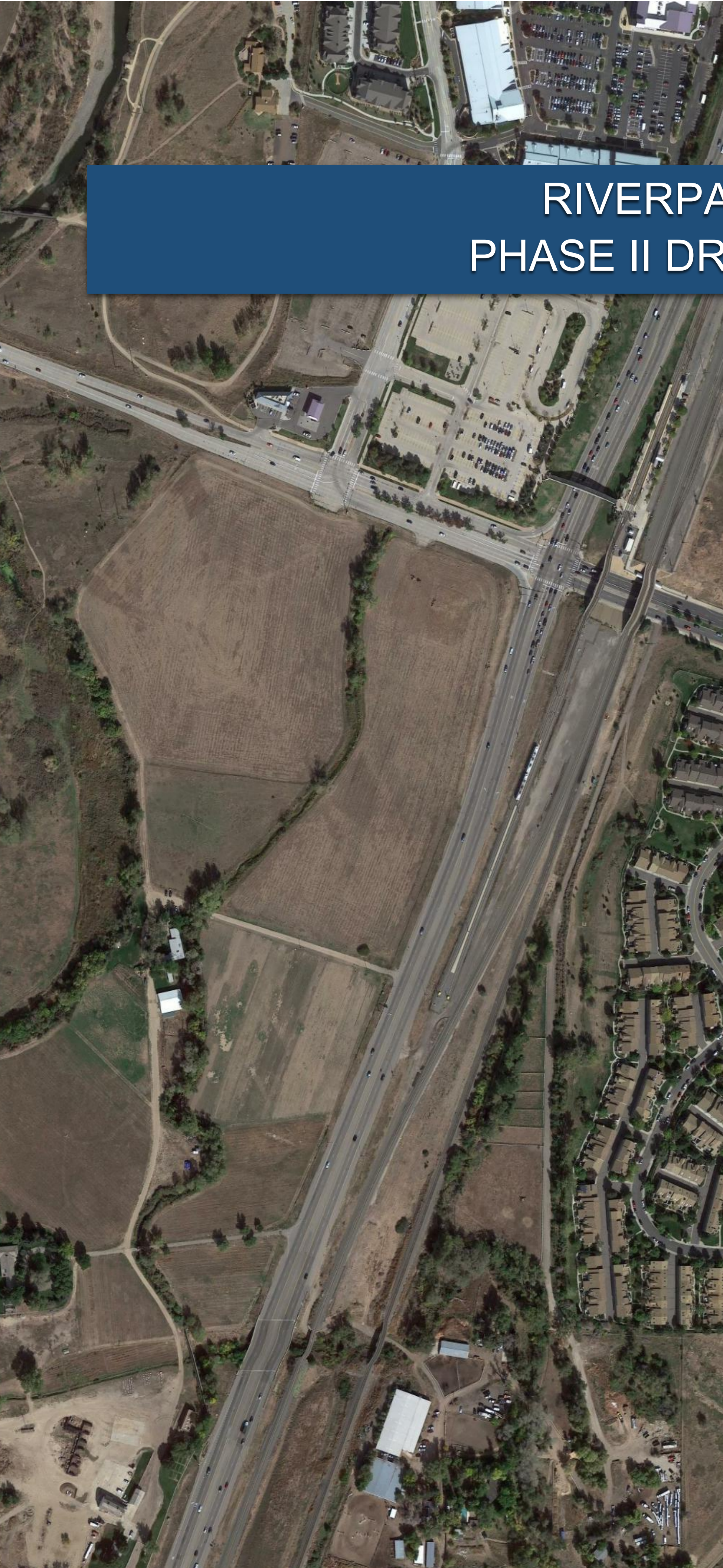
RIVERPARK SUBDIVISION
PHASE II DRAINAGE REPORT



HARRIS KOCHER SMITH

DENVER • DALLAS/FORT WORTH

PHASE II DRAINAGE REPORT

FOR

RiverPark Subdivision
at
South Santa Fe Drive and West Mineral Avenue
Arapahoe County, CO

November 2018
Revised August 2019

Prepared for:
Evergreen Development
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Harris Kocher Smith Project No. 160605

ENGINEERS CERTIFICATION

"I hereby certify that this report and plan for the Phase II drainage design of the RiverPark Subdivision was prepared by me (or under my direct supervision) in accordance with the provisions of City of Littleton Storm Drainage Design and Technical Criteria for the owners thereof. I understand that City of Littleton does not and will not assume liability for drainage facilities designed by others."

____

Mark A. West, P.E., C.F.M.

State of Colorado Registration No. 38561

On behalf of Harris Kocher Smith

Evergreen Development hereby certifies that the drainage facilities for the RiverPark Subdivision shall be constructed according to the design presented in this report. I understand that the City of Littleton does not and will not assume the liability for the drainage facilities designed and/or certified by my engineer. I understand that the City of Littleton reviews drainage plans but cannot, on behalf of the RiverPark Subdivision, guarantee that final drainage design review will absolve Evergreen Development and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the Final Plat and/or Final Development Plan does not imply approval of my engineer's drainage design".

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Name of Developer

____

Authorized Signature Date

I. INTRODUCTION

A. Background

The purpose of this report by Harris Kocher Smith is to document the methods, procedures and calculations used in the development of RiverPark Subdivision.

B. Project Location

The proposed RiverPark North Subdivision project (hereinafter referred to as "Site") is located in the Northwest ¼ of Section 32, Township 5 South, Range 68 West of the 6th Principal Meridian, County of Arapahoe, State of Colorado. The Site is platted land known as Lot 1, Block 1 of the Santa Fe Park Filing No.1 (Rec #93-161781). The Site is bounded by West Mineral Avenue on the north, by undeveloped land on the south, South Santa Fe Drive to the east, and by the South Platte River on the west. The site is highlighted in the Vicinity Map included in Appendix A for reference.

C. Property Description

The Site is comprised of approximately 33.3 acres. Ground cover within the Site is primarily native sandy soil with some native grasses and weeds. The site currently operates with light farming activities. The entire Site generally slopes west to the South Platte at grades of 1% to 10%. According to the National Resources Conservation Service's Soil Survey for the Arapahoe County Area, Colorado the soil type within the Site is a combination of Fort Collins loam (FrB) and Nunn loam (NIB), and Terrace escarpments (Tc). The soils generally consist of very deep, well drained soils that formed in mixed eolian sediments and alluvium. The SCS hydrologic soil group for sandy loams is Group C. A copy of the Custom Soil Resource Report is included in Appendix A for reference.

Existing off-site utility drainage infrastructure includes a 60" RCP storm outfall system on the north side of Mineral Avenue which discharges into an open natural channel and ultimately outfalls into the South Platte River just off the northwest corner of the Site. The Englewood Ditch traverses the site running south to north. The entire Site lies within the Jackass Gulch (JAG) major drainage basin, which is tributary to the South Platte River directly downstream of the Site.

The nature of proposed development is envisioned to be commercial and residential distributed throughout site. This report is part of a Subdivision for the Site to further define development characteristics.

D. Previous Investigations

The Site is shown to be in a Zone X (unshaded) Flood Area according to FIRM map 08035C0434K, Arapahoe County, Colorado, December 17, 2010. Zone X (unshaded) is described in this map as areas determined to be outside 500-year flood plain. A copy of the Site FIRMette map is in Appendix A.

Additionally, the following documents present previous hydrologic and hydraulic investigations of the Site:

- Flood Hazard Area Delineation (FHAD) Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. dated November 1990.

- Outfall Systems Plan (OSP) Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. dated February 1991.

- Santa Fe Park North Use by Special Exception, City of Littleton Case No. ENG17-0005

II. DRAINAGE SYSTEM DESCRIPTION

A. Existing Drainage Conditions

The Site consists of undeveloped land covered in native grasses and weeds. Stormwater runoff from the Site travels overland west and discharges into the South Platte River floodplain directly west of the Site. The Englewood Ditch traverses the site running south to north; however, larger storms will overtop these facilities and follow the overall drainage patterns.

Developed flows will mimic existing flow patterns. Channelization of the routed JAG developed flows through the off-site detention pond will help to mitigate the existing flooding effects on the Site caused by the 100-year storm event. A table has been provided on the Drainage Plan included in the Appendix G of this report to summarize both the pre-developed and developed peak flows for the Site.

B. Master Drainage Basin

The entire Site lies within the Jackass Gulch major drainage basin, which is tributary to the South Platte River directly downstream of the Site. The upstream basin is fully developed primarily as single-family housing in the central portions with a small amount of multifamily residential, commercial, and light industrial uses on the east ends of the basin.

The storm drainage system in the area consists of a natural channel, and portions of the middle reach are currently part of the Jackass Gulch Stabilization Project underway by the UDFCD. All of the existing developments in the upper basin have been designed to detain stormwater runoff for the 100-year event with private on-site storm sewer facilities. The lower basin (west of Santa Fe Drive) is a commercial area and has a 60" RCP storm outfall system which discharges into an open channel which outfalls to the South Platte River just off the northwest corner of the Site.

The lower half of Jackass Gulch is a well-defined drainageway with a preserved floodplain area adjacent to Mineral Avenue. The (JAG) major drainageway is studied in the Dad Clark Gulch Lower and DFA 0068 Flood Hazard Area Delineation (FHAD) and Outfall Systems Plan (OSP) dated 1990 and 1991 respectively. An excerpt from the referenced FHAD drainage report can be found in Appendix B.

C. Offsite Tributary Area

The FHAD and OSP detail that 100-year storm event flood waters will pond at the intersection of Santa Fe Drive and Mineral Avenue to a depth of approximately 7 feet. This ponding of Jackass Gulch overflows west into the Site at a high point in Mineral Avenue, creating a 100-year flow path and shallow overflow area through the Site.

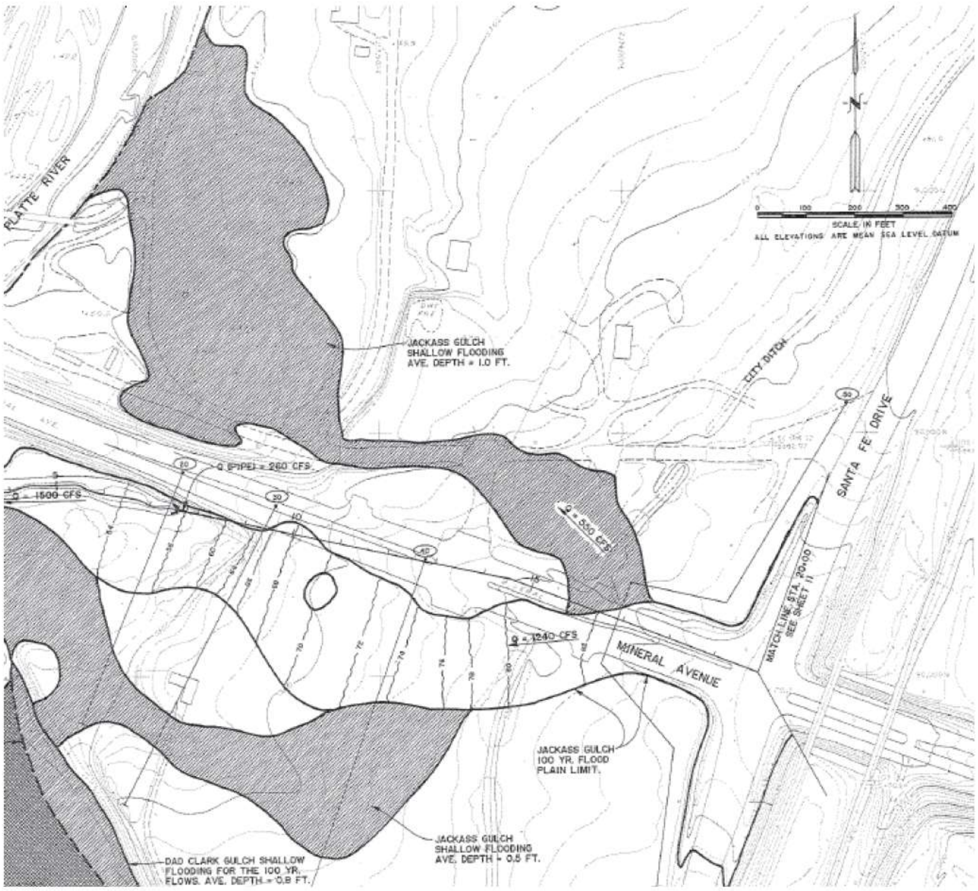


Figure 1: 1990 FHAD at Site

In the proposed condition, the JAG will be channelized on the south side of Mineral Avenue. At the downstream end of the channel these flows enter to an off-site detention and water quality pond, which will act as a flow spreader to distribute flows to the South Platte River floodplain in a pattern echoing historic conditions. This system was conceptually designed and approved by the City of Littleton with a Use by Special Exception Process further described below.

D. Approved Floodplain Use by Special Exception

A Floodplain Use by Special Exception, Case Number: ENG17-0005, was developed for the site updating the floodplain limits shown in the FHAD study. The approved Use by Special Exception Documents are included in Appendix C.

E. Proposed Drainage System Description

The site area will be mixed use development with associated access, drives, curbs, sidewalks, and building. Stormwater runoff from rooftops will enter roof drains and release directly to adjacent pavements or be collected in downspouts and piped to storm sewer mains. The site will contain drive isles and parking areas that will collect the roof drain, sidewalk, and open area runoff to gutters and curbs. The design will seek to minimize directly connected impervious areas by routing roof flows through sidewalk chase drains to shallow swales before releasing to storm sewers. Where gutters and curbs reach their capacity to convey the runoff, storm sewer inlets will be placed to intercept the stormwater and route the developed flow to an off-site detention pond bounded by the South Platte River and the Beaver Pond wetlands.

1. Site Drainage Basins

The site has been delineated as three overall drainage basins for the purpose of this Phase II Report and is shown on Final Drainage Plan (see Appendix G) and further described below.

Basin A (10.75 acres) is in the east portion of the Site and will consist of roof area, pavements, and landscaped areas. The site will consist of small to medium sized buildings with associated access, drives, curbs, sidewalks. Peak runoff rates for the 5-year minor and 100-year major event were determined for this basin to be 22.78 cfs and 62.81 cfs respectively. Runoff will be routed to Design Point 1 (DP1) and ultimately released into the off-site water and detention quality pond.

Basin B (13.04 acres) is in the west portion of the Site and will consist of roof area, pavements, and landscaped areas. The site will consist of small to medium sized buildings with associated access, drives, curbs, sidewalks. Peak runoff rates for the 5-year minor and 100-year major event were determined for this basin to be 26.66 cfs and 49.97 cfs respectively. Runoff will be routed to DP2 and ultimately released into the off-site water quality and detention pond.

Basin C (9.55 acres) is in the south east portion of the Site and will consist of roof area, pavements, and landscaped areas. The site will consist of small to medium sized buildings with associated access, drives, curbs, sidewalks. Peak runoff rates for the 5-year minor and 100-year major event were determined for this basin to be 18.52 cfs and 42.10 cfs respectively. Runoff will be routed to DP3 and ultimately released into the off-site water quality and detention pond.

2. Updated Jackass Gulch Floodplain Hydraulics Analysis

To mitigate the JAG flooding effects on the Site, it is proposed that the flows in Jackass Gulch be routed to a channel south of Mineral Avenue to provide safe conveyance for the Jackass Gulch flows west to the outfall in the off-site detention pond at the northwest corner of the site. A box culvert is utilized to facilitate the connection of South Platte River Drive thru the Site, and hydraulic drop structures are required to control grade and dissipate energy.

The proposed JAG channel was initially approved with a Floodplain Use by Special Exception, Case Number: ENG17-0005. Mapping for the Use by Special Exception study was developed for the site initially using available LiDAR data to supplement the existing FHAD study topography. Following the Floodplain Use by Special Exception study, further site investigation was performed. Additional survey data collected during this investigation was used to develop a more accurate terrain surface. The current existing floodplain delineation is based on the updated topography which more accurately reflects existing site conditions.

A summary of the revisions to the approved Floodplain Use by Special Exception, Case Number: ENG17-0005 are as follows:

- Existing topography revisions per updated survey
    - Revised exiting floodplain elevations
- Addition of a third lower drop structure as entrance to detention pond
- Pools added to downstream ends of drop structures
- Removal of TRM in channel
- Minor revisions to drop structure placement and channel grades

The JAG channel and detention pond design is further described below.

Channel Design

The proposed grass lined channel is situated directly south of Mineral Avenue to capture JAG flows and provide safe conveyance for JAG west to the outfall through the off-site detention pond. Three grouted boulder drops structures into and out of a proposed culvert at S. Platte Parkway, and into the proposed detention pond are added to control grade, dissipate energy, slow outlet velocities, and improve the vertical transitions.

Parameters such as flowrate, channel section geometry, roughness coefficients, and main channel bank stations were input into a one-dimensional steady flow HEC-RAS model to analyze existing and proposed conditions. HEC-RAS cross sections were placed frequently along the channel perpendicular to the channel centerline and water flow path to adequately evaluate the design hydraulic characteristics. A Floodplain Workmap indicating hydraulic cross section locations and floodplain limits is included in the Appendix F.

The design for this reach of the Jackass Gulch channel will conform to a high functioning low maintenance (HFLM) design approach and will seek to armor the channel and drop structures as needed to provide protection from all flow events.

Per the UDFCD Criteria Manual prudent values for channel hydraulic parameters below:

Design Parameter	Cohesive Soils and Vegetation
Maximum Froude number	0.80
Maximum 100-year Flow velocity (average of section)	7 ft/s
Maximum Depth outside bankfull channel	5 ft

With the proposed channel revisions in place, the design meets the above design parameters for Froude Number and Maximum Velocity. Isolated areas around the drop structures where the flow becomes critical do not meet these criteria, and these areas are protected with hard riprap armoring located in the channel bottom, sides, and in the pools of the Drop Structures as further described below. The constructed channel meets the 5-foot maximum depth in all locations.

Channel Vegetation

The channel will be planted with appropriate grasses to establish vegetation along the channel and its banks to retain cohesion of the mat and provide a stable substrate for the anticipated flowrates. The final design of the channel grasses will be based on site specific soil conditions. Channel grasses will be maintained post-construction to ensure vegetation is established.

Channel Drop Structures

Drop Structures are proposed in the channel and are design to be Grouted Sloping Boulder (GSB) drops per Section 2.2, UDFCD Criteria Manual Volume 2 Chapter 9. The drops contain stilling basin elements and will be surrounded by void filled riprap. The upstream ends of the drops will have adequate seepage cutoff walls and a weep drain system installed.

Detention and Water Quality Facilities

Working with the City of Littleton and the South Suburban Parks and Recreation the ponds have been designed to have a natural look and blend into the open space. With the functionality of the facility to disperse delivery of frequent storm events to the Beaver Pond Wetland area to aid in maintaining wetland hydrology, an ecologist has been added to the project team and has prepared a wetland study investigating the effects and benefits of the water delivery to the Beaver Pond wetlands. This report is submitted with the ADP under a separate cover.

The off-site detention and water quality pond is situated just west of the lower south east corner of the Site. This pond is designed to contain the water quality capture volume WQCV for the site in an upper basin which outlets southeast into the natural low terrace to provide hydrology to the degraded Beaver wetlands.

The water quality pond will contain a grasscrete forebay, soft bottom trickle channel and spillway which will all be constructed to meet current City of Littleton and UDFCD design standards for an Extended Detention Basins (EDB). The off-site detention pond will contain a grass swale with underdrain BMP and outlet structure to provide additional water quality treatment and full spectrum detention. Both will contain outlet structures that will release stormwater from the developed site at reduced rates into the adjacent wetlands.

Flows within the WQ pond will be released through a concrete outlet structure and pipe into the adjacent Beaver Pond wetlands at a modified release rate. Flow in excess of the WQCV release will spill into the main detention pond. The two ponds are designed to function together to provide full spectrum detention for the Site. The off-site detention pond is designed to detain the full 100-year detention volume required for the site and release at a modified release rate into the adjacent wetlands through a separate outlet structure and pipe.

Detention Pond and JAG Hydraulics

The JAG channel terminates into the proposed detention pond to be constructed off-site to the west in an area owned by the City of Littleton and maintained as Open Space by South Suburban Parks and Recreation. This pond is also the outlet for the Site storm sewer infrastructure and provides Site stormwater detention. The timing of incoming storm hydrograph peaks into the pond were examined to ensure that the detention pond functions to spread incoming JAG flows during major events.

The detention pond is designed to fill faster than the peak of the JAG hydrograph, meaning the pond has a long duration in which the pond is full following an event. This will improve the function of the pond to provide JAG overflows through the spillway to the detention pond, which is designed to spread flows across the floodplain to echo historic conditions. For further information regarding the pond design see the detention facilities portion of section D below.

Peak flow timing was determined for the JAG channel into the detention pond from CUHP and SWMM prepared for the JAG basin as outlined in the OSP. This modeling indicates that the 100-year storm peak for the JAG watershed reaches the proposed detention pond in approximately 50 minutes. The JAG channel has potential to be active during storms in excess of the 10-year event.

Rational method calculations indicate that the Site will drain to the detention pond in approximately 22 minutes. The UD Detention design workbook prepared for the detention ponds indicates that pond has a drain time of over 21 hours for storms in excess of the 10-year event.

As the pond will fill faster than the peak of the JAG hydrograph reaches the pond, and the pond is full for long durations after an event, the pond will function to provide JAG overflows through the spillway of the detention pond, which is designed to spread flows across the floodplain to echo historic conditions.

The final locations of the outlet structures for the ponds are dependent on existing topography within the wetlands and the ability to outlet each pond into the wetlands at a reasonable slope, with adequate cover and pipe capacity. A spillway has been added near the adjacent wetlands to spill flows in excess of the 100-year into the wetlands.

Maintenance access has been provided near the northeast side of the water quality pond. Existing overhead electric distribution lines as well as sanitary sewer lines and appurtenances are also located in the proposed pond area, and have been left at existing grades as to not disturb this infrastructure. Drainage easements will be provided for the proposed 60" irrigation line relocation through the site, for the off-site ponds for maintenance, and for the JAG channel.

The final report will contain a completed Stormwater Detention and Infiltration design data sheet to indicate compliance with CRS 37-92-602(8).

3. Englewood Ditch

The constructed JAG channel will cross the proposed Englewood Ditch irrigation line that will be partially relocated with this project. The existing irrigation open channel that traverses the Site will be piped, and will tie to the existing 54" RCP outlet at the northern border of the site directly south of Mineral Avenue. The elevation of the crossing is shown in the Channel Plan and Profile indicating its constraint on the vertical placement of the channel. A box culvert is proposed for the irrigation channel as it crosses the JAG channel in order to provide an increased channel depth over the crossing. A concrete junction structure upstream of the JAG channel will transition the Englewood Ditch to a box culvert under the proposed JAG channel. Correspondence with the City Ditch indicates the intent to work with the property owner in allowing them to modify the City owned ditch to get the most use possible out of their property. The current design is to be submitted to Englewood on 6/28/2019, and further correspondence will be shared with City of Littleton upon receipt from Englewood.

F. Drainage Facility Maintenance

General Facility Description

This facility consists of one water quality pond to provide WQCV and one regional detention pond to provide EURV and flood control. Inflows are generated through surface runoff from the surrounding development. In the major event, flows from Jackass Gulch will enter and overtop the detention facility in the major event, effectively spreading flows to mimic historic conditions. Both ponds release to the Beaver Pond Wetlands and the South Platte River to the southwest of the site. City policy requires that safe maintenance access for vehicles be provided to all storm drainage facilities to assure continuous operational capability of the system

Maintenance Responsibility

The property owner or a future assigned metro-district type entity will provide maintenance for the ponds.

Outline of Maintenance and Operations Procedures

1. Maintenance Frequency

   Routine maintenance tasks, including mowing and debris removal, should be performed on an as-needed basis. Debris removal should be done prior to the summer storm season and following significant rainfall events. In addition, the property owner should perform a site inspection on an annual basis to evaluate the need for additional maintenance, including sediment removal, erosion control, revegetation, and structural repairs. If additional maintenance is required, the property owner may request assistance from UDFCD.

2. Equipment and special tools required:

   Submersible Pump/ Generator
   Long-reach rake or broom (7ft)
   Long-reach track excavator
   Skid steer
   Dump Truck

Maintenance Procedure

1. **Dewatering**

   These ponds have no natural baseflow, but will receive storm and irrigation runoff on a frequent basis. Permanent pools form in the micropool and forebay. These two areas must be pumped to dewater. If pump does not have fine screening at the intake, alternately pump from one pool to the other to prevent sediment-laden discharge.

2. **Sediment Removal**

   Sediment must be removed from the forebay and micropool when they have reached ¾ capacities. The grasscrete-lined forebay is accessed form a maintenance ramp off the maintenance road, and can be cleaned with a skid-steer or loader. Hand removal may be necessary adjacent to the vertical walls. The micropool can be cleaned with a long-reach excavator or backhoe from the maintenance road.

3. **Debris removal**

   Debris buildup is expected at all trash racks and water quality screens. All debris should be collected and disposed offsite.

4. **Site Inspection**

   The following items should be inspected a minimum of once per year and maintained as needed:

   General:

   Soft Bottom Trickle Channels

   Maintenance Road

   Erosion

   Vegetation

Equipment and Structures

Forebay

Grasscrete Slab

Grass Plugs

Earthen Containment Berm

9” Reinforced Concrete Pipe

54” Reinforced Concrete Pipe

WQ Outlet Structure

Concrete Structure

Overflow Grate

Trash Racks

Water Quality Screen

Orifice Plate

48” Reinforced Concrete Pipe

12” Reinforced Concrete Pipe

100-Yr Outlet Structure

Concrete Structure

Overflow Grate

Trash Racks

Water Quality Screen

Orifice Plate

48” Reinforced Concrete Pipe

5. Post-Maintenance Considerations

Following completion of maintenance activities, all debris, trash, and excavated sediment must be removed offsite. If necessary, All paved surfaces including public roads along the access route must be swept clean.

III. DRAINAGE ANALYSIS & DESIGN CRITERIA

A. Regulations

The principal design criteria used for this study were:

1. City of Littleton Storm Drainage Design and Technical Criteria (Littleton SDDTC) Revised July 2019.

2. Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual, Vol. 1 Revised March 2017

3. Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual, Vol. 2 Revised September 2017

4. Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual, Vol. 3 Revised April 2018

B. Development Criteria

There are no major drainage constraints for the Site. The City of Littleton requests that discharge from off-site detention and water quality be used to recharge the adjacent wetlands.

C. Hydrologic Criteria

Runoff Calculation

The Rational Method is used to determine runoff peak discharges for watersheds up to 160-acres in size and was used for the on-site analysis. Sections 2.2 and 2.3 in the Runoff chapter of Volume 1 of the UDFCD Manual provide detailed explanations of the Rational Method and the use of the UD-Rational spreadsheet to complete Rational Method calculations. Result spreadsheets for the 5-year minor and 100-year major events are found in the Appendix D.

D. Hydraulic Criteria

The City of Littleton Strom Drainage Criteria Manual and the Urban Drainage Criteria Manuals were utilized in the analysis for culvert and storm sewer design.

Inlet Capacity

Inlet calculations will be included in the final Phase III drainage report.

Storm Sewer Sizing

Storm sewer sizing calculations will be included in the final Phase III drainage report.

Detention Volume

Required Storage Volumes for the proposed facility are calculated using the Full Spectrum Detention (FSD) method. FSD is a multi-stage detention method that considers several storm events to determine storage and water quality requirements. FSD calculates a 100-YR detention volume using equations specific to the UDFCD region. Excess Urban Runoff Volume (EURV) represents the difference in runoff produced by the change from an undeveloped to developed site condition. FSD releases the EURV over 72 hours.

To provide general sizing, the Detention Basin Volume Estimating Workbook, UD-Detention, from UDFCD was used to calculate 100 year detention volume and the Excess Urban Runoff Volume (EURV) for stormwater flows contained onsite. This analysis determined that both ponds will provide the required 3.79 acre-ft of volume. In order to provide the required detention volume for the site the water quality pond will have a depth of 7.85 ft and a surface area of 0.30 acres. The off-site detention pond will have a depth of 6.40 ft and a surface area of 1.09 acres. Calculations are provided in Appendix D for reference and results are shown on the Drainage Plan.

Open Channel and Culvert Capacity

The open channel capacity and water surface elevations for the JAG channel and the South Platte Parkway culvert were determined through the use of USACE HEC-RAS modeling software and flow rates from the historic FHAD for the site. Culvert capacity was determined initially through the use of FWHA HY8 modeling software, and then capacities were confirmed through the HEC-RAS modeling of the channel itself.

E. Variances from Criteria

No Variance is being requested.

IV. GRADING & EROSION & SEDIMENT CONTROL PLAN

A. Additional Site Information

According to the National Resources Conservation Service's Soil Survey for the Arapahoe County Area, Colorado the soil type within the Site is a combination of Fort Collins loam (FrB) and Nunn loam (NlB), and Terrace escarpments (Tc). The soils generally consist of very deep, well drained soils that formed in mixed eolian sediments and alluvium. The SCS hydrologic soil group for sandy loams is Group C. A copy of the Custom Soil Resource Report is included in Appendix A for reference.

B. Erosion Control Measures

During construction there will be a storm water quality control plan for this site following the City's Grading, Erosion and Sediment Control (GESC) and Drainage, Erosion and Sediment Control (DESC) manuals and permits. Several Best Management Practices (BMPs) will be implemented. Appropriate construction limits will be surrounded by silt fence. The construction entrances will have Vehicle Tracking Control to limit the spreading of debris onto the existing streets. Inlet protection will be placed around all existing and proposed inlets within the site and adjacent to the site. All of these will allow the storm water quality to be increased before leaving the Site and will allow the standards of the Storm Water Quality Specifications to be met during construction.

Anticipated sources of wastewater pollution include:

- Surface Disturbance
- Storage of Pesticides, Herbicides and Fertilizers during construction
- Storage of Construction Equipment
- Concrete Washout Areas
- Vehicle Tracking of Sediment
- On-Site Waste Storage

Most of these activities will occur daily and the level of toxicity and concentration is minimal. These activities will take place on the existing vegetation until proposed parking areas are constructed. When pavements are in place, all storage and washout areas will be located on pavement. Provisions have been made to reduce or eliminate their effect on the stormwater leaving the site. Non-Structural BMPs will be maintained during construction. Structural BMPs will be constructed and maintained after construction.

The following BMPs will be implemented to increase the storm water quality before leaving our site and to allow the standards of the GESC and DESC manuals to be met during construction. Anticipated BMPs are described in more detail below.

Structural BMPs

- Water Quality provided by the proposed detention and water quality pond

Non-Structural BMPs

- Preventative Maintenance
- Spill Response Procedures
- Preservation of Natural Vegetation
- Schedule of Activities
- Prohibition of Specific Practices

General BMP Specifications

1. Permanent stabilization will be achieved when site landscape is installed and all hardscape construction paving and walks is complete. Permanent, post-construction water quality for the site will be provided by the onsite detention and water quality pond.

2. Soil will not be stockpiled on the site after construction. Stockpiles to be left inactive for 30 days must be mulch and tacked. A layer of suitable mulch is to be applied to all disturbed portions of the site within 7 days after land disturbances have temporarily or permanently ceased. This mulch is to be applied and tacked or fastened by an approved method suitable for the type of mulch used. All soils must be protected from wind and water erosion from the time grading is completed until permanent landscape is applied with any of the following: mulching, temporary revegetation, or erosion control matting and geotextiles.

3. All storm piping must be installed in conjunction with overlot grading. As the storm sewer inlets are being installed, the appropriate inlet protection devices shall be placed. During overlot grading, a predefined, bermed containment area for the cleaning of concrete truck chutes will be created onsite. The placement of the concrete washout area will be determined by the contractor. During curb and gutter or street work in the private drive or any public right of way, the contractor shall protect all storm sewer facilities adjacent to any location where pavement cutting operations or any operations may discharge waste products to the storm sewer.

4. Silt fences are to be placed around the perimeter of the site on the downstream side to prohibit sediment from leaving the site. Vehicle Tracking Control (VTC) is to be placed at entrances to the site for a width of 24 feet, or wide enough to cover the entire width of the entrance, and a minimum of 60 feet long. Approved BMPs are to be placed around outside storage areas during construction and all outside storage areas are to be covered to eliminate contact with stormwater. It is not anticipated that the outside storage areas will contain any toxic materials. Equipment

maintenance and fueling are not anticipated to occur on site. The placement of these BMPs will be shown in the Grading, Drainage and Erosion Control Plan to be prepared with the site construction plans.

5. The only anticipated sources of pollution include stormwater runoff and irrigation. Based on the topography and soils in the area, dewatering of groundwater is not anticipated to be required during construction.

6. In the event that dewatering is required the contractor shall discharge any runoff to an onsite sediment trap and allow this water to permeate into the soil. There will not be any loading or unloading of toxic chemicals or any outside storage of toxic chemicals on site. All loading, unloading and storage areas are to be at least 100 feet from any storm inlet when possible.

7. The adjacent streets shall be cleaned daily. This includes cleaning all mud and sediment that is tracked onto public streets by the Owner, Site Developer, contractor, and/or their authorized agents. Street cleaning will include shoveling and sweeping with special care taken to ensure that no sediment is washed down unprotected inlets into the storm sewer system.

8. Trash will be disposed of in an approved container stored on site. Disposal and pick up of trash will be addressed by the contractor. Contractor is responsible for proper placement, staking, maintenance, and cleaning of porta-toilets. Spills of construction-related materials such as trash or waste from porta-toilets will be cleaned up immediately and disposed of properly. Site trash must be cleaned and placed in designated dumpsters at the end of each day.

9. All BMPs must be checked and maintained every 7 days and no more than 24-hours after any precipitation or snowmelt event. Sediment must be cleaned from straw bales, wattles and silt fences every 7 days, no more than 24-hours after any precipitation or snowmelt event and when there is sediment built up to ensure that

all BMPs are operational and maintaining an acceptable level of sediment behind the inlet protection. The construction site perimeter, all disturbed areas and all areas used for storage or cleanout must be inspected per the timing listed above for all BMPs. A record of all inspection forms and maintenance operations must be kept on site.

10. The owner understands that additional erosion control measures may be needed if unforeseen erosion problems occur or if the submitted plan does not function as intended. The requirements of this plan shall run with the land and be the obligation of the landowner until such time as the plan is properly completed, modified or voided.

C. Schedule

1. Install construction entrance with VTC
2. Install silt fence
3. Install temporary sediment basin above existing basin
4. Begin overlot grading
5. Install storm piping
6. Install inlet protection and straw bales
7. Build concrete truck cleaning containment areas
8. Soil stabilization/mulching
9. Complete site construction
10. Remove VTC once parking and delivery areas are paved
11. Remove silt fence and inlet protection after landscaping is established and hardscape construction is complete
12. BMP maintenance and inspections, as needed

D. Maintenance

Erosion Control Measure inspection and maintenance shall be performed in accordance with Arapahoe County Grading, Erosion, and Sediment Control Manual section 6.2.

V. CONCLUSIONS

A. Compliance with Criteria

This Site's conceptual drainage design complies with the City of Littleton Storm Drainage Design and Technical Criteria and the Urban Storm Drainage Criteria Manuals. Tables 2E and 2D have been included from the City of Littleton Storm Drainage Design and Technical Criteria in Appendix H.

B. Design Effectiveness

The developed flows will be detained in the off-site detention pond and released at a modified release rate into the Beaver Pond wetlands. The water quality pond will provide water treatment for the site and discharge at a modified release rate into the wetlands providing an additional benefit. Developed flows will be detained and released at comparable rates to existing.

C. Areas in Flood Hazard Zone

This Site does not lie within a FEMA regulatory floodplain. However, the Site is subject to flooding as outlined in the UDFCD Flood Hazard Area Delineation (FHAD) for the Jackass Gulch drainageway.

VI. REFERENCES

1. City of Littleton Storm Drainage Design and Technical Criteria (Littleton SDDTC) Revised July 2019

2. Urban Storm Drainage Criteria Manual, Vol. 1 and Vol. 2, Urban Drainage and Flood Control District, 2017.

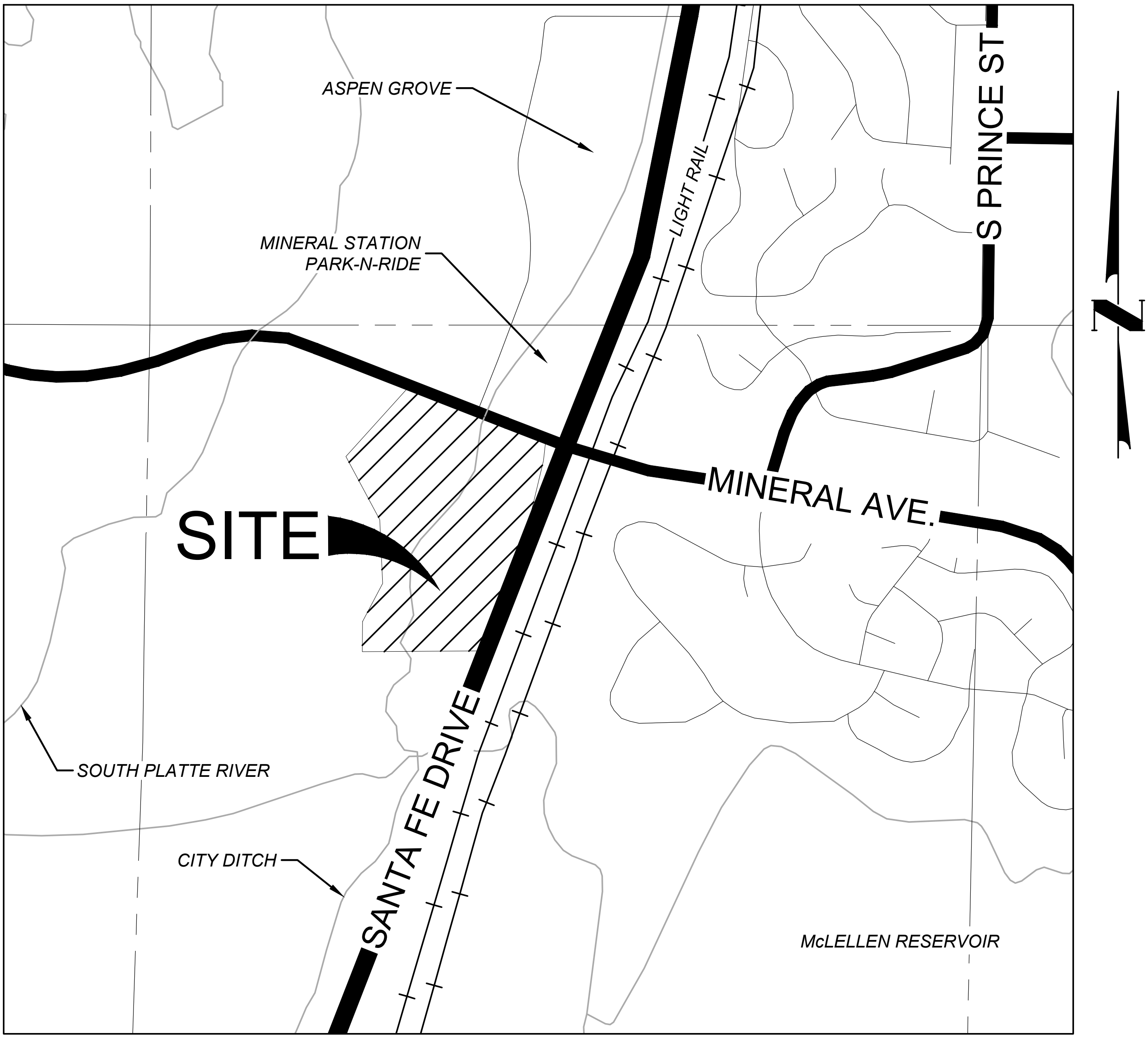
3. Urban Storm Drainage Criteria Manual, Vol. 3, Urban Drainage and Flood Control District, November 2010 and November 2015.

4. FIRM map 08035C0434K, Arapahoe County, Colorado, December 17, 2010, Federal Emergency Management Agency.

5. Flood Hazard Area Delineation (FHAD) Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. dated November 1990.

6. Outfall Systems Plan (OSP) Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. dated February 1991.

APPENDIX A – VICINITY MAP, FIRM MAP AND SOIL SURVEY



VICINITY MAP

SCALE: 1" = 1,000'

National Flood Hazard Layer FIRMette

FEMA

39°34'54.21"N

105°1'59.46"W

105°1'22.00"W

39°34'26.48"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 5/1/2019 at 11:12:12 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for

Arapahoe County, Colorado

Santa Fe and Mineral

April 17, 2017

Preface

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

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

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

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

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

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

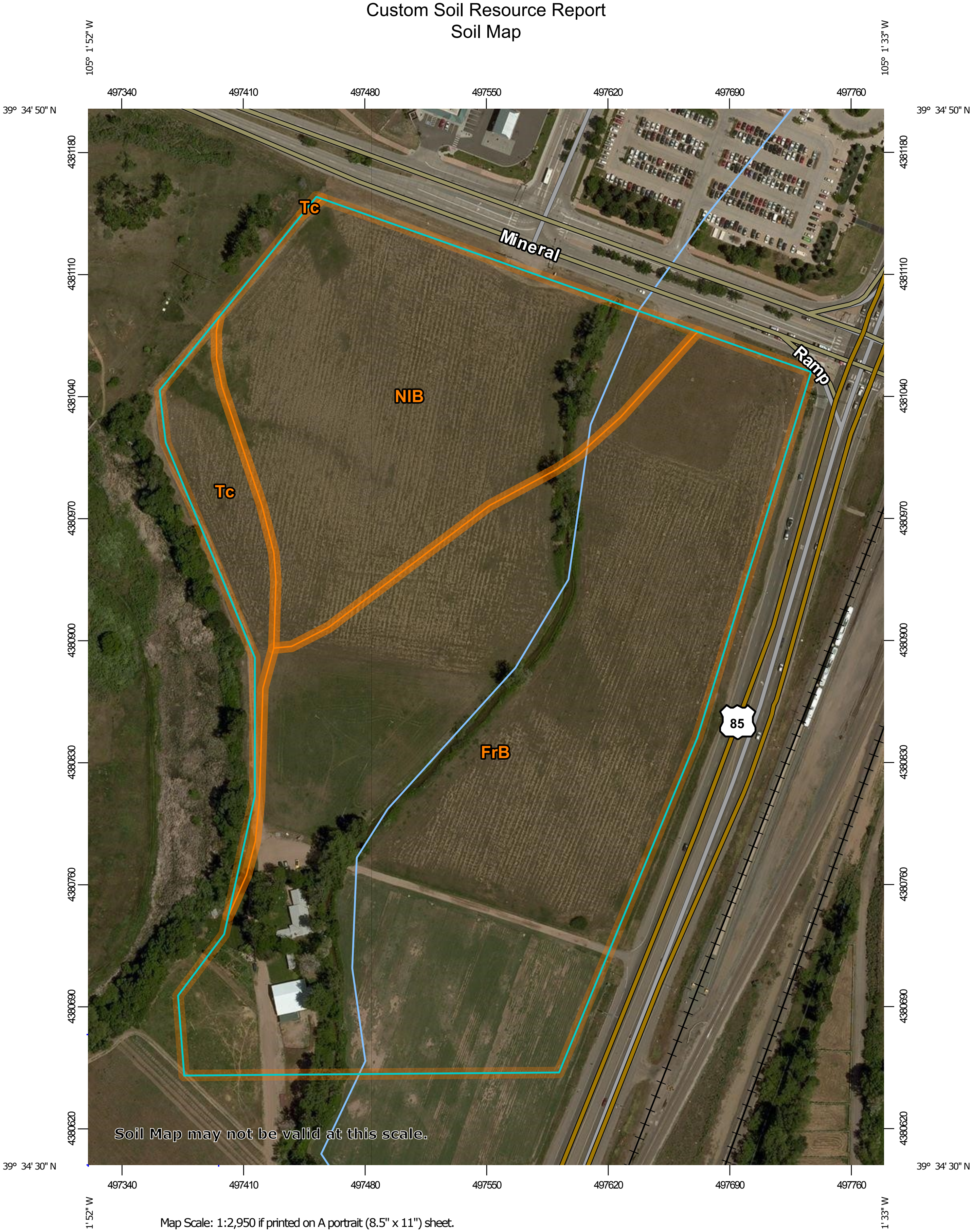
The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

Soil Map

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

Soil Map



Map Scale: 1:2,950 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 40, 80, 160, 240

Feet: 0, 100, 200, 400, 600

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

MAP LEGEND

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Arapahoe County, Colorado
Survey Area Data: Version 12, Sep 22, 2016

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

Date(s) aerial images were photographed: Jun 10, 2014—Aug 21, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Arapahoe County, Colorado (CO005)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
FrB	Fort Collins loam, 0 to 3 percent slopes	21.0	65.4%
NlB	Nunn loam, 1 to 3 percent slopes	9.5	29.6%
Tc	Terrace escarpments	1.6	5.1%
Totals for Area of Interest		**32.0**	**100.0%**

Map Unit Descriptions

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

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

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

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

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

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

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

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

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

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

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

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

Arapahoe County, Colorado

FrB—Fort Collins loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2tlnc
Elevation: 4,020 to 6,730 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 46 to 48 degrees F
Frost-free period: 143 to 154 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

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

Description of Fort Collins

Setting

Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pleistocene or older alluvium derived from igneous, metamorphic and sedimentary rock and/or eolian deposits

Typical profile

Ap - 0 to 4 inches: loam
Bt1 - 4 to 9 inches: clay loam
Bt2 - 9 to 16 inches: clay loam
Bk1 - 16 to 29 inches: loam
Bk2 - 29 to 80 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 12 percent
Salinity, maximum in profile: Nonsaline (0.1 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 0.5
Available water storage in profile: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: Loamy Plains (R067BY002CO)
Hydric soil rating: No

Minor Components

Nunn

Percent of map unit: 10 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy Plains (R067BY002CO)
Hydric soil rating: No

Vona

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

NIB—Nunn loam, 1 to 3 percent slopes

Map Unit Setting

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

Map Unit Composition

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

Description of Nunn

Setting

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

Typical profile

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

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

Properties and qualities

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

Interpretive groups

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

Minor Components

Wages

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

Fort collins

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

Haverson, very rarely flooded

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

Tc—Terrace escarpments

Map Unit Setting

National map unit symbol: 34zj
Elevation: 3,500 to 6,500 feet
Mean annual precipitation: 12 to 15 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Terrace escarpments: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Terrace Escarpments

Setting

Landform: Terraces, cliffs, drainageways, streams
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous, stratified clayey and/or stratified, calcareous sandy

Typical profile

H1 - 0 to 3 inches: variable
H2 - 3 to 19 inches: sandy loam, loam, gravelly loam
H2 - 3 to 19 inches: weathered bedrock
H2 - 3 to 19 inches:
H3 - 19 to 24 inches:

Properties and qualities

Slope: 10 to 60 percent
Depth to restrictive feature: 10 to 30 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Hydric soil rating: No

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APPENDIX B – REFERENCE DRAINAGE REPORTS

FLOOD HAZARD AREA DELINEATION

LOWER DAD CLARK GULCH AND DFA 0068

URBAN DRAINAGE & FLOOD CONTROL DISTRICT

CITY OF LITTLETON

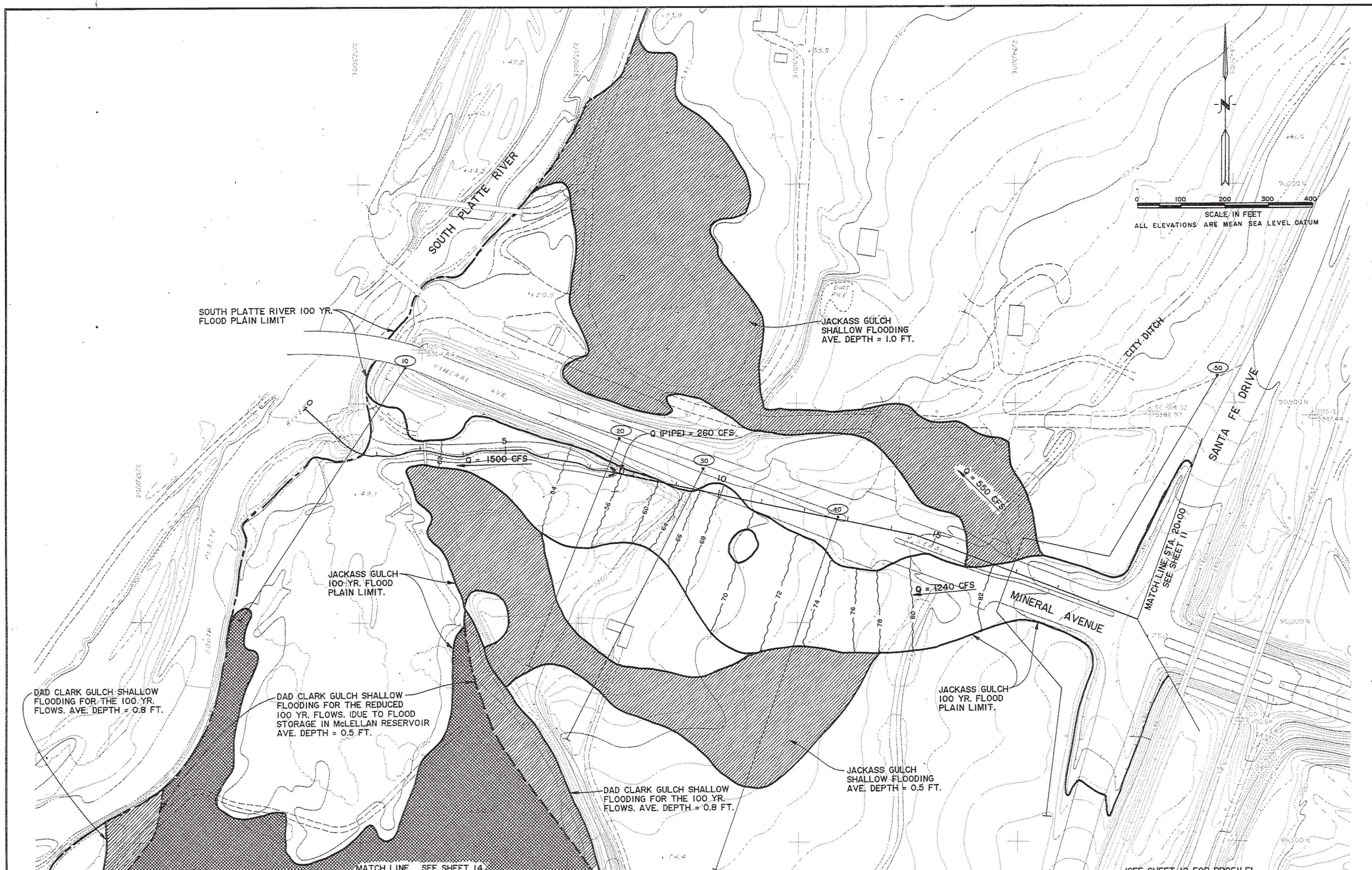
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT-69-

NOVEMBER 1990

CENTENNIAL ENGINEERING INC

TABLE B-1
(Continued)

Cross Section Number	Station[1/]	Stream Thalweg Elevation	Floodplain Data				Floodway Data					10-Year Data		50-Year Data	
			100-Year Discharge (cfs)	100-Year Water Surface Elevation	Floodplain Top Width (ft)	100-Year Channel Velocity (ft/sec)	Floodway Water Surface Elevation	Floodway Top Width (ft)	Floodway[2/] Width Left (ft)	Floodway[2/] Width Right (ft)	Floodway Channel Velocity (ft/sec)	Discharge (cfs)	Water Surface Elevation	Discharge (cfs)	Water Surface Elevation
JACKASS GULCH															
10	1+40	5348.6	1500	5350.4	518	6.4	FLOODWAY NOT DEFINED					690	5350.1	1170	5350.3
20	7+40	5349.5	1500	5354.6	213	5.5	"					690	5353.7	1170	5354.3
30	9+40	5362.0	1240	5365.5	170	6.0	"					430	5364.6	910	5365.1
40	12+80	5372.7	1240	5373.9	230	5.6	"					430	5373.4	910	5373.8
50	16+90	5380.2	1240	5382.1	240	4.5	"					430	5381.4	910	5381.8
60	26+60	5397.6	1240	5400.0	179	6.1	"					430	5399.2	910	5399.8
65	27+90	5413.0	1240	5413.7	433	4.5	"					430	5413.4	910	5413.6
70	30+65	5412.8	1500	5416.9	136	4.2	FLOODWAY IN CHANNEL					690	5416.0	1170	5416.7
75	33+05	5417.7	1500	5420.5	108	7.7	"					690	5419.7	1170	5420.2
85	34+80	5419.4	1300	5436.1	247	1.0	5436.1	88	33	55	1.2	640	5434.9	1070	5435.9
86	36+10	5424.0	1300	5436.1	131	1.7	5436.1	76	48	28	1.9	640	5434.9	1070	5435.9
90	41+50	5431.8	1300	5438.0	42	9.9	FLOODWAY IN CHANNEL					640	5436.6	1070	5437.6
95	48+20	5450.9	1300	5459.0	43	10.0	"					640	5456.3	1070	5458.4
100	54+25	5466.7	1300	5472.3	48	9.7	"					640	5471.0	1070	5471.9
105	60+00	5481.2	1300	5486.9	51	9.4	"					640	5485.6	1070	5486.5
110	61+75	5491.5	1300	5493.8	120	7.1	"					640	5493.1	1070	5493.6
115	69+40	5507.9	450	5511.0	61	6.3	"					180	5510.4	330	5510.8
120	73+15	5523.7	450	5525.6	55	6.4	FLOODWAY NOT DEFINED					180	5524.9	330	5525.3



GROUND CONTROL SURVEY BY LANDMARK, LTD.
AERIAL PHOTOGRAPHY BY SCHARF & ASSOC.
TOPOGRAPHIC MAPPING BY LANDMARK, LTD.
CONTOUR INTERVAL 2 FT DATE FLOWN 4-13-89

CENTENNIAL ENGINEERING INC
ARVADA CO. 80001 420-0221
CEI JN. 906.00

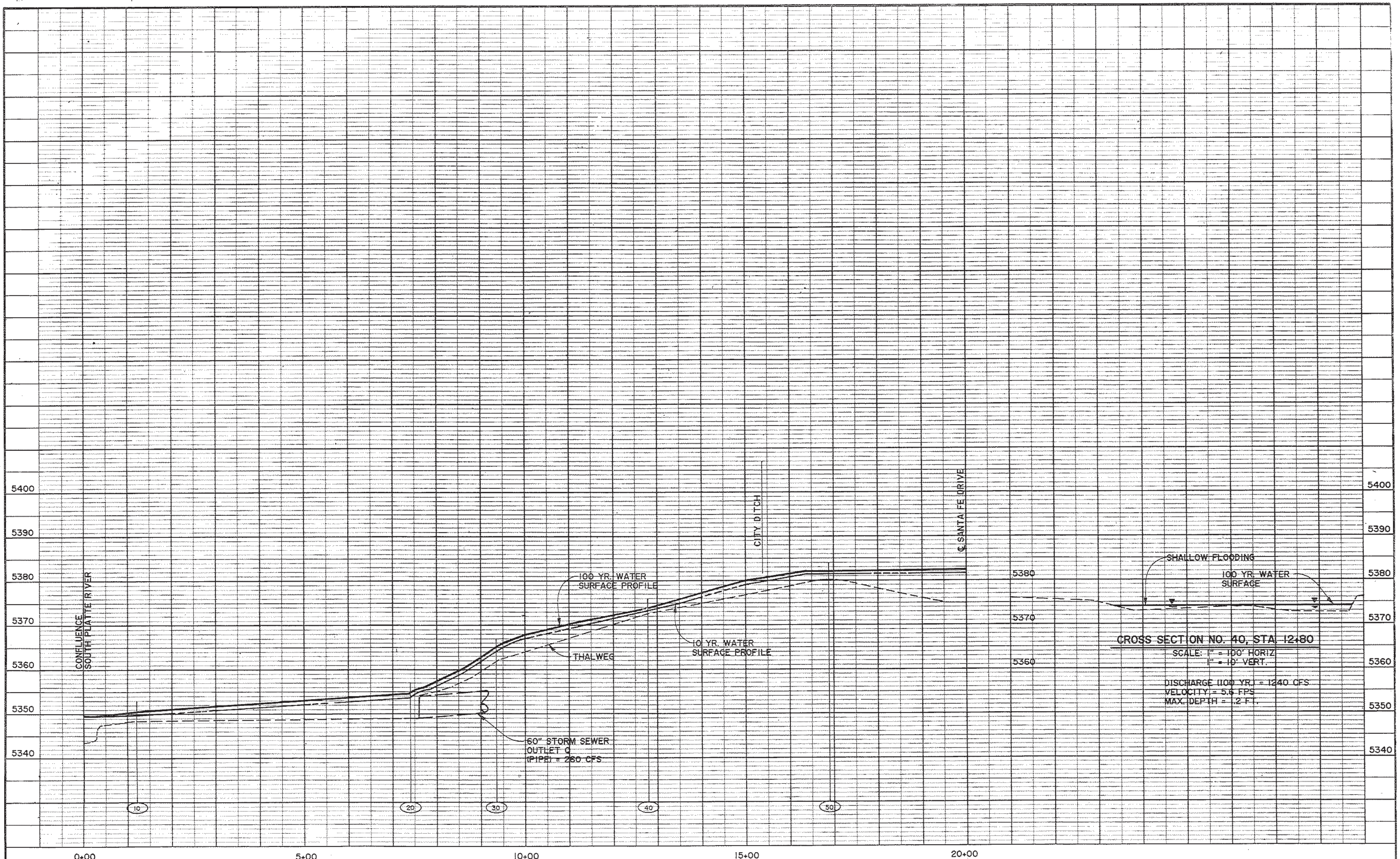
DESIGNED DJN DATE 4/90
DRAWN GGH DATE 7/90
CHECKED DLM DATE 7/90
REVISED DATE

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
CITY OF LITTLETON

FLOOD HAZARD AREA DELINEATION
LOWER DAD CLARK GULCH AND DFA 0068

PLAN
JACKASS GULCH
STA. 0+00 TO STA. 20+00

SHEET 9
OF 16



(SEE SHEET 9 FOR PLAN)

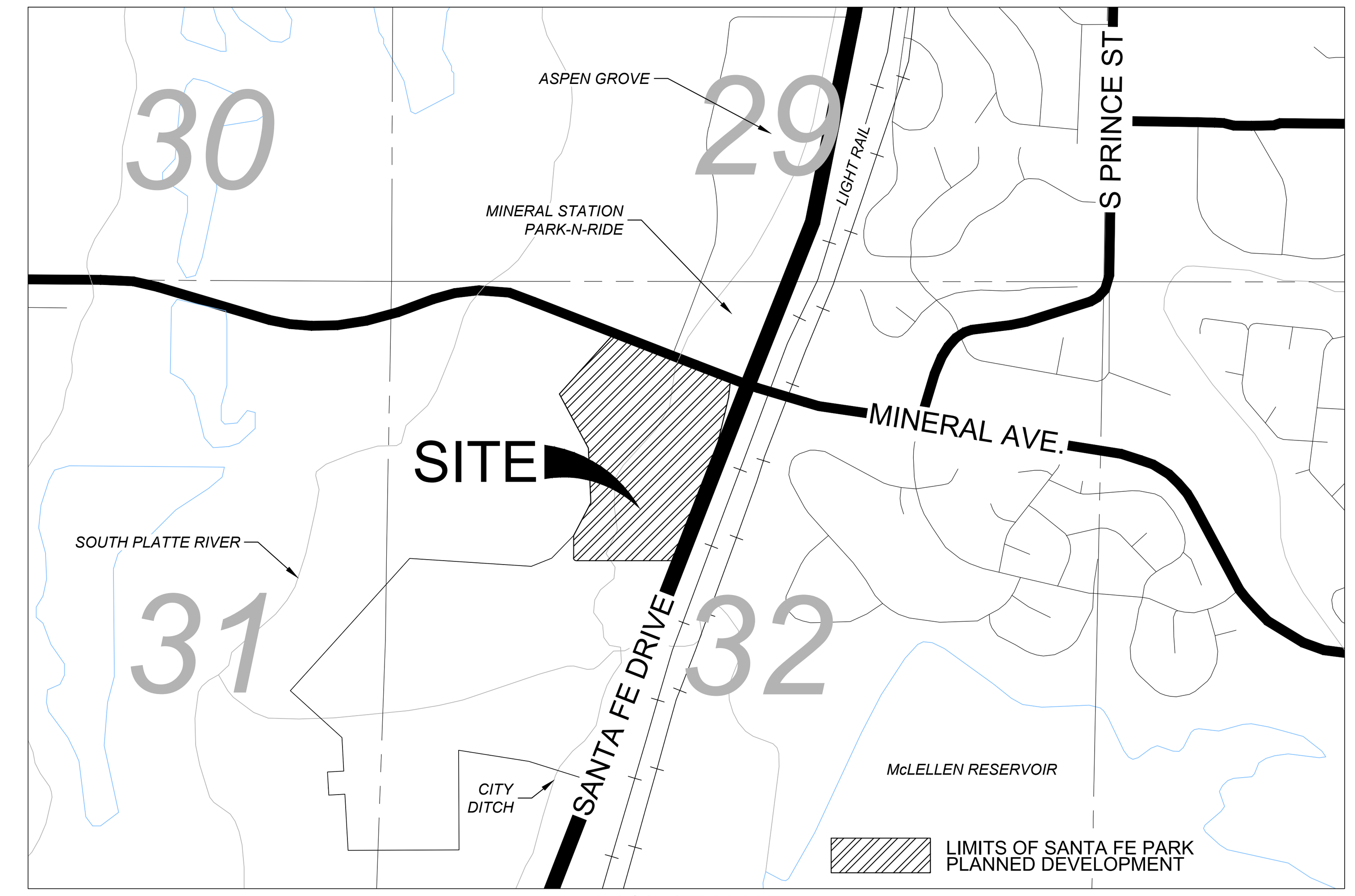
GROUND CONTROL SURVEY BY LANDMARK, LTD. AERIAL PHOTOGRAPHY BY SCHARF & ASSOC. TOPOGRAPHIC MAPPING BY LANDMARK, LTD. CONTOUR INTERVAL 2 FT DATE FLOWN 4-13-89	CENTENNIAL ENGINEERING INC ARVADA CO. 80001 420-0221 CEI JN. 906.00	DESIGNED DJN DATE 4/90 DRAWN GGH DATE 7/90 CHECKED DLM DATE 7/90 REVISED ____ DATE ____	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT CITY OF LITTLETON	FLOOD HAZARD AREA DELINEATION LOWER DAD CLARK GULCH AND DFA 0068	PROFILE JACKASS GULCH STA. 0+00 TO STA. 20+00	SHEET 10 OF 16

APPENDIX C – APPROVED FLOODPLAIN USE BY SPECIAL EXCEPTION ANALYSIS AND EXHIBITS

SANTA FE PARK SITE PLAN
USE BY SPECIAL EXCEPTION

SITUATED IN THE NORTHWEST 1/4 OF SECTION 32, TOWNSHIP 5 SOUTH, RANGE 68 WEST OF THE 6TH P.M.
COUNTY OF ARAPAHOE, STATE OF COLORADO
CASE NUMBER: ENG17-0005

FHAD*		Corrected Effective (Existing)		Proposed Conditions		
Q100 = 1240 cfs		Q100 = 1240 cfs		Q100 = 1240 cfs		
FHAD XS	100-YR WSEL	HEC XS	100-YR WSEL	HEC XS	100-YR WSEL	Δ WSEL (Ex to Prop)
10	5350.40	49.75	5350.45	49.75	5350.23	-0.22
20	5354.60	703.45	5355.98	703.45	5355.81	-0.17
30	5365.50	907.92	5364.99	907.92	5363.24	-1.75
40	5373.90	1254.10	5374.33	1263.80	5370.81	-3.52
50	5382.10	1700.25	5382.09	1697.64	5382.20	0.11
*Per FHAD -Lower Dad Clark Gulch and DFA 0068						



VICINITY MAP
SCALE: 1" = 1,000'

CERTIFICATION OF DEDICATION AND OWNERSHIP:

KNOW ALL MEN BY THESE PRESENTS THAT KENTON C. ENSOR, JR; AND K. C. ENSOR REALTY CO., A COLORADO CORPORATION, BEING THE OWNERS OF CERTAIN LANDS IN THE CITY OF LITTLETON, COUNTY OF ARAPAHOE, STATE OF COLORADO, DESCRIBED AS FOLLOWS:

A PARCEL OF LAND BEING LOT 1, BLOCK 1, SANTA FE PARK FILING NO. 1, RECORDED AT RECEPTION NO. 161781 OF THE RECORDS OF THE ARAPAHOE COUNTY CLERK AND RECORDER, TOGETHER WITH A PORTION OF THE PARCEL DESCRIBED IN BOOK 4160 AT PAGE 33 OF SAID RECORDS, AND TOGETHER WITH A PORTION OF THE PARCEL DESCRIBED IN BOOK 3603 AT PAGE 77 OF SAID RECORDS, SITUATED IN THE NORTHWEST QUARTER OF SECTION 32, TOWNSHIP 5 SOUTH, RANGE 68 WEST OF THE 6TH PRINCIPAL MERIDIAN, CITY OF LITTLETON, COUNTY OF ARAPAHOE, STATE OF COLORADO, MORE PARTICULARLY DESCRIBED AS FOLLOWS:

COMMENCING AT THE NORTH QUARTER CORNER OF SAID SECTION 32;
THENCE SOUTH 89°29'27" WEST ALONG THE NORTH LINE OF SAID NORTHWEST QUARTER, A DISTANCE OF 1039.53 FEET;
THENCE SOUTH 00°30'33" EAST, A DISTANCE OF 181.09 FEET TO A POINT ON THE SOUTH LINE OF WEST MINERAL AVENUE, SAID POINT ALSO BEING THE NORTH CORNER OF SAID LOT 1 AND THE POINT OF BEGINNING;
THENCE SOUTH 69°39'40" EAST ALONG SAID SOUTH LINE, A DISTANCE OF 930.25 FEET TO THE WEST LINE OF SANTA FE DRIVE;
THENCE ALONG SAID WEST LINE THE FOLLOWING THREE (3) COURSES:
1) SOUTH 06°15'04" WEST, A DISTANCE OF 134.04 FEET;
2) SOUTH 13°24'58" WEST, A DISTANCE OF 590.30 FEET;
3) SOUTH 21°30'04" WEST, A DISTANCE OF 672.17 FEET TO THE SOUTH LINE OF SAID PARCEL DESCRIBED IN BOOK 3603 AT PAGE 77;
THENCE ALONG THE SOUTH AND WEST LINES OF SAID PARCEL THE FOLLOWING THREE (3) COURSES:
1) SOUTH 89°39'28" WEST, A DISTANCE OF 758.44 FEET;
2) NORTH 00°16'35" EAST, A DISTANCE OF 189.77 FEET;
3) NORTH 27°39'51" EAST, A DISTANCE OF 272.39 FEET TO THE SOUTHWEST CORNER OF SAID PARCEL DESCRIBED IN BOOK 4160 AT PAGE 33;
THENCE NORTH 02°37'05" WEST ALONG THE WEST LINE OF SAID PARCEL, A DISTANCE OF 201.93 FEET TO THE SOUTHWEST CORNER OF SAID LOT 1;
THENCE ALONG THE WEST LINE OF SAID LOT 1 THE FOLLOWING THREE (3) COURSES:
1) CONTINUING NORTH 02°37'05" WEST, A DISTANCE OF 200.00 FEET;
2) NORTH 28°04'01" WEST, A DISTANCE OF 451.10 FEET;
3) NORTH 42°00'11" EAST, A DISTANCE OF 578.80 FEET TO THE POINT OF BEGINNING;

SAID PARCEL CONTAINS 1,452,240 SQUARE FEET OR 33.34 ACRES, MORE OR LESS;

HAS BY THESE PRESENTS LAID OUT, PLATTED AND SUBDIVIDED THE SAME INTO A PARCEL AS SHOWN ON THIS PLAT, UNDER THE NAME AND STYLE OF SANTA FE PARK SUBDIVISION EXEMPTION.

