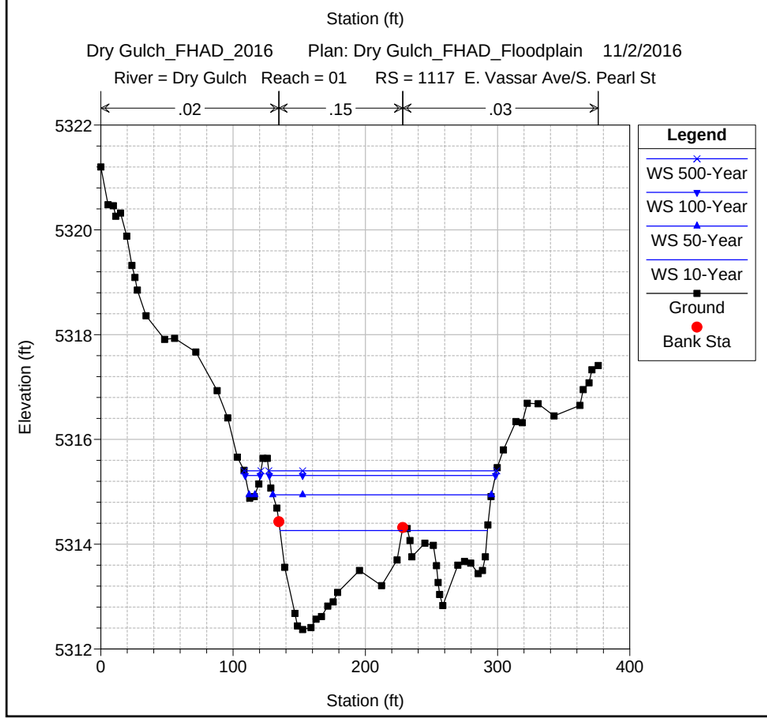

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1583
.15
.15
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

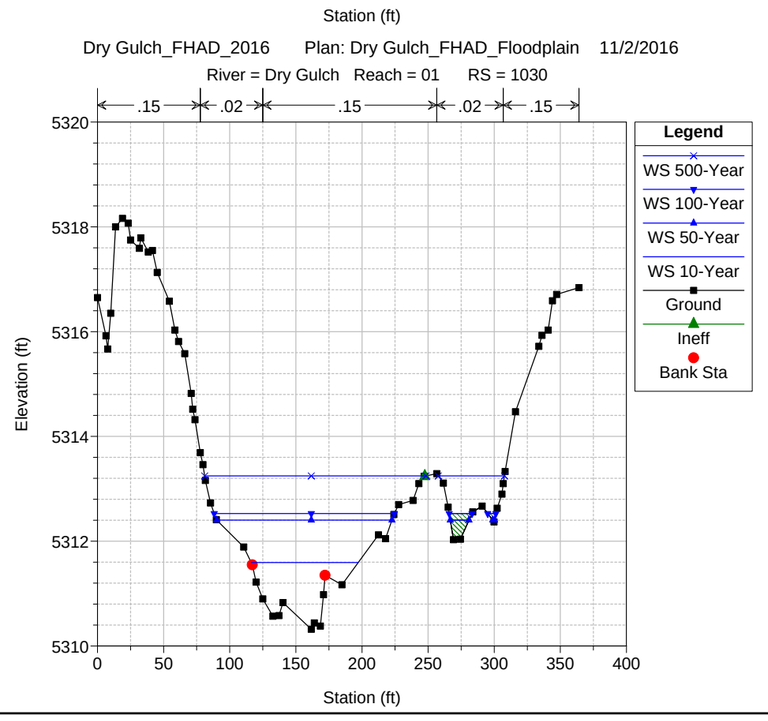

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1416
.15
.15
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

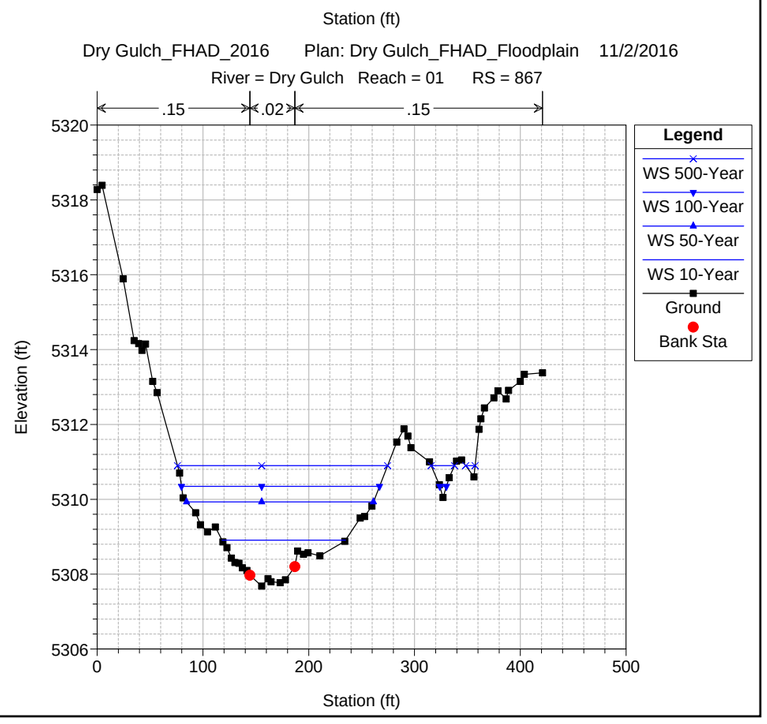

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1306
.15
.15
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

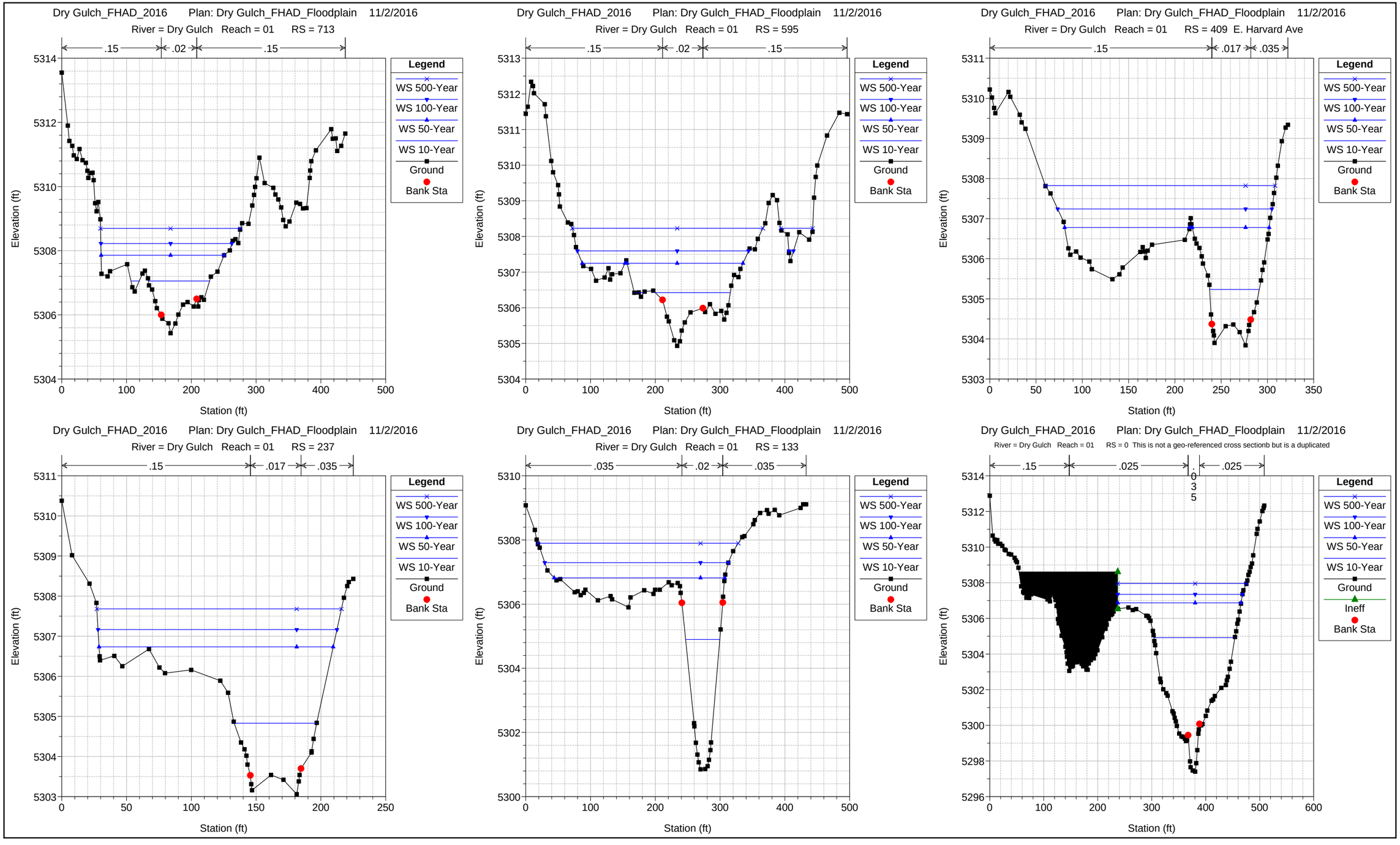

Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1258
.15
.15
.02
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1224 E. Vassar Ave/S. Washington St
.15
.15
.03
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1117 E. Vassar Ave/S. Pearl St
.02
.15
.03
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 1030
.15
.02
.15
.02
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 867
.15
.02
.15
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 713
.15
.02
.15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 595
.15
.02
.15
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 409 E. Harvard Ave
.15
.017
.035
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 237
.15
.017
.035
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 133
.035
.02
.035
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Bank Sta
Dry Gulch_FHAD_2016 Plan: Dry Gulch_FHAD_Floodplain 11/2/2016
River = Dry Gulch Reach = 01 RS = 0 This is not a geo-referenced cross sectionb but is a duplicated
.15
.025
.025
Elevation (ft)
Station (ft)
Legend
WS 500-Year
WS 100-Year
WS 50-Year
WS 10-Year
Ground
Ineff
Bank Sta

Appendix D – Floodplain and Floodway Data Table

Agreement Table

TABLE D-1 FLOODPLAIN AND FLOODWAY DATA TABLE
Harvard Gulch

REFERENCE LOCATION	RIVER STATION	CROSS SECTION	THALWEG ELEVATION (FT)	PEAK DISCHARGES				WATER SURFACE ELEVATION				100-YEAR FLOODPLAIN		100-YEAR FLOODWAY (0.5' EGL)				COMMENTS
				10-YR FLOW (CFS)	50-YR FLOW (CFS)	100-YR FLOW (CFS)	500-YR FLOW (CFS)	10-YR W.S. ELEV (FT)	50-YR W.S. ELEV (FT)	100-YR W.S. ELEV (FT)	500-YR W.S. ELEV (FT)	WIDTH (FT)	E.G. ELEV (FT)	W.S. ELEV (FT)	WIDTH (FT)	AREA (SQ FT)	VELOCITY (FT/S)	
Harvard Gulch: South Platte River to S. Colorado Blvd.																		
S. Logan St	41+17	4117	5294.4	1,995	3,905	4,894	6,385	5303.7	5305.9	5306.4	5306.9	413	5306.9	5306.4	280	875	5.6	Downstream study limit of channel floodplain at Harvard Gulch Park
	46+13	4613	5296.4	1,995	3,905	4,894	6,385	5304.8	5306.7	5307.1	5307.6	298	5307.6	5307.2	174	892	5.5	Harvard Gulch Park
	47+15	4715	5297.4	1,995	3,905	4,894	6,385	5304.9	5306.9	5307.4	5308.0	235	5307.7	5307.4	235	1041	4.7	Floodway coincident with floodplain, top width doesn't include Dry Gulch
	48+22	4822	5298.5	1,995	3,905	4,894	6,385	5304.9	5306.9	5307.3	5307.9	187	5307.9	5307.4	187	814	6.0	Floodway coincident with floodplain, top width doesn't include Dry Gulch
	49+72	4972	5299.5	1,995	3,905	4,894	6,385	5305.2	5307.0	5307.5	5308.1	177	5308.3	5307.5	177	710	6.9	Floodway coincident with floodplain, top width doesn't include Dry Gulch
	51+22	5122	5299.7	1,995	3,905	4,894	6,385	5305.8	5307.4	5307.9	5308.5	175	5308.6	5307.9	175	714	6.9	Floodway coincident with floodplain, top width doesn't include Dry Gulch
	52+21	5221	5300.1	1,995	3,905	4,894	6,385	5305.9	5307.4	5307.9	5308.7	178	5309.0	5307.9	178	584	8.4	Floodway coincident with floodplain, top width doesn't include Dry Gulch
	53+85	5385	5300.7	1,216	1,380	1,451	1,633	5306.6	5308.5	5309.3	5310.2	54	5309.8	5309.3	54	297	4.9	Floodway coincident with floodplain
Baffled Conc. Chute	54+10	5410	Inl Struct															
	54+13	5413	5311.2	1,216	1,380	1,451	1,633	5317.4	5317.9	5318.1	5318.7	68	5319.0	5318.1	68	323	7.6	Floodway coincident with floodplain, top width includes ineffective flow area
	54+53	5453	5311.5	1,216	1,380	1,451	1,633	5318.1	5318.7	5318.9	5319.6	72	5319.3	5318.9	72	309	4.7	Floodway coincident with floodplain
	57+16	5716	5311.4	1,216	1,380	1,451	1,633	5318.5	5319.0	5319.3	5319.9	73	5319.6	5319.3	72	321	4.5	Floodway coincident with floodplain
	60+27	6027	5311.4	1,216	1,380	1,451	1,633	5318.9	5319.4	5319.6	5320.2	84	5319.9	5319.6	84	362	4.0	Floodway coincident with floodplain
Lateral Weir	60+60	6060	Lat Struct															
	62+34	6234	5311.6	1,393	1,780	1,823	1,920	5319.0	5319.5	5319.7	5320.2	77	5320.2	5319.7	77	315	5.8	Floodway coincident with floodplain
	63+07	6307	5311.6	1,393	1,780	1,823	1,920	5318.8	5318.9	5319.1	5319.6	31	5321.2	5319.1	31	201	11.6	Floodway coincident with floodplain, top width includes ineffective flow area
Ogden St/Downing St	67+10	6710	Culvert															
	71+14	7114	5314.7	1,393	1,780	1,823	1,920	5324.7	5328.1	5328.4	5328.7	39	5329.2	5328.9	39	318	6.8	Floodplain/floodway top width include ineffective flow area, FP=FW
	71+59	7159	5316.4	1,393	1,780	1,823	2,150	5324.7	5328.5	5328.8	5329.0	59	5329.3	5329.3	59	381	4.8	Split flow at right bank, floodplain = floodway
	72+27	7227	5316.6	1,393	1,780	2,060	2,150	5324.8	5328.5	5328.7	5329.0	82	5329.3	5329.2	83	407	5.1	Split flow at right bank, floodplain = floodway
Alley	72+40	7240	Bridge															
	72+58	7258	5316.7	1,393	1,170	1,570	2,150	5326.8	5328.8	5329.1	5329.6	139	5329.4	5329.6	91	498	3.2	Split flow at right bank
	72+89	7289	5316.9	1,457	2,873	3,559	4,747	5326.9	5328.7	5329.0	5329.5	907	5329.7	5329.5	549	1907	1.9	Floodplain top width include high ground
	73+62	7362	5317.2	1,346	2,663	3,300	4,463	5327.0	5329.1	5329.4	5330.0	953	5329.8	5329.7	340	1396	2.4	Floodplain top width include high ground and ineffective flow area
	73+85	7385	5317.4	1,346	2,663	3,300	4,463	5327.4	5329.3	5329.7	5330.4	1040	5329.9	5330.0	305	1597	2.1	Floodplain top width include ineffective flow area
S. Marion St	74+10	7410	Bridge															
	74+35	7435	5317.6	1,346	2,663	3,300	4,463	5327.4	5329.3	5329.7	5330.4	951	5330.1	5330.0	301	1437	2.3	Floodplain top width include high ground and ineffective flow area
	74+64	7464	5317.7	1,346	2,663	3,300	4,463	5327.4	5329.4	5329.9	5330.7	832	5330.2	5330.2	300	1343	2.5	
	75+31	7531	5318.0	1,346	2,663	3,300	4,463	5327.6	5329.6	5330.1	5330.9	855	5330.2	5330.4	300	1445	2.3	
	75+56	7556	5318.1	1,346	2,663	3,300	4,463	5327.6	5329.5	5330.0	5330.7	884	5330.4	5330.2	300	1552	2.1	
Alley	75+70	7570	Bridge															
	75+88	7588	5318.2	1,346	2,663	3,300	4,463	5329.2	5329.8	5330.3	5331.1	913	5330.6	5330.6	300	1711	1.9	Floodplain top width includes ineffective flow area
	76+13	7613	5318.3	1,346	2,663	3,300	4,463	5329.2	5329.7	5330.2	5331.0	869	5330.7	5330.5	300	1192	2.8	
	76+87	7687	5318.8	1,346	2,663	3,300	4,463	5329.2	5330.0	5330.6	5331.5	906	5330.8	5331.0	300	1071	3.1	
	77+13	7713	5318.9	1,346	2,663	3,300	4,463	5329.2	5329.9	5330.5	5331.5	1189	5330.9	5330.9	309	1443	2.3	Floodplain top width include high ground and ineffective flow area
S. Lafayette St	77+40	7740	Bridge															
	77+68	7768	5319.1	1,346	2,663	3,300	4,463	5329.3	5330.1	5330.7	5331.6	921	5331.3	5331.1	310	1207	2.7	
	77+92	7792	5319.2	1,346	2,663	3,300	4,463	5329.3	5330.4	5331.1	5332.1	920	5331.4	5331.5	312	1150	2.9	Block obstruction was used at ROB to remove unrealistic flow area.
	78+62	7862	5319.5	1,346	2,663	3,300	4,463	5329.3	5330.3	5331.0	5331.9	910	5331.6	5331.3	320	1143	2.9	Floodplain top width includes high ground
	78+88	7888	5319.6	1,346	2,663	3,300	4,463	5329.4	5330.5	5331.1	5332.0	918	5331.6	5331.4	322	1280	2.6	Floodplain top width includes high ground
Alley	79+00	7900	Bridge															
	79+18	7918	5319.5	1,346	2,663	3,300	4,463	5329.4	5330.8	5331.5	5332.4	919	5331.9	5331.9	320	1423	2.3	
	79+43	7943	5319.7	1,346	2,663	3,300	4,463	5329.4	5330.7	5331.4	5332.4	906	5332.1	5331.8	310	1146	2.9	Floodplain top width includes high ground
	80+15	8015	5320.1	1,346	2,663	3,300	4,463	5329.4	5330.7	5331.4	5332.4	855	5332.3	5331.9	229	895	3.7	Floodplain top width includes high ground
	80+40	8040	5320.3	1,346	2,663	3,300	4,463	5329.5	5331.2	5331.9	5332.9	884	5332.4	5332.1	209	984	3.4	Floodplain top width includes high ground
S. Humboldt St	80+70	8070	Bridge															
	80+94	8094	5320.9	1,346	2,663	3,300	4,463	5330.3	5331.6	5332.3	5333.3	852	5332.8	5332.4	197	908	3.6	Floodplain top width include high ground
	81+21	8121	5321.3	1,346	2,663	3,300	4,463	5330.2	5331.5	5332.2	5333.2	805	5333.4	5332.3	197	694	4.8	Floodplain top width includes high ground and shallow flow from u/s
	83+41	8341	5325.4	1,346	2,663	3,300	4,463	5331.9	5335.1	5336.1	5337.1	766	5337.9	5336.1	275	408	8.1	Floodplain/floodway top width include high ground and floodplain top width includes shallow flow from u/s

