I-25 CIMARRON INTERCHANGE
ENVIRONMENTAL ASSESSMENT REEVALUATION

ATTACHMENT 5

I-25 Cimarron Interchange Project
Floodplain Development Permit

COLORADO
Department of
Transportation

Pikes Peak Regional Building Department

Permit # 14057 **FLOOD PLAIN DEVELOPMENT PERMIT** **Date 29-May-2014**

Owner Information

Name: CDOT **Phone: (719) 227-3249**

Address: 1480 QUAIL LOOP
COLORADO SPRINGS, CO 80906
Attention: LESLEY MACE

Project Location

Address:

, CO

Location/Directions: I-25/US 24/Cimarron St. Interchange Reconstruction Project

Contractor/Engineer: Phone:

Project Description

Single Family Residential:	[ ]	Addition/Remodel (<50%):	[ ]
Multi-Family Residential:	[ ]	Rehabilitation	[ ]
Manuf. (Mobile Home:	[ ]	Subst. (>50 Appraisal) Imprv:	[ ]
Non-Residential	[ ]	Fill	[ ]
New Construction	[ ]	Bridge/Culvert	[X]
Watercourse Modification:	[X]	Levee:	[ ]

Project Cost: $0.00 Structure Market Value: $0.00
Creek:
Description of work: I-25/US 24/Cimarron St. Interchange Reconstruction Project

Flood Hazard Data

Location:
Base (1%) Flood Elevation:
Lowest Floor Elevation:
Floodproofing Level:
Source Document:

Permit Action

Permit Granted (Y/N): Yes Variance Granted (Y/N): No
Action Comments: Label mean sea level elevations of proposed lowest floor. Flood proofing level must be noted on plans for new structures.

A state of Colorado licensed engineer must certify that construction in a floodway will not increase of flood elevations.

Compliance Section

Elevation Certificate: N Date:

LOMA: N Date: CLOMR: N Date: LOMR: N Date:

Site Inspection:
Preliminary Required: Y Date:
Final Required: Y Date:

For Inspection Requests call: Michael 327-2938

Compliance Comments: Label mean sea level elevations of proposed lowest floor. Flood proofing level must be noted on plans for new structures.

A state of Colorado licensed engineer must certify that construction in a floodway will not increase of flood elevations.

APPROVED
MAY 29 2014
RBD Floodplain

Regional Floodplain Division: Date 29-May-2014

NOTE: This permit expires twelve (12) months from the date it is issued.

PIKES PEAK REGIONAL BUILDING DEPARTMENT

2880 International Circle
Colorado Springs, Colorado 80910
Website: http://www.pprbd.org

5/29/2014 9:20:39 AM
(KEITH)
Receipt #: 1197534

Invoice

Customer: CDOT

Transaction Summary

Account	Description	Reference	Amount
3306600	FLOODPLAIN PERMIT FEES	14057	$500.00

Total Due: $500.00

Payment Summary

Account	Description	Reference	Amount
5020000	COLLECTION, CHECK	203625	$500.00

Total Tendered: $500.00

Comment: FP# 14057--I-25/US 24/CIMARRON ST. INTERCHANGE RECONSTRUCTION PROJECT

I-25/US 24/Cimarron St. Interchange Reconstruction Project

Floodplain Development Permit Application

May 27, 2014

Prepared By:

5755 Mark Dabling Blvd., Ste. 220
Colorado Springs, CO 80919
719-520-5800 phone
719-520-0108 fax

Prepared For:

Colorado Department of Transportation, Region 2
1480 Quail Lake Loop
Colorado Springs, CO
719-227-3249

WILSON & COMPANY
5755 Mark Dabling Blvd., Ste. 220
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Alaska
Arizona
California
Colorado
Florida
Kansas
Louisiana
Missouri
Nebraska
New Mexico
Oklahoma
Texas
Utah

May 27, 2014

Mr. Keith Curtis
Floodplain Administrator
Pikes Peak Regional Building Department
2880 International Circle
Colorado Springs, CO 80910

RE: Floodplain Development Permit Application, I-25/US 24/Cimarron St. Interchange Reconstruction Project

Dear Mr. Curtis;

The Colorado Department of Transportation is planning a major reconstruction of the I-25/US 24/Cimarron St. Interchange which potentially impacts adjacent regulatory floodplains on Lower Fountain Creek, Upper Fountain Creek, Monument Creek and Bear Creek. The project will be constructed under a design-build contract between CDOT and a contractor yet to be determined. CDOT is making an application for a floodplain development permit as the project owner to provide the contractor with a preliminary design that will not adversely impact regulatory floodplains.

Wilson & Company has described preliminary designs and completed hydraulic analyses that show how adverse impacts to the regulatory floodplains can be avoided. The proposed designs and analyses are briefly described below and are described in more detail in the attached report entitled, I-25/US 24/Cimarron St. Interchange Reconstruction, Floodplain Hydraulic Analyses for Floodplain Development Permit. The design-build contractor will be required to design and construct improvements that do not adversely impact the regulatory floodplains or submit Conditional Letter of Map Revisions where the proposed design is expected to cause adverse impacts. The design-build contractor will be required to submit and obtain approval of a Letter of Map Revision from FEMA for the completed project under the contract for design and construction of the project.

Project Description

The I-25/US 24/Cimarron St. interchange is located in the southwest corner of the confluence of Fountain Creek with Monument Creek. Generally, the interchange will be relocated about 70 feet west and 50 feet south of its current location. The planned interchange configuration includes replacement of existing bridges over Lower and Upper Fountain Creek and adds new bridges for the south-bound off ramp and for pedestrians over Monument Creek.

In addition to the bridge improvements the project includes the reconstruction of about 1,200 linear feet of Upper Fountain Creek, new and realigned regional trail improvements and the extension of the Bear Creek culvert under I-25.

Improvements along Lower Fountain Creek and Monument Creek will be limited to areas of transition to the new bridges and trails in the overbank areas or encroachment into the flood fringe and will not cause changes to the main channel bed or banks.

Proposed improvements potentially affecting regulatory floodplains are shown on Exhibits A and B in the attached report and summarized as follows:

<u>Lower Fountain Creek</u>

- Cimarron St. Bridge Replacement
    - replaces 3 piers in floodway with 2 piers
    - changes westerly sloping abutment to a vertical abutment
    - regional trail realignment
    - no changes to the channel bed or banks or existing drop structure configuration
- I-25 Realignment and Widening
    - Retaining wall along eastern edge of highway in right bank flood fringe between RS 28098 and RS 29130 (as defined by the WH Pacific DFIRM floodplain study)
    - Retaining wall along western edge of highway in Bear Creek flood fringe and floodway

<u>Upper Fountain Creek</u>

- Replace existing bridges for I-25 and the north-bound on ramp with piers in the floodway and the regional trail break-away bridge
- Construct new bridge for the south-bound off ramp with piers in the floodway
- Lower and widen channel from the Monument Creek confluence to the US 24 bridge in the floodway
- Construct boulder-lined low-flow channel
- Stabilization includes 3 drop structures and riprap protection downstream of US 24 bridge
- Construct regional trail along north bank

<u>Monument Creek</u>

- Construct new free-span, break-away pedestrian bridge over Monument Creek

<u>Bear Creek</u>

- Extend existing box culvert east and west under widened I-25
- Realign existing trail connections to transition into longer culvert

- Stabilize upstream and downstream transitions into the adjoining channel

Regulatory Floodplains and Proposed DFIRM

There are regulatory floodplains along Lower and Upper Fountain Creek, Monument Creek and Bear Creek adjacent to the project area (Map Panel No. 08041C0729 F). However, a major update of the flood hydrology for Fountain Creek and its regulatory floodplains is in the process of being completed through FEMA's Digital Flood Insurance Rate Map (DFIRM) program. The proposed changes to flood flows are documented in a Hydrology Study for Fountain Creek completed by Michael Baker Jr. Inc. for FEMA (April, 2010). In addition, two hydraulic studies of Fountain Creek floodplains were completed by WH Pacific Inc. (June, 2013) and Anderson Consulting Engineers, Inc. (May, 2013). These documents contain the technical analyses that are being incorporated into the DFIRMs and have been approved by FEMA.