SECTION 10-6-8: USE BY SPEICAL EXEMPTION - SITE PLAN

1. THE EXISTING ADJACENT DEVELOPMENTS HAVE COMMERCIAL AND RESIDENTIAL USES
2. THE PROPOSED USE OF THE SITE IS COMMERCIAL AND RESIDENTIAL DEVELOPMENT

NOTES:

1. EFFECTIVE JACKASS GULCH FLOODING FROM THE FLOOD HAZARD AREA DELINEATION (FHAD) FOR LOWER DAD CLARK GULCH AND DFA 0068 BY THE URBAN DRAINAGE AND FLOOD CONTROL DISTRICT AND THE CITY OF LITTLETON, 1990.
2. ALL FLOODPLAINS SHALL BE CONTAINED IN TRACTS, SHOWN ON THE FINAL PLAT, AND SHALL CONTAIN A DESCRIPTION OF PURPOSE, OWNERSHIP, AND MAINTENANCE RESPONSIBILITY OF SAID TRACTS.
3. THIS SITE PLAN REPRESENTS THE GENERAL DEVELOPMENT INTENT OF THE DEVELOPER IN THE EVENT THAT AN AMENDMENT TO THE CURRENT ZONING IS APPROVED.
4. ALL ROAD LOCATIONS AND ALIGNMENTS ARE CONCEPTUAL AND FOR ILLUSTRATIVE PURPOSES ONLY. FINAL LOCATIONS AND ALIGNMENTS WILL BE THROUGH PRELIMINARY AND FINAL PLATS AND SITE DEVELOPMENT PLAN(S).
5. ALL DEVELOPMENT AREA LOCATIONS AND LAYOUTS ARE PRELIMINARY AND ARE SUBJECT TO CHANGE. HOWEVER, NO STRUCTURE SHALL BE PLACED WITHIN THE FLOODPLAIN AS DETERMINED BY THE SPECIAL EXCEPTION PERMIT, CASE NO. ENG17-0005. IF ANY ADDITIONAL MODIFICATIONS OF THE FLOODPLAIN ARE PROPOSED, A NEW SPECIAL USE BY SPECIAL EXCEPTION PERMIT MUST BE SUBMITTED, REVIEWED, AND APPROVED PRIOR TO ALLOWING ANY STRUCTURES TO BE PLACED WITHIN THE FLOODPLAIN.
6. ALL STRUCTURES LOWEST FLOORS MUST BE 1' ABOVE THE HIGHEST PROPOSED WATER SURFACE ELEVATION ADJACENT TO THAT STRUCTURE.
7. BUILDING SITES SHOULD BE GRADED, SO IN THE EVENT OF A CHANNEL SPILL, SHALLOW OVERLAND FLOW SHALL BE DIRECTED AWAY FROM BUILDINGS PER FLOODPLAIN REGULATIONS SECTION 10-6-8(B)2(A)3 AND (B)3.
8. MOBILE HOMES ARE NOT ALLOWED PER FLOODPLAIN REGULATIONS SECTION 10-6-8.
9. BASED ON A TOTAL SITE AREA OF 33.3 ACRES AND A 90% WATERSHED IMPERVIOUSNESS YIELDS AN ALLOWABLE IMPERVIOUS AREA OF 30.0 ACRES.

LEGEND:

- ZONE DISTRICT BOUNDARY
- PROPOSED RIGHT OF WAY
- PROPOSED LOT
- PROPOSED SITE JAG 100-YR FLOODING LIMITS
- EXISTING WATER SUPPLY LINE
- EXISTING SITE JAG 100-YR FLOODING LIMITS
- FHAD JAG 100-YR FLOODING LIMITS
- EXISTING SANITARY SEWER
- EXISTING STORM SEWER
- EXISTING CONTOURS
- PROPOSED CONTOURS
- EXISTING / PROPOSED FLOW ARROW
- EXISTING FLOODPLAIN

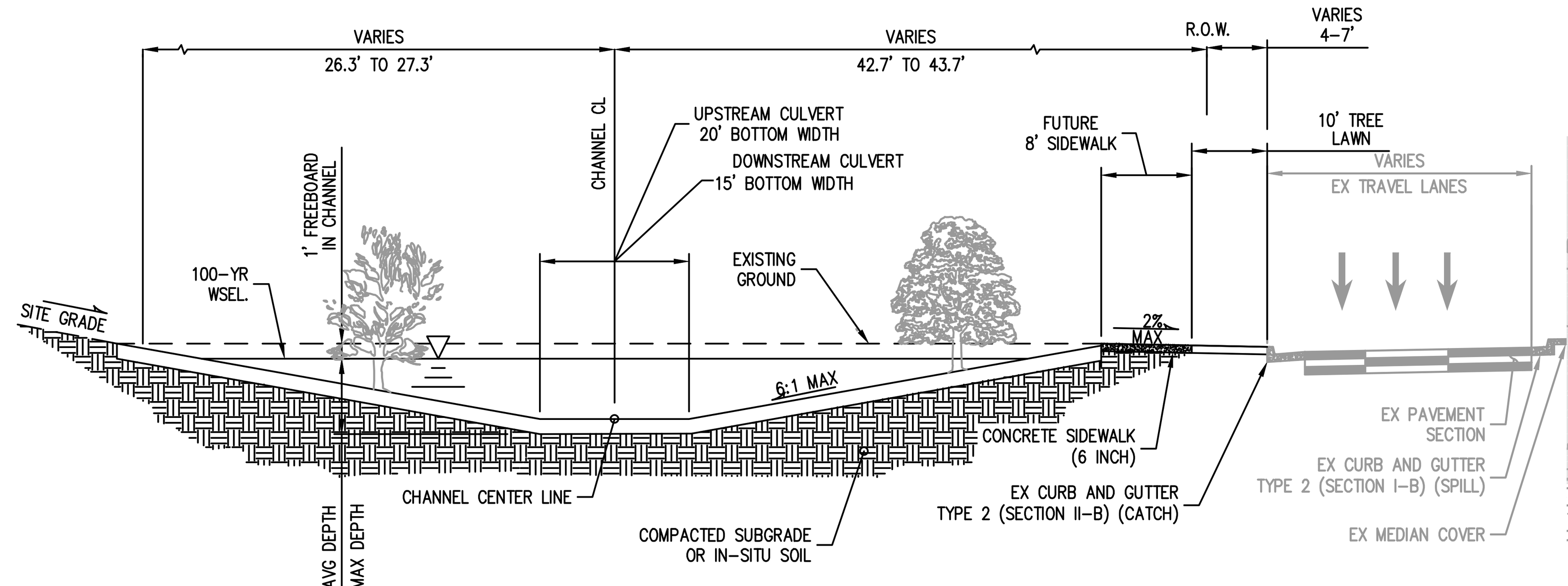
HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

PROJECT NUMBER: 160605

REVISION DATE:
ISSUE DATE: 11/21/2017

SANTA FE PARK SITE PLAN
USE BY SPECIAL EXCEPTION

JACKASS GULCH PLAN AND PROFILE VIEW
CASE NUMBER: ENG17-0005

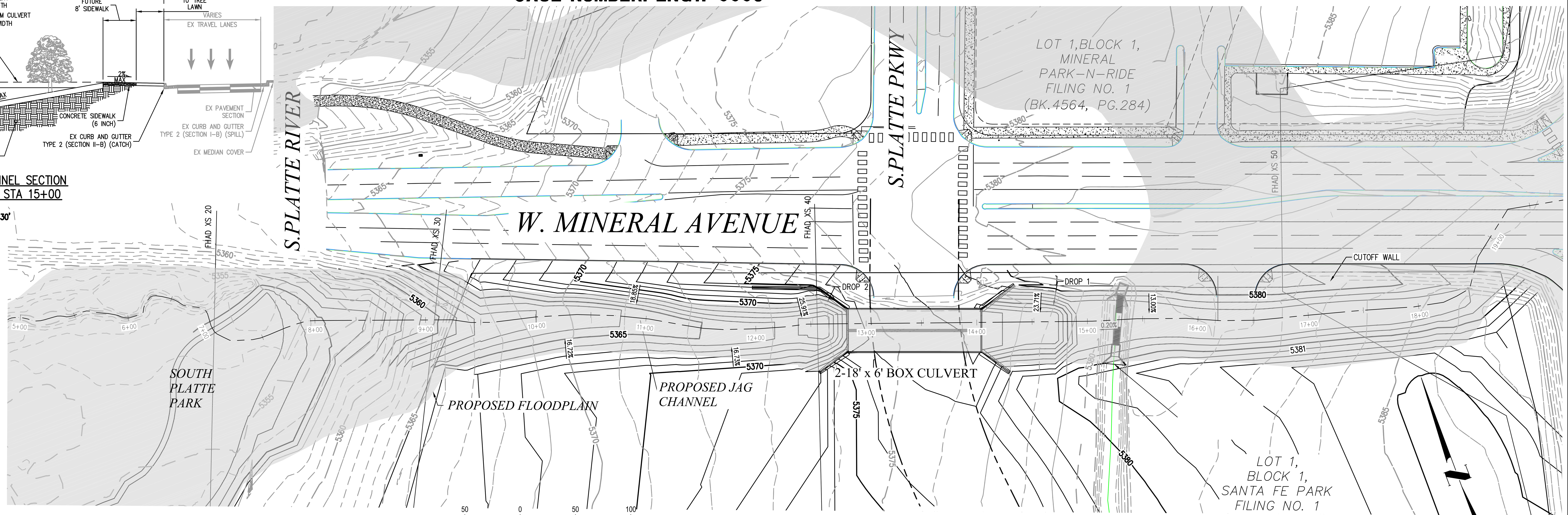


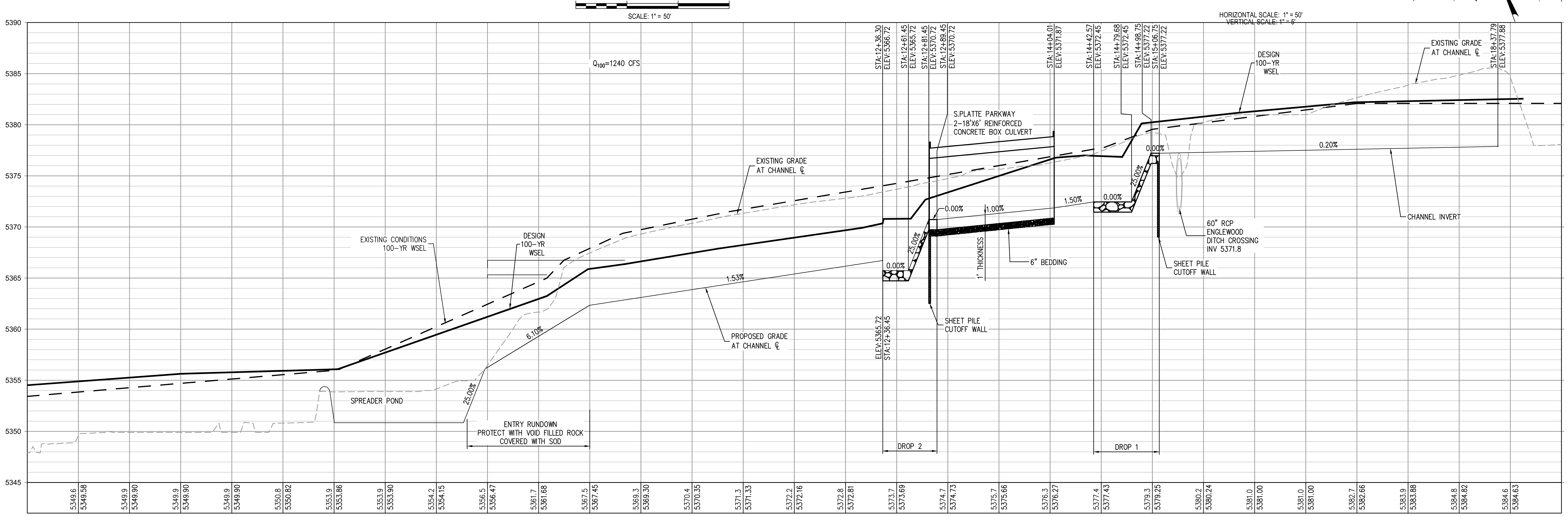
TYPICAL JAG CHANNEL SECTION
CL STA 8+50 TO STA 15+00

SCALE 1"=30'

GENERAL NOTES:

1. CHANNEL IS TO BE PERMANENTLY LINED WITH TURF REINFORCEMENT MAT. PERMISSIBLE SHEAR STRESSES WITH THE PLANTED MAT APPLICATION ARE 16 LB/SQ-FT. MAXIMUM ALLOWABLE VELOCITIES ARE 25.0 FT/SEC.
2. CHANNEL TURF REINFORCEMENT MAT TO BE PLANTED WITH APPROPRIATE GRASSES TO RETAIN COHESION OF MAT BASED ON SITE SPECIFIC SOIL CONDITIONS. CHANNEL GRASSES SHALL BE MAINTAINED POST-CONSTRUCTION TO ENSURE VEGETATION ESTABLISHMENT.





NEW JACKASS GULCH PROFILE
HORIZONTAL SCALE: 1" = 50'
VERTICAL SCALE: 1" = 5'

HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

PROJECT NUMBER: <PROJECT NUMBER>

REVISION DATE: ISSUE DATE: 11/21/2017 SHEET 2 OF 2

November 27, 2017

City of Littleton
2255 W. Berry Avenue
Littleton, CO 80120

Attn: Ms. Carol Kuhn, AICP, Principal Planner

From: Mr. Mark A. West, PE, CFM, LEEDAP

RE: SANTA FE PARK NORTH
USE BY SPECIAL EXCEPTION – FHAD MEMORANDUM
CITY OF LITTLETON CASE NO. SDE17-0007
HKS PROJECT NO. 160605

Dear Ms. Kuhn,

This memorandum is provided as a technical support document to the Use by Special Exception application. This memo addresses the existing predevelopment and post development Flood Hazard Area Delineation (FHAD) or 100-Year event flooding limits within the subject Site from the Jackass Gulch (JAG) drainageway.

In support of the Phase I Drainage Report and Use by Special Exception Site Plan, and in response to information gathered in meetings with the City of Littleton and the Urban Drainage and Flood Control District (UDFCD) regarding this development, the following major items are addressed herein:

1. Upstream JAG Regional Detention Investigation

2. JAG Mineral Avenue Split Flow 2D Modeling (for information only)

3. Site Channel and HEC-RAS Modeling

General Background

The proposed South Santa Fe PD project (Site) is located in the Northwest ¼ of Section 32, Township 5 South, Range 68 West of the 6th Principal Meridian, County of Arapahoe, State of Colorado. The Site is comprised of approximately 33.3 acres of platted land known as Lot 1, Block 1 of the Santa Fe Park Filing No.1 (Rec #93-161781). The Site is bounded by West Mineral Avenue on the north, by undeveloped land on the south, South Santa Fe Drive to the east, and by the South Platte River on the west.

The Site is shown to be in a FEMA Zone X (unshaded) Flood Area according to FIRM map 08035C0434K, Arapahoe County, Colorado, December 17, 2010. Zone X (unshaded) is described in this map as areas determined to be outside 500-year flood plain. The Jackass Gulch major drainageway is studied in the Dad Clark Gulch Lower and DFA 0068 Flood Hazard Area Delineation (FHAD) and Outfall Systems Plan (OSP) dated 1990 and 1991 respectively.

The entire Site lies within the Jackass Gulch major drainage basin, which is tributary to the South Platte River directly downstream of the Site. The overall basin is fully developed primarily as single family housing on the central portions with a small amount of multifamily residential, commercial, and light industrial uses on the east ends of the basin. The lower half of Jackass Gulch is a well-defined drainageway with a preserved floodplain area adjacent to Mineral Avenue.

Offsite flows from the east directed towards the site crest the high point in Mineral near the northeast corner of the Site and enter the project area. In the 100-year event flood water will pond at the intersection of Santa Fe Drive and Mineral Avenue to a depth of approximately 7 feet. This ponding overflows to the west into the Site at a high point in Mineral Avenue, which in turn create flood hazard and shallow overflow areas through the Site.

I. Upstream JAG Detention Investigation

The overall Jackass Gulch basin lies south of Rangeview Gulch and is approximately 500 acres in size elongated east-west from South Broadway to the South Platte River. The basin is zoned almost entirely as Planned Development. The upper basin east of the Highline Canal is mostly commercial with some multifamily residential. All of the existing developments in the upper basin have been designed to detain stormwater runoff for the 100-year event with private on-site storm sewer facilities. The lower basin (west of Santa Fe Drive) is a commercial area and has a 60" RCP storm outfall system which discharges into an open channel which outfalls to the South Platte River in the northwest corner of the Site. The area between the Highline canal and the Railroad lines east of Santa Fe is zoned primarily as residential. The storm drainage system in the area consists of a natural channel, and portions of this middle reach are currently part of the Jackass Gulch Stabilization Project underway by the UDFCD.

The 1991 Outfall Systems Plan (OSP) for Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. presents conceptual layouts of several inline upstream detention ponds to ultimately reduce flooding effects of the JAG on the Santa Fe and Mineral intersection, and at the Site. At the time of the 1191 OSP, these ponds are located in open space or areas controlled by the City of Littleton.

Numerous developments and parcel ownership changes have occurred in the basin since the 1991 OSP was published. With this project the feasibility and effectiveness of implementation of the upstream detention ponds per the 1991 OSP was explored. To model the proposed system, the paper OSP CUHP model was recreated in CUHP 2005 Version 2.0 for use as SWMM input for the Conceptual system. Project CUHP and SWMM modeling is included with this memorandum.

The results of the upstream detention analysis in terms of total volume provided is tabulated below, and the major differences between the OSP and the 2017 conditions models are noted.

Ponds Per OSP	1991 OSP Detention Volume (ac-ft)	2017 Conceptual Detention Volume (ac-ft)	Changes from OSP
Lower RR Pond	7.2	6.3	Grading Volumetric Constraints
Upper RR Pond	17.6	11.5	Grading Volumetric Constraints
JAG Channel Pond	7.0	-	Parcel now under Private Ownership
Lower Open Space Pond	11.2	13.2	Combined Open Space Pond
Upper Open Space Pond	11.1	-	Combined Open Space Pond
Total Upstream Volume	54.1 ac-ft	31.0 ac-ft	

Roughly 65% of the total detention volume called out in the OSP could be constructed in present land use conditions. These results indicate that while upstream detention ponds may reduce the required width of the 100-year flood channel cross section on-site, but will not eliminate the need for the channel entirely, or the flooding at the Santa Fe and Mineral intersection.

There remains a large gap between detention needs and the availability for implementation of these facilities. The timing and costs of these facilities are also complex from a site development perspective, and are currently technically and economically unfeasible. From this conclusion the project will present revised HEC-RAS modeling for a flood control channel on the Site as presented below rather than further investigating upstream detention.

II. JAG Split Flow 2D Modeling (for information only)

The UDFCD Flood Hazard Area Delineation (FHAD) for the Jackass Gulch drainageway details the 100-year storm event ponding at the intersection of Santa Fe Drive and Mineral Avenue. A map excerpt from the current FHAD is included on the next page. The intersection ponding of Jackass Gulch overflows to the west into the Site at a high point in Mineral Avenue, which in turn creates a 100-year flow path and shallow overflow area through the Site. Flows at the high point in Mineral also create a shallow overflow to the north of Mineral through the RTD Park and Ride site.

The 1990 FHAD conservatively estimates the JAG 100-year flows entering the site at the split flow location as the total flow to the Mineral Avenue intersection of 1240 cfs from the upstream basins. However, the FHAD also indicates a portion of these flows that overtop the ponding at Mineral Avenue travel to the north overland to the South Platte River (550 cfs). The RTD Park and Ride site has since been developed using this split flowrate assumption.

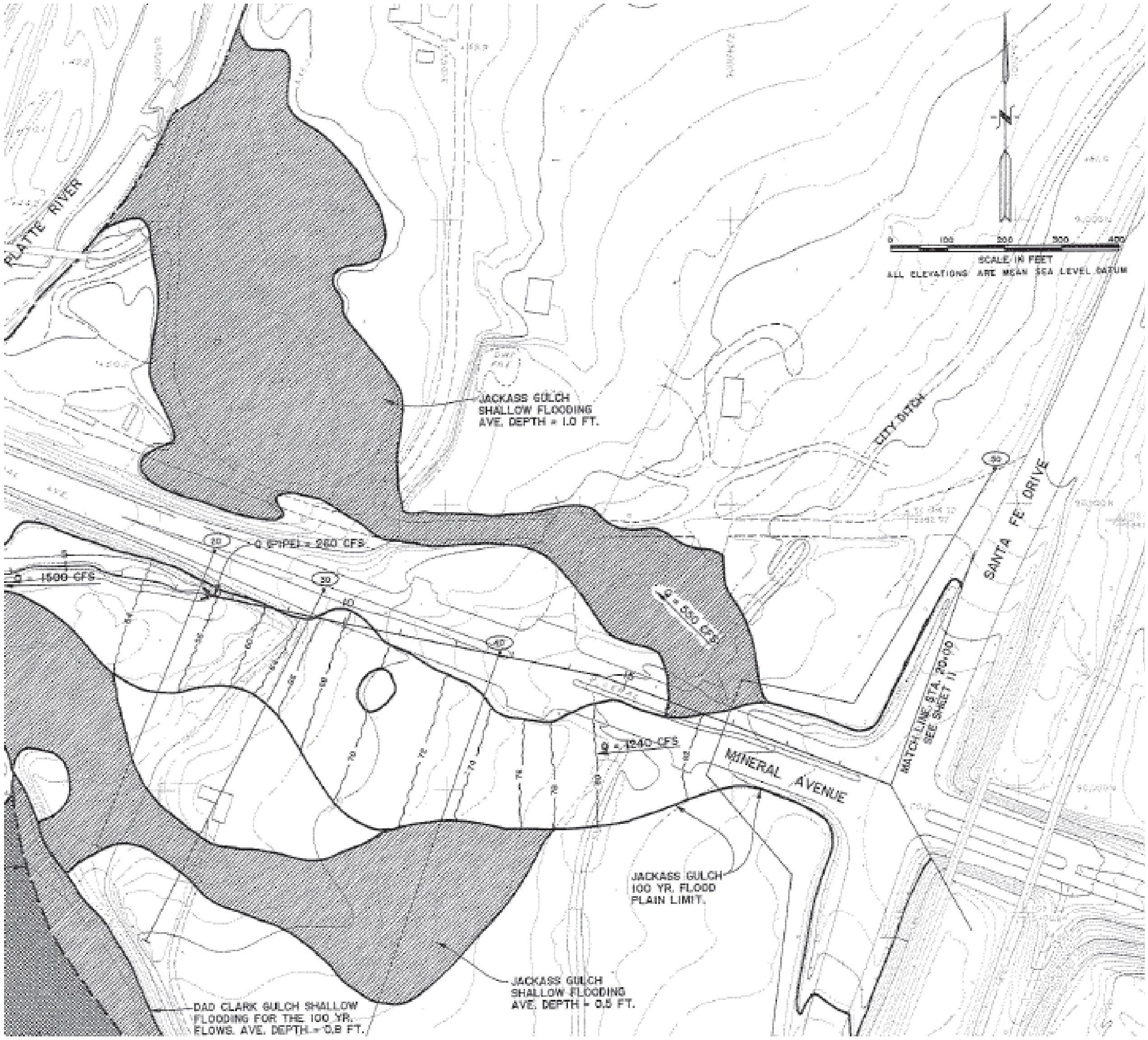
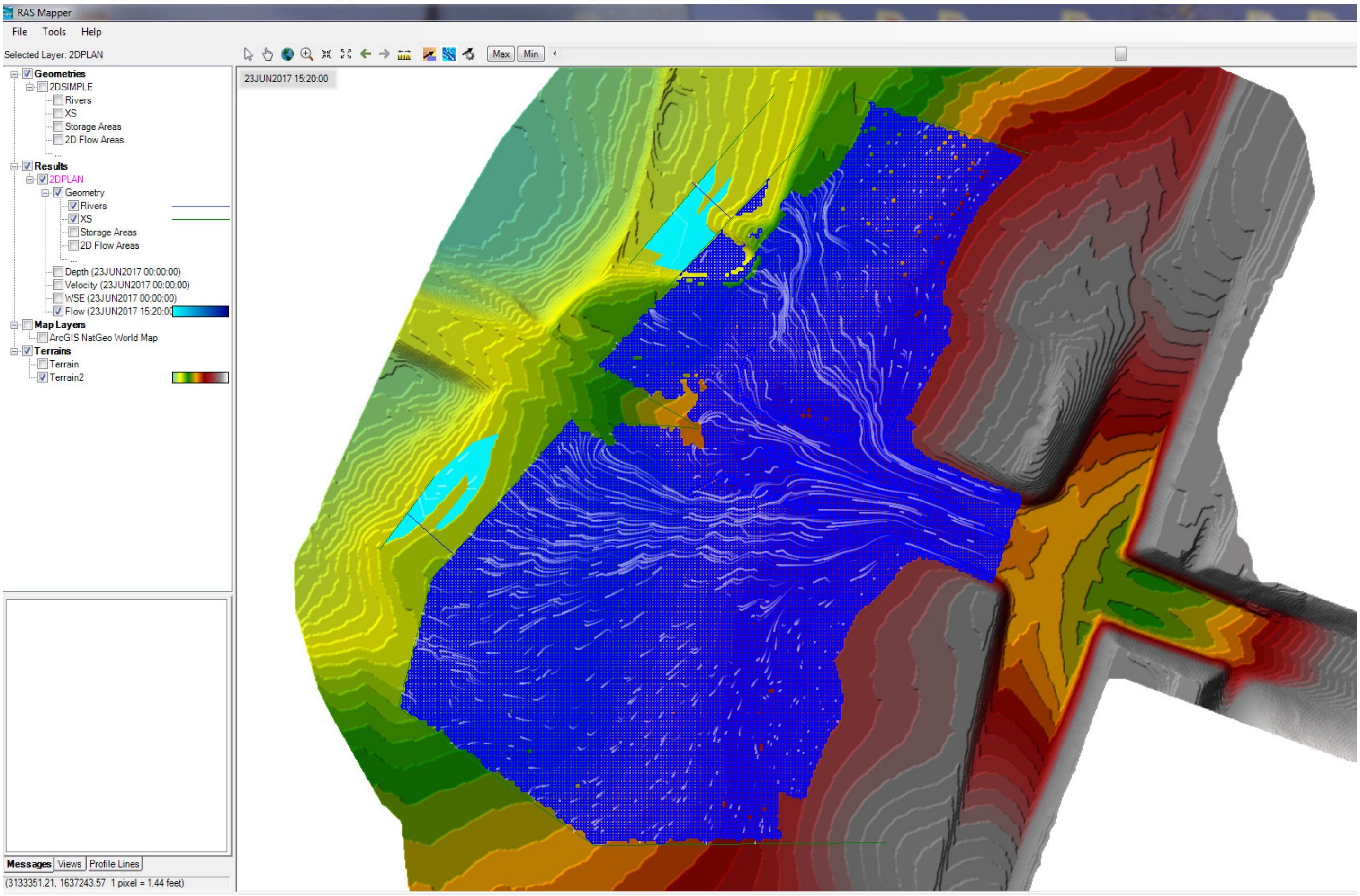


Figure 1: 1990 FHAD Flow Split Detail

To determine the design 100-year JAG channel flowrate through the site, a combined one-dimensional (1D) and two-dimensional (2D) HEC-RAS model was prepared. 2016 DRCOG DRAP project LiDAR data was obtained and reduced for the purposes of creating a terrain surface for HEC-RAS 2D model computation. An unsteady flow simulation was performed using a 24-hour duration event at continuous flowrate of 1240 cfs to allow the model to stabilize. This HEC-RAS NEWJAG2D.prj model is included in the appendix.

In this analysis the Flow Rate Split South (Q Split) is compared to the Total Combined Flow Rate (Q total), over a range of profile timesteps to determine the Split Flow relationship that can then be used to create the steady state 1-D regulatory model. Profiles that contained a Total Combined Flowrate at the downstream cross sections of within 10% of the 1240 cfs were used in the analysis, corresponding to the points the 2D model had the greatest stability. Results are included in the table below.

Figure 2: 2D RAS Mapper Particle Tracking



Profile	Flow Split South Q Split (cfs)	Total Combined Model Flow Rate Q Total (cfs)	Site Split %
23JUN2017 1330	446	1186	38%
23JUN2017 1520	496	1218	41%
23JUN2017 1740	585	1160	50%
23JUN2017 2020	643	1297	50%
23JUN2017 2050	666	1355	49%
23JUN2017 2100	509	1124	45%
		Average =	45%

While the 2D modeling is one approach for flow split determination; the existing flow patterns are also considered. As discussed previously, the RTD Park-and-Ride site to the north has been designed for the current FHAD flow of 550 cfs. The difference between the total JAG flow at this location of 1240 cfs and the FHAD split flow of 550cfs to the north is 690 cfs to the south; or 56% of the flow. Based on this analysis, the split flowrate south into the Site is modeled as the conservative case of 56% or 690 cfs.

III. Site Channel and HEC-RAS Modeling

Proposed Channel and Flowrates

The proposed constructed channel is situated directly south of Mineral Avenue to capture JAG flows and provide safe conveyance for JAG west to the outfall at the South Platte River. The JAG channel is proposed to be grass lined with drop structures into and out of the proposed culvert at S. Platte Parkway. The drops will control grade as well as dissipate energy, slow outlet velocities, and improve the vertical transitions into and out of the culvert.

The channel will extend to a point in the Mineral intersection to accept the additional flows from JAG, over those in the existing condition. This study provides evaluation of multiple design storms to see variations in flow patterns for different storm events and the resulting velocities, flow depths, etc. The following flowrates are the full FHAD flowrates used in the site channel analysis:

Q10 = 430 cfs
Q50 = 910 cfs
Q100 = 1240 cfs

It is intended that all flowrates will be confined within the channel and eliminate the wide and shallow flow across the site. The location of this channel is shown on the Site Plan. A box culvert with associated wing walls is needed to facilitate the channel crossing of future South Platte River Drive thru the Site.

Channel Hydraulics

For both the existing and proposed conditions, a HEC-RAS one-dimensional steady flow model is prepared using a series of input parameters including flowrate, channel cross section geometry, roughness coefficients, and main channel bank stations. Initial sizing of the culvert was performed with HY-8 based on the flow to the site of 1240 cfs, and this design verified within HEC-RAS.

HEC-RAS cross sections are be placed frequently along the channel in order to adequately evaluate the design hydraulic characteristics. Cross sections are generally oriented perpendicular to the channel centerline and the water flow path. A Floodplain Workmap is included with the submittal indicating cross section locations and floodplain limits.

In order to confirm that the proposed channel does not cause rises in the 100-year water surface elevation (WSEL), Table 1 is prepared detailing changes in WSEL between the FHAD, existing, and proposed conditions. The HEC-RAS model files included with this memorandum and HEC-RAS report files are included in the Appendix.

Table 1: WSEL Comparison Table

FHAD*		Corrected Effective (Existing)		Proposed Conditions		
Q_{100} = 1240 cfs		Q100 = 1240 cfs		Q100 = 1240 cfs		
FHAD XS	100-YR WSEL	HEC XS	100-YR WSEL	HEC XS	100-YR WSEL	Δ WSEL (Ex to Prop)
10	5350.40	49.75	5350.45	49.75	5350.23	-0.22
20	5354.60	703.45	5355.98	703.45	5356.08	0.10
30	5365.50	907.92	5364.99	907.92	5363.24	-1.75
40	5373.90	1254.10	5374.33	1263.80	5370.81	-3.52
50	5382.10	1700.25	5382.09	1697.64	5382.20	0.11

*Per FHAD -Lower Dad Clark Gulch and DFA 0068

From the HECRAS modeling analysis numerous output variables are reviewed to confirm that the design falls within acceptable criteria. These results are indicated in Table 2 for the 10-Year event and Table 3 for the 100-year event.

Table 2: 10-Year event Existing and Proposed Channel Shear Stress and Velocity

FHAD XS	SHEAR STRESS (LB/SQFT)					
	LOB		CHANNEL		ROB	
	EXISTING	PROPOSED	EXISTING	PROPOSED	EXISTING	PROPOSED
10	0.36	0.02	1.20	0.68	0.25	*
20	0.56	0.01	1.60	0.77	0.36	0.36
30	0.36	*	0.93	1.01	0.22	*
40	0.56	*	0.54	0.40	0.02	*
50	*	*	0.44	0.37	*	*

*No overbank flow

FHAD XS	VELOCITY (FT/S)					
	LOB		CHANNEL		ROB	
	EXISTING	PROPOSED	EXISTING	PROPOSED	EXISTING	PROPOSED
10	2.74	0.32	8.15	5.69	2.17	*
20	3.41	0.25	9.18	5.86	2.52	2.12
30	2.58	*	6.44	6.62	1.85	*
40	3.14	*	3.65	4.52	0.34	*
50	*	*	3.93	4.23	*	*

*No overbank flow

Table 3: 100-Year event Existing and Proposed Channel Shear Stress and Velocity

FHAD XS	SHEAR STRESS (LB/SQFT)					
	LOB		CHANNEL		ROB	
	EXISTING	PROPOSED	EXISTING	PROPOSED	EXISTING	PROPOSED
10	0.44	0.16	1.27	0.99	0.25	0.15
20	0.49	0.26	1.33	0.70	0.44	0.35
30	0.53	*	1.34	1.37	0.42	*
40	0.74	*	0.78	0.83	0.23	*
50	0.05	0.01	0.93	0.38	0.16	0.11

*No overbank flow

FHAD XS	VELOCITY (FT/S)					
	LOB		CHANNEL		ROB	
	EXISTING	PROPOSED	EXISTING	PROPOSED	EXISTING	PROPOSED
10	3.33	1.33	9.03	7.36	2.55	1.28
20	3.46	1.91	8.94	6.14	3.18	2.33
30	3.48	*	8.56	8.34	2.99	*
40	3.62	*	5.02	6.93	1.69	*
50	0.69	0.28	6.22	4.66	1.43	3.16

*No overbank flow

Per the UDFCD Criteria Manual prudent values for natural channel hydraulic parameters below:

Design Parameter	**Cohesive Soils and Vegetation**
Flow velocity (average of section)	7 ft/s
Depth outside bankfull channel	5 ft

The hydraulic performance of the proposed channel reach compares favorably to these design parameters; however, there are locations in the reach where these parameters are slightly exceeded. This is primarily due to the increased slope of the main channel reach (per UDFCD comment) in order to reduce the amount of drop structures shown in the initial design. Additionally, several efforts were made to improve the hydraulics in the locations that exceed the parameters. These efforts include widening of the channel bottom width from 5-feet to 15-feet and decreasing the channel side slopes from 4:1 to 6:1.

With these revisions there remain isolated areas where increased velocities and shear exist within the modeled results; however, these are primarily at locations into and out of the channel drop structures where the flow is critical and the areas are protected with hard armoring. Within the constructed channel, the maximum channel depth meets 5-foot depth criteria in all locations. Additionally, these design parameters are for natural channels; whereas the proposed channel will be lined with a with Turf Reinforcement Mat product, which have permissible allowable shear stresses of 16 lb/square-foot, and with a maximum allowable velocity of 25 ft/sec per below.

Channel Lining and Vegetation
Vegetation measures including grasses along the channel banks are proposed with the design. To establish this vegetation and provide a stable substrate for the anticipated flowrates, the channel is to be permanently lined with Turf Reinforcement Mat product, which have permissible allowable shear stresses of 16 lb/square-foot, and with a maximum allowable velocity of 25 ft/sec when properly vegetated. The channel turf reinforcement mat will be planted with appropriate grasses to retain cohesion of the mat and substrate. The final design of the mat and grasses will be based on site specific soil conditions. Channel grasses will be maintained post-construction to ensure vegetation establishment.

Drop Structures
Drop structures are proposed in the channel and are designed to be either Grouted Sloping Boulder (GSB) drops or Sculpted Concrete (SC) drops, designed per Section 2.0, UDFCD Criteria Manual Volume 2. The drops may contain stilling basin elements will be surrounded by void filled riprap. There will be a weep drain system installed in the drops, and the upstream ends of the drops will have adequate seepage cutoff walls.

Parallel Storm Sewer
UDFCD preference is to route parallel storm sewer system flows into adjacent open channels. In this case the storm sewer in Mineral Ave adjacent to the site is very deep (> 24'); the mid-manhole shelf at an adjacent manhole being at EL~5359. The JAG channel as described herein adjacent to the sewer is at elevation EL~5380. Since the storm sewer is not able to gravity flow into the proposed JAG channel, these flows are proposed to remain in the existing storm sewer system.

Englewood Ditch
The channel will cross the existing Englewood Ditch in place. The Englewood Ditch enters a concrete box structure with a 60" RCP outlet at the northern border of the site, directly south of Mineral Avenue. The elevation of the invert has been shown in the channel profile to indicate its constraint on the vertical placement of the channel.

IV. References

1. Urban Storm Drainage Criteria Manual, Vol. 1 and Vol. 2, Urban Drainage and Flood Control District, 2017.

2. Flood Hazard Area Delineation (FHAD) Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. dated November 1990.

3. Outfall Systems Plan (OSP) Lower Dad Clark Gulch and DFA 0068 by Centennial Engineering, Inc. dated February 1991.

APPENDIX

EXHIBITS

1. Excerpt from Dad Clark Gulch Lower and DFS 0068 OSP Ph B 1991.pdf
2. Upstream Pond Layout and Summary.pdf
3. HEC-RAS Standard Tables
4. HEC-RAS Cross Sections
5. HEC-RAS Profiles
6. HEC-RAS Culvert Output
7. Floodplain Workmap

MODEL FILES

CUHP

- CUHP_200.xltm
- JAG OUT.xlsx

HEC RAS

- JAGProposedChanne.prj

SWMM (.ini, .inp, .out, & .rpt files)

- JAG
- JAG-1
- JAG-2
- JAG-3
- JAG-4

NOTES

1. THIS DRAWING REPRESENTS MASTER PLANNING AND CONCEPTUAL ENGINEERING. IT SHALL NOT BE USED FOR CONSTRUCTION PURPOSES. IT IS SUBJECT TO CHANGE.

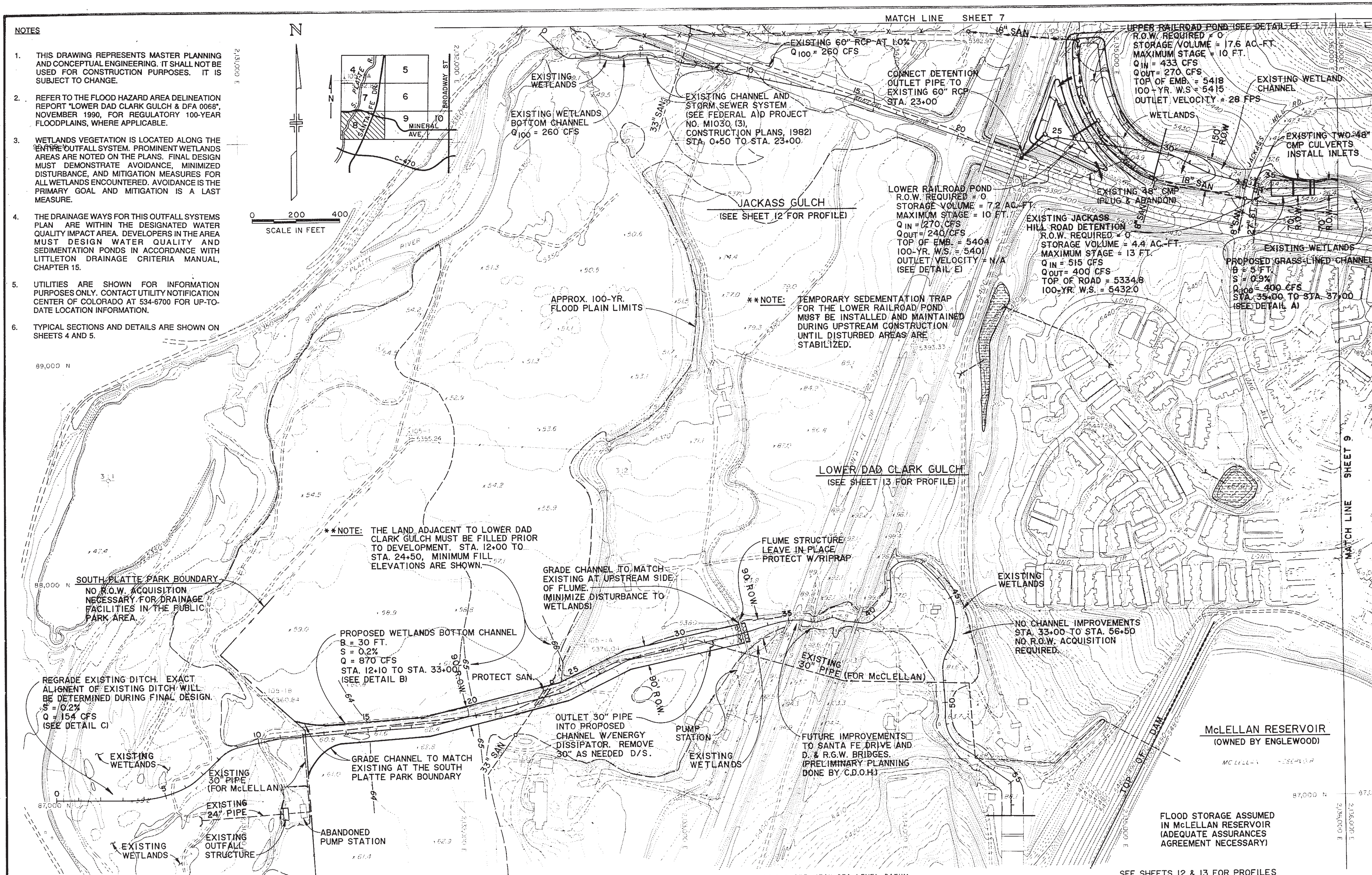
2. REFER TO THE FLOOD HAZARD AREA DELINEATION REPORT "LOWER DAD CLARK GULCH & DFA 0068", NOVEMBER 1990, FOR REGULATORY 100-YEAR FLOODPLAINS, WHERE APPLICABLE.

3. WETLANDS VEGETATION IS LOCATED ALONG THE ENTIRE OUTFALL SYSTEM. PROMINENT WETLANDS AREAS ARE NOTED ON THE PLANS. FINAL DESIGN MUST DEMONSTRATE AVOIDANCE, MINIMIZED DISTURBANCE, AND MITIGATION MEASURES FOR ALL WETLANDS ENCOUNTERED. AVOIDANCE IS THE PRIMARY GOAL AND MITIGATION IS A LAST MEASURE.

4. THE DRAINAGE WAYS FOR THIS OUTFALL SYSTEMS PLAN ARE WITHIN THE DESIGNATED WATER QUALITY IMPACT AREA. DEVELOPERS IN THE AREA MUST DESIGN WATER QUALITY AND SEDIMENTATION PONDS IN ACCORDANCE WITH LITTLETON DRAINAGE CRITERIA MANUAL, CHAPTER 15.

5. UTILITIES ARE SHOWN FOR INFORMATION PURPOSES ONLY. CONTACT UTILITY NOTIFICATION CENTER OF COLORADO AT 534-6700 FOR UP-TO-DATE LOCATION INFORMATION.

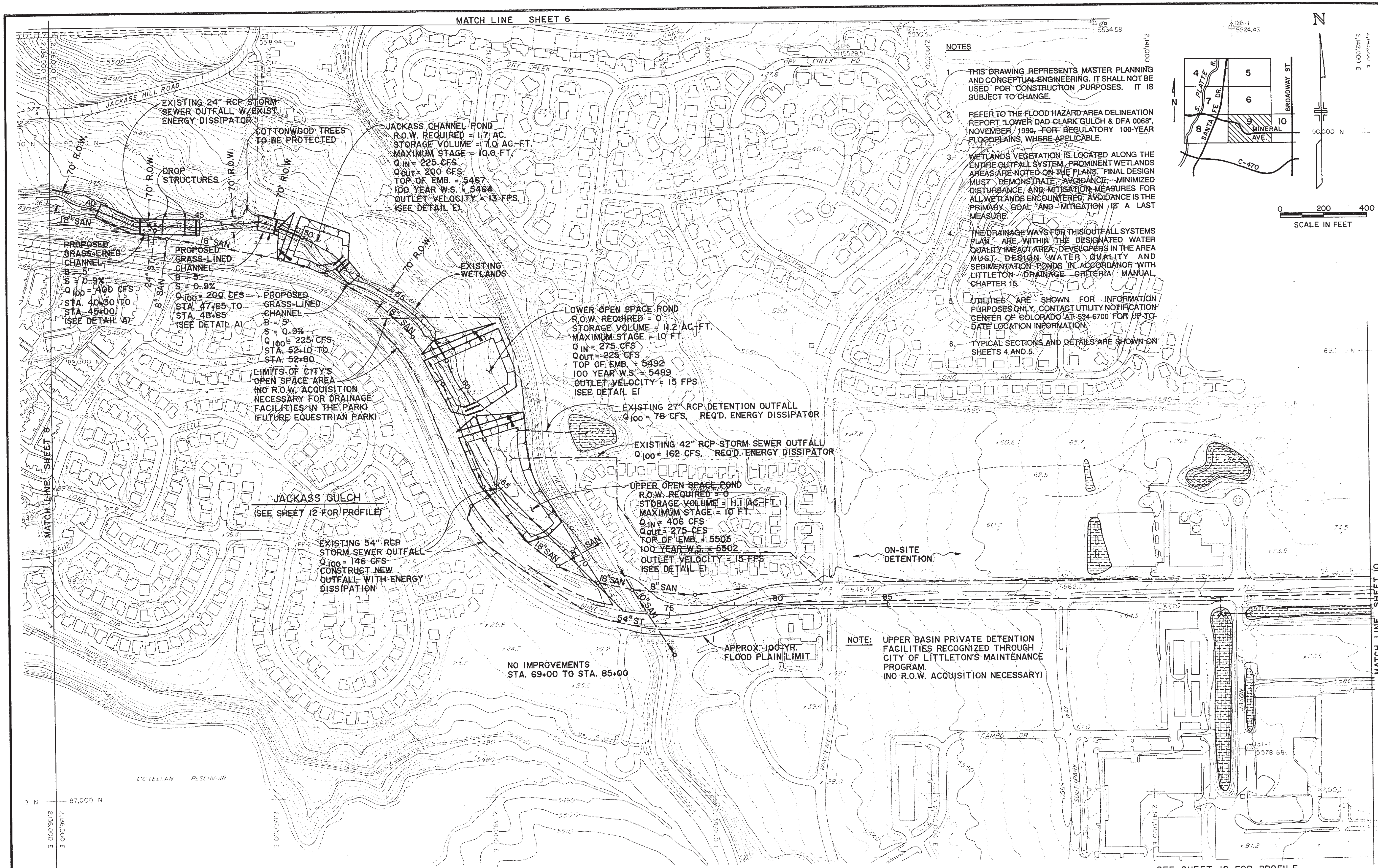
6. TYPICAL SECTIONS AND DETAILS ARE SHOWN ON SHEETS 4 AND 5.



ALL ELEVATIONS ARE MEAN SEA LEVEL DATUM

SEE SHEETS 12 & 13 FOR PROFILES

GROUND CONTROL SURVEY BY LANDMARK, LTD. AERIAL PHOTOGRAPHY BY SCHARF & ASSOC. TOPOGRAPHIC MAPPING BY LANDMARK, LTD. CONTOUR INTERVAL 2 FT DATE FLOWN 4-13-89	CENTENNIAL ENGINEERING INC ARVADA CO. 80001 420-0221 CEI JN. 906.00	DESIGNED DJN DATE 8/90 DRAWN CJH DATE 11/90 CHECKED DLM DATE 2/91 REVISED DATE	URBAN DRAINAGE AND FLOOD CONTROL DISTRICT CITY OF LITTLETON	OUTFALL SYSTEMS PLANNING LOWER DAD CLARK GULCH AND DFA 0068	PLAN JACKASS GULCH AND LOWER DAD CLARK GULCH	SHEET 8 OF 13



GROUND CONTROL SURVEY BY LANDMARK, LTD.
AERIAL PHOTOGRAPHY BY SCHARF & ASSOC.
TOPOGRAPHIC MAPPING BY LANDMARK, LTD.
CONTOUR INTERVAL 2 FT DATE FLOWN 4-13-89

CENTENNIAL ENGINEERING INC
ARVADA CO. 80001 420-0221
CEI JN. 90? 00

DESIGNED	DJN	DATE	8/90
DRAWN	CJH	DATE	11/90
CHECKED	DLM	DATE	2/91
REVISED		DATE	

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
CITY OF LITTLETON

OUTFALL SYSTEMS PLANNING
LOWER DAD CLARK GULCH AND DFA 0068

PLAN
JACKASS GULCH

Existing Upper RR Pond

Stage (ft)	Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
0.00	0	0.000		
1.00	1756	0.040	860	0.020
2.00	6157	0.141	4,773	0.110
3.00	16168	0.371	15,997	0.367
4.00	30173	0.693	39,167	0.899
5.00	42158	0.968	75,333	1.729
6.00	54414	1.249	123,619	2.838

Expanded Upper Railroad Pond

Stage (ft)	Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
	0	0.000		
1.00	10591	0.243	5,190	0.119
2.00	24014	0.551	22,358	0.513
3.00	36891	0.847	53,050	1.218
4.00	46705	1.072	94,848	2.177
5.00	53476	1.228	144,938	3.327
6.00	60352	1.385	201,852	4.634
7.00	67332	1.546	265,694	6.100
8.00	74416	1.708	336,568	7.727
9.00	81602	1.873	414,577	9.517
10.00	88889	2.041	499,823	11.474

Lower Railroad Pond

Stage (ft)	Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
	0	0.000		
1.00	2411	0.055	1,181	0.027
2.00	9236	0.212	6,937	0.159
3.00	20805	0.478	22,049	0.506
4.00	28272	0.649	46,588	1.070
5.00	31422	0.721	76,435	1.755
6.00	34672	0.796	109,482	2.513
7.00	38022	0.873	145,829	3.348
8.00	41474	0.952	185,577	4.260
9.00	45025	1.034	228,826	5.253
10.00	48677	1.117	275,677	6.329

Santa Fe Park Subdivision Exemption
Jackass Gulch (JAG)
Offsite Flood Control -- Detention Options Summary

Condition	SWMM Model	OffSite Ponds Constructed	Upstream Detention Volume (ac-ft)	Total JAG Mineral Ave 100-yr Flow (cfs)	JAG Split Santa Fe Site 100-yr Flow (cfs) 70%	Onsite Channel Bottom Width / S. Platte River Dr. Culvert Size
1990 FHAD	Paper Report	None	2.8 (existing pond)	1240	1240 *no flow split	54 foot channel width / (2) 12' x 6' RCBC
A New Base Condition	JAG.inp *new model of EX conditions	None	2.8 (existing pond)	1240	868	38 foot channel width / 12' x 6' RCBC
B	JAG-1.inp	Rev Upper RR	11.5	916	641	28 foot channel width / 12' x 6' RCBC
C	JAG-2.inp	Rev Upper RR Lower RR	11.5 6.3 17.8	911	638	28 foot channel width / 12' x 6' RCBC
D	JAG-3.inp	Rev Upper RR Open Space	11.5 13.3 24.8	720	504	22 foot channel width / 10' x 5' RCBC
E	JAG-4.inp	Open Space	13.3	792	554	24 foot channel width / 10' x 5' RCBC

Open Space Pond

Stage (ft)	Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
0.00	0	0.000		
1.00	16946	0.389	8,304	0.191
2.00	38624	0.887	35,872	0.824
3.00	51831	1.190	81,485	1.871
4.00	56827	1.305	135,814	3.118
5.00	62036	1.424	195,245	4.482
6.00	67501	1.550	260,014	5.969
7.00	73203	1.681	330,366	7.584
8.00	79126	1.816	406,530	9.333
9.00	85247	1.957	488,717	11.219
10.00	91545	2.102	577,113	13.249

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PLOTTED: TUE 05/23/17 10:01:14A BY: MARK WEST

Know what's below. Call before you dig.

CALL 3 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

DESIGNED BY: MAW
CHECKED BY: MM
DRAWN BY: MAW

HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

EXHIBIT 1
JAG OFFSITE - UPPER BASIN

SANTA FE PARK SUBDIVISION
ARAPAHOE COUNTY, CO
SOUTH SANTA FE DRIVE AT MINERAL AVENUE

ISSUE DATE: May 2017 | PROJECT #: 160308

DATE	REVISION COMMENTS

PRELIMINARY NOT FOR CONSTRUCTION

SHEET NO.
1

HEC-RAS Plan: CorrEff River: Jackass Gulch Reach: Jackass Gulch Ch Profile: Q100

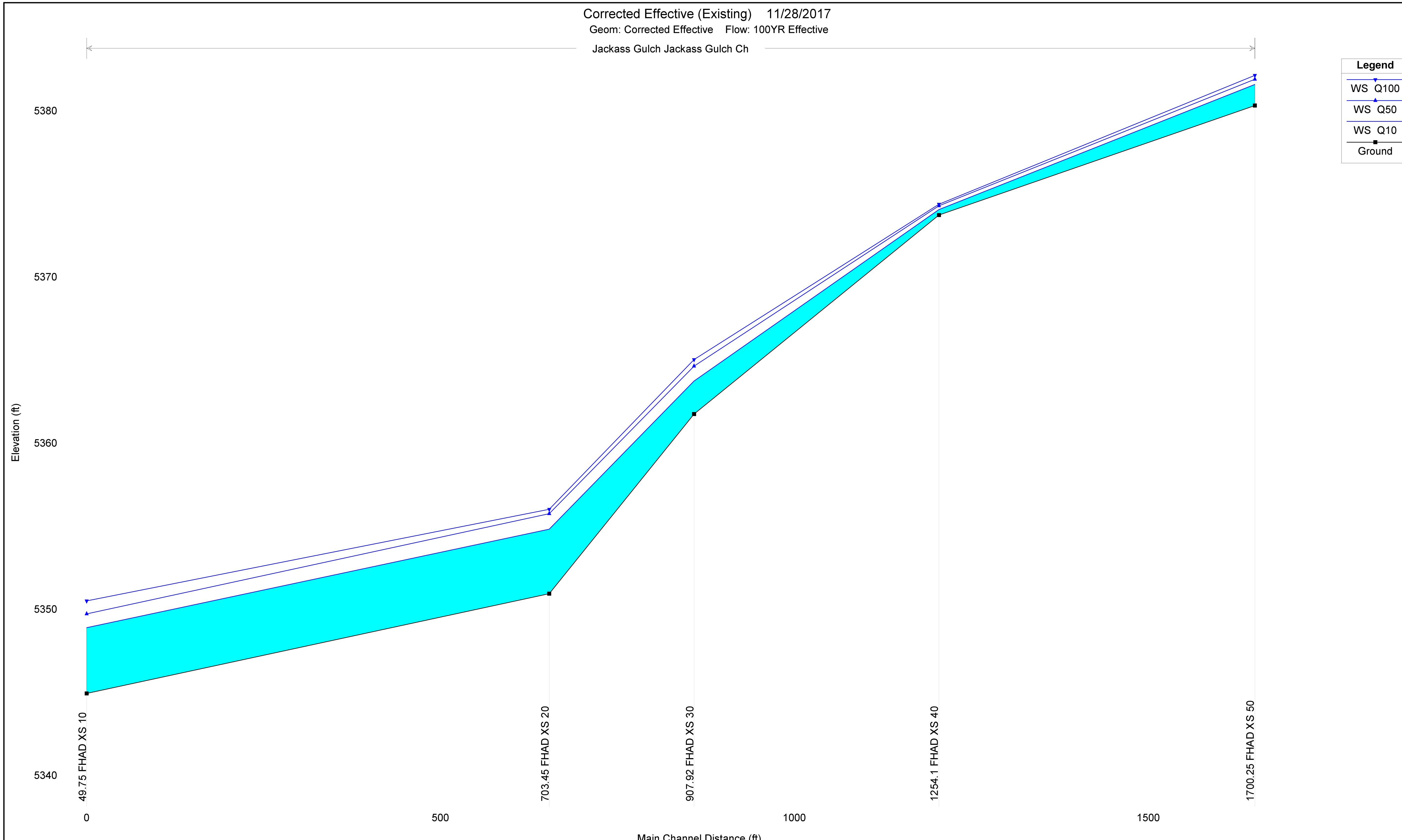
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Jackass Gulch Ch	1700.25	Q100	1240.00	5380.27	5382.09	5382.09	5382.69	0.012461	6.22	200.39	176.62	1.00
Jackass Gulch Ch	1254.1	Q100	1240.00	5373.68	5374.33	5374.33	5374.61	0.022360	5.02	302.91	568.34	1.18
Jackass Gulch Ch	907.92	Q100	1240.00	5361.71	5364.99	5364.99	5365.95	0.007865	8.56	186.78	109.78	0.91
Jackass Gulch Ch	703.45	Q100	1500.00	5350.90	5355.98	5355.98	5356.69	0.006020	8.94	303.58	191.77	0.82
Jackass Gulch Ch	49.75	Q100	1500.00	5344.90	5350.46	5350.46	5351.41	0.004651	9.03	263.12	152.77	0.75

HEC-RAS Plan: CorrEff River: Jackass Gulch Reach: Jackass Gulch Ch Profile: Q50

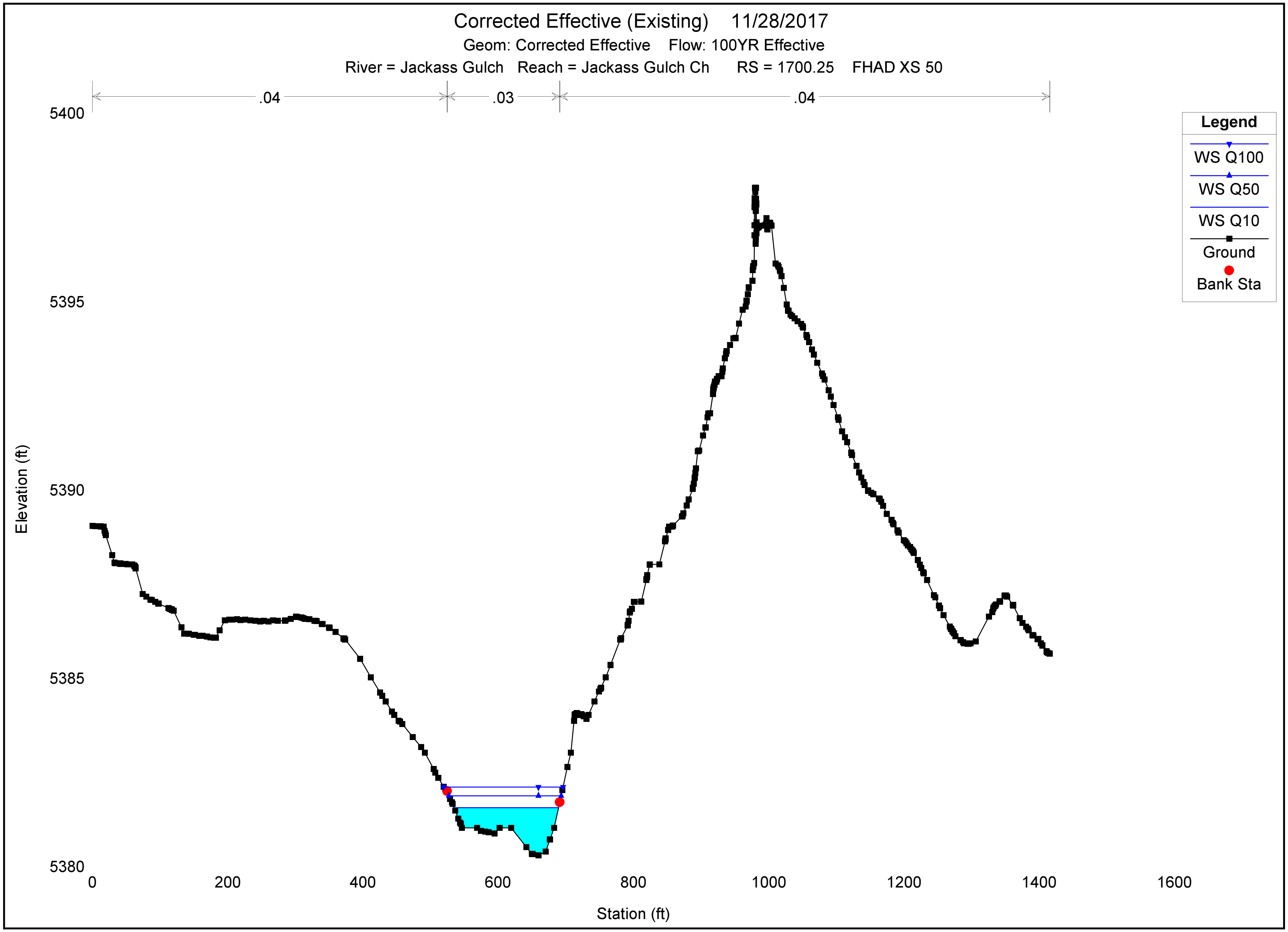
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Jackass Gulch Ch	1700.25	Q50	910.00	5380.27	5381.85	5381.85	5382.35	0.013486	5.67	160.75	166.20	1.01
Jackass Gulch Ch	1254.1	Q50	910.00	5373.68	5374.23	5374.23	5374.46	0.022552	4.46	249.48	559.87	1.15
Jackass Gulch Ch	907.92	Q50	910.00	5361.71	5364.59	5364.59	5365.39	0.007860	7.71	145.80	95.56	0.88
Jackass Gulch Ch	703.45	Q50	1170.00	5350.90	5355.71	5355.71	5356.36	0.005728	8.29	253.37	181.21	0.79
Jackass Gulch Ch	49.75	Q50	1170.00	5344.90	5349.69	5349.69	5350.87	0.006748	9.59	162.69	83.98	0.88

HEC-RAS Plan: CorrEff   River: Jackass Gulch   Reach: Jackass Gulch Ch   Profile: Q10

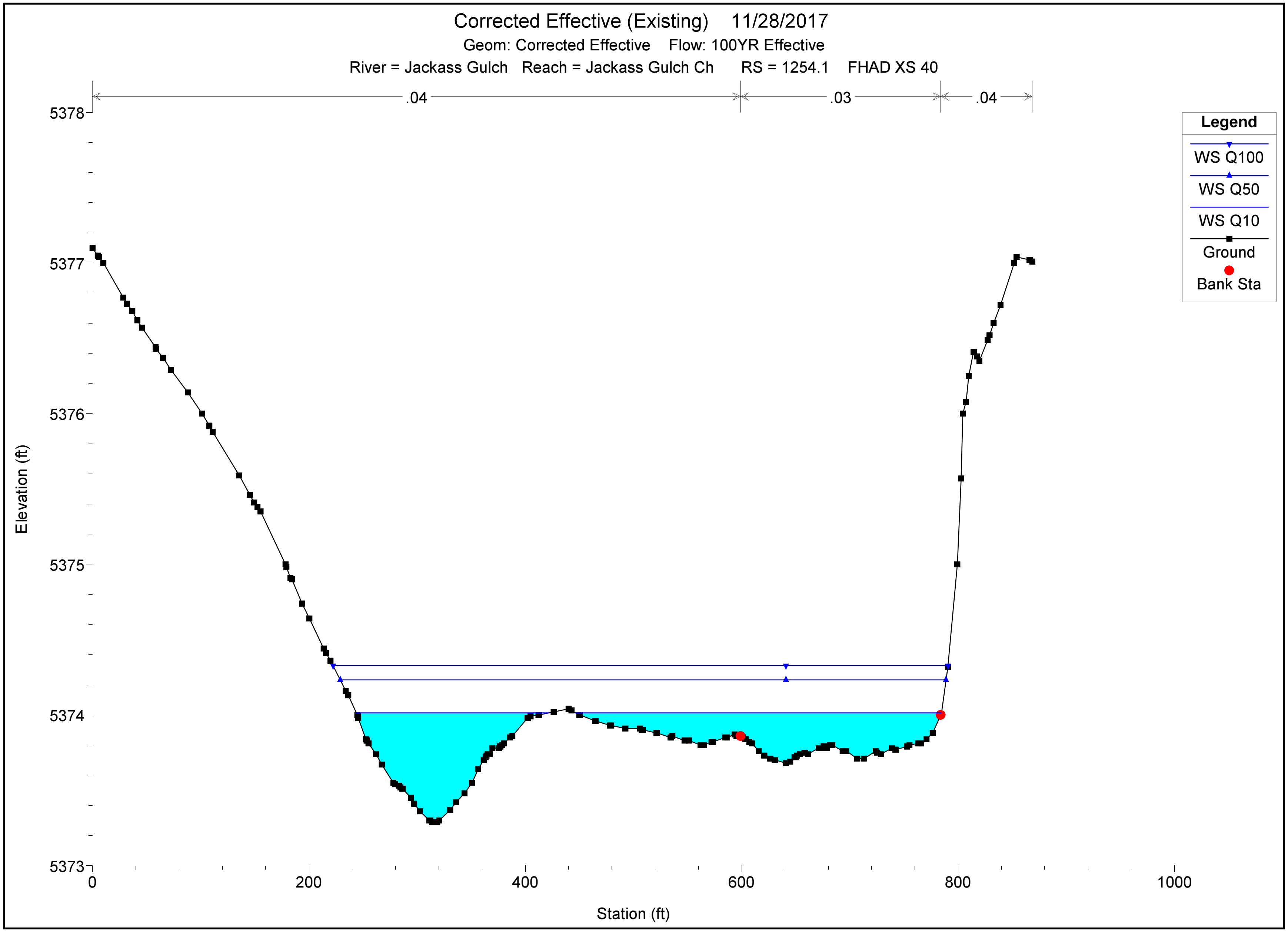
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Jackass Gulch Ch	1700.25	Q10	430.00	5380.27	5381.54		5381.77	0.009945	3.93	109.54	154.53	0.82
Jackass Gulch Ch	1254.1	Q10	430.00	5373.68	5374.01	5374.01	5374.19	0.035312	3.65	129.72	516.69	1.30
Jackass Gulch Ch	907.92	Q10	430.00	5361.71	5363.70	5363.70	5364.31	0.010306	6.44	73.28	63.06	0.94
Jackass Gulch Ch	703.45	Q10	690.00	5350.90	5354.78	5354.78	5355.80	0.010717	9.18	108.63	88.10	1.02
Jackass Gulch Ch	49.75	Q10	690.00	5344.90	5348.86	5348.86	5349.79	0.006835	8.15	103.92	62.91	0.85