TABLE D-1 FLOODPLAIN AND FLOODWAY DATA TABLE
Harvard Gulch

REFERENCE LOCATION	RIVER STATION	CROSS SECTION	THALWEG ELEVATION (FT)	PEAK DISCHARGES				WATER SURFACE ELEVATION				100-YEAR FLOODPLAIN		100-YEAR FLOODWAY (0.5' EGL)				COMMENTS
				10-YR FLOW (CFS)	50-YR FLOW (CFS)	100-YR FLOW (CFS)	500-YR FLOW (CFS)	10-YR W.S. ELEV (FT)	50-YR W.S. ELEV (FT)	100-YR W.S. ELEV (FT)	500-YR W.S. ELEV (FT)	WIDTH (FT)	E.G. ELEV (FT)	W.S. ELEV (FT)	WIDTH (FT)	AREA (SQ FT)	VELOCITY (FT/S)	
Harvard Gulch: South Platte River to S. Colorado Blvd.																		
	83+73	8373	5325.5	1,346	2,663	3,300	4,463	5332.1	5337.1	5337.8	5338.9	856	5338.3	5337.8	279	1031	3.2	Floodplain top width include ineffective flow areas, and high ground
S. Franklin St	84+00	8400	Bridge															
	84+26	8426	5325.9	1,346	2,663	3,300	4,463	5333.7	5337.8	5337.9	5339.3	822	5338.7	5338.2	261	845	3.9	Floodplain top width include ineffective flow areas, and high ground
	84+57	8457	5326.0	1,346	2,663	3,300	4,463	5333.8	5337.8	5337.9	5339.2	779	5338.9	5338.1	249	652	5.1	Floodplain top width include ineffective flow areas, and high ground
	86+52	8652	5326.9	1,302	2,567	3,190	4,337	5334.0	5337.8	5337.9	5339.1	706	5339.7	5338.1	215	541	5.9	Floodplain top width includes high ground and overland flooding from u/s
	87+00	8700	5327.2	1,302	2,567	3,190	4,337	5333.9	5337.8	5338.1	5340.4	748	5339.8	5338.4	228	653	4.9	Floodplain top width includes high ground and overland flooding from u/s
S. Gilpin St	87+30	8730	Bridge															
	87+58	8758	5327.4	1,302	2,567	3,190	4,337	5334.7	5340.3	5340.4	5341.6	817	5340.8	5340.5	230	1107	2.9	Floodplain top width includes high ground and ineffective flow areas
	88+02	8802	5327.7	1,302	2,567	3,190	4,337	5334.7	5340.2	5340.4	5341.6	808	5340.9	5340.5	230	978	3.3	Floodplain top width includes high ground and ineffective flow areas
	89+75	8975	5328.4	1,302	2,567	3,190	4,337	5335.0	5340.3	5340.4	5341.6	360	5341.3	5340.5	269	670	4.8	Floodplain and floodway top width include high ground
	90+28	9028	5328.7	1,302	2,567	3,190	4,337	5335.4	5340.2	5340.3	5341.5	307	5342.0	5340.5	285	576	5.5	Floodplain/floodplain top width include and high ground
S. Williams St	90+50	9050	Bridge															
	90+88	9088	5329.1	1,302	2,567	3,190	4,337	5336.3	5340.2	5343.4	5343.5	877	5344.1	5343.9	340	1425	2.2	Floodplain top width includes high ground and ineffective flow areas
	91+28	9128	5329.4	1,302	2,567	3,190	4,337	5336.3	5340.1	5343.3	5343.5	945	5344.2	5343.8	310	975	3.3	Floodplain/floodplain top width include high ground and ineffective flow area
	92+02	9202	5329.8	1,302	2,567	3,190	4,337	5336.4	5340.5	5344.0	5344.8	705	5344.3	5344.2	250	1098	2.9	Floodplain top width includes high ground
Alley	92+25	9225	Bridge															
	92+45	9245	5329.9	1,302	2,567	3,190	4,337	5337.0	5343.6	5344.0	5344.9	695	5344.6	5344.2	216	1065	3.0	
	92+74	9274	5330.1	1,302	2,567	3,190	4,337	5337.0	5343.6	5344.0	5344.9	689	5344.6	5344.2	200	895	3.6	
	93+60	9360	5330.8	1,302	2,567	3,190	4,337	5337.0	5343.6	5344.0	5344.9	647	5344.7	5344.3	190	916	3.5	
S. High St	93+90	9390	Bridge															
	94+16	9416	5331.0	1,302	2,567	3,190	4,337	5340.2	5343.8	5344.3	5345.3	590	5344.7	5344.7	190	983	3.2	
	94+53	9453	5331.2	1,302	2,567	3,190	4,337	5340.2	5343.7	5344.2	5345.2	488	5344.7	5344.7	190	930	3.4	
	96+04	9604	5331.9	1,302	2,567	3,190	4,337	5340.3	5343.7	5344.2	5345.2	371	5345.3	5344.6	210	673	4.7	
	96+85	9685	5332.4	1,302	2,567	3,190	4,337	5340.3	5343.7	5344.2	5345.1	306	5345.5	5344.6	209	610	5.2	
S. Race St	97+20	9720	Bridge															
	97+49	9749	5332.3	1,302	2,567	3,190	4,337	5341.9	5344.3	5344.7	5345.8	381	5345.5	5345.2	223	735	4.3	Floodplain top width includes high ground.
	98+39	9839	5337.6	1,302	2,567	3,190	4,337	5341.7	5344.3	5344.8	5346.2	390	5345.5	5345.2	170	614	5.2	
	101+03	10103	5339.5	1,302	2,567	3,190	4,337	5343.4	5344.6	5345.2	5346.8	487	5345.9	5345.3	146	458	7.0	Floodplain top width includes high ground and ineffective flow areas
	103+19	10319	5339.9	1,302	2,567	3,190	4,337	5344.9	5345.5	5345.9	5346.8	223	5347.0	5346.3	185	404	7.9	Floodplain/floodplain top width include high ground.
	103+96	10396	5340.0	1,302	2,567	3,190	4,337	5345.6	5346.5	5346.8	5347.4	401	5347.6	5347.1	228	494	6.5	Floodplain top width include high ground, ineffective flow area and shallow flow from u/s
Pedestrian Bridge	104+05	10405	Bridge															
	104+09	10409	5340.0	1,302	2,567	3,190	4,337	5346.5	5347.3	5347.7	5348.3	430	5348.0	5347.9	231	645	5.0	Floodplain top width includes high ground and ineffective flow areas
	104+25	10425	5340.4	1,302	2,567	3,190	4,337	5346.6	5347.4	5347.8	5348.3	448	5348.0	5348.1	229	692	4.6	Floodplain top width includes high ground and ineffective flow areas
	105+48	10548	5341.6	1,302	2,567	3,190	4,337	5346.7	5347.5	5347.8	5348.4	383	5348.5	5348.3	190	641	5.0	
	106+71	10671	5342.4	1,302	2,567	3,190	4,337	5347.1	5348.2	5348.5	5349.0	484	5348.9	5348.9	263	855	3.7	Floodplain top width includes high ground.
	108+91	10891	5343.4	1,302	2,567	3,190	4,337	5348.2	5348.8	5349.1	5349.7	575	5349.6	5349.2	353	554	5.8	Cross section skew 43°.
	109+26	10926	5344.0	1,302	2,567	3,190	4,337	5348.2	5349.4	5349.6	5350.0	624	5349.8	5349.6	323	555	5.8	Cross section skew 43°.
S. York St	109+65	10965	Culvert															
	110+02	11002	5344.1	1,302	2,567	3,190	4,337	5348.6	5349.2	5349.8	5350.5	646	5352.1	5349.8	92	279	11.9	Cross section skew 43°. Floodplain/floodway top width include ineffective flow areas and high ground. Floodway mapping could not include high ground.
	110+45	11045	5344.4	1,302	2,567	3,190	4,337	5348.6	5350.0	5350.5	5351.5	644	5352.5	5350.6	80	305	10.5	Floodplain top width includes ineffective flow areas and high ground.
	111+39	11139	5344.7	1,302	2,567	3,190	4,337	5349.7	5351.2	5351.8	5353.3	547	5353.8	5351.9	78	301	10.6	Floodplain top width includes ineffective flow areas and high ground.
	111+41	11141	5345.5	1,302	2,567	3,190	4,337	5349.9	5351.4	5352.0	5353.4	549	5354.0	5352.1	79	301	10.6	Floodplain top width includes ineffective flow areas and high ground.
	112+28	11228	5346.9	1,302	2,567	3,190	4,337	5351.3	5353.0	5353.8	5354.8	138	5354.6	5353.8	137	469	6.8	
	113+25	11325	5347.6	1,302	2,567	3,190	4,337	5352.0	5353.9	5354.6	5355.6	571	5355.0	5354.6	182	733	4.4	Floodplain top width includes ineffective flow areas.
S. University Blvd	113+85	11385	Culvert															
	114+40	11440	5346.5	1,302	2,567	3,190	4,337	5352.5	5354.5	5355.1	5355.5	663	5355.5	5355.6	190	827	3.9	Floodplain top width includes ineffective flow areas and high ground.
	114+93	11493	5347.2	1,302	2,567	3,190	4,337	5352.5	5354.4	5355.1	5355.4	278	5356.0	5355.5	145	483	6.6	
	116+76	11676	5348.8	1,216	2,405	3,016	4,006	5354.2	5355.5	5356.1	5356.8	260	5357.3	5356.3	106	380	7.9	Floodplain top width includes high ground. Blocked obstruction was used at ROB to remove unrealistic flow area.
	117+70	11770	5349.9	1,216	2,405	3,016	4,006	5354.7	5356.3	5356.9	5358.0	280	5357.8	5357.1	180	480	6.3	Floodplain top width includes high ground.

TABLE D-1 FLOODPLAIN AND FLOODWAY DATA TABLE
Harvard Gulch

REFERENCE LOCATION	RIVER STATION	CROSS SECTION	THALWEG ELEVATION (FT)	PEAK DISCHARGES				WATER SURFACE ELEVATION				100-YEAR FLOODPLAIN		100-YEAR FLOODWAY (0.5' EGL)				COMMENTS
				10-YR FLOW (CFS)	50-YR FLOW (CFS)	100-YR FLOW (CFS)	500-YR FLOW (CFS)	10-YR W.S. ELEV (FT)	50-YR W.S. ELEV (FT)	100-YR W.S. ELEV (FT)	500-YR W.S. ELEV (FT)	WIDTH (FT)	E.G. ELEV (FT)	W.S. ELEV (FT)	WIDTH (FT)	AREA (SQ FT)	VELOCITY (FT/S)	
Harvard Gulch: South Platte River to S. Colorado Blvd.																		
S. Josephine St	118+15	11815	Bridge															
	118+54	11854	5349.8	1,216	2,405	3,016	4,006	5355.9	5358.1	5358.6	5359.1	307	5359.0	5359.0	201	781	3.9	Floodplain top width includes high ground.
	119+06	11906	5349.8	1,216	2,405	3,016	4,006	5356.0	5358.1	5358.6	5359.2	308	5359.1	5359.1	149	636	4.7	Floodplain top width includes high ground. Blocked obstruction was used at LOB to remove unrealistic flow area.
	121+11	12111	5349.8	1,216	2,405	3,016	4,006	5356.2	5358.2	5358.6	5359.1	209	5359.9	5359.1	70	377	8.0	Floodplain top width includes high ground and ineffective flow areas
	121+87	12187	5349.8	1,216	2,405	3,016	4,006	5356.8	5358.8	5359.5	5360.5	228	5360.3	5359.7	81	480	6.3	Floodplain top width includes ineffective flow areas and high ground.
S. Columbine St	122+20	12220	Bridge															
	122+48	12248	5350.4	1,216	2,405	3,016	4,006	5357.5	5360.2	5360.5	5360.6	336	5361.0	5360.9	163	753	4.5	Floodplain/floodway top width include ineffective flow areas.
	122+76	12276	5350.6	1,216	2,405	3,016	4,006	5357.5	5360.2	5360.5	5360.6	194	5361.1	5360.9	109	578	5.2	Floodplain top width includes ineffective flow areas.
	124+49	12449	5352.7	1,216	2,405	3,016	4,006	5357.7	5360.4	5360.8	5361.6	242	5361.5	5361.1	91	404	7.5	Floodplain top width includes ineffective flow areas.
	126+34	12634	5354.8	1,216	2,405	3,016	4,006	5359.3	5360.9	5361.2	5361.8	105	5362.2	5361.6	76	370	8.2	
	129+44	12944	5359.3	1,006	1,927	2,388	3,144	5362.1	5362.9	5363.2	5364.2	237	5364.2	5363.3	94	261	9.2	Floodplain top width includes shallow flooding from u/s.
	131+72	13172	5360.2	1,006	1,927	2,388	3,144	5364.7	5366.1	5366.3	5366.7	282	5367.1	5366.4	160	325	7.4	Floodplain top width includes high ground.
	132+32	13232	5360.4	1,006	1,927	2,388	3,144	5366.1	5366.7	5367.1	5367.4	316	5367.8	5367.1	200	392	6.1	Floodplain top width includes ineffective flow areas.
Pedestrian Bridge	132+40	13240	Bridge															
	132+52	13252	5360.5	1,006	1,927	2,388	3,144	5367.1	5368.0	5368.3	5368.8	454	5368.5	5368.8	209	729	3.3	Floodplain top width includes ineffective flow areas.
	133+32	13332	5361.2	1,006	1,927	2,388	3,144	5367.1	5368.0	5368.4	5368.9	321	5368.6	5368.8	170	656	3.6	
	136+25	13625	5363.5	1,006	1,927	2,388	3,144	5368.7	5370.0	5370.4	5370.7	190	5371.3	5370.6	117	298	8.0	
	139+98	13998	5366.2	1,006	1,927	2,388	3,144	5371.3	5372.1	5372.4	5372.8	345	5372.7	5372.7	139	434	5.5	
	142+31	14231	5368.2	957	1,817	2,242	2,954	5372.0	5373.0	5373.5	5374.0	98	5374.8	5373.5	61	212	10.6	
	145+44	14544	5370.7	957	1,817	2,242	2,954	5375.0	5376.0	5376.4	5377.1	319	5377.1	5376.8	136	411	5.5	
	145+58	14558	5370.6	957	1,817	2,242	2,954	5375.4	5376.2	5376.5	5377.1	320	5377.1	5376.8	128	418	5.4	Floodplain top width includes high ground.
Alley	145+70	14570	Bridge															
	145+95	14595	5370.0	957	1,817	2,242	2,954	5376.0	5376.4	5378.1	5378.8	405	5378.4	5378.3	120	517	4.3	
	146+47	14647	5370.6	957	1,817	2,242	2,954	5376.1	5376.7	5378.1	5378.8	212	5378.5	5378.4	73	362	6.2	Floodplain top width includes ineffective flow areas and high ground.
	146+99	14699	5371.0	957	1,817	2,242	2,954	5376.3	5377.3	5378.3	5379.0	362	5378.6	5378.8	129	558	4.0	Floodplain top width includes ineffective flow areas.
S. Adams St	147+70	14770	Culvert															
	148+34	14834	5371.5	957	1,817	2,242	2,954	5377.1	5378.5	5379.1	5379.6	322	5379.3	5379.6	154	659	3.4	Floodplain top width includes high ground.
	149+03	14903	5372.0	957	1,817	2,242	2,954	5377.2	5378.6	5379.2	5379.7	371	5379.3	5379.6	138	608	3.7	
	150+27	15027	5372.9	957	1,817	2,242	2,954	5377.3	5378.6	5379.2	5379.8	257	5379.5	5379.7	153	553	4.1	
	151+03	15103	5373.4	957	1,817	2,242	2,954	5377.5	5378.7	5379.3	5379.8	251	5379.8	5379.7	184	484	4.6	
S. Cook St	151+35	15135	Bridge															
	151+65	15165	5372.9	957	1,817	2,242	2,954	5379.2	5380.4	5380.9	5381.4	265	5381.0	5381.3	200	755	3.0	
	152+12	15212	5373.1	957	1,817	2,242	2,954	5379.2	5380.3	5380.7	5381.2	259	5381.3	5381.2	77	398	5.6	Floodplain top width includes ineffective flow areas and high ground.
	152+60	15260	5373.1	887	1,677	2,068	2,716	5379.2	5380.4	5380.9	5381.4	255	5381.4	5381.3	72	371	5.6	Floodplain top width includes ineffective flow areas and high ground.
	152+81	15281	5375.4	887	1,677	2,068	2,716	5379.1	5380.3	5380.8	5381.3	253	5381.6	5381.2	69	285	7.3	Floodplain top width includes ineffective flow areas and high ground.
	153+52	15352	5374.6	887	1,677	2,068	2,716	5379.6	5380.6	5381.1	5381.9	220	5382.9	5381.1	50	188	11.0	Floodplain top width includes high ground and overland flooding from u/s.
	154+32	15432	5373.6	887	1,677	2,068	2,716	5380.7	5382.2	5382.8	5384.0	297	5383.9	5382.8	63	283	8.0	Floodplain top width includes ineffective flow areas, high ground and overland flooding from u/s, floodway top width includes ineffective flow areas.
S. Madison St	154+65	15465	Bridge															
	154+95	15495	5374.0	887	1,677	2,068	2,716	5381.2	5383.6	5384.0	5384.1	342	5384.5	5384.2	177	472	5.0	Floodplain top width includes ineffective flow areas and high ground, floodway top width includes ineffective flow areas.
	155+58	15558	5375.8	887	1,677	2,068	2,716	5381.3	5383.7	5384.1	5384.4	113	5384.7	5384.2	62	320	6.5	
	157+08	15708	5376.3	887	1,677	2,068	2,716	5382.0	5384.0	5384.4	5384.8	120	5385.1	5384.7	76	334	6.2	Floodplain top width includes high ground.
	157+68	15768	5377.2	887	1,677	2,068	2,716	5382.3	5384.1	5384.6	5385.0	100	5385.3	5384.8	76	317	6.5	
S. Monroe St	158+00	15800	Bridge															
	158+36	15836	5377.3	887	1,677	2,068	2,716	5382.9	5385.6	5386.2	5386.7	339	5386.6	5386.7	97	469	4.4	Floodplain top width includes ineffective flow areas and high ground.
	158+89	15889	5377.7	887	1,677	2,068	2,716	5383.0	5385.7	5386.3	5387.0	300	5386.7	5386.7	73	427	4.8	Floodplain top width includes high ground.
	159+98	15998	5377.9	866	1,627	2,003	2,619	5383.2	5385.8	5386.4	5387.0	93	5386.9	5386.7	61	318	6.3	Floodplain top width includes high ground.
	160+06	16006	5379.0	866	1,627	2,003	2,619	5383.3	5385.7	5386.3	5387.0	91	5387.0	5386.7	61	317	6.3	
	161+53	16153	5379.9	866	1,627	2,003	2,619	5385.0	5386.1	5386.7	5387.4	199	5387.6	5386.8	52	226	8.9	Floodplain top width includes high ground.
	164+25	16425	5383.4	866	1,627	2,003	2,619	5387.3	5388.6	5389.4	5390.2	96	5390.8	5389.6	94	239	8.4	Floodplain top width includes high ground.