Pre-project / Post-Project Comparisons

Because the technical evaluation of floodplains along Lower and Upper Fountain Creek through the project area has been completed and approved by FEMA for the DFIRM program, these analyses were used to evaluate potential project impacts. The proposed pedestrian bridge over Monument Creek will be a "clear-span", "break-away" structure with its abutments set into the banks of Monument Creek without encroachment into the floodway. Therefore, no analysis of the potential impacts of this bridge crossing was necessary. The Bear Creek floodplain was not updated with the DFIRM program studies and no effective model data was available. Therefore, project impacts were evaluated based on pre-project conditions.

<u>Lower Fountain Creek</u>

Cimarron St. Bridge - The proposed DFIRM floodway of Lower Fountain Creek is contained within the bridge opening of the existing Cimarron St. bridge. The proposed bridge replacement will also span the regulatory floodway. Replacement of the bridge will not change the main channel cross section or the configuration of the existing drop structure located at the downstream face of the existing bridge. The replacement bridge will reduce the number of piers in the floodway from 3 to 2. The eastern sloping bridge abutment will remain unchanged and the western bridge abutment will change from a sloping abutment to a vertical abutment.

The hydraulic analysis of the pre-project and post-project conditions shows that the proposed improvements will not increase in the proposed DFIRM Base Flood Elevation at the upstream face of the existing bridge, approximately at the location of FIS section ED.

I-25 Retaining Wall – The widening and realignment of I-25 will encroach into the flood fringe of Lower Fountain Creek between RS 28098 and RS 29130 as defined by the WH Pacific DFIRM

floodplain study. The proposed highway design will place fill and a retaining wall into the flood fringe area causing a rise in the 100-year BFE of about 0.2 feet at RS 28809. The rise in the water surface diminishes to 0.00 at RS 29130. The proposed improvements will be located entirely in the right overbank area of Lower Fountain Creek and will not alter the bed or banks of the main channel.

Upper Fountain Creek

The proposed DFIRM floodway through this reach includes the hydraulic effects of the existing bridges for the north-bound I-25 on ramp, the I-25 bridge and the regional trail pedestrian bridge. The proposed DFIRM floodway is contained within CDOT right-of-way, however, the 100-year floodplain extends onto adjacent private property to the north.

Proposed changes to Upper Fountain Creek between the Monument Creek confluence and US 24 include realigning, widening and lowering about 1,200 feet of the channel to a point about 170 feet downstream of the US 24 bridge where 3 drop structures will raise the invert to the elevation of the existing invert elevation at the downstream face of the bridge. Also, each of the existing bridges will be replaced and a new bridge will be added for the south-bound I-25 off ramp.

The hydraulic analysis of the pre-project and post-project conditions through the improved reach of Upper Fountain Creek shows that the post-project Base Flood Elevations will be no higher than the proposed DFIRM Base Flood Elevations at any location along the improved channel or at the upstream face of the US 24 bridge.

Bear Creek

Bear Creek currently joins Lower Fountain Creek as it passes through a double 14’ x 10’ concrete box culvert located approximately 100 feet upstream of the west bank of the creek. The upstream entrance creates backwater that transitions into a steep gradient channel on the main stem of Bear Creek. A regional concrete trail has been constructed in the north cell of the double box culvert above the culvert invert. No supporting documentation of the original analysis was available to compare to the current analysis.

Based on existing conditions it does not appear that the FIS mapping accurately shows the elevation of the existing culvert. Based on field survey data the upstream invert of the culvert is 1.34 feet higher than the elevation shown on the FIS profile. Therefore, the impact of the proposed improvements was evaluated based on the calculated difference between pre-project and post-project conditions rather than a direct comparison of FIS Base Flood Elevations.

Proposed improvements on Bear Creek include extending the box culvert downstream about 34 feet and upstream about 40 feet. The existing culvert invert slope of about 1.72% will be continued to the ends of the extended culvert. To maintain acceptable clearance over the trail, which rises sharply at the upstream end of the existing culvert, the culvert height at the upstream end will be increased from 10 feet to 12.5 feet. To ensure that the proposed improvements do not raise the upstream water surface elevations above pre-project conditions the southern cell of the box culvert will be widened from 14 feet to 20 feet.

Please accept the attached Floodplain Development Permit application and the supporting technical report for review and approval. We will be happy to answer any questions you may have during your review.

Certified by,

Vancel Fossinger

Vancel Fossinger, PE
For and on Behalf of
Wilson & Company

COLORADO REGISTERED
VANCEL S FOSSINGER
31972
5-27-14
PROFESSIONAL ENGINEER

Attachments

Floodplain Development Permit Form

I-25/US 24/Cimarron St. Interchange Reconstruction - Floodplain Hydraulic Analysis for Floodplain Development Permit Report, Wilson & Company, May, 2014

CD Labeled - I-25/US 24/Cimarron St. Interchange Reconstruction– Floodplain Development Permit Application and Hydraulic Model Files, May 27, 2014

Submit by Email | Print Form

PIKES PEAK REGIONAL FLOODPLAIN MANAGMENT OFFICE

Floodplain Development Permit Application

Date May 27

This application is required for authorization of any construction or modification within a designated floodplain. If you need further information regarding this application and regulations, call 719-327-2907. Submit application and attachments to the Regional Floodplain Administration at Pikes Peak Regional Building Department.

OFFICE USE ONLY

F.P. Permit #

Building Permit #

Property Owner Colorado Department of Transportation, Region 2

Address 1480 Quail Lake Loop

City Colorado Springs State CO Zip Code 80906

email Phone 719-227-3249

Contact Lesley Mace Phone 719-227-3249 email lesley.mace@state.co.us

Project Address/Location I-25 at US 24/Cimarron St. Interchange

Community # Colorado Springs 080060 Zip Code 80910 Creek Fountain

Parcel # FIRM # 0841C0729F **Base Flood Elevation** 5,960

Contractor To be determined Phone Number

email Fax Number

Project Type: *(Check all that apply to your project.)*

- [x] New Construction
- [ ] Addition/Remodel Repair
- [ ] Single Family
- [ ] Multi-Family
- [ ] Manufactured Unit
- [ ] Non-Residential Use
- [x] Water course modification
- [x] Fill/Excavation
- [x] Bridge
- [x] Culvert
- [ ] Other

Project Description: Reconst. I-25/US 24/Cimarron St. Interchange, see Wilson & Company report, Vance Fossinger.