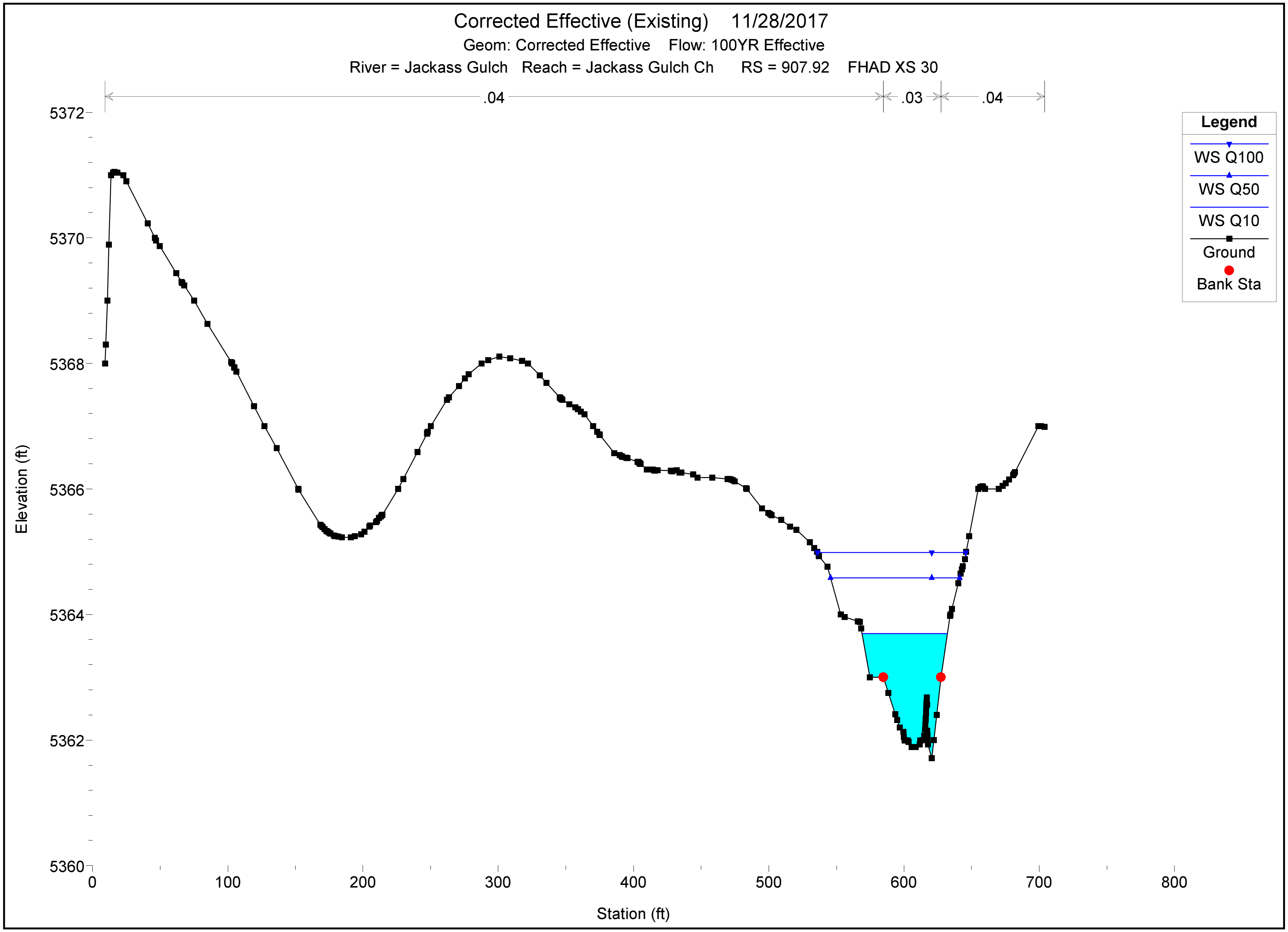
Corrected Effective (Existing) 11/28/2017
Geom: Corrected Effective Flow: 100YR Effective
Jackass Gulch Jackass Gulch Ch
Legend
WS Q100
WS Q50
WS Q10
Ground
Elevation (ft)
5380
5370
5360
5350
5340
49.75 FHAD XS 10
703.45 FHAD XS 20
907.92 FHAD XS 30
1254.1 FHAD XS 40
1700.25 FHAD XS 50
0
500
1000
1500
Main Channel Distance (ft)



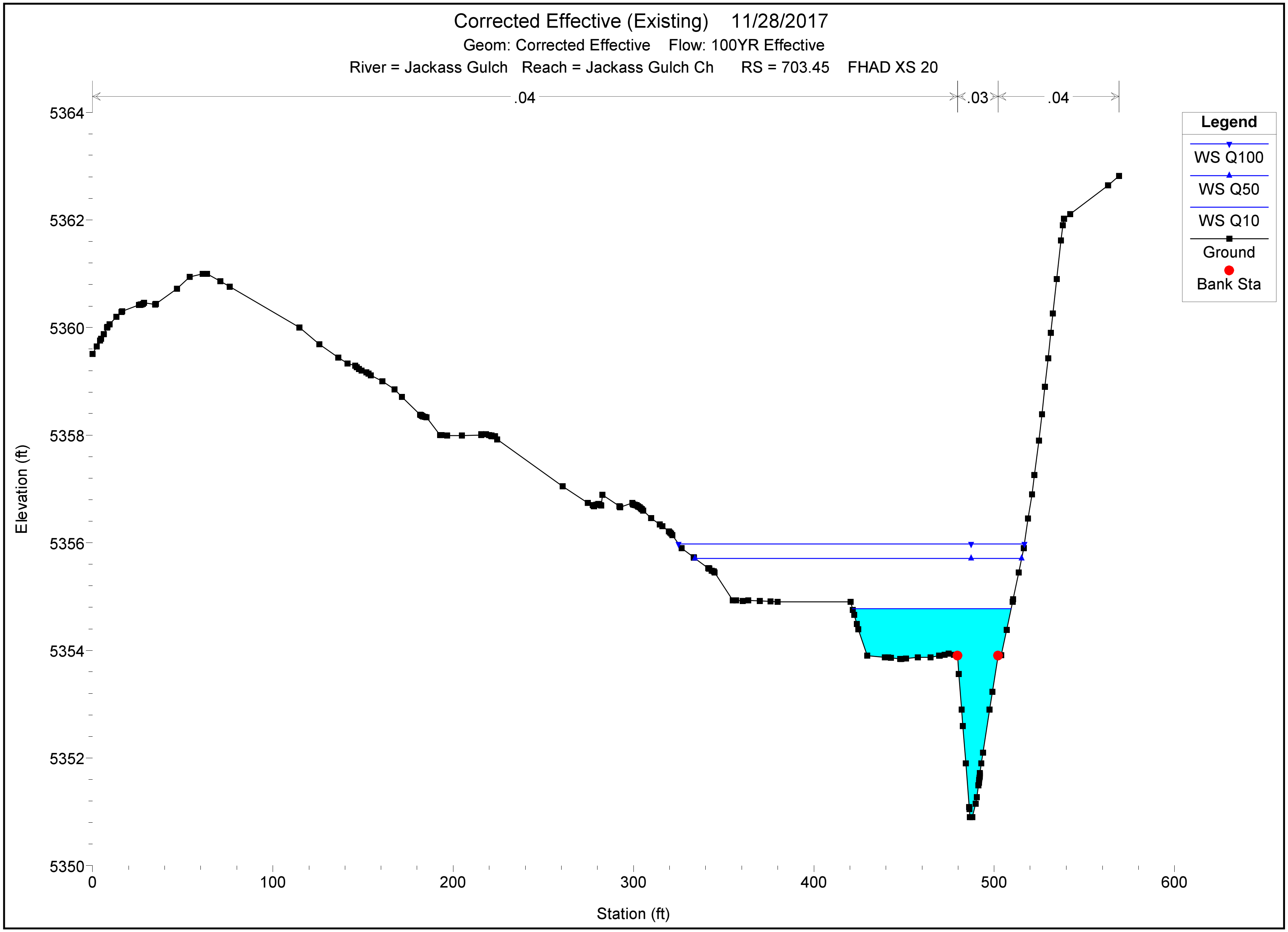
Corrected Effective (Existing) 11/28/2017
Geom: Corrected Effective Flow: 100YR Effective
River = Jackass Gulch Reach = Jackass Gulch Ch RS = 1700.25 FHAD XS 50
.04
.03
.04
Legend
WS Q100
WS Q50
WS Q10
Ground
Bank Sta
Elevation (ft)
5400
5395
5390
5385
5380
0
200
400
600
800
1000
1200
1400
1600
Station (ft)



Corrected Effective (Existing) 11/28/2017
Geom: Corrected Effective Flow: 100YR Effective
River = Jackass Gulch Reach = Jackass Gulch Ch RS = 1254.1 FHAD XS 40
.04
.03
.04
Legend
WS Q100
WS Q50
WS Q10
Ground
Bank Sta
Elevation (ft)
5378
5377
5376
5375
5374
5373
0
200
400
600
800
1000
Station (ft)



Corrected Effective (Existing) 11/28/2017
Geom: Corrected Effective Flow: 100YR Effective
River = Jackass Gulch Reach = Jackass Gulch Ch RS = 907.92 FHAD XS 30
.04
.03
.04
Legend
WS Q100
WS Q50
WS Q10
Ground
Bank Sta
Elevation (ft)
5360
5362
5364
5366
5368
5370
5372
Station (ft)
0
100
200
300
400
500
600
700
800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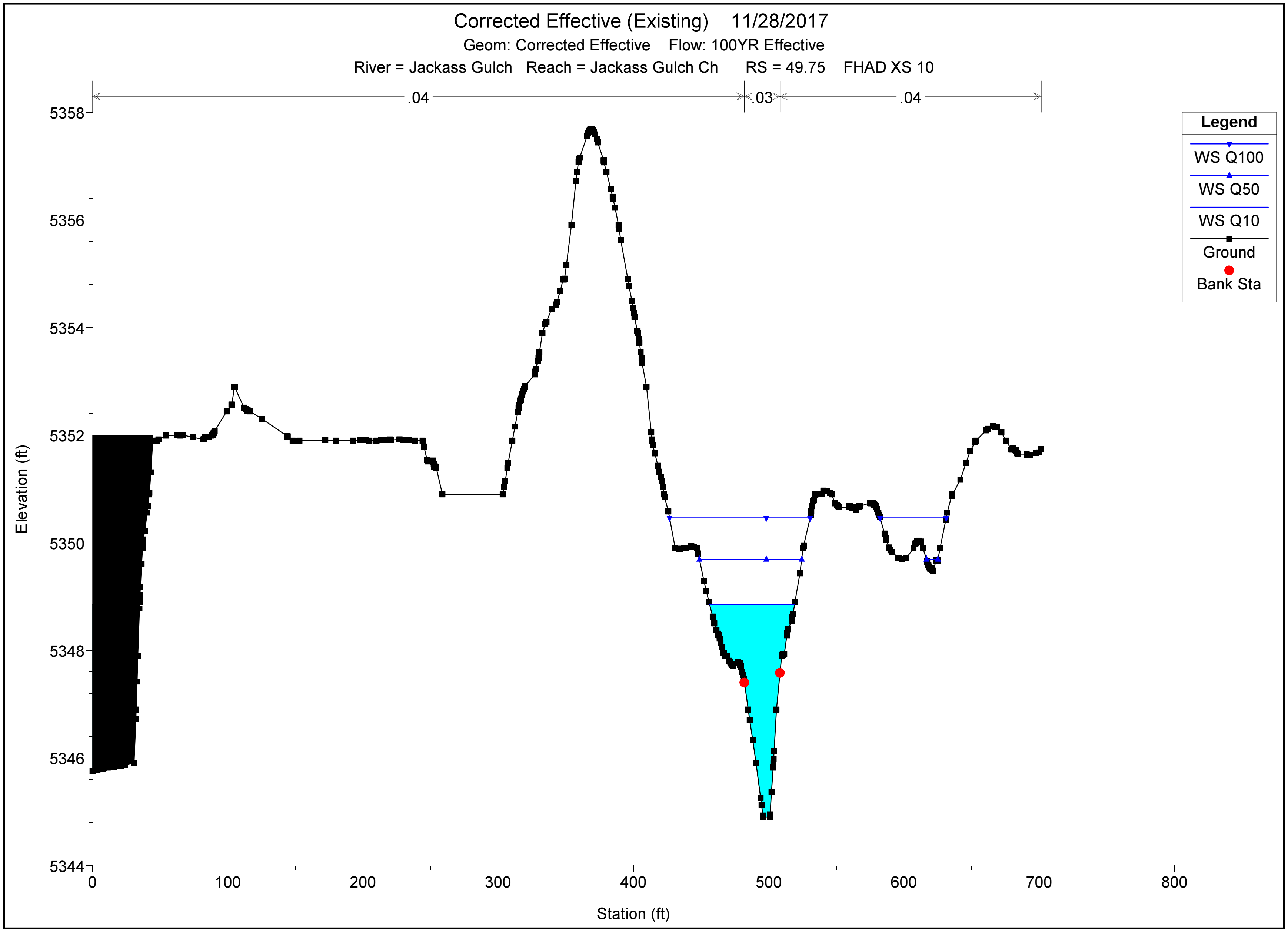
Geom: Corrected Effective Flow: 100YR Effective
River = Jackass Gulch Reach = Jackass Gulch Ch RS = 703.45 FHAD XS 20
.04
.03
.04
Legend
WS Q100
WS Q50
WS Q10
Ground
Bank Sta
Elevation (ft)
5364
5362
5360
5358
5356
5354
5352
5350
0
100
200
300
400
500
600
Station (ft)



Corrected Effective (Existing) 11/28/2017
Geom: Corrected Effective Flow: 100YR Effective
River = Jackass Gulch Reach = Jackass Gulch Ch RS = 49.75 FHAD XS 10
.04
.03
.04
Legend
WS Q100
WS Q50
WS Q10
Ground
Bank Sta
Elevation (ft)
5358
5356
5354
5352
5350
5348
5346
5344
0
100
200
300
400
500
600
700
800
Station (ft)

HEC-RAS Plan: Proposed River: Jackass Gulch Reach: New Jackass Gulc Profile: Q100

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
New Jackass Gulc	1862.83	Q100	1240.00	5378.20	5382.55		5382.59	0.000188	1.55	808.87	351.20	0.15
New Jackass Gulc	1697.64	Q100	1240.00	5377.60	5382.20		5382.50	0.001937	4.66	291.15	155.69	0.46
New Jackass Gulc	1584.87	Q100	1240.00	5377.38	5381.18	5380.85	5382.07	0.006979	7.55	164.16	65.93	0.84
New Jackass Gulc	1489.47	Q100	1240.00	5377.20	5380.13	5380.13	5381.24	0.010310	8.46	146.59	66.70	1.01
New Jackass Gulc	1470.56	Q100	1240.00	5372.62	5376.85		5377.73	0.005576	7.53	164.63	55.57	0.77
New Jackass Gulc	1433.68	Q100	1240.00	5371.99	5376.93		5377.49	0.003016	6.02	206.14	61.35	0.58
New Jackass Gulc	1405.54	Q100	1240.00	5371.57	5376.78	5374.83	5377.40	0.002491	6.35	195.32	38.19	0.49
New Jackass Gulc	1345		Culvert									
New Jackass Gulc	1278.14	Q100	1240.00	5369.36	5372.68	5372.68	5374.25	0.010258	10.06	123.23	39.55	1.01
New Jackass Gulc	1263.8	Q100	1240.00	5365.78	5370.81		5371.55	0.004131	6.93	178.94	54.39	0.67
New Jackass Gulc	1237.26	Q100	1240.00	5365.33	5370.78		5371.42	0.003823	6.37	194.68	62.17	0.63
New Jackass Gulc	1236.26	Q100	1240.00	5366.29	5370.35	5370.08	5371.37	0.007456	8.11	152.94	57.76	0.88
New Jackass Gulc	1215.88	Q100	1240.00	5366.00	5369.91	5369.91	5371.18	0.009929	9.03	137.37	54.75	1.00
New Jackass Gulc	1075.48	Q100	1240.00	5363.98	5367.88	5367.88	5369.19	0.009957	9.16	135.30	52.71	1.01
New Jackass Gulc	983.76	Q100	1240.00	5362.78	5366.36	5366.36	5367.52	0.010280	8.63	143.74	63.29	1.01
New Jackass Gulc	948.22	Q100	1240.00	5362.22	5365.87	5365.87	5366.97	0.010177	8.41	147.41	66.98	1.00
New Jackass Gulc	907.92	Q100	1240.00	5359.78	5363.24	5363.24	5364.32	0.010244	8.34	148.63	68.78	1.00
New Jackass Gulc	703.45	Q100	1500.00	5350.90	5356.08		5356.59	0.004309	6.14	324.23	194.49	0.67
New Jackass Gulc	550.88	Q100	1500.00	5349.90	5355.64		5356.08	0.002567	5.97	389.85	236.46	0.54
New Jackass Gulc	368.16	Q100	1500.00	5347.73	5354.28	5354.28	5355.35	0.005902	8.52	217.49	346.84	0.81
New Jackass Gulc	216.6	Q100	1500.00	5345.87	5352.64	5352.64	5353.68	0.006164	8.38	219.51	439.33	0.81
New Jackass Gulc	49.75	Q100	1500.00	5344.90	5350.23	5349.90	5351.05	0.006004	7.36	228.50	183.06	0.79

HEC-RAS Plan: Proposed River: Jackass Gulch Reach: New Jackass Gulc Profile: Q50

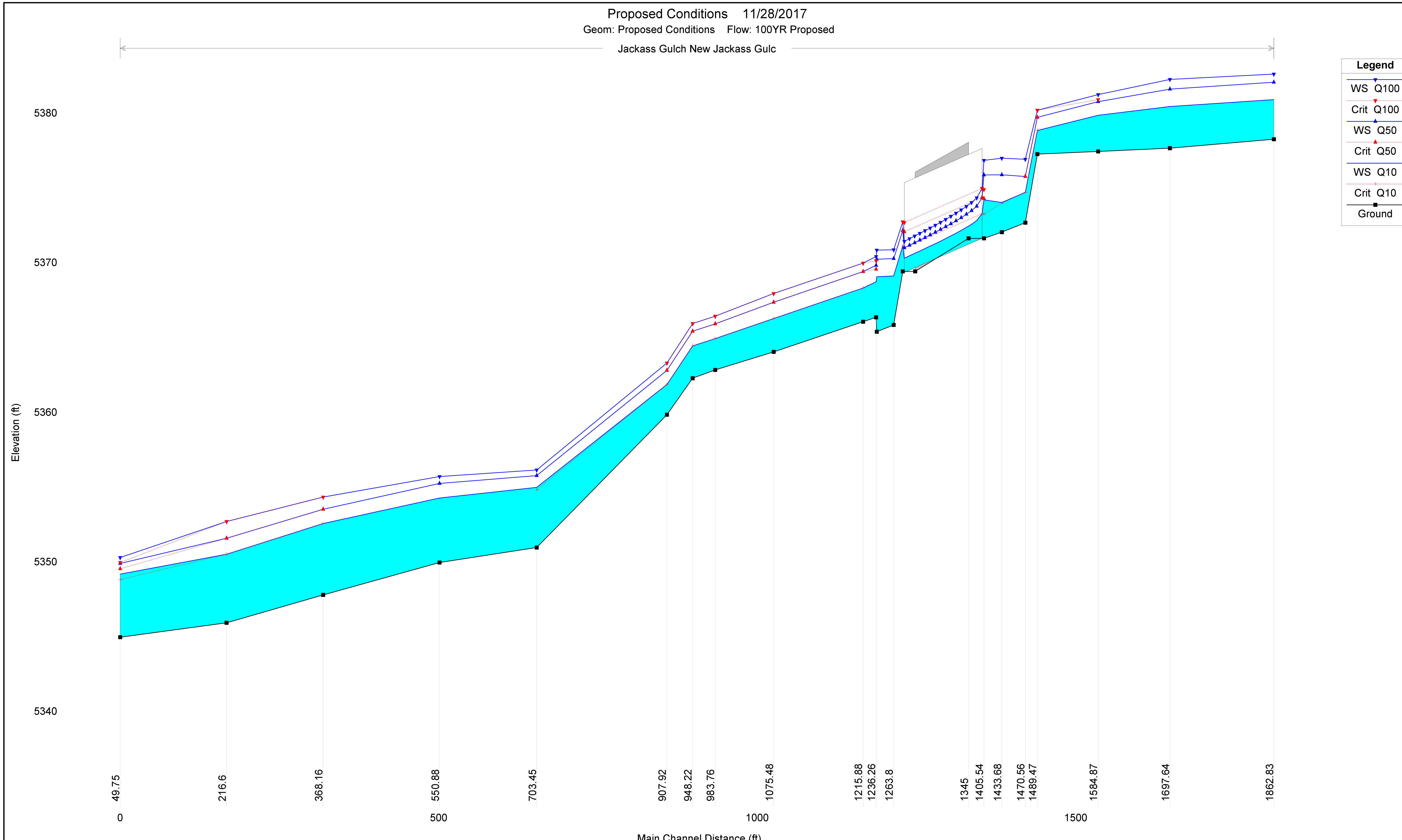
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
New Jackass Gulc	1862.83	Q50	910.00	5378.20	5382.01		5382.05	0.000237	1.55	621.24	343.05	0.16
New Jackass Gulc	1697.64	Q50	910.00	5377.60	5381.54		5381.93	0.002914	5.06	195.37	143.56	0.55
New Jackass Gulc	1584.87	Q50	910.00	5377.38	5380.71		5381.42	0.006482	6.76	134.55	60.37	0.80
New Jackass Gulc	1489.47	Q50	910.00	5377.20	5379.66	5379.66	5380.61	0.010800	7.83	116.27	61.60	1.00
New Jackass Gulc	1470.56	Q50	910.00	5372.62	5375.70	5375.70	5376.85	0.010402	8.60	105.83	46.88	1.01
New Jackass Gulc	1433.68	Q50	910.00	5371.99	5375.82		5376.44	0.004380	6.36	143.16	51.94	0.68
New Jackass Gulc	1405.54	Q50	910.00	5371.57	5375.81	5374.23	5376.32	0.002555	5.75	158.28	37.95	0.50
New Jackass Gulc	1345		Culvert									
New Jackass Gulc	1278.14	Q50	910.00	5369.36	5372.09	5372.09	5373.37	0.010636	9.09	100.12	39.33	1.00
New Jackass Gulc	1263.8	Q50	910.00	5365.78	5370.22		5370.81	0.003711	6.13	148.41	50.06	0.63
New Jackass Gulc	1237.26	Q50	910.00	5365.33	5370.18		5370.69	0.003555	5.73	158.90	56.24	0.60
New Jackass Gulc	1236.26	Q50	910.00	5366.29	5369.77	5369.51	5370.65	0.007582	7.51	121.22	52.07	0.87
New Jackass Gulc	1215.88	Q50	910.00	5366.00	5369.35	5369.35	5370.45	0.010354	8.43	107.96	49.25	1.00
New Jackass Gulc	1075.48	Q50	910.00	5363.98	5367.30	5367.30	5368.44	0.010418	8.57	106.23	47.42	1.01
New Jackass Gulc	983.76	Q50	910.00	5362.78	5365.85	5365.85	5366.86	0.010744	8.06	112.92	56.95	1.01
New Jackass Gulc	948.22	Q50	910.00	5362.22	5365.36	5365.36	5366.33	0.010762	7.93	114.80	59.49	1.01
New Jackass Gulc	907.92	Q50	910.00	5359.78	5362.74	5362.74	5363.70	0.010810	7.83	116.15	61.51	1.01
New Jackass Gulc	703.45	Q50	1170.00	5350.90	5355.71		5356.19	0.004805	5.85	254.16	181.42	0.69
New Jackass Gulc	550.88	Q50	1170.00	5349.90	5355.19		5355.64	0.002862	5.79	285.56	222.85	0.56
New Jackass Gulc	368.16	Q50	1170.00	5347.73	5353.46	5353.46	5354.71	0.008884	9.03	136.56	198.50	0.95
New Jackass Gulc	216.6	Q50	1170.00	5345.87	5351.52	5351.52	5353.00	0.009917	9.75	120.00	325.89	1.00
New Jackass Gulc	49.75	Q50	1170.00	5344.90	5349.84	5349.48	5350.56	0.006001	6.84	176.69	140.21	0.78

HEC-RAS Plan: Proposed River: Jackass Gulch Reach: New Jackass Gulc Profile: Q10

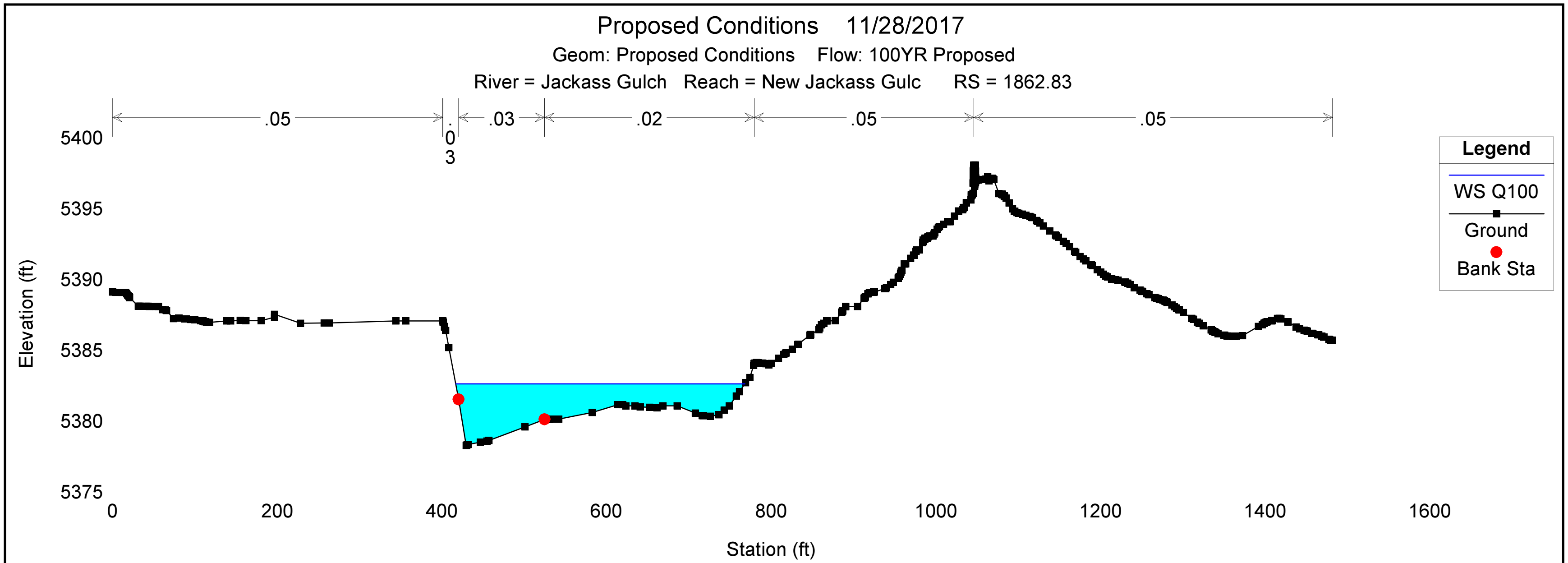
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
New Jackass Gulc	1862.83	Q10	430.00	5378.20	5380.84		5380.89	0.000737	1.97	241.02	231.66	0.26
New Jackass Gulc	1697.64	Q10	430.00	5377.60	5380.38		5380.66	0.003106	4.23	101.59	53.03	0.54
New Jackass Gulc	1584.87	Q10	430.00	5377.38	5379.79		5380.20	0.005271	5.11	84.21	49.37	0.69
New Jackass Gulc	1489.47	Q10	430.00	5377.20	5378.78	5378.78	5379.44	0.012476	6.48	66.37	52.13	1.01
New Jackass Gulc	1470.56	Q10	430.00	5372.62	5374.65	5374.65	5375.43	0.011621	7.11	60.48	38.87	1.00
New Jackass Gulc	1433.68	Q10	430.00	5371.99	5373.97	5373.92	5374.73	0.010546	7.01	61.38	37.37	0.96
New Jackass Gulc	1405.54	Q10	430.00	5371.57	5374.14	5373.19	5374.46	0.002783	4.51	95.40	37.54	0.50
New Jackass Gulc	1345		Culvert									
New Jackass Gulc	1278.14	Q10	430.00	5369.36	5371.07	5371.07	5371.86	0.012061	7.14	60.26	38.94	1.01
New Jackass Gulc	1263.8	Q10	430.00	5365.78	5369.06		5369.38	0.002816	4.52	95.15	41.35	0.53
New Jackass Gulc	1237.26	Q10	430.00	5365.33	5369.00		5369.29	0.002797	4.32	99.58	44.70	0.51
New Jackass Gulc	1236.26	Q10	430.00	5366.29	5368.67		5369.26	0.007811	6.17	69.72	41.20	0.84
New Jackass Gulc	1215.88	Q10	430.00	5366.00	5368.25	5368.25	5369.05	0.011645	7.16	60.02	38.23	1.01
New Jackass Gulc	1075.48	Q10	430.00	5363.98	5366.21	5366.21	5367.01	0.011553	7.20	59.70	37.44	1.01
New Jackass Gulc	983.76	Q10	430.00	5362.78	5364.87	5364.87	5365.59	0.012046	6.80	63.22	44.88	1.01
New Jackass Gulc	948.22	Q10	430.00	5362.22	5364.38	5364.38	5365.09	0.012016	6.78	63.46	45.23	1.01
New Jackass Gulc	907.92	Q10	430.00	5359.78	5361.81	5361.81	5362.49	0.012011	6.62	64.91	47.90	1.00
New Jackass Gulc	703.45	Q10	690.00	5350.90	5354.93	5354.75	5355.45	0.008539	5.86	123.34	149.06	0.85
New Jackass Gulc	550.88	Q10	690.00	5349.90	5354.22		5354.60	0.003661	5.18	157.60	97.99	0.60
New Jackass Gulc	368.16	Q10	690.00	5347.73	5352.50	5352.50	5353.50	0.010168	8.00	87.50	170.75	0.97
New Jackass Gulc	216.6	Q10	690.00	5345.87	5350.45	5350.45	5351.62	0.010610	8.66	79.63	156.17	1.00
New Jackass Gulc	49.75	Q10	690.00	5344.90	5349.12	5348.76	5349.63	0.006007	5.69	121.34	102.56	0.74

Plan: Proposed   Jackass Gulch   New Jackass Gulc RS: 1345   Culv Group: Culvert #1   Profile: Q100

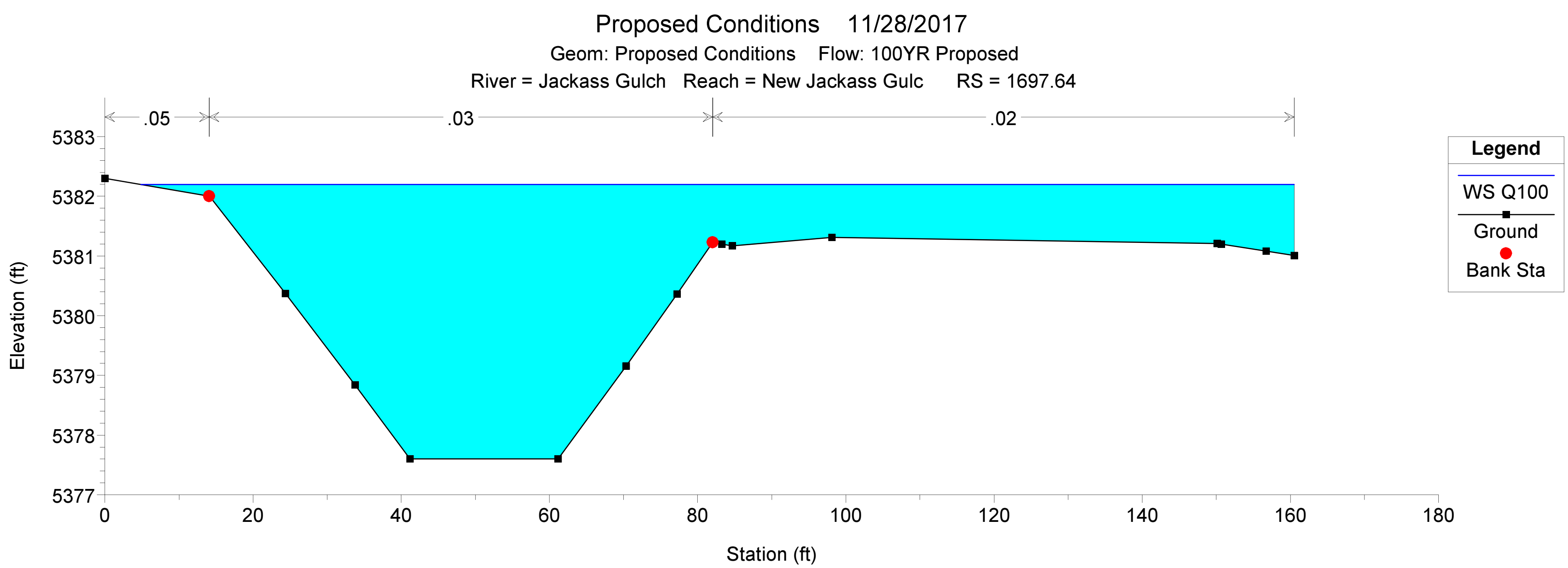
Q Culv Group (cfs)	1240.00	Culv Full Len (ft)	
# Barrels	2	Culv Vel US (ft/s)	10.35
Q Barrel (cfs)	620.00	Culv Vel DS (ft/s)	16.63
E.G. US. (ft)	5377.41	Culv Inv El Up (ft)	5371.58
W.S. US. (ft)	5376.78	Culv Inv El Dn (ft)	5369.30
E.G. DS (ft)	5374.25	Culv Frctn Ls (ft)	0.00
W.S. DS (ft)	5372.68	Culv Exit Loss (ft)	1.42
Delta EG (ft)	3.16	Culv Entr Loss (ft)	0.83
Delta WS (ft)	4.10	Q Weir (cfs)	
E.G. IC (ft)	5376.88	Weir Sta Lft (ft)	
E.G. OC (ft)	5377.41	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	5374.91	Weir Max Depth (ft)	
Culv WS Outlet (ft)	5371.37	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.72	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	3.33	Min El Weir Flow (ft)	5378.01



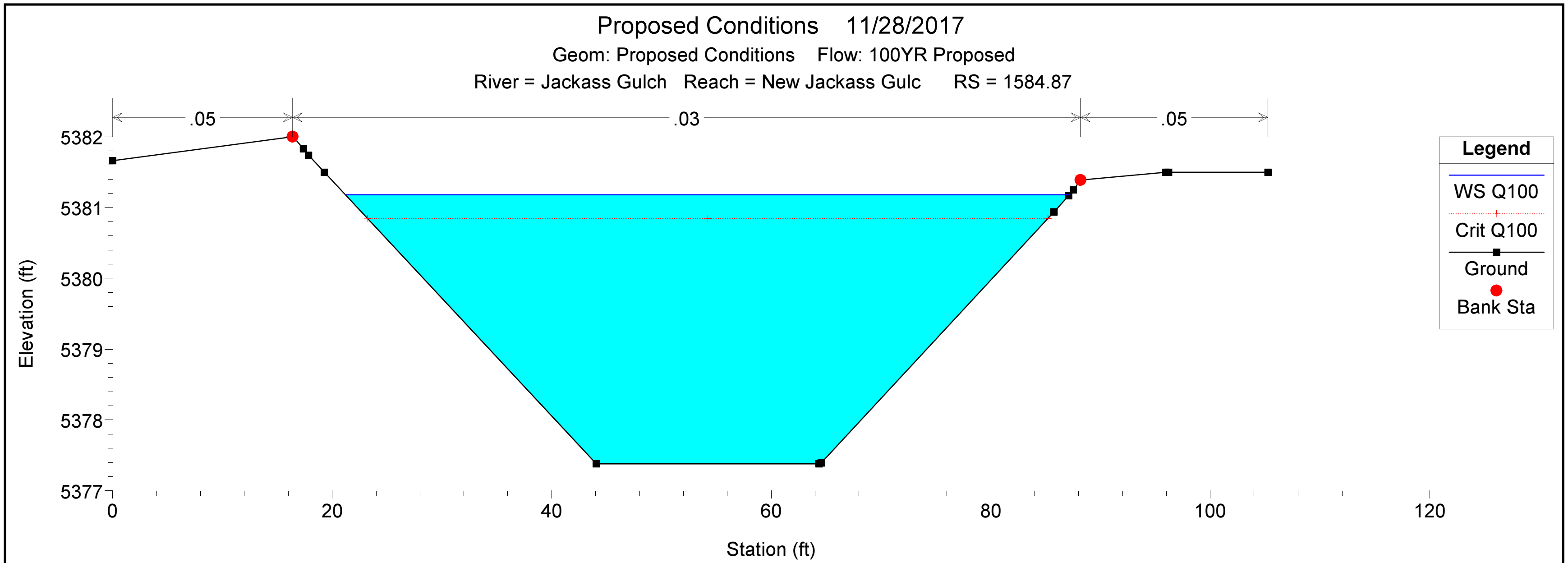
Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
Jackass Gulch New Jackass Gulc
Legend
WS Q100
Crit Q100
WS Q50
Crit Q50
WS Q10
Crit Q10
Ground
Elevation (ft)
5380
5370
5360
5350
5340
49.75
216.6
368.16
550.88
703.45
907.92
948.22
983.76
1075.48
1215.88
1236.26
1263.8
1345
1405.54
1433.68
1470.56
1489.47
1584.87
1697.64
1862.83
0
500
1000
1500
Main Channel Distance (ft)

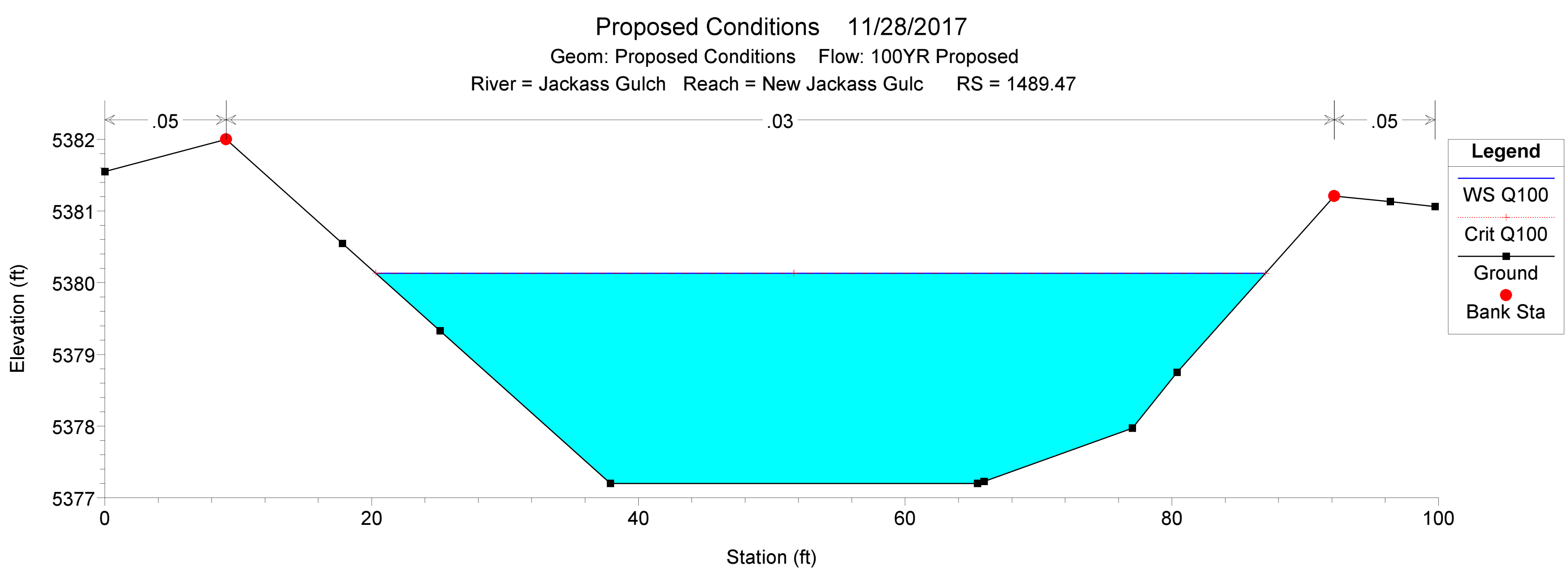


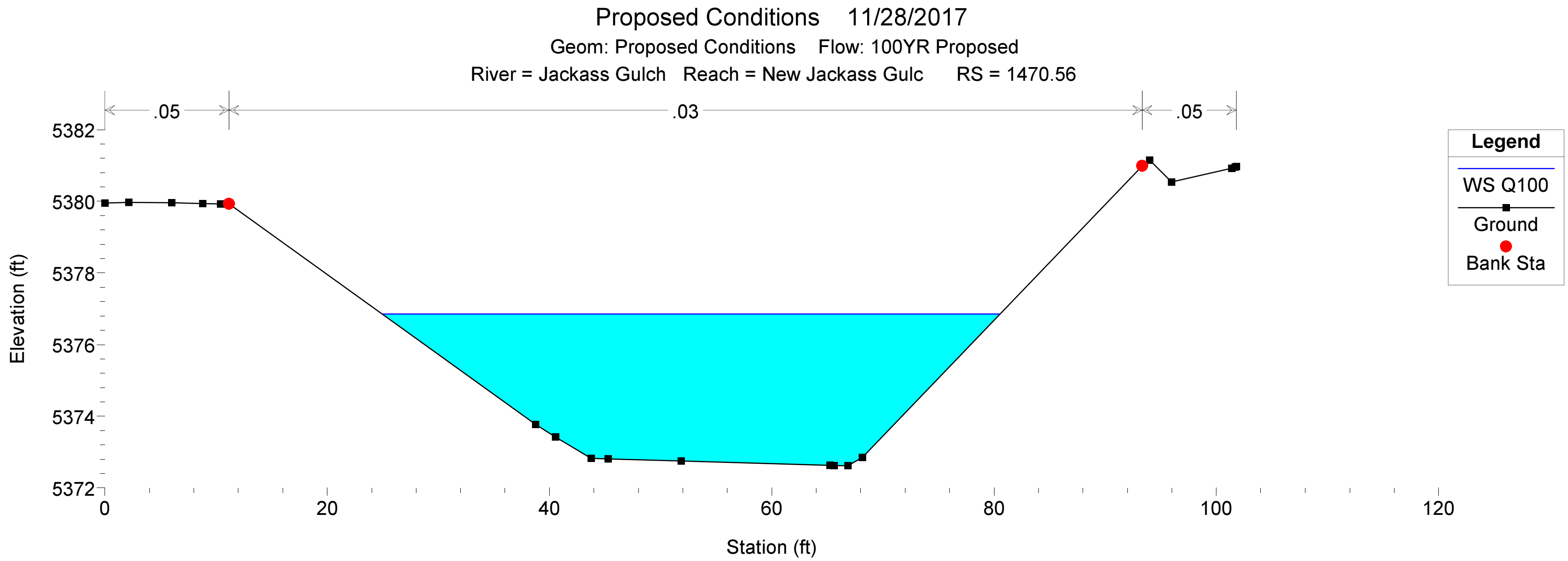
Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1862.83
.05
.03
.03
.02
.05
.05
Legend
WS Q100
Ground
Bank Sta
Elevation (ft)
5400
5395
5390
5385
5380
5375
0
200
400
600
800
1000
1200
1400
1600
Station (ft)

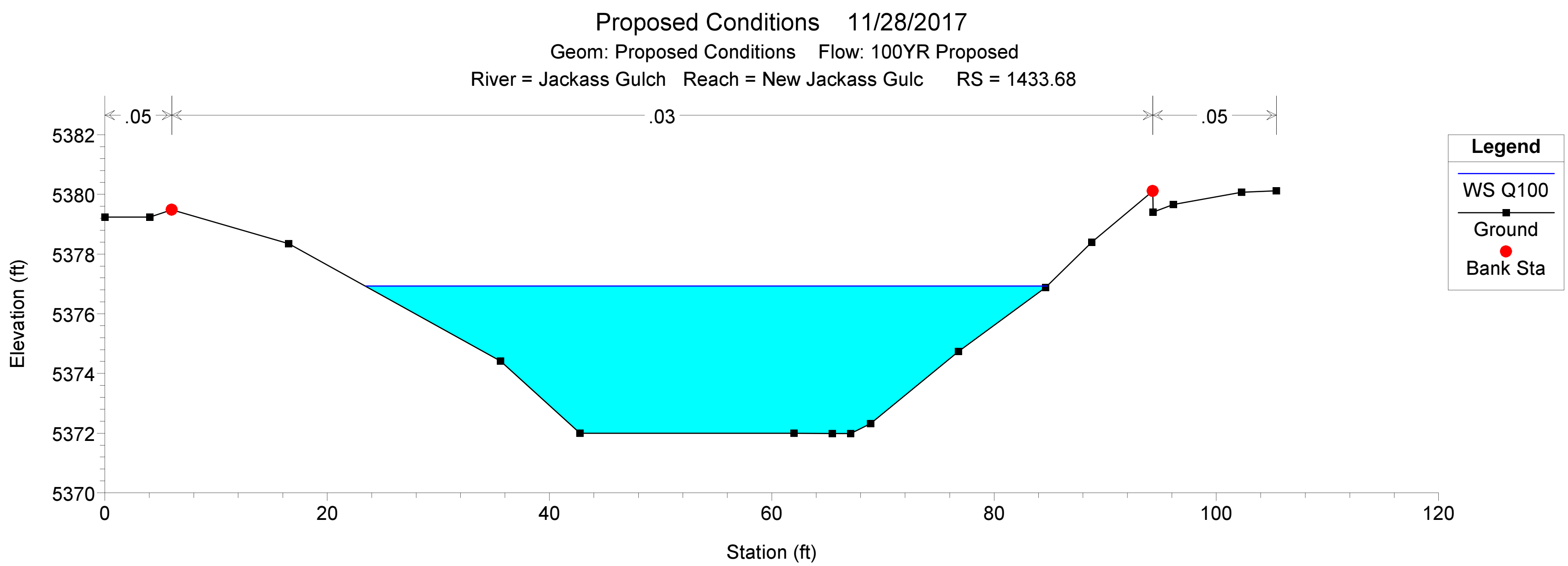


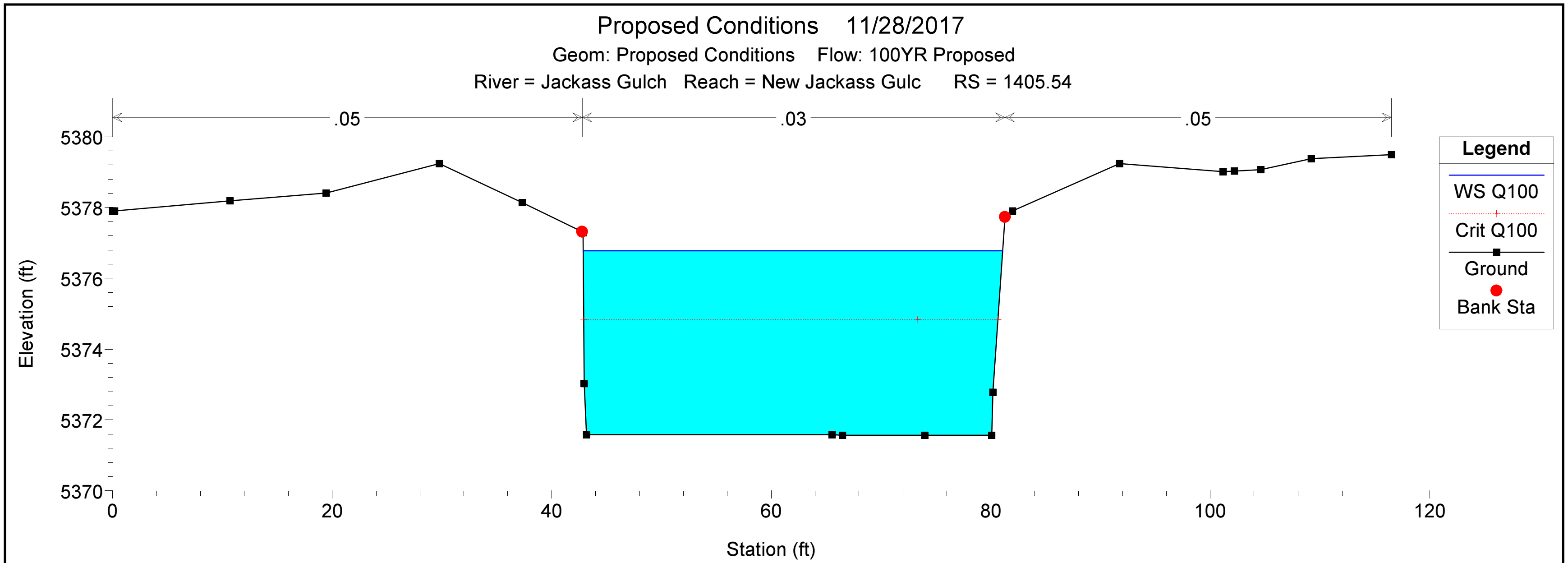
Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1697.64
.05
.03
.02
Legend
WS Q100
Ground
Bank Sta
Elevation (ft)
5383
5382
5381
5380
5379
5378
5377
0
20
40
60
80
100
120
140
160
180
Station (ft)

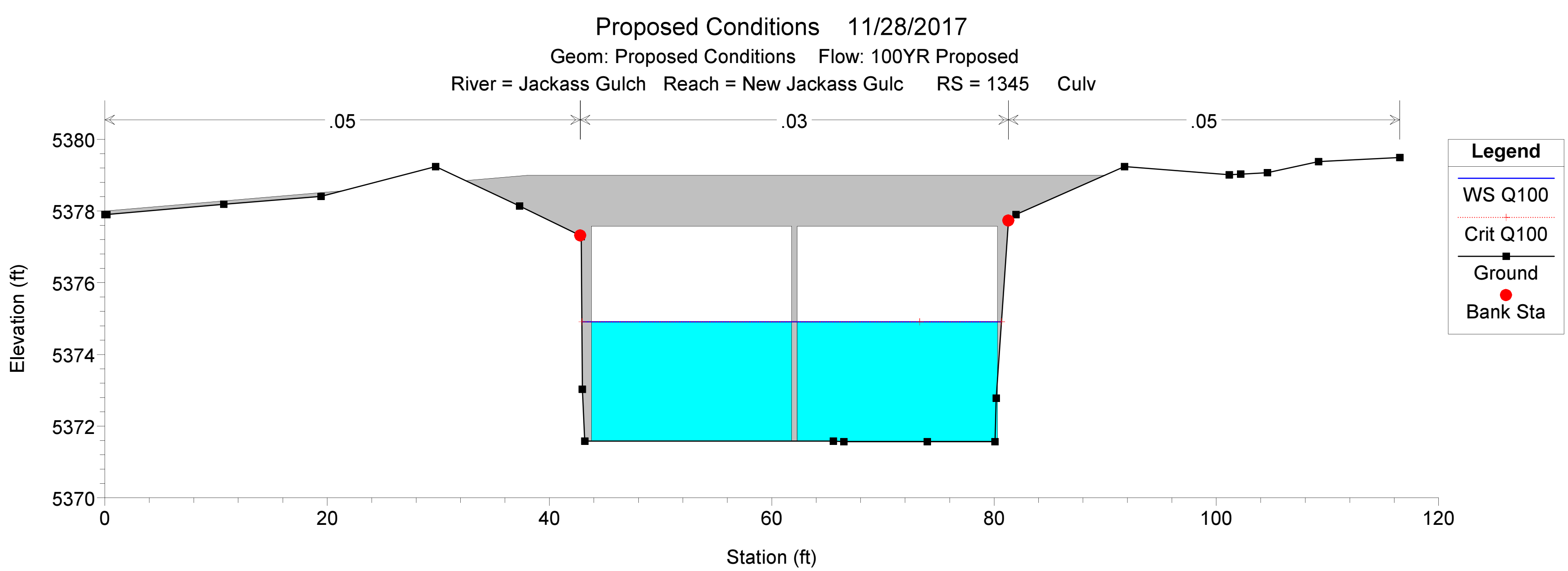

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1584.87
.05
.03
.05
Legend
WS Q100
Crit Q100
Ground
Bank Sta
Elevation (ft)
5382
5381
5380
5379
5378
5377
0
20
40
60
80
100
120
Station (ft)

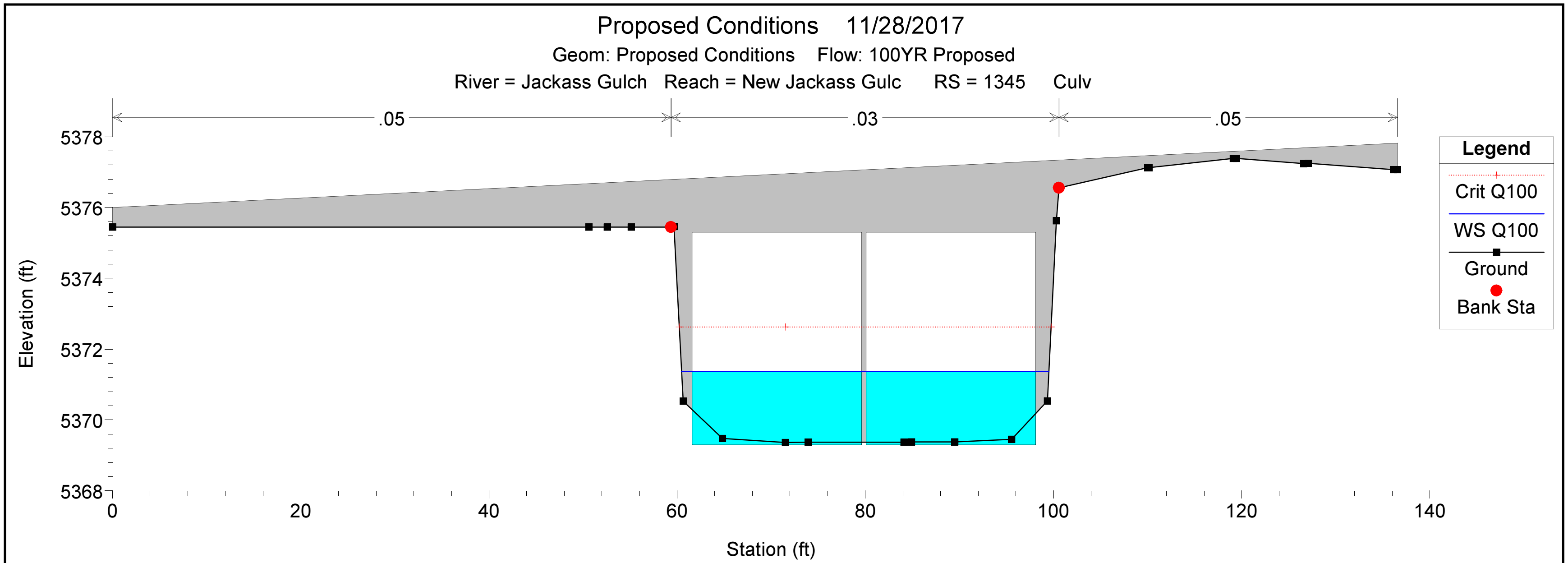

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1489.47
.05
.03
.05
Legend
WS Q100
Crit Q100
Ground
Bank Sta
Elevation (ft)
5382
5381
5380
5379
5378
5377
0
20
40
60
80
100
Station (ft)


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1470.56
.05
.03
.05
Elevation (ft)
5372
5374
5376
5378
5380
5382
0
20
40
60
80
100
120
Station (ft)
Legend
WS Q100
Ground
Bank Sta

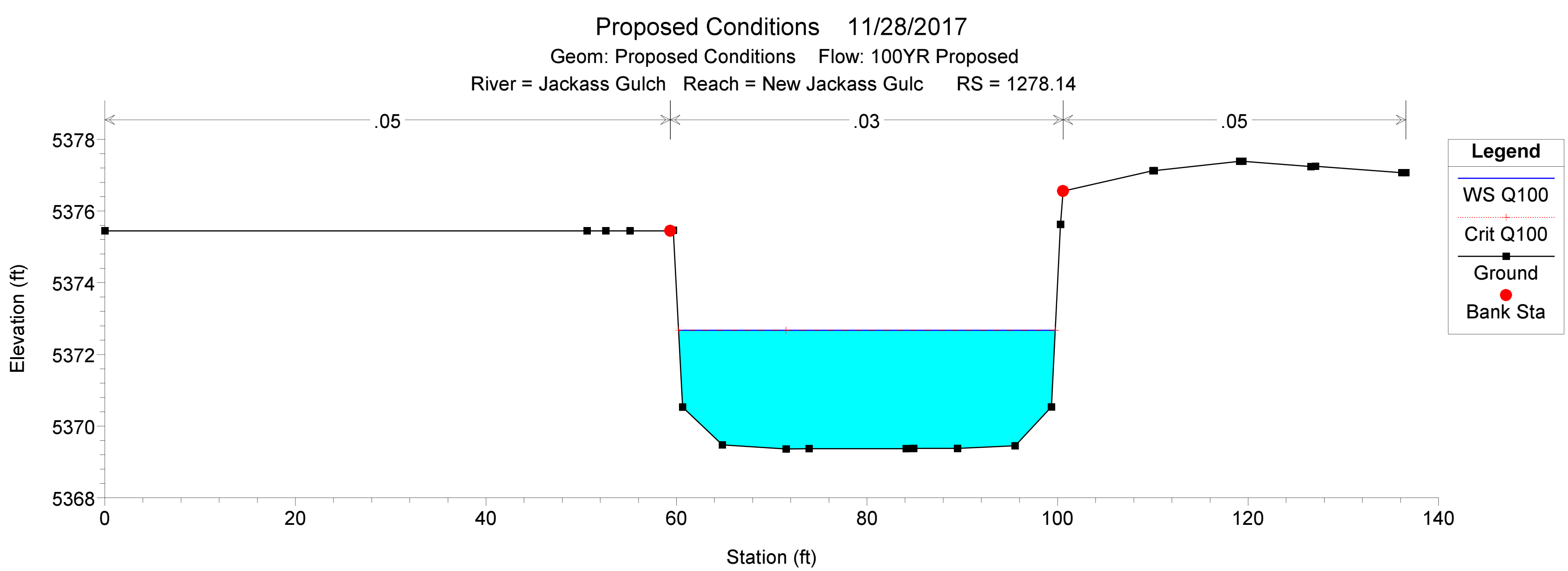

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1433.68
.05
.03
.05
Elevation (ft)
5370
5372
5374
5376
5378
5380
5382
0
20
40
60
80
100
120
Station (ft)
Legend
WS Q100
Ground
Bank Sta


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1405.54
.05
.03
.05
Legend
WS Q100
Crit Q100
Ground
Bank Sta
Elevation (ft)
5370
5372
5374
5376
5378
5380
0
20
40
60
80
100
120
Station (ft)

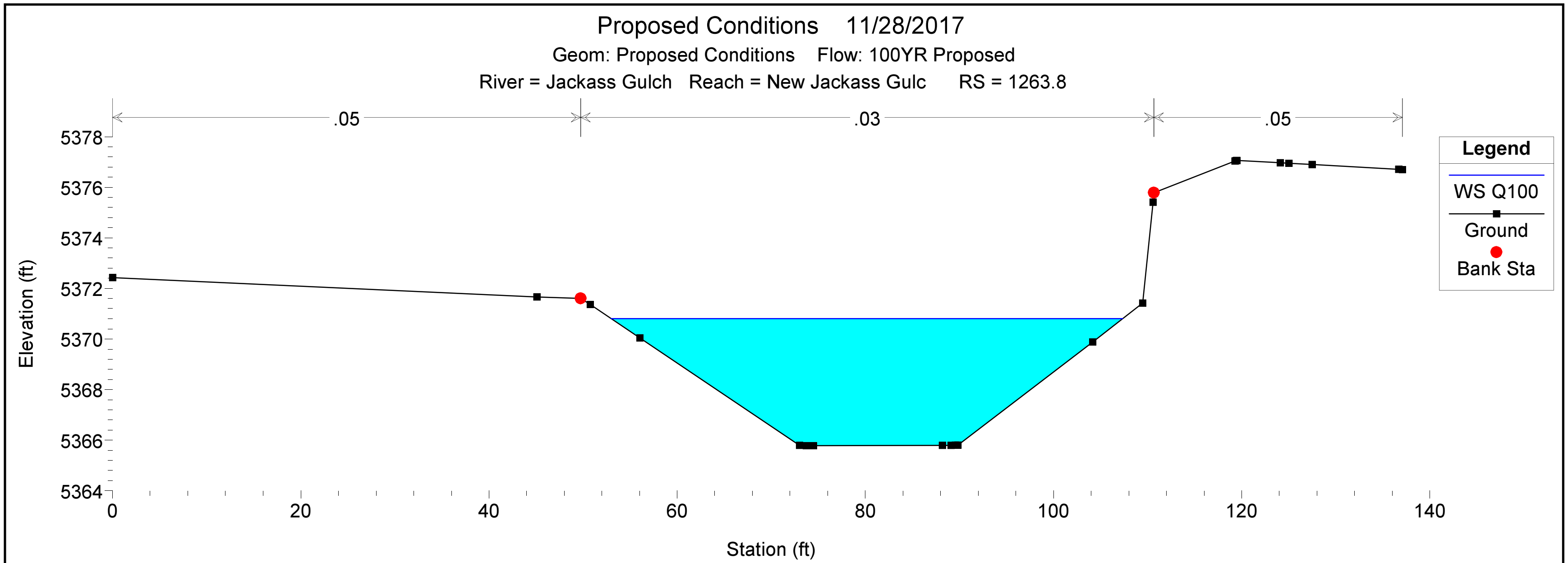

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1345 Culv
.05
.03
.05
Legend
WS Q100
Crit Q100
Ground
Bank Sta
Elevation (ft)
5370
5372
5374
5376
5378
5380
0
20
40
60
80
100
120
Station (ft)

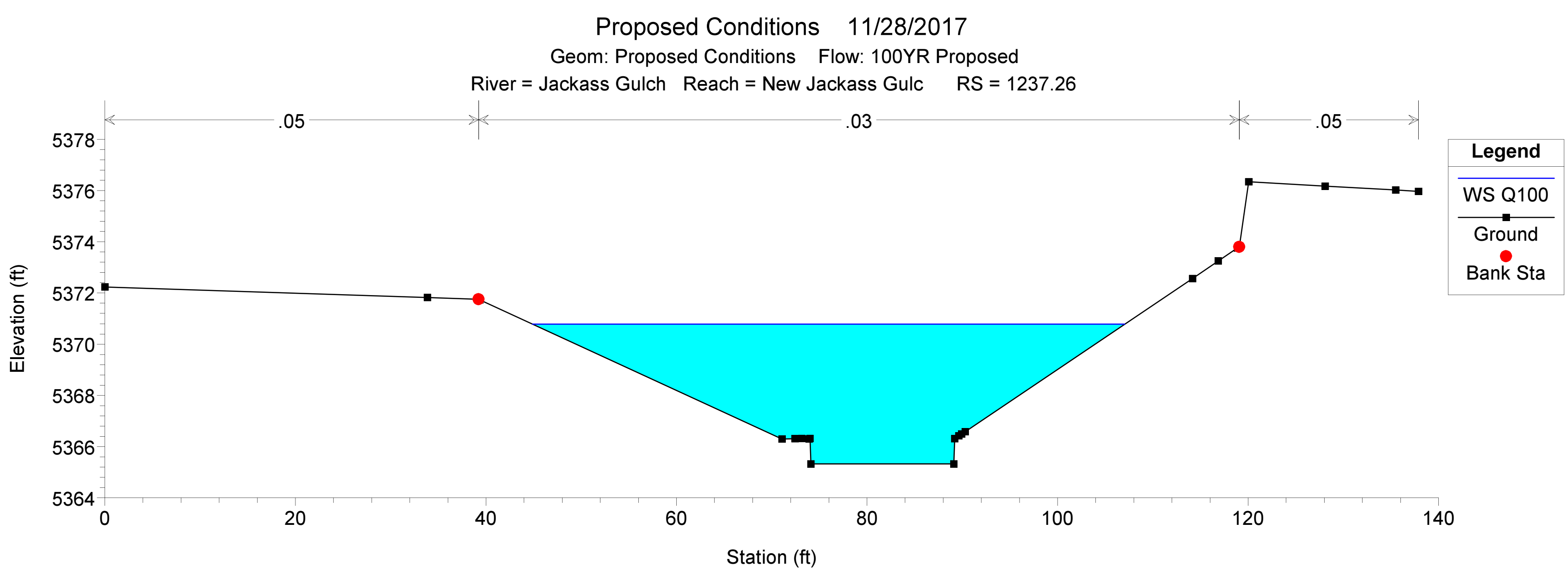


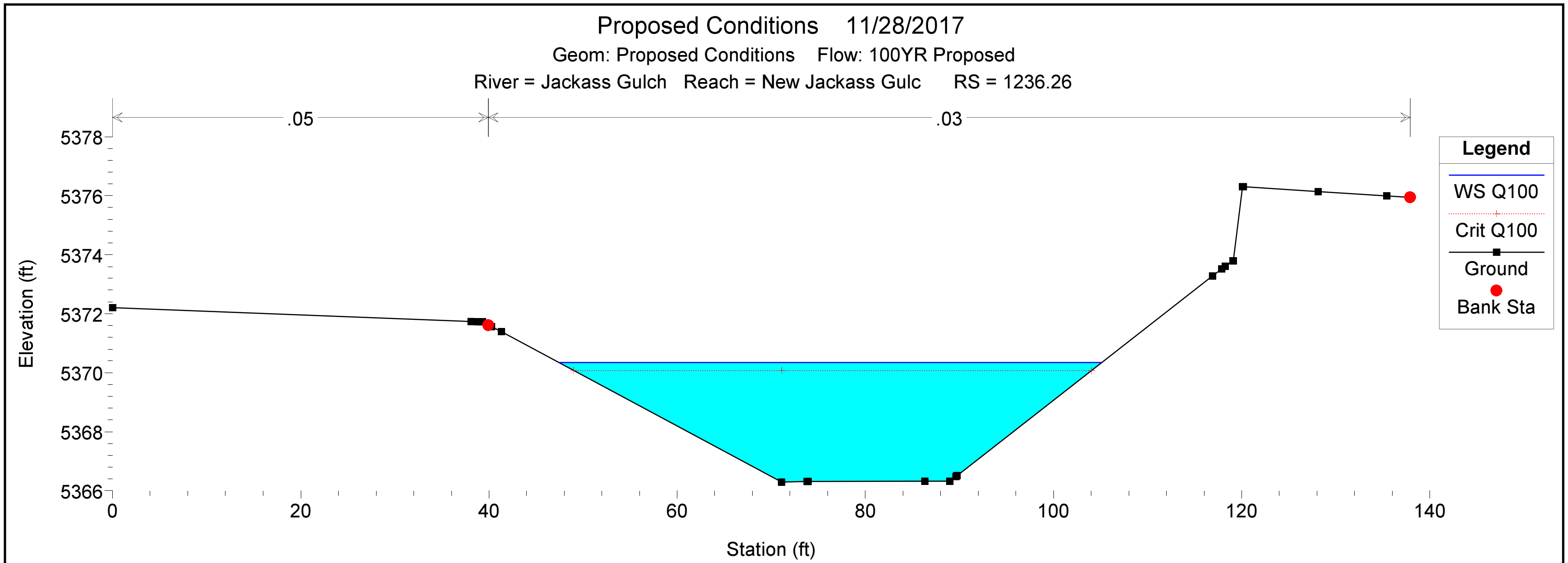
Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1345 Culv
.05
.03
.05
Legend
Crit Q100
WS Q100
Ground
Bank Sta
Elevation (ft)
5368
5370
5372
5374
5376
5378
Station (ft)
0
20
40
60
80
100
120
140