TABLE D-1 FLOODPLAIN AND FLOODWAY DATA TABLE
Harvard Gulch

REFERENCE LOCATION	RIVER STATION	CROSS SECTION	THALWEG ELEVATION (FT)	PEAK DISCHARGES				WATER SURFACE ELEVATION				100-YEAR FLOODPLAIN		100-YEAR FLOODWAY (0.5' EGL)				COMMENTS
				10-YR FLOW (CFS)	50-YR FLOW (CFS)	100-YR FLOW (CFS)	500-YR FLOW (CFS)	10-YR W.S. ELEV (FT)	50-YR W.S. ELEV (FT)	100-YR W.S. ELEV (FT)	500-YR W.S. ELEV (FT)	WIDTH (FT)	E.G. ELEV (FT)	W.S. ELEV (FT)	WIDTH (FT)	AREA (SQ FT)	VELOCITY (FT/S)	
Harvard Gulch: South Platte River to S. Colorado Blvd.																		
	164+87	16487	5383.7	866	1,627	2,003	2,619	5388.1	5389.4	5390.2	5391.1	91	5391.5	5390.3	91	238	8.4	
S. Jackson St	165+20	16520	Bridge															
	165+52	16552	5384.2	866	1,627	2,003	2,619	5390.3	5392.2	5392.7	5393.4	167	5393.1	5393.2	94	498	4.0	
	165+79	16579	5384.4	866	1,627	2,003	2,619	5390.3	5392.2	5392.7	5393.4	137	5393.1	5393.2	90	462	4.3	
	167+36	16736	5385.1	866	1,627	2,003	2,619	5390.6	5391.9	5392.4	5392.9	68	5393.9	5392.9	54	231	8.7	
	167+90	16790	5385.3	866	1,627	2,003	2,619	5391.7	5393.0	5393.6	5394.3	68	5394.1	5393.8	45	311	6.4	
Harvard Gulch Split Flow: Harvard Gulch Park to S. Downing Street																		
	1+39	139	5307.6	241	1,493	2,108	3,114	5308.3	5309.3	5309.7	5310.2	182	5310.5	5309.7	182	296	7.1	Floodway coincident with floodplain. Model indicates reach length of 153' is between the most upstream cross section 5221 in Reach 1 and the first cross section 139 in Split Flow Reach 1 measured through the junction. However, 139' is based on station on the Split Flow Reach.
	2+00	200	5311.4	241	1,493	2,108	3,114	5312.3	5313.2	5313.6	5314.0	191	5314.4	5313.6	191	300	7.0	Floodway coincident with floodplain
	2+61	261	5314.6	241	1,493	2,108	3,114	5315.5	5316.6	5317.0	5317.5	194	5317.8	5317.0	194	307	6.9	Floodway coincident with floodplain
	3+25	325	5316.4	241	1,493	2,108	3,114	5317.1	5318.0	5318.3	5318.8	187	5319.1	5318.4	187	297	7.1	Floodway coincident with floodplain
	4+11	411	5310.1	241	1,493	2,108	3,114	5317.3	5318.8	5319.3	5320.1	526	5319.4	5319.3	526	3217	1.8	Floodway coincident with floodplain, top width includes ineffective flow areas.
	6+37	637	5311.0	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.2	477	5319.4	5319.4	477	2148	1.1	Floodway coincident with floodplain, top width includes ineffective flow areas.
	7+34	734	5311.0	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.2	364	5319.4	5319.4	364	1454	1.5	Floodway coincident with floodplain
	7+61	761	5312.1	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.1	341	5319.4	5319.4	341	1143	1.8	Floodway coincident with floodplain
	7+85	785	5312.2	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.2	322	5319.5	5319.4	322	1111	1.9	Floodway coincident with floodplain
	8+71	871	5312.5	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.2	331	5319.5	5319.4	331	1088	1.9	Floodway coincident with floodplain
	8+87	887	5312.4	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.2	332	5319.5	5319.4	332	1071	2.0	Floodway coincident with floodplain
	9+28	928	5312.9	241	1,493	2,108	3,114	5317.3	5318.9	5319.4	5320.2	339	5319.5	5319.4	339	942	2.2	Floodway coincident with floodplain
	11+36	1136	5314.4	64	1,093	1,736	2,827	5317.4	5318.9	5319.4	5320.2	234	5319.7	5319.4	234	409	4.2	Floodway coincident with floodplain
	12+21	1221	5315.6	64	1,093	1,736	2,827	5317.3	5321.9	5322.8	5323.8	195	5323.7	5322.9	195	343	5.1	Floodway coincident with floodplain, top width includes high ground.
S. Ogden St	12+55	1255	Culvert															
	12+85	1285	5314.9	64	1,093	1,736	2,827	5317.5	5324.1	5324.3	5324.5	326	5325.0	5324.7	213	452	3.8	
	13+51	1351	5318.7	64	1,093	1,736	2,827	5319.6	5323.7	5324.8	5326.7	452	5326.7	5324.8	241	369	4.7	Floodplain top width includes high ground.
	14+26	1426	5319.4	64	1,093	1,736	2,827	5320.1	5325.0	5326.7	5328.3	701	5326.9	5326.7	410	2207	0.8	
	15+04	1504	5319.9	64	1,093	1,736	2,827	5321.0	5324.9	5326.7	5328.4	643	5326.9	5326.7	480	1812	1.0	
	15+94	1594	5321.6	64	1,093	1,736	2,827	5322.0	5325.1	5326.8	5328.4	750	5327.0	5326.8	560	2307	0.8	
	16+79	1679	5320.8	64	1,093	1,736	2,827	5322.3	5324.9	5326.7	5328.3	605	5327.0	5326.7	595	1807	1.0	
	17+55	1755	5321.7	64	1,093	1,736	2,827	5322.3	5325.4	5326.9	5328.5	791	5327.1	5326.9	550	1864	0.9	
	18+38	1838	5324.2	64	1,093	1,736	2,827	5324.8	5326.4	5326.9	5328.4	451	5327.7	5327.0	349	326	5.3	Floodway and floodplain top widths include high ground.
	19+23	1923	5325.9	64	1,093	1,736	2,827	5326.4	5327.2	5327.7	5328.8	612	5327.9	5327.8	374	402	4.3	
	19+66	1966	5326.8	64	1,093	1,736	2,827	5327.0	5327.8	5328.1	5328.7	756	5328.5	5328.5	412	346	5.0	Floodplain top width includes high ground.
	20+16	2016	5325.8	64	1,093	1,736	2,597	5327.3	5328.9	5329.2	5329.6	842	5329.2	5329.7	515	1007	1.7	
	20+89	2089	5325.1	64	1,093	1,499	2,597	5327.3	5329.0	5329.4	5329.8	869	5329.4	5329.9	533	1972	0.8	
	21+22	2122	5324.9	64	1,703	1,989	2,597	5327.3	5329.0	5329.4	5329.9	899	5329.4	5329.9	501	1917	1.0	Floodplain top width includes high ground.

TABLE D-2 FLOODPLAIN AND FLOODWAY DATA TABLE
Dry Gulch

REFERENCE LOCATION	RIVER STATION	CROSS SECTION	THALWEG ELEVATION (FT)	PEAK DISCHARGES				WATER SURFACE ELEVATION				100-YEAR FLOODPLAIN		100-YEAR FLOODWAY (0.5' EGL)				COMMENTS
				10-YR FLOW (CFS)	50-YR FLOW (CFS)	100-YR FLOW (CFS)	500-YR FLOW (CFS)	10-YR W.S. ELEV (FT)	50-YR W.S. ELEV (FT)	100-YR W.S. ELEV (FT)	500-YR W.S. ELEV (FT)	WIDTH (FT)	E.G. ELEV (FT)	W.S. ELEV (FT)	WIDTH (FT)	AREA (SQ FT)	VELOCITY (FT/S)	
Dry Gulch: E. Harvard Avenue to E. Yale Avenue (City and County of Denver)																		
E. Harvard Avenue	1+33	133	5300.9	264	792	1,070	1,520	5304.9	5306.8	5307.3	5307.9	285	5307.5	5307.3	221	431	2.5	
	2+37	237	5303.1	264	792	1,070	1,520	5304.8	5306.7	5307.2	5307.7	186	5307.7	5307.2	132	301	3.6	
	4+09	409	5303.8	264	792	1,070	1,520	5305.2	5306.8	5307.2	5307.8	238	5307.9	5307.2	201	329	3.3	
	5+95	595	5304.9	264	792	1,070	1,520	5306.4	5307.3	5307.6	5308.2	357	5308.4	5307.7	121	192	5.6	Floodplain top width includes high ground and flooding from u/s.
	7+13	713	5305.4	264	792	1,070	1,520	5307.1	5307.9	5308.2	5308.7	314	5309.1	5308.3	55	124	8.6	Floodplain top width includes high ground and flooding from u/s.
	8+67	867	5307.7	264	792	1,070	1,520	5308.9	5309.9	5310.4	5310.9	275	5311.4	5310.5	52	132	8.1	Floodplain top width includes high ground and flooding from u/s.
	10+30	1030	5310.3	264	792	1,070	1,520	5311.6	5312.4	5312.5	5313.3	213	5313.7	5313.0	58	131	8.2	Floodplain top width includes high ground and ineffective flow areas.
	11+17	1117	5312.4	264	792	1,070	1,520	5314.3	5314.9	5315.3	5315.4	188	5315.8	5315.8	151	326	3.3	Floodplain/floodway top width includes high ground.
	12+24	1224	5313.6	264	792	1,070	1,520	5315.4	5316.2	5316.5	5317.0	133	5317.2	5317.0	98	283	3.8	
	12+58	1258	5313.9	264	792	1,070	1,520	5316.1	5316.7	5317.3	5318.0	151	5318.3	5317.8	67	200	5.4	
	13+06	1306	5313.6	264	792	1,070	1,520	5317.1	5318.7	5319.1	5319.6	230	5319.2	5319.6	110	435	2.5	
	14+16	1416	5313.6	264	792	1,070	1,520	5317.3	5319.1	5319.6	5320.3	223	5319.7	5320.1	139	765	1.4	
	15+83	1583	5315.1	264	792	1,070	1,520	5317.6	5319.5	5320.1	5320.8	214	5320.1	5320.6	159	704	1.5	
	17+80	1780	5317.1	264	792	1,070	1,520	5319.5	5320.8	5321.4	5322.2	118	5321.6	5321.8	71	268	4.0	
	18+79	1879	5318.0	264	792	1,070	1,520	5321.2	5322.8	5323.4	5324.2	110	5323.5	5323.9	69	327	3.3	
E. Yale Avenue	19+27	1927	5326.1	264	792	1,070	1,520	5327.1	5327.6	5327.8	5328.1	195	5328.3	5328.0	93	148	7.2	
Dry Gulch: E. Yale Avenue to S. University Blvd (City of Englewood)																		
	21+00	2100	5322.5	222	711	970	1,393	5327.3	5328.1	5328.3	5328.6	251	5328.5	5328.8	85	428	2.3	
	22+65	2265	5323.2	222	711	970	1,393	5327.3	5328.1	5328.3	5328.7	250	5328.5	5328.8	87	406	2.4	
	24+03	2403	5323.7	222	711	970	1,393	5327.3	5328.1	5328.4	5328.7	302	5328.6	5328.8	87	321	3.0	Floodplain top width includes high ground.
	25+33	2533	5325.0	222	711	970	1,393	5327.4	5328.3	5328.6	5329.1	350	5328.7	5328.8	158	294	3.3	
	26+25	2625	5325.6	222	711	970	1,393	5327.4	5328.3	5328.7	5329.2	347	5328.7	5329.2	231	563	1.7	
	27+67	2767	5327.9	222	711	970	1,393	5328.6	5329.0	5329.2	5329.5	370	5329.7	5329.6	324	240	4.0	Floodplain/floodway top width includes high ground.
	28+52	2852	5328.3	189	646	886	1,278	5329.2	5329.7	5329.9	5330.2	469	5330.4	5330.2	293	235	3.8	Floodplain/floodway top width includes high ground.
	29+54	2954	5328.6	189	646	886	1,278	5329.9	5330.5	5330.6	5330.9	517	5331.0	5330.8	330	232	3.8	Floodplain/floodway top width includes high ground.
	30+87	3087	5329.2	189	646	886	1,278	5330.6	5331.5	5331.9	5332.5	550	5332.7	5331.9	151	163	5.4	Floodplain/floodway top width includes high ground.
	32+89	3289	5330.3	189	646	886	1,278	5331.6	5332.6	5333.0	5333.4	322	5333.1	5333.2	172	277	3.2	Floodplain/floodway top width includes high ground.
	35+25	3525	5334.3	189	646	886	1,278	5336.6	5337.4	5337.7	5338.2	530	5338.3	5337.9	374	141	6.3	Floodplain/floodway top width includes obstructions (masonry wall).
	36+89	3689	5335.2	153	575	798	1,160	5337.1	5338.1	5338.5	5338.9	263	5338.5	5339.0	222	622	1.3	
	39+23	3923	5335.8	153	575	798	1,160	5337.1	5338.1	5338.5	5338.9	202	5338.8	5339.0	90	240	3.3	Floodplain top width includes high ground.
	40+86	4086	5336.4	153	575	798	1,160	5337.4	5338.3	5338.6	5339.0	93	5339.2	5339.1	91	184	4.3	
	42+15	4215	5342.8	153	575	798	1,160	5343.5	5344.0	5344.1	5344.4	208	5344.6	5344.3	99	127	6.3	
	42+47	4247	5343.0	153	575	798	1,160	5343.7	5344.3	5344.6	5345.0	362	5344.7	5344.9	123	207	3.9	
	44+12	4412	5341.1	157	545	747	1,075	5343.8	5344.5	5344.8	5345.1	318	5344.8	5345.3	236	757	1.0	
	47+12	4712	5343.1	157	545	747	1,075	5344.0	5344.7	5344.9	5345.2	242	5345.5	5345.4	204	373	2.0	Floodplain/floodway top width includes high ground.
	48+72	4872	5343.8	157	545	747	1,075	5344.8	5345.5	5345.9	5346.4	325	5346.1	5345.9	202	307	2.4	
	50+98	5098	5344.7	157	545	747	1,075	5346.1	5346.8	5347.1	5347.5	203	5347.7	5347.1	156	162	4.6	
E Dartmouth Ave/S Corona St	52+67	5267	5347.8	157	545	747	1,075	5348.6	5349.1	5349.3	5349.6	263	5349.9	5349.6	161	232	3.2	
	53+67	5367	5348.3	157	545	747	1,075	5349.4	5350.1	5350.3	5350.6	250	5350.6	5350.6	163	249	3.0	
	54+76	5476	5348.8	157	545	747	1,075	5349.9	5350.6	5350.8	5351.1	263	5351.2	5351.1	148	197	3.8	
E Dartmouth Ave/S Downing St	55+48	5548	5350.0	157	545	747	1,075	5350.8	5351.3	5351.5	5351.7	210	5351.9	5351.7	99	119	6.3	Floodplain top width includes high ground.
	57+34	5734	5351.2	157	545	747	1,075	5352.4	5353.2	5353.5	5354.1	76	5354.4	5353.6	74	118	6.3	
S Downing St	59+34	5934	5350.9	157	545	747	1,075	5353.2	5354.2	5354.6	5355.3	239	5354.7	5354.7	65	153	4.9	
	63+00	6300	5350.2	318	655	833	1,116	5353.9	5354.5	5355.1	5355.6	145	5355.9	5355.6	53	151	5.5	
	65+25	6525	5351.2	318	655	833	1,116	5354.6	5355.7	5356.4	5358.0	107	5358.1	5356.5	31	83	10.1	Floodplain top width includes overland flooding from u/s.