Requirements of construction plans include:

- Label mean sea level elevations of proposed lowest floor. Flood proofing level must be noted on plans for new structures.
- All structural elements must be designed to withstand the effects of flooding by an engineer licensed by the state of Colorado.
- A state of Colorado licensed engineer must certify that construction in a *floodway* will not increase of flood elevations.
- Plans must be drawn to scale and include applicable items (listed in box).

- [x] Drawn to Scale
- [x] Dimensions
- [x] Elevations
- [x] Located correctly on site
- [x] All structures on plan
- [x] Fill areas indicated
- [ ] Drainage Plan
- [ ] Preliminary Elevation Certificate
- [ ] Finished Elevation Certificate

Created by

Office Use Only: FEMA Submttals

[ ] CLOMR	[ ] Approved	Date	
[ ] CLOMR-F	[ ] Approved	Date	
[ ] LOMR	[ ] Approved	Date	
[ ] LOMR-F	[ ] Approved	Date	

I-25/US 24/Cimarron St. Interchange Reconstruction
Colorado Springs, CO

Floodplain Hydraulic Analyses for Floodplain Development Permit Report

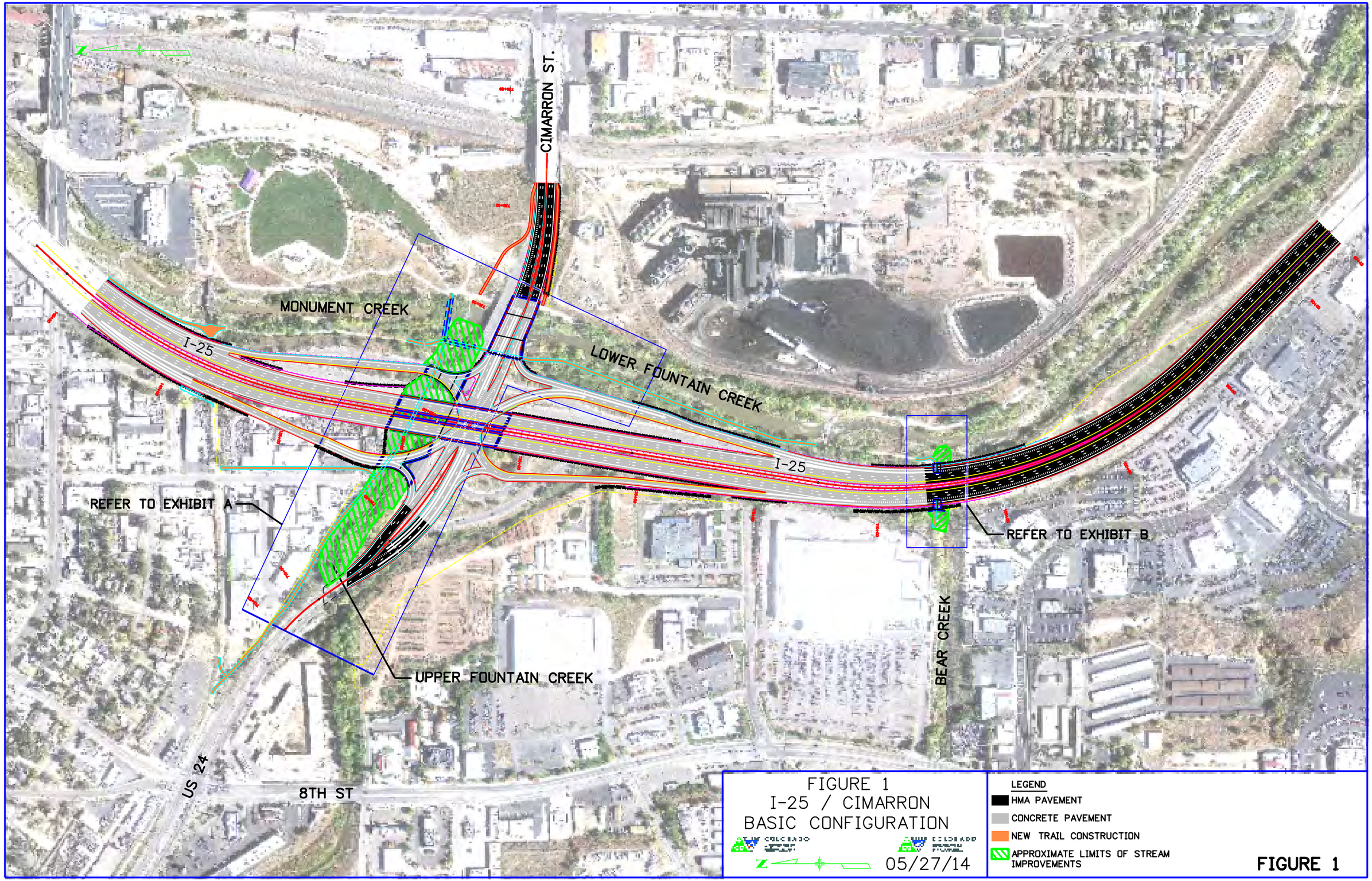
May 27, 2014

Introduction

This report describes hydraulic analyses completed to evaluate the potential impact to the regulatory floodplains in drainageways associated with the proposed reconstruction of the Interstate 25 (I-25)/US Highway 24 (US 24)/Cimarron St. Interchange located in Colorado Springs, El Paso County, Colorado. (see Figure 1). The evaluation was completed for the Colorado Department of Transportation (CDOT) in preparation of the assembly of design-build bid documents for the project. The evaluation addresses floodplain issues related to portions of Lower and Upper Fountain Creek near the confluence with Monument Creek and to the Bear Creek tributary which joins Lower Fountain Creek within the project area approximately 2,100 feet south of the Monument Creek confluence.

Project Description

The I-25/Cimarron St. interchange is located in the southwest corner of the confluence of Fountain Creek with Monument Creek (confluence). The confluence divides Lower Fountain Creek and Upper Fountain Creek. The project involves the reconstruction of the existing interchange from a combined cloverleaf and J ramp configuration to a "single point interchange" configuration. Generally, the interchange will be relocated about 70 feet west and 50 feet south of its current location. The planned interchange configuration includes replacement of the I-25 bridge over Upper Fountain Creek approximately 400 feet west of the confluence, replacement of the bridge over Upper Fountain Creek for the north-bound on ramp about 250 feet west of the confluence, replacement of the Cimarron St. bridge over Lower Fountain Creek about 150 feet south of the confluence and replacement of the pedestrian bridge over the Upper Fountain Creek about 150 west of the confluence. A new bridge over Upper Fountain Creek will be constructed about 700 feet west of the confluence for the south-bound off ramp of the new interchange. All of the roadway bridges will have pier supports located within the floodway. A new pedestrian bridge will be constructed about 100 north of the confluence over Monument Creek connecting the regional trail along the west bank of the creek to the eastern trail system. The US 24 bridge over Upper Fountain Creek about 1,200 feet west of the confluence which will remain in place.


CIMARRON ST.
MONUMENT CREEK
I-25
LOWER FOUNTAIN CREEK
I-25
REFER TO EXHIBIT A
REFER TO EXHIBIT B
UPPER FOUNTAIN CREEK
BEAR CREEK
US 24
8TH ST
FIGURE 1
I-25 / CIMARRON
BASIC CONFIGURATION
05/27/14
LEGEND
HMA PAVEMENT
CONCRETE PAVEMENT
NEW TRAIL CONSTRUCTION
APPROXIMATE LIMITS OF STREAM IMPROVEMENTS
FIGURE 1

In addition to the bridge improvements the project includes the reconstruction of about 1,200 linear feet of Upper Fountain Creek west of the confluence to the US 24 bridge. Proposed channel improvements include lowering the channel invert and redefining the channel section to pass flood flows under the new bridges. The low flow channel is expected to require 3 small grade control structures to raise the lowered channel invert to the existing invert elevation at the downstream side of the US 24 bridge.