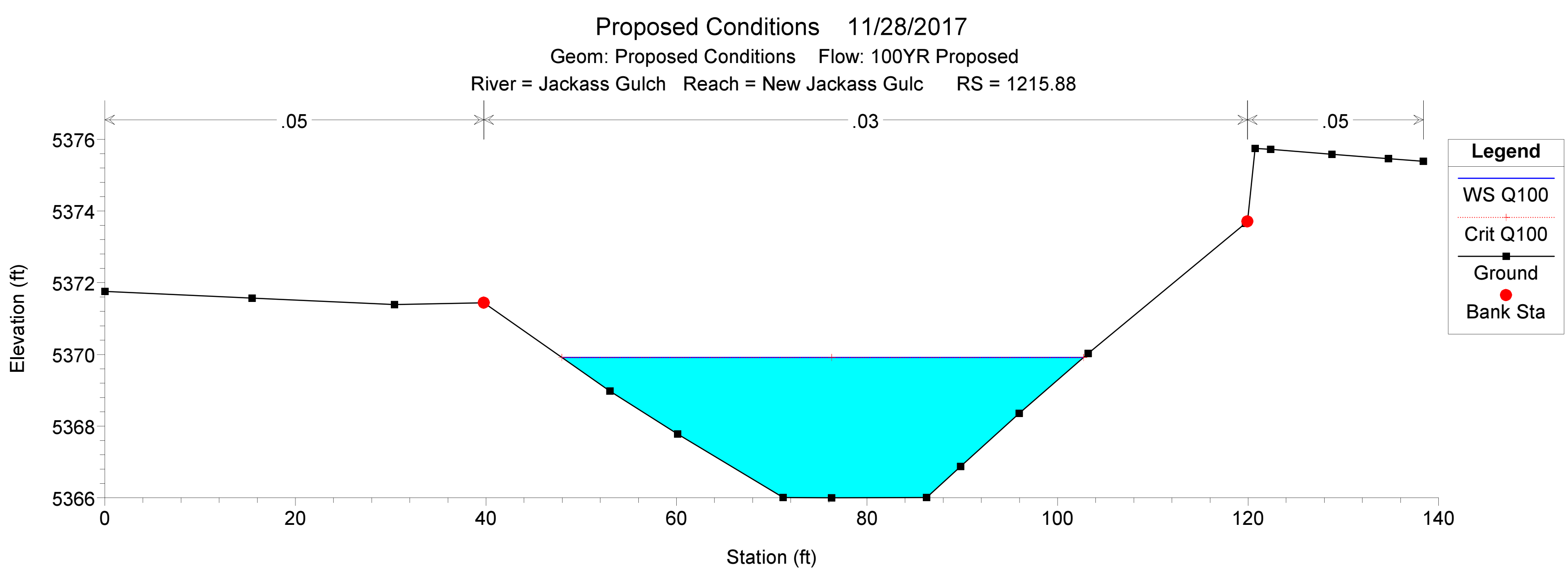


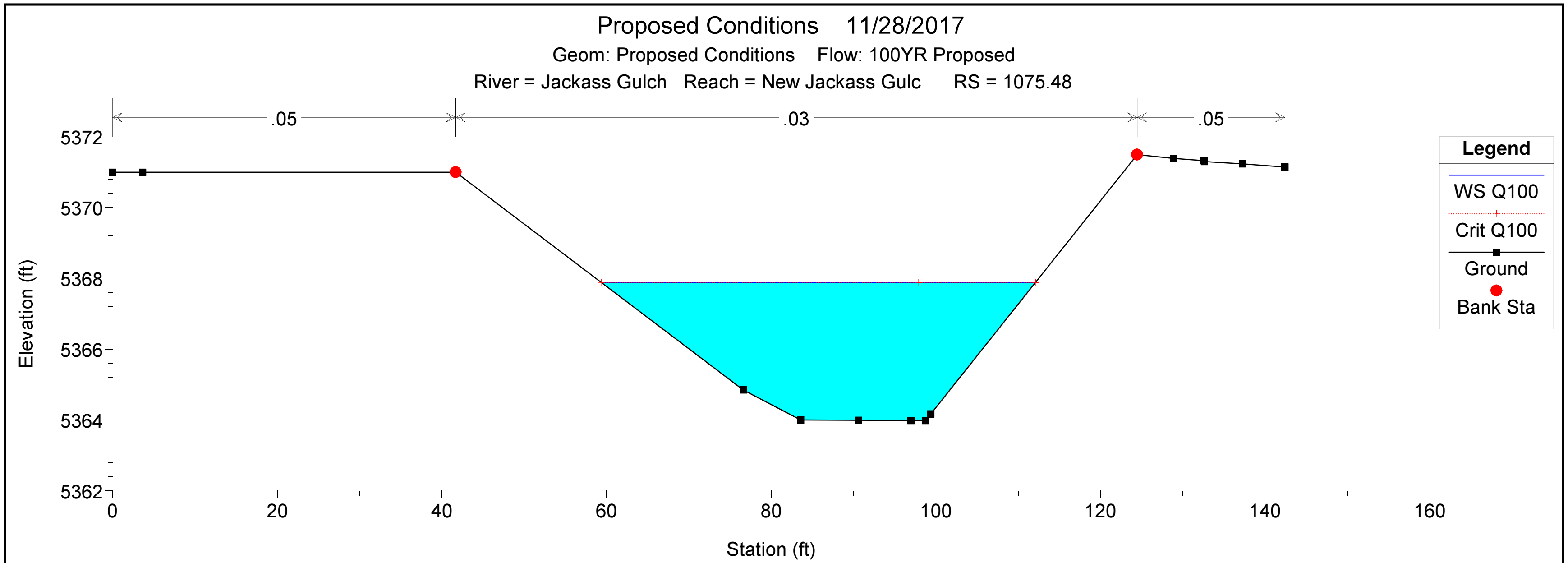
Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1278.14
.05
.03
.05
Legend
WS Q100
Crit Q100
Ground
Bank Sta
Elevation (ft)
5368
5370
5372
5374
5376
5378
Station (ft)
0
20
40
60
80
100
120
140

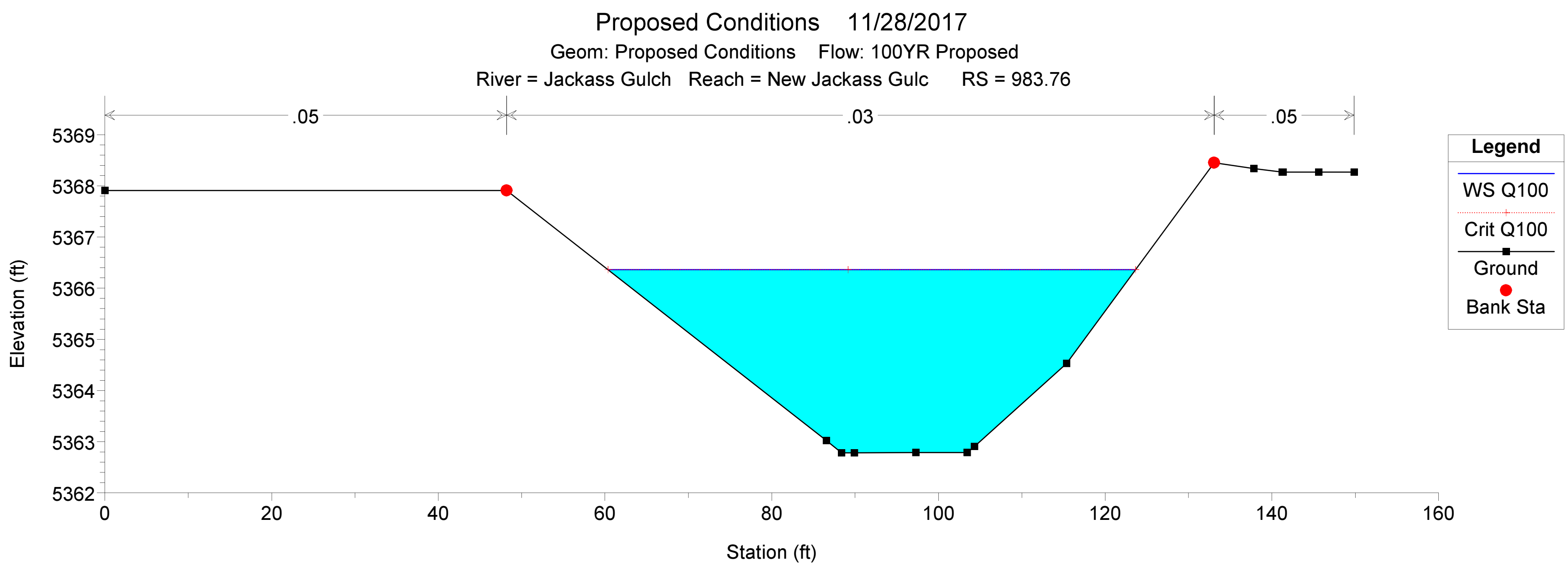

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1263.8
.05
.03
.05
Elevation (ft)
Station (ft)
Legend
WS Q100
Ground
Bank Sta

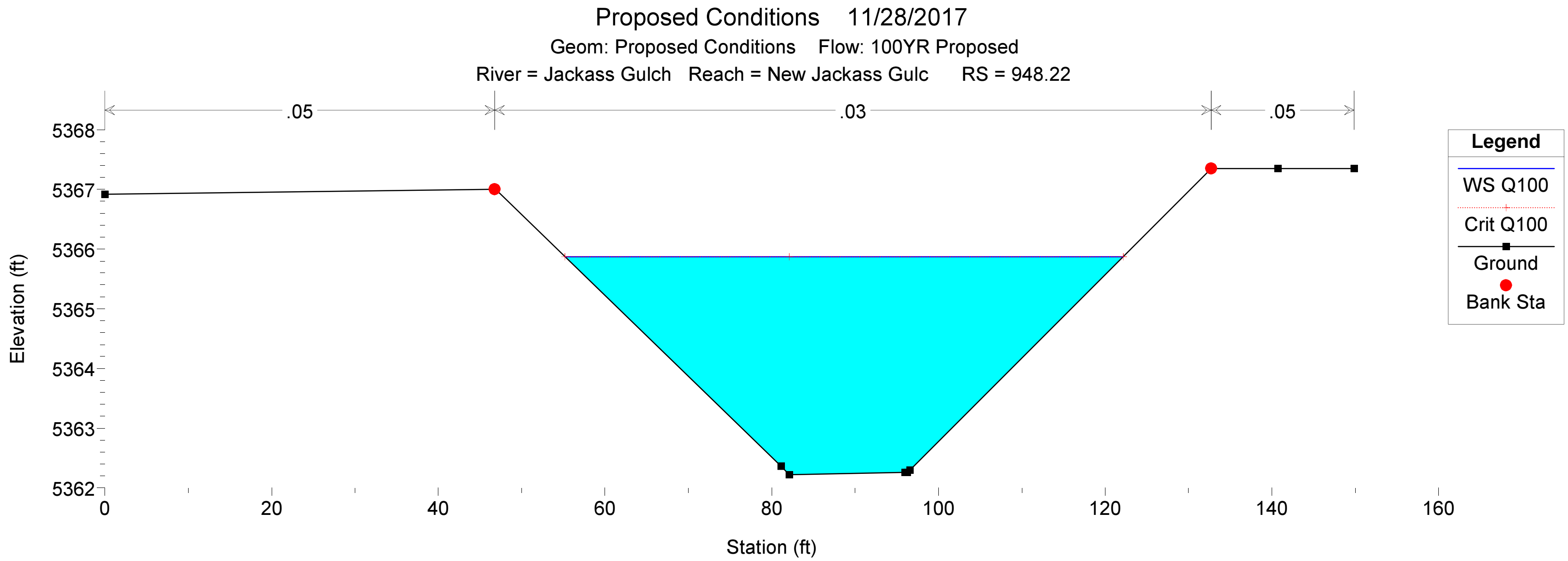

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1237.26
.05
.03
.05
Elevation (ft)
Station (ft)
Legend
WS Q100
Ground
Bank Sta

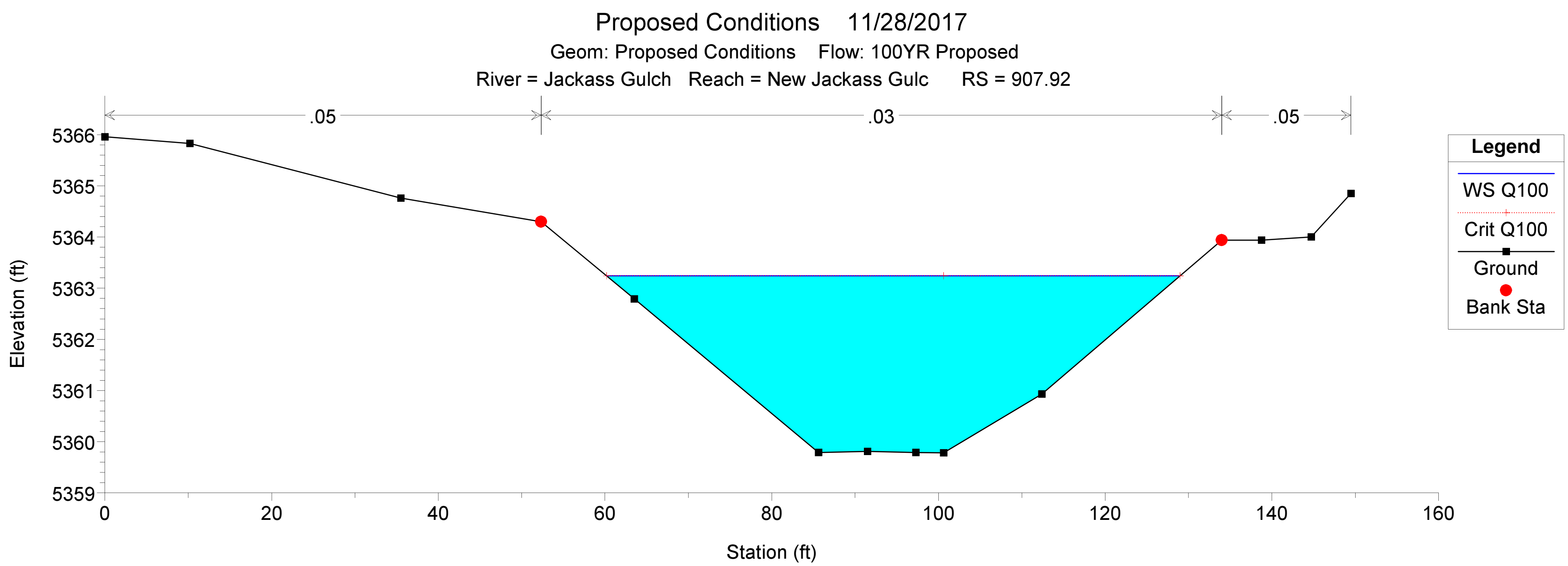

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1236.26
.05
.03
Elevation (ft)
5378
5376
5374
5372
5370
5368
5366
0
20
40
60
80
100
120
140
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Bank Sta

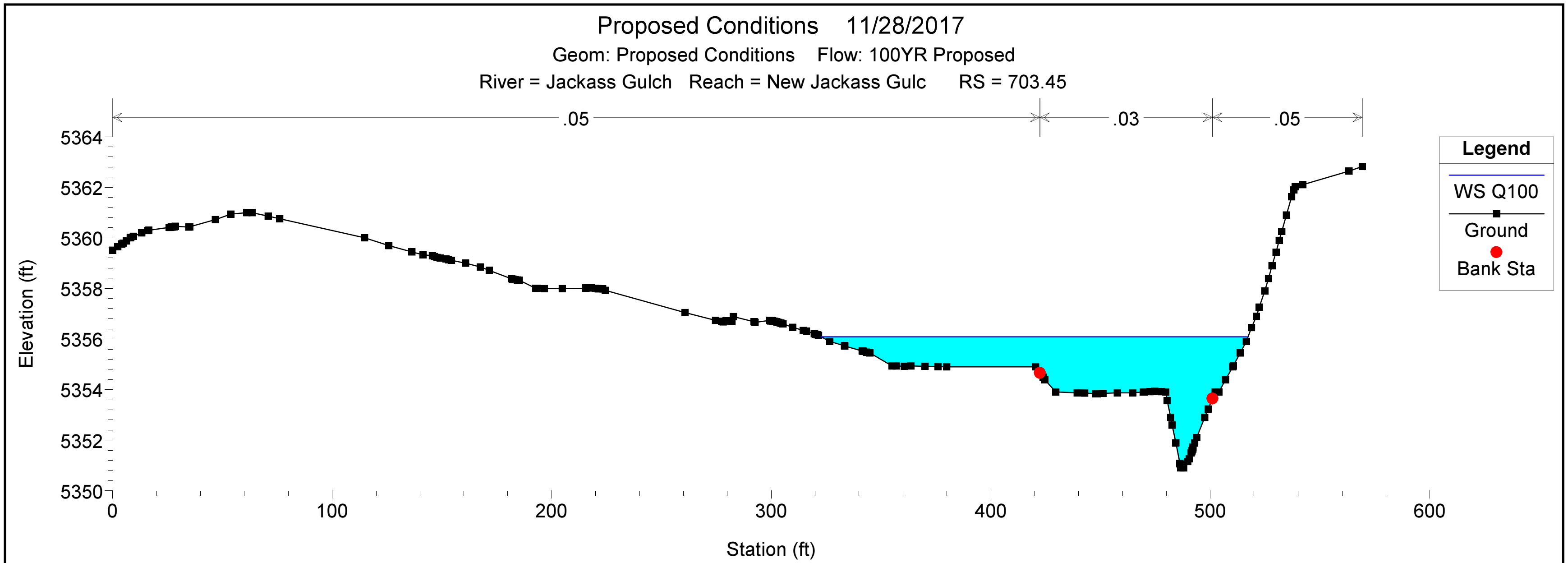

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1215.88
.05
.03
.05
Elevation (ft)
5376
5374
5372
5370
5368
5366
0
20
40
60
80
100
120
140
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Bank Sta

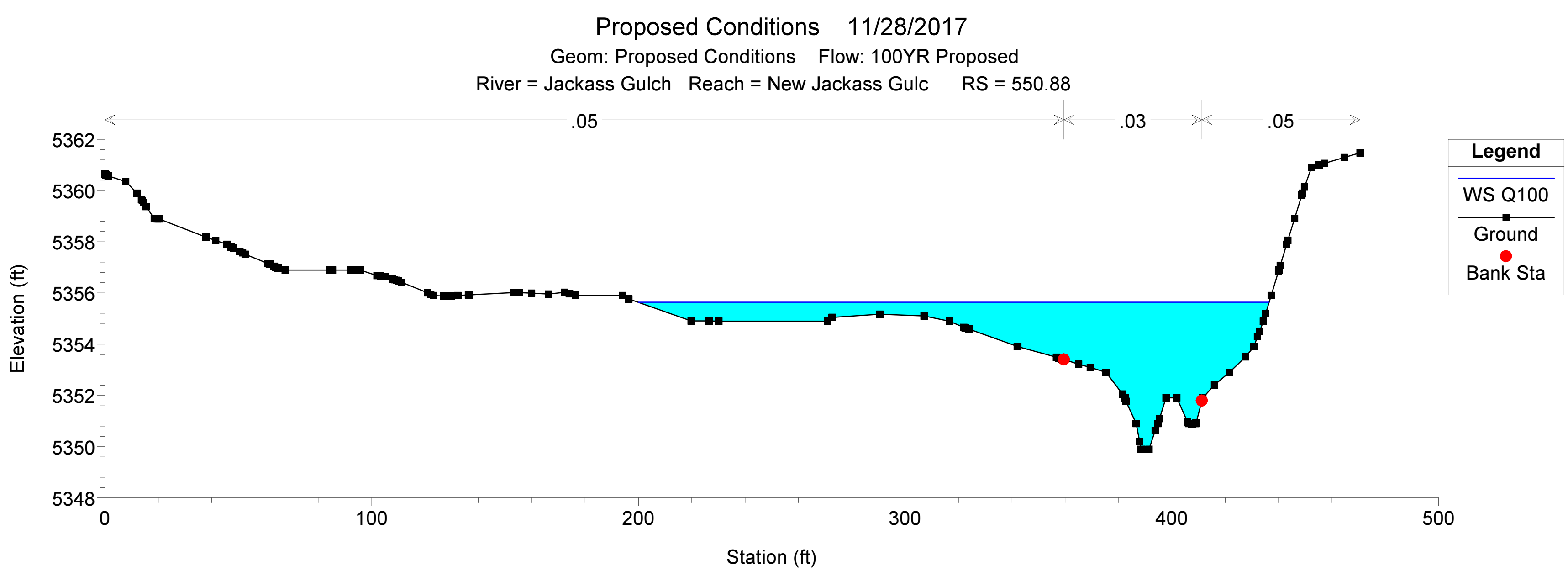

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 1075.48
.05
.03
.05
5372
5370
5368
5366
5364
5362
Elevation (ft)
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Bank Sta

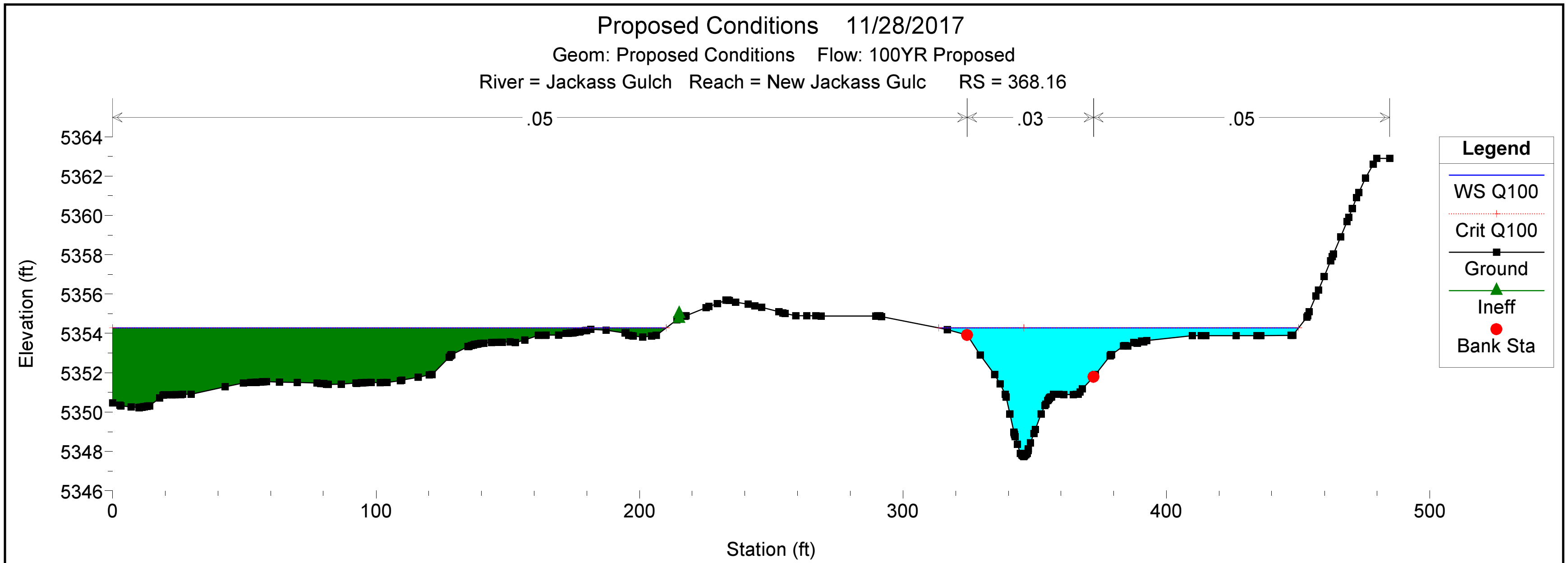

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 983.76
.05
.03
.05
5369
5368
5367
5366
5365
5364
5363
5362
Elevation (ft)
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Bank Sta

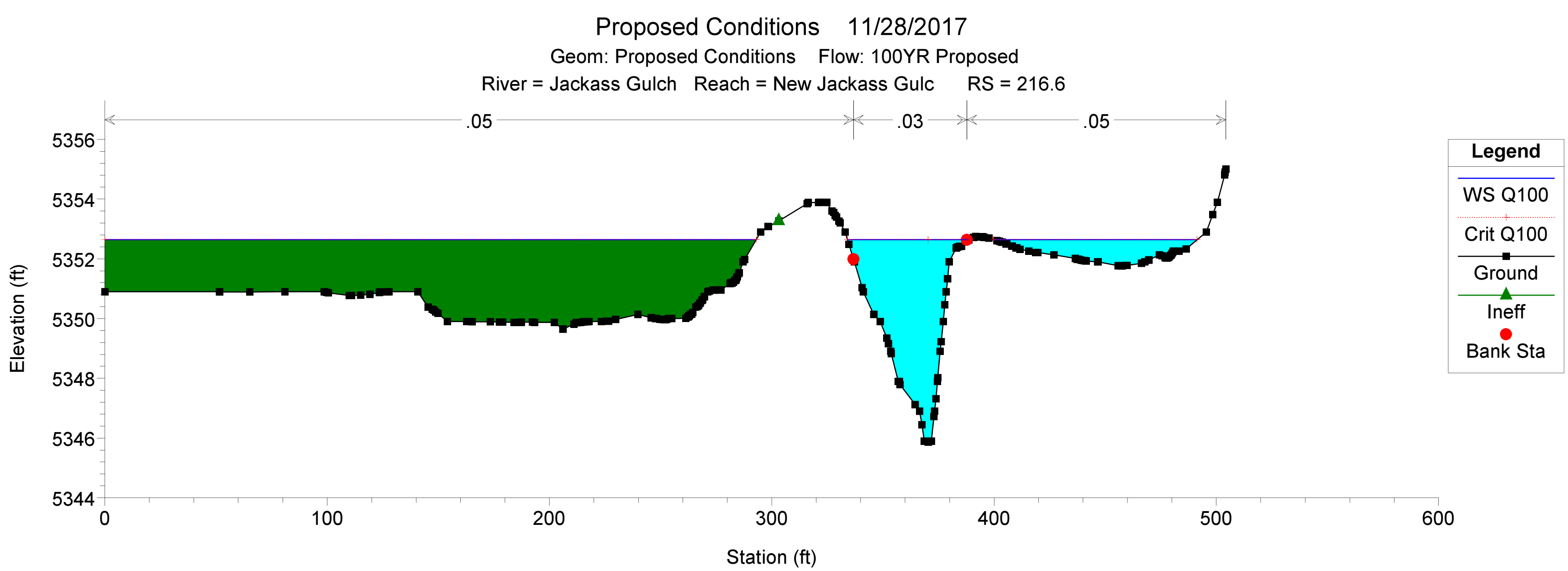

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 948.22
.05
.03
.05
Elevation (ft)
5368
5367
5366
5365
5364
5363
5362
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Bank Sta

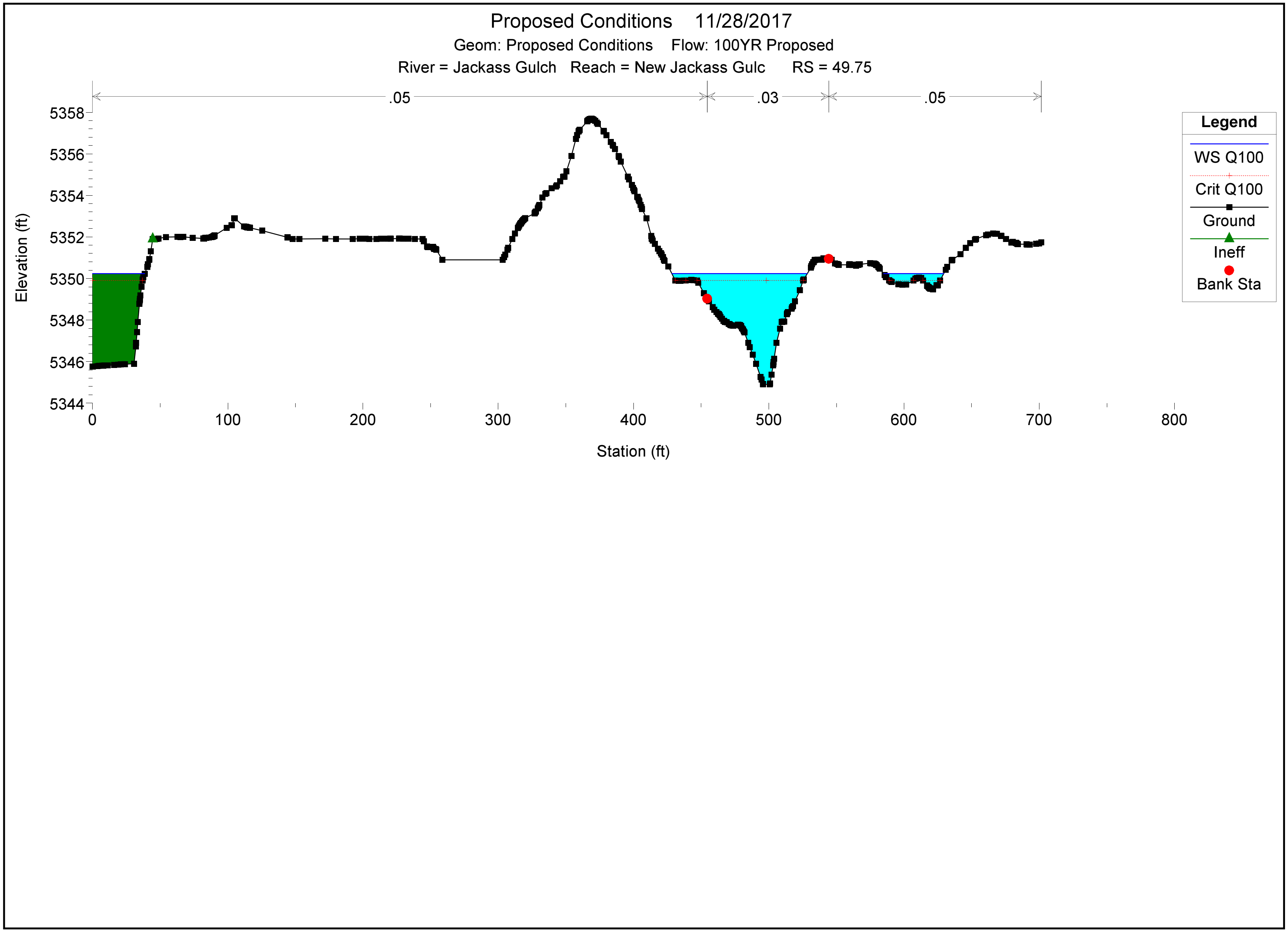

Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 907.92
.05
.03
.05
Elevation (ft)
5366
5365
5364
5363
5362
5361
5360
5359
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Bank Sta


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 703.45
.05
.03
.05
Legend
WS Q100
Ground
Bank Sta
Elevation (ft)
Station (ft)


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 550.88
.05
.03
.05
Legend
WS Q100
Ground
Bank Sta
Elevation (ft)
Station (ft)


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 368.16
.05
.03
.05
5364
5362
5360
5358
5356
5354
5352
5350
5348
5346
Elevation (ft)
0
100
200
300
400
500
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Ineff
Bank Sta


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 216.6
.05
.03
.05
5356
5354
5352
5350
5348
5346
5344
Elevation (ft)
0
100
200
300
400
500
600
Station (ft)
Legend
WS Q100
Crit Q100
Ground
Ineff
Bank Sta


Proposed Conditions 11/28/2017
Geom: Proposed Conditions Flow: 100YR Proposed
River = Jackass Gulch Reach = New Jackass Gulc RS = 49.75
.05
.03
.05
Legend
WS Q100
Crit Q100
Ground
Ineff
Bank Sta
Elevation (ft)
5358
5356
5354
5352
5350
5348
5346
5344
0
100
200
300
400
500
600
700
800
Station (ft)

FHAD*		Corrected Effective (Existing)		Proposed Conditions		
Q100 = 1240 cfs		Q100 = 1240 cfs		Q100 = 1240 cfs		
FHAD XS	100-YR WSEL	HEC XS	100-YR WSEL	HEC XS	100-YR WSEL	Δ WSEL (Ex to Prop)
10	5350.40	49.75	5350.45	49.75	5350.23	-0.22
20	5354.60	703.45	5355.98	703.45	5356.08	0.10
30	5365.50	907.92	5364.99	907.92	5363.24	-1.75
40	5373.90	1254.10	5374.33	1263.80	5370.81	-3.52
50	5382.10	1700.25	5382.09	1697.64	5382.20	0.11
*Per FHAD -Lower Dad Clark Gulch and DFA 0068						

LEGEND

PROPOSED 100-YR FLOODPLAIN

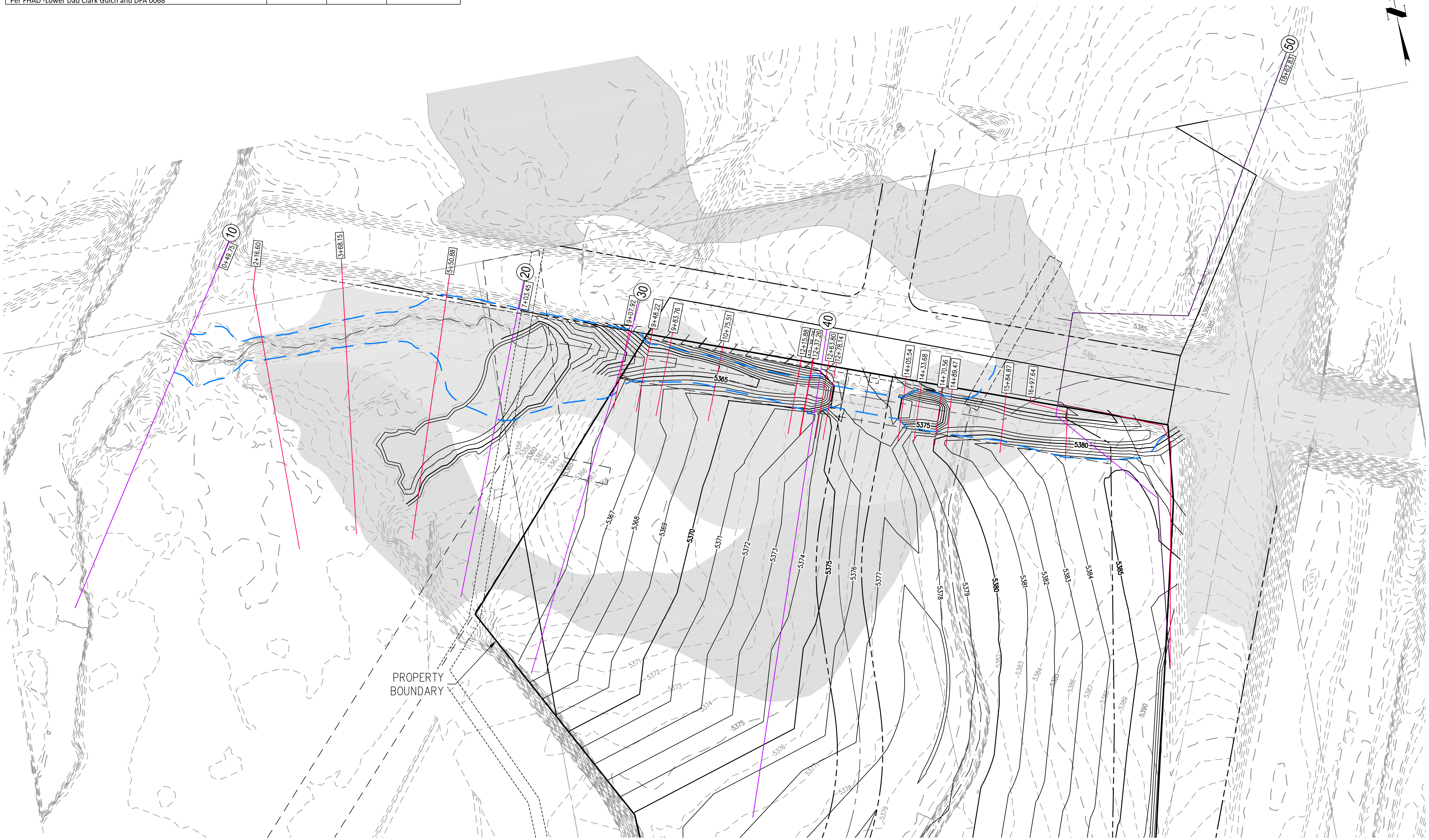
FHAD 100-YR FLOODPLAIN

PROPOSED CROSS-SECTIONS 2+16.60

FHAD CROSS-SECTIONS 10

PROPOSED CONTOURS

EXISTING CONTOURS



FILEPATH: P:\160605\ENGINEERING\DRAINAGE\FLOODPLAIN WORKMAP.DWG LAYOUT: LAYOUT1
PLOTTED: TUE 11/28/17 1:59:47P BY: RACHEL MOLLENHOFF

811 Know what's below. Call before you dig.

CALL 3 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

80 0 80 160

SCALE: 1" = 80'

DESIGNED BY: RHM
CHECKED BY: MAW
DRAWN BY: RHM

HKS HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

JACKASS GULCH
FLOODPLAIN WORKMAP

ISSUE DATE: 11/28/2017 PROJECT #: 160605

DATE	REVISION COMMENTS
####	####
####	####
####	####
####	####
####	####
####	####
####	####

PRELIMINARY NOT FOR CONSTRUCTION

SHEET NO.

1

1 OF 1

HARRIS KOCHER SMITH
DENVER • DALLAS/FORT WORTH

November 28, 2017

City of Littleton
Community Development
Ms. Carol Kuhn, AICP
Principal Planner
2255 W Berry Ave
Littleton, Colorado 80120

RE: Santa Fe Park North
Use By Special Exception - Floodplain Development
Letter of Intent / Project Narrative
HKS Project No. 160605

Dear Ms. Kuhn,

As required by the City of Littleton ("Littleton") this letter is intended to serve as the letter of intent and project narrative for the Use By Special Exception - Floodplain Development application for the Santa Fe Park North project. The project is located at the southwest corner of Colorado State Highway 85 (S. Santa Fe Drive) and W. Mineral Avenue, City of Littleton, Arapahoe County, Colorado.

Section 10-6-1 (B) Floodplain Regulations

With respect to the Floodplain Development Requirements listed in Littleton City Code, the floodplain modifications proposed with the application are consistent with the purpose and intent of the city's floodplain regulations Section 10-6-1 (B). The Applicant has promoted the public health, safety, and general welfare by complying with the following:

1. Protecting human life and health by reducing the flooding extents;

2. Minimizing expenditures of public money for costly flood control projects by creating a flood conveyance channel funded by private development;

3. Minimizing the need for post-flood rescue and relief efforts which are, generally, undertaken at public expense by reducing the flooding extents;

4. Minimizing prolonged business interruptions by reducing the flooding extents;

5. Minimizing damage to public facilities and utilities which are located in flood plains, such as water and gas mains, electric, telephone and sewer lines, streets and bridges by reducing the flooding extents;

6. Maintaining a stable tax base by providing for the sound use and development of flood plains which has minimum flood damage potential by reducing the flooding extents thereby creating area for development that would add to the tax base;

7. Ensuring that information is available to potential buyers that property is in a flood plain; by publishing the results of the floodplain analysis in a Flood Hazard Area Delineation (FHAD) the regulatory authority for floodplains not regulated by FEMA.

8. Ensuring that those who occupy flood plains know that they are responsible for their actions; by disallowing occupation of the floodplain as it is sited in the 70' building setback from Mineral Avenue.

Section 10-6-8 (A) Procedure

The enclosed application includes a site plan, certified by a registered engineer competent in open channel hydraulics; developed to meet the requirements of Littleton City Code, Section 10-6-8 (A)1. The general intent of this application is to request development within the floodplain on the subject tract to reduce the overall spread of the shallow floodplain flow within the subject property. The spread of the floodplain will be reduced with the installation of approximately 680 lineal feet of open drainage channel and a 120 lineal foot box culvert. The box culvert is placed at the intersection of W. Mineral Avenue and S. Platte River Parkway in anticipation of future development of the subject tract.

(a) The enclosed site plan includes the following items:

(1) Existing zone district boundaries;

(2) Location of floodplain/floodway limits and watercourse;

(3) Legal description of the property;

(4) Description of all existing adjacent development located in or out of the floodplain;

(5) Description of the proposed use;

(6) Elevations of the site and immediately surrounding area, in relation to mean sea level;

(7) Location and size of existing and proposed structures, and the elevation of the lowest floor of these structures;

(8) Location and elevation of all excavation and fill;

(9) Location and elevation of adjacent streets and on site areas of impervious surface; and

(10) Location and elevation of water supply, sanitary facilities, and other utilities.

(b) A typical valley cross section showing the watercourse and adjoining floodplain, the cross sectional area to be occupied by the proposed development, and the base flood elevation.

(c) Profile showing the slope of the bottom of the watercourse, e.g., channel of a stream; and showing the existing and proposed base flood elevations.

(d) Specifications for building construction including, but not limited to, material types, flood proofing measures, and water and sanitation facilities; are not provided as building construction within the floodplain will not be allowed, as the channel is within the 70' building setback from Mineral Avenue.

Section 10-6-8 (B) Floodplain Development Requirements:

With respect to the Floodplain Development Requirements listed in Littleton City Code, Section 10-6-8 (B), no buildings are proposed to be constructed with this permit. Any future building proposals will be required to comply with the requirements from this section which can be found listed below. All the general standards, materials and methods for construction and specific standards followed are in accordance with Littleton and Urban Drainage and Flood Control District requirements.

1. General Standards: In all floodplains, the following standards shall apply:

(a) Anchoring:

(1) All new construction and substantial improvements shall be anchored to prevent flotation, collapse, or lateral movement, and shall resist the hydrostatic and hydrodynamic loads of floods. (Revised 6-12-1992)

(2) All manufactured homes must be elevated and anchored to resist flotation, collapse or lateral movement, and the hydrostatic and hydrodynamic loads of floods. This requirement is in addition to state and local anchoring requirements for wind forces. (Ord. 25, Series of 2010)

(b) Materials And Methods For All New Construction And Substantial Improvements:

(1) Materials and utility equipment capable of resisting flood damage shall be used.

(2) Accepted methods and practices that minimize flood damage shall be applied.

(3) Electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities shall be designed and/or located to prevent water from entering into these service facilities during floods. (Revised 6-12-1992)

(4) Fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are

subject to flooding shall be designed to automatically equalize hydrodynamic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect; or have a minimum of two (2) openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding, the bottom of all openings shall be no higher than one foot (1') above grade, and openings may be equipped with screens, louvers, valves or other coverings or devices provided they permit automatic entry and exit of floodwaters. (Ord. 25, Series of 2010)

(c) New And Replacement Utility Systems:

(1) Water supply systems shall be designed to minimize or eliminate infiltration of floodwaters;

(2) Sanitary sewage systems shall be designed to minimize or eliminate infiltration of floodwaters into the systems, and to prohibit discharges from the systems into floodwaters; and

(3) On site waste disposal systems shall be located to avoid being damaged, or from releasing contaminants, during flooding.

(d) Proposed Subdivisions In Floodplains:

(1) Shall be designed in a manner consistent with the flood protection objectives of these regulations;

(2) Shall have utility systems and facilities located and designed to minimize flood damage potential;

(3) Shall meet the requirements of the Littleton "Storm Drainage Criteria Manual"; and

(4) Base flood elevation data shall be provided for all lots within, and immediately adjacent to, the floodplain.

2. Specific Standards: In all floodplains, the following standards shall apply:

(a) Residential New Construction And Substantial Improvement:

(1) Any residential structure shall have the lowest floor (including basement) elevated to one foot (1') above the base flood elevation. (Revised 6-12-1992)

(2) Within zones A, AO, AH, or areas of shallow flooding, residential structures shall have the lowest floor (including basement) elevated one foot (1') above the highest adjacent grade, or the base flood elevation, or to the depth number specified on the FIRM, whichever is greater. (Ord. 25, Series of 2010)

(3) Within areas of shallow flooding, on site drainage shall be directed around and away from existing and proposed structures.

(b) Nonresidential New Construction And Substantial Improvement:

(1) Any nonresidential structure shall either have the lowest floor (including basement) elevated to one foot (1') above the level of the base flood elevation; or, together with utility and sanitary services, shall:

A. Be flood proofed below an elevation one foot (1') above the base flood elevation with substantially watertight walls;

B. Have structural components which withstand hydrostatic and hydrodynamic loads of flood flows, and the effects of buoyancy; and

C. Have certified, in a manner acceptable to the administrator, by a registered professional engineer or architect that the proposed design and methods of construction are in accordance with accepted standards for meeting the requirements of these regulations. (Revised 6-12-1992)

(2) Within zones A, AO, AH, or areas of shallow flooding, nonresidential structures shall have the lowest floor (including basement) elevated one foot (1') above the highest adjacent grade, or the base flood elevation, or to the depth number specified on the FIRM, whichever is greater; or, together with utility and sanitary services, shall be flood proofed below an elevation one foot (1') above the base flood elevation, or to the depth number specified on the FIRM, whichever is greater with substantially watertight walls. (Ord. 25, Series of 2010)

(3) Within areas of shallow flooding, on site drainage shall be directed around and away from existing and proposed structures. (Revised 6-12-1992)

(c) Manufactured Homes:

(1) Manufactured homes shall be anchored in accordance with one or more of the following requirements:

A. Over the top ties at each of the four (4) corners of each unit; for units greater than fifty feet (50') long, two (2) additional ties per side at intermediate locations; and for units less than fifty feet (50') long, one additional tie per side.

B. Frame ties at each corner of each unit; for units greater than fifty feet (50') long, five (5) additional ties per side at intermediate points; for units less than fifty feet (50') long, four (4) additional ties per side.

C. Each component of the anchoring system shall be capable of sustaining a force of four thousand eight hundred (4,800) pounds.

D. Any additions to a manufactured home shall be similarly anchored.

(2) All new manufactured homes, which are placed or substantially improved or have suffered substantial damage as a result of a flood in an existing, expanded, or new manufactured home park or subdivision in zones A99, AH, and AE shall be placed on a permanent foundation so that the lowest floor is elevated one foot (1') above the base flood elevation; and be securely anchored to a foundation system to resist flotation, collapse and lateral movement and shall be securely anchored as required by this subsection (B)2(c). (Ord. 25, Series of 2010)

(d) Placement Of Fill Material: Placement of fill material on a site located within a floodplain is permitted only upon approval of a use by special exception by the commission and based upon findings that: (Revised 6-12-1992; amd. Ord. 19, Series of 2012; Ord. 15, Series of 2016)

(1) Placement of fill material in a floodplain shall not adversely affect the efficiency of the watercourse to convey storm runoff.

(2) The amount of fill material to be deposited shall only be the minimum necessary to achieve the required floodproofing of structures.

(3) No fill materials are being placed in any floodway.

(4) Fill materials shall be adequately protected against erosion by strong vegetative cover, riprap, or bulkheads.

(5) A determination that the granting of the use by special exception will not result in increased flood heights, additional threats to public safety, extraordinary public expense, create nuisances, or conflict with other existing local laws or ordinances. (Revised 6-12-1992)

(e) Recreational Vehicles: Recreational vehicles placed on sites within zones A, AE, AH, AO, and A99 on the city's FIRM shall either:

(1) Be on a site for fewer than one hundred eighty (180) days.

(2) Be fully licensed and ready for highway use. A recreational vehicle is ready for highway use if it is on its wheels, is attached to the site only by quick disconnect type utilities and security devices, and has no permanent attached structures.

(3) Meet the elevation and anchoring requirements for manufactured homes in subsection (B)2(c) of this section. (Ord. 25, Series of 2010)

To date, the Applicant has met with Littleton, Urban Drainage Flood Control District and has held an informational neighborhood meeting at Hudson Gardens on July 5, 2017. As requested, the neighborhood meeting notification area exhibit, notification mail list, notification and sign-in sheet from the neighborhood meeting have all been sent to Littleton staff. The meeting was attended by a handful of individuals that did not voice any concerns regarding the proposed floodplain development.

An Approved Jurisdiction Determination for the subject tract has been obtained from the U.S. Army Corps of Engineers and is attached to this letter.

As requested, the Applicant has reached out / sent material to Brad Sheehan with the Colorado Department of Transportation ("CDOT"), but has yet to receive a response. The Applicant will continue to work with CDOT to gain their general approval of the proposed floodplain improvements, as applicable. It should be noted that the proposed floodplain development improvements are located completely along Littleton public right-of-way, and based on past experience on similar projects no CDOT permits should be required for these improvements.

In accordance with the Littleton" Application Submittal Materials" checklist, there is no mortgage holder for the subject tract.

In accordance with the Littleton "Application Submittal Materials" checklist, to our best knowledge and belief this application complies with all applicable codes, requirements, and any adopted design guidelines that would apply to the proposed floodplain development.

In accordance with the Littleton "Application Submittal Materials" checklist, it is the Applicant's opinion that the Littleton comprehensive plan or adopted neighborhood plans do not apply to the proposed floodplain development improvements. That said, the Applicant will provide any additional information requested by Littleton during the review process related to this specific issue.

As mentioned above, this development application is specific to the proposed floodplain development improvements and at this time no other improvements are proposed. That said, preliminary roadway alignments and lots (with finished floor elevation information) have been shown on the site plan as requested by Littleton staff. The Applicant is currently processing a Subdivision Exemption for the subject property that is near completion.

If you require any additional information please feel free to contact me directly at mmoore@hkseng.com or (303) 623-6300.

Sincerely,

HARRIS KOCHER SMITH

HARRIS KOCHER SMITH
DENVER • DALLAS/FORT WORTH

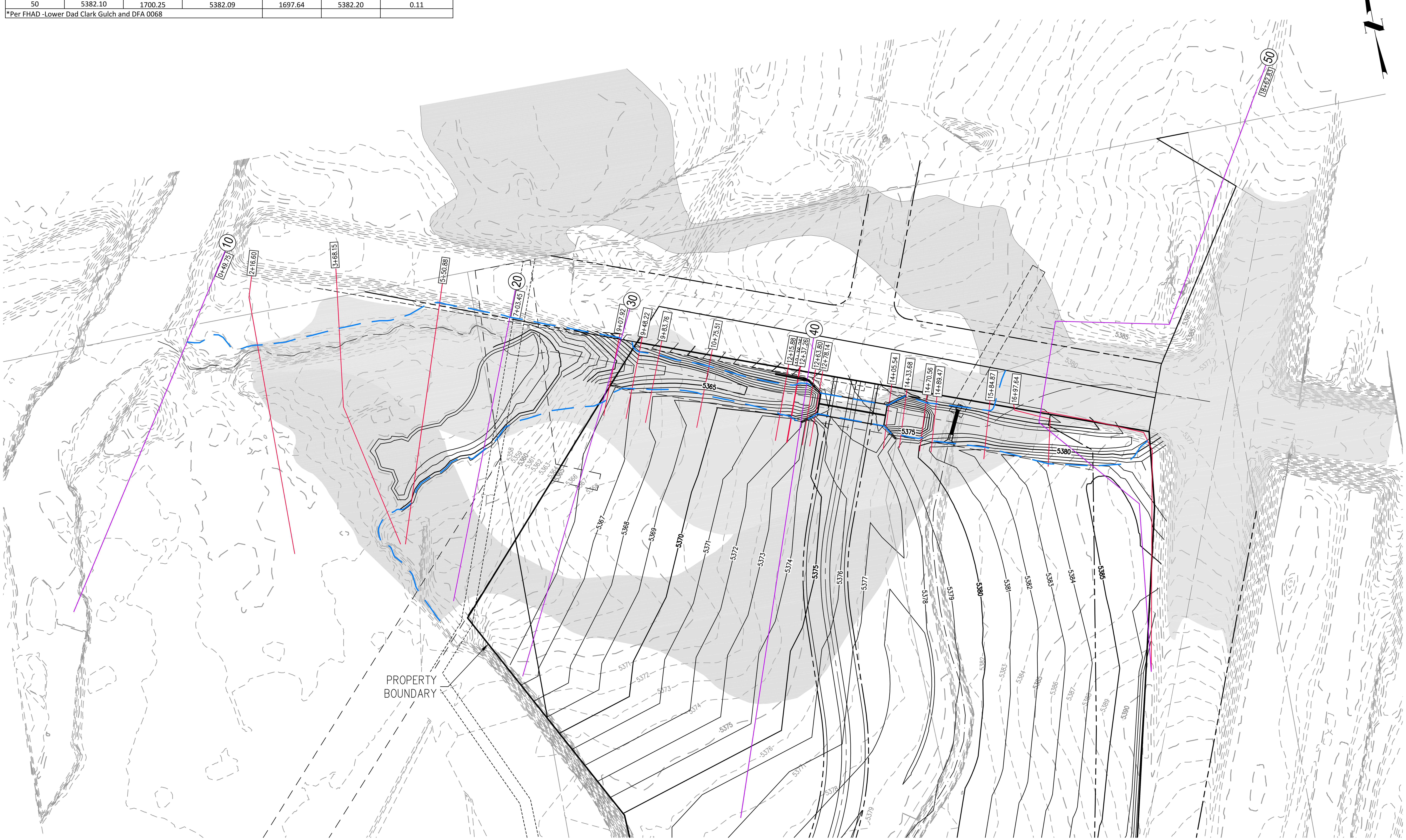
Michael Moore, P.E.
Project Manager

Cc: Mr. Jeff Wikstrom, Evergreen Devco, Inc.
Mr. Robert Place, Evergreen Devco, Inc.
Mr. Ken Ensor

FHAD*		Corrected Effective (Existing)		Proposed Conditions		
Q100 = 1240 cfs		Q100 = 1240 cfs		Q100 = 1240 cfs		
FHAD XS	100-YR WSEL	HEC XS	100-YR WSEL	HEC XS	100-YR WSEL	Δ WSEL (Ex to Prop)
10	5350.40	49.75	5350.45	49.75	5350.23	-0.22
20	5354.60	703.45	5355.98	703.45	5355.81	-0.17
30	5365.50	907.92	5364.99	907.92	5363.24	-1.75
40	5373.90	1254.10	5374.33	1263.80	5370.81	-3.52
50	5382.10	1700.25	5382.09	1697.64	5382.20	0.11
*Per FHAD -Lower Dad Clark Gulch and DFA 0068						

LEGEND

PROPOSED 100-YR FLOODPLAIN
FHAD 100-YR FLOODPLAIN
PROPOSED CROSS-SECTIONS (2+16.60)
FHAD CROSS-SECTIONS (10)
PROPOSED CONTOURS
EXISTING CONTOURS



FILEPATH: P:\160605\ENGINEERING\DRAINAGE\FLOODPLAIN WORKMAP.DWG LAYOUT: LAYOUT1
PLOTTED: THU 11/30/17 3:23:25A BY: RACHEL MOLLENHOFF

811 Know what's below. Call before you dig.

CALL 3 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

80 0 80 160
SCALE: 1" = 80'

DESIGNED BY: RHM
CHECKED BY: MAW
DRAWN BY: RHM

HKS HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

JACKASS GULCH
FLOODPLAIN WORKMAP

ISSUE DATE: 11/28/2017 PROJECT #: 160605

DATE	REVISION COMMENTS
####	####
####	####
####	####
####	####
####	####
####	####

PRELIMINARY NOT FOR CONSTRUCTION

SHEET NO.

1

1 OF 1

APPENDIX D – RATIONAL METHOD AND DETENTION CALCULATIONS

Project Name: Santa Fe Park North

Composite C-Value Computations

Project No: 160605
Date: 09/19/18
Revised: 05/14/19
Design by: DLQ
Checked by: MAW

BASIN	TOTAL AREA (ACRES)	MIXED USE (80%)	DRIVES & WALKS (90%)	GARAGE & STREETS (100%)	CHANNEL AREA (2%)	LANDSCAPE AREA (0%)	PERCENT IMPERVIOUS	C_5=	C_{100}=
A	10.75	10.75					80.00%	0.69	0.81
B	13.04	13.04					80.00%	0.69	0.81
C	9.55	9.55					80.00%	0.69	0.81
A Hist	10.75						2.00%	0.05	0.49
B Hist	13.04						2.00%	0.05	0.49
C Hist	9.55						2.00%	0.05	0.49
Total	33.34						80.00%	0.69	0.81

TYPE C HYDRAULIC SOIL		
5 YR - C_C =	$0.82i+.035$	< Table 6-4 USDCM
100 YR - C_C =	$0.41i+0.484$	< Table 6-4 USDCM

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential lots (lot area only):	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

https://udfcd.org/wp-content/uploads/uploads/vol1%20criteria%20manual/06_Runoff.pdf

1-HR Rainfall

Return Interval (YR)	1-hour Rainfall
2	**0.97**
5	**1.38**
100	**2.67**

Section 5.3 City of Littletom Storm Drainage Design and Technical Criteria Manual

tc	2yr	5yr	100yr
5	3.290	4.681	9.056
6	3.127	4.449	8.608
7	2.982	4.242	8.208
8	2.851	4.056	7.847
9	2.732	3.887	7.521
10	2.624	3.733	7.223
11	2.526	3.593	6.952
12	2.435	3.464	6.702
13	2.351	3.345	6.472
14	2.274	3.235	6.259
15	2.202	3.133	6.061
16	2.135	3.038	5.877
17	2.073	2.949	5.706
18	2.014	2.866	5.545
19	1.960	2.788	5.394
20	1.908	2.715	5.252
21	1.860	2.646	5.119
22	1.814	2.580	4.992
23	1.770	2.519	4.873
24	1.729	2.460	4.760

USDCM Equation 5-1
https://udfcd.org/wp-content/uploads/uploads/vol1%20criteria%20manual/05_Rainfall.pdf

Project Name: Santa Fe Park North
Project No: 160605
Date: 09/19/18

Revised: 05/14/19

STANDARD FORM SF-2
TIME OF CONCENTRATION

Designed By: DLQ
Checked By: MAW

SUB-BASIN DATA			INITIAL/OVERLAND TIME (T_i)			TRAVEL TIME (T_t)					Tc CHECK (URBANIZED BASINS)			FINAL	REMARKS
BASIN	AREA (AC)	C_5	LENGTH (FT)	SLOPE %	Ti (MIN)	LENGTH (FT)	SLOPE %	C_v	VELOCITY (FPS)	Tt (MIN)	COMPOS. Tc (MIN)	TOTAL LENGTH	$Tc = (26-17i)+L_t/(60*(14i+9)*sqrtS_t$ (MIN)	Tc (MIN)	
A	10.75	0.69	300	2.09	10.16	786	1.40	20.00	2.37	5.54	15.69	1,086	17.88	15.69	
B	13.04	0.69	300	2.44	9.65	1232	2.01	20.00	2.84	7.24	16.89	1,532	19.57	16.89	
C	9.55	0.69	300	1.86	10.56	974	0.98	20.00	1.98	8.20	18.76	1,274	20.52	18.76	
A Hist	10.75	0.05	300	2.42	24.80	874	0.65	7.00	0.56	25.81	50.61	1,174	45.13	45.13	
B Hist	13.04	0.05	300	3.41	22.12	1006	2.16	7.00	1.03	16.30	38.42	1,306	37.95	37.95	
C Hist	9.55	0.05	300	1.23	31.08	686	0.72	7.00	0.59	19.25	50.33	986	40.18	40.18	

Surface Condition	*Coefficient, C_v*
Forest with heavy ground liter and meadows	2.5
Fallow or minimum tillage cultivation	5.0
Short grass, pasture and lawns	7.0
Nearly bare ground	1.0
Grassed waterway	15.0
Paved, sheet flow, shallow gutter flow	20.0

City of Littleton Storm Drainage Design and Technical Criteria
file:///E:/Users/dquintana/Downloads/Storm%20Drainage%20Design%20and%20Technical%20Criteria%20Manual%20(4).pdf

Project Name: Santa Fe Park North
Project No: 160605
Date: 09/19/18
Revised: 05/14/19

STANDARD FORM SF-2
Post-Development
Rational Method Procedure

Designed By: DLQ
Checked By: MAW
Design Storm: 5 YR

		DIRECT RUNOFF						TOTAL RUNOFF			
BASIN (s)	DESIGN POINT	AREA (AC)	RUNOFF COEFF	T_c (min)	C x A (AC)	I (IN/HR)	DIRECT RUNOFF, Q (CFS)	T_c (MAX)	Σ(C x A) (AC)	I (IN/HR)	TOTAL RUNOFF, Q (CFS)
A	1	10.75	0.69	15.69	7.43	3.07	22.78	15.69	7.43	3.07	22.78
B	2	13.04	0.69	16.89	9.01	2.96	26.66	16.89	9.01	2.96	26.66
C	3	9.55	0.69	18.76	6.60	2.81	18.52	18.76	6.60	2.81	18.52
Sum at DP 1	1							21.72	14.03	2.60	36.45
Sum at DP 2	2							22.58	23.04	2.54	58.62
A Hist		10.75	0.05	45.13	0.55	1.68	0.93	45.13	0.55	1.68	0.93
B Hist		13.04	0.05	37.95	0.67	1.88	1.26	37.95	0.67	1.88	1.26
C Hist		9.55	0.05	40.18	0.49	1.81	0.89	40.18	0.49	1.81	0.89

	STREET/INLET					STORM SEWER PIPE				TRAVEL TIME			CARRYOVER FLOWS					
BASIN (s)	SLOPE (%)	STREET FLOW (CFS)	INLET DESIGN FLOW (CFS)	STREET OR INLET INTERCEPTION (CFS)	CARRYOVER (CFS)	DESIGN FLOW (CFS)	PIPE SLOPE (%)	PIPE SIZE (IN)	QFULL (CFS)	LENGTH (FT)	VELOCITY (FPS)	T_t (min)	BYPASS RUNOFF, Q (CFS)	LENGTH (FT)	SLOPE (%)	VELOCITY (FPS)	T_t (min)	REMARKS
A						22.78	0.50	48	132.04	540	10.5	0.86						Pipe to Design Point 2
B																		
C						18.52	0.50	18	9.66	233	5.5	0.71						Pipe to Design Point 2
						18.52	0.50	24	20.80	694	6.6	1.75						Pipe to Design Point 2
						18.52	0.66	30	43.32	265	8.8	0.50						Pipe to Design Point 2
						18.52	0.50	48	132.04	540	10.5	0.86						Pipe to Design Point 2
Sum at DP 1																		
Sum at DP 2																		
A Hist																		
B Hist																		
C Hist																		

Allowed Detained Release 7.67 cfs
Unit Release 0.23 cfs/acre

14.2.2.2. Maximum Release Rates

Maximum release rates from detention ponds at the pond depths corresponding to the10- and 100-year volumes shall be calculated using the following equation:

Q_{allow} = R x A, where (Equation 1404)

Q_{allow} = Allowable release rate at maximum pond depth (cfs)
R = Release rate coefficient (see Table 14A)
A = Tributary area (acres). See section14.2.2.1

Table 14A - Allowable Release Rate Coefficients for Detention Ponds

Control Frequency	Soil Group A	B	C & D
10-year	0.13	0.23	0.30
100-year	0.50	0.85	1.00

file:///E:/Users/dquintana/Downloads/Storm%20Drainage%20Design%20and%20Technical%20Criteria%20Manual%20(3).pdf

Project Name: Santa Fe Park North
Project No: 160605
Date: 09/19/18
Revised: 05/14/19

STANDARD FORM SF-2
Post-Development
Rational Method Procedure

Designed By: DLQ
Checked By: MAW
Design Storm: 100 YR

		DIRECT RUNOFF						TOTAL RUNOFF			
BASIN (s)	DESIGN POINT	AREA (AC)	RUNOFF COEFF	T_c (min)	C x A (AC)	I (IN/HR)	DIRECT RUNOFF, Q (CFS)	T_c (MAX)	Σ(C x A) (AC)	I (IN/HR)	TOTAL RUNOFF, Q (CFS)
A	1	10.75	0.81	15.69	8.73	5.93	51.78	15.69	8.73	5.93	51.78
B	2	13.04	0.81	16.89	10.59	5.72	60.61	16.89	10.59	5.72	60.61
C	3	9.55	0.81	18.76	7.75	5.43	42.10	18.76	7.75	5.43	42.10
Sum at DP1	1							21.72	16.48	5.03	82.87
Sum at DP2	2							22.58	27.07	4.92	133.27
A Hist		10.75	0.49	45.13	5.29	3.26	17.23	45.13	5.29	3.26	17.23
B Hist		13.04	0.49	37.95	6.42	3.63	23.32	37.95	6.42	3.63	23.32
C Hist		9.55	0.49	40.18	4.70	3.51	16.48	40.18	4.70	3.51	16.48

	STREET/INLET					STORM SEWER PIPE				TRAVEL TIME			CARRYOVER FLOWS					
BASIN (s)	SLOPE (%)	STREET FLOW (CFS)	INLET DESIGN FLOW(CFS)	STREET OR INLET INTERCEPTION (CFS)	CARRYOVER (CFS)	DESIGN FLOW(CFS)	PIPE SLOPE (%)	PIPE SIZE (IN)	QFULL (CFS)	LENGTH (FT)	VELOCITY (FPS)	T_t (min)	BYPASS RUNOFF, Q (CFS)	LENGTH (FT)	SLOPE (%)	VELOCITY (FPS)	T_t (min)	REMARKS
A						51.78	0.50	48	132.04	540	10.5	0.86						Pipe to Design Point 2
B																		
C						42.10	0.50	18	9.66	233	5.5	0.71						Pipe to Design Point 2
						42.10	0.50	24	20.80	694	6.6	1.75						Pipe to Design Point 2
						42.10	0.66	30	43.32	265	8.8	0.50						Pipe to Design Point 2
						42.10	0.50	48	132.04	540	10.5	0.86						Pipe to Design Point 2
Sum at DP1																		
Sum at DP2																		
A Hist																		
B Hist																		
C Hist																		

Allowed Detained Release 28.34 cfs
Unit Release 0.85 cfs/acre

14.2.2.2. Maximum Release Rates

Maximum release rates from detention ponds at the pond depths corresponding to the10- and 100-year volumes shall be calculated using the following equation:

Q_{allow} = R x A, where (Equation 1404)

Q_{allow} = Allowable release rate at maximum pond depth (cfs)
R = Release rate coefficient (see Table 14A)
A = Tributary area (acres). See section14.2.2.1

Table 14A - Allowable Release Rate Coefficients for Detention Ponds

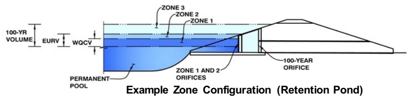
Control Frequency	Soil Group A	Soil Group B	Soil Group C & D
10-year	0.13	0.23	0.30
100-year	0.50	0.85	1.00

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: RiverPark 160605

Basin ID: Water Quality Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	33.34	acres		
Watershed Length =	1,200	ft		
Watershed Slope =	0.050	ft/ft		
Watershed Imperviousness =	80.00%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	100.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	Littleton - City Hall			
Water Quality Capture Volume (WQCV) =	0.912	acre-feet	Optional User Override	
Excess Urban Runoff Volume (EURV) =	2.620	acre-feet	1-hr Precipitation	
2-yr Runoff Volume (P1 = 0.81 in.) =	1.720	acre-feet		inches
5-yr Runoff Volume (P1 = 1.08 in.) =	2.470	acre-feet		inches
10-yr Runoff Volume (P1 = 1.31 in.) =	3.075	acre-feet		inches
25-yr Runoff Volume (P1 = 1.66 in.) =	4.140	acre-feet		inches
50-yr Runoff Volume (P1 = 1.94 in.) =	4.942	acre-feet		inches
100-yr Runoff Volume (P1 = 2.24 in.) =	5.900	acre-feet		inches
500-yr Runoff Volume (P1 = 3.01 in.) =	8.209	acre-feet		inches
Approximate 2-yr Detention Volume =	1.615	acre-feet		
Approximate 5-yr Detention Volume =	2.326	acre-feet		
Approximate 10-yr Detention Volume =	2.786	acre-feet		
Approximate 25-yr Detention Volume =	3.273	acre-feet		
Approximate 50-yr Detention Volume =	3.481	acre-feet		
Approximate 100-yr Detention Volume =	3.793	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.912	acre-feet	
Select Zone 2 Storage Volume (Optional) =		acre-feet	**Total detention volume is less than 100-year volume.**
Select Zone 3 Storage Volume (Optional) =		acre-feet	
Total Detention Basin Volume =	0.912	acre-feet	
Initial Surcharge Volume (ISV) =	user	ft^3	
Initial Surcharge Depth (ISD) =	user	ft	
Total Available Detention Depth (H_{total}) =	user	ft	
Depth of Trickle Channel (H_{TC}) =	user	ft	
Slope of Trickle Channel (S_{TC}) =	user	ft/ft	
Slopes of Main Basin Sides (S_{main}) =	user	H:V	
Basin Length-to-Width Ratio ($R_{L/W}$) =	user		
Initial Surcharge Area (A_{ISV}) =	user	ft^2	
Surcharge Volume Length (L_{ISV}) =	user	ft	
Surcharge Volume Width (W_{ISV}) =	user	ft	
Depth of Basin Floor (H_{FLOOR}) =	user	ft	
Length of Basin Floor (L_{FLOOR}) =	user	ft	
Width of Basin Floor (W_{FLOOR}) =	user	ft	
Area of Basin Floor (A_{FLOOR}) =	user	ft^2	
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3	
Depth of Main Basin (H_{MAIN}) =	user	ft	
Length of Main Basin (L_{MAIN}) =	user	ft	
Width of Main Basin (W_{MAIN}) =	user	ft	
Area of Main Basin (A_{MAIN}) =	user	ft^2	
Volume of Main Basin (V_{MAIN}) =	user	ft^3	
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet	