TABLE D-2 FLOODPLAIN AND FLOODWAY DATA TABLE
Dry Gulch

REFERENCE LOCATION	RIVER STATION	CROSS SECTION	THALWEG ELEVATION (FT)	PEAK DISCHARGES				WATER SURFACE ELEVATION				100-YEAR FLOODPLAIN		100-YEAR FLOODWAY (0.5' EGL)				COMMENTS
				10-YR FLOW (CFS)	50-YR FLOW (CFS)	100-YR FLOW (CFS)	500-YR FLOW (CFS)	10-YR W.S. ELEV (FT)	50-YR W.S. ELEV (FT)	100-YR W.S. ELEV (FT)	500-YR W.S. ELEV (FT)	WIDTH (FT)	E.G. ELEV (FT)	W.S. ELEV (FT)	WIDTH (FT)	AREA (SQ FT)	VELOCITY (FT/S)	
S Lafayette St	65+59	6559	5357.4	97	413	578	841	5358.0	5358.6	5358.7	5358.9	185	5359.1	5358.9	67	89	6.5	
	66+33	6633	5359.9	97	413	578	841	5361.1	5361.7	5361.8	5362.0	171	5362.2	5362.1	94	101	5.7	
	68+30	6830	5361.3	97	413	578	841	5362.9	5364.1	5364.4	5364.9	376	5364.4	5364.9	161	484	1.2	Floodplain top width includes high ground.
S Humboldt St	69+12	6912	5360.5	97	413	578	841	5362.9	5364.1	5364.4	5364.9	458	5364.4	5364.9	180	735	0.8	
	69+86	6986	5362.0	97	413	578	841	5362.9	5364.1	5364.4	5364.9	313	5364.5	5364.9	175	381	1.5	
	71+80	7180	5364.4	97	413	578	841	5366.1	5366.8	5367.1	5367.4	390	5367.2	5367.3	134	271	2.1	Floodplain top width includes high ground.
S Franklin St	72+53	7253	5364.0	97	413	578	841	5366.1	5366.9	5367.2	5367.5	347	5367.2	5367.3	139	398	1.5	
	73+25	7325	5365.1	115	356	481	682	5366.1	5366.9	5367.2	5367.5	262	5367.2	5367.3	143	231	2.1	Floodplain top width includes high ground.
	75+00	7500	5366.0	115	356	481	682	5367.0	5367.6	5367.8	5368.2	311	5367.9	5368.3	175	312	1.5	
E Eastman Ave/S Gilpin St	76+09	7609	5365.9	115	356	481	682	5367.1	5367.7	5367.9	5368.3	335	5368.0	5368.4	181	404	1.2	
	76+97	7697	5366.4	115	356	481	682	5367.3	5368.0	5368.2	5368.6	130	5368.9	5368.3	87	104	4.7	Floodplain top width includes high ground.
	78+70	7870	5369.3	115	356	481	682	5370.2	5370.8	5371.0	5371.4	188	5371.6	5371.0	125	93	5.2	Floodplain top width includes high ground.
E Eastman Ave/S Williams St	79+49	7949	5370.2	115	356	481	682	5371.0	5371.4	5371.6	5372.1	276	5371.9	5371.6	129	119	4.0	Floodplain top width includes ineffective flow areas.
	80+16	8016	5370.7	115	356	481	682	5371.9	5372.5	5372.8	5373.1	280	5373.4	5372.8	106	100	4.8	Floodplain top width includes high ground and ineffective flow areas.
	82+02	8202	5372.1	115	356	481	682	5373.3	5373.9	5374.2	5374.5	56	5374.9	5374.2	55	74	6.5	
E Eastman Ave/S High St	82+73	8273	5373.5	115	356	481	682	5374.1	5374.6	5374.8	5375.3	217	5375.3	5375.1	54	73	6.6	Floodplain top width includes ineffective flow areas, shallow flooding in LOB is not included in top width.
	83+44	8344	5373.7	115	356	481	682	5374.9	5375.6	5375.9	5376.3	115	5376.6	5375.9	51	77	6.3	Floodplain top width includes high ground.
	85+28	8528	5375.3	115	356	481	682	5376.6	5377.2	5377.5	5377.9	57	5378.3	5377.6	44	68	7.1	
E Eastman Ave/S Race St	85+90	8590	5375.6	115	356	481	682	5377.0	5377.7	5378.1	5378.7	110	5378.5	5378.2	76	106	4.5	
	86+99	8699	5376.4	115	356	481	682	5377.6	5378.3	5378.4	5378.8	196	5378.7	5378.5	67	100	4.8	Floodplain top width includes high ground and ineffective flow areas.
	88+35	8835	5378.2	115	356	481	682	5379.1	5379.8	5380.0	5380.4	68	5380.7	5380.1	45	67	7.2	
E Eastman Ave/S Vine St	89+22	8922	5379.2	115	356	481	682	5380.0	5380.5	5380.7	5381.3	184	5381.1	5380.9	52	71	6.8	Floodplain top width includes high ground.
	90+00	9000	5380.3	115	356	481	682	5381.1	5381.8	5382.1	5382.4	89	5382.7	5382.1	43	67	7.2	
	91+42	9142	5382.0	115	356	481	682	5382.9	5383.5	5383.8	5384.1	85	5384.4	5383.8	48	70	6.9	
E Eastman Ave/S Vine Ct	92+21	9221	5382.7	115	356	481	682	5383.7	5384.3	5384.5	5384.7	131	5384.9	5384.5	55	73	6.6	
	93+01	9301	5383.8	115	356	481	682	5384.8	5385.5	5385.7	5386.2	80	5386.4	5385.8	44	67	7.1	
	94+41	9441	5385.8	115	356	481	682	5386.6	5387.3	5387.5	5387.9	77	5388.2	5387.6	48	69	7.0	
	94+99	9499	5386.2	115	356	481	682	5387.0	5387.6	5387.9	5388.4	183	5388.4	5388.0	59	81	5.9	Floodplain top width includes ineffective flow areas.
	95+75	9575	5387.3	115	356	481	682	5388.1	5388.9	5389.2	5389.6	142	5389.9	5389.3	39	66	7.3	Floodplain top width includes high ground and ineffective flow areas.
	96+85	9685	5388.6	115	356	481	682	5389.4	5390.1	5390.3	5390.7	154	5390.9	5390.4	45	69	7.0	Floodplain top width includes high ground and ineffective flow areas.
E Eastman Ave/S York St	97+31	9731	5389.1	115	356	481	682	5390.0	5390.5	5390.7	5391.0	212	5391.3	5390.8	57	75	6.4	Floodplain top width includes ineffective flow areas.
	98+37	9837	5390.4	115	356	481	682	5391.6	5392.2	5392.5	5392.8	87	5393.1	5392.6	38	65	7.4	
E Eastman Ave/E Floyd Ave	99+05	9905	5391.5	115	356	481	682	5392.4	5392.8	5393.0	5393.4	141	5393.4	5393.4	74	104	4.6	
	99+52	9952	5391.9	115	356	481	682	5393.1	5393.6	5393.8	5394.1	163	5394.3	5394.0	58	77	6.3	
	100+11	10011	5392.2	115	356	481	682	5393.5	5394.0	5394.1	5394.4	122	5394.6	5394.6	64	103	4.7	
	100+72	10072	5392.6	115	356	481	682	5393.9	5394.5	5394.8	5395.2	79	5395.5	5394.9	51	71	6.7	
	101+13	10113	5392.8	115	356	481	682	5394.2	5394.8	5395.1	5395.5	90	5395.6	5395.1	52	74	6.5	
	101+80	10180	5393.7	115	356	481	682	5394.6	5395.4	5395.7	5396.2	331	5395.8	5395.9	99	181	2.7	
S University Blvd	102+15	10215	5394.5	115	356	481	682	5395.0	5395.4	5395.7	5396.2	220	5395.9	5395.9	101	121	4.0	

Table D-3 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver
Flooding Source: Harvard Gulch - 0.5' ΔEGL
Reach: S. Downing Street to S. Colorado Boulevard

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
Harvard Gulch: South Platte River to S. Colorado Blvd.																
S. Logan St	4117	41+17	4117	4117	4117	4,117	4,117	4,117	413	413	280	280	5306.4	5306.4	OK	**Downstream study limit of channel floodplain at Harvard Gulch Park**
	4613	46+13	497	497	497	4,613	4,613	4,613	297	298	174	174	5307.1	5307.1		Harvard Gulch Park
	4715	47+15	102	102	102	4,715	4,715	4,715	231	235	231	235	5307.4	5307.4		Floodway coincident with floodplain, top width doesn't include Dry Gulch
	4822	48+22	107	107	107	4,822	4,822	4,822	186	187	186	187	5307.3	5307.3		Floodway coincident with floodplain, top width doesn't include Dry Gulch
	4972	49+72	150	150	150	4,972	4,972	4,972	176	177	176	177	5307.5	5307.5		Floodway coincident with floodplain, top width doesn't include Dry Gulch
	5122	51+22	150	150	150	5,122	5,122	5,122	175	175	175	175	5307.9	5307.9		Floodway coincident with floodplain, top width doesn't include Dry Gulch
	5221	52+21	99	99	99	5,221	5,221	5,221	178	178	178	178	5307.9	5307.9	OK	Floodway coincident with floodplain, top width doesn't include Dry Gulch
	5385	53+85	164	164	164	5,385	5,385	5,385	55	54	55	54	5309.3	5309.3	OK	Floodway coincident with floodplain
Baffled Conc. Chute	5410	54+10														
	5413	54+13	28	28	28	5,413	5,413	5,413	68	68	68	68	5318.1	5318.1		Floodway coincident with floodplain, top width includes ineffective flow area
	5453	54+53	41	41	41	5,453	5,453	5,453	72	72	72	72	5318.9	5318.9	OK	Floodway coincident with floodplain
	5716	57+16	262	262	262	5,716	5,716	5,716	73	73	73	72	5319.3	5319.3		Floodway coincident with floodplain
	6027	60+27	312	312	312	6,027	6,027	6,027	84	84	84	84	5319.6	5319.6		Floodway coincident with floodplain
Lateral Weir	6060	60+60														
	6234	62+34	206	206	206	6,234	6,234	6,234	77	77	77	77	5319.7	5319.7		Floodway coincident with floodplain
	6307	63+07	73	73	73	6,307	6,307	6,307	30	31	30	31	5319.1	5319.1	OK	Floodway coincident with floodplain, top width includes ineffective flow area
Ogden St/Downing St	6710	67+10														
	7114	71+14	808	808	808	7,114	7,114	7,114	39	39	39	39	5328.4	5328.4		Floodplain/floodway top width include ineffective flow area, FP=FW
	7159	71+59	45	45	45	7,159	7,159	7,159	60	59	60	59	5328.8	5328.8		Split flow at right bank, floodplain = floodway
	7227	72+27	68	68	68	7,227	7,227	7,227	82	82	82	83	5328.7	5328.7	OK	Split flow at right bank, floodplain = floodway
Alley	7240	72+40														
	7258	72+58	31	31	31	7,258	7,258	7,258	139	139	93	91	5329.1	5329.1		Split flow at right bank
	7289	72+89	31	31	31	7,289	7,289	7,289	905	907	550	549	5329.0	5329.0		Floodplain top width include high ground
	7362	73+62	73	73	73	7,362	7,362	7,362	953	953	340	340	5329.4	5329.4		Floodplain top width include high ground and ineffective flow area
	7385	73+85	23	23	23	7,385	7,385	7,385	1040	1040	305	305	5329.7	5329.7		Floodplain top width include ineffective flow area
S. Marion St	7410	74+10														
	7435	74+35	50	50	50	7,435	7,435	7,435	951	951	300	301	5329.7	5329.7		Floodplain top width include high ground and ineffective flow area
	7464	74+64	28	28	28	7,464	7,464	7,464	833	832	300	300	5329.9	5329.9	OK	
	7531	75+31	68	68	68	7,531	7,531	7,531	858	855	300	300	5330.1	5330.1		
	7556	75+56	25	25	25	7,556	7,556	7,556	879	884	300	300	5330.0	5330.0		
Alley	7570	75+70														
	7588	75+88	32	32	32	7,588	7,588	7,588	912	913	300	300	5330.3	5330.3		Floodplain top width includes ineffective flow area
	7613	76+13	26	26	26	7,613	7,613	7,613	874	869	300	300	5330.2	5330.2		
	7687	76+87	73	73	73	7,687	7,687	7,687	906	906	305	300	5330.6	5330.6		
	7713	77+13	26	26	26	7,713	7,713	7,713	1189	1189	312	309	5330.5	5330.5		Floodplain top width include high ground and ineffective flow area
S. Lafayette St	7740	77+40														
	7768	77+68	55	55	55	7,768	7,768	7,768	921	921	310	310	5330.7	5330.7	OK	
	7792	77+92	23	23	23	7,792	7,792	7,792	917	920	310	312	5331.1	5331.1		Block obstruction was used at ROB to remove unrealistic flow area.
	7862	78+62	70	70	70	7,862	7,862	7,862	909	910	320	320	5331.0	5331.0		Floodplain top width includes high ground
	7888	78+88	26	26	26	7,888	7,888	7,888	916	918	320	322	5331.1	5331.1		Floodplain top width includes high ground
Alley	7900	79+00														

Table D-3 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver
Flooding Source: Harvard Gulch - 0.5' ΔEGL
Reach: S. Downing Street to S. Colorado Boulevard

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
Harvard Gulch: South Platte River to S. Colorado Blvd.																
	7918	79+18	30	30	30	7,918	7,918	7,918	918	919	325	320	5331.5	5331.5		
	7943	79+43	25	25	25	7,943	7,943	7,943	908	906	307	310	5331.4	5331.4		Floodplain top width includes high ground
	8015	80+15	73	73	73	8,015	8,015	8,015	855	855	227	229	5331.4	5331.4		Floodplain top width includes high ground
	8040	80+40	24	24	24	8,040	8,040	8,040	886	884	207	209	5331.9	5331.9	OK	Floodplain top width includes high ground
S. Humboldt St	8070	80+70														
	8094	80+94	55	55	55	8,094	8,094	8,094	851	852	197	197	5332.3	5332.3		Floodplain top width include high ground
	8121	81+21	26	26	26	8,121	8,121	8,121	648	805	197	197	5332.2	5332.2	OK	Floodplain top width includes high ground and shallow flow from u/s
	8341	83+41	220	220	220	8,341	8,341	8,341	279	766	275	275	5336.1	5336.1	OK	Floodplain/floodway top width include high ground and floodplain top width includes shallow flow from u/s
	8373	83+73	33	33	33	8,373	8,373	8,373	865	856	280	279	5337.8	5337.8		Floodplain top width include ineffective flow areas, and high ground
S. Franklin St	8400	84+00														
	8426	84+26	53	53	53	8,426	8,426	8,426	824	822	260	261	5337.9	5337.9		Floodplain top width include ineffective flow areas, and high ground
	8457	84+57	31	31	31	8,457	8,457	8,457	778	779	248	249	5337.9	5337.9		Floodplain top width include ineffective flow areas, and high ground
	8652	86+52	195	195	195	8,652	8,652	8,652	215	706	218	215	5337.9	5337.9	OK	Floodplain top width includes high ground and overland flooding from u/s
	8700	87+00	48	48	48	8,700	8,700	8,700	314	748	230	228	5338.1	5338.1	OK	Floodplain top width includes high ground and overland flooding from u/s
S. Gilpin St	8730	87+30														
	8758	87+58	58	58	58	8,758	8,758	8,758	817	817	230	230	5340.4	5340.4		Floodplain top width includes high ground and ineffective flow areas
	8802	88+02	45	45	45	8,802	8,802	8,802	806	808	230	230	5340.4	5340.4		Floodplain top width includes high ground and ineffective flow areas
	8975	89+75	173	173	173	8,975	8,975	8,975	360	360	270	269	5340.4	5340.4		Floodplain and floodway top width include high ground
	9028	90+28	53	53	53	9,028	9,028	9,028	306	307	285	285	5340.3	5340.3	OK	Floodplain/floodplain top width include and high ground
S. Williams St	9050	90+50														
	9088	90+88	60	60	60	9,088	9,088	9,088	877	877	340	340	5343.4	5343.4		Floodplain top width includes high ground and ineffective flow areas
	9128	91+28	40	40	40	9,128	9,128	9,128	945	945	310	310	5343.3	5343.3		Floodplain/floodplain top width include high ground and ineffective flow area
	9202	92+02	75	75	75	9,202	9,202	9,202	706	705	250	250	5344.0	5344.0	OK	Floodplain top width includes high ground
Alley	9225	92+25														
	9245	92+45	42	42	42	9,245	9,245	9,245	695	695	215	216	5344.0	5344.0		
	9274	92+74	29	29	29	9,274	9,274	9,274	683	689	200	200	5344.0	5344.0		
	9360	93+60	86	86	86	9,360	9,360	9,360	642	647	190	190	5344.0	5344.0		
S. High St	9390	93+90														
	9416	94+16	56	56	56	9,416	9,416	9,416	592	590	190	190	5344.3	5344.3		
	9453	94+53	38	38	38	9,453	9,453	9,453	487	488	190	190	5344.2	5344.2		
	9604	96+04	151	151	151	9,604	9,604	9,604	369	371	210	210	5344.2	5344.2		
	9685	96+85	81	81	81	9,685	9,685	9,685	306	306	209	209	5344.2	5344.2		
S. Race St	9720	97+20														
	9749	97+49	64	64	64	9,749	9,749	9,749	382	381	223	223	5344.7	5344.7		Floodplain top width includes high ground.
	9839	98+39	90	90	90	9,839	9,839	9,839	392	390	170	170	5344.8	5344.8	OK	
	10103	101+03	264	264	264	10,103	10,103	10,103	485	487	146	146	5345.2	5345.2		Floodplain top width includes high ground and ineffective flow areas
	10319	103+19	216	216	216	10,319	10,319	10,319	223	223	185	185	5345.9	5345.9		Floodplain/floodplain top width include high ground.
	10396	103+96	76	76	76	10,396	10,396	10,396	402	401	229	228	5346.8	5346.8	OK	Floodplain top width include high ground, ineffective flow area and shallow flow from u/s
Pedestrian Bridge	10405	104+05														
	10409	104+09	14	14	14	10,409	10,409	10,409	429	430	229	231	5347.7	5347.7		Floodplain top width includes high ground and ineffective flow areas
	10425	104+25	15	15	15	10,425	10,425	10,425	446	448	230	229	5347.8	5347.8		Floodplain top width includes high ground and ineffective flow areas