A regional, Tier 1, concrete pedestrian trail is proposed along the north bank of Upper Fountain Creek connecting the existing regional trails on Lower Fountain Creek and Monument Creek with the new pedestrian bridges and the existing Midland Trail.

Improvements along Lower Fountain Creek and Monument Creek will be limited to areas of transition to the new bridges and trails in the overbank areas or encroachment into the flood fringe and will not cause changes to the main channel bed or banks or to Base Flood Elevations.

Widening and realignment of I-25 along the west bank of Lower Fountain Creek will shift the edge of the highway about 35 feet east toward Lower Fountain Creek and about 40 feet west toward Bear Creek which is tributary to Lower Fountain Creek at about I-25 Station 107+50.

Exhibits A and B show existing conditions and proposed improvements for the major drainageways.

Regulatory Floodplains

There are regulatory floodplains and floodways on Lower and Upper Fountain Creek, Monument Creek and Bear Creek adjacent to the project area. (See Figure 2) The current Effective Maps on Fountain Creek and Monument Creek through the project area are based on the Flood Insurance Study (FIS), revised August 23, 1999 and two Letters of Map Revision (LOMR), one dated July 2, 2003 and the other dated December 30, 2004. The FIRM Map Panel No. is 08041C0729 F. The 2003 LOMR modified Base Flood Elevations (BFEs) along Lower Fountain Creek between sections DZ and ED. Section ED is located immediately upstream of the Cimarron St. bridge over Lower Fountain Creek and just downstream of the Monument Creek confluence. The 2004 LOMR modified BFEs along Upper Fountain Creek between section EJ and EO. Section EJ is located just upstream of the US 24 bridge, west of the project area.

A major update of flood hydrology for Fountain Creek and the regulatory floodplain is in the process of being completed through FEMA's Digital Flood Insurance Rate Map (DFIRM) program. The proposed changes to flood flows are documented in a Hydrology Study for Fountain Creek completed by Michael Baker Jr. Inc. for FEMA (April, 2010).

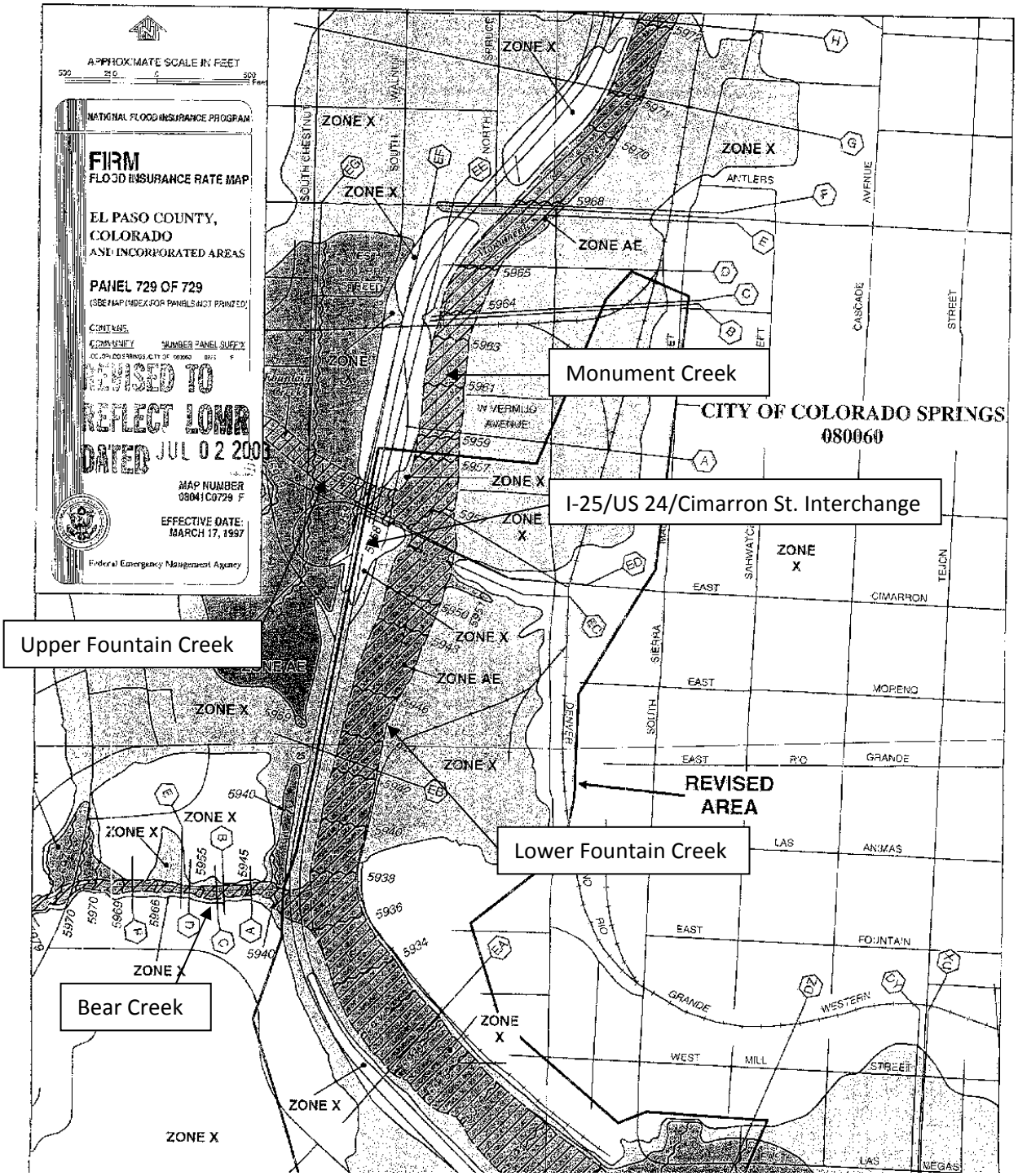


Figure 2 – FEMA FIRM Near I-25/US 24/Cimarron St. Interchange

The FIS flood flows and the updated DFIRM flows are summarized in Table 1. Two hydraulic studies of Fountain Creek floodplains were completed by WH Pacific Inc. (June, 2013) and

Anderson Consulting Engineers, Inc. (May, 2013). These documents contain the technical analyses that are being incorporated into the DFIRMs and have been approved by FEMA. Acceptance letters, portions of the reports, and relevant workmaps for the two floodplain studies are included in Appendix A of this report.

Table 1 – Summary of Flood Flows by Stream Reach

Source	Stream Reach	10-year (cfs)	50-year (cfs)	100-year (cfs)	500-year (cfs)
FIS					
	Lower Fountain Creek	9,200	28,500	42,200	98,000
	Upper Fountain Creek	4,400	14,000	20,500	47,000
	Monument Creek[1]	11,500	23,500	32,000	57,000
	Bear Creek[1]	1,140	2,940	4,140	8,200
DFIRM[2]					
	Lower Fountain Creek	7,900	14,300	18,000	29,400
	Upper Fountain Creek	1,380	2,960	3,920	6,880

1. The Monument Creek and Bear Creek floodplains are not being restudied as part of the DFIRM program so reported flows are based on the Effective FIS.
2. DFIRM flows are based on the hydrology report completed by Michael Baker and as used for the hydraulic analyses by WHPacific and Anderson Consulting. These values must be validated by the final published DFIRM documents prior to their use for design and floodplain analysis and mapping.