Depth Increment = ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	182	0.004		
5356	--	0.43	--	--	--	192	0.004	78	0.002
5357	--	1.43	--	--	--	392	0.009	368	0.008
5358	--	2.43	--	--	--	942	0.022	1,039	0.024
5359	--	3.43	--	--	--	2,215	0.051	2,618	0.060
5360	--	4.43	--	--	--	3,783	0.087	5,617	0.129
5361	--	5.43	--	--	--	5,611	0.129	10,314	0.237
5362	--	6.43	--	--	--	8,393	0.193	17,316	0.398
5363	--	7.43	--	--	--	10,887	0.250	26,956	0.619
5364	--	8.43	--	--	--	14,122	0.324	39,460	0.906
5365	--	9.43	--	--	--	17,475	0.401	55,259	1.269
5366	--	10.43	--	--	--	20,464	0.470	74,228	1.704
5366.39	--	10.82	--	--	--	22,106	0.507	82,530	1.895
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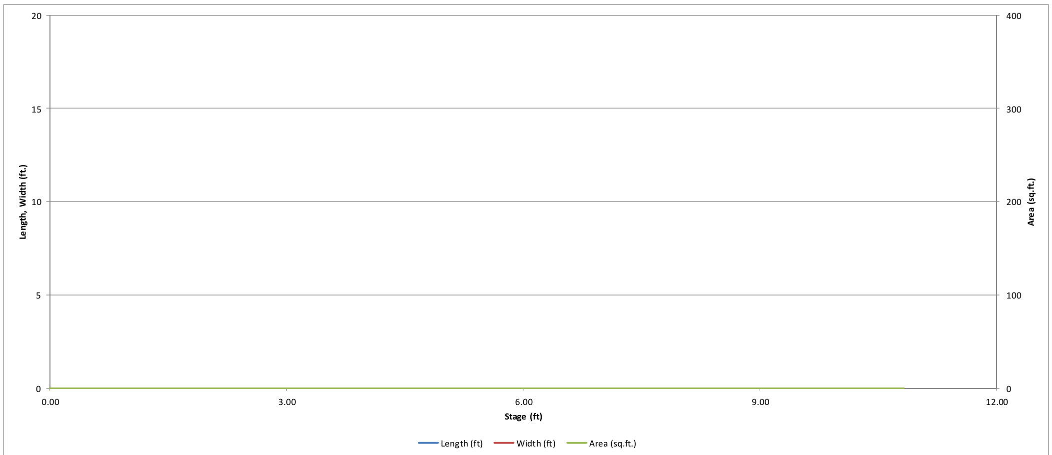
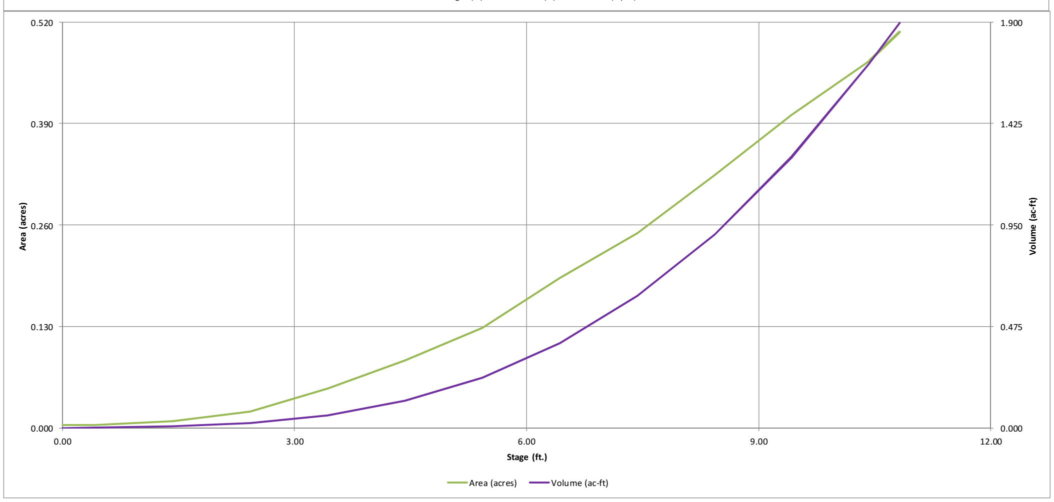
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



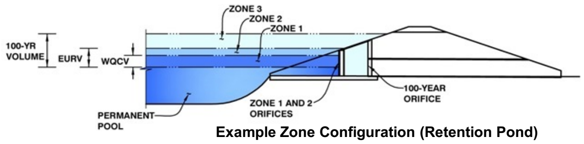


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: RiverPark 160605

Basin ID: Water Quality Pond



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	8.45	0.912	Orifice Plate
Zone 2			Not Utilized
Zone 3			Not Utilized
		0.912	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	8.45	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	33.80	inches
Orifice Plate: Orifice Area per Row =	1.80	sq. inches (diameter = 1-1/2 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	1.250E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	2.82	5.63					
Orifice Area (sq. inches)	1.80	1.80	1.80					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Not Selected	Not Selected	
Overflow Weir Front Edge Height, Ho =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	N/A	N/A	feet
Overflow Weir Slope =	N/A	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	N/A	N/A	feet
Overflow Grate Open Area % =	N/A	N/A	%, grate open area/total area
Debris Clogging % =	N/A	N/A	%

Calculated Parameters for Overflow Weir

	Not Selected	Not Selected	
Height of Grate Upper Edge, H_t =	N/A	N/A	feet
Over Flow Weir Slope Length =	N/A	N/A	feet
Grate Open Area / 100-yr Orifice Area =	N/A	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	N/A	N/A	ft^2
Overflow Grate Open Area w/ Debris =	N/A	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Not Selected	Not Selected	
Depth to Invert of Outlet Pipe =	N/A	N/A	ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Not Selected	Not Selected	
Outlet Orifice Area =	N/A	N/A	ft^2
Outlet Orifice Centroid =	N/A	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	8.45	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	55.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	0.00	feet

Calculated Parameters for Spillway

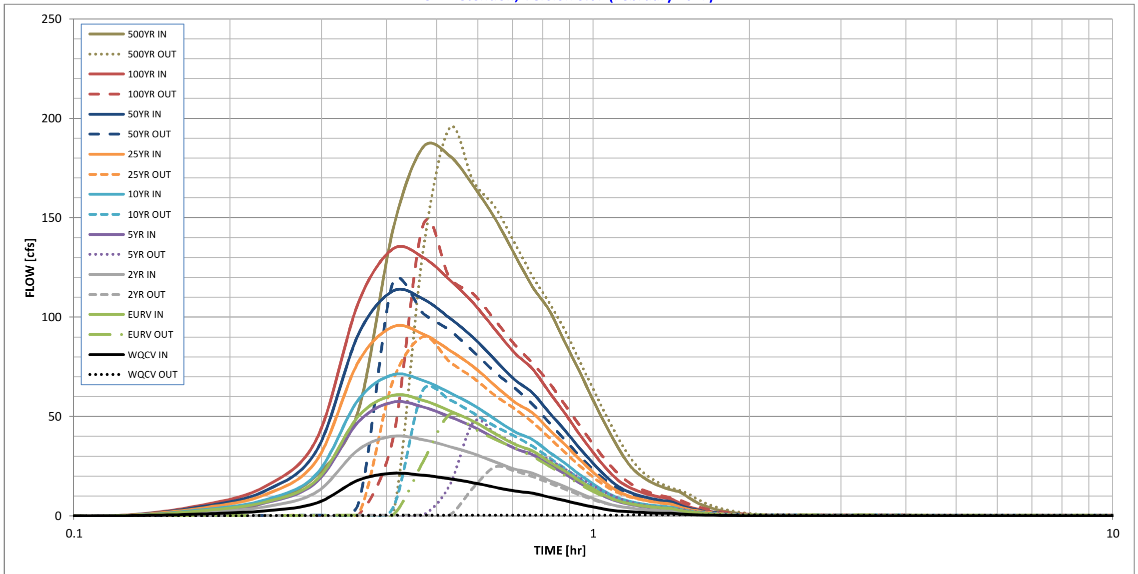
Spillway Design Flow Depth=	0.84	feet
Stage at Top of Freeboard =	9.29	feet
Basin Area at Top of Freeboard =	0.39	acres

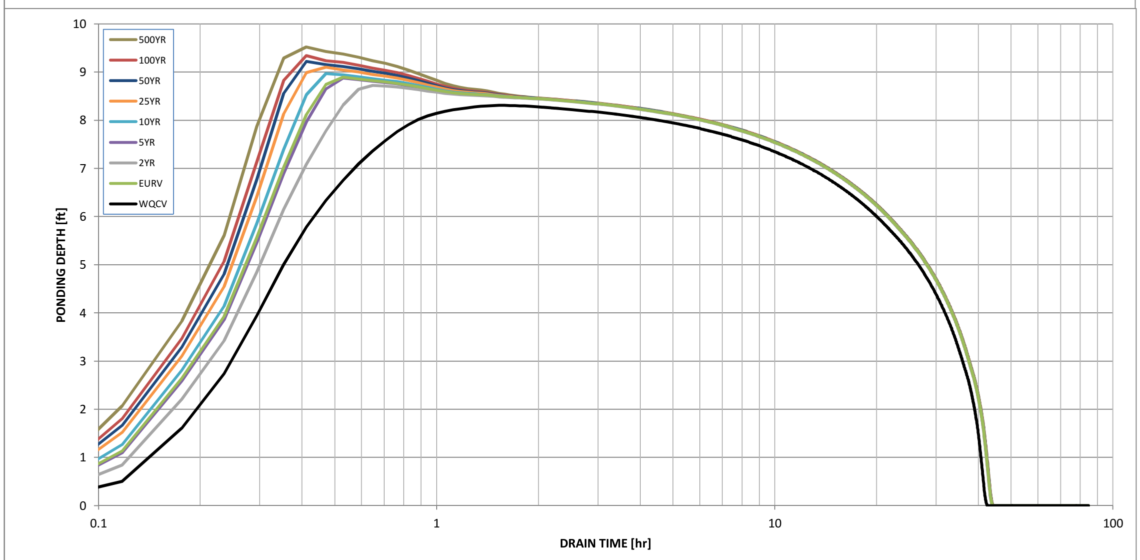
Routed Hydrograph Results

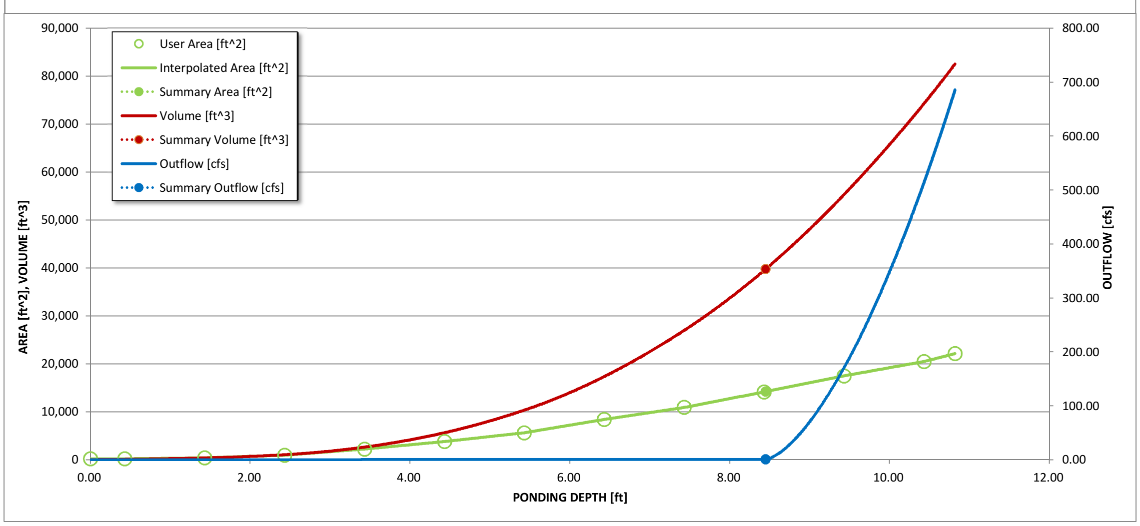
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.81	1.08	1.31	1.66	1.94	2.24	3.01
Calculated Runoff Volume (acre-ft) =	0.912	2.620	1.720	2.470	3.075	4.140	4.942	5.900	8.209
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.913	2.622	1.721	2.471	3.077	4.143	4.946	5.897	8.216
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.02	0.14	0.38	0.95	1.30	1.72	2.67
Predevelopment Peak Q (cfs) =	0.0	0.0	0.5	4.6	12.7	31.6	43.3	57.3	89.0
Peak Inflow Q (cfs) =	21.4	60.6	40.0	57.2	71.0	95.1	113.1	134.3	185.5
Peak Outflow Q (cfs) =	0.4	51.0	24.6	63.3	63.3	90.1	117.4	146.0	195.1
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	10.3	5.0	2.9	2.7	2.5	2.2
Structure Controlling Flow =	Plate	Spillway	Spillway	Spillway	Spillway	Spillway	Spillway	Spillway	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	35	37	35	34	32	30	29	25
Time to Drain 99% of Inflow Volume (hours) =	40	39	40	39	39	38	37	36	35
Maximum Ponding Depth (ft) =	8.31	8.90	8.72	8.87	8.97	9.10	9.22	9.34	9.52
Area at Maximum Ponding Depth (acres) =	0.31	0.36	0.35	0.36	0.36	0.37	0.39	0.39	0.41
Maximum Volume Stored (acre-ft) =	0.864	1.063	1.003	1.056	1.089	1.137	1.186	1.229	1.305

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename: .\Outflow Hydrographs.xlsx

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

Time Interval	Hydrograph Constant
3.53 min	1.418

SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:03:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:07:04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:10:35	0.94	2.58	1.73	2.44	3.00	3.95	4.62	5.37	7.07
0:14:07	2.54	7.08	4.71	6.69	8.27	10.97	12.93	15.20	20.46
0:17:39	6.53	18.19	12.10	17.18	21.23	28.16	33.20	39.02	52.55
0:21:11	17.93	49.91	33.21	47.14	58.25	77.20	91.00	106.87	143.75
0:24:43	21.39	60.61	40.01	57.18	70.98	95.08	113.09	134.30	185.47
0:28:14	20.43	58.10	38.30	54.80	68.10	91.48	109.12	130.05	181.17
0:31:46	18.60	52.88	34.86	49.87	61.97	83.32	99.52	118.79	166.02
0:35:18	16.64	47.54	31.28	44.83	55.76	75.05	89.68	107.08	149.76
0:38:50	14.40	41.43	27.16	39.05	48.66	65.66	78.55	93.91	131.67
0:42:22	12.53	36.07	23.60	33.98	42.41	57.32	68.63	82.11	115.25
0:45:53	11.36	32.65	21.40	30.77	38.35	51.74	61.87	73.92	103.45
0:49:25	9.40	27.27	17.82	25.69	32.06	43.36	51.95	62.21	87.51
0:52:57	7.70	22.53	14.68	21.22	26.52	35.93	43.09	51.65	72.75
0:56:29	5.97	17.74	11.49	16.69	20.92	28.47	34.23	41.14	58.26
1:00:01	4.47	13.59	8.73	12.77	16.08	21.99	26.51	31.93	45.40
1:03:32	3.23	10.06	6.40	9.44	11.94	16.42	19.86	24.00	34.30
1:07:04	2.49	7.60	4.87	7.14	9.00	12.32	14.85	17.89	25.43
1:10:36	2.05	6.15	3.97	5.79	7.27	9.90	11.91	14.31	20.23
1:14:08	1.74	5.19	3.35	4.88	6.13	8.34	10.02	12.02	16.96
1:17:40	1.52	4.53	2.93	4.26	5.34	7.25	8.70	10.44	14.69
1:21:11	1.37	4.06	2.63	3.82	4.78	6.49	7.78	9.32	13.10
1:24:43	1.26	3.72	2.42	3.50	4.38	5.94	7.12	8.52	11.96
1:28:15	0.92	2.75	1.78	2.59	3.25	4.43	5.33	6.42	9.12
1:31:47	0.68	2.00	1.30	1.88	2.36	3.21	3.86	4.63	6.57
1:35:19	0.50	1.48	0.96	1.39	1.74	2.37	2.85	3.43	4.88
1:38:50	0.37	1.10	0.71	1.03	1.29	1.76	2.12	2.55	3.62
1:42:22	0.26	0.80	0.51	0.75	0.94	1.29	1.56	1.88	2.67
1:45:54	0.19	0.57	0.36	0.54	0.68	0.93	1.12	1.35	1.93
1:49:26	0.13	0.41	0.26	0.39	0.49	0.67	0.81	0.98	1.40
1:52:58	0.09	0.29	0.18	0.27	0.34	0.47	0.57	0.69	0.99
1:56:29	0.05	0.18	0.11	0.17	0.22	0.30	0.37	0.45	0.65
2:00:01	0.03	0.10	0.06	0.09	0.12	0.17	0.21	0.26	0.39
2:03:33	0.01	0.04	0.02	0.04	0.05	0.08	0.10	0.12	0.19
2:07:05	0.00	0.01	0.00	0.01	0.01	0.02	0.03	0.04	0.06
2:10:37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:14:08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:17:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:21:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:24:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:28:16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:31:47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:35:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:38:51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:42:23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:45:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:49:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:52:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:56:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:03:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:07:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:10:37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:14:09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:17:41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:21:13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:24:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:28:16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:31:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:35:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:38:52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:42:23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:45:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:49:27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:52:59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:56:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:03:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:07:06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:10:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:14:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]
WQCV	8.45	14,189	0.326	39,743	0.912	0.42

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

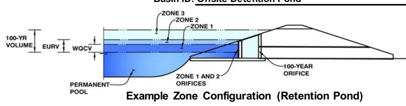
Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: RiverPark 160605

Basin ID: Offsite Detention Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	33.34	acres		
Watershed Length =	1,200	ft		
Watershed Slope =	0.050	ft/ft		
Watershed Imperviousness =	80.00%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	100.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	Littleton - City Hall			
Water Quality Capture Volume (WQCV) =	0.912	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	2.620	acre-feet		
2-yr Runoff Volume (P1 = 0.81 in.) =	1.720	acre-feet		inches
5-yr Runoff Volume (P1 = 1.08 in.) =	2.470	acre-feet		inches
10-yr Runoff Volume (P1 = 1.31 in.) =	3.075	acre-feet		inches
25-yr Runoff Volume (P1 = 1.66 in.) =	4.140	acre-feet		inches
50-yr Runoff Volume (P1 = 1.94 in.) =	4.942	acre-feet		inches
100-yr Runoff Volume (P1 = 2.24 in.) =	5.900	acre-feet		inches
500-yr Runoff Volume (P1 = 3.01 in.) =	8.209	acre-feet		inches
Approximate 2-yr Detention Volume =	1.615	acre-feet		
Approximate 5-yr Detention Volume =	2.326	acre-feet		
Approximate 10-yr Detention Volume =	2.786	acre-feet		
Approximate 25-yr Detention Volume =	3.273	acre-feet		
Approximate 50-yr Detention Volume =	3.481	acre-feet		
Approximate 100-yr Detention Volume =	3.793	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (EURV-WQCV) =	1.708	acre-feet	**WQCV not provided!**
Zone 2 Volume (100-year - Zone 1) =	2.086	acre-feet	
Select Zone 3 Storage Volume (Optional) =		acre-feet	
Total Detention Basin Volume =	3.793	acre-feet	
Initial Surcharge Volume (ISV) =	user	ft^3	
Initial Surcharge Depth (ISD) =	user	ft	
Total Available Detention Depth (H_{total}) =	user	ft	
Depth of Trickle Channel (H_{TC}) =	user	ft	
Slope of Trickle Channel (S_{TC}) =	user	ft/ft	
Slopes of Main Basin Sides (S_{main}) =	user	H:V	
Basin Length-to-Width Ratio ($R_{L/W}$) =	user		
Initial Surcharge Area (A_{ISV}) =	user	ft^2	
Surcharge Volume Length (L_{ISV}) =	user	ft	
Surcharge Volume Width (W_{ISV}) =	user	ft	
Depth of Basin Floor (H_{FLOOR}) =	user	ft	
Length of Basin Floor (L_{FLOOR}) =	user	ft	
Width of Basin Floor (W_{FLOOR}) =	user	ft	
Area of Basin Floor (A_{FLOOR}) =	user	ft^2	
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3	
Depth of Main Basin (H_{MAIN}) =	user	ft	
Length of Main Basin (L_{MAIN}) =	user	ft	
Width of Main Basin (W_{MAIN}) =	user	ft	
Area of Main Basin (A_{MAIN}) =	user	ft^2	
Volume of Main Basin (V_{MAIN}) =	user	ft^3	
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet	

Depth Increment = ______ ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	109	0.003		
5354	--	0.20	--	--	--	109	0.003	21	0.000
5355	--	1.20	--	--	--	4,279	0.098	2,173	0.050
5356	--	2.20	--	--	--	25,693	0.590	17,202	0.395
5357	--	3.20	--	--	--	32,592	0.748	46,344	1.064
5358	--	4.20	--	--	--	39,905	0.916	82,593	1.896
5359	--	5.20	--	--	--	47,138	1.082	126,114	2.895
5359.78	--	5.98	--	--	--	53,443	1.227	165,341	3.796
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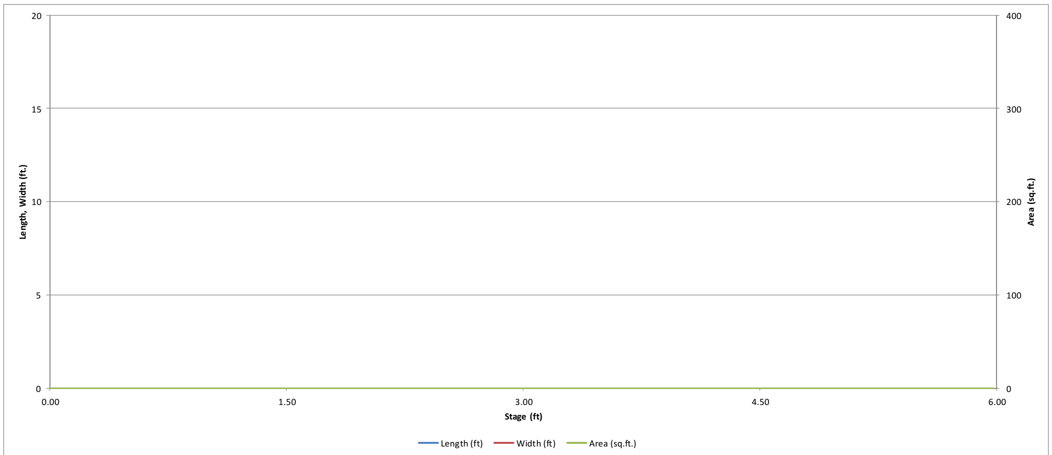
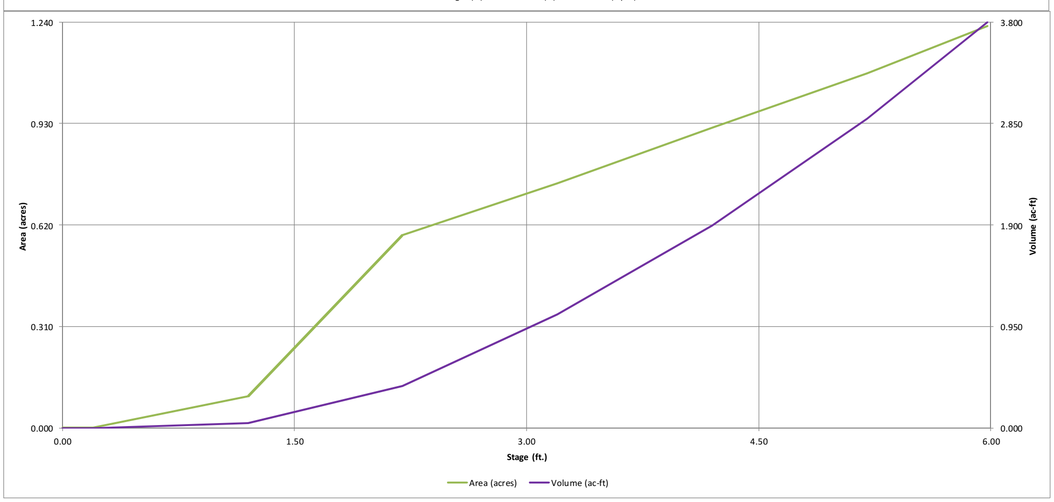
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



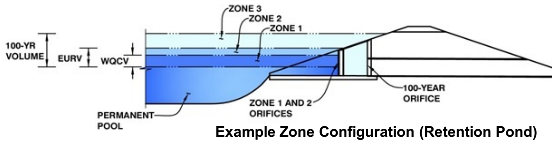


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: RiverPark 160605

Basin ID: Offsite Detention Pond



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (EURV - WQCV)	4.00	1.708	Orifice Plate
Zone 2 (100-year)	5.98	2.086	Weir&Pipe (Restrict)
Zone 3			Not Utilized
		3.793	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	4.00	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	16.00	inches
Orifice Plate: Orifice Area per Row =	19.06	sq. inches (use rectangular openings)

Calculated Parameters for Plate

WQ Orifice Area per Row =	1.324E-01	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.33	2.67					
Orifice Area (sq. inches)	19.06	19.06	19.06					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 2 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.00	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	6.00	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	6.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 2 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	5.50	N/A	feet
Over Flow Weir Slope Length =	6.18	N/A	feet
Grate Open Area / 100-yr Orifice Area =	33.07	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	25.98	N/A	ft^2
Overflow Grate Open Area w/ Debris =	12.99	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 2 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	12.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	12.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 2 Restrictor	Not Selected	
Outlet Orifice Area =	0.79	N/A	ft^2
Outlet Orifice Centroid =	0.50	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	3.14	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.98	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	300.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	0.00	feet

Calculated Parameters for Spillway

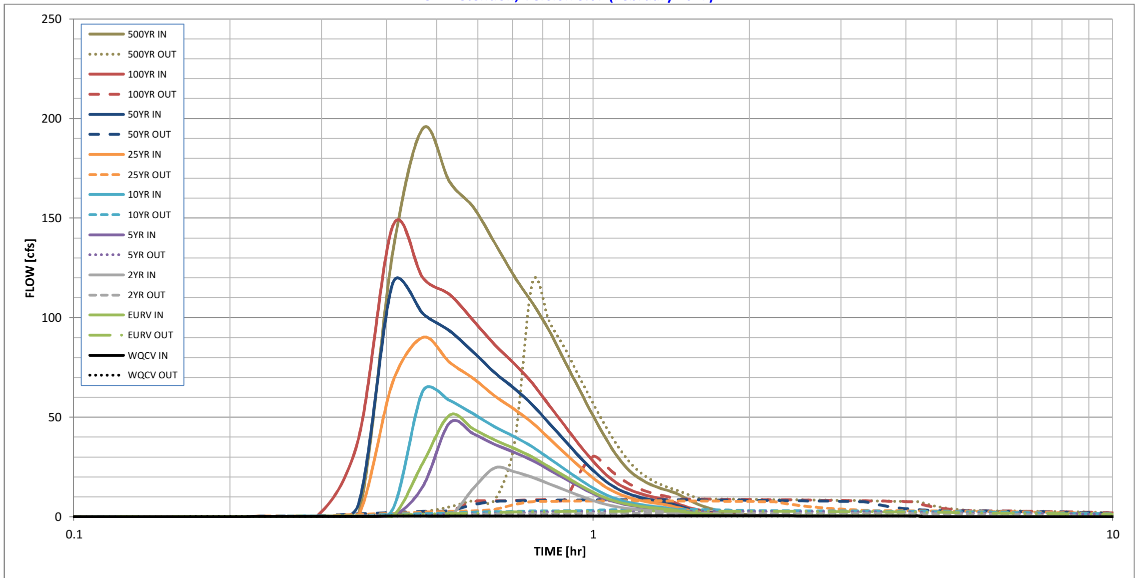
Spillway Design Flow Depth=	0.29	feet
Stage at Top of Freeboard =	6.27	feet
Basin Area at Top of Freeboard =	1.23	acres

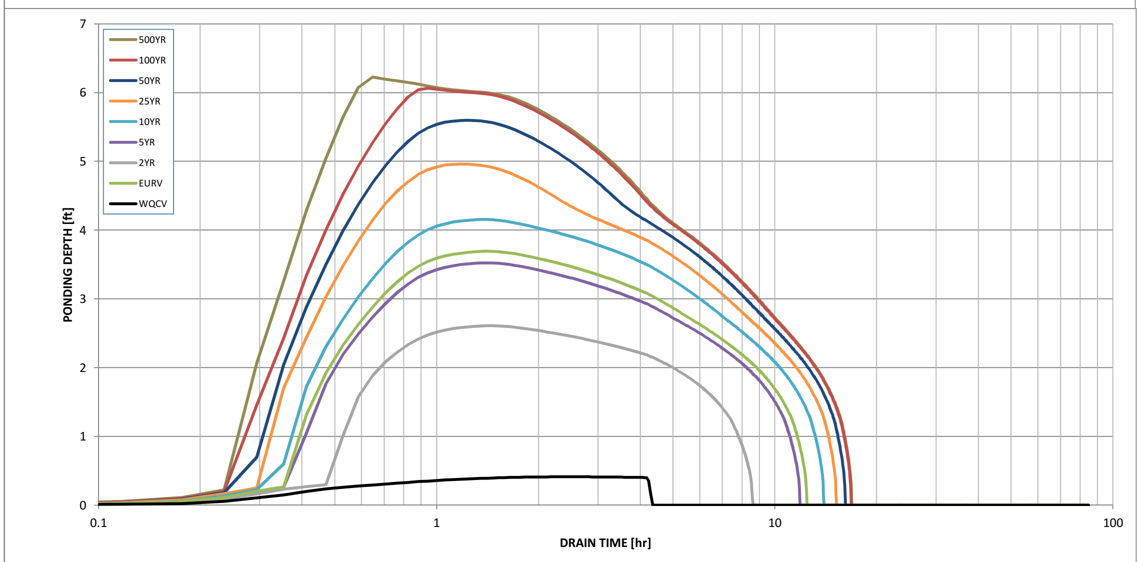
Routed Hydrograph Results

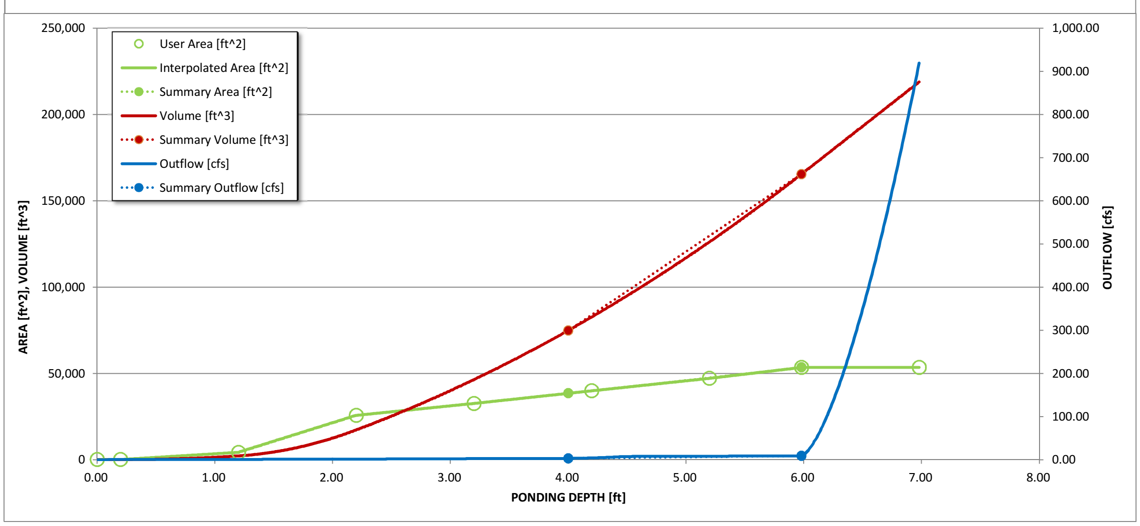
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	0.81	1.08	1.31	1.66	1.94	2.24	3.01
Calculated Runoff Volume (acre-ft) =	0.912	2.620	1.720	2.470	3.075	4.140	4.942	5.900	8.209
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.132	1.788	0.889	1.638	2.243	3.307	4.109	5.060	7.377
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.02	0.14	0.38	0.95	1.30	1.72	2.67
Predevelopment Peak Q (cfs) =	0.0	0.0	0.5	4.6	12.7	31.6	43.3	57.3	89.0
Peak Inflow Q (cfs) =	0.4	51.0	24.6	47.1	63.3	90.1	117.4	146.0	195.1
Peak Outflow Q (cfs) =	0.4	2.8	1.8	2.7	3.8	8.0	8.5	30.3	117.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.6	0.3	0.3	0.2	0.5	1.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Spillway	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.0	0.2	0.2	0.2	0.2
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	3	11	8	11	13	13	14	15	14
Time to Drain 99% of Inflow Volume (hours) =	4	12	8	12	13	15	15	16	15
Maximum Ponding Depth (ft) =	0.41	3.69	2.61	3.52	4.15	4.96	5.60	6.06	6.22
Area at Maximum Ponding Depth (acres) =	0.02	0.83	0.65	0.80	0.91	1.04	1.15	1.23	1.23
Maximum Volume Stored (acre-ft) =	0.003	1.451	0.650	1.312	1.850	2.640	3.331	3.894	4.090

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

Storm Inflow Hydrographs UD-Detention, Version 3.07 (February 2017)

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

Time Interval: 3.53 min

Hydrograph Constant: 1.418

SOURCE	USER	USER	USER	USER	USER	USER	USER	USER	USER
TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:03:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:07:04	0.04	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.09
0:10:35	0.08	0.10	0.09	0.10	0.10	0.14	0.15	0.16	0.18
0:14:07	0.10	0.18	0.16	0.18	0.19	0.21	0.22	0.23	0.24
0:17:39	0.18	0.24	0.22	0.24	0.28	0.32	0.34	0.36	0.39
0:21:11	0.22	0.35	0.30	0.35	0.37	0.41	5.85	38.46	132.85
0:24:43	0.27	0.40	0.36	0.40	3.93	67.80	117.37	146.03	195.10
0:28:14	0.31	27.14	0.39	15.36	63.26	90.11	101.93	119.93	168.28
0:31:46	0.34	50.98	0.41	47.12	58.42	77.58	93.37	111.60	155.47
0:35:18	0.36	44.06	14.25	41.65	51.67	69.43	82.69	98.52	137.47
0:38:50	0.37	38.51	24.56	36.33	45.11	60.60	72.35	86.32	120.60
0:42:22	0.38	34.25	22.58	32.31	40.14	53.96	64.40	76.82	107.24
0:45:53	0.39	29.93	19.78	28.24	35.06	47.07	56.16	66.97	93.47
0:49:25	0.40	24.99	16.54	23.58	29.25	39.27	46.85	55.89	78.13
0:52:57	0.40	20.36	13.47	19.21	23.85	32.04	38.26	45.68	63.95
0:56:29	0.40	16.05	10.60	15.14	18.81	25.30	30.24	36.14	50.71
1:00:01	0.41	12.34	8.13	11.63	14.47	19.51	23.34	27.91	39.23
1:03:32	0.41	9.41	6.21	8.87	11.02	14.84	17.73	21.19	29.70
1:07:04	0.41	7.40	4.91	6.98	8.66	11.61	13.84	16.49	22.99
1:10:36	0.41	6.09	4.05	5.75	7.12	9.54	11.37	13.54	18.86
1:14:08	0.41	5.19	3.45	4.90	6.07	8.14	9.70	11.55	16.10
1:17:40	0.41	4.56	3.02	4.30	5.33	7.15	8.52	10.15	14.14
1:21:11	0.41	4.10	2.71	3.87	4.80	6.44	7.68	9.14	12.74
1:24:43	0.41	3.52	2.34	3.33	4.12	5.51	6.56	7.81	10.87
1:28:15	0.41	2.80	1.89	2.65	3.25	4.31	5.12	6.07	8.40
1:31:47	0.41	2.17	1.49	2.05	2.51	3.30	3.90	4.60	6.33
1:35:19	0.41	1.68	1.17	1.59	1.94	2.53	2.98	3.51	4.82
1:38:50	0.41	1.30	0.92	1.24	1.50	1.95	2.29	2.69	3.68
1:42:22	0.41	1.02	0.74	0.97	1.16	1.50	1.75	2.06	2.80
1:45:54	0.41	0.80	0.58	0.77	0.90	1.16	1.35	1.58	2.13
1:49:26	0.41	0.64	0.50	0.61	0.72	0.89	1.04	1.21	1.62
1:52:58	0.41	0.53	0.42	0.51	0.57	0.71	0.80	0.92	1.22
1:56:29	0.41	0.44	0.42	0.43	0.48	0.55	0.62	0.71	0.90
2:00:01	0.41	0.42	0.42	0.42	0.42	0.46	0.50	0.54	0.67
2:03:33	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.44	0.52
2:07:05	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:10:37	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:14:08	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:17:40	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:21:12	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:24:44	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:28:16	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:31:47	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:35:19	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:38:51	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:42:23	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:45:55	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2:49:26	0.41	0.42	0.41	0.42	0.42	0.42	0.42	0.42	0.42
2:52:58	0.41	0.41	0.41	0.41	0.41	0.42	0.42	0.42	0.42
2:56:30	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.42	0.42
3:00:02	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:03:34	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:07:05	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:10:37	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:14:09	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:17:41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:21:13	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:24:44	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:28:16	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:31:48	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:35:20	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:38:52	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:42:23	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:45:55	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:49:27	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:52:59	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3:56:31	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
4:00:02	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
4:03:34	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
4:07:06	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
4:10:38	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
4:14:10	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]
EURV	4.00	38,442	0.883	74,758	1.716	3.05
100-YR	5.98	53,443	1.227	165,341	3.796	8.85

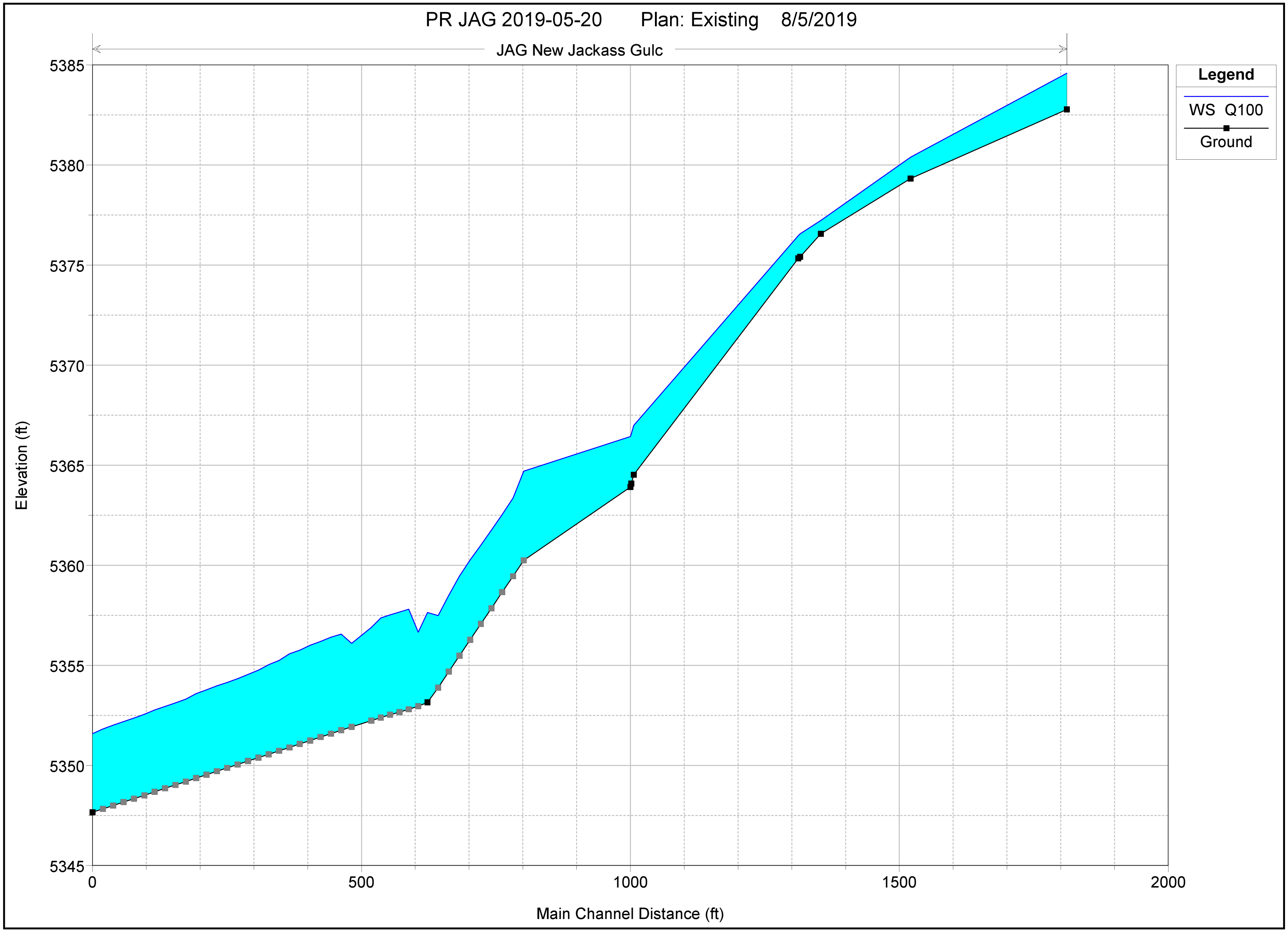
For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

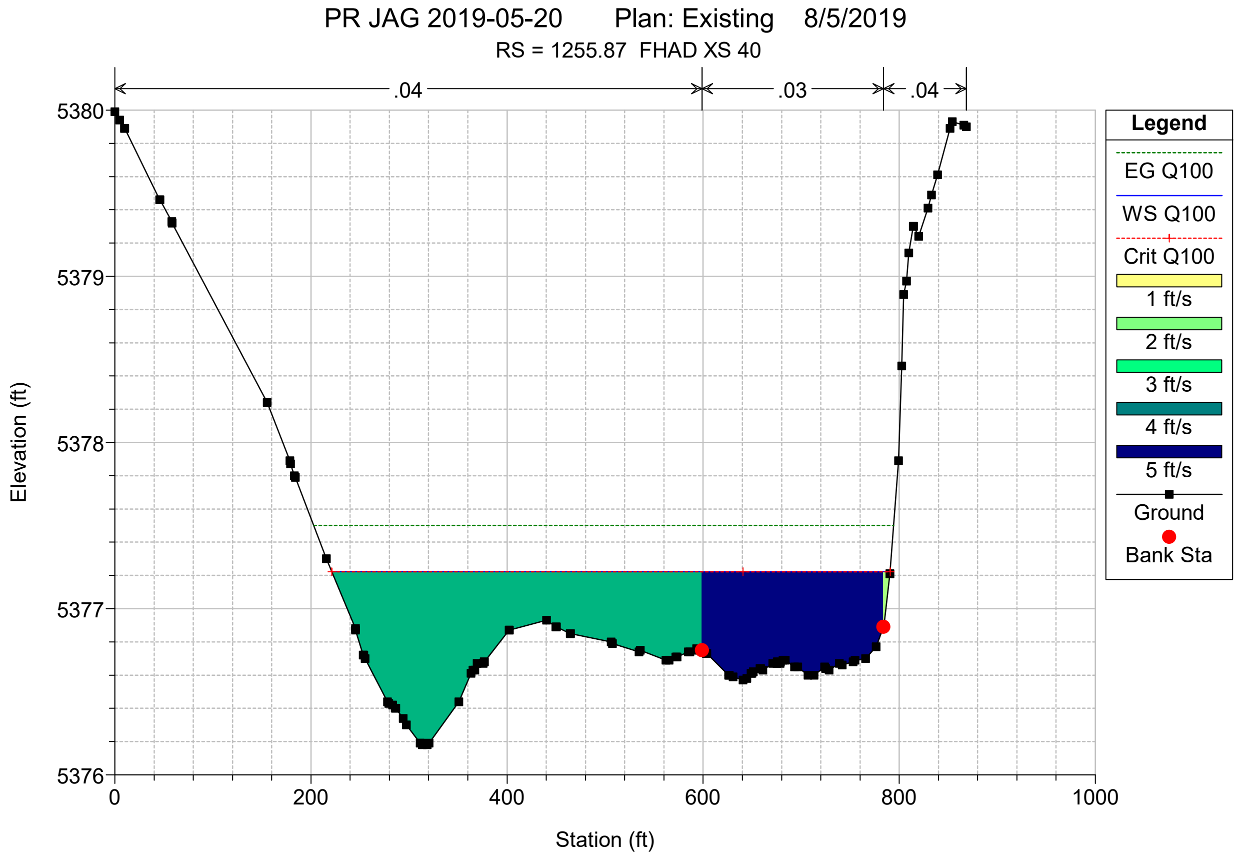
Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

APPENDIX E – UPDATED JACKASS GULCH FLOODPLAIN HYDRAULICS ANALYSIS

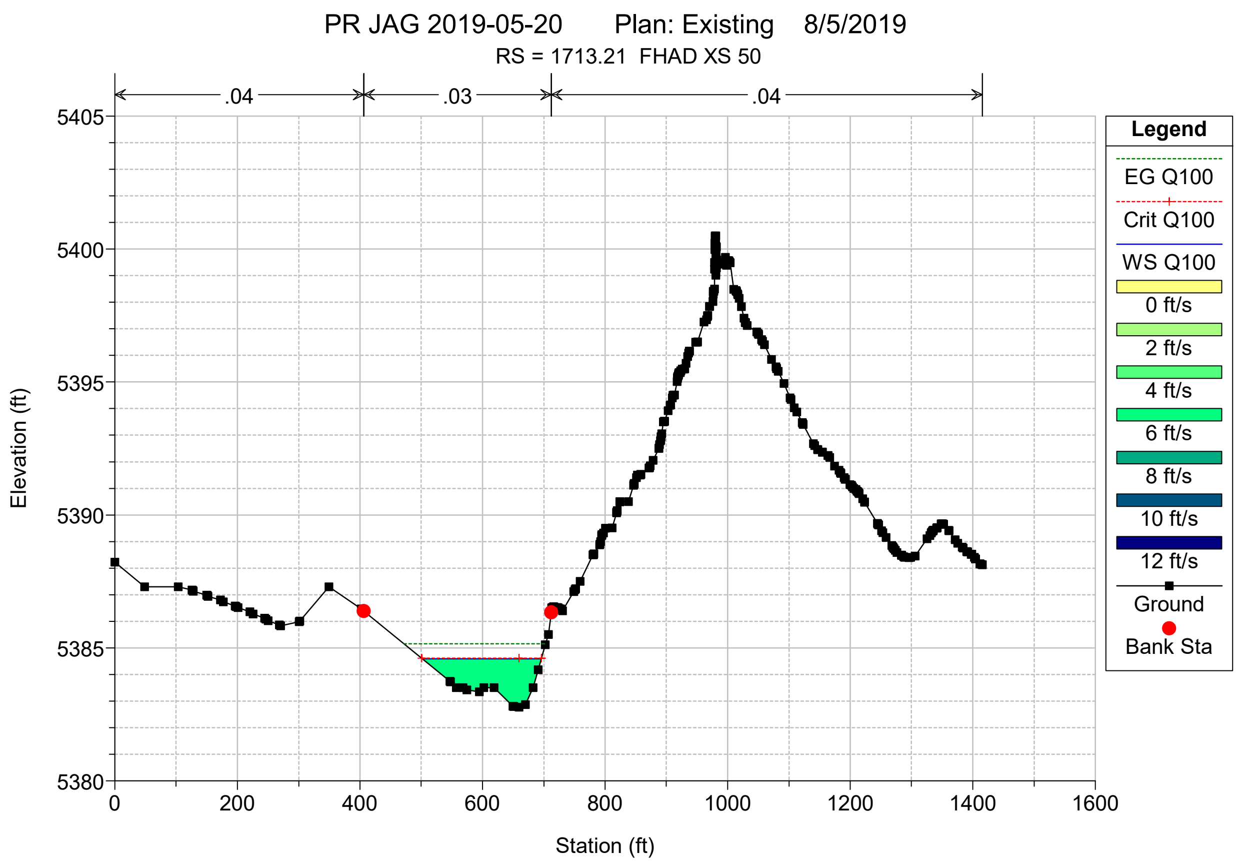
HEC-RAS Plan: EX XSCTNS   River: JAG   Reach: New Jackass Gulc   Profile: Q100

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
New Jackass Gulc	1713.21	Q100	1240.00	5382.77	5384.59	5384.61	5385.16	0.013993	6.07	204.34	193.78	1.04
New Jackass Gulc	1423.02	Q100	1240.00	5379.32	5380.39	5380.38	5380.63	0.016298	3.94	314.35	637.89	0.99
New Jackass Gulc	1255.87	Q100	1240.00	5376.57	5377.22	5377.22	5377.50	0.021634	4.97	306.03	568.79	1.17
New Jackass Gulc	1217.5	Q100	1240.00	5375.42	5376.56	5376.54	5376.82	0.014972	4.06	305.42	557.00	0.97
New Jackass Gulc	1214.09	Q100	1240.00	5375.33	5376.48	5376.48	5376.76	0.017396	4.26	291.42	554.35	1.03
New Jackass Gulc	907.98	Q100	1240.00	5364.53	5366.99	5367.64	5369.05	0.030395	11.52	107.65	69.61	1.63
New Jackass Gulc	903.56	Q100	1240.00	5364.09	5366.57	5367.30	5368.87	0.041395	12.17	101.90	76.48	1.86
New Jackass Gulc	902	Q100	1240.00	5363.91	5366.44	5367.17	5368.80	0.046434	12.32	100.67	80.91	1.95
New Jackass Gulc	703.45	Q100	1500.00	5353.15	5357.64	5358.23	5359.47	0.016861	13.33	197.92	167.06	1.33
New Jackass Gulc	49.75	Q100	1500.00	5347.66	5351.59	5351.51	5352.63	0.010004	9.80	200.81	97.32	1.02

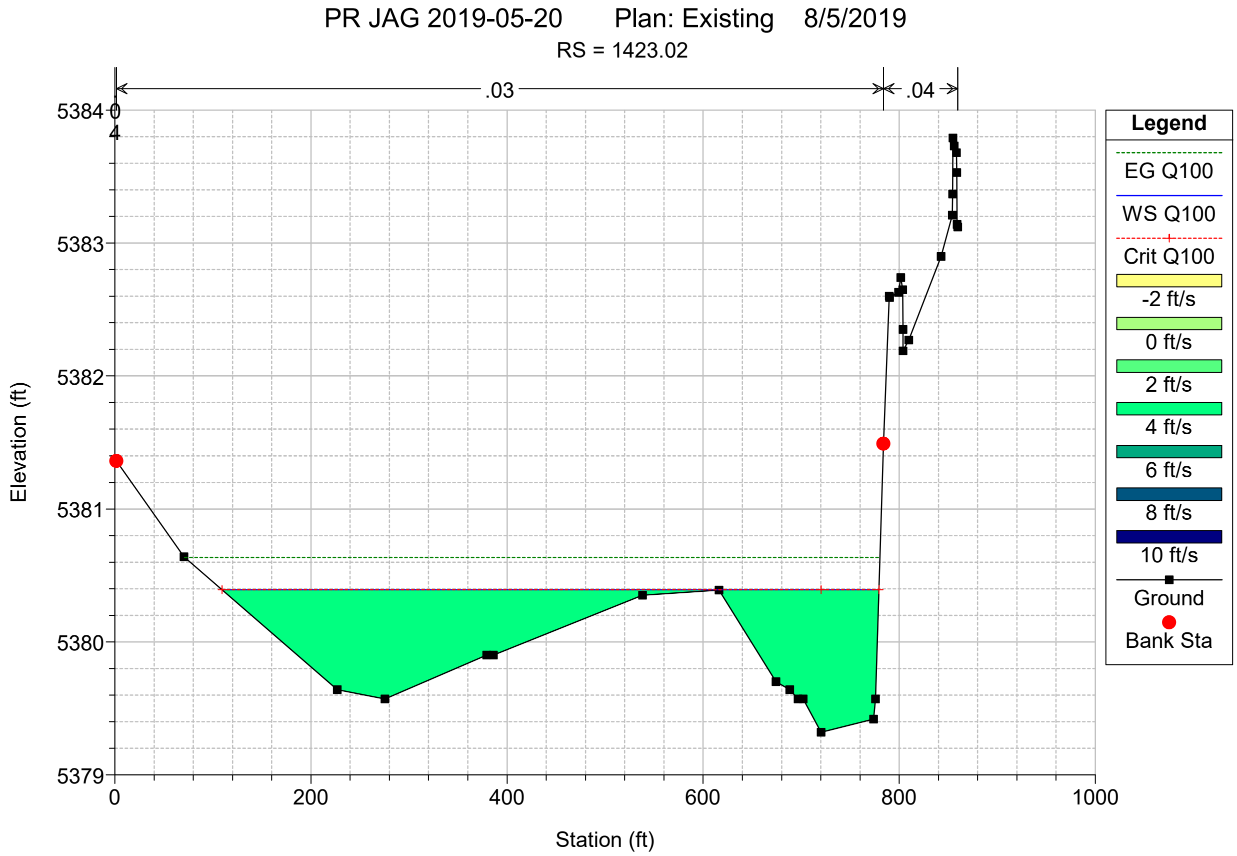

PR JAG 2019-05-20 Plan: Existing 8/5/2019
JAG New Jackass Gulc
Legend
WS Q100
Ground
Elevation (ft)
Main Channel Distance (ft)
5385
5380
5375
5370
5365
5360
5355
5350
5345
0
500
1000
1500
2000

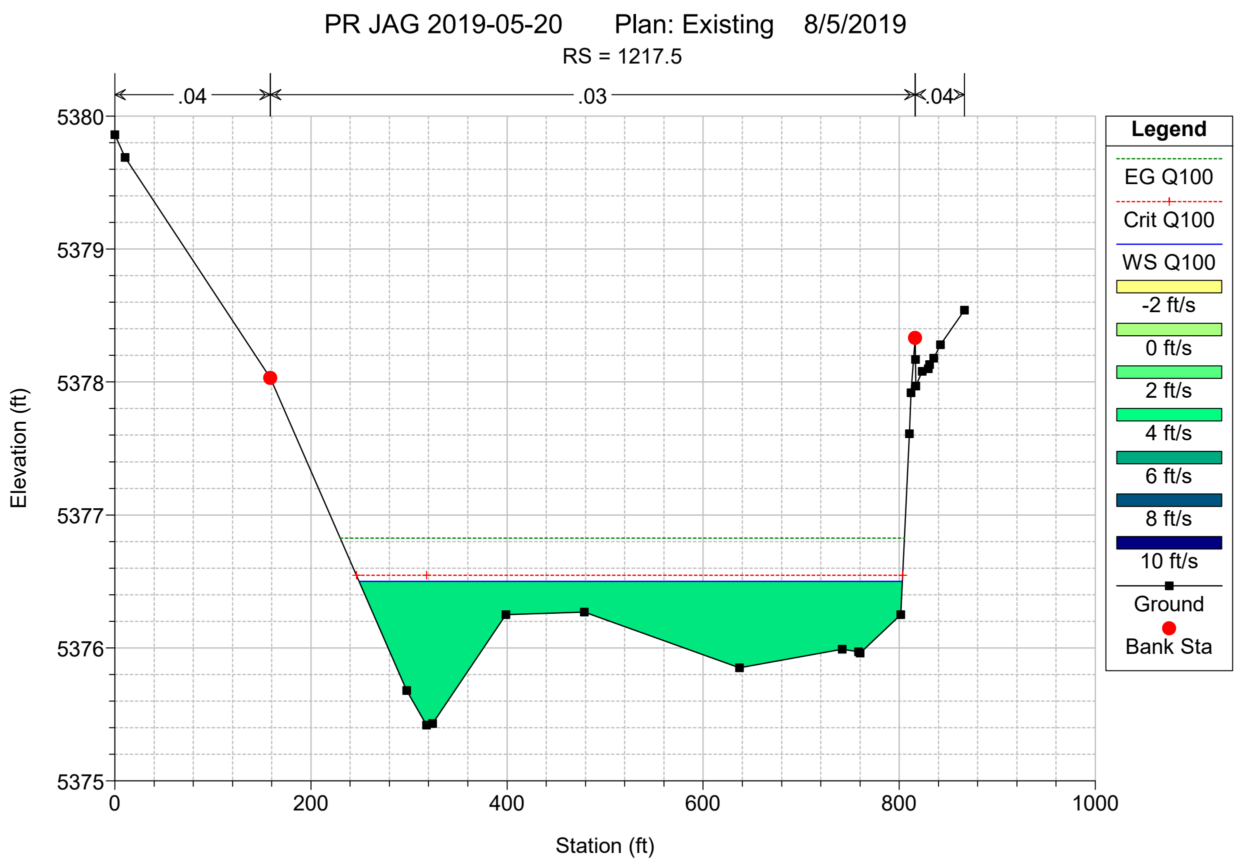


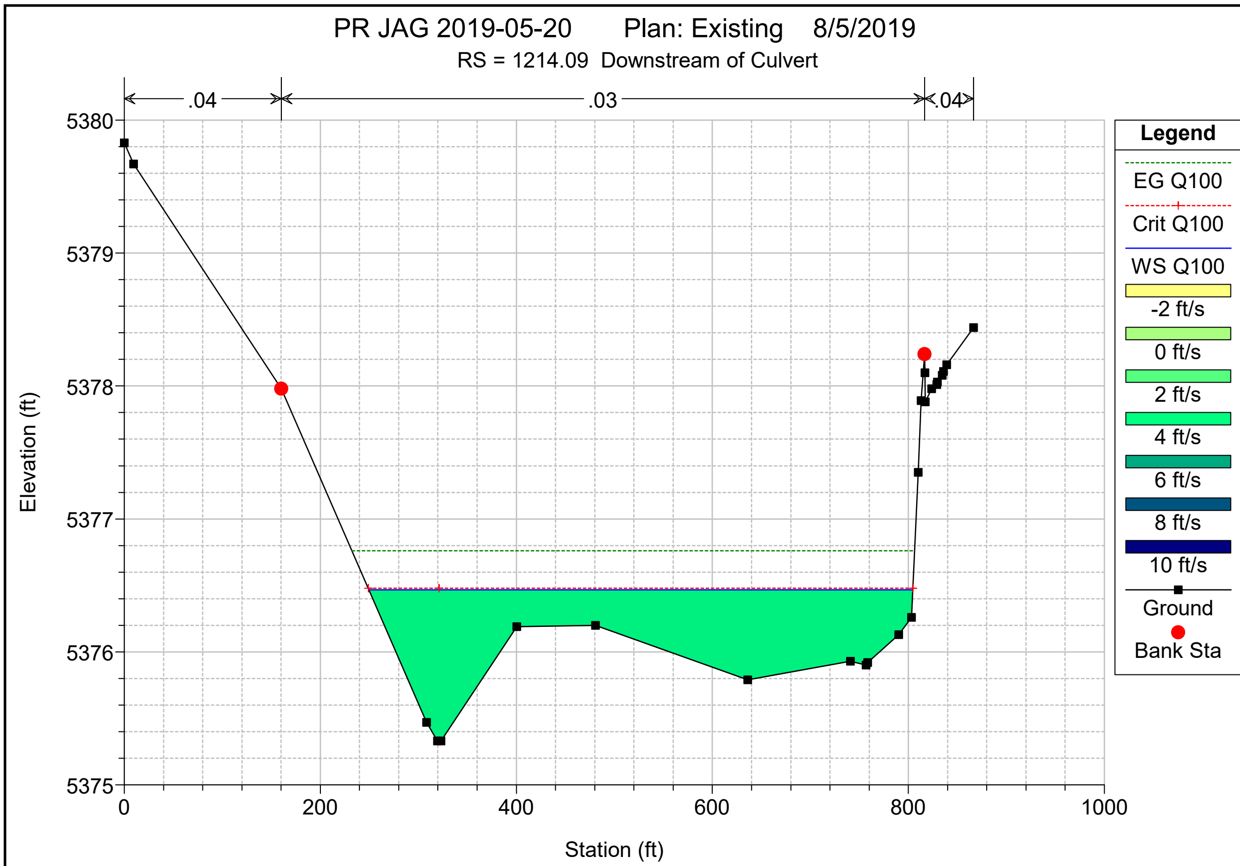
PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 1255.87 FHAD XS 40
.04
.03
.04
Elevation (ft)
5380
5379
5378
5377
5376
0
200
400
600
800
1000
Station (ft)
Legend
EG Q100
WS Q100
Crit Q100
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Bank Sta



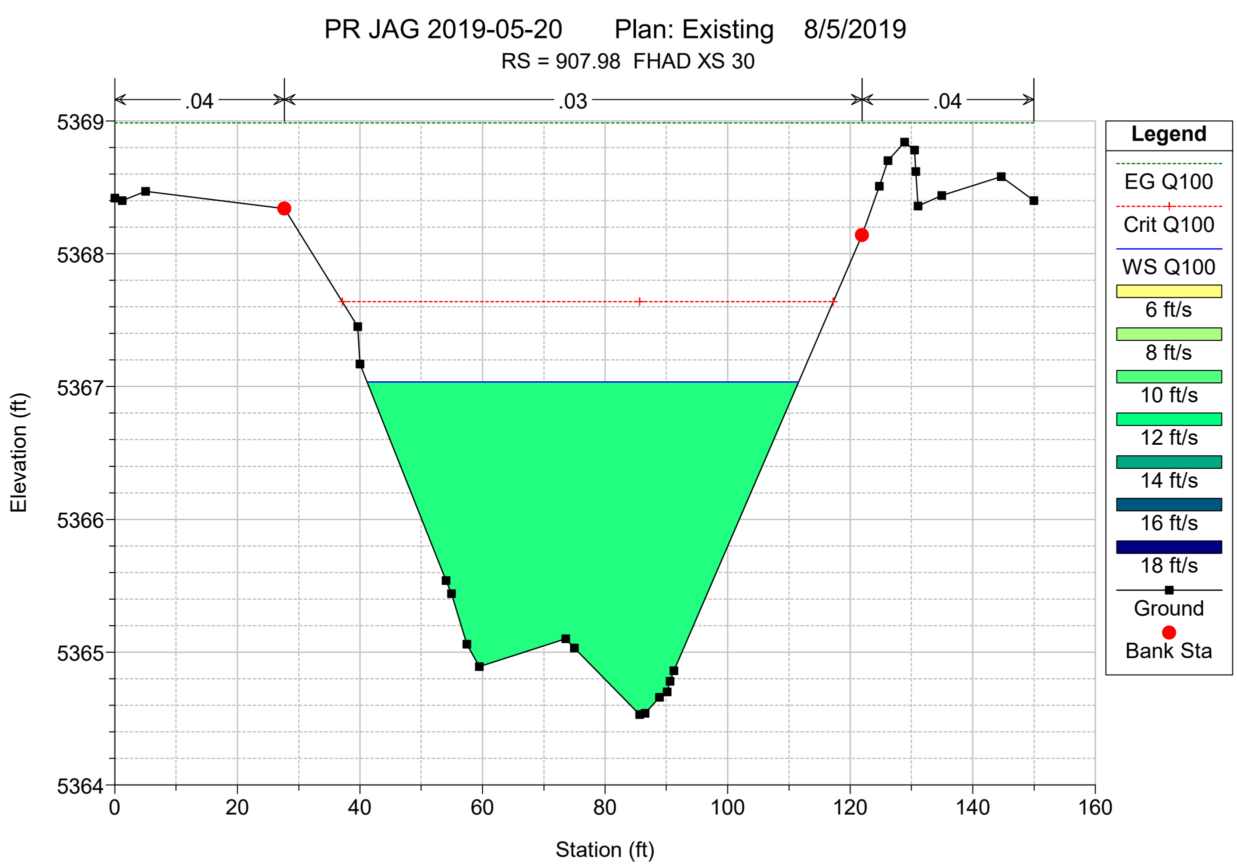
PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 1713.21 FHAD XS 50
.04
.03
.04
Elevation (ft)
5405
5400
5395
5390
5385
5380
0
200
400
600
800
1000
1200
1400
1600
Station (ft)
Legend
EG Q100
Crit Q100
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 1423.02
.03
.04
Elevation (ft)
Station (ft)
5384
5383
5382
5381
5380
5379
0
200
400
600
800
1000
Legend
EG Q100
WS Q100
Crit Q100
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta

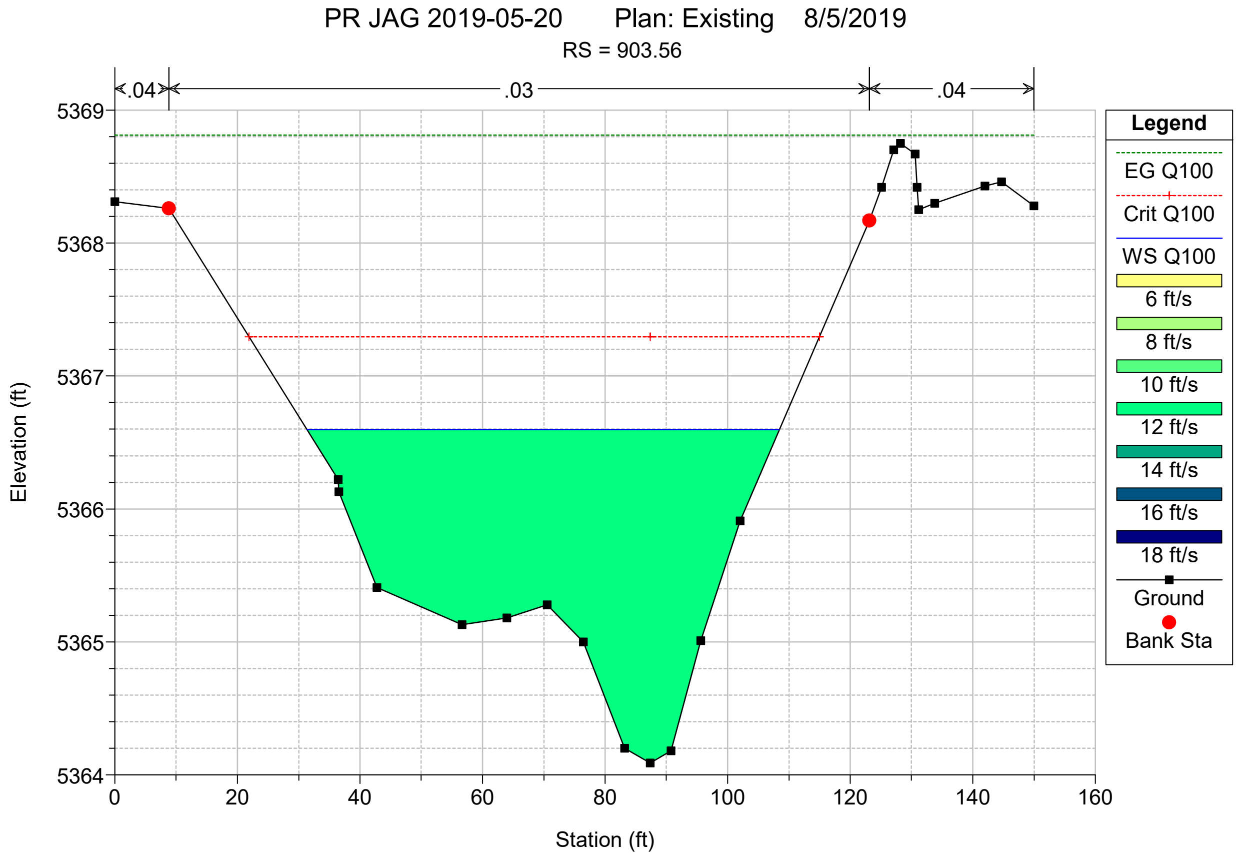

PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 1217.5
.04
.03
.04
Elevation (ft)
Station (ft)
5380
5379
5378
5377
5376
5375
0
200
400
600
800
1000
Legend
EG Q100
Crit Q100
WS Q100
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta

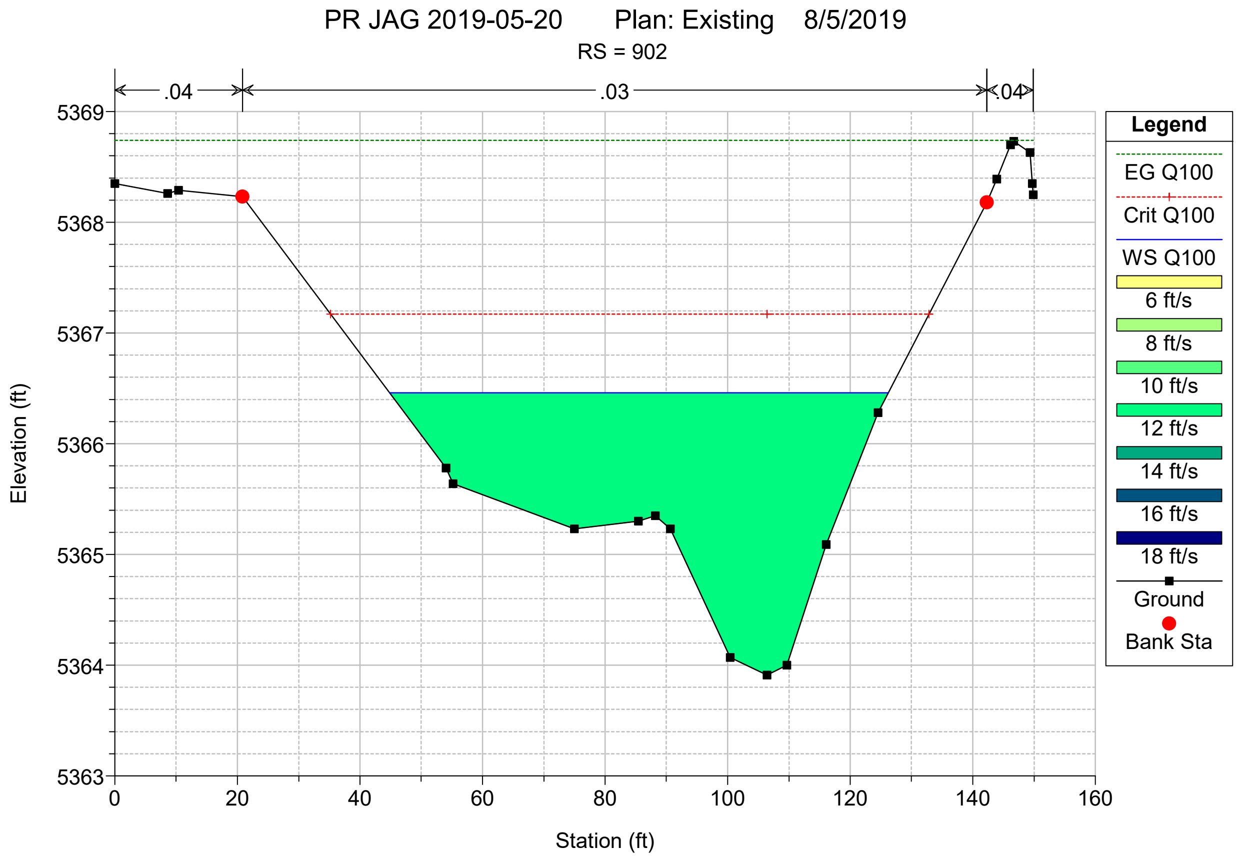


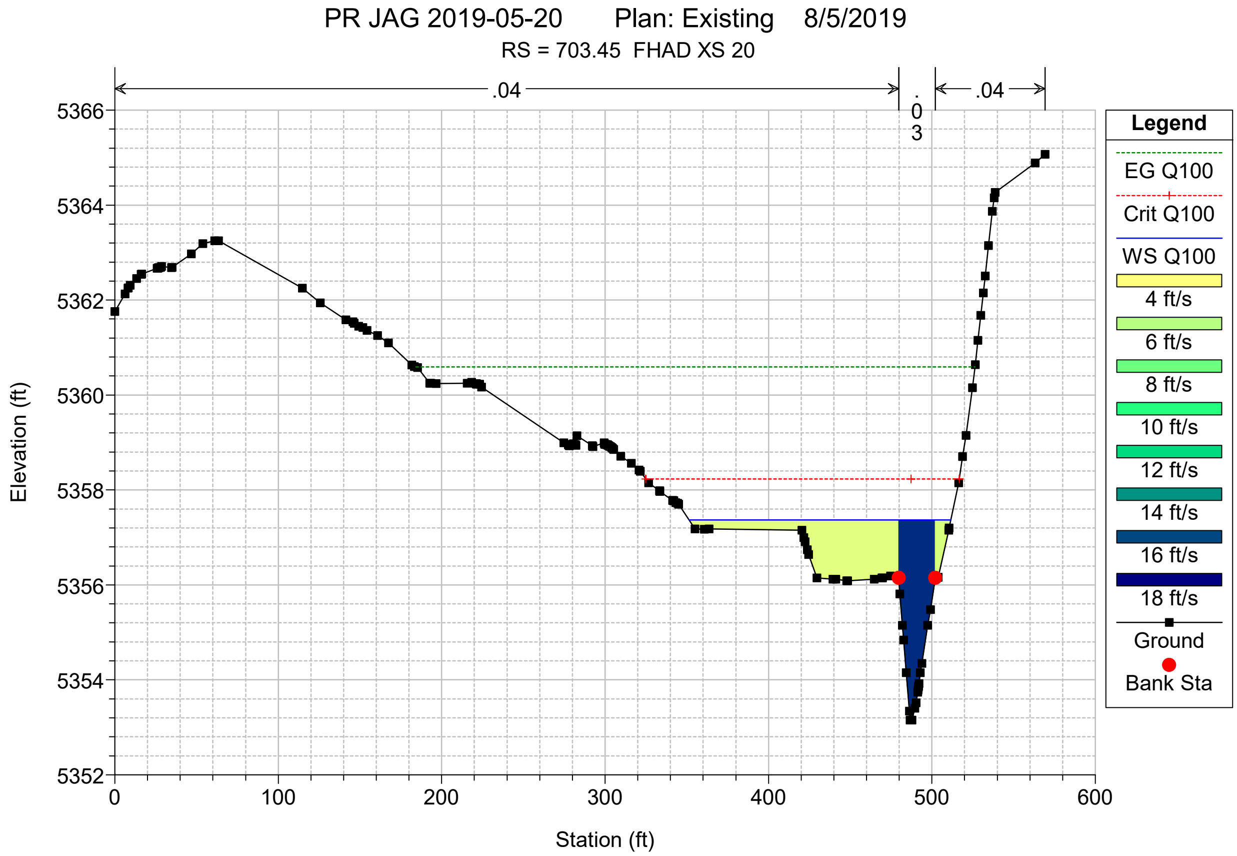
PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 1214.09 Downstream of Culvert
.04
.03
.04
Elevation (ft)
Station (ft)
5375
5376
5377
5378
5379
5380
0
200
400
600
800
1000
Legend
EG Q100
Crit Q100
WS Q100
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta



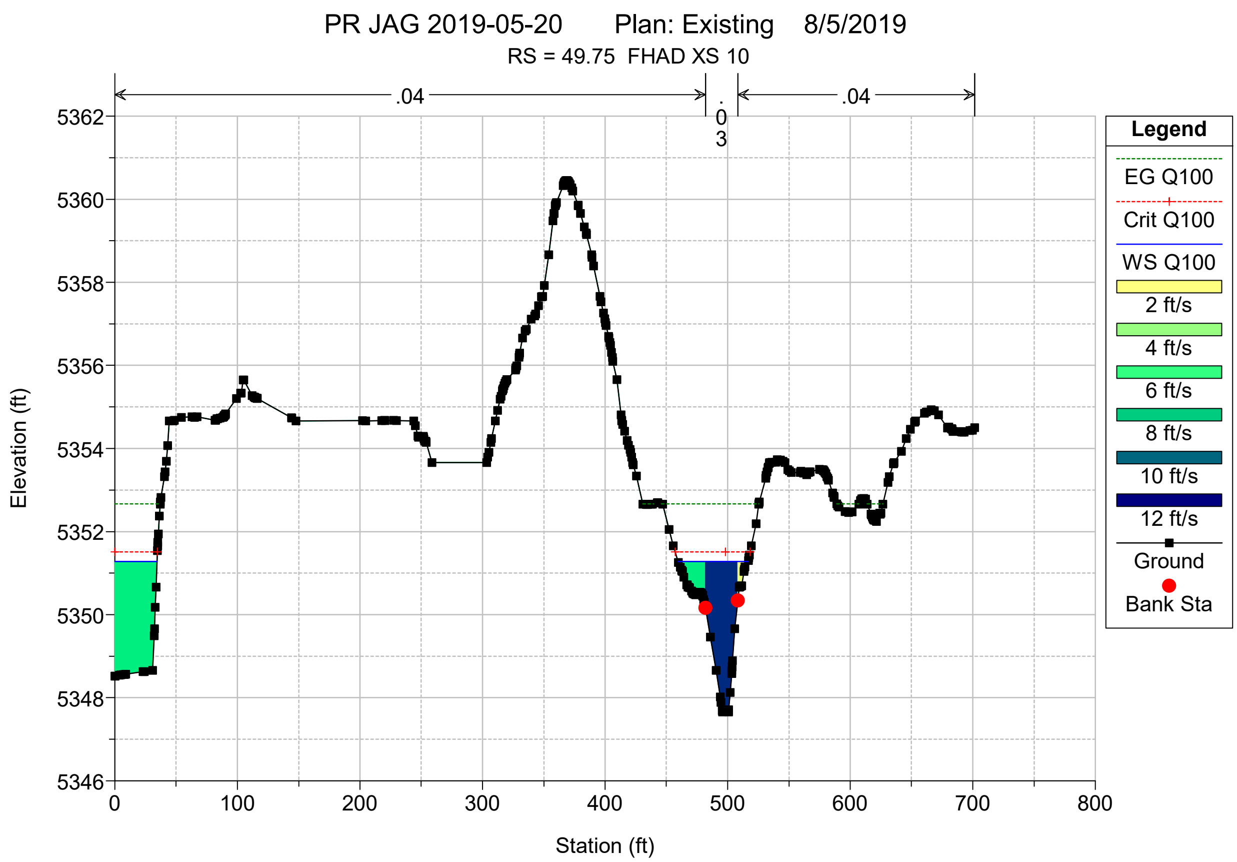
PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 907.98 FHAD XS 30
.04
.03
.04
Elevation (ft)
Station (ft)
5364
5365
5366
5367
5368
5369
0
20
40
60
80
100
120
140
160
Legend
EG Q100
Crit Q100
WS Q100
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
18 ft/s
Ground
Bank Sta


PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 903.56
.04
.03
.04
Elevation (ft)
Station (ft)
Legend
EG Q100
Crit Q100
WS Q100
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
18 ft/s
Ground
Bank Sta


PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 902
.04
.03
.04
Elevation (ft)
Station (ft)
Legend
EG Q100
Crit Q100
WS Q100
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
18 ft/s
Ground
Bank Sta



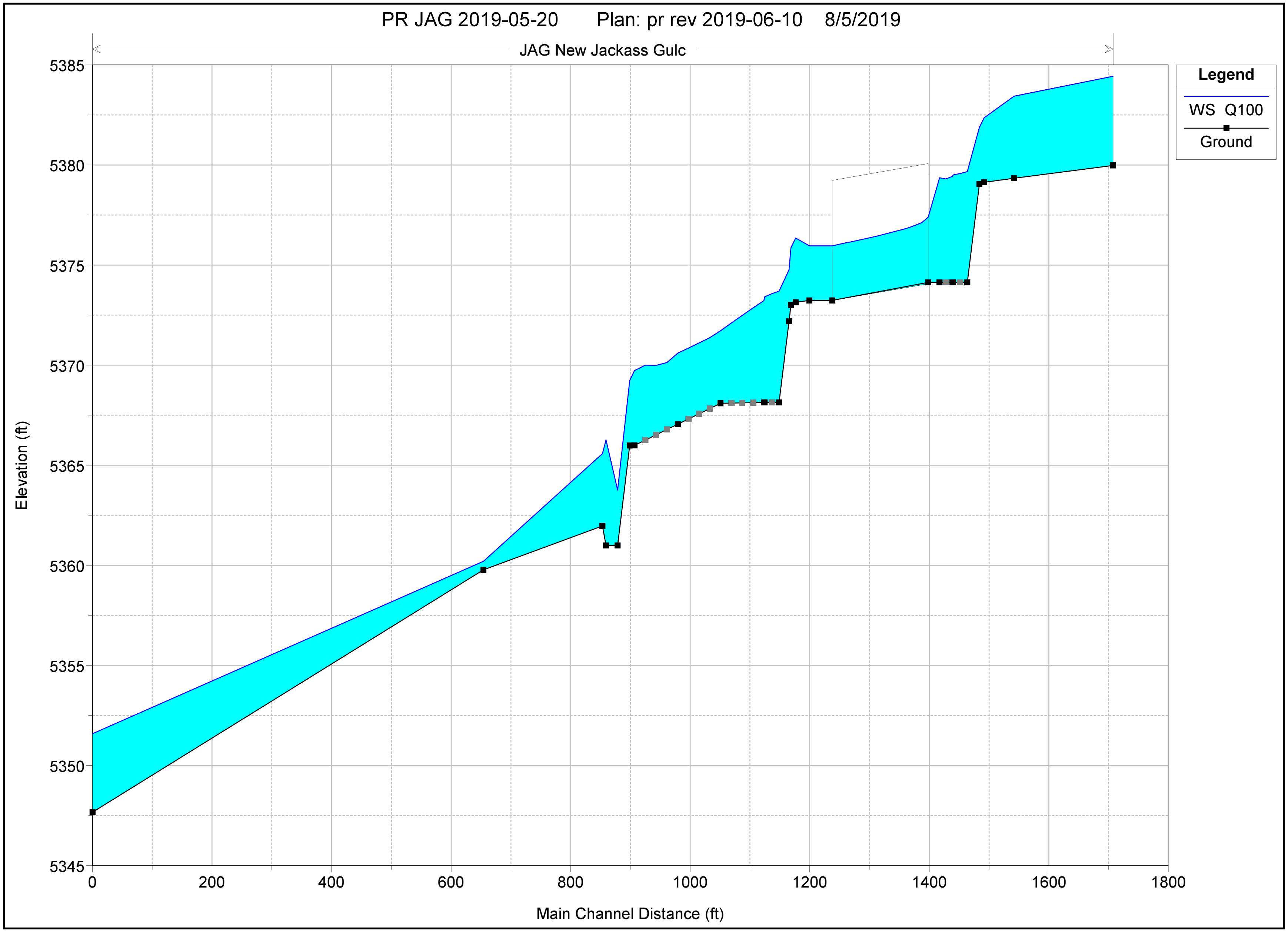
PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 703.45 FHAD XS 20
.04
.
0
3
.04
Legend
EG Q100
Crit Q100
WS Q100
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
18 ft/s
Ground
Bank Sta
Elevation (ft)
5366
5364
5362
5360
5358
5356
5354
5352
0
100
200
300
400
500
600
Station (ft)

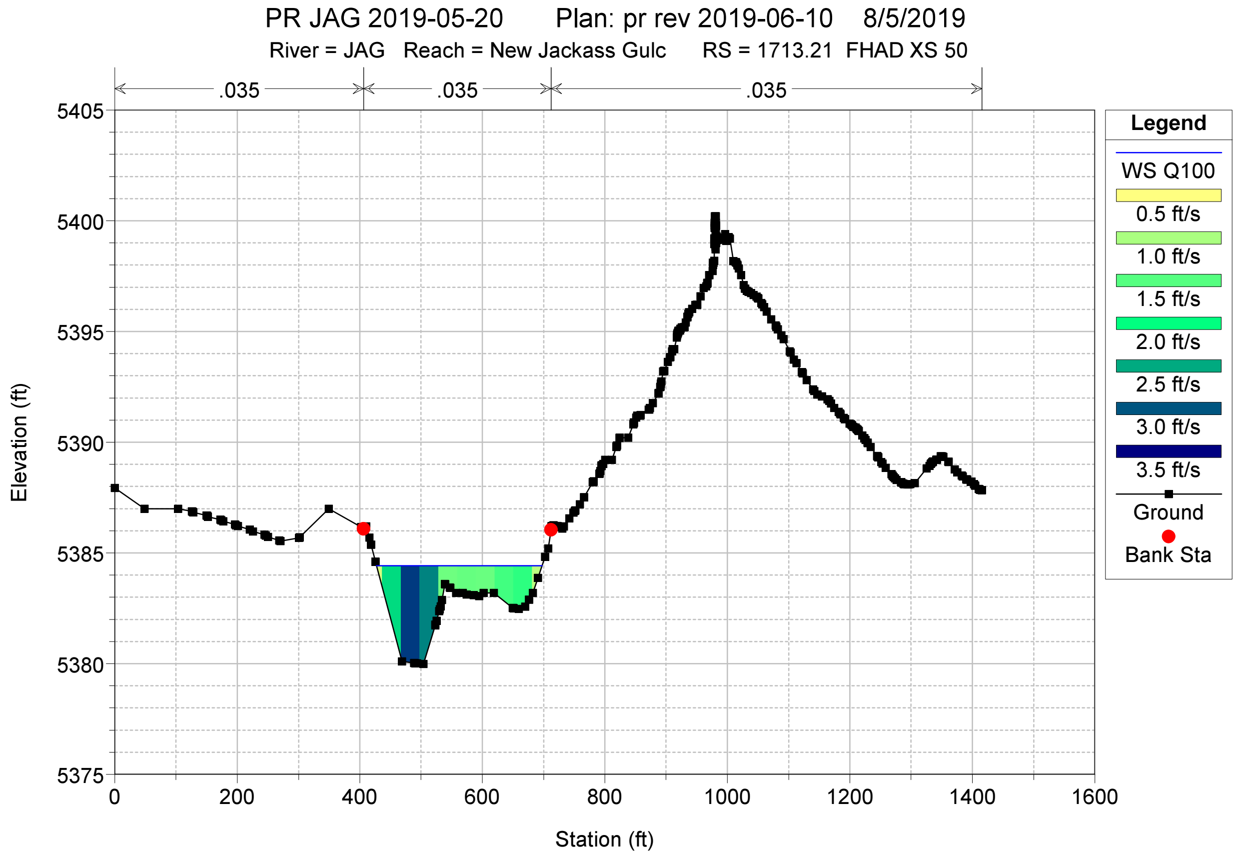


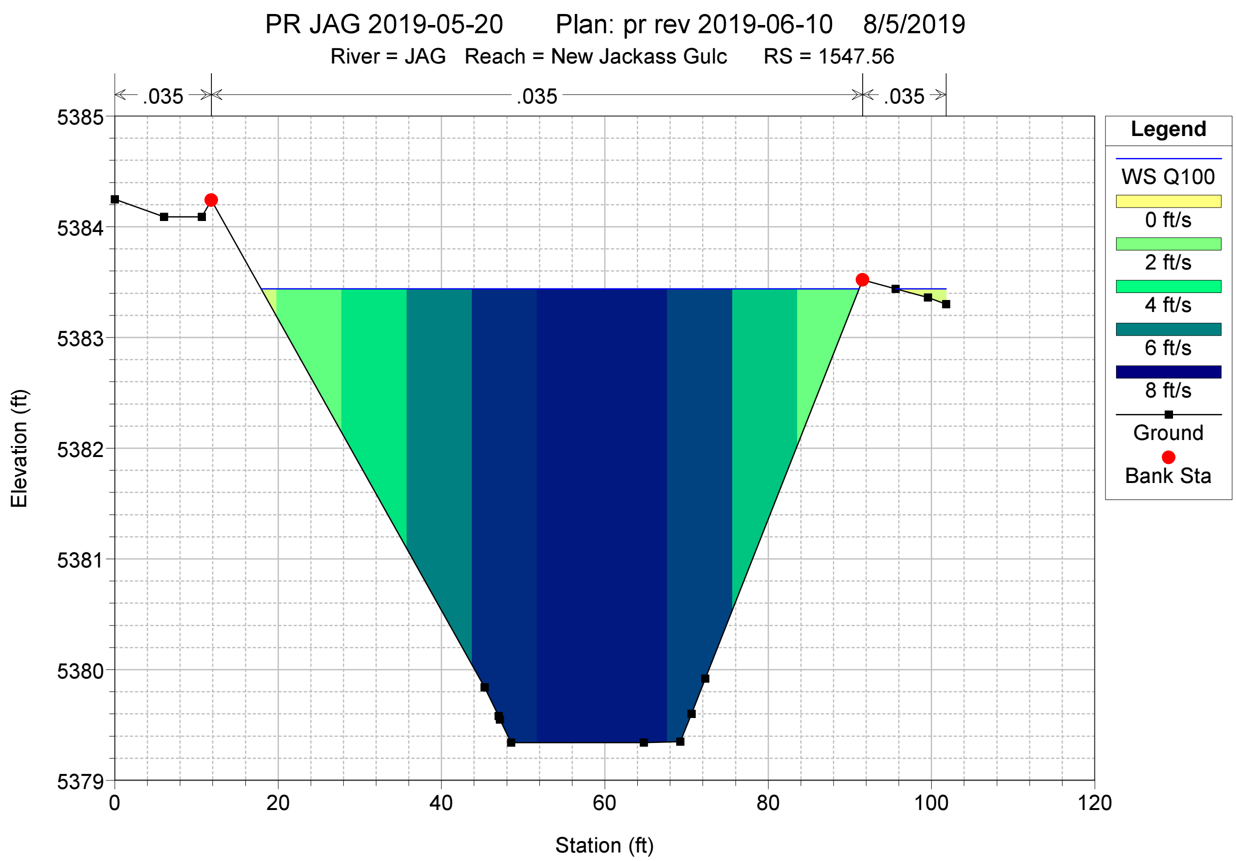
PR JAG 2019-05-20 Plan: Existing 8/5/2019
RS = 49.75 FHAD XS 10
.04
.
0
3
.04
Legend
EG Q100
Crit Q100
WS Q100
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Elevation (ft)
5362
5360
5358
5356
5354
5352
5350
5348
5346
0
100
200
300
400
500
600
700
800
Station (ft)

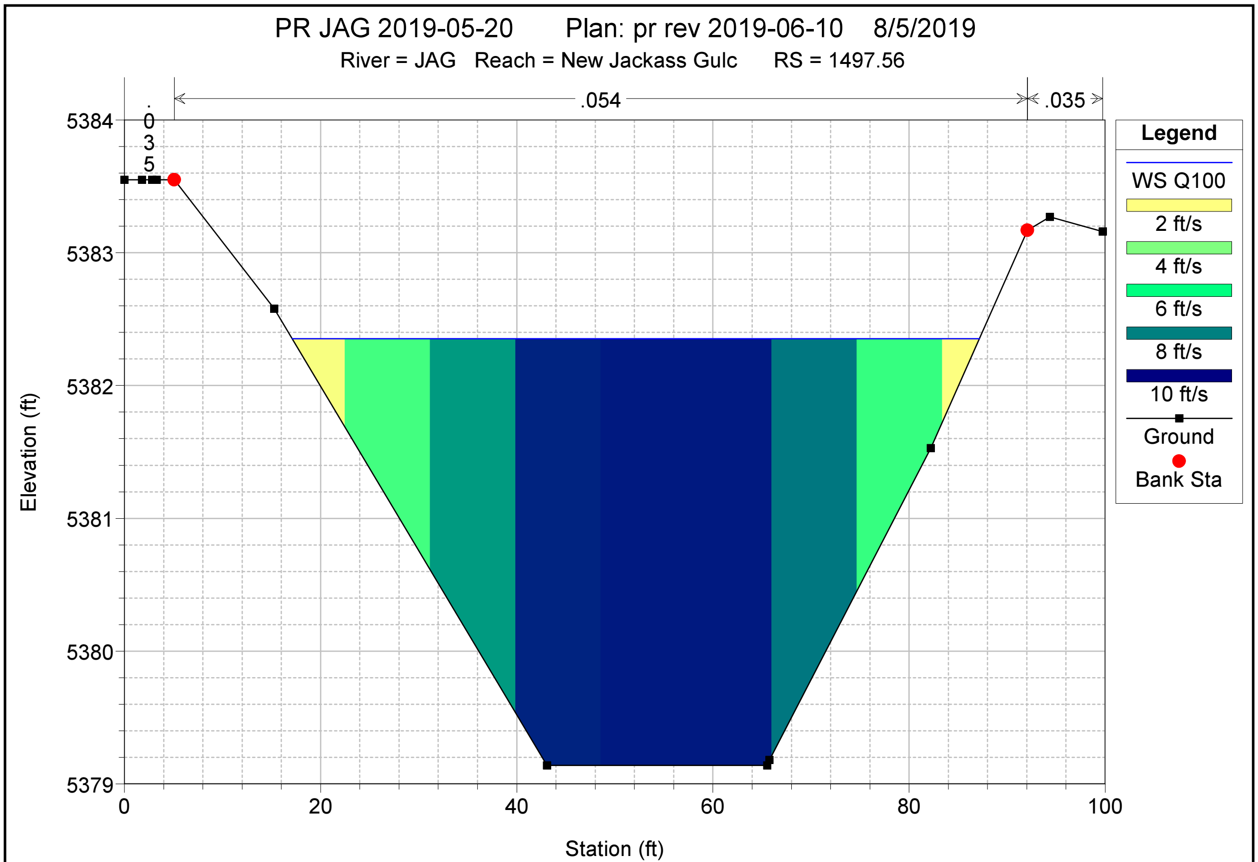
HEC-RAS Plan: 061019 River: JAG Reach: New Jackass Gulc Profile: Q100

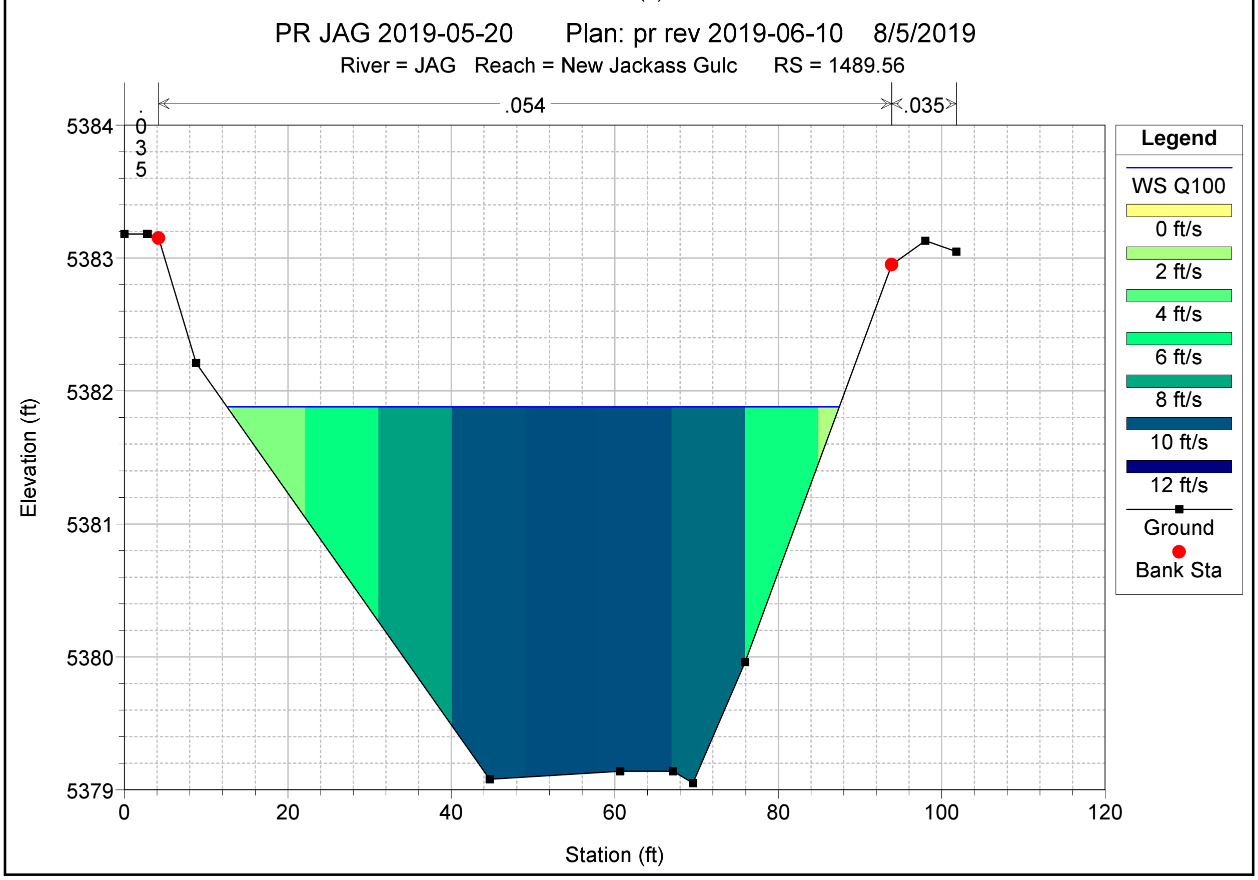
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
New Jackass Gulc	1713.21	Q100	1240.00	5379.98	5384.57	5382.78	5384.63	0.000865	2.09	593.10	273.11	0.25
New Jackass Gulc	1547.56	Q100	1240.00	5379.34	5383.84		5384.32	0.004217	5.56	226.13	86.94	0.58
New Jackass Gulc	1497.56	Q100	1240.00	5379.14	5382.35	5382.35	5383.42	0.033315	8.29	149.54	70.06	1.00
New Jackass Gulc	1489.56	Q100	1240.00	5379.05	5381.88	5382.07	5383.10	0.045399	8.87	139.86	74.87	1.14
New Jackass Gulc	1469.58	Q100	1240.00	5374.14	5379.67	5377.80	5380.06	0.006108	5.05	245.68	66.95	0.46
New Jackass Gulc	1445.57	Q100	1240.00	5374.14	5379.50		5379.90	0.006337	5.03	246.34	69.27	0.47
New Jackass Gulc	1444.57	Q100	1240.00	5374.14	5379.43		5379.89	0.007920	5.41	229.24	68.43	0.52
New Jackass Gulc	1423.02	Q100	1240.00	5374.13	5379.35	5377.20	5379.73	0.002124	4.90	252.83	61.52	0.43
New Jackass Gulc	1323.81		Culvert									
New Jackass Gulc	1235.5	Q100	1240.00	5373.23	5375.96	5376.22	5377.75	0.019454	10.73	115.56	61.74	1.15
New Jackass Gulc	1225.5	Q100	1240.00	5373.14	5376.35	5376.07	5377.17	0.022335	7.23	171.61	75.13	0.84
New Jackass Gulc	1217.5	Q100	1240.00	5373.01	5375.86	5375.86	5376.93	0.032649	8.30	149.45	70.75	1.01
New Jackass Gulc	1214.09	Q100	1240.00	5372.19	5374.76	5375.31	5376.69	0.072841	11.14	111.29	61.77	1.46
New Jackass Gulc	1197.5	Q100	1240.00	5368.14	5373.70	5372.21	5374.20	0.008296	5.67	218.62	64.70	0.54
New Jackass Gulc	1173.5	Q100	1240.00	5368.14	5373.41		5373.97	0.010075	6.00	206.77	65.05	0.59
New Jackass Gulc	1172.4	Q100	1240.00	5368.14	5373.22		5373.94	0.014859	6.80	182.22	63.42	0.71
New Jackass Gulc	1099.83	Q100	1240.00	5368.09	5371.71	5371.71	5372.84	0.014034	8.50	145.84	65.72	1.01
New Jackass Gulc	1028.2	Q100	1240.00	5367.05	5370.60	5370.66	5371.76	0.014990	8.65	143.36	66.18	1.04
New Jackass Gulc	955.56	Q100	1240.00	5366.00	5369.73	5369.40	5370.49	0.021595	6.99	177.35	79.78	0.83
New Jackass Gulc	947.56	Q100	1240.00	5365.98	5369.22	5369.22	5370.25	0.035032	8.12	152.79	74.78	1.00
New Jackass Gulc	927.56	Q100	1240.00	5361.00	5363.75	5365.18	5368.53	0.178406	17.53	70.74	36.46	2.22
New Jackass Gulc	907.98	Q100	1240.00	5361.00	5366.27	5365.15	5366.85	0.011665	6.11	203.07	65.98	0.61
New Jackass Gulc	902	Q100	1240.00	5361.97	5365.59	5365.59	5366.72	0.014056	8.54	145.20	65.18	1.01
New Jackass Gulc	703.45	Q100	1500.00	5359.78	5360.20	5360.39	5360.83	0.070471	6.36	236.16	558.90	1.72
New Jackass Gulc	49.75	Q100	1500.00	5347.66	5351.59	5351.52	5352.63	0.010005	9.80	200.81	97.33	1.02

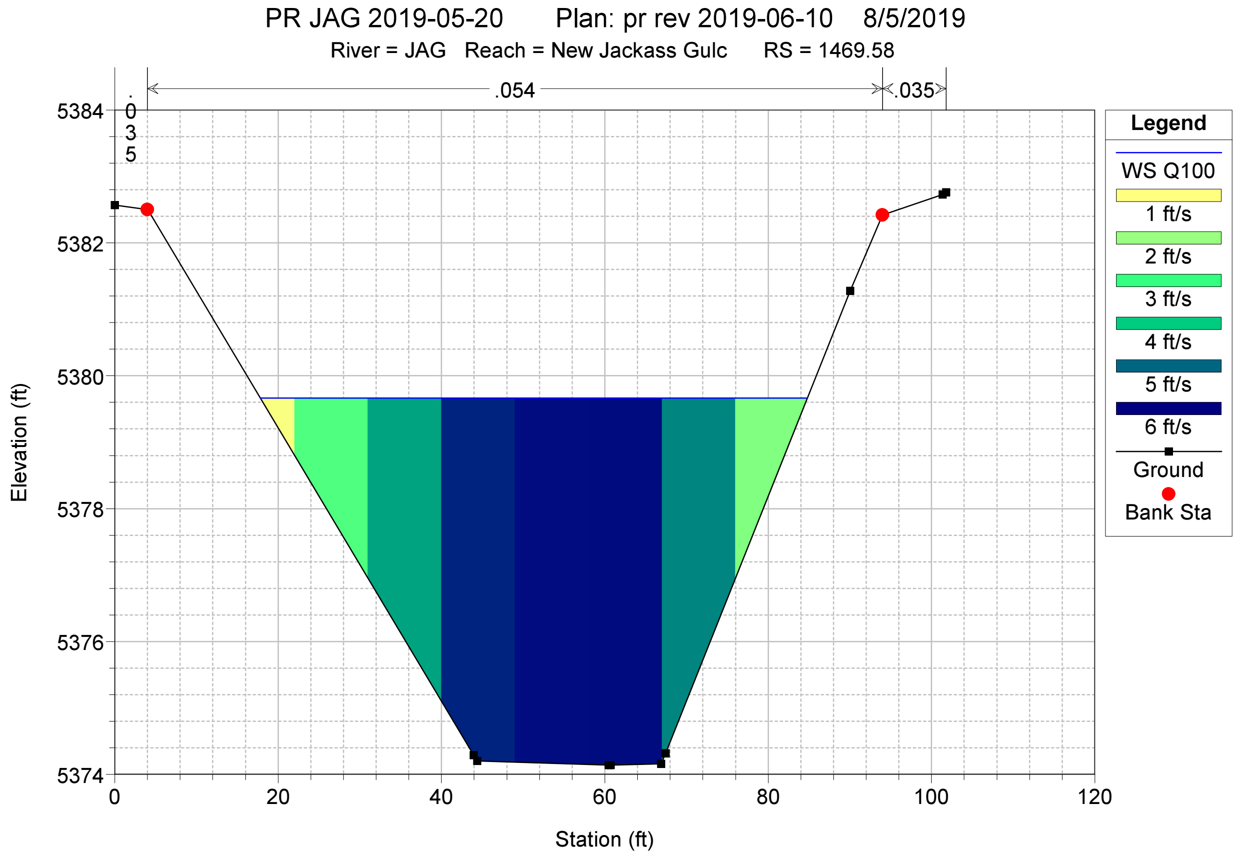

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
JAG New Jackass Gulc
Legend
WS Q100
Ground
Elevation (ft)
Main Channel Distance (ft)
5345
5350
5355
5360
5365
5370
5375
5380
5385
0
200
400
600
800
1000
1200
1400
1600
1800


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1713.21 FHAD XS 50
.035
.035
.035
Legend
WS Q100
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
3.5 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
5375
5380
5385
5390
5395
5400
5405
0
200
400
600
800
1000
1200
1400
1600

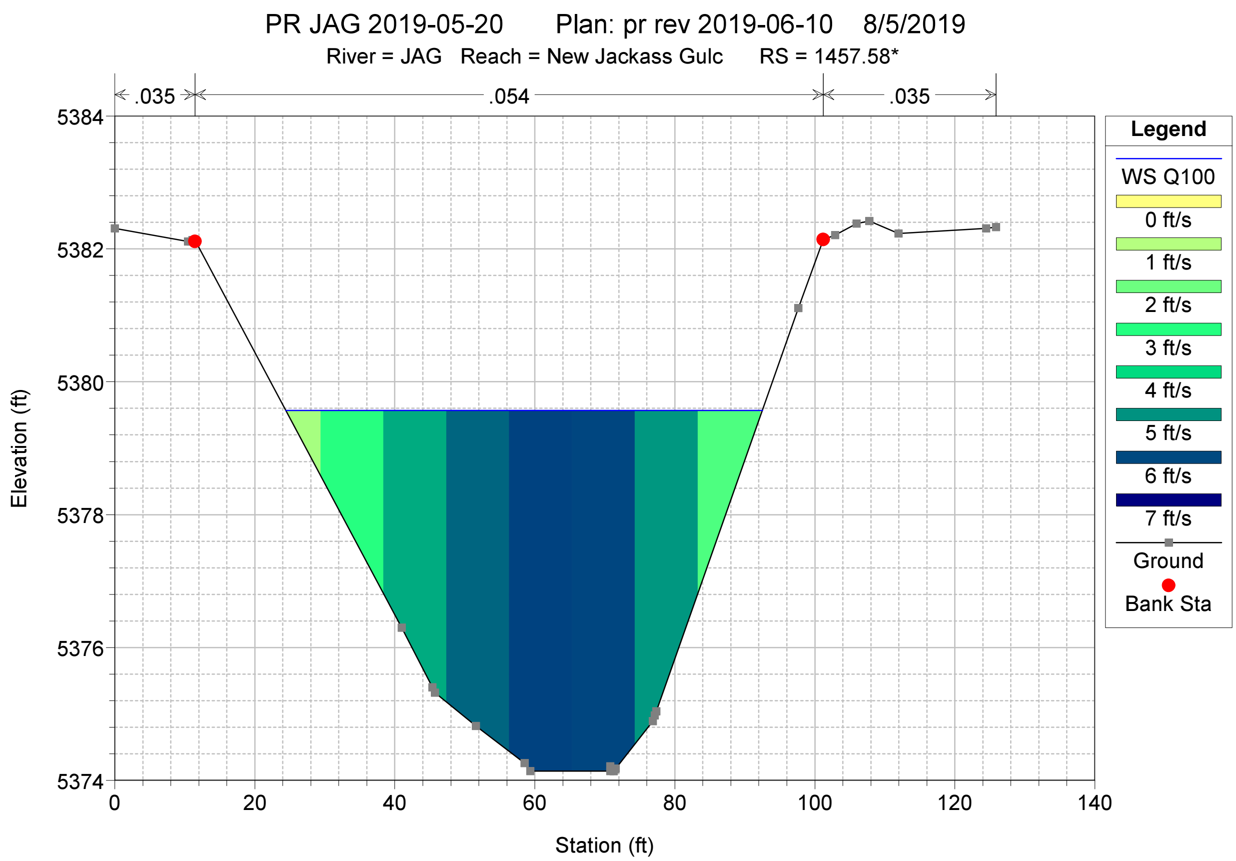

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1547.56
.035
.035
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
5379
5380
5381
5382
5383
5384
5385
0
20
40
60
80
100
120


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1497.56
.054
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta

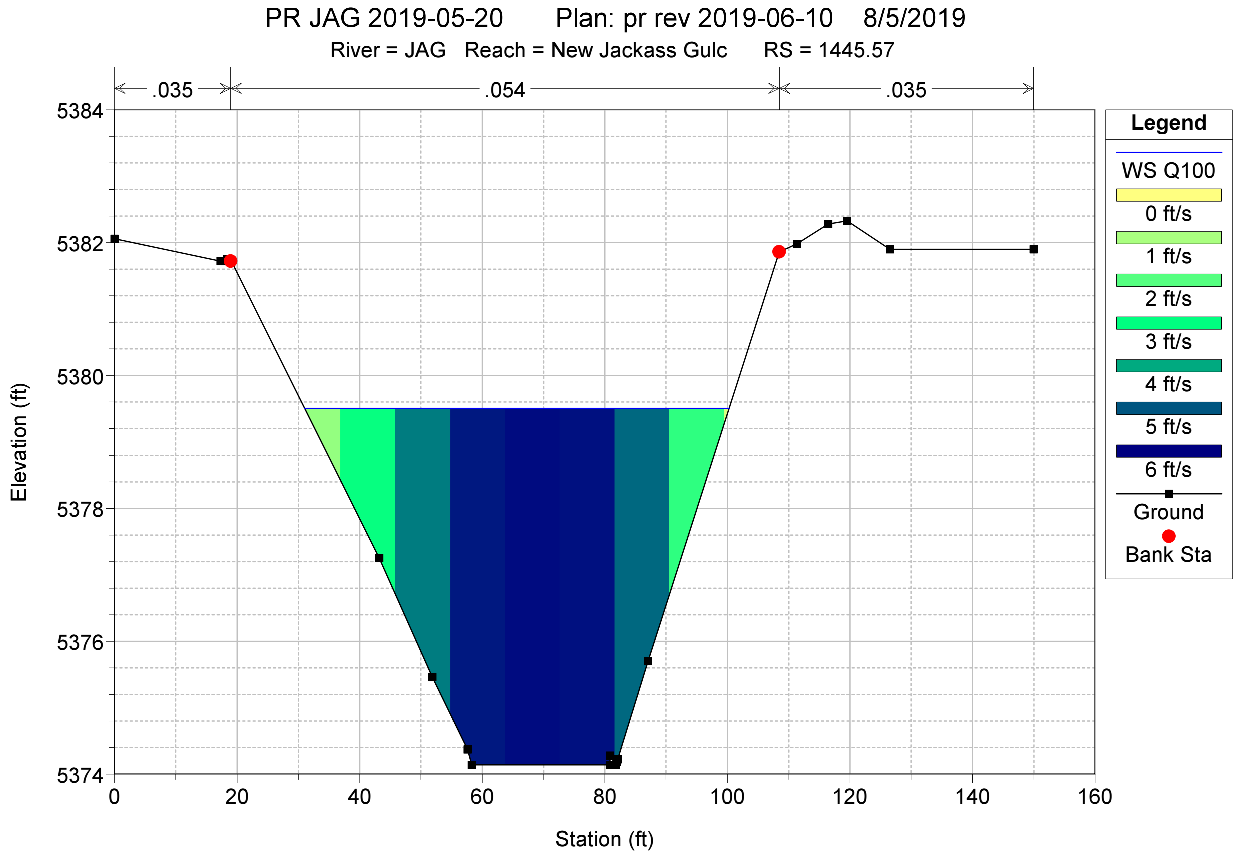

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1489.56
.054
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta



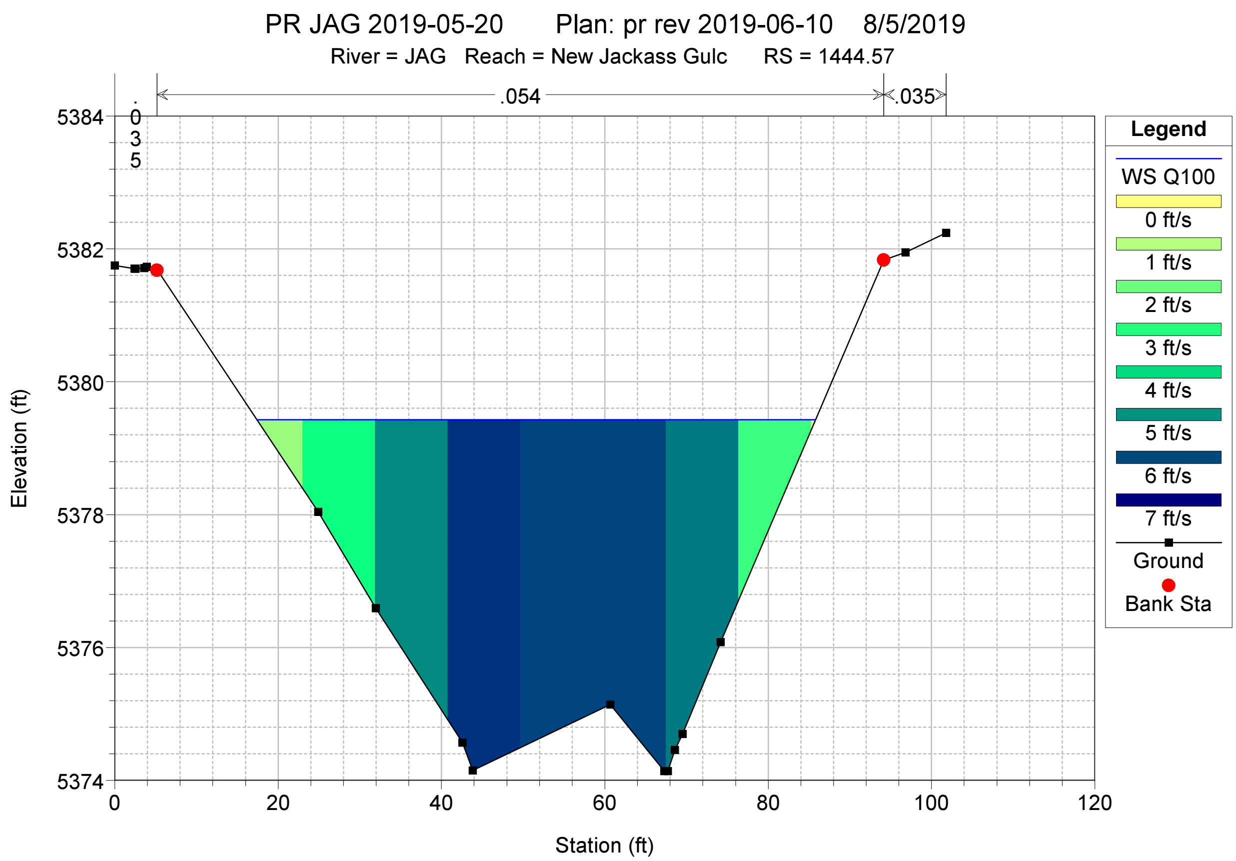
PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1469.58
.035
.054
.035
Legend
WS Q100
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)



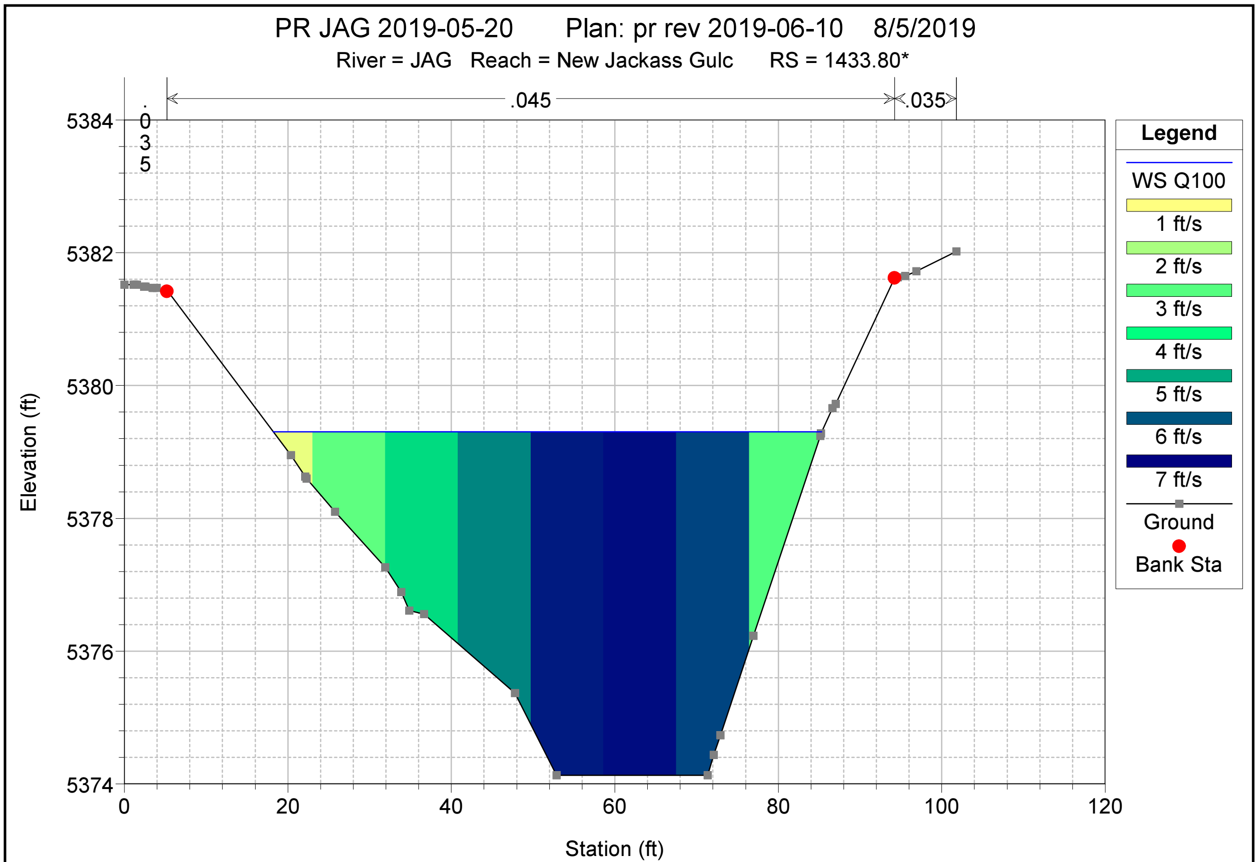
PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1457.58*
.035
.054
.035
Legend
WS Q100
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)

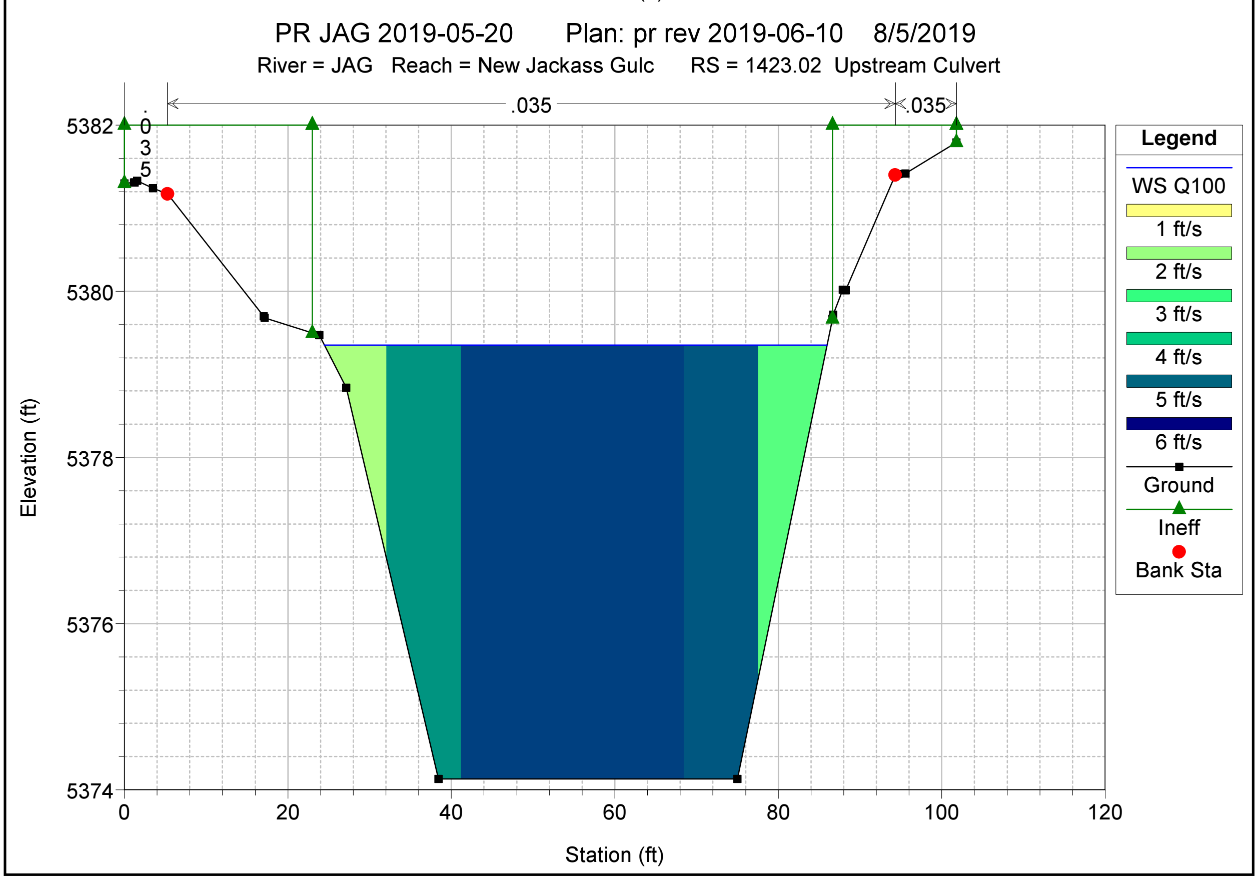


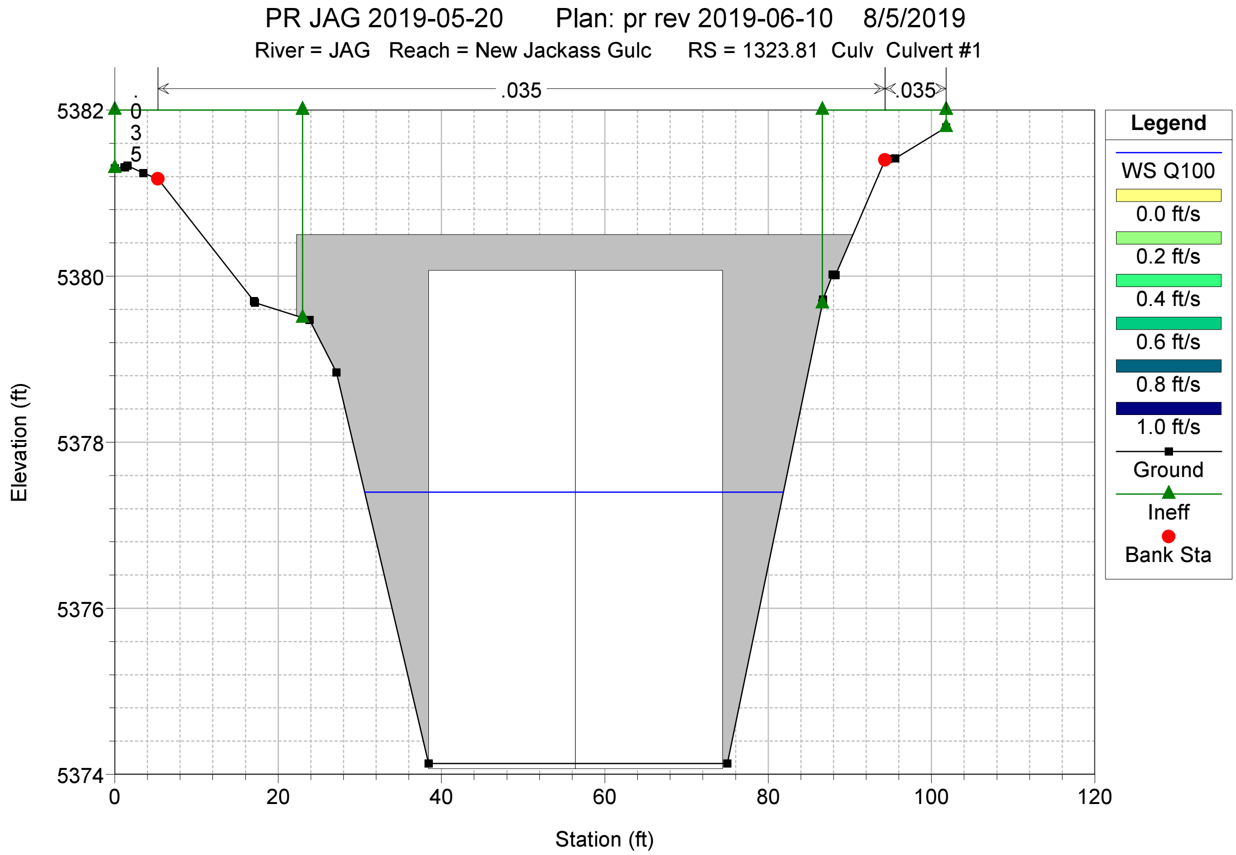
PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1445.57
.035
.054
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta

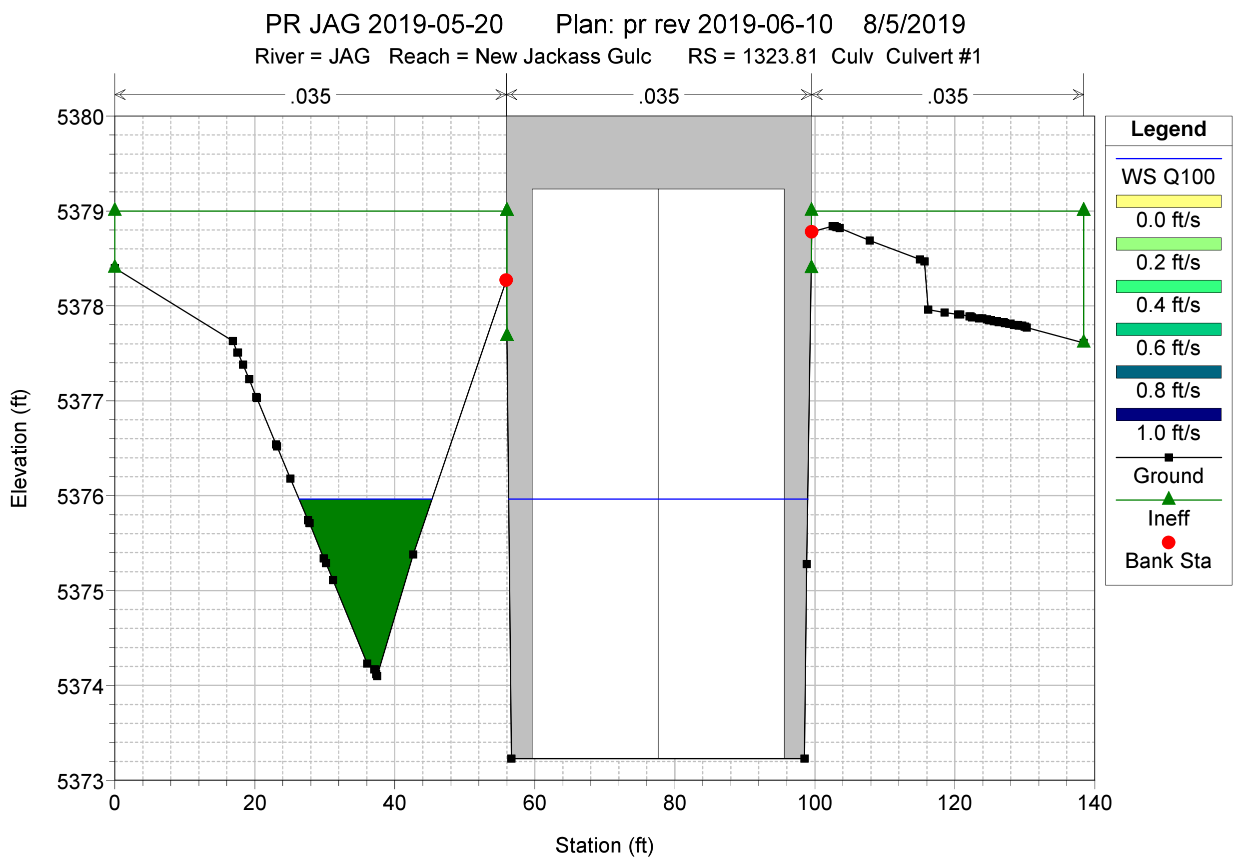


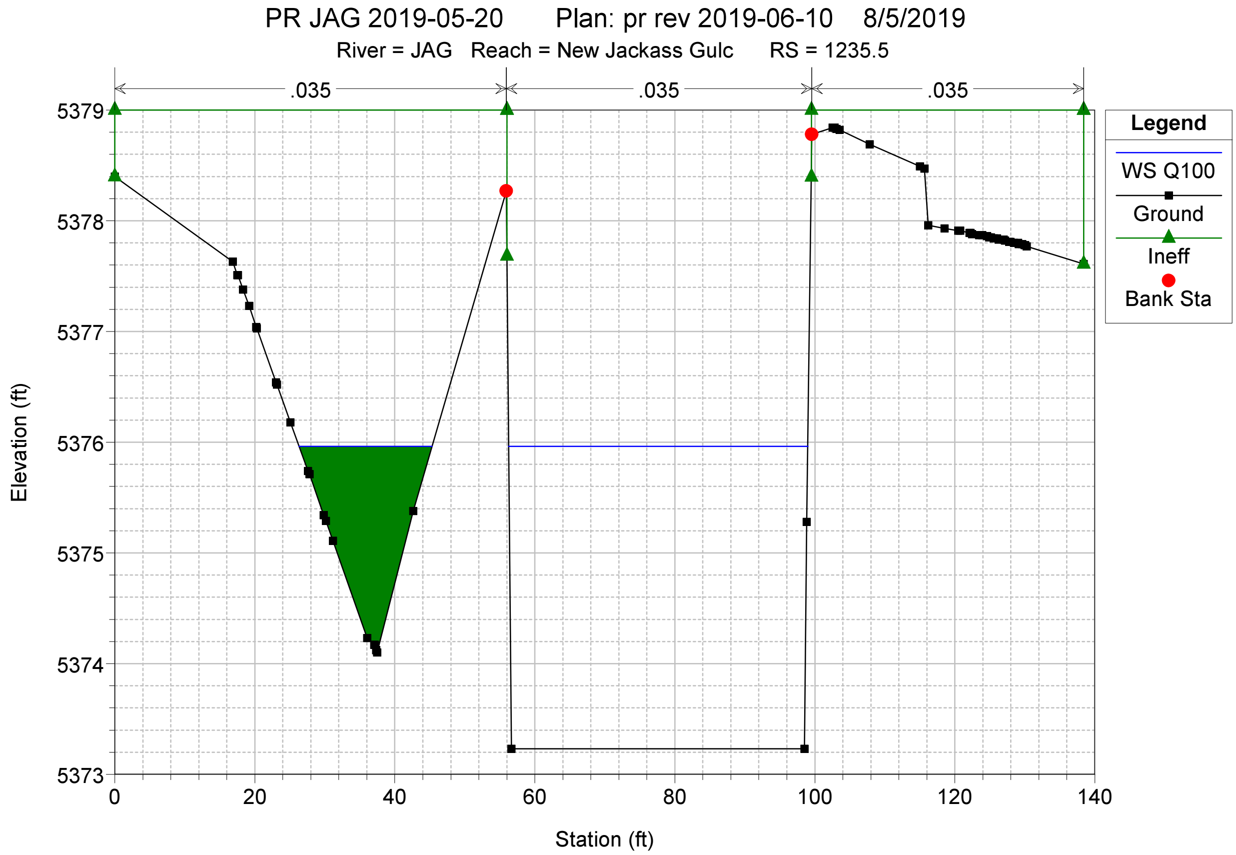
PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1444.57
.035
.054
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta

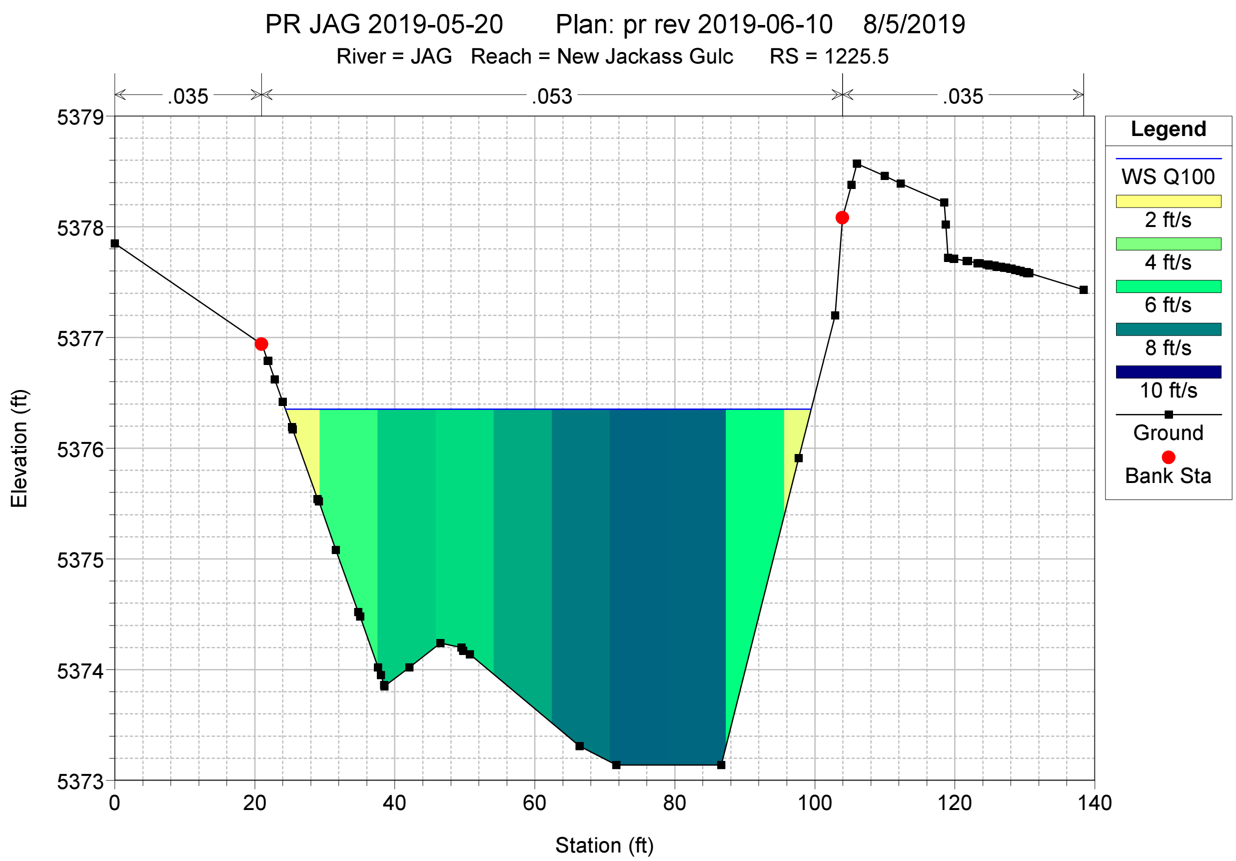

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1433.80*
.045
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta

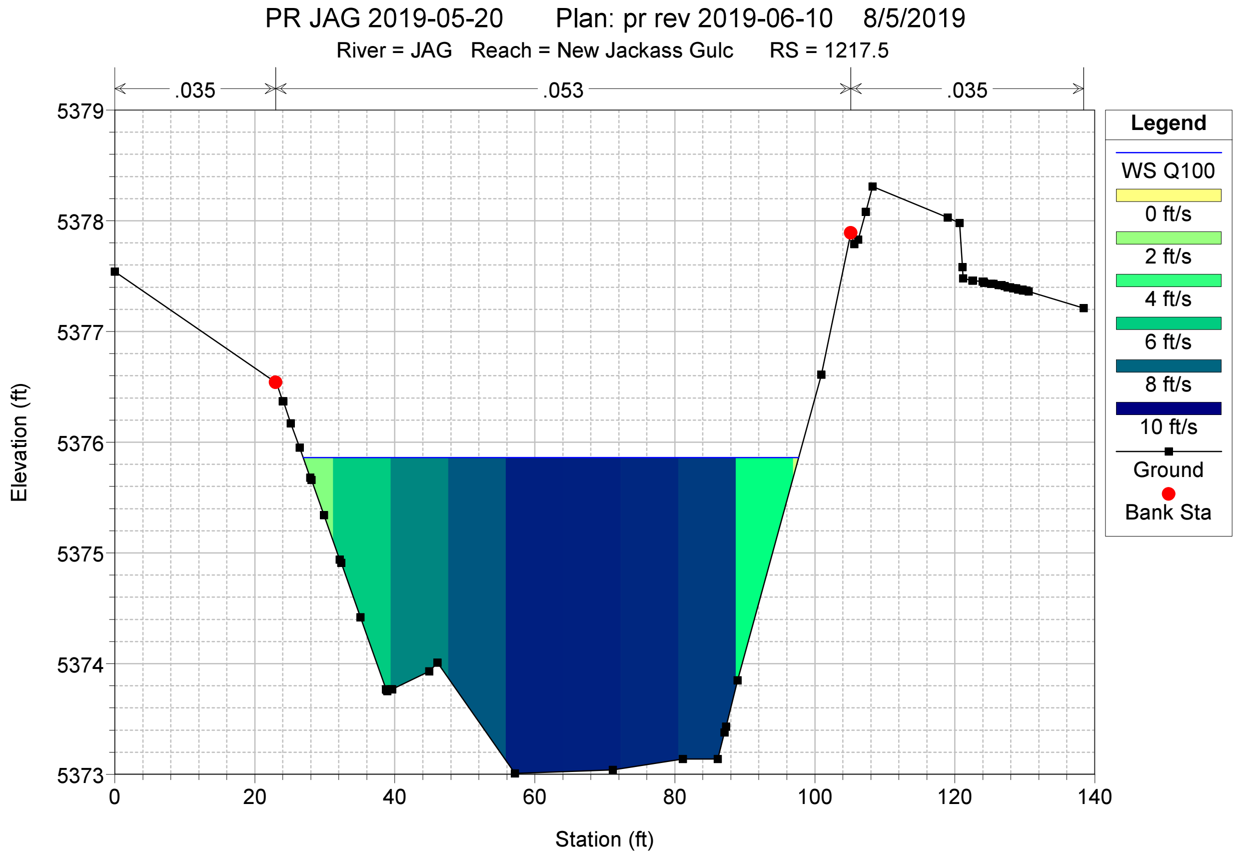

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1423.02 Upstream Culvert
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

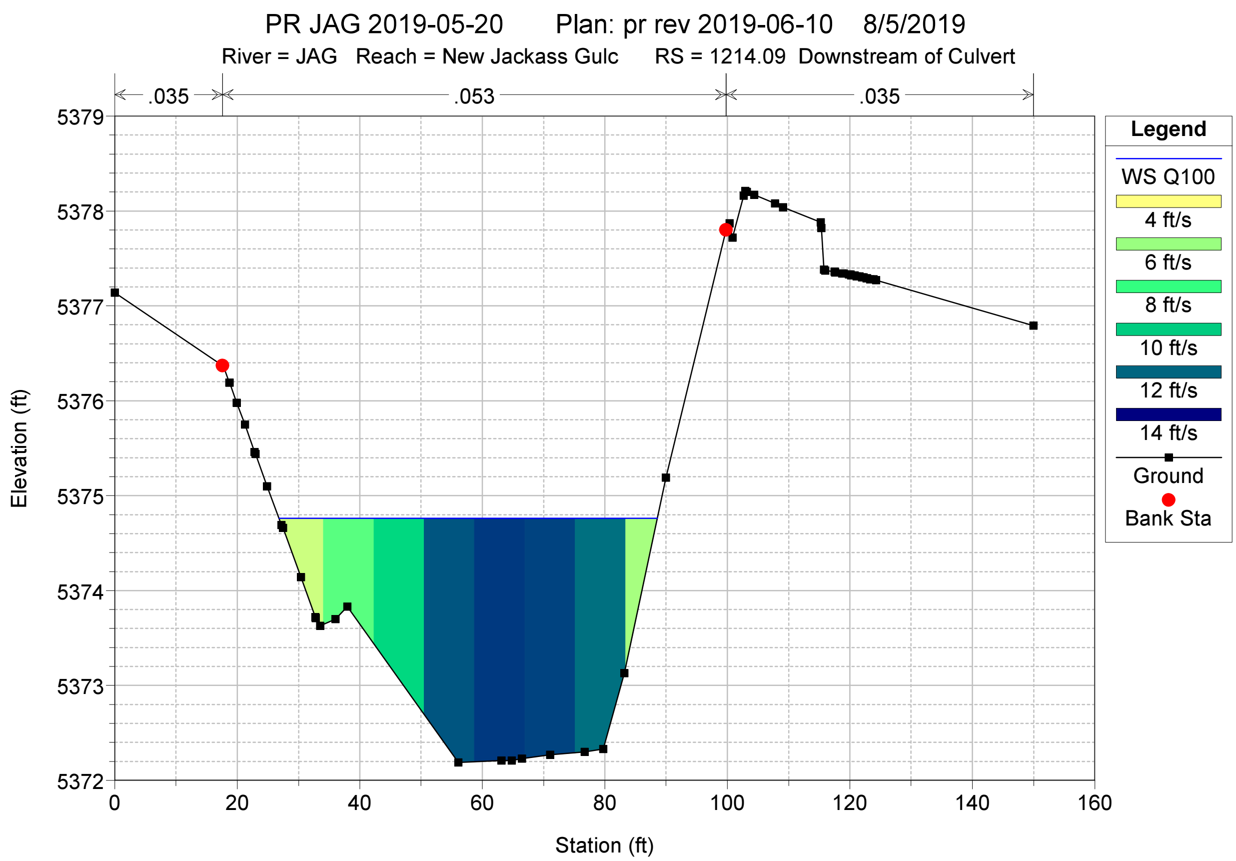

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1323.81 Culv Culvert #1
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Ineff
Bank Sta

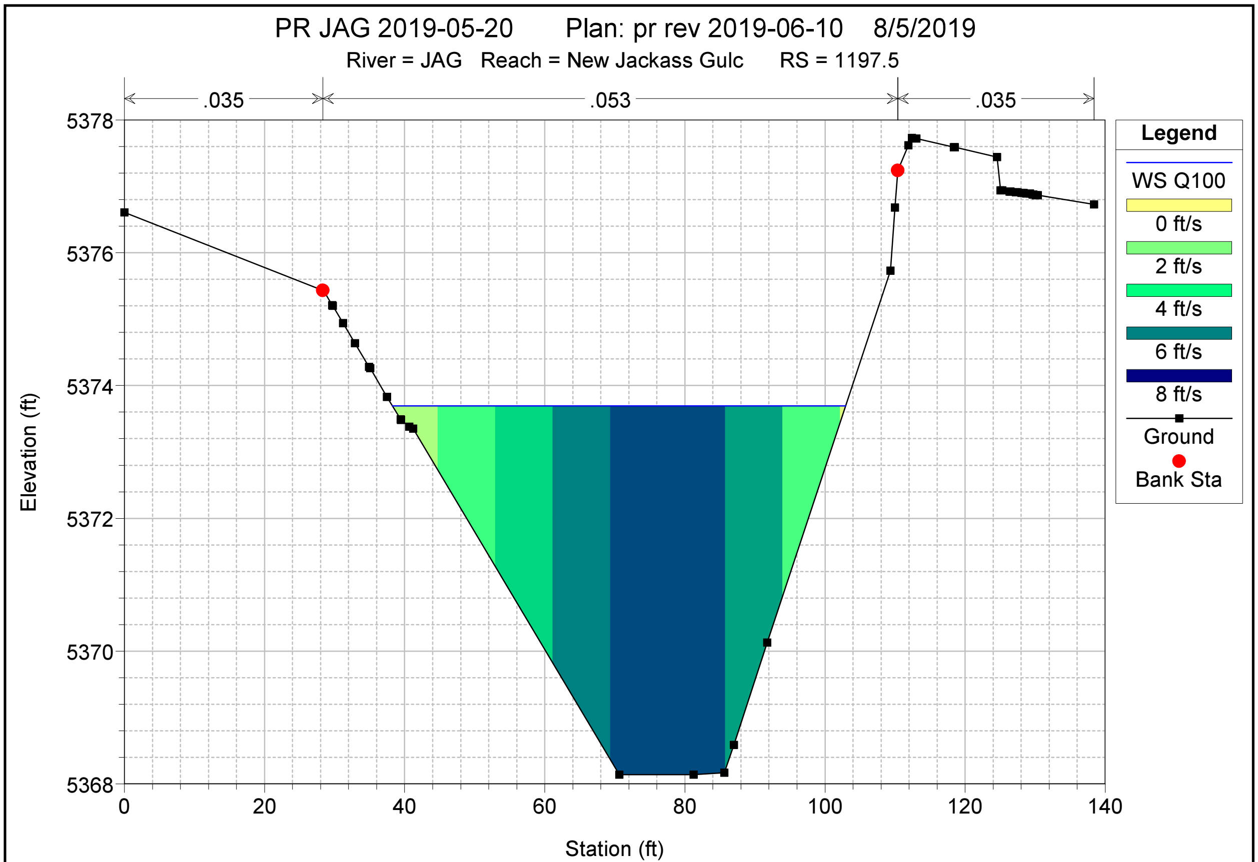

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1323.81 Culv Culvert #1
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Ineff
Bank Sta

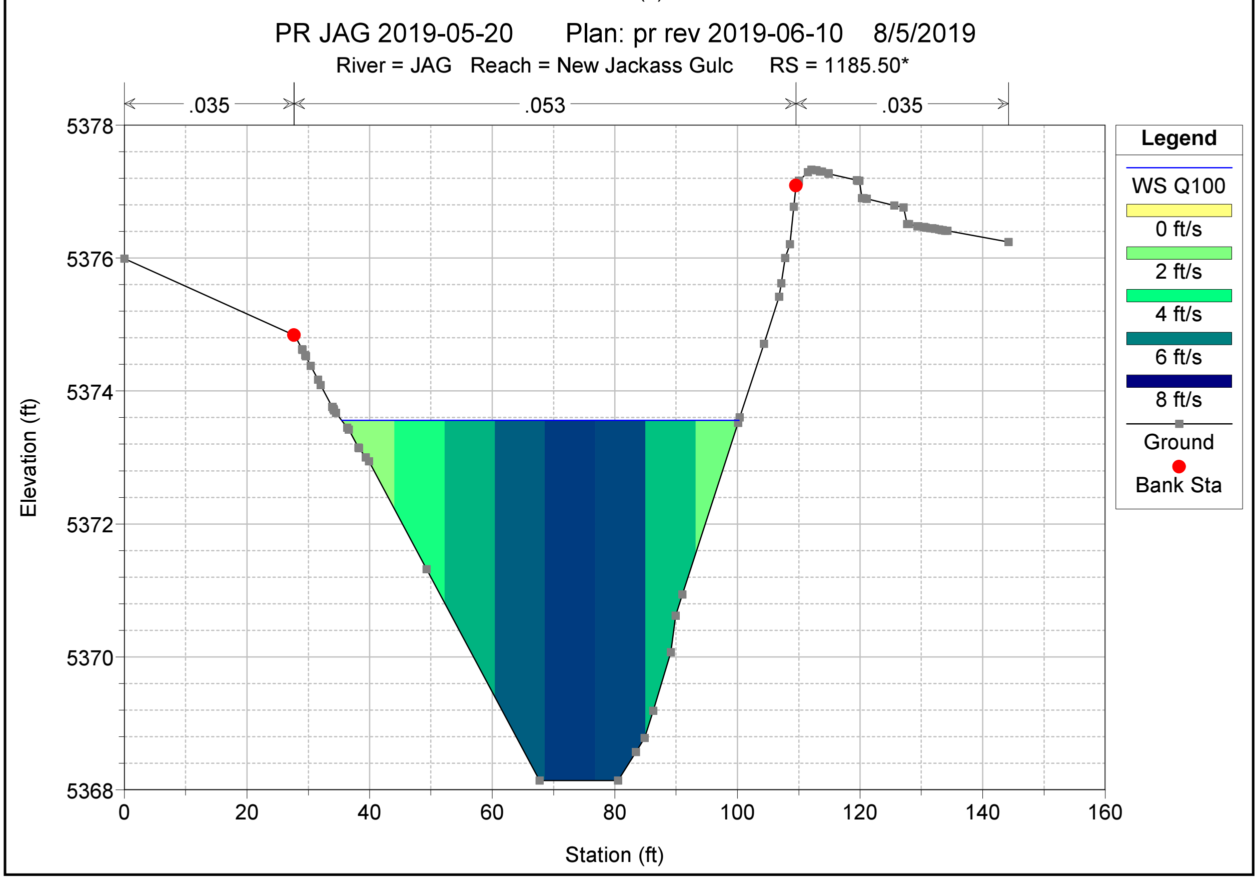

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1235.5
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
Ground
Ineff
Bank Sta

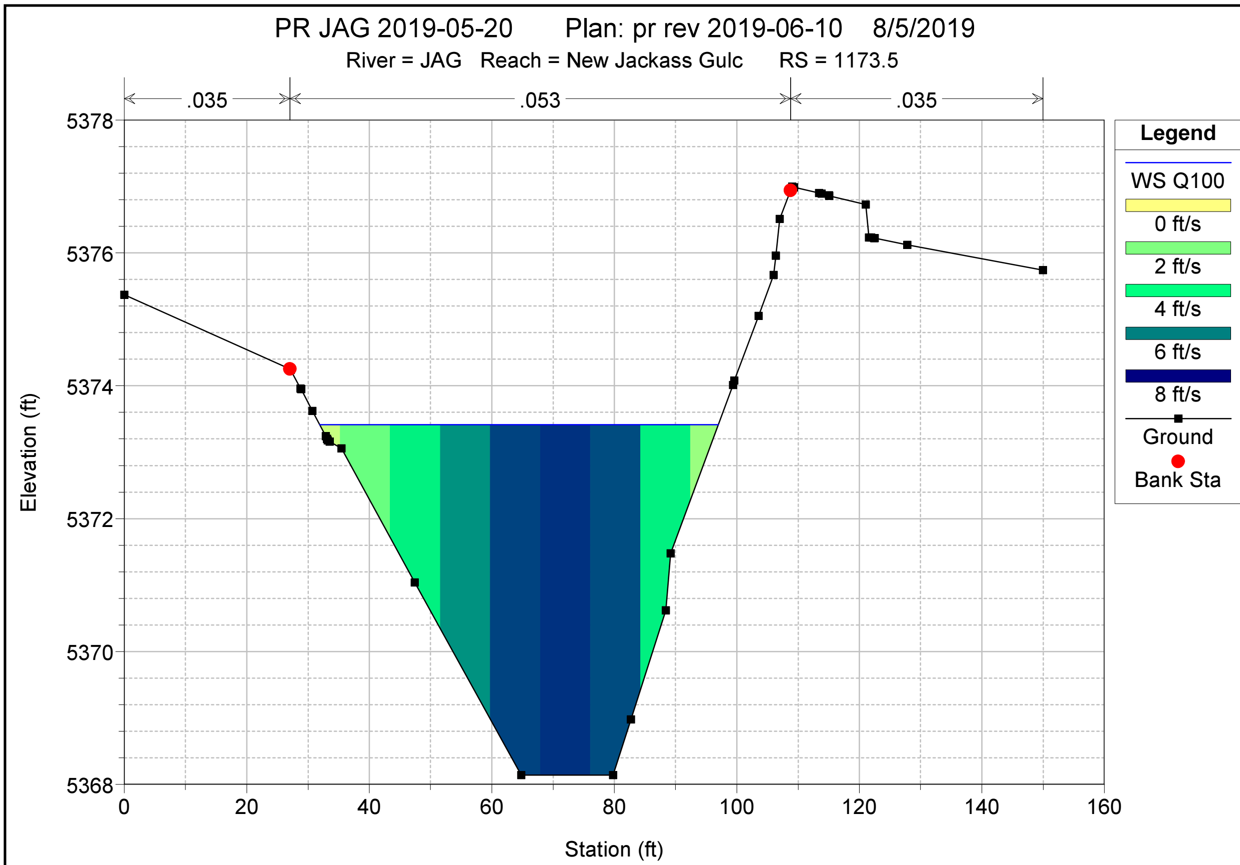

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1225.5
.035
.053
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta

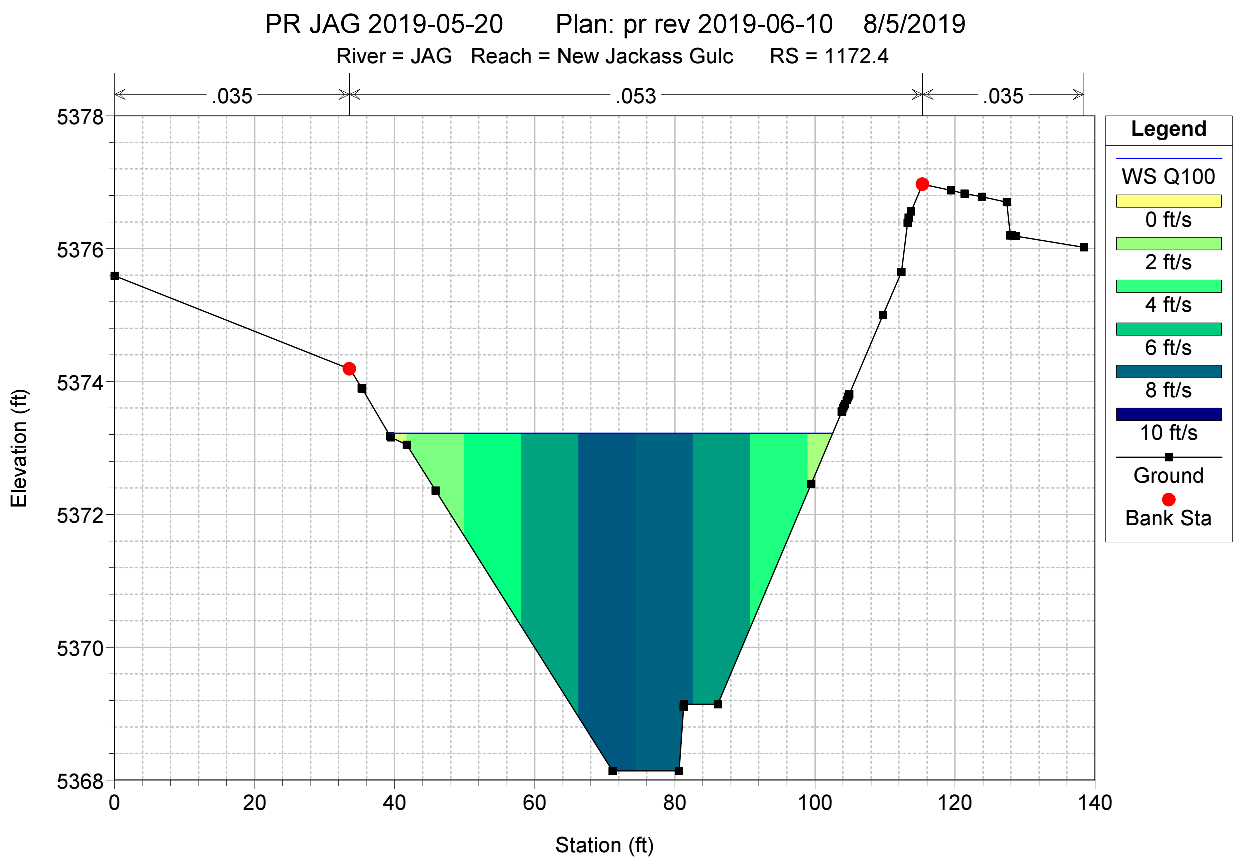

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1217.5
.035
.053
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
5373
5374
5375
5376
5377
5378
5379
0
20
40
60
80
100
120
140

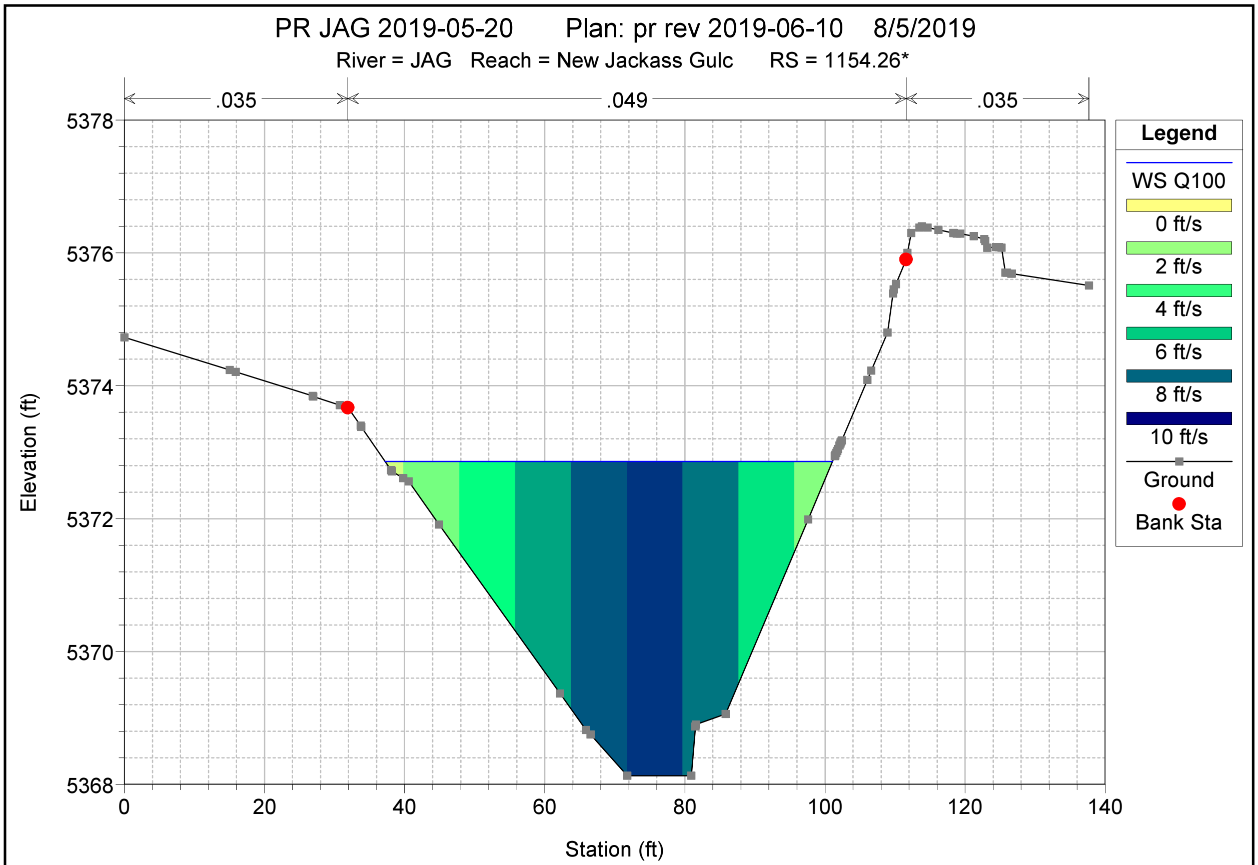

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1214.09 Downstream of Culvert
.035
.053
.035
Legend
WS Q100
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
5372
5373
5374
5375
5376
5377
5378
5379
0
20
40
60
80
100
120
140
160

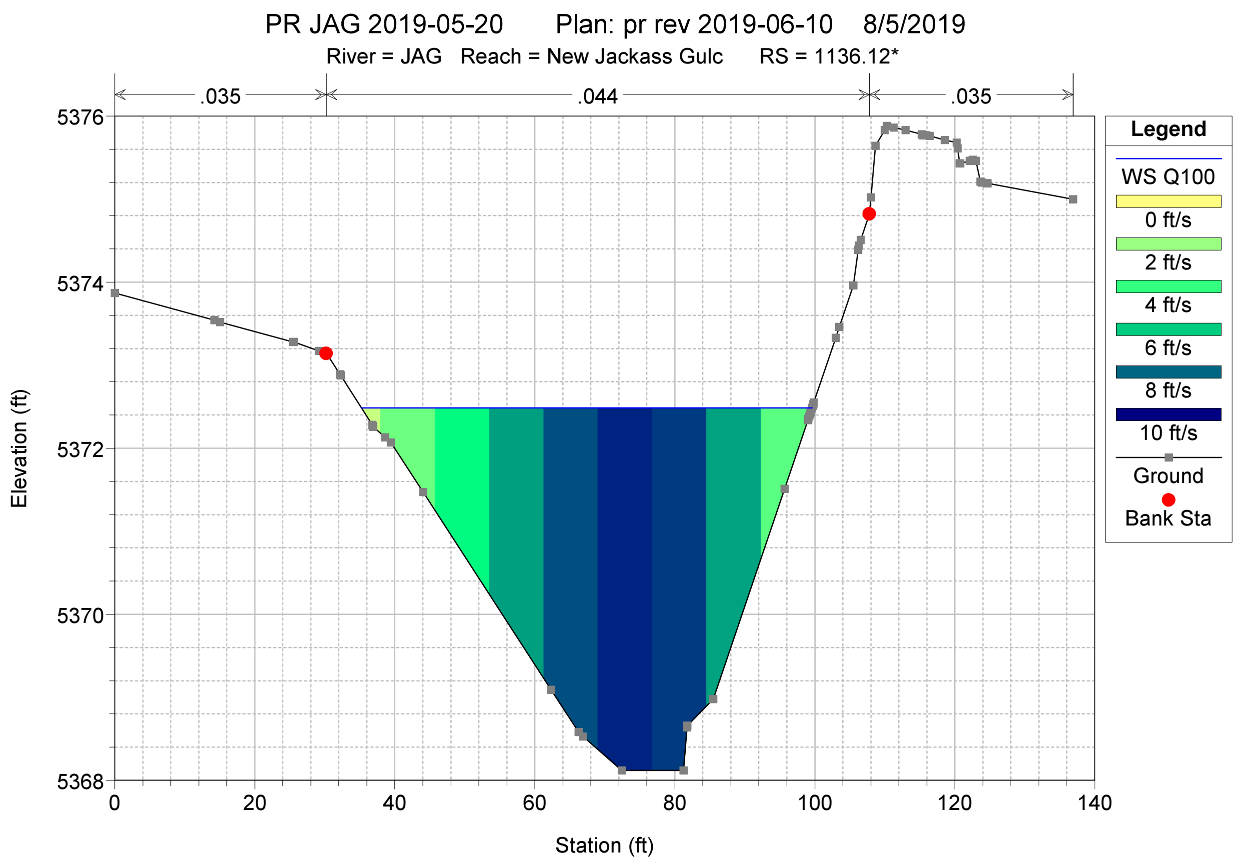

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1197.5
.035
.053
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Bank Sta

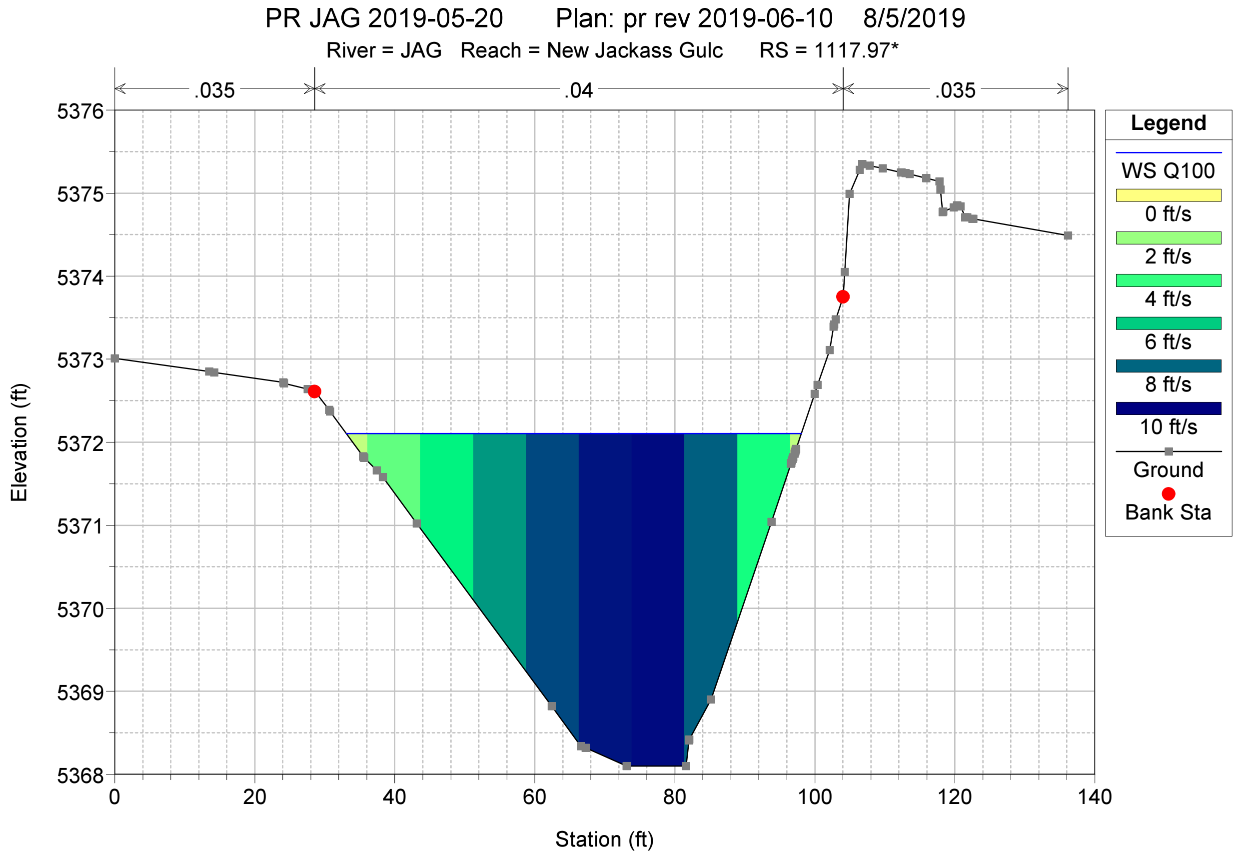

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1185.50*
.035
.053
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Bank Sta

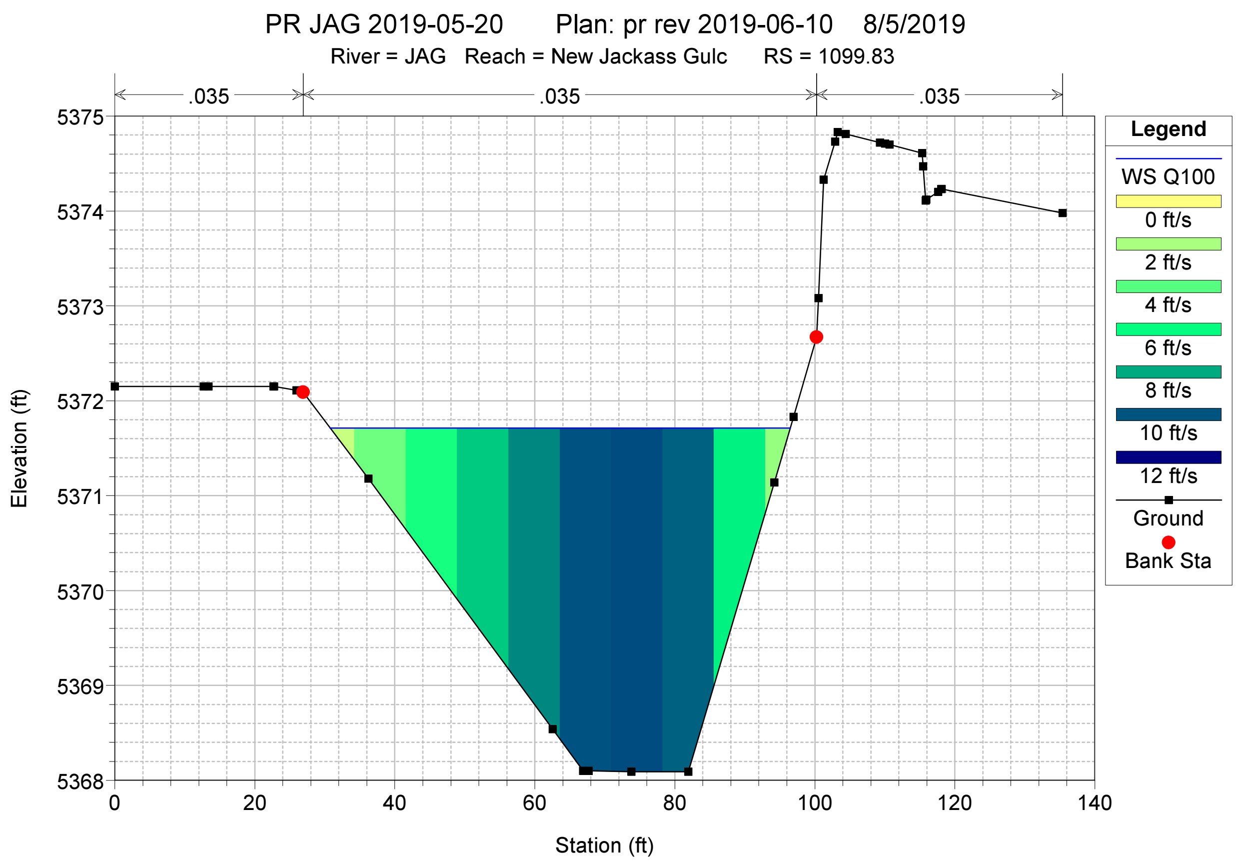

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1173.5
.035
.053
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)

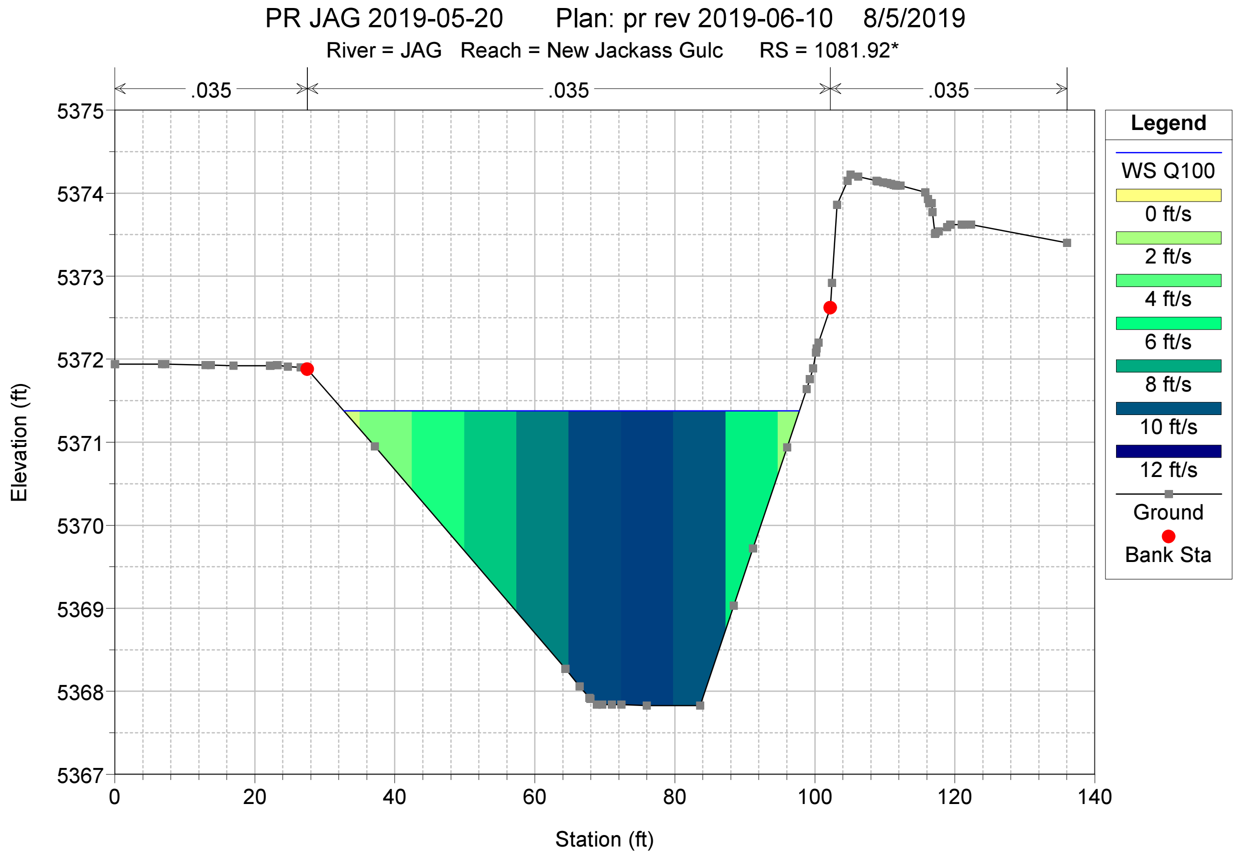

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1172.4
.035
.053
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)

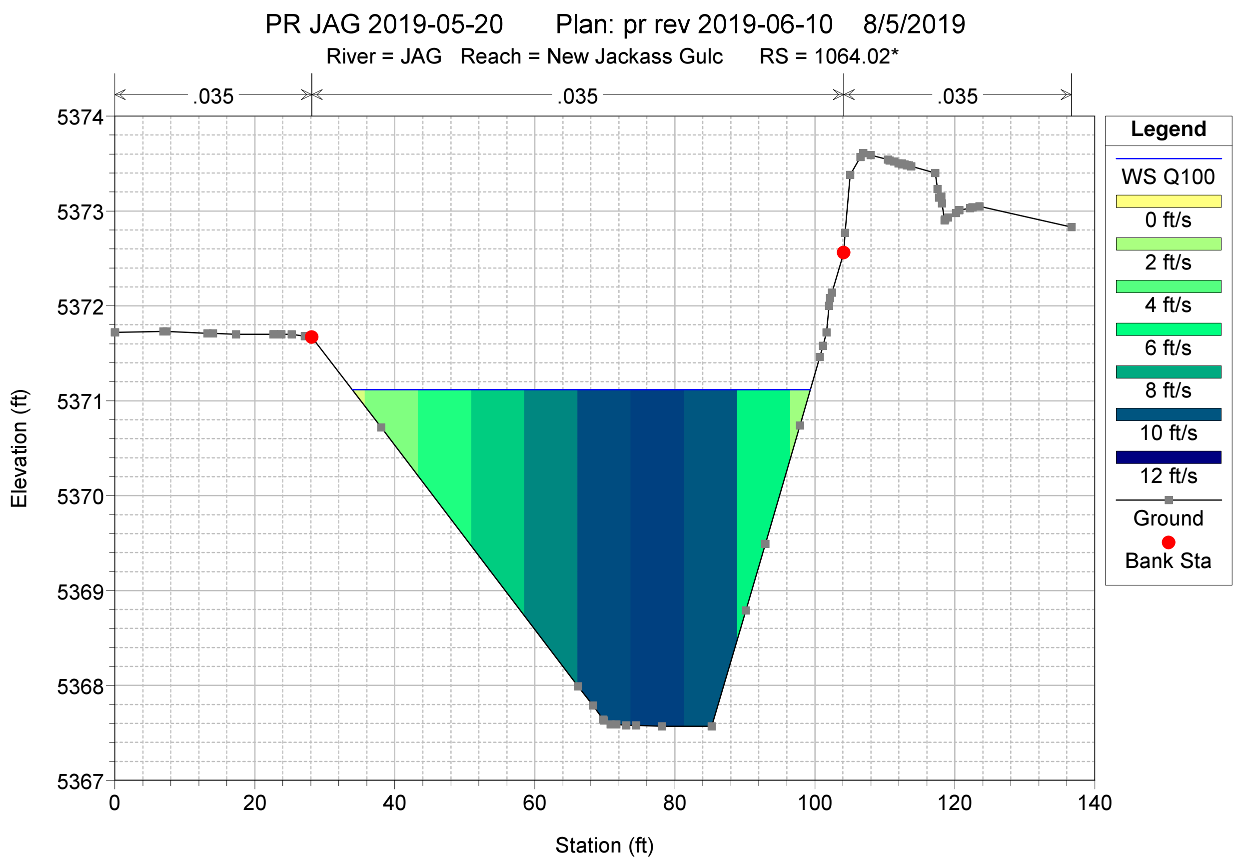

PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1154.26*
.035
.049
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta
Elevation (ft)
5378
5376
5374
5372
5370
5368
0
20
40
60
80
100
120
140
Station (ft)


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1136.12*
.035
.044
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta
Elevation (ft)
5376
5374
5372
5370
5368
0
20
40
60
80
100
120
140
Station (ft)


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1117.97*
.035
.04
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1099.83
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1081.92*
.035
.035
.035
Elevation (ft)
Station (ft)
5367
5368
5369
5370
5371
5372
5373
5374
5375
0
20
40
60
80
100
120
140
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


PR JAG 2019-05-20 Plan: pr rev 2019-06-10 8/5/2019
River = JAG Reach = New Jackass Gulc RS = 1064.02*
.035
.035
.035
Elevation (ft)
Station (ft)
5367
5368
5369
5370
5371
5372
5373
5374
0
20
40
60
80
100
120
140
Legend
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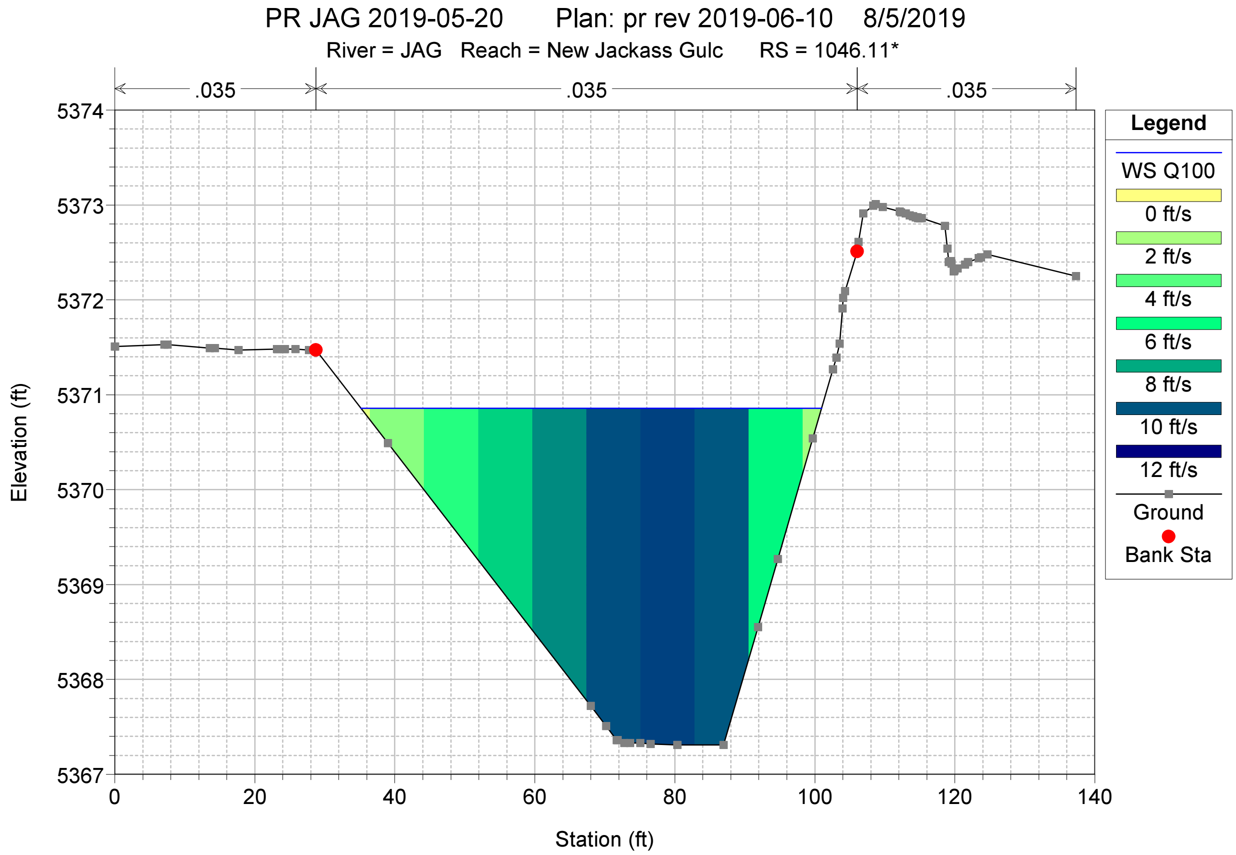
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta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River = JAG Reach = New Jackass Gulc RS = 1046.11*
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Q100
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2 ft/s
4 ft/s
6 ft/s
8 ft/s
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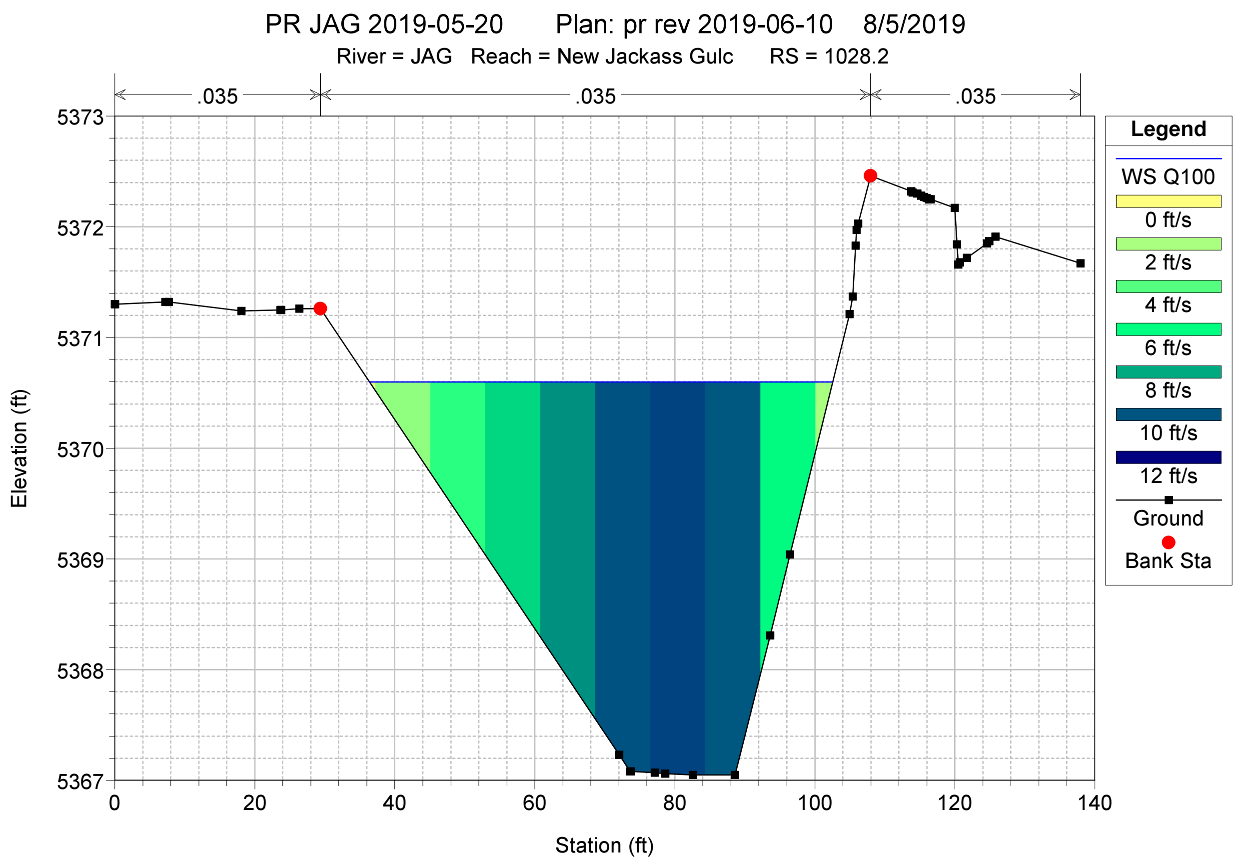
Ground
Bank Sta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Station (ft)
Legend
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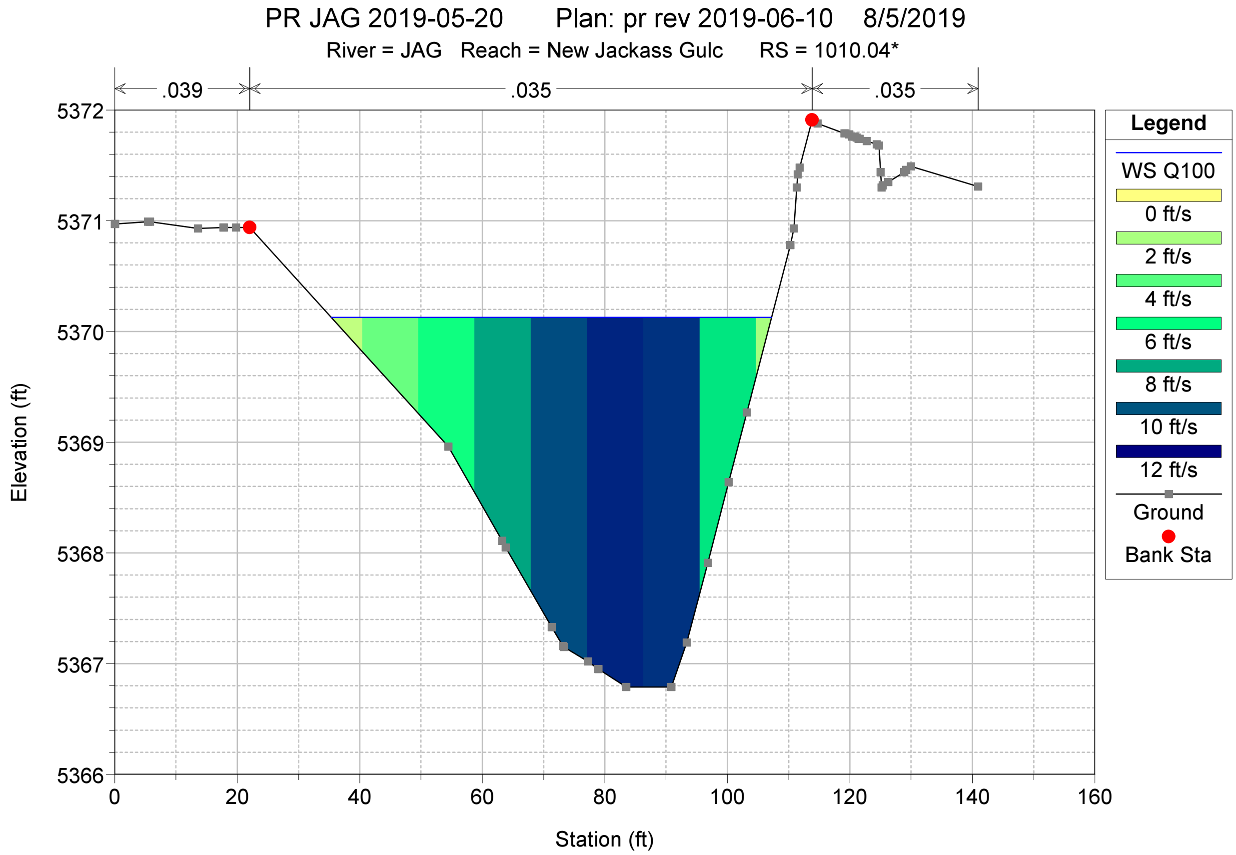
12 ft/s
Ground
Bank Sta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.035
.035
Legend
WS Q100
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
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5367
5368
5369
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5371
5372
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20
40
60
80
100
120
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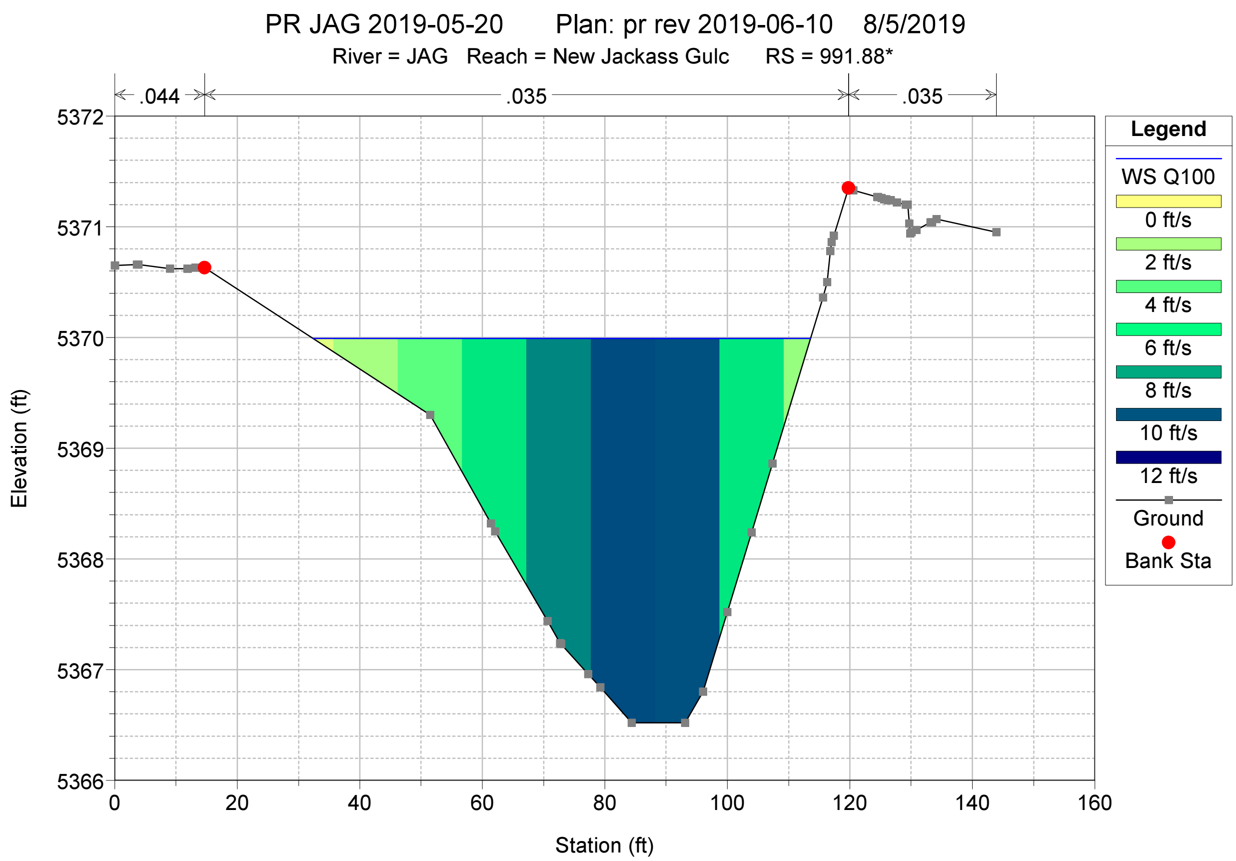
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.035
.035
Legend
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0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
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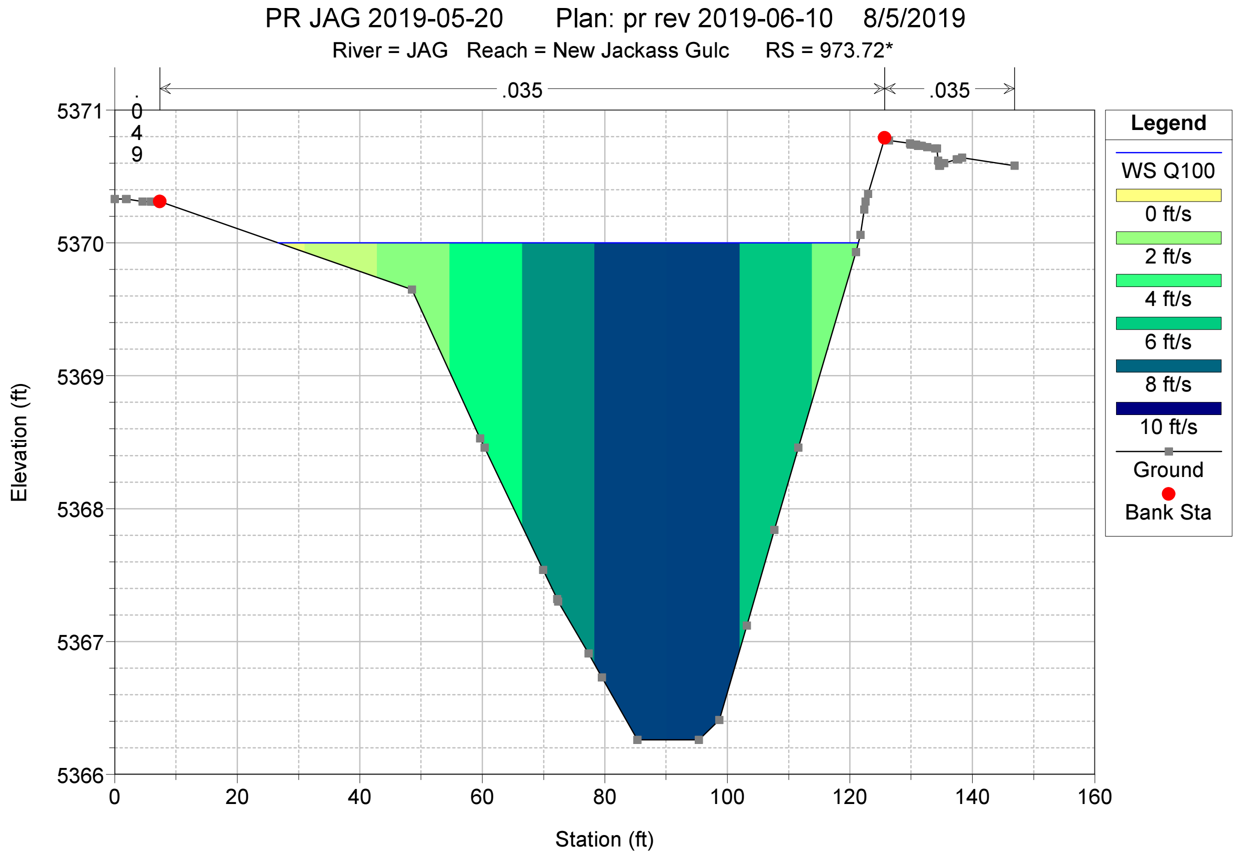
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.035
.049
Elevation (ft)
Station (ft)
Legend
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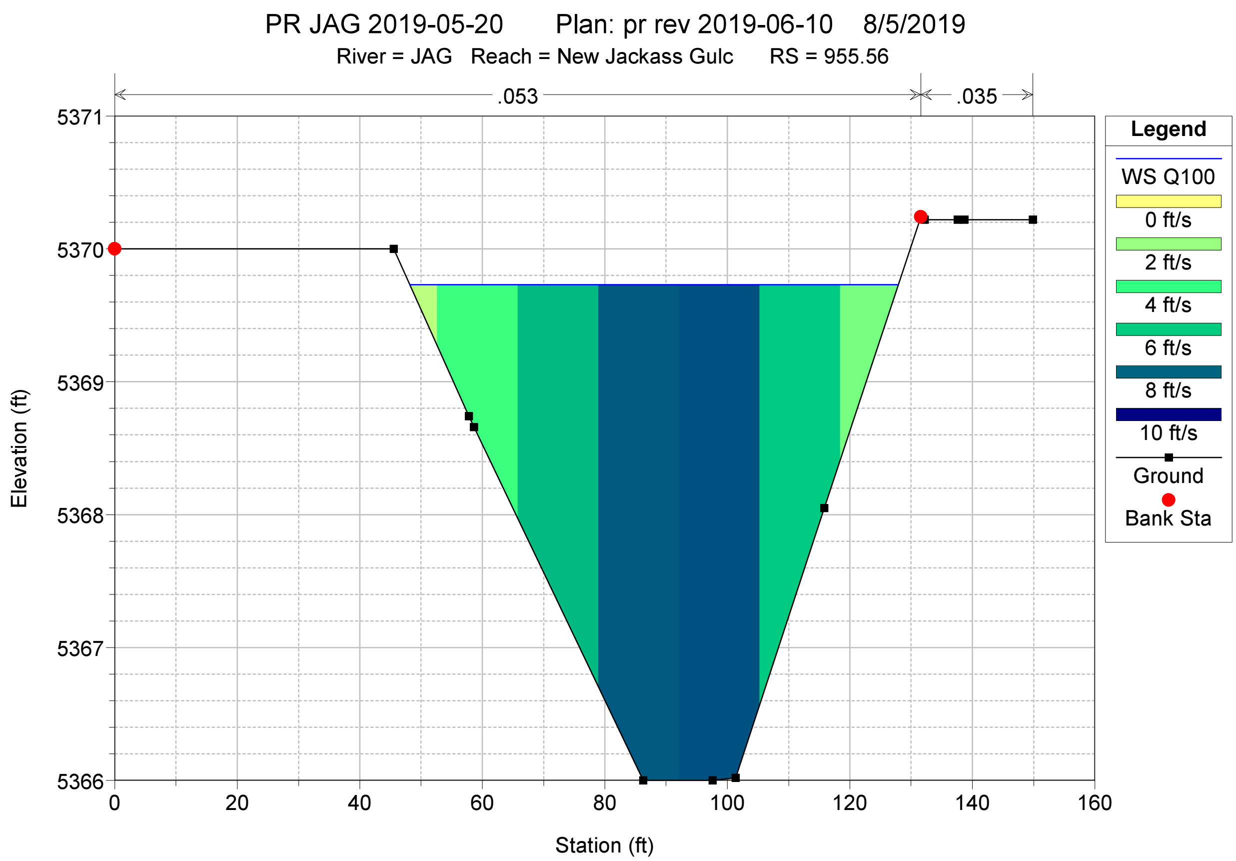
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.035
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Station (ft)
Legend
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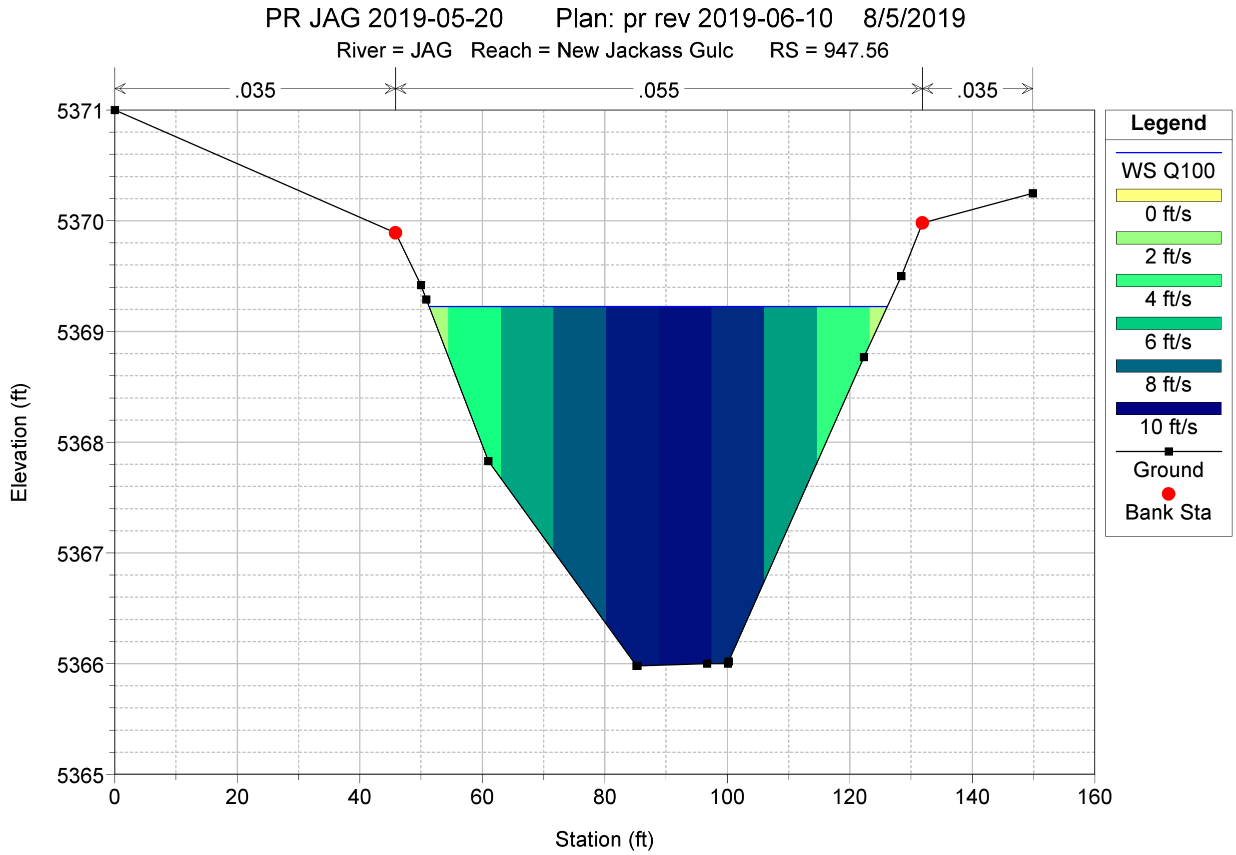
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.055
.035
Legend
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0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
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80
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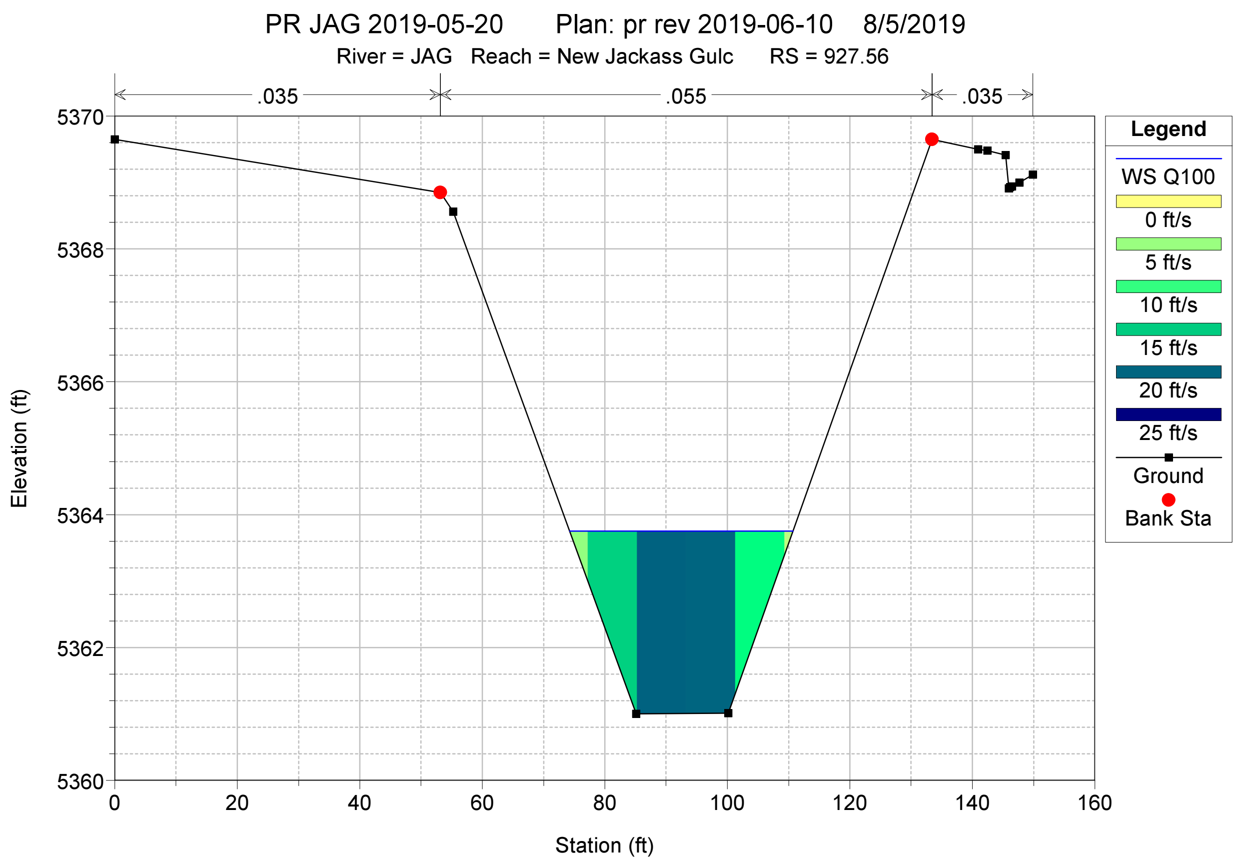
160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.055
.035
Legend
WS Q100
0 ft/s
5 ft/s
10 ft/s
15 ft/s
20 ft/s
25 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
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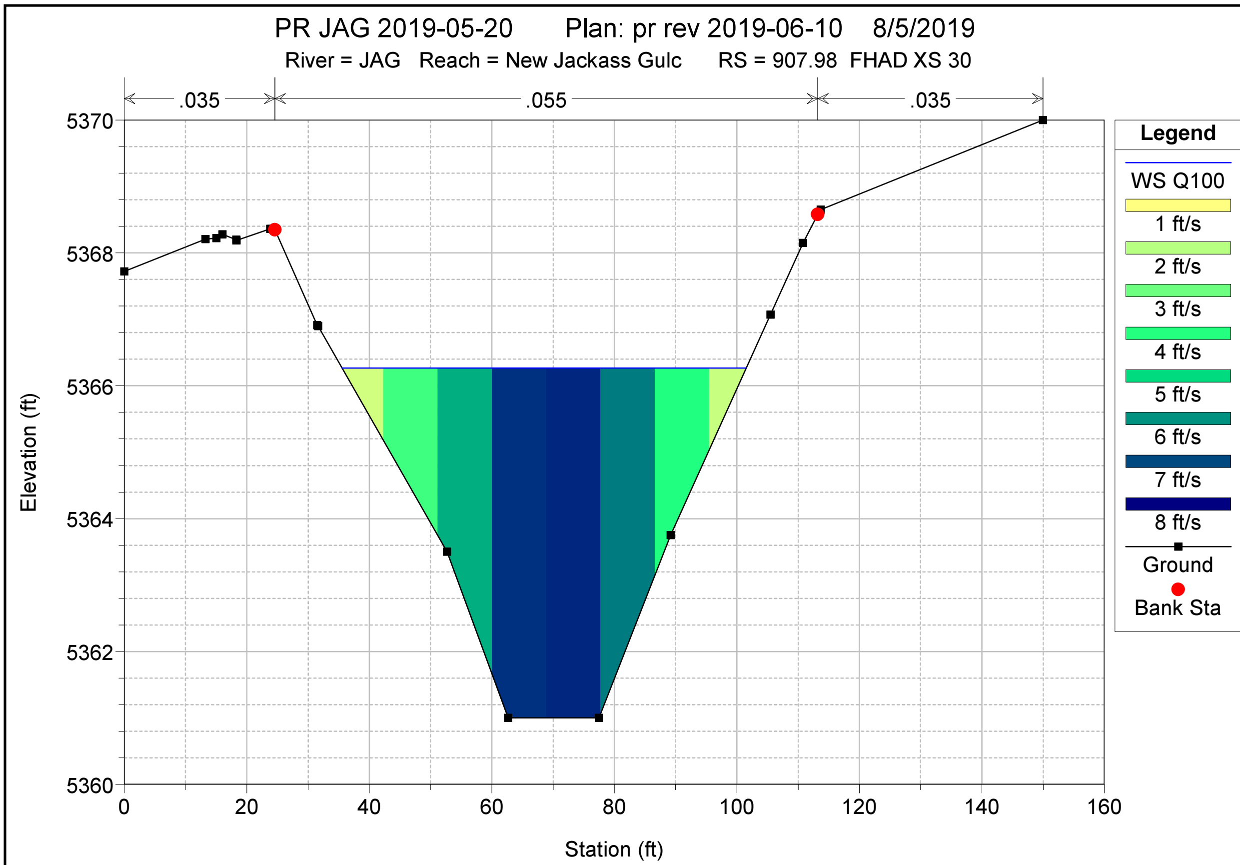
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.055
.035
Elevation (ft)
Station (ft)
Legend
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3 ft/s
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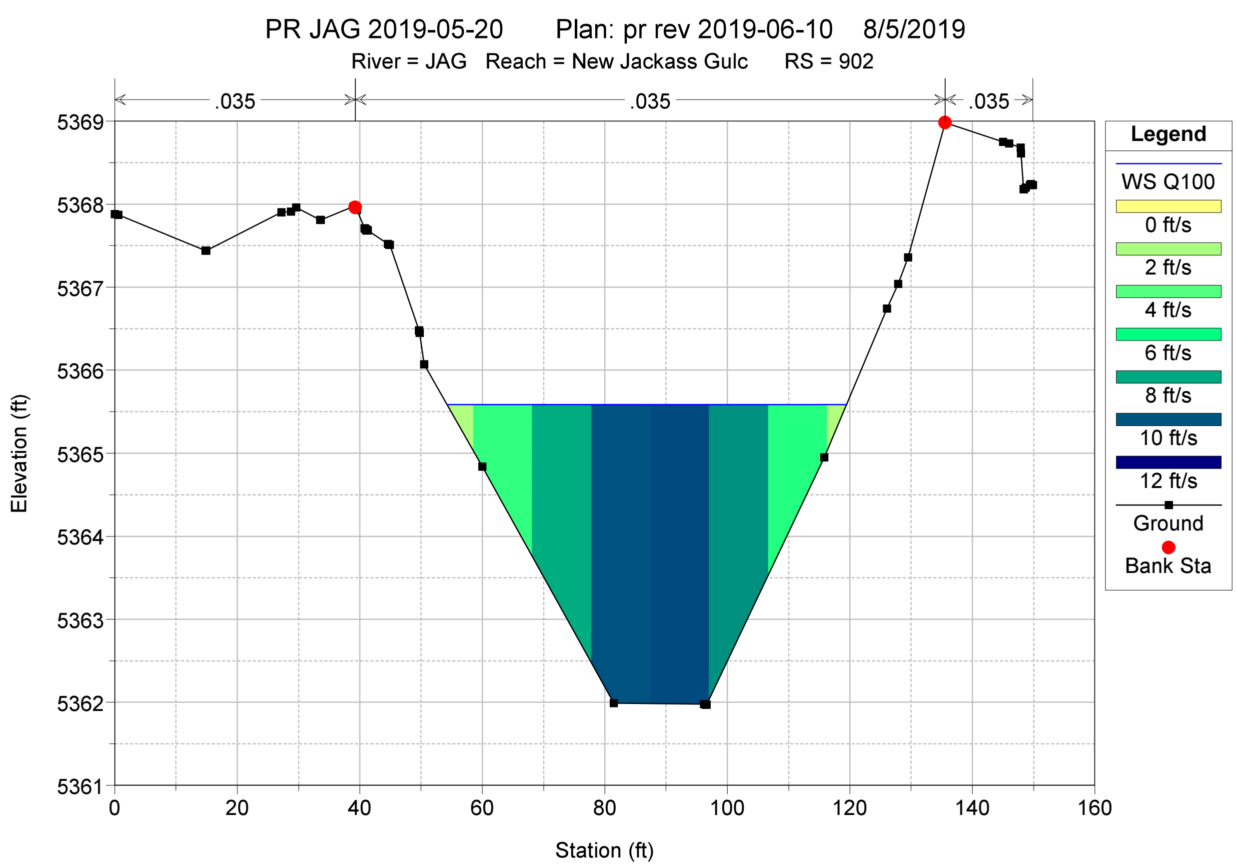
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta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.035
.035
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Station (ft)
Legend
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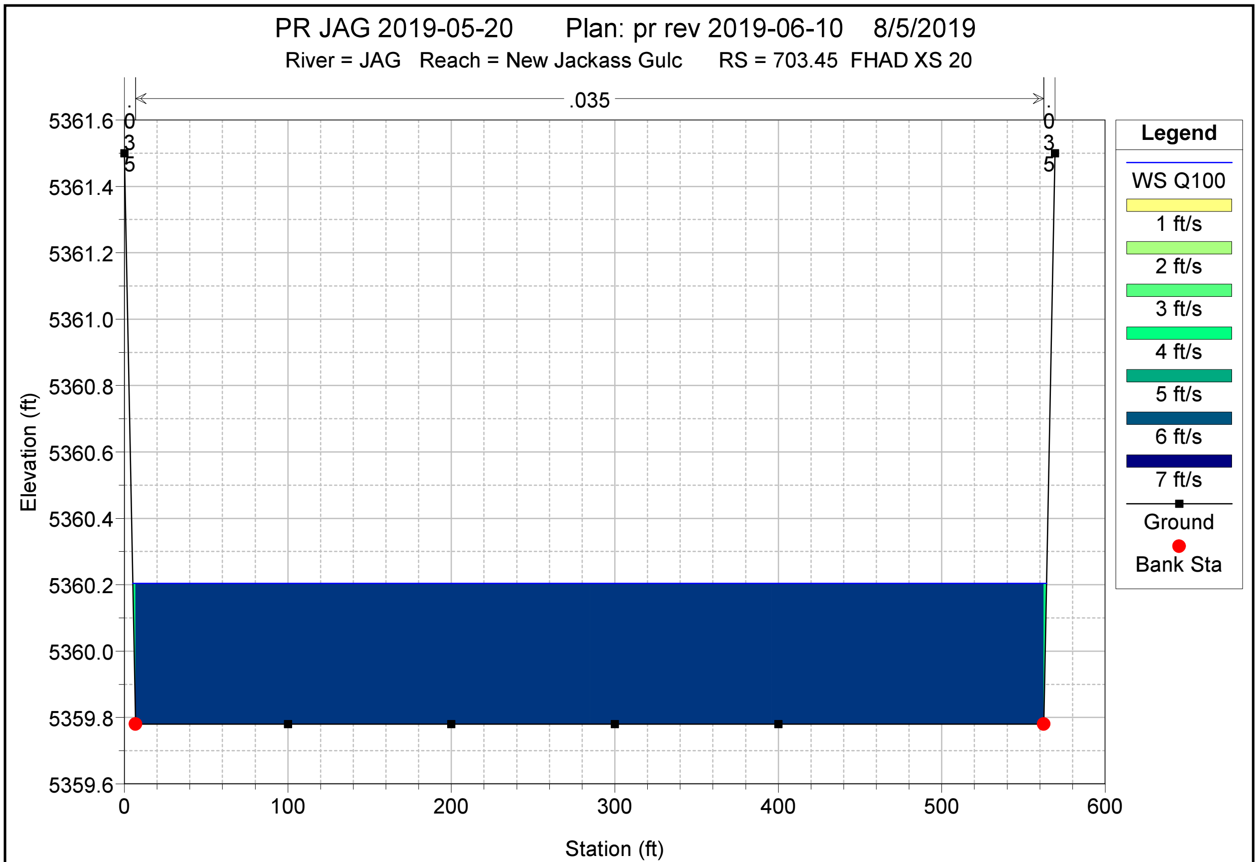
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta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.035
Legend
WS Q100
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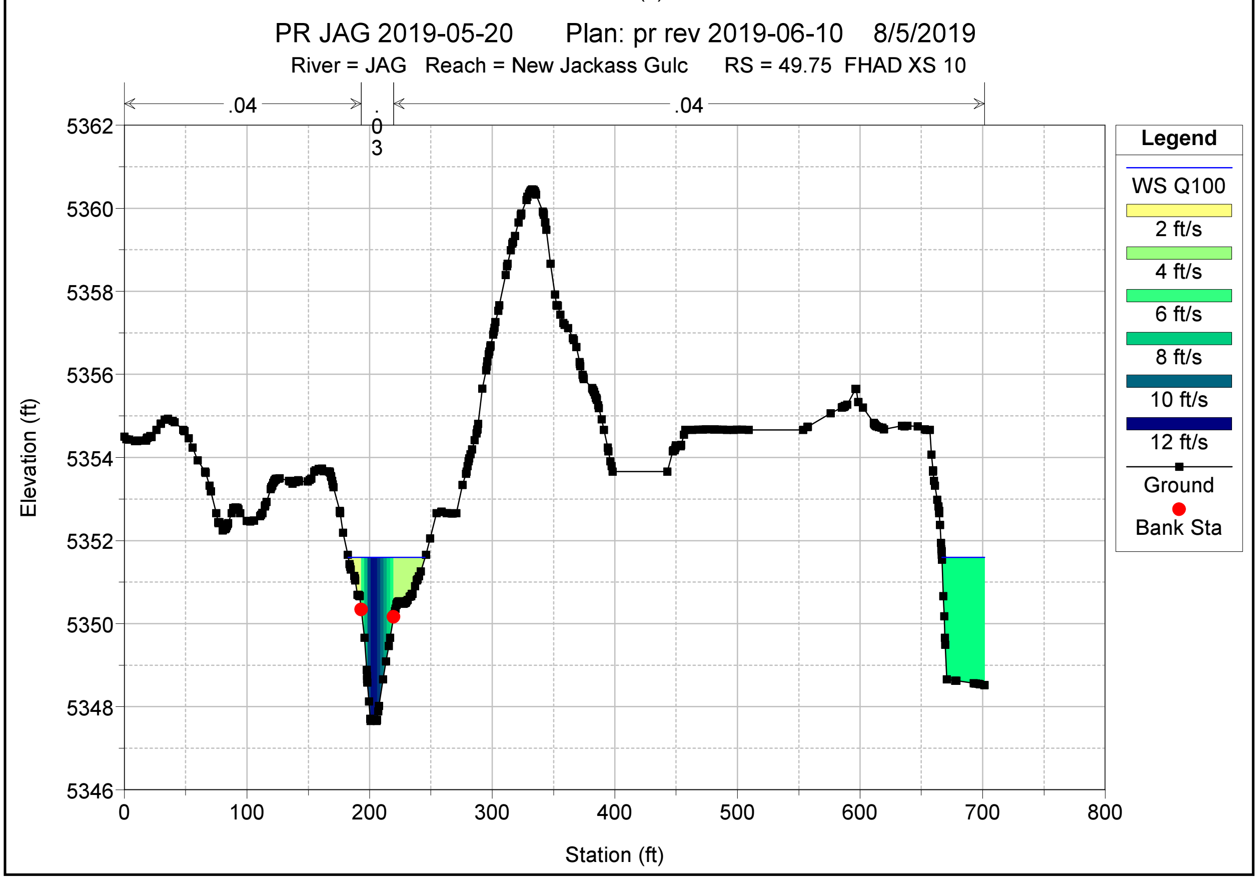
6 ft/s
7 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)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.04
Legend
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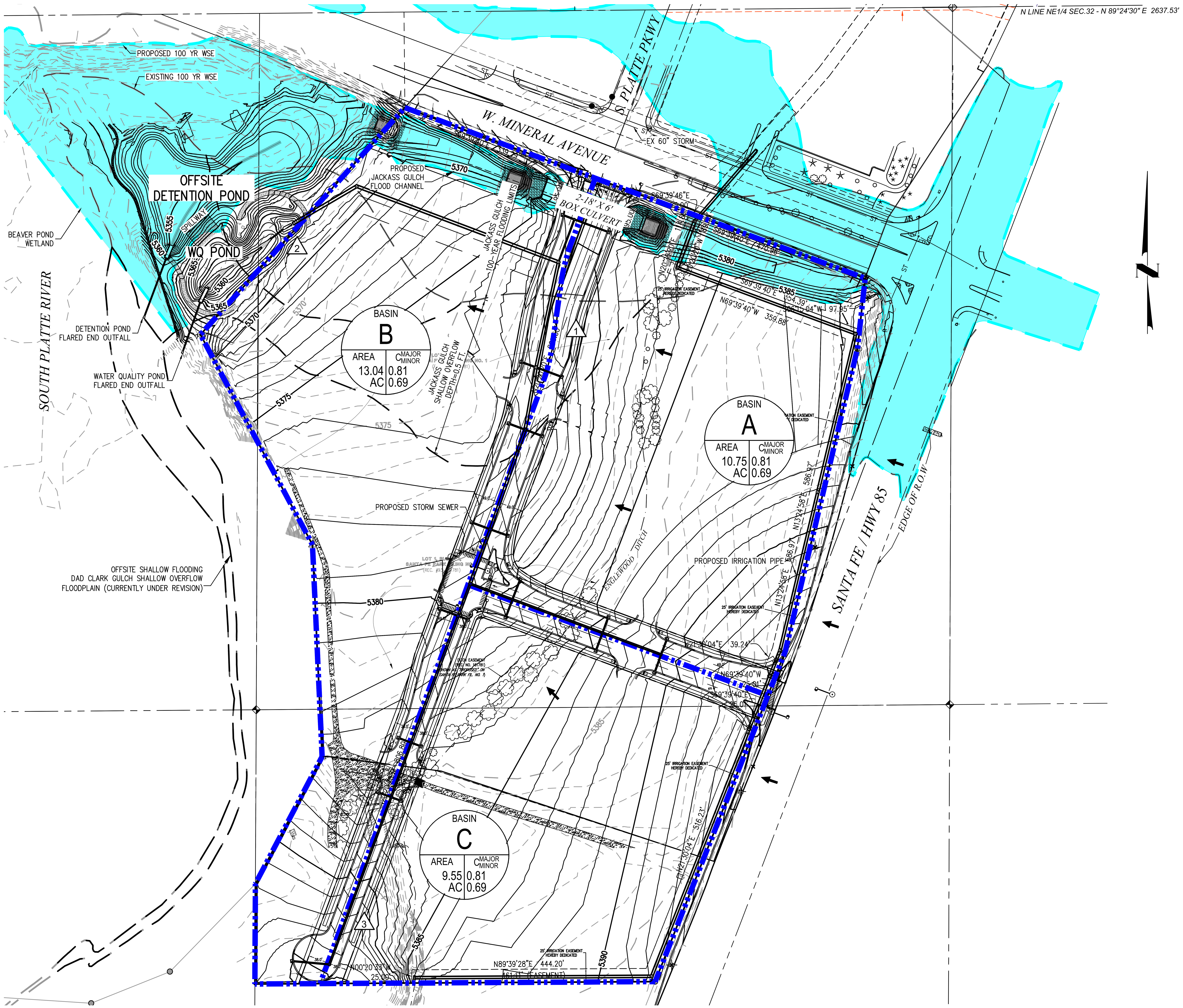
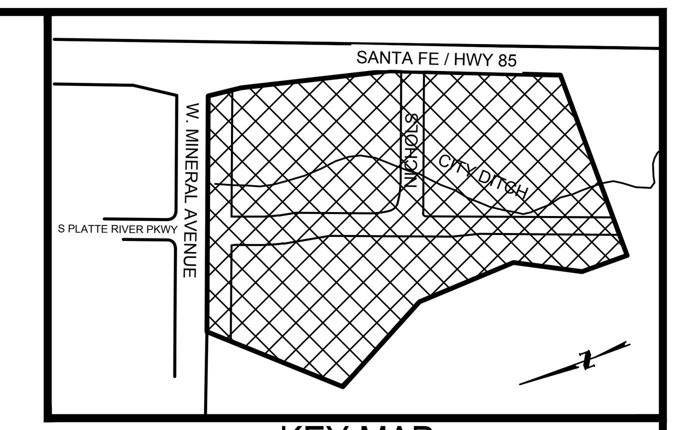
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)