Table D-3 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver
Flooding Source: Harvard Gulch - 0.5' ΔEGL
Reach: S. Downing Street to S. Colorado Boulevard

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
Harvard Gulch: South Platte River to S. Colorado Blvd.																
	10548	105+48	124	124	124	10,548	10,548	10,548	380	383	190	190	5347.8	5347.8	OK	
	10671	106+71	122	122	122	10,671	10,671	10,671	484	484	263	263	5348.5	5348.5		Floodplain top width includes high ground.
	10891	108+91	221	221	221	10,891	10,891	10,891	419	575	258	353	5349.1	5349.1	OK	Cross section skew 43°.
	10926	109+26	34	34	34	10,926	10,926	10,926	456	624	237	323	5349.6	5349.6		Cross section skew 43°.
S. York St	10965	109+65														
	11002	110+02	76	76	76	11,002	11,002	11,002	473	646	170	92	5349.8	5349.8	OK	Cross section skew 43°. Floodplain/floodway top width include ineffective flow areas and high ground. Floodway mapping could not include high ground.
	11045	110+45	43	43	43	11,045	11,045	11,045	643	644	81	80	5350.5	5350.5	OK	Floodplain top width includes ineffective flow areas and high ground.
	11139	111+39	94	94	94	11,139	11,139	11,139	547	547	77	78	5351.8	5351.8		Floodplain top width includes ineffective flow areas and high ground.
	11141	111+41	2	2	2	11,141	11,141	11,141	556	549	80	79	5352.0	5352.0	OK	Floodplain top width includes ineffective flow areas and high ground.
	11228	112+28	87	87	87	11,228	11,228	11,228	139	138	138	137	5353.8	5353.8		
	11325	113+25	98	98	98	11,325	11,325	11,325	571	571	182	182	5354.6	5354.6	OK	Floodplain top width includes ineffective flow areas.
S. University Blvd	11385	113+85														
	11440	114+40	115	115	115	11,440	11,440	11,440	661	663	191	190	5355.1	5355.1		Floodplain top width includes ineffective flow areas and high ground.
	11493	114+93	53	53	53	11,493	11,493	11,493	277	278	146	145	5355.1	5355.1	OK	
	11676	116+76	182	182	182	11,676	11,676	11,676	259	260	106	106	5356.1	5356.1		Floodplain top width includes high ground. Blocked obstruction was used at ROB to remove unrealistic flow area.
	11770	117+70	95	95	95	11,770	11,770	11,770	277	280	185	180	5356.9	5356.9	OK	Floodplain top width includes high ground.
S. Josephine St	11815	118+15														
	11854	118+54	83	83	83	11,854	11,854	11,854	306	307	200	201	5358.6	5358.6		Floodplain top width includes high ground.
	11906	119+06	53	53	53	11,906	11,906	11,906	306	308	149	149	5358.6	5358.6		Floodplain top width includes high ground. Blocked obstruction was used at LOB to remove unrealistic flow area.
	12111	121+11	205	205	205	12,111	12,111	12,111	208	209	70	70	5358.6	5358.6	OK	Floodplain top width includes high ground and ineffective flow areas
	12187	121+87	75	75	75	12,187	12,187	12,187	223	228	82	81	5359.5	5359.5	OK	Floodplain top width includes ineffective flow areas and high ground.
S. Columbine St	12220	122+20														
	12248	122+48	61	61	61	12,248	12,248	12,248	336	336	163	163	5360.5	5360.5		Floodplain/floodway top width include ineffective flow areas.
	12276	122+76	29	29	29	12,276	12,276	12,276	194	194	109	109	5360.5	5360.5		Floodplain top width includes ineffective flow areas.
	12449	124+49	172	172	172	12,449	12,449	12,449	251	242	91	91	5360.8	5360.8	OK	Floodplain top width includes ineffective flow areas.
	12634	126+34	186	186	186	12,634	12,634	12,634	104	105	76	76	5361.2	5361.2	OK	
	12944	129+44	310	310	310	12,944	12,944	12,944	170	237	93	94	5363.2	5363.2	OK	Floodplain top width includes shallow flooding from u/s.
	13172	131+72	228	228	228	13,172	13,172	13,172	281	282	160	160	5366.3	5366.3	OK	Floodplain top width includes high ground.
	13232	132+32	59	59	59	13,232	13,232	13,232	316	316	199	200	5367.1	5367.1	OK	Floodplain top width includes ineffective flow areas.
Pedestrian Bridge	13240	132+40														
	13252	132+52	21	21	21	13,252	13,252	13,252	454	454	208	209	5368.3	5368.3		Floodplain top width includes ineffective flow areas.
	13332	133+32	79	79	79	13,332	13,332	13,332	322	321	170	170	5368.4	5368.4	OK	
	13625	136+25	294	294	294	13,625	13,625	13,625	189	190	118	117	5370.4	5370.4	OK	
	13998	139+98	373	373	373	13,998	13,998	13,998	345	345	138	139	5372.4	5372.4	OK	
	14231	142+31	232	232	232	14,231	14,231	14,231	98	98	60	61	5373.5	5373.5	OK	
	14544	145+44	313	313	313	14,544	14,544	14,544	319	319	136	136	5376.4	5376.4		
	14558	145+58	14	14	14	14,558	14,558	14,558	320	320	127	128	5376.5	5376.5	OK	Floodplain top width includes high ground.
Alley	14570	145+70														
	14595	145+95	37	37	37	14,595	14,595	14,595	403	405	120	120	5378.1	5378.1		
	14647	146+47	52	52	52	14,647	14,647	14,647	210	212	73	73	5378.1	5378.1		Floodplain top width includes ineffective flow areas and high ground.

Table D-3 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver
Flooding Source: Harvard Gulch - 0.5' ΔEGL
Reach: S. Downing Street to S. Colorado Boulevard

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
Harvard Gulch: South Platte River to S. Colorado Blvd.																
	14699	146+99	52	52	52	14,699	14,699	14,699	361	362	129	129	5378.3	5378.3	OK	Floodplain top width includes ineffective flow areas.
S. Adams St	14770	147+70														
	14834	148+34	135	135	135	14,834	14,834	14,834	320	322	155	154	5379.1	5379.1		Floodplain top width includes high ground.
	14903	149+03	69	69	69	14,903	14,903	14,903	370	371	140	138	5379.2	5379.2		
	15027	150+27	124	124	124	15,027	15,027	15,027	257	257	155	153	5379.2	5379.2		
	15103	151+03	76	76	76	15,103	15,103	15,103	248	251	185	184	5379.3	5379.3	OK	
S. Cook St	15135	151+35														
	15165	151+65	62	62	62	15,165	15,165	15,165	264	265	200	200	5380.9	5380.9		
	15212	152+12	47	47	47	15,212	15,212	15,212	259	259	77	77	5380.7	5380.7		Floodplain top width includes ineffective flow areas and high ground.
	15260	152+60	48	48	48	15,260	15,260	15,260	257	255	76	72	5380.9	5380.9		Floodplain top width includes ineffective flow areas and high ground.
	15281	152+81	21	21	21	15,281	15,281	15,281	252	253	69	69	5380.8	5380.8	OK	Floodplain top width includes ineffective flow areas and high ground.
	15352	153+52	71	71	71	15,352	15,352	15,352	51	220	51	50	5381.1	5381.1	OK	Floodplain top width includes high ground and overland flooding from u/s.
	15432	154+32	80	80	80	15,432	15,432	15,432	272	297	65	63	5382.8	5382.8	OK	Floodplain top width includes ineffective flow areas, high ground and overland flooding from u/s, floodway top width includes ineffective flow areas.
S. Madison St	15465	154+65														
	15495	154+95	63	63	63	15,495	15,495	15,495	343	342	177	177	5384.0	5384.0	OK	Floodplain top width includes ineffective flow areas and high ground, floodway top width includes ineffective flow areas.
	15558	155+58	63	63	63	15,558	15,558	15,558	113	113	61	62	5384.1	5384.1		
	15708	157+08	150	150	150	15,708	15,708	15,708	119	120	75	76	5384.4	5384.4		Floodplain top width includes high ground.
	15768	157+68	59	59	59	15,768	15,768	15,768	99	100	74	76	5384.6	5384.6	OK	
S. Monroe St	15800	158+00														
	15836	158+36	68	68	68	15,836	15,836	15,836	338	339	97	97	5386.2	5386.2		Floodplain top width includes ineffective flow areas and high ground.
	15889	158+89	53	53	53	15,889	15,889	15,889	300	300	70	73	5386.3	5386.3		Floodplain top width includes high ground.
	15998	159+98	109	109	109	15,998	15,998	15,998	93	93	56	61	5386.4	5386.4		Floodplain top width includes high ground.
	16006	160+06	7	7	7	16,006	16,006	16,006	91	91	62	61	5386.3	5386.3		
	16153	161+53	147	147	147	16,153	16,153	16,153	199	199	50	52	5386.7	5386.7	OK	Floodplain top width includes high ground.
	16425	164+25	272	272	272	16,425	16,425	16,425	93	96	93	94	5389.4	5389.4	OK	Floodplain top width includes high ground.
	16487	164+87	62	62	62	16,487	16,487	16,487	90	91	90	91	5390.2	5390.2	OK	
S. Jackson St	16520	165+20														
	16552	165+52	65	65	65	16,552	16,552	16,552	167	167	94	94	5392.7	5392.7		
	16579	165+79	27	27	27	16,579	16,579	16,579	136	137	90	90	5392.7	5392.7		
	16736	167+36	158	158	158	16,736	16,736	16,736	68	68	54	54	5392.4	5392.4	OK	
	16790	167+90	53	53	53	16,790	16,790	16,790	68	68	45	45	5393.6	5393.6		

Table D-3 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver
Flooding Source: Harvard Gulch - 0.5' ΔEGL
Reach: S. Downing Street to S. Colorado Boulevard

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
Harvard Gulch: South Platte River to S. Colorado Blvd.																
Harvard Gulch Split Flow: Harvard Gulch Park to S. Downing Street																
	139	1+39	153	153	153	153	153	153	182	182	181	182	5309.7	5309.7	OK	Floodway coincident with floodplain. Model indicates reach length of 153' is between the most upstream cross section 5221 in Reach 1 and the first cross section 139 in Split Flow Reach 1 measured through the junction. However, 139' is based on station on the Split Flow Reach.
	200	2+00	61	61	61	214	214	214	191	191	191	191	5313.6	5313.6	OK	Floodway coincident with floodplain
	261	2+61	61	61	61	275	275	275	194	194	193	194	5317.0	5317.0	OK	Floodway coincident with floodplain
	325	3+25	64	64	64	339	339	339	187	187	187	187	5318.3	5318.3	OK	Floodway coincident with floodplain
	411	4+11	86	86	86	425	425	425	528	526	527	526	5319.3	5319.3		Floodway coincident with floodplain, top width includes ineffective flow areas.
	637	6+37	225	225	225	651	651	651	477	477	476	477	5319.4	5319.4		Floodway coincident with floodplain, top width includes ineffective flow areas.
	734	7+34	97	97	97	748	748	748	365	364	362	364	5319.4	5319.4		Floodway coincident with floodplain
	761	7+61	28	28	28	776	776	776	341	341	340	341	5319.4	5319.4		Floodway coincident with floodplain
	785	7+85	24	24	24	799	799	799	322	322	321	322	5319.4	5319.4		Floodway coincident with floodplain
	871	8+71	85	85	85	885	885	885	331	331	329	331	5319.4	5319.4		Floodway coincident with floodplain
	887	8+87	17	17	17	902	902	902	333	332	332	332	5319.4	5319.4		Floodway coincident with floodplain
	928	9+28	41	41	41	942	942	942	339	339	337	339	5319.4	5319.4	OK	Floodway coincident with floodplain
	1136	11+36	208	208	208	1,150	1,150	1,150	236	234	230	234	5319.4	5319.4	OK	Floodway coincident with floodplain
	1221	12+21	85	85	85	1,235	1,235	1,235	195	195	195	195	5322.8	5322.8	OK	Floodway coincident with floodplain, top width includes high ground.
S. Ogden St	1255	12+55														
	1285	12+85	64	64	64	1,299	1,299	1,299	326	326	214	213	5324.3	5324.3		
	1351	13+51	66	66	66	1,365	1,365	1,365	448	452	241	241	5324.8	5324.8	OK	Floodplain top width includes high ground.
	1426	14+26	76	76	76	1,440	1,440	1,440	700	701	410	410	5326.7	5326.7	OK	
	1504	15+04	78	78	78	1,518	1,518	1,518	641	643	480	480	5326.7	5326.7		
S. Corona St	1594	15+94	90	90	90	1,608	1,608	1,608	750	750	560	560	5326.8	5326.8		
	1679	16+79	84	84	84	1,693	1,693	1,693	605	605	595	595	5326.7	5326.7		
	1755	17+55	76	76	76	1,769	1,769	1,769	797	791	550	550	5326.9	5326.9	OK	
	1838	18+38	83	83	83	1,852	1,852	1,852	452	451	348	349	5326.9	5326.9	OK	Floodway and floodplain top widths include high ground.
S Downing St	1923	19+23	86	86	86	1,937	1,937	1,937	619	612	375	374	5327.7	5327.7		
	1966	19+66	43	43	43	1,980	1,980	1,980	755	756	411	412	5328.1	5328.1	OK	Floodplain top width includes high ground.
	2016	20+16	50	50	50	2,030	2,030	2,030	842	842	515	515	5329.2	5329.2		
	2089	20+89	73	73	73	2,103	2,103	2,103	867	869	530	533	5329.4	5329.4		
	2122	21+22	34	34	34	2,136	2,136	2,136	899	899	500	501	5329.4	5329.4		Floodplain top width includes high ground.

Table D-4 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver/ City of Englewood
Flooding Source: Dry Gulch - 0.5' ΔEGL
Reach: E. Harvard Avenue to S. University Blvd

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
Dry Gulch: E. Harvard Avenue to E. Yale Avenue (City and County of Denver)																
E. Harvard Avenue	133	1+33	133	133	133	133	133	133	283	285	221	221	5307.3	5307.3		
	237	2+37	104	104	104	237	237	237	184	186	129	132	5307.2	5307.2		
	409	4+09	172	172	172	409	409	409	231	238	203	201	5307.2	5307.2		
	595	5+95	186	186	186	595	595	595	334	357	118	121	5307.6	5307.6	OK	Floodplain top width includes high ground and flooding from u/s.
	713	7+13	118	118	118	713	713	713	202	314	55	55	5308.2	5308.2	OK	Floodplain top width includes high ground and flooding from u/s.
	867	8+67	154	154	154	867	867	867	250	275	51	52	5310.4	5310.4	OK	Floodplain top width includes high ground and flooding from u/s.
	1030	10+30	163	163	163	1,030	1,030	1,030	213	213	56	58	5312.5	5312.5	OK	Floodplain top width includes high ground and ineffective flow areas.
	1117	11+17	87	87	87	1,117	1,117	1,117	189	188	151	151	5315.3	5315.3	OK	Floodplain/floodway top width includes high ground.
	1224	12+24	107	107	107	1,224	1,224	1,224	133	133	101	98	5316.5	5316.5	OK	
	1258	12+58	34	34	34	1,258	1,258	1,258	152	151	64	67	5317.3	5317.3	OK	
	1306	13+06	48	48	48	1,306	1,306	1,306	232	230	110	110	5319.1	5319.1		
	1416	14+16	110	110	110	1,416	1,416	1,416	229	223	139	139	5319.6	5319.6	OK	
	1583	15+83	167	167	167	1,583	1,583	1,583	214	214	159	159	5320.1	5320.1	OK	
	1780	17+80	197	197	197	1,780	1,780	1,780	117	118	70	71	5321.4	5321.4	OK	
	1879	18+79	100	100	100	1,879	1,879	1,879	110	110	69	69	5323.4	5323.4	OK	
E. Yale Avenue	1927	19+27	48	48	48	1,927	1,927	1,927	196	195	93	93	5327.8	5327.8	OK	
Dry Gulch: E. Yale Avenue to S. University Blvd (City of Englewood)																
	2100	21+00	173	173	173	2,100	2,100	2,100	251	251	85	85	5328.3	5328.3		
	2265	22+65	165	165	165	2,265	2,265	2,265	249	250	87	87	5328.3	5328.3		
	2403	24+03	138	138	138	2,403	2,403	2,403	301	302	85	87	5328.4	5328.4		Floodplain top width includes high ground.
	2533	25+33	130	130	130	2,533	2,533	2,533	351	350	158	158	5328.6	5328.6		
	2625	26+25	91	91	91	2,625	2,625	2,625	346	347	230	231	5328.7	5328.7	OK	
	2767	27+67	142	142	142	2,767	2,767	2,767	370	370	325	324	5329.2	5329.2		Floodplain/floodway top width includes high ground.
	2852	28+52	85	85	85	2,852	2,852	2,852	471	469	287	293	5329.9	5329.9	OK	Floodplain/floodway top width includes high ground.
	2954	29+54	102	102	102	2,954	2,954	2,954	518	517	330	330	5330.6	5330.6	OK	Floodplain/floodway top width includes high ground.
	3087	30+87	132	132	132	3,087	3,087	3,087	551	550	150	151	5331.9	5331.9	OK	Floodplain/floodway top width includes high ground.
	3289	32+89	202	202	202	3,289	3,289	3,289	327	322	168	172	5333.0	5333.0	OK	Floodplain/floodway top width includes high ground.
	3525	35+25	236	236	236	3,525	3,525	3,525	433	530	375	374	5337.7	5337.7	OK	Floodplain/floodway top width includes obstructions (masonry wall).
	3689	36+89	164	164	164	3,689	3,689	3,689	263	263	221	222	5338.5	5338.5		
	3923	39+23	234	234	234	3,923	3,923	3,923	202	202	90	90	5338.5	5338.5		Floodplain top width includes high ground.
	4086	40+86	163	163	163	4,086	4,086	4,086	91	93	91	91	5338.6	5338.6	OK	
	4215	42+15	129	129	129	4,215	4,215	4,215	207	208	99	99	5344.1	5344.1		
S Ogden St	4247	42+47	32	32	32	4,247	4,247	4,247	363	362	119	123	5344.6	5344.6		
	4412	44+12	165	165	165	4,412	4,412	4,412	323	318	238	236	5344.8	5344.8		
	4712	47+12	299	299	299	4,712	4,712	4,712	236	242	203	204	5344.9	5344.9	OK	Floodplain/floodway top width includes high ground.
	4872	48+72	160	160	160	4,872	4,872	4,872	326	325	203	202	5345.9	5345.9	OK	
	5098	50+98	226	226	226	5,098	5,098	5,098	203	203	156	156	5347.1	5347.1		