Both the current Effective FIRM maps and the studies being used to create the DFIRMs are based on the NVGD 29 vertical datum. However, new FEMA mapping and the project datum is based on the NAVD 88 vertical datum. All analyses completed for this evaluation are based on the NAVD 88 vertical datum. The conversion from NVGD 29 to NAVD 88 was made by adding 3.50 feet to all elevations.

Pre-project / Post-Project Evaluation

Because the technical evaluation of floodplains along Lower and Upper Fountain Creek through the project area has been completed and approved by FEMA as part of the DFIRM program, these analyses were used to evaluate potential project impacts on these reaches. The proposed pedestrian bridge over Monument Creek will be a “clear-span”, ”break-away” structure with its abutments set into the banks of Monument Creek without encroachment into

the floodway. Therefore, no analysis of the potential impacts of this bridge crossing was completed. The Bear Creek floodplain was not updated with the DFIRM program studies and no effective model data was available. Therefore, the evaluation of potential project impacts on this reach was based on pre-project conditions using current topographic mapping and field surveys. Each of the hydraulic analyses was executed using the US Army Corps of Engineers computer program HEC-RAS 4.1.0.

Lower Fountain Creek

Cimarron St. Bridge - The proposed DFIRM floodway of Lower Fountain Creek is contained within the bridge opening of the existing Cimarron St. bridge. The existing bridge is about 87 feet wide and has three pier supports in the floodway and the bridge is located just upstream of a 6 foot high drop structure. The proposed bridge replacement will also span the regulatory floodway. The replacement bridge will be about 110 feet wide and be located approximately 50 feet downstream. Replacement of the bridge will not change the main channel cross section or the configuration of the drop structure. The replacement bridge will have two bridge piers within the floodway. The eastern sloping bridge abutment will remain unchanged and the western bridge abutment will change from a sloping abutment to a vertical abutment. The location of the existing trail will remain along the western abutment on the overbank of the channel at approximately the same location and elevation as the existing trail. The location of the existing and proposed bridges and trails is shown on Exhibit A.

To evaluate the potential impact of the proposed improvements the pre-project (DFIRM) model was modified to represent the post-project improvements and the resulting 100-year water surface elevations were compared to the pre-project water surface elevations for the 100-year flow using the updated DFIRM flow rate.

The hydraulic analysis shows that the proposed bridge and trail realignment does not increase the water surface at the next upstream DFIRM model section RS 30623 (approx. FIS section ED), located immediately upstream of the existing Cimarron St. bridge. The detailed results of the hydraulic analysis are included in summary reports and cross section and profile plots provided in Appendix B. The hydraulic model files are provided on the enclosed CD.

No changes to the channel are required for stabilization. The existing drop structure will remain in place providing a fixed location of the bed and banks of Lower Fountain Creek where it passes under the new bridge.

I-25 Retaining Wall – The widening and realignment of I-25 will encroach into the flood fringe of Lower Fountain Creek between RS 28098 and 29130 as defined by the WH Pacific DFIRM floodplain study. The proposed highway design will place fill and a retaining wall into the flood fringe area causing a rise in the 100-year BFE of about 0.2 feet at RS 28809 which diminishes to 0.00 at RS 29130. The proposed improvements will be located entirely in the right overbank area of Lower Fountain Creek and will not alter the bed or banks of the main channel. The proposed project improvements and the encroachment are shown on Exhibit B.

Upper Fountain Creek

The proposed DFIRM floodway through this reach includes the hydraulic effects of the existing bridges for the north-bound I-25 on ramp, the I-25 bridge and the regional trail pedestrian bridge over the creek. The proposed DFIRM floodway is contained within CDOT right-of-way, however, the 100-year flood fringe extends onto adjacent private property to the north.

Proposed changes to Upper Fountain Creek between the Monument Creek confluence and US 24. include lowering the channel profile from the confluence to about 170 feet downstream of the US 24 bridge at a slope of 0.7%. A 2 foot deep, 15 foot wide low-flow channel will be constructed in the bottom of an 80 foot wide main channel. Three rock drop structures of less than 1.0 foot each will raise the channel invert to match the elevation of the existing channel at the downstream face of the Cimarron St. bridge. Existing conditions and proposed improvements are shown on Exhibit A.

The pre-project (DFIRM) model was modified to represent the proposed improvements. The hydraulic analyses of the pre-project and post-project conditions between DFIRM RS 15 and 1432 on Upper Fountain Creek show that the planned lowering and widening of the channel will result in no rise in the 100-year water surface through this reach and the entire floodplain will be contained within the flood control channel and CDOT right-of-way. Results of the hydraulic analysis are included in summary reports and cross section and profile plots provided in Appendix C.

Proposed channel improvements will be stabilized through revegetation and hardened surfaces as needed. Stabilization along the low-flow channel will be provided by a boulder and cobble rock lining and 3 grade control structures. Riprap protection will be required through the transition downstream of the existing US 24 bridge to where the typical channel cross section begins, approximately 200 feet downstream of the bridge face.

Bear Creek

Bear Creek currently joins Fountain Creek as it passes through a double 14' x 10' concrete box culvert located approximately 100 feet upstream of the west bank of Lower Fountain Creek. The upstream entrance creates backwater that transitions into a steep gradient channel on the main stem of Bear Creek. The FIS shows that 100-year flood water would pond to the north along the I-25 embankment and to the south where it overtops into the shallow side channel along the westerly edge of I-25 and ultimately overtops I-25. No supporting documentation of the original analysis was available to compare to the current analysis.

A regional concrete trail has been constructed in the north cell of the double box culvert that is 10 feet wide and 7.5 inches above the culvert invert. The construction of the trail creates a small, shallow channel between the edge of the trail and the dividing wall of the double box culvert and effecting the capacity of the northerly culvert cell.

Based on existing conditions and the FIS 100-year flow of 4,140 cfs it does not appear that the FIS mapping accurately shows the effects of the existing culvert. The FIS report indicates that the upstream culvert invert is at about elevation 5,929.0 and that the Base Flood Elevation just upstream of the culvert entrance is 5,943.4 indicating a backwater depth of 14.4 feet. The BFE at the first FIS cross section (Section A) on Bear Creek is reported to be 5,943.4, 14.4 feet above the culvert invert. Adjusting to the NAVD 88 datum the invert and BFE elevations would be 5,932.5 and 5,946.9, respectively.

Based on field survey data the upstream invert of the culvert is at elevation 5,933.84 feet, indicating a difference of 1.34 feet between the FIS invert elevation and surveyed elevations. Therefore, based on the reported backwater depth from the FIS and accurate survey data for the culvert invert the adjusted BFEs at the upstream entrance to the culvert and at Section A should be 5,948.24.