APPENDIX F – DRAINGE MAPS AND PLANS

- **OVERALL DRAINAGE PLAN**
- **FLOODPLAIN WORKMAP**
- **JAG PLAN AND PROFILE**
- **DETENTION POND PLAN**





KEY MAP

SCALE : 1"=600'

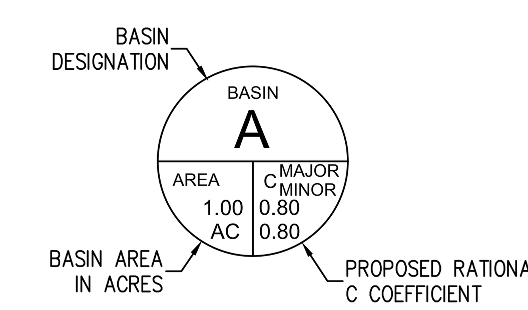
DIRECT RUNOFF SUMMARY TABLE				
SUB-BASIN	AREA (AC)	Q5 (CFS)	Q100 (CFS)	HISTORIC Q100 (CFS)
A	10.75	22.78	62.81	38.22
B	13.04	26.66	49.97	46.36
C	9.55	18.52	42.10	33.95

WATER QUALITY AND OFFSITE DETENTION POND VOLUME TABLE

EVENT	STAGE (FT)	AREA (FT^2)	AREA (ACRES)	VOLUME (FT^3)	VOLUME (AC-FT)	TOTAL OUTFLOW
WQCV	8.45	14,189	0.326	39,743	0.912	0.42
EURV	4.00	38,442	0.883	74,758	1.716	3.05
100-YEAR	5.98	53,443	1.227	165,341	3.796	8.85

LEGEND:

PROPOSED CONTOURS
EXISTING CONTOURS
DRAINAGE BASIN BOUNDARY
DESIGN POINT
EXISTING / PROPOSED FLOW ARROW



NOTES:

1. NO BUILDING, STRUCTURE, OR FILL WILL BE PLACED IN THE DETENTION AREAS AND NO CHANGES OR ALTERATIONS AFFECTING THE HYDRAULIC CHARACTERISTICS OF THE DETENTION AREAS WILL BE MADE WITHOUT THE APPROVAL OF THE CITY ENGINEER.
2. MAINTENANCE AND OPERATION OF THE DETENTION AND WATER QUALITY AREAS IS THE RESPONSIBILITY OF PROPERTY OWNER. IF OWNER FAILS IN THE RESPONSIBILITY, THE CITY HAS THE RIGHT TO ENTER THE PROPERTY, MAINTAIN THE DETENTION AREAS, AND BE REIMBURSED FOR COSTS INCURRED.
3. DETENTION POND VOLUMES, ALL DRAINAGE APPURTENANCES, AND BASIN BOUNDARIES SHALL BE VERIFIED. AS-BUILT DRAWINGS SHALL BE PREPARED BY A REGISTERED PROFESSIONAL ENGINEER PRIOR TO ISSUANCE OF CERTIFICATE OF OCCUPANCY FOR ANY STRUCTURE WITHIN THE DEVELOPMENT.
4. BETWEEN STATIONS 8+00.00 AND 11+72.40 CHANNEL IS TO BE PERMANENTLY LINED WITH TURF REINFORCEMENT MAT. PERMISSIBLE SHEAR STRESSES WITH THE PLANTED MAT APPLICATION ARE 16 LB/SQ-FT. MAXIMUM ALLOWABLE VELOCITIES AREA 25.0 FT/SEC.
5. CHANNEL TURF REINFORCEMENT MAT TO BE PLANTED WITH APPROPRIATE GRASSES TO RETAIN COHESION OF MAT BASED ON SITE SPECIFIC SOIL CONDITIONS. CHANNEL GRASSES SHALL BE MAINTAINED POST-CONSTRUCTION TO ENSURE VEGETATION ESTABLISHMENT.
6. PERMISSION TO REPRODUCE THESE PLANS IS HEREBY GIVEN TO THE CITY OF LITTLETON FOR CITY PURPOSES ASSOCIATED WITH PLAN REVIEW, APPROVAL, PERMITTING, INSPECTION AND CONSTRUCTION OF THE WORK.

100 0 100 200
SCALE: 1" = 100'

DESIGNED BY: DLQ
CHECKED BY: MAW
DRAWN BY: TMW

HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

Evergreen
Development | Services | Investments

RIVERPARK
FINAL DRAINAGE PLAN

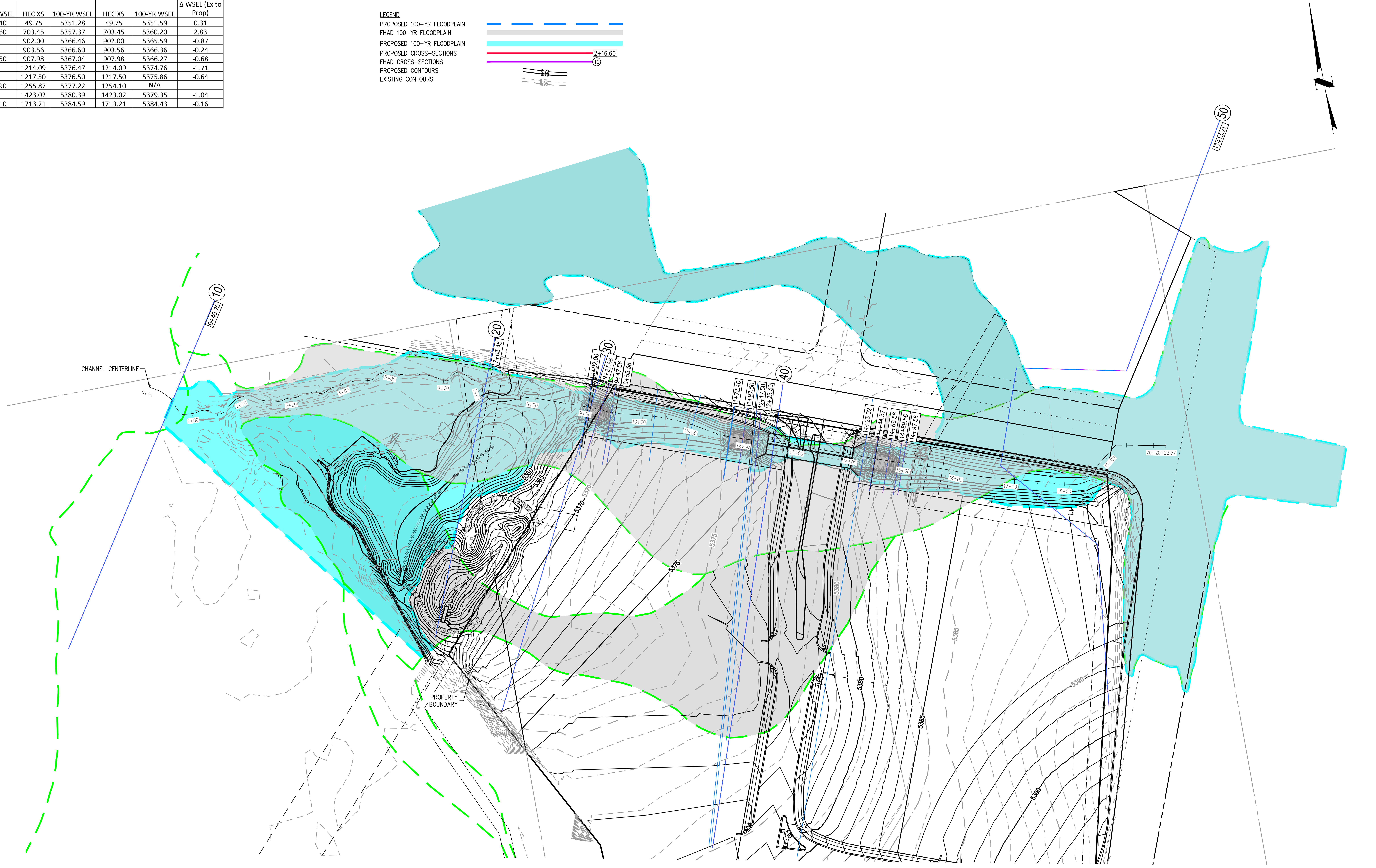
ISSUE DATE: 08-05-2019 | PROJECT #: 160605

DATE	REVISION COMMENTS

PRELIMINARY NOT FOR CONSTRUCTION

FHAD*		Existing Conditions		Proposed Conditions		
Q100=1240 cfs		Q100=1240 cfs		Q100=1240 cfs		
FHAD XS	100-YR WSEL	HEC XS	100-YR WSEL	HEC XS	100-YR WSEL	Δ WSEL (Ex to Prop)
10	5350.40	49.75	5351.28	49.75	5351.59	0.31
20	5354.60	703.45	5357.37	703.45	5360.20	2.83
		902.00	5366.46	902.00	5365.59	-0.87
		903.56	5366.60	903.56	5366.36	-0.24
30	5365.50	907.98	5367.04	907.98	5366.27	-0.68
		1214.09	5376.47	1214.09	5374.76	-1.71
		1217.50	5376.50	1217.50	5375.86	-0.64
40	5373.90	1255.87	5377.22	1254.10	N/A	
		1423.02	5380.39	1423.02	5379.35	-1.04
50	5382.10	1713.21	5384.59	1713.21	5384.43	-0.16

LEGEND
PROPOSED 100-YR FLOODPLAIN
FHAD 100-YR FLOODPLAIN
PROPOSED 100-YR FLOODPLAIN
PROPOSED CROSS-SECTIONS
FHAD CROSS-SECTIONS
PROPOSED CONTOURS
EXISTING CONTOURS



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5 XREFs: e-legal, p-base, p-drng, p-legal, p-util
PLOTTED: MON 08/05/19 8:26:07P BY: KENT STEINHAUS

811 Know what's below. Call before you dig.

CALL 3 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

80 0 80 160
SCALE: 1" = 80'

DESIGNED BY: RHM
CHECKED BY: MAW
DRAWN BY: RHM

HKS HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

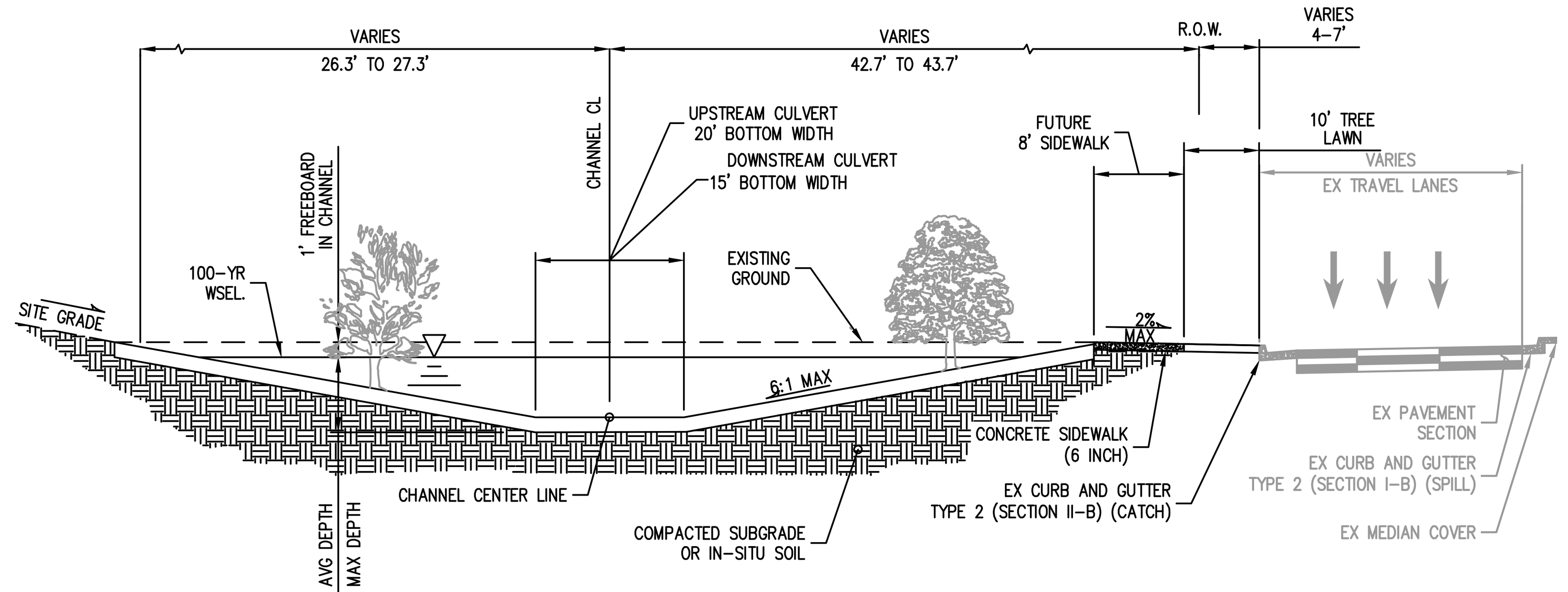
JACKASS GULCH
FLOODPLAIN WORKMAP

ISSUE DATE: 08/05/2019 PROJECT #: 160605

DATE	REVISION COMMENTS

PRELIMINARY NOT FOR CONSTRUCTION

SHEET NO.
1
1 OF 1

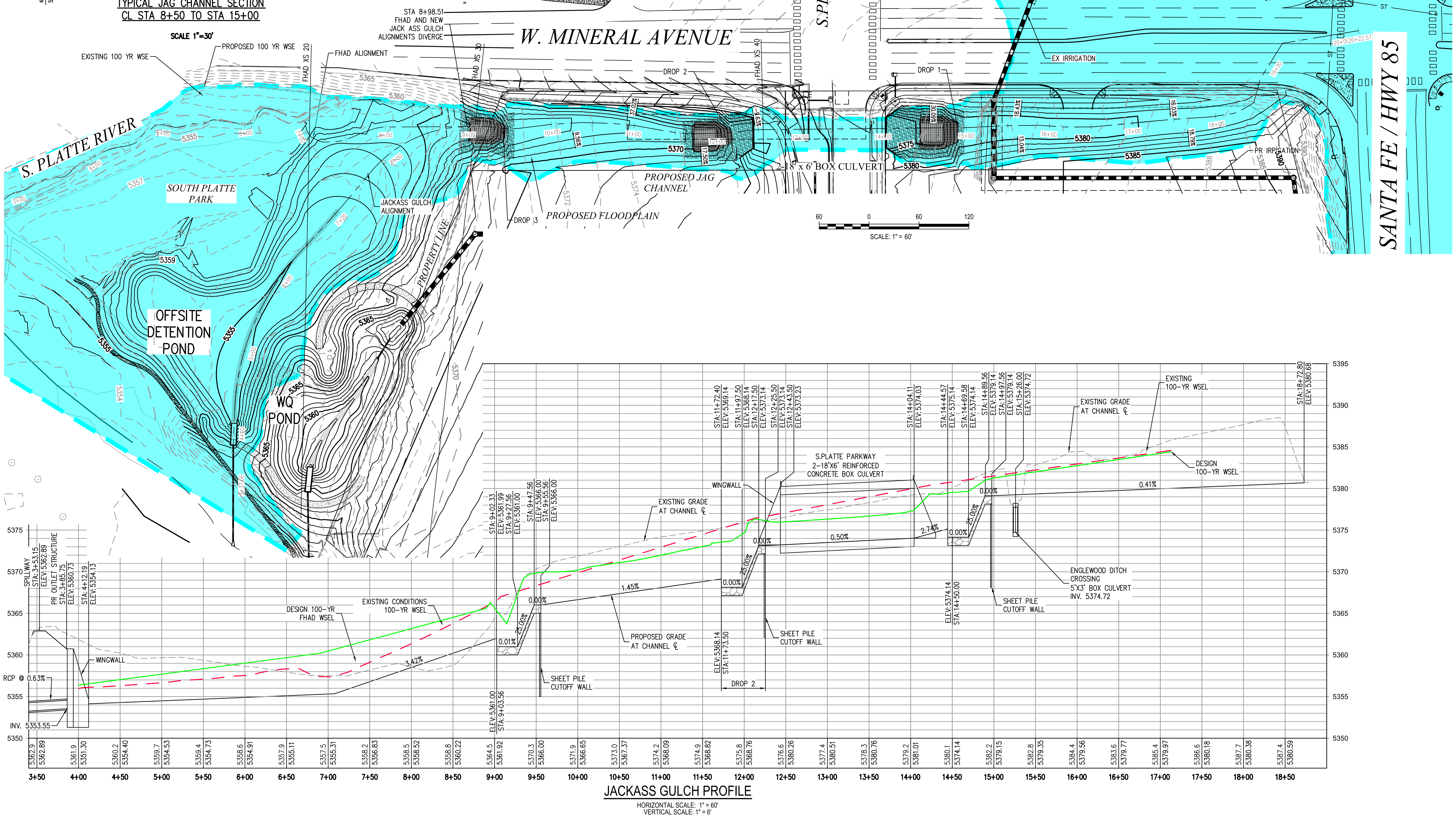


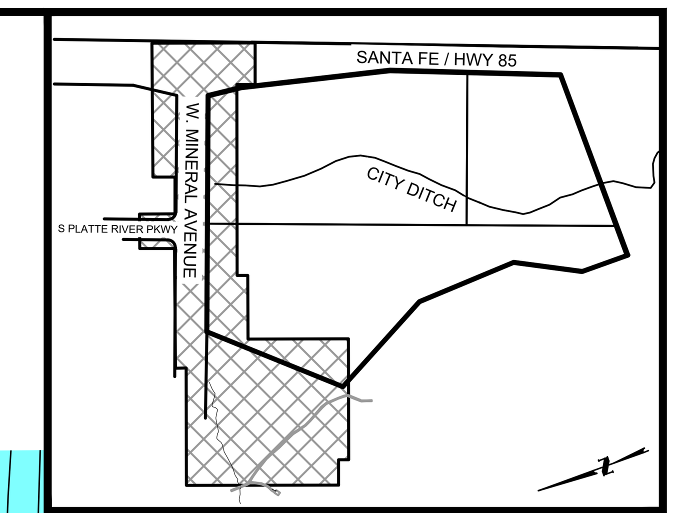
TYPICAL JAG CHANNEL SECTION
CL STA 8+50 TO STA 15+00

SCALE 1"=30'

GENERAL NOTES:

1. BETWEEN STATIONS 8+00.00 AND 11+72.40 CHANNEL IS TO BE PERMANENTLY LINED WITH TURF REINFORCEMENT MAT. PERMISSIBLE SHEAR STRESSES WITH THE PLANTED MAT APPLICATION ARE 16 LB/SQ-FT. MAXIMUM ALLOWABLE VELOCITIES AREA 25.0 FT/SEC.
2. CHANNEL TURF REINFORCEMENT MAT TO BE PLANTED WITH APPROPRIATE GRASSES TO RETAIN COHESION OF MAT BASED ON SITE SPECIFIC SOIL CONDITIONS. CHANNEL GRASSES SHALL BE MAINTAINED POST-CONSTRUCTION TO ENSURE VEGETATION ESTABLISHMENT.





KEY MAP
SCALE : 1"=600'

NO CHANGES ARE TO BE MADE TO THIS DRAWING WITHOUT WRITTEN PERMISSION OF HARRIS KOCHER SMITH

FILEPATH: P:\160605\ENGINEERING\DRAINAGE\CHANNEL PLAN AND PROFILE.DWG LAYOUT: LAYOUT1

811 Know what's below. Call before you dig.

CALL 3 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

SCALE: 1" = 60'

DESIGNED BY: DLQ
CHECKED BY: MAW
DRAWN BY: DLQ

HARRIS KOCHER SMITH
1120 Lincoln Street, Suite 1000
Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

Evergreen
Development | Services | Investments

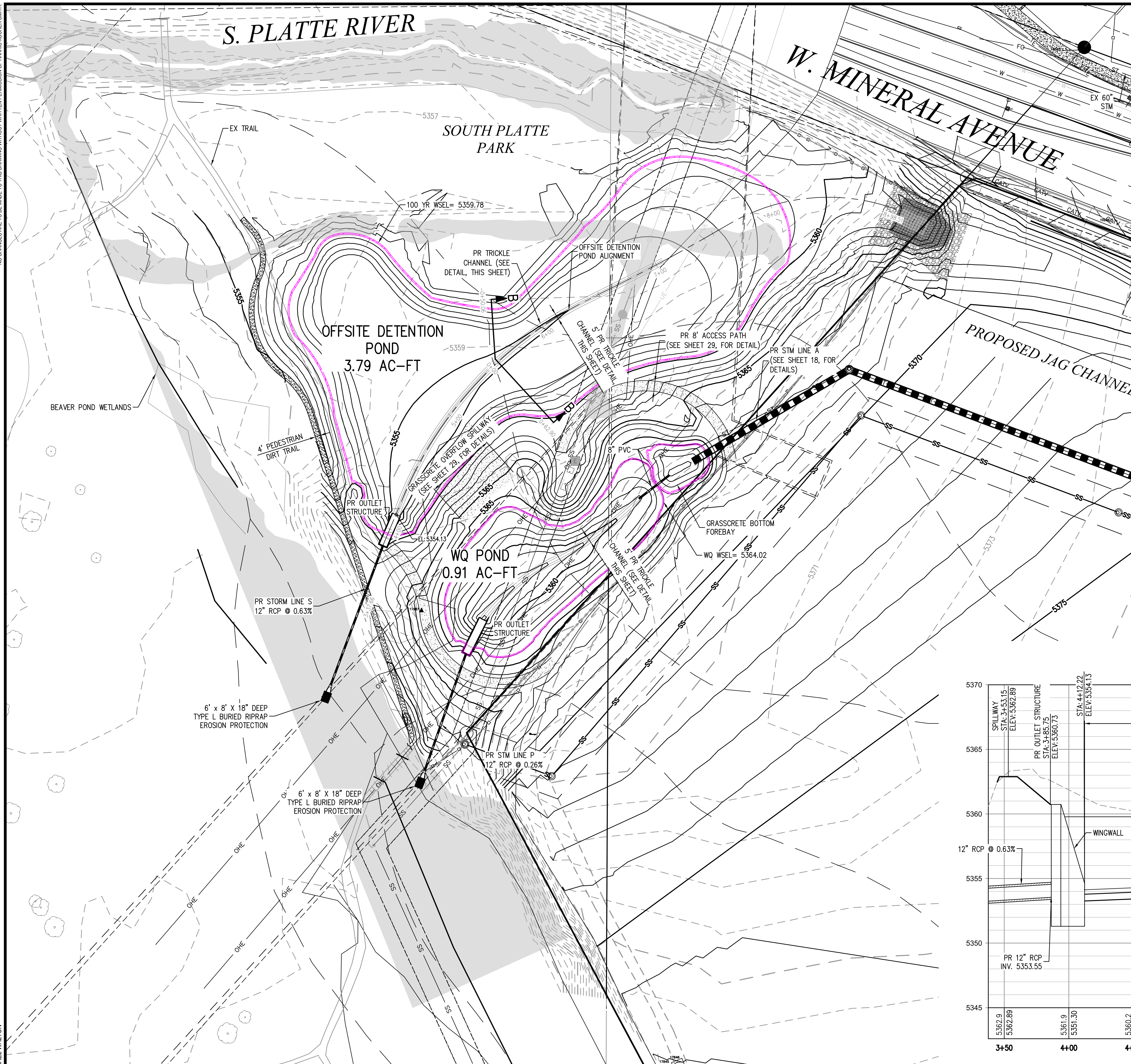
RIVERPARK
JAG CHANNEL PLAN AND PROFILE

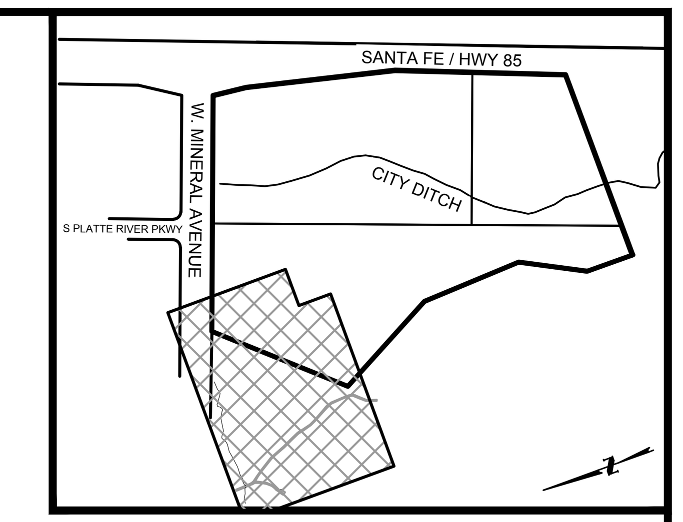
ISSUE DATE: 06-23-2017 | PROJECT #: 160605

DATE	REVISION COMMENTS

PRELIMINARY NOT FOR CONSTRUCTION

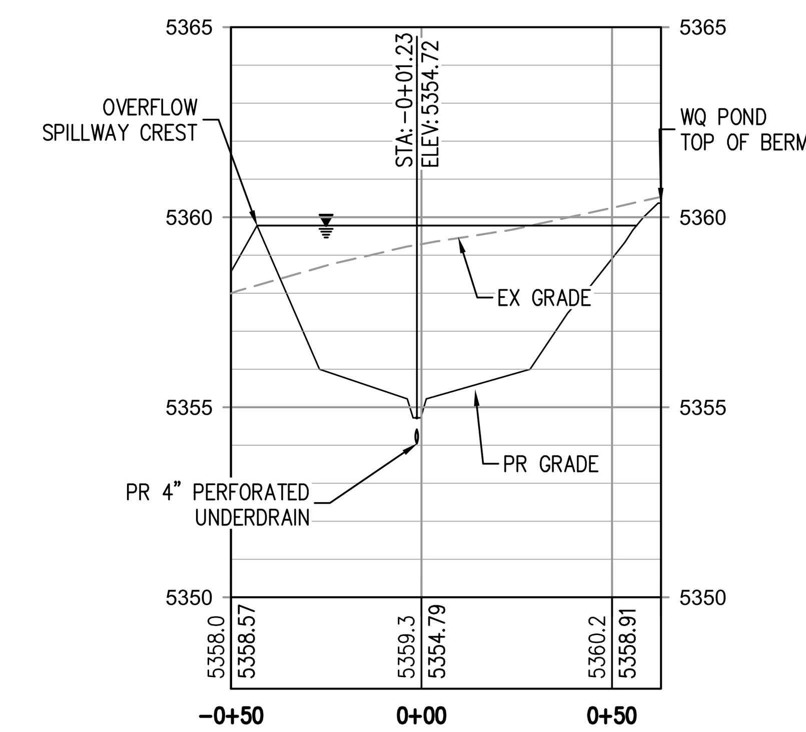
SHEET NO.
28





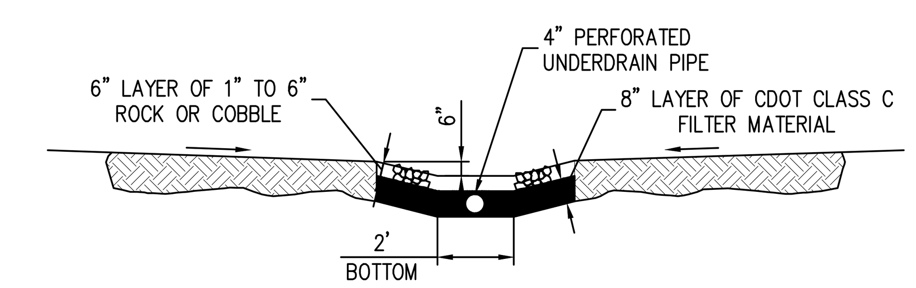
KEY MAP

SCALE : 1"=600'



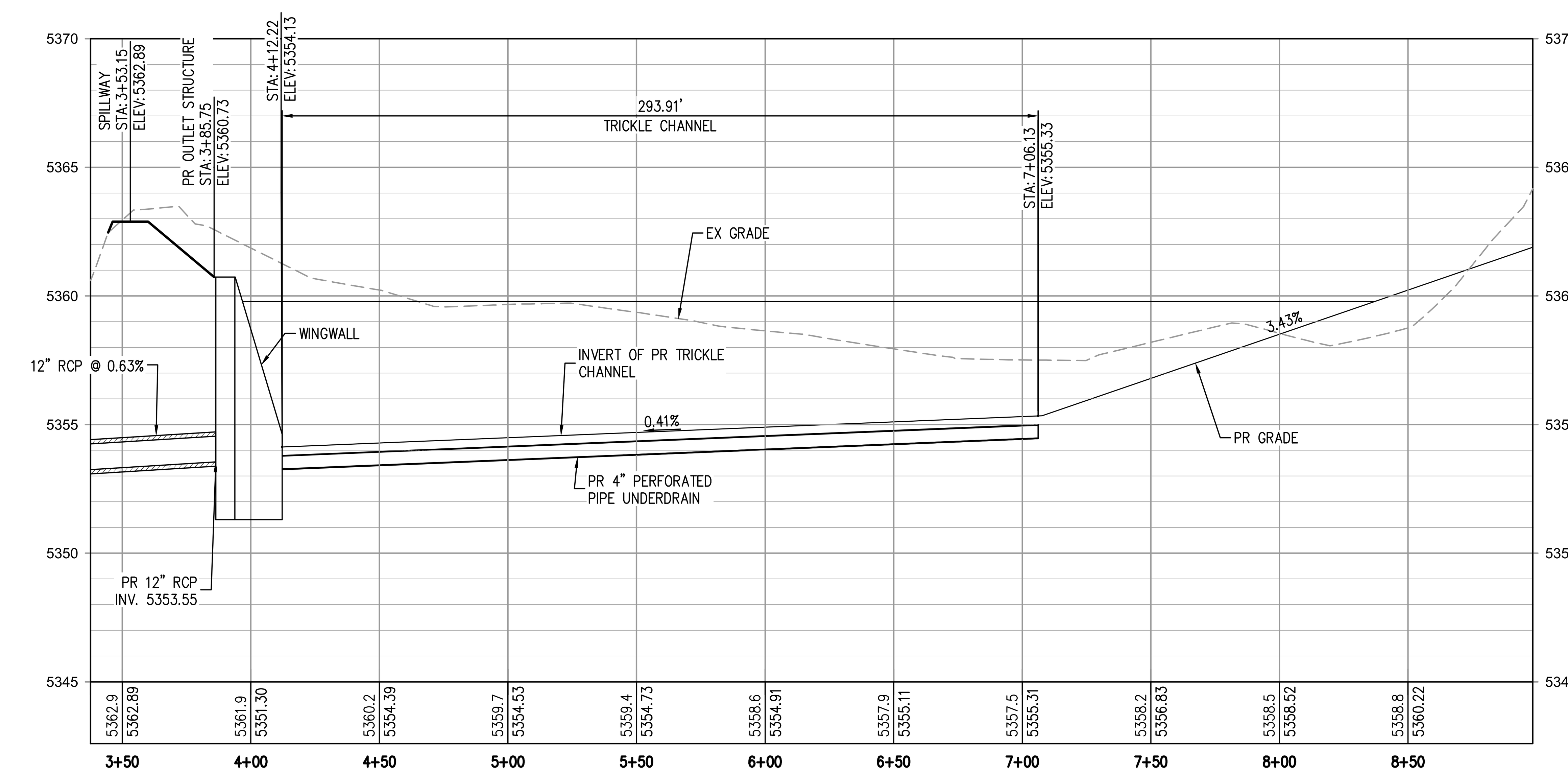
SECTION B-B PROFILE

HORIZONTAL SCALE: 1" = 40'
VERTICAL SCALE: 1" = 4'



TRICKLE CHANNEL DETAIL

SCALE: 1" = 4'



OFFSITE DETENTION POND PROFILE

HORIZONTAL SCALE: 1" = 40'
VERTICAL SCALE: 1" = 4'

811 Know what's below. Call before you dig.

CALL 3 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

SCALE: 1" = 40'

DESIGNED BY: DLQ
CHECKED BY: MAW
DRAWN BY: DLQ

HKS HARRIS KOCHER SMITH
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Denver, Colorado 80203
P: 303.623.6300 F: 303.623.6311
HarrisKocherSmith.com

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RIVERPARK
DETENTION POND PLAN

ISSUE DATE: 08-05-2019 | PROJECT #: 160605

DATE	REVISION COMMENTS

PRELIMINARY NOT FOR CONSTRUCTION

SHEET NO.

30

APPENDIX G – CRITERIA MANUAL CHECK LIST

Table 2D

City of Littleton Storm Drainage Design and Technical Criteria

Drainage Report Checklist

Instructions:

1. Applicant to identify with a "*check-mark* " if information is provided with report. If applicant believes information is not required, indicate with "*n/a*" and attach separate sheet with explanation.
2. City will determine if information labeled "*n/a*" is required and whether information must be submitted.
3. Those items noted with an "*asterisk*" are not required for a conceptual report.
4. Submit three (3) copies of report and include copy of check list bound with report.

TITLE PAGE

A Type of report (Conceptual, Final, Flood Hazard)
B Project name
C Preparer name, firm, address, number, and date.
D. Professional Engineers seal of preparer

I INTRODUCTION

A. Background
- ✓ 1 Identify report preparer and purpose
- ✓ 2 Identify date of letter with previous City comments.

B. Project Location
- ✓ 1 Identify Township, Range, and Section
- ✓ 2 Identify adjacent street and subdivision names
- ✓ 3 Reference to General Location Map

C. Property Description
- ✓ 1 Identify area in acres of entire contiguous ownership.
- ✓ 2 Describe existing ground cover, vegetation, soils, topography and slopes.
- ✓ 3 Describe existing drainage facilities, such as channels, detention areas, or structures.
- ✓ 4 Describe existing irrigation facilities, such as ditches, head-gates, or diversions.
- ✓ 5 Identify proposed types of land use and encumbrances.

D. Previous Investigations
- ✓ 1 Identify Major Drainageway Planning Study, Outfall System Planning Study, Flood Hazard Area Delineation Study, Flood Hazard Zones, and flood insurance rate maps.
- ✓ 2 Identify other master drainage plan for the area.

II DRAINAGE SYSTEM DESCRIPTION

A. Existing Drainage Conditions
- 1 Describe existing topography and provide map with contours extending a minimum of 100-feet beyond property limits
- ✓ 2 Identify major drainageway or outfall drainageway and describe map showing location of proposed development within the drainageways.
- ✓ 3 Identify pre-developed drainage patterns and describe map showing pre-developed sub-basins and concentrated discharge locations. Provide calculations of pre-developed peak flows entering and leaving the site.

B. Master Drainage Plan
- ✓ Describe location of the project relative to a previously prepared master drainage plan, including drainage plans prepared for adjacent development.

C. Offsite Tributary Area
- ✓ 1 Identify all offsite drainage basins that are tributary to the project.
- ✓ 2 Identify assumptions regarding existing and future land use and effects of offsite detention on peak flows.

✓ D. Proposed Drainage System Description
- ✓ 1 Identify how offsite storm water is collected and conveyed through the site.
- ✓ 2 Identify sub-basins and describe, in general terms, how onsite storm water is collected and conveyed through the site for each location where storm water is discharged from the site.
- N/A * 3 Describe detention volumes, release rates and pool elevations.
- N/A * 4 Identify the difference in elevation between pond invert and the groundwater table.
- ✓ 5 Describe how stormwater is discharged from the site, including both concentrated and dispersed discharges.
- ✓ 6 Describe storm water quality facilities.
- N/A * 7 Describe maintenance access aspects of design
- N/A * 8 Describe easements and tracts for drainage purposes, including limitations on use.

E Drainage Facility Maintenance
- N/A * 1 Identify responsible parties for maintenance of each drainage and water quality facility.
- N/A * 2 Identify general maintenance activities and schedules.

Table 2D Continued
Drainage Report Checklist

III DRAINAGE ANALYSIS AND DESIGN CRITERIA

A. Regulations

✓ — 1 Identify that analysis and design was prepared in accordance with the provisions of the City's CRITERIA.

✓ — 2 Identify other City regulations or criteria which have been used to prepare analysis and design.

B. Development Criteria

✓ — 1 Identify drainage constraints placed on the project by a Major Drainageway Planning Study, an Outfall Systems Study, a master drainage plan, or other area wide development plan.

✓ — 2 Identify drainage constraints placed on the project from major street alignments, utilities, rapid transit, existing structures, and other developments.

C. Hydrologic Criteria

✓ — (If CRITERIA was followed without deviation, then a statement to that effect is all that is required. Otherwise provide the following information.)

✓ — 1 Identify how storm runoff peak flows and volumes were determined, including rainfall intensity or incremental amounts.

✓ — 2 Identify which storm events were used for minor and major flood analysis and design.

N/A — 3 Identify how and why any other deviations from the CRITERIA occurred.

D. Hydraulic Criteria

✓ — (If CRITERIA was followed without deviation, then a statement to that effect is all that is required. Otherwise provide the following information)

N/A * — 1 Identify type(s) of streets within and adjacent to development and source for allowable street capacity.

N/A * — 2 Identify which type(s) of storm inlets were analyzed or designed and source for allowable capacity.

N/A * — 3 Identify which type of storm sewers which were analyzed or designed and Manning's n-values used.

✓ * — 4 Identify which method was used to determine detention volume requirements and how allowable release rates were determined.

N/A * — 5 Identify how the capacity of open channels and culverts were determined.

N/A * — 6 Identify any special analysis or design requirements not contained within the CRITERIA.

N/A — 7 Identify how and why any other deviations from the CRITERIA occurred.

E. Variance from Criteria

N/A — 1 Identify which provisions of the CRITERIA a variance is requested.

N/A — 2 Identify pre-existing conditions which cause the variance request.

* **IV GRADING & EROSION & SEDIMENT CONTROL PLAN (ESCP) See CRITERIA, Chapter 13 for requirements.**

* A. Additional Site Information

✓ * — 1 Describe soils, including hydrologic group, mapping units, erodibility, permeability, depth, texture and structure.

✓ * — 2 Provide estimate of fill and excavation quantities and surface area of disturbance.

* B. Erosion Control Measures

✓ * — Describe methods used to control erosion and sediment discharges from the site during and after construction.

* C. Schedule

✓ * — Identify anticipated start and completion times for site grading construction sequence, BMP installation and removal, stockpiles, exposure time for each area prior to completion of temporary measures.

* D. Maintenance

N/A * — Provide schedule of regular inspections and repair activities, including removal of sediment.

* E. Cost Estimate

N/A * — Provide an estimate of installation and maintenance costs for erosion and sediment control measures for the purpose of determining amount of surety or bonding requirements.

* F. Calculations

N/A * — Provide calculations performed for design of erosion and sediment control facilities.

* G. Owner's Certification

N/A * — A signature page shall be provided for the owner/developer acknowledging the review and acceptance of the responsibility for the plan. The certification shall be worded as provided in Section 2.3.

* H Spill Prevention, Containment and Clean-up

✓ — Describe spill prevention, containment and cleanup procedures to be used during construction phase.

I Standard Drainage and Erosion Control Notes

Include standard drainage and erosion control notes (see Chapter 17)

Table 2D Continued

Drainage Report Checklist

* V STORMWATER MANAGEMENT PLAN (SWMP). See CRITERIA, Chapter 15 for requirements.

* A. Storm Water Quality Control Measures

✓ * Describe BMPs to control discharge of pollutants from the project site.

* B. Calculations

N/A Provide methods and calculations for WQCV, sediment storage, and water quality outlet structure.

VI CONCLUSIONS

A. Compliance with Criteria

✓ Compliance with CRITERIA, major drainageway and outfall systems planning studies.

B. Design Effectiveness

N/A Effectiveness of drainage design to control impacts of storm runoff.

C. Areas in Flood Hazard Zone

Meet requirements of Floodplain Regulations (Title 10-Chapter 66-Article 5) of the City of Littleton, otherwise, Special Use Permit required.

D. Variances from Criteria

Applicant shall indentify any requested variances and provide basis for approving variance. If no variances are requested, applicant shall state that none are requested.

VII REFERENCES

✓ Provide a reference list of all criteria, master plans, drainage reports, and technical information used..

TABLES

✓ Include copy of all tables prepared for report.

FIGURES

✓ A. General Location Map (see Section 2.4.2(A))

✓ B. Flood Plain Information (see Section 2.4.2(B))

✓ C. Drainage Plan (see Section 2.4.2 (C))

✓ D. Other pertinent figures.

APPENDICES

A. DESIGN CHARTS

✓ Provide copy of all design charts (i.e.: tables, figures, charts from other criteria) used for the report.

B. HYDROLOGIC CALCULATIONS (see CRITERIA, Chapters 5 and 6)

✓ 1 Land use assumptions for off-site runoff calculations

✓ 2 Time of concentration and runoff coefficients for pre-existing and post developed conditions

✓ 3 Pre-developed hydrologic computations

✓ 4 Developed conditions hydrologic computations.

C. HYDRAULIC CALCULATIONS

✓ 1 Capacity of existing channels, streets, storm sewers, inlets, culverts and other facilities.

N/A 2 Calculations for existing storm sewer and open channel.

✓ 3 Irrigation ditch flows and ditch system capacity

N/A * 4 Detention pond design (see CRITERIA, Chapter 14 for requirements):

N/A * a. Storage volume, release rates, and pool elevations for 10-year and 100-year storm

N/A * b. Outlet structure dimensions, orifice diameter, weir lengths, pipe headwater and other data.

N/A * c. Outlet velocity and energy dissipation requirements.

N/A * d. Routing of outlet flows and emergency spillway flows.

N/A * 5 Street capacity calculations, if data in CRITERIA not used (see Chapter 10).

N/A * 6 Storm inlet capacity calculations, if data in CRITERIA not used (see Chapter 9).

N/A * 7 Storm sewer capacity calculations, if data in CRITERIA not used (see Chapter 8).

N/A * 8 Channel capacity calculations, if data in CRITERIA not used (see Chapter 7).

N/A * 9 Culvert capacity calculations. (see CRITERIA, Chapter 11).

N/A * 10 Other hydraulic structure calculations (see CRITERIA, Chapter 12)

D. STORMWATER QUALITY CALCULATIONS

✓ 1 Water Quality Capture Volume (WQCV)

N/A * 2 Storage volume for sediment volume and pool elevations for WQCV.

N/A * 3 Outlet calculations for required area per row, diameter of individual holes, number of holes per row, and number or holes per column.

ACKNOWLEDGMENTS

Drainage Report checklist was prepared by ______________________________

Table 2E

City of Littleton Storm Drainage Design and Criteria

Drainage Construction Plan Checklist

Instructions:

1. Applicant to identify with a "check-mark " if information is provided. If applicant believes information is not required, indicate with "n/a".
2. City will determine if information labeled "n/a" is required and whether information must be submitted.

I EXISTING FACILITIES

- ✓ A. Contours at two foot intervals, based on USGS datum. Contours to extend at least 50 feet past property line
- ✓ B. Location and elevation of USGS benchmarks or benchmarks referenced to USGS.
- ✓ C. Property lines
- ✓ D. Drainage easements
- ✓ E. Street names
- ✓ F. Major and minor channels and floodplains.

II PROPOSED FACILITIES

- ✓ A. Contours at two foot intervals, based on USGS datum.
- ✓ B. Property lines
- ✓ C. Drainage easements
- ✓ D. Street names and grades
- ✓ E. Right of way and easement
- N/A F. Finished floor elevations for protection from major storm run-off.
- G. Detention pond information:
  - ✓ 1. Localon of each detention pond with site plan at 1" = 50' scale or larger with 2-foot contour intervals.
  - N/A 2. Inlet and outlet structure, and trickle channel design details.
  - N/A 3. Details of emergency spillway and channel.
  - ✓ 4. Landscape information, including side slopes, vegetation and planting requirements.
  - N/A 5. Details of water quality outlet structure.
- H. Channel information:
  - ✓ 1. Profiles with existing and proposed grades.
  - N/A 2. Cross sections on 100-foot stations showing existing and proposed topograhy and required rights of way.
  - ✓ 3. Locations and size of all existing and proposed structures.
  - ✓ 4. Locations and profiles of adjacent utilities.
  - ✓ 5. Typical channel section and lining details.
- I. Storm sewer information:
  - ✓ 1. Alignment and location of manholes, inlets, and outlet structures.
  - ✓ 2. Profile of invert and pipe crown.
  - ✓ 3. Invert elevations at manholes and inlets.
  - ✓ 4. Lengths and grades between manholes and inlets.
  - ✓ 5. Locations and elevations of utilities adjacent to and crossing storm sewer.
  - ✓ 6. Easement and other O&M access geometry.
  - ✓ 7. Outlet details, such as end sections, headwall and wingwalls, erosion control, and vegetation.
- N/A J. Street cross section with desing 100-year flood depth.
- ✓ K. Other drainage related structures and facilities, including under drains and sump pump discharge lines.

III HYDRAULIC AND HYDROLOGIC INFORMATION

- ✓ A. Routing and accumulative runoff peaks at upstream and downstream ends of the site and at various critical points onsite for initial and major storms. Inflow and outflow from each subbasin shall be shown for both initial and major storms.
- N/A B. Street cross sections showing 100-year flood levels.
- ✓ C. Major and minor channels and floodplains.
- D. Detention pond data:
  - ✓ 1. Release rates for 10- and 100-year storm events.
  - ✓ 2. Required and provided volumes for 10- and 100-year storm events.
  - ✓ 3. Design depths for 10- and 100-year storm events.
  - ✓ 4. Water quality capture volume and pool elevation.
- E. Channel data:
  - ✓ 1. Water surface profiles.
  - N/A 2. Representative 100-year flow velocity and Froude number
- F. Storm sewer data:
  - N/A 1. Profile of water surface for design flow rate.
  - N/A 2. Peak flows for design flow, 5-year and 100-year storm events.

IV STANDARD NOTES

- ✓ A. No building, structure, or fill will be placed in the detention areas and no changes or alternations affecting the hydraulic characteristics of the detention areas will be made without the approval of the City Engineer.
- ✓ B. Maintenance and operation of the detention and water quality areas is the responsibility of property owner. If owner fails in this responsibility, the City has the right to enter the property, maintain the detention areas, and be reimbursed for costs incurred."
- ✓ C. Detention pond volumes, all drainage appurtenances, and basin boundaries shall be verified. As-built drawings shall be prepared by a registered professional engineer prior to issuance of certificate of occupany for any structure within the development.
- ✓ D. Permission to reproduce these plans is hereby given to the City of Littleton for City purposes associated with plan review, approval, permitting, inspection and construction of the work

✓ **V. PROFESSIONAL ENGINEERS SEAL AND SIGNATURE**

VI. OTHER

- A. Horizontal and vertical control information and ties to existing and proposed features.

ACKNOWLEDGMENTS

Drainage Construction Plan checklist was prepared by ______________________________