Table D-4 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver/ City of Englewood
Flooding Source: Dry Gulch - 0.5' ΔEGL
Reach: E. Harvard Avenue to S. University Blvd

Engineer: Robert Krehbiel / Hung-Teng Ho
Date: 2/14/2017

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
E Dartmouth Ave/S Corona St	5267	52+67	169	169	169	5,267	5,267	5,267	263	263	159	161	5349.3	5349.3	OK	
	5367	53+67	100	100	100	5,367	5,367	5,367	250	250	164	163	5350.3	5350.3		
	5476	54+76	109	109	109	5,476	5,476	5,476	263	263	148	148	5350.8	5350.8	OK	
E Dartmouth Ave/S Downing St	5548	55+48	72	72	72	5,548	5,548	5,548	211	210	96	99	5351.5	5351.5	OK	Floodplain top width includes high ground.
	5734	57+34	186	186	186	5,734	5,734	5,734	78	76	77	74	5353.5	5353.5	OK	
S Downing St	5934	59+34	199	199	199	5,934	5,934	5,934	241	239	63	65	5354.6	5354.6	OK	
	6300	63+00	367	367	367	6,300	6,300	6,300	147	145	52	53	5355.1	5355.1	OK	
	6525	65+25	225	225	225	6,525	6,525	6,525	31	107	29	31	5356.4	5356.4	OK	Floodplain top width includes overland flooding from u/s.
S Lafayette St	6559	65+59	34	34	34	6,559	6,559	6,559	185	185	67	67	5358.7	5358.7	OK	
	6633	66+33	74	74	74	6,633	6,633	6,633	172	171	92	94	5361.8	5361.8	OK	
	6830	68+30	196	196	196	6,830	6,830	6,830	376	376	159	161	5364.4	5364.4		Floodplain top width includes high ground.
S Humboldt St	6912	69+12	82	82	82	6,912	6,912	6,912	456	458	180	180	5364.4	5364.4		
	6986	69+86	74	74	74	6,986	6,986	6,986	317	313	175	175	5364.4	5364.4	OK	
	7180	71+80	194	194	194	7,180	7,180	7,180	390	390	135	134	5367.1	5367.1		Floodplain top width includes high ground.
S Franklin St	7253	72+53	73	73	73	7,253	7,253	7,253	350	347	138	139	5367.2	5367.2		
	7325	73+25	72	72	72	7,325	7,325	7,325	262	262	143	143	5367.2	5367.2		Floodplain top width includes high ground.
	7500	75+00	175	175	175	7,500	7,500	7,500	312	311	175	175	5367.8	5367.8		
E Eastman Ave/S Gilpin St	7609	76+09	109	109	109	7,609	7,609	7,609	335	335	181	181	5367.9	5367.9	OK	
	7697	76+97	88	88	88	7,697	7,697	7,697	129	130	87	87	5368.2	5368.2	OK	Floodplain top width includes high ground.
	7870	78+70	173	173	173	7,870	7,870	7,870	190	188	128	125	5371.0	5371.0		Floodplain top width includes high ground.
E Eastman Ave/S Williams St	7949	79+49	79	79	79	7,949	7,949	7,949	275	276	130	129	5371.6	5371.6		Floodplain top width includes ineffective flow areas.
	8016	80+16	67	67	67	8,016	8,016	8,016	284	280	108	106	5372.8	5372.8	OK	Floodplain top width includes high ground and ineffective flow areas.
	8202	82+02	186	186	186	8,202	8,202	8,202	55	56	56	55	5374.2	5374.2		
E Eastman Ave/S High St	8273	82+73	71	71	71	8,273	8,273	8,273	217	217	52	54	5374.8	5374.8	OK	Floodplain top width includes ineffective flow areas, shallow flooding in LOB is not included in top width.
	8344	83+44	71	71	71	8,344	8,344	8,344	115	115	51	51	5375.9	5375.9	OK	Floodplain top width includes high ground.
	8528	85+28	185	185	185	8,528	8,528	8,528	58	57	43	44	5377.5	5377.5	OK	
E Eastman Ave/S Race St	8590	85+90	61	61	61	8,590	8,590	8,590	109	110	76	76	5378.1	5378.1		
	8699	86+99	110	110	110	8,699	8,699	8,699	196	196	70	67	5378.4	5378.4	OK	Floodplain top width includes high ground and ineffective flow areas.
	8835	88+35	136	136	136	8,835	8,835	8,835	67	68	42	45	5380.0	5380.0		
E Eastman Ave/S Vine St	8922	89+22	87	87	87	8,922	8,922	8,922	185	184	51	52	5380.7	5380.7	OK	Floodplain top width includes high ground.
	9000	90+00	78	78	78	9,000	9,000	9,000	90	89	41	43	5382.1	5382.1	OK	
	9142	91+42	142	142	142	9,142	9,142	9,142	85	85	48	48	5383.8	5383.8		
E Eastman Ave/S Vine Ct	9221	92+21	79	79	79	9,221	9,221	9,221	131	131	55	55	5384.5	5384.5	OK	
	9301	93+01	80	80	80	9,301	9,301	9,301	81	80	44	44	5385.7	5385.7	OK	
	9441	94+41	140	140	140	9,441	9,441	9,441	77	77	47	48	5387.5	5387.5		

Table D-4 AGREEMENT TABLE: FDT - PROFILE - MAP

PROJECT NAME: Harvard Gulch & Dry Gulch FHAD **CASE/PROJECT No:** 15.155.023.005

Community(ies): City and County of Denver/ City of Englewood **Engineer:** Robert Krehbiel / Hung-Teng Ho
Flooding Source: Dry Gulch - 0.5' ΔEGL **Date:** 2/14/2017
Reach: E. Harvard Avenue to S. University Blvd

Reference Location	Cross Section	River Station	Distance b/a RS, ft			Cumulative Distance, ft			FP Width, ft		FW Width, ft		BFE, ft		BFE Loc.	Comments and Explanations
			FDT	Profile	Map	FDT	Profile	Map	Model	Map	FDT	Map	FDT	Profile		
			+/- 10% of FDT			+/-5% of FDT			Largest value: 25 feet or 5% of Width on Map				+/- 0.5ft			
S Gaylord St	9499	94+99	57	57	57	9,499	9,499	9,499	185	183	58	59	5387.9	5387.9	OK	Floodplain top width includes ineffective flow areas.
	9575	95+75	76	76	76	9,575	9,575	9,575	143	142	39	39	5389.2	5389.2		Floodplain top width includes high ground and ineffective flow areas.
	9685	96+85	110	110	110	9,685	9,685	9,685	156	154	44	45	5390.3	5390.3		Floodplain top width includes high ground and ineffective flow areas.
E Eastman Ave/S York St	9731	97+31	46	46	46	9,731	9,731	9,731	213	212	56	57	5390.7	5390.7		Floodplain top width includes ineffective flow areas.
	9837	98+37	106	106	106	9,837	9,837	9,837	87	87	39	38	5392.5	5392.5		
E Eastman Ave/E Floyd Ave	9905	99+05	69	69	69	9,905	9,905	9,905	138	141	74	74	5393.0	5393.0		
	9952	99+52	47	47	47	9,952	9,952	9,952	162	163	57	58	5393.8	5393.8		
	10011	100+11	58	58	58	10,011	10,011	10,011	120	122	64	64	5394.1	5394.1		
	10072	100+72	61	61	61	10,072	10,072	10,072	79	79	49	51	5394.8	5394.8		
	10113	101+13	41	41	41	10,113	10,113	10,113	88	90	51	52	5395.1	5395.1		
	10180	101+80	67	67	67	10,180	10,180	10,180	333	331	99	99	5395.7	5395.7		
S University Blvd	10215	102+15	35	35	35	10,215	10,215	10,215	220	220	101	101	5395.7	5395.7		

Appendix E – Wetland and Riparian Inventory

Figure E-1 ERO Resources Corp Report Maps for Wetland and Riparian Inventory (8 Sheets)

Path: P:\6100 Projects\6184 Weir Gulch and Harvard Gulch Env Assessments\Maps\Harvard Gulch.mxd

HW

Transect HG1

SE/PC/SB

HGT1-DP4
HGT1-DP3
HGT1-DP5
HGT1-DP2
HGT1-DP1

HW
HG1-DP6

HG1-DP9
HW
HW
HG1-DP7

HW

SE/PC/SB

SE/PC/SB

E HARVARD AVE

S PENNSYLVANIA ST

S PEARL ST

S WASHINGTON ST

S CLARKSON ST

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point
- Inlet

Image Source: © 2014 Google

Waters of the U.S.
- Open Water
- Wetland

Riparian Communities
- HW - Herbaceous Wetland
- SW/MG - Sandbar willow/Mesic graminoid Shrubland
- PC/SB - Plains cottonwood/Smooth brome Woodland
- SE/PC/SB - Siberian elm/Plains cottonwood/Smooth brome Woodland



Figure 3a
Harvard Gulch
Existing Wetland and Riparian Communities

Prepared for: City and County of Denver
File: Harvard Gulch.mxd (WH)
June 2, 2015

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S EMERSON ST
E WESLEY AVE
S OGDEN ST
S CORONA ST
S MARION ST
E HARVARD AVE
HW
HW
SE/PC/SB
HW
HG1-DP8
P3
SE/PC/SB

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point

Image Source: © 2014 Google

- Diversion/Stream Gage
- Inlet
- Outlet

Waters of the U.S.
- Open Water
- Wetland

Riparian Communities
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0 50 100 feet

N

Figure 3b
Harvard Gulch
Existing Wetland and Riparian Communities

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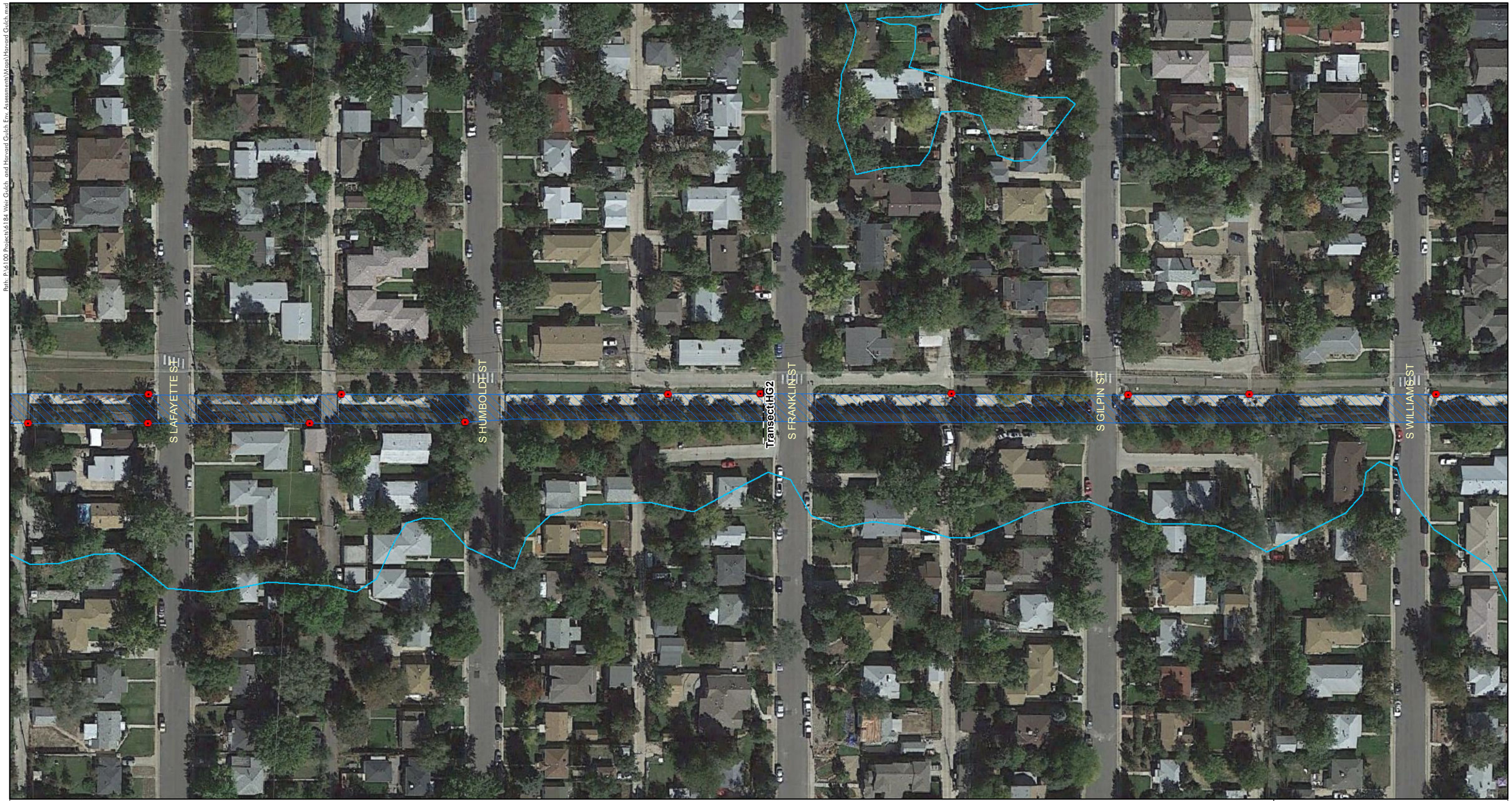

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point
- Inlet

Image Source: © 2014 Google

Waters of the U.S.
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- Wetland

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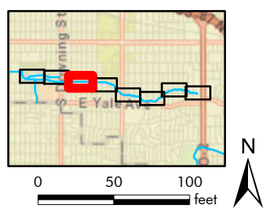

Figure 3c
Harvard Gulch
Existing Wetland and Riparian Communities

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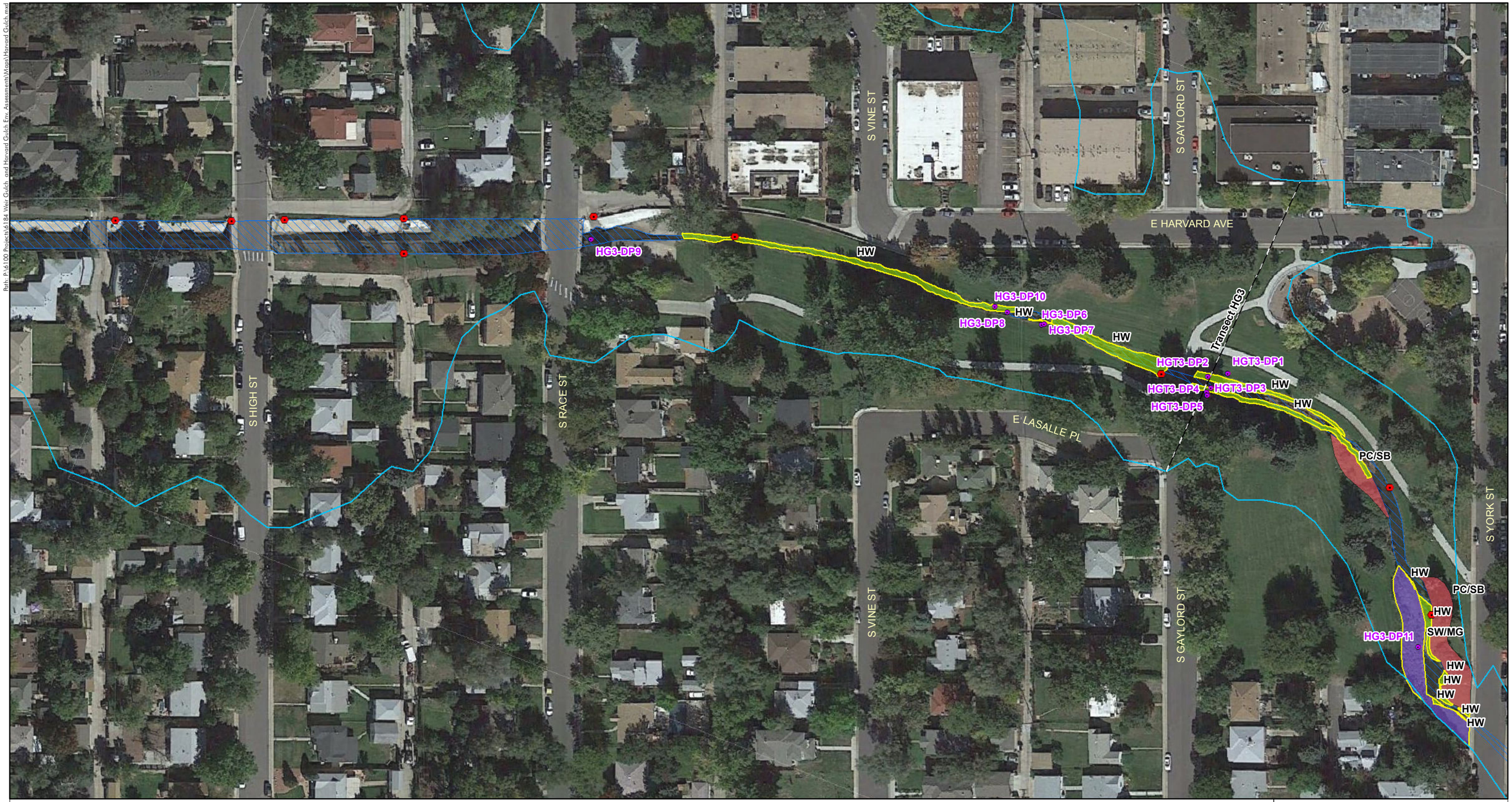