A pre-project hydraulic model was created to represent existing conditions at the crossing. The hydraulic evaluation of the pre-project culvert configuration shows that the 100-year flow of 4,140 cfs causes a backwater elevation of 5947.75 at the upstream face of the culvert and 5947.41 at FIS Section A (RS 347). This analysis shows that there is only a backwater depth of 13.91 feet at the upstream face of the culvert or about 0.5 feet less than indicated by the FIS profile.

To ensure that the proposed improvements do not raise the upstream water surface elevations above pre-project conditions proposed project improvements were adjusted to cause 100-year

water surface elevations no higher than pre-project levels. Proposed improvements at Bear Creek include extending the box culvert downstream about 34 feet and upstream about 40 feet. The existing culvert invert slope of about 1.72% will be continued to the ends of the extended culvert. To maintain acceptable clearance over the trail which rises sharply at the upstream end of the existing culvert, the culvert height at the upstream end will be increased from 10 feet to 12.5 feet. To avoid raising the 100-year water surface at the upstream end of the culvert the southern cell will be widened from 14 feet to 20 feet. Improvements also include transitions to the concrete trails at the entrance and exit of the culvert and stabilization of the inflow and outflow channels. Existing site conditions and proposed improvements are shown on Exhibit B.

The pre-project hydraulic model was modified to represent the proposed conditions and to show that the post-project 100-year water surface elevations will not be high than pre-project elevations. The results of this analysis are summarized in Appendix D.

References

Flood Insurance Study, El Paso County, Colorado and Incorporated Areas, August 23, 1999, FEMA.

Letter of Map Revision, City of Colorado Springs, July 2, 2003, Case No.:02-08-490P, FEMA.

Letter of Map Revision, City of Colorado Springs, December 30, 2004, Case No.:04-08-0314P, FEMA.

Hydrology Report for Fountain Creek, El Paso CO, April, 2010, Michael Baker Jr. Inc.

Fountain Creek Floodplain Restudy, Monument Creek to Colorado Springs Southern City Limit, June, 2013, WHPacific, Project No. 500907/501007.

Revised Hydraulic Modeling and Flood Hazard Mapping for Upper Fountain Creek, May 14, 2013, Anderson Consulting Engineers, Inc.

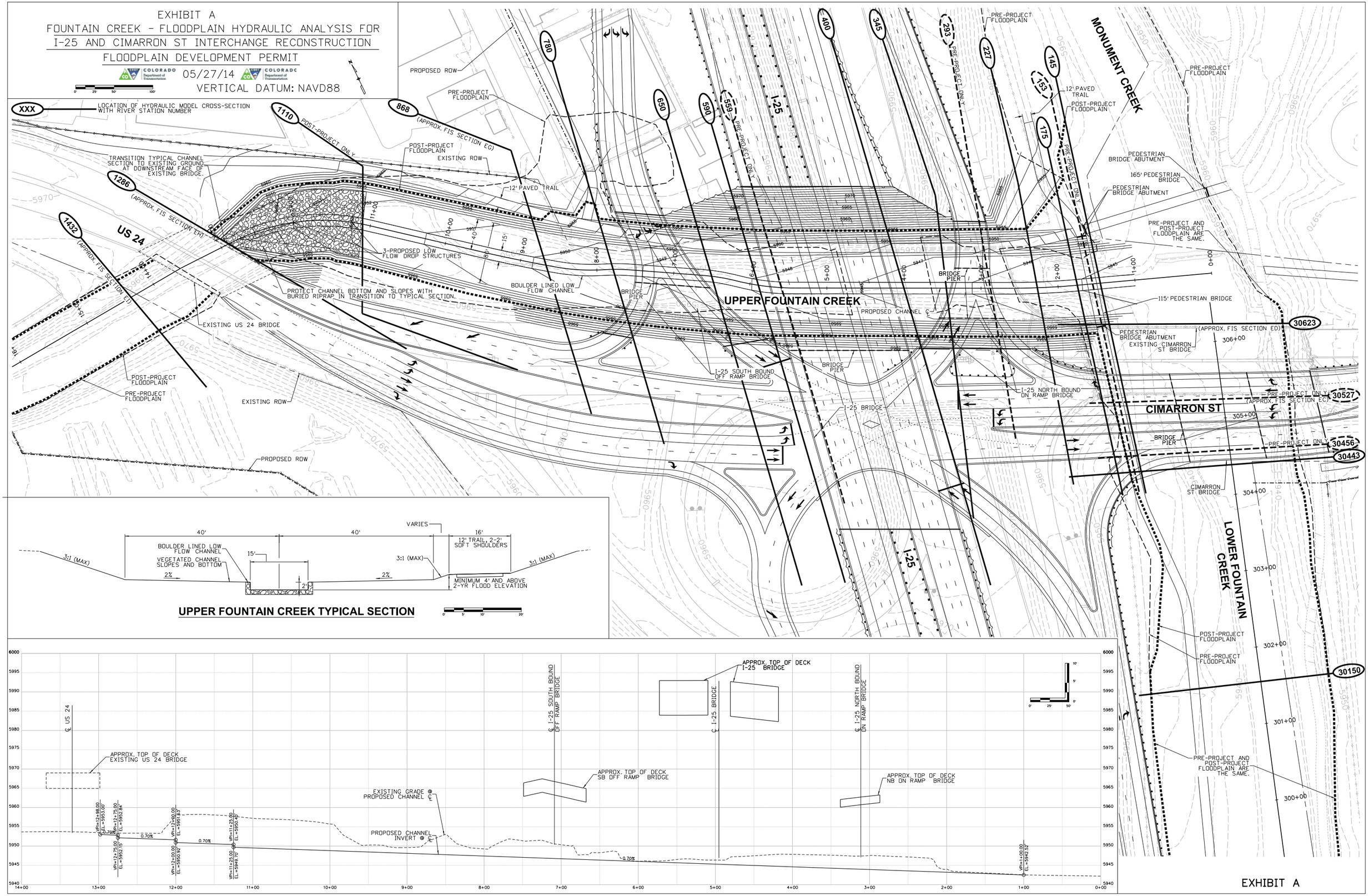
EXHIBIT A

FOUNTAIN CREEK - FLOODPLAIN HYDRAULIC ANALYSIS FOR I-25 AND CIMARRON ST INTERCHANGE RECONSTRUCTION

FLOODPLAIN DEVELOPMENT PERMIT

COLORADO Department of Transportation — 05/27/14 — COLORADO Department of Transportation

VERTICAL DATUM: NAVD88



UPPER FOUNTAIN CREEK TYPICAL SECTION

EXHIBIT A

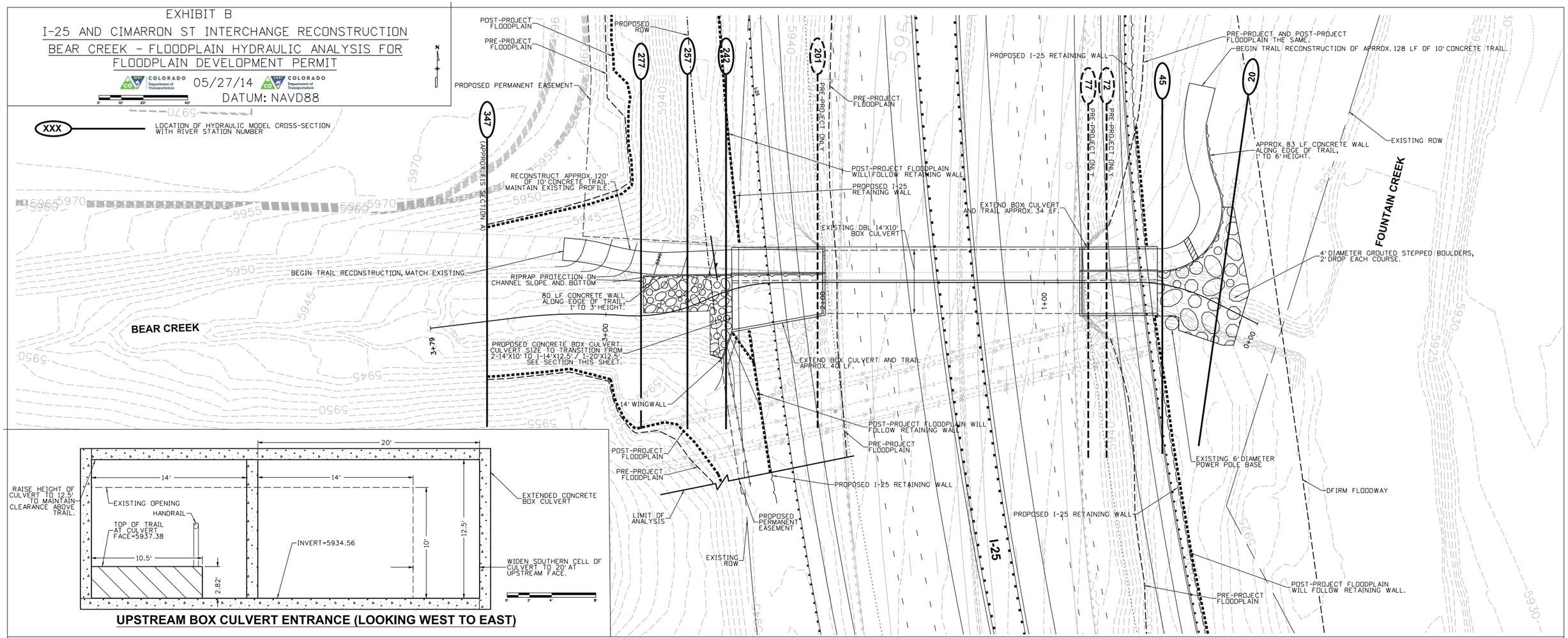
EXHIBIT B

I-25 AND CIMARRON ST INTERCHANGE RECONSTRUCTION

BEAR CREEK - FLOODPLAIN HYDRAULIC ANALYSIS FOR FLOODPLAIN DEVELOPMENT PERMIT

COLORADO Department of Transportation 05/27/14 COLORADO Department of Transportation

DATUM: NAVD88



UPSTREAM BOX CULVERT ENTRANCE (LOOKING WEST TO EAST)

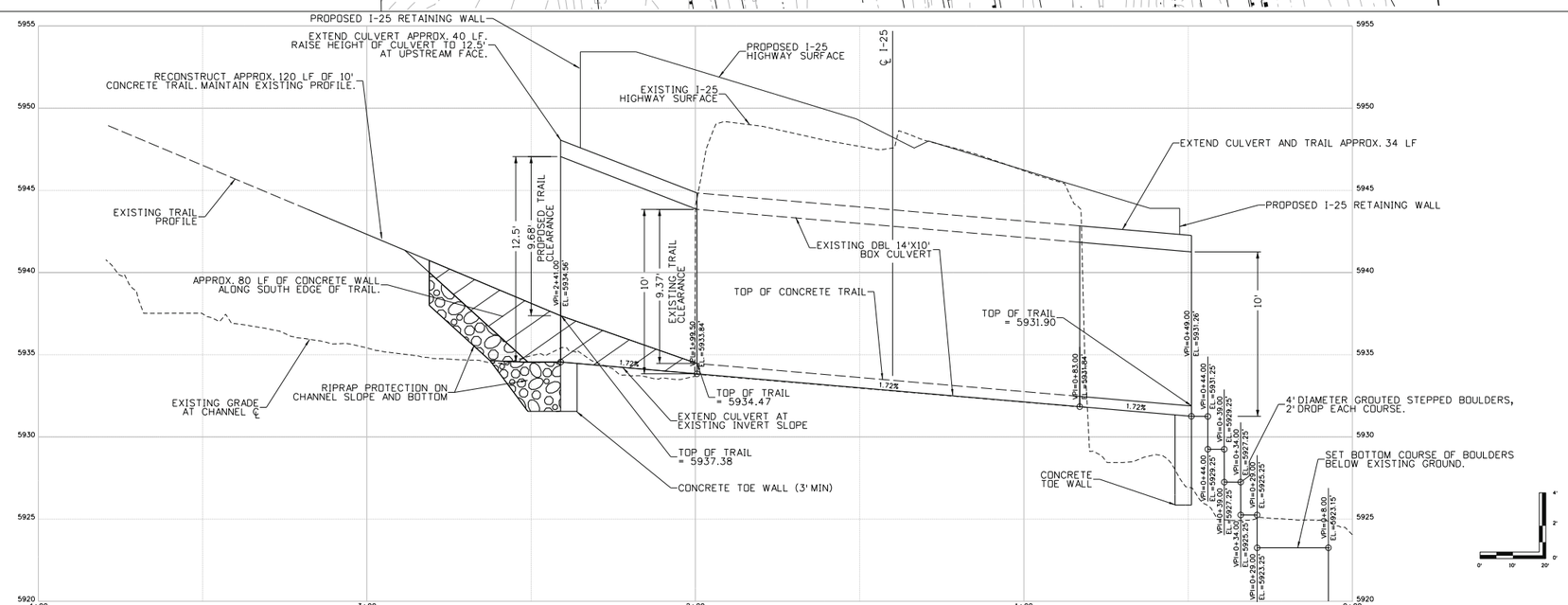


EXHIBIT B

Appendix A

DFIRM Floodplain Study Acceptance Letters and Report Portions and Work Maps

BakerAECOM
An Integrated Production Team

In coordination with FEMA

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Kansas City, MO 64108
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June 19, 2013

Ms. Jeanne Boyle, P.E.
WHPacific
1536 Cole Boulevard, Suite 150
Lakewood, CO 80401

Ms. Boyle,

You recently submitted the revised report entitled, "Fountain Creek Floodplain Restudy", prepared by WHPacific and dated June 2013, along with supporting documentation for our comment and review. Under direction of the FEMA Region VIII office, we have completed a review of the submitted hydraulic and floodplain mapping analysis for Fountain Creek within El Paso County, Colorado. The purpose of this letter is to summarize our review comments and provide corresponding documentation of our review.

The above referenced report provided a hydraulic analysis for approximately 5.2 miles of detailed study for Fountain Creek from the downstream limit at the southern city limit of Colorado Springs to the upstream limit at the confluence of Monument Creek. Hydraulic analyses were completed using the USACE HEC-RAS Version 3.1.3. Floodplain mapping data provided included digital workmaps, floodplain boundaries, profiles and floodway data tables.

We found the above referenced report and supporting documentation to be reasonable and complete. If you have any questions or comments regarding this letter or review, please contact me at 816-502-9420 x4981.