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point
- Inlet

Image Source: © 2014 Google

Waters of the U.S.
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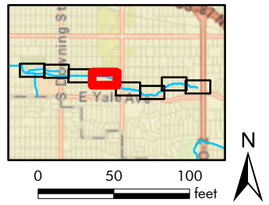

Figure 3d
Harvard Gulch
Existing Wetland and Riparian Communities

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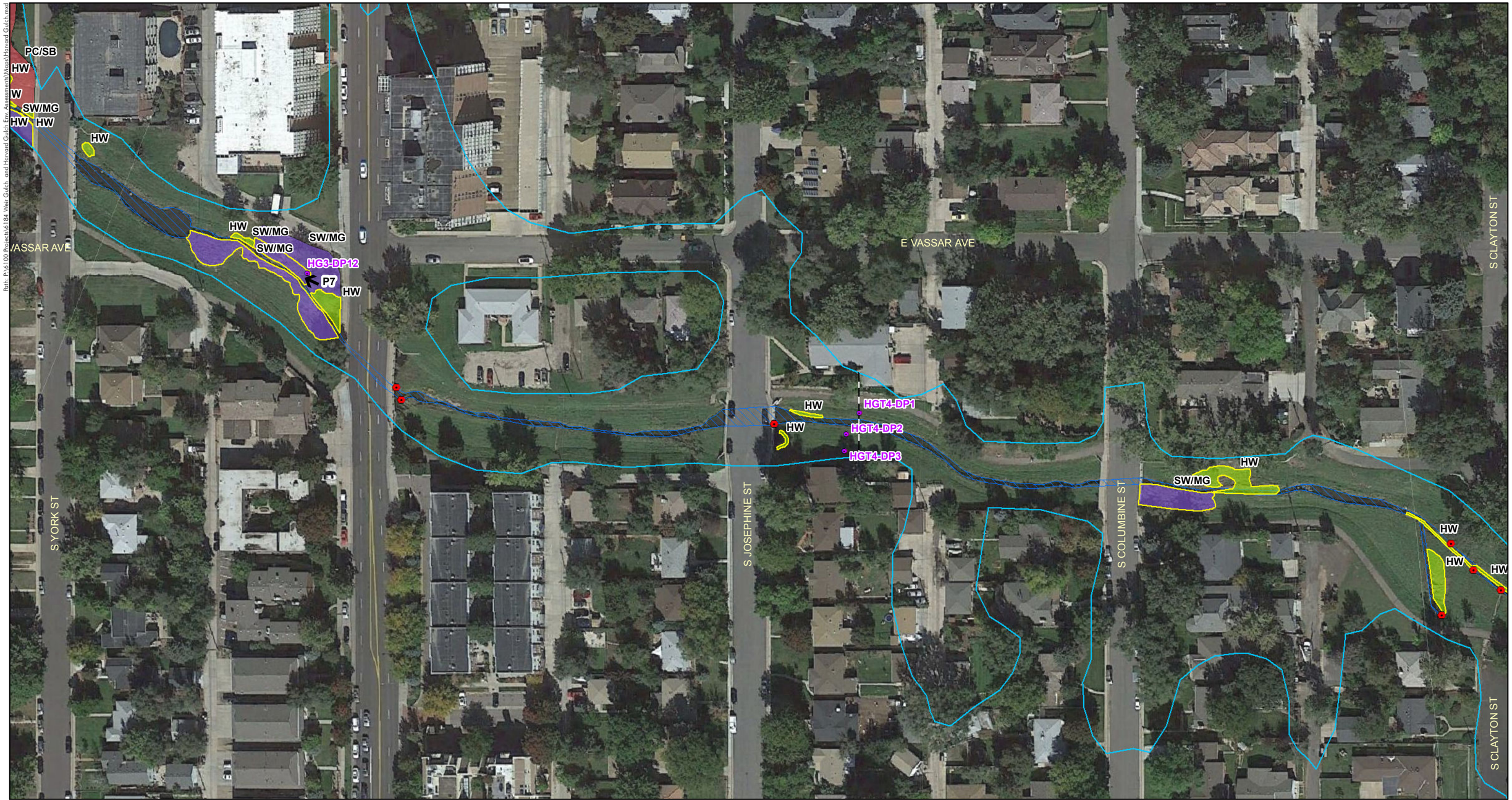

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point
- Inlet

Image Source: © 2014 Google

Waters of the U.S.
- Open Water
- Wetland

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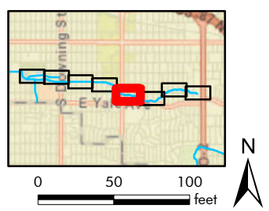

Figure 3e
Harvard Gulch
Existing Wetland and Riparian Communities

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E VASSAR AVE
S CLAYTON ST
S FILLMORE ST
S MILWAUKEE ST
S SAINT PAUL ST
S STEELE ST
S LANGLEY CT
HW
P2
P6
PC/SB
Transect HG5
HGT5-DP1
HGT5-DP2
HGT5-DP3
HGT5-DP4
HG5-DP5
HG5-DP6

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point
- Inlet

Image Source: © 2014 Google

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0 50 100 feet

N

Figure 3f
Harvard Gulch
Existing Wetland and Riparian Communities

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S STEELE ST
S ADAMS ST
S COOK ST
S MADISON ST
S MONROE ST
E VASSAR AVE
S GARFIELD WAY
Transect HG6
HGT6-DP1
HGT6-DP2
HGT6-DP3
HGT6-DP4
HG6-DP5
HG5-DP6
HG5-DP7
P1
HW
SE/PC/SB
SW/M
SE/PC

Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point

Image Source: © 2014 Google

Waters of the U.S.
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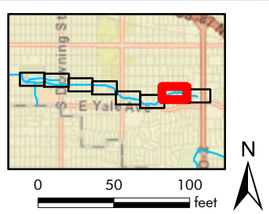

Figure 3g
Harvard Gulch
Existing Wetland and Riparian Communities

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Harvard Gulch

- Survey Transect
- Floodplain/Project Area
- Data Point
- Photo Point
- Inlet

Image Source: © 2014 Google

Waters of the U.S.
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- PC/SB - Plains cottonwood/Smooth brome Woodland
- SE/PC/SB - Siberian elm/Plains cottonwood/Smooth brome Woodland

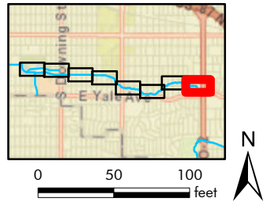

Figure 3h
Harvard Gulch
Existing Wetland and Riparian Communities

Prepared for: City and County of Denver
File: Harvard Gulch.mxd (WH)
June 2, 2015

ERO Resources Corp.

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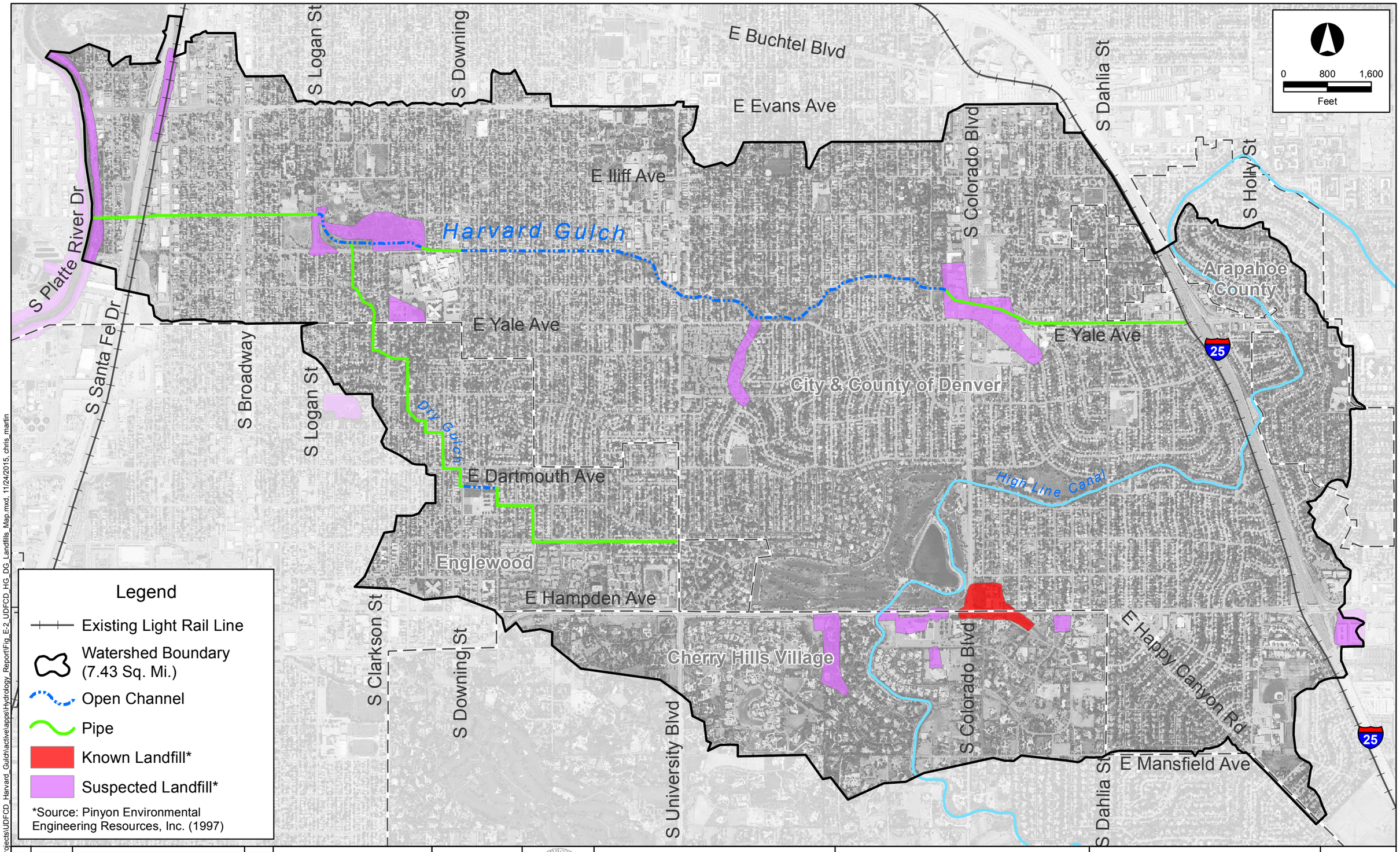


Legend

- Existing Light Rail Line
- Watershed Boundary (7.43 Sq. Mi.)
- Open Channel
- Pipe
- Known Landfill*
- Suspected Landfill*

*Source: Pinyon Environmental Engineering Resources, Inc. (1997)

No.	DATE	DESCRIPTION	APPR.

Matrix DESIGN GROUP

designed by:
drawn by: CM
checked by: RK
project no.: 15.155.023
date: 11/24/2015

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT, CITY AND COUNTY OF DENVER

FLOOD HAZARD AREA DELINEATION
HARVARD GULCH & DRY GULCH

HISTORICAL LANDFILLS

FIGURE
E-2

FILE: G:\gis_projects\UDFCD_Harvard_Gulch\active\apps\Hydrology_Report\Fig_E-2_UDFCD_HG_DG_Landfills_Map.mxd, 11/24/2015, chris_martin

Appendix G – Flood Maps

Flood Hazard Area Delineation

Harvard Gulch

Sheet 1 of 2

February 2017

Matrix Design Group, Inc.
1601 Blake St. #200
Denver, CO 80202
(303) 572-0200

N

0 100 200 400

Feet

Note: 100-year shallow flooding (based on FLO-2D) within the limits of the South Platte River regulatory floodplain only reflects potential flooding from the Harvard Gulch watershed. This area would be subject to additional flooding from the South Platte River.

Legend

- Municipal Boundary
- Parcel
- HEC-RAS Cross Section
- South Platter River Regulatory 100-Year Floodplain
- Letter of Map Amendment (LOMA) - Approved
- Letter of Map Amendment (LOMA) - Denied
- Contours (10 ft)
- Contours (2 ft)
- Base Flood Elevation
- 100-Year Floodplain (1% Annual Chance Flood)
- 500-Year Floodplain (0.2% Annual Chance Flood)

100-year Shallow Flooding (Based on FLO-2D)

Average Flow Depth (Click HERE to activate)

- Average Depth <= 1 ft
- Average Depth <= 2 ft
- Average Depth <= 3ft

Overland Flow Depth at Cell (Click HERE to activate)

- 6" - 12"
- 1' - 1.5'
- 1.5' - 3'
- 3' - 4.5'
- 4.5' - 6'
- > 6'

Notes:

Vertical Datum: NAVD 88

Horizontal Datum: NAD83

Contour Interval: 2 Feet

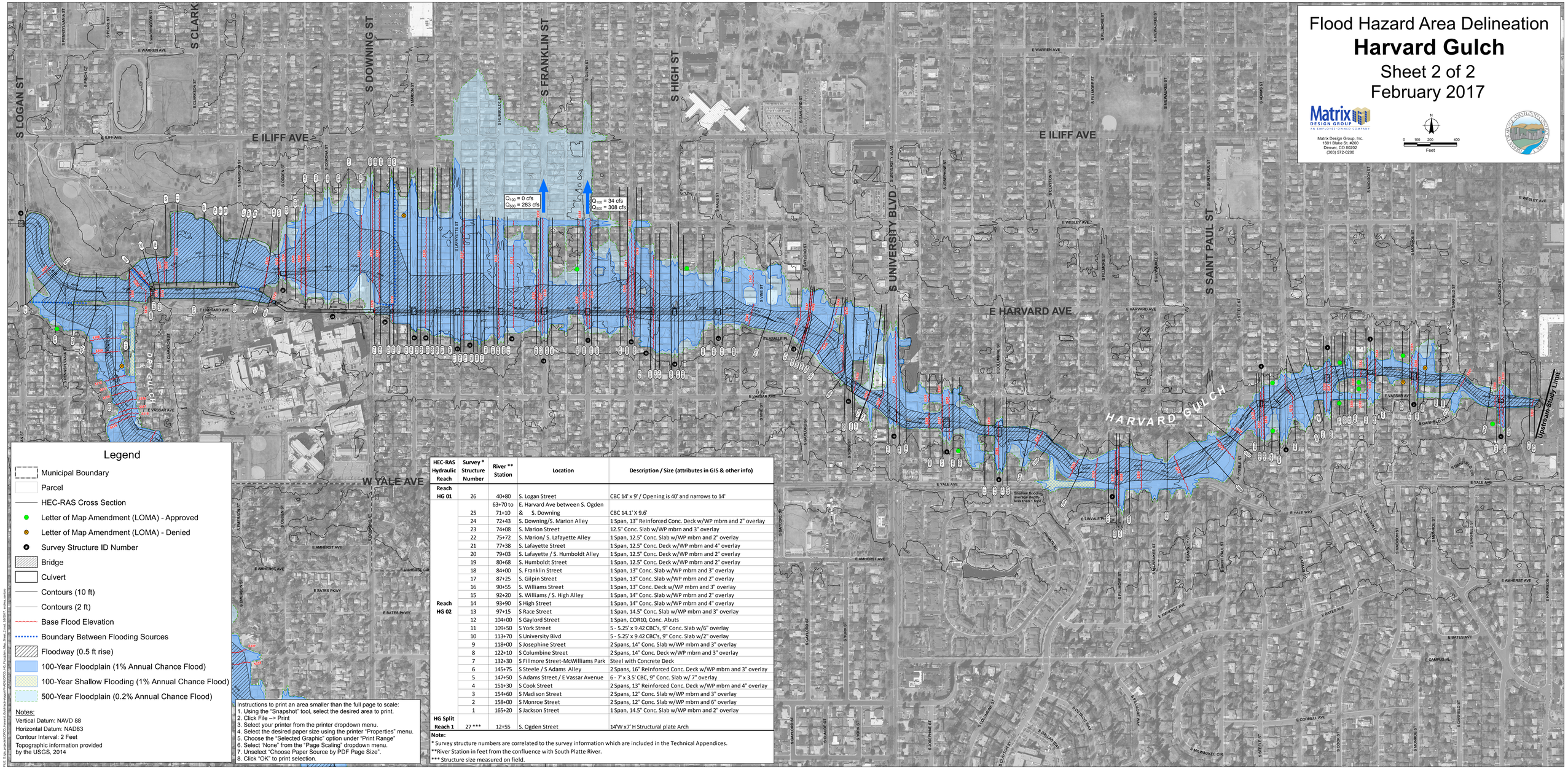
Topographic information provided by the USGS, 2014

Instructions to print an area smaller than the full page to scale:
1. Using the “Snapshot” tool, select the desired area to print.
2. Click File –> Print
3. Select your printer from the printer dropdown menu.
4. Select the desired paper size using the printer “Properties” menu.
5. Choose the “Selected Graphic” option under “Print Range”
6. Select ‘None” from the “Page Scaling” dropdown menu.
7. Unselect “Choose Paper Source by PDF Page Size”.
8. Click “OK” to print selection.

City & County of Denver
City of Englewood

Downstream Study Limit

FILE: G:\gis_projects\UDFCD_Harvard_Gulch\active\apps\FHAD\UDFCD_HG_Floodplain_Map_Sheet_1.mxd, 3/13/2017, Andrea_Santoro



Flood Hazard Area Delineation

Harvard Gulch

Sheet 2 of 2

February 2017

Matrix Design Group, Inc.
1601 Blake St. #200
Denver, CO 80202
(303) 572-0200

N

0 100 200 400
Feet

Legend

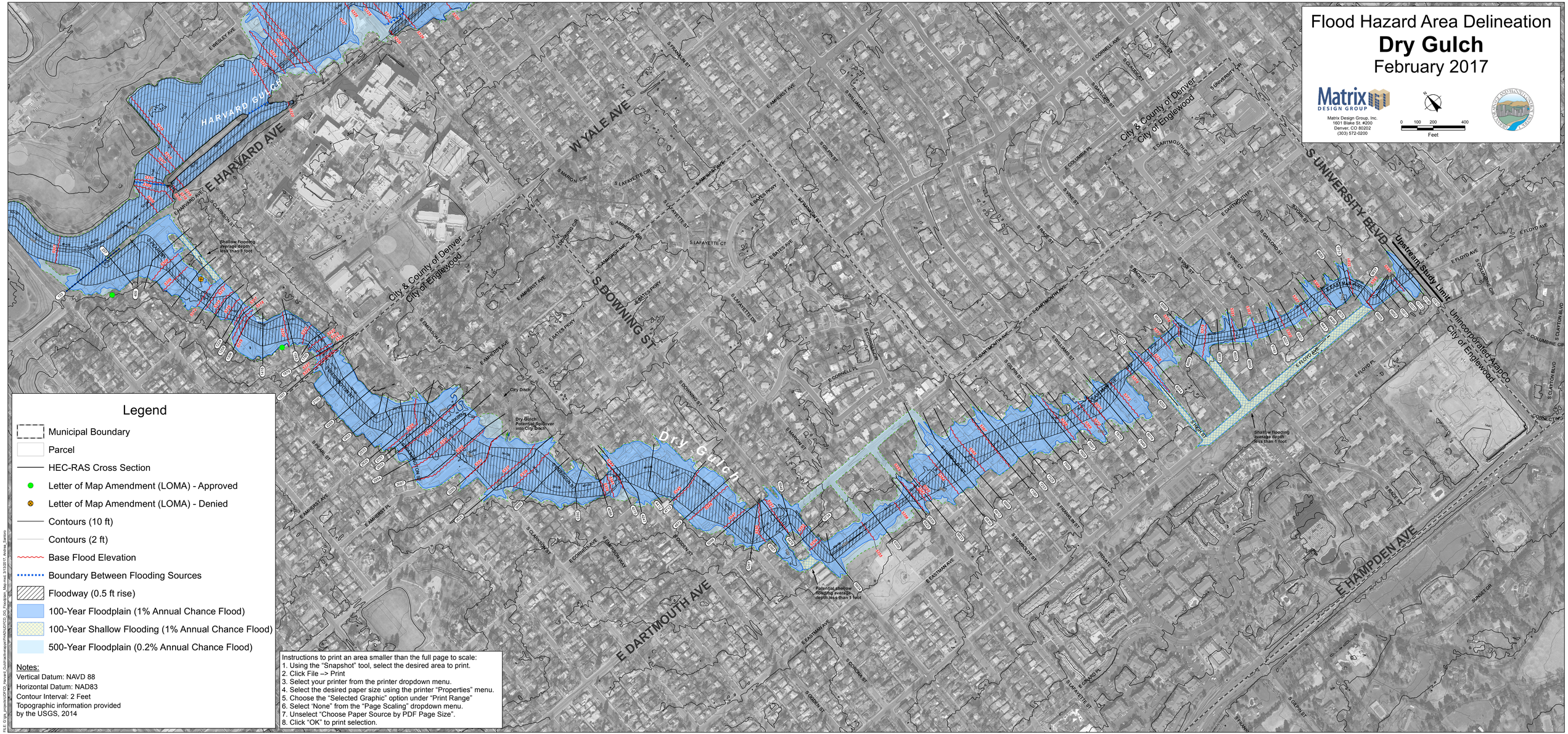
- Municipal Boundary
- Parcel
- HEC-RAS Cross Section
- Letter of Map Amendment (LOMA) - Approved
- Letter of Map Amendment (LOMA) - Denied
- Survey Structure ID Number
- Bridge
- Culvert
- Contours (10 ft)
- Contours (2 ft)
- Base Flood Elevation
- Boundary Between Flooding Sources
- Floodway (0.5 ft rise)
- 100-Year Floodplain (1% Annual Chance Flood)
- 100-Year Shallow Flooding (1% Annual Chance Flood)
- 500-Year Floodplain (0.2% Annual Chance Flood)

Notes:
Vertical Datum: NAVD 88
Horizontal Datum: NAD83
Contour Interval: 2 Feet
Topographic information provided by the USGS, 2014

HEC-RAS Hydraulic Reach	Survey * Structure Number	River ** Station	Location	Description / Size (attributes in GIS & other info)
Reach HG 01	26	40+80	S. Logan Street	CBC 14' x 9' / Opening is 40' and narrows to 14'
	25	63+70 to 71+10	E. Harvard Ave between S. Ogden & S. Downing	CBC 14.1' X 9.6'
	24	72+43	S. Downing/S. Marion Alley	1 Span, 13" Reinforced Conc. Deck w/WP mbrn and 2" overlay
	23	74+08	S. Marion Street	12.5" Conc. Slab w/WP mbrn and 3" overlay
	22	75+72	S. Marion/ S. Lafayette Alley	1 Span, 12.5" Conc. Slab w/WP mbrn and 2" overlay
	21	77+38	S. Lafayette Street	1 Span, 12.5" Conc. Deck w/WP mbrn and 4" overlay
	20	79+03	S. Lafayette / S. Humboldt Alley	1 Span, 12.5" Conc. Deck w/WP mbrn and 2" overlay
	19	80+68	S. Humboldt Street	1 Span, 12.5" Conc. Deck w/WP mbrn and 2" overlay
	18	84+00	S. Franklin Street	1 Span, 13" Conc. Slab w/WP mbrn and 3" overlay
	17	87+25	S. Gilpin Street	1 Span, 13" Conc. Slab w/WP mbrn and 2" overlay
	16	90+55	S. Williams Street	1 Span, 13" Conc. Deck w/WP mbrn and 3" overlay
	15	92+20	S. Williams / S. High Alley	1 Span, 14" Conc. Slab w/WP mbrn and 2" overlay
Reach HG 02	14	93+90	S High Street	1 Span, 14" Conc. Slab w/WP mbrn and 4" overlay
	13	97+15	S Race Street	1 Span, 14.5" Conc. Slab w/WP mbrn and 3" overlay
	12	104+00	S Gaylord Street	1 Span, COR10, Conc. Abuts
	11	109+50	S York Street	5 - 5.25' x 9.42 CBC's, 9" Conc. Slab w/6" overlay
	10	113+70	S University Blvd	5 - 5.25' x 9.42 CBC's, 9" Conc. Slab w/2" overlay
	9	118+00	S Josephine Street	2 Spans, 14" Conc. Slab w/WP mbrn and 3" overlay
	8	122+10	S Columbine Street	2 Spans, 14" Conc. Deck w/WP mbrn and 3" overlay
	7	132+30	S Fillmore Street-McWilliams Park	Steel with Concrete Deck
	6	145+75	S Steele / S Adams Alley	2 Spans, 16" Reinforced Conc. Deck w/WP mbrn and 3" overlay
	5	147+50	S Adams Street / E Vassar Avenue	6 - 7' x 3.5' CBC, 9" Conc. Slab w/ 7" overlay
	4	151+30	S Cook Street	2 Spans, 13" Reinforced Conc. Deck w/WP mbrn and 4" overlay
	3	154+60	S Madison Street	2 Spans, 12" Conc. Slab w/WP mbrn and 3" overlay
	2	158+00	S Monroe Street	2 Spans, 12" Conc. Slab w/WP mbrn and 6" overlay
	1	165+20	S Jackson Street	1 Span, 14.5" Conc. Slab w/WP mbrn and 2" overlay
HG Split Reach 1	27 ***	12+55	S. Ogden Street	14'W x7' H Structural plate Arch

Note:
* Survey structure numbers are correlated to the survey information which are included in the Technical Appendices.
**River Station in feet from the confluence with South Platte River.
*** Structure size measured on field.

Instructions to print an area smaller than the full page to scale:
1. Using the "Snapshot" tool, select the desired area to print.
2. Click File --> Print
3. Select your printer from the printer dropdown menu.
4. Select the desired paper size using the printer "Properties" menu.
5. Choose the "Selected Graphic" option under "Print Range"
6. Select "None" from the "Page Scaling" dropdown menu.
7. Unselect "Choose Paper Source by PDF Page Size".
8. Click "OK" to print selection.

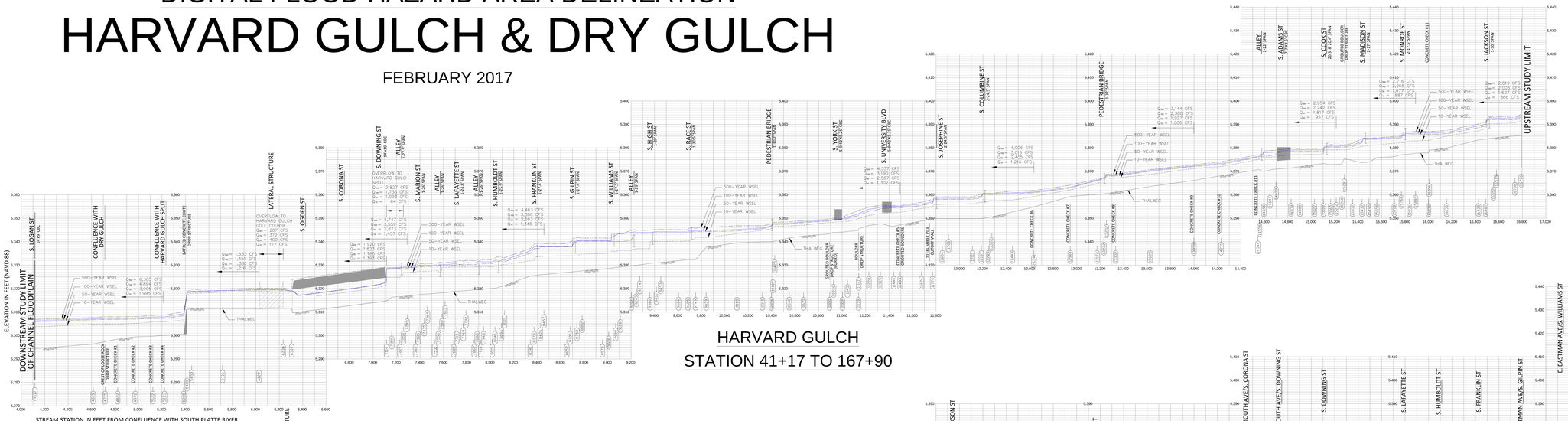

Flood Hazard Area Delineation
Dry Gulch
February 2017
Matrix DESIGN GROUP
Matrix Design Group, Inc.
1601 Blake St. #200
Denver, CO 80202
(303) 572-0200
0 100 200 400
Feet
Legend
Municipal Boundary
Parcel
HEC-RAS Cross Section
Letter of Map Amendment (LOMA) - Approved
Letter of Map Amendment (LOMA) - Denied
Contours (10 ft)
Contours (2 ft)
Base Flood Elevation
Boundary Between Flooding Sources
Floodway (0.5 ft rise)
100-Year Floodplain (1% Annual Chance Flood)
100-Year Shallow Flooding (1% Annual Chance Flood)
500-Year Floodplain (0.2% Annual Chance Flood)
Notes:
Vertical Datum: NAVD 88
Horizontal Datum: NAD83
Contour Interval: 2 Feet
Topographic information provided by the USGS, 2014
Instructions to print an area smaller than the full page to scale:
1. Using the "Snapshot" tool, select the desired area to print.
2. Click File --> Print
3. Select your printer from the printer dropdown menu.
4. Select the desired paper size using the printer "Properties" menu.
5. Choose the "Selected Graphic" option under "Print Range"
6. Select 'None" from the "Page Scaling" dropdown menu.
7. Unselect "Choose Paper Source by PDF Page Size".
8. Click "OK" to print selection.
Harvard Gulch
Dry Gulch
City & County of Denver
City of Englewood
Unincorporated Arapco
City of Englewood
Upstream Study Limit
Shallow flooding average depth less than 1 foot
City Ditch
Dry Gulch Potential Spillover into City Ditch
Potential shallow flooding average depth less than 1 foot
E HARVARD AVE
W YALE AVE
E AMHERST AVE
E DARTMOUTH AVE
E HAMPDEN AVE
S DOWNING ST
S UNIVERSITY BLVD
E FLOYD AVE
S CLAYTON BLVD
S COLUMBINE CIR
CONNECTING
PRIVATE

Appendix H – Flood Profiles

DIGITAL FLOOD HAZARD AREA DELINEATION

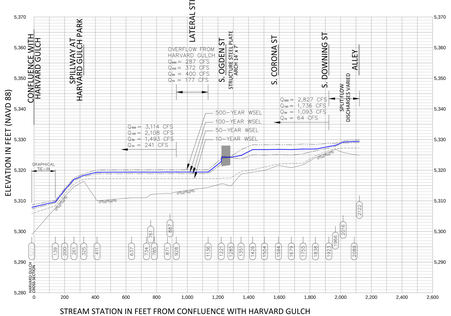
HARVARD GULCH & DRY GULCH

FEBRUARY 2017



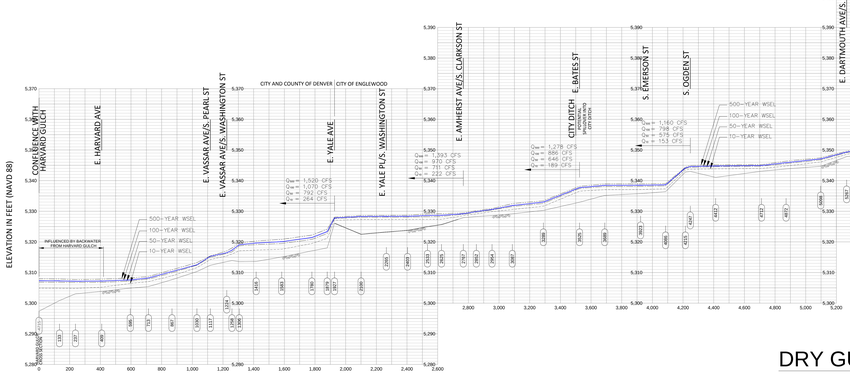
HARVARD GULCH

STATION 41+17 TO 167+90



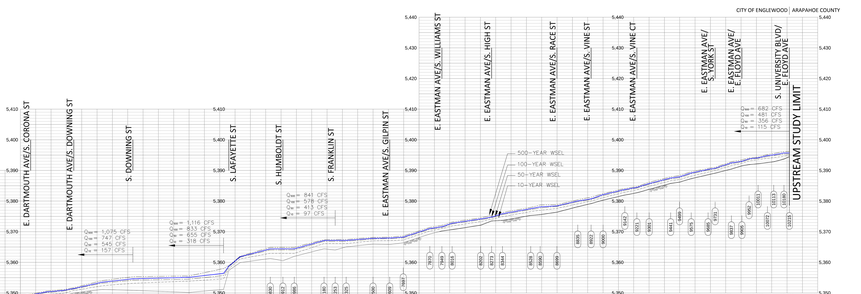
HARVARD GULCH SPLIT FLOW

STATION 00+00 TO 21+22



DRY GULCH

STATION 00+00 TO 102+15



LEGEND

- 0.2% ANNUAL CHANCE FLOOD (500-YEAR)
- 1% ANNUAL CHANCE FLOOD (100-YEAR)
- 2% ANNUAL CHANCE FLOOD (50-YEAR)
- 10% ANNUAL CHANCE FLOOD (10-YEAR)
- STREAM BED
- CROSS SECTION (HEC-RAS)
- EXISTING CULVERT
- EXISTING ROADWAY/PEDESTRIAN BRIDGE
- EXISTING LATERAL STRUCTURE

SCALE

ORIGINAL PAPER SCALE: 1" = 100'
ORIGINAL VERT SCALE: 1" = 10'

INSTRUCTION TO PRINT AN AREA SMALLER THAN THE FULL PAGE TO SCALE:

1. USING THE "SNAPSHOT" TOOL, SELECT THE DESIRED AREA TO PRINT.
2. CLICK FILE>PRINT...
3. SELECT YOUR PRINTER FROM THE PRINTER DROPDOWN MENU.
4. SET THE DESIRED PAPER SIZE USING THE PRINTER "PROPERTIES" MENU.
5. CHOOSE THE "SELECTED GRAPHIC" OPTION UNDER "PRINT RANGE".
6. SELECT "NONE" FROM THE "PAGE SCALING" DROPDOWN MENU.
7. UNSELECT "CHOOSE PAPER SOURCE BY PDF SIZE".
8. CLICK "OK" TO PRINT SELECTION.

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