Sincerely,

Stephanie Porter, CFM

Cc: Ms. Dawn Gladwell, Mr. Ryan Carroll, Mr. Dan Bare, Mr. Bob Cope, Ms. Thuy Patton, Mr. Greg Koch, Mr. Travis Rounsaville, Mr. Ben Ackert, Mr. Colin McKernan, Ms. Amanda Banks

FOUNTAIN CREEK FLOODPLAIN RESTUDY

MONUMENT CREEK TO THE COLORADO SPRINGS SOUTHERN CITY LIMIT

Prepared by:

WHPacific
1536 Cole Boulevard, Suite 150
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303-458-5550

Prepared for:

CITY OF COLORADO SPRINGS
30 S. Nevada Avenue, Suite 502
Colorado Springs, CO 80901

April 2009
Revised January 2011
Revised June 2011
Revised August 2011
Revised March 2013
Revised May 2013
Revised June 2013

WHPacific Project No. 500907/501007

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COLORADO REGISTERED
JEANNE M. BOYLE
27639
PROFESSIONAL ENGINEER

APPENDICES

Appendix A: Fountain Creek Main Channel HEC-RAS Modeling

Appendix B: Interstate 25 Split Flow HEC-RAS Modeling

Appendix C: Las Vegas WWTP Split Flow HEC-RAS Modeling

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REPORT	Fountain Creek Floodplain Restudy Monument Creek to the Colorado Springs Southern City Limit

INTRODUCTION

A restudy of all flooding sources in the El Paso County FIS is currently underway and being managed by the Colorado Water Conservation Board (CWCB). WHPacific is contributing to this restudy by carrying out updated floodplain modeling for the 4.6 mile reach of Fountain Creek from the Monument Creek confluence to the southern City of Colorado Springs limit at the Southern Pacific Railroad Army Spur Bridge. The bridge is located just upstream of the confluence with Sand Creek and the Highway 85/87 Bridge. WHPacific's work has been funded by the City of Colorado Springs and was initiated and originally completed in August 2011, earlier than the rest of the El Paso County restudy, because it was needed for an on-going stabilization study of Fountain Creek also being carried out by WHPacific. Since August 2011, the floodway for this reach was analyzed by Anderson Consulting Engineers (ACE) in conjunction with the El Paso County DFIRM conversion project. The ACE analysis is documented in the Revisions to Fountain Creek and Upper Fountain Creek Floodplain/Floodway Mapping report, dated June 15, 2012. The ACE floodplain analysis for Fountain Creek utilized the HEC-RAS model prepared by WHPacific, and also incorporated recent abutment protection measures near Circle Drive and made adjustments to the WHPacific floodplain analysis in three other areas, including:

- Refining the ineffective flow area on the left overbank just downstream of Nevada Avenue.
- Revised the ineffective flow area at the upstream end of the Las Vegas WWTP area and revised the North Overflow flow split analysis method. This revision is further discussed in Appendix C.
- Revised the cross section and starting water surface elevations at the downstream end of the study reach at the Army Railroad Spur Bridge to match the upstream section of the URS floodplain study that was approved in 2012, after the original August 2011 Fountain Creek Restudy was completed. This revision is further discussed in the Hydraulic Analysis - Boundary Conditions section of this report.

ACE's report was submitted to FEMA for review. The review was performed by BakerAECOM who provided comments to ACE dated August 16, 2012. The March 2013 update to the Fountain Creek Floodplain Restudy was prepared by WHPacific to include the floodway analysis and to address the August 16, 2012 review comments by BakerAECOM. This May 2013 update to the Fountain Creek Floodplain Restudy addresses BakerAECOM review comments dated April 17, 2013 and includes flood profiles, floodway data tables, and updated workmaps with Base Flood Elevations (BFEs).

HYDROLOGY

The most current hydrologic data for Fountain Creek is contained in the *Hydrology Report for Fountain Creek, El Paso County, CO* (HRFC) by Michael Baker Jr. Inc. (Revised: April 2010). In that study, seven USGS gage locations were studied to determine the 10-, 2-, 1-, and 0.2- percent-annual-chance-exceedance hydrologic peak flows for Fountain Creek. The gages were located along Fountain Creek within El Paso and Pueblo counties. The HRFC streamflows have been accepted by FEMA for updates to the El Paso County FIS and have been utilized by WHPacific for the restudy of Fountain Creek. HRFC existing condition flows are presented in **Table 1**. The HRFC streamflows are significantly lower than those used in the effective FIS entitled *Flood Insurance Study, El Paso County, Colorado and Incorporated Areas,* FEMA (Revised: August 23, 1999). Effective FIS flows are presented in **Table 2** for comparison.

Table 1 – 2010 Hydrology Report for Fountain Creek Summary of Discharges

Location Description	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
Fountain Creek at Colorado Springs, CO	7,900	14,300	18,000	29,400
Fountain Creek at Janitell, CO	11,800	18,800	22,400	32,200

Table 2 – 1999 Effective FIS Summary of Discharges

Location Description	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
Fountain Creek from below Monument Creek to above Sand Creek	9,200	28,500	42,200	98,000

MAPPING AND SURVEY DATA

Aerial Photography. Aerial photography utilized in the study was provided by Colorado Springs Utilities (CSU) from their Facility Information Management System (FIMS). The date of the photography is 2005.

Topographic Mapping. Topographic mapping used for the Fountain Creek restudy was compiled from four sources:

1) Colorado Springs Utilities (CSU) Facility Information Management System (FIMS). Topography provided by CSU is from 2000. The vertical datum for this information is NGVD 1929.
2) 2008 Field Survey of the Fountain Creek channel bottom by the 4M Group. The vertical datum for this information is NGVD 1929.
3) I-25/Nevada/Tejon post-project topographic mapping provided by Moser & Associates. The mapping is based on CDOT as-built surveys of improvements to Interstate 25 and the Nevada

and Tejon Interchanges completed in 2004. The vertical datum for this information is NAVD 1988.

4) 2009 Field Survey of portions of the Fountain Creek channel bottom, between Cimarron and Tejon Streets, by Shavano Land Survey, Inc. The vertical datum for this information is NGVD 1929.

For a majority of the study area, the FIMS surface model was combined with a surface model of the channel bottom developed from the 2008 field survey. The 2009 field survey data was then spliced into the surface for about 3,000 feet of the channel bottom to create a single topographic map of the floodplain. The FIMS data, though, pre-dates modifications to Interstate 25 and the S. Nevada Avenue and S. Tejon Street interchanges completed in 2004. A request for Letter of Map Revision (LOMR) was developed by Moser and Associates for CDOT Region 2 based on updated topographic mapping for the modified reach. The report is entitled *Letter of Map Revision Request, Fountain Creek, Cheyenne Creek and Fountain Creek Overflow* (September 2005). It is our understanding that, to date, the LOMR has not been submitted or approved. Moser provided the LOMR mapping for this area to WHPacific. To incorporate this mapping into the study, the datum had to be adjusted from NAVD88 to NGVD29 by subtracting 3.48 feet. WHPacific converted the Moser topography to a surface model, subtracted 3.48 ft from all data points and regenerated the topography. The datum converted Moser mapping was then used for modeling of that reach of Fountain Creek where highway modifications had taken place. Each of the plan sheets showing the restudy floodplain boundaries includes a note specifying which mapping was used on the sheet. Sheet 2 utilizes the Moser topography adjusted to NGVD29 combined with the 2009 channel bottom survey, while all other sheets utilize the FIMS mapping combined with the 2008 and 2009 channel bottom surveys.

HYDRAULIC ANALYSIS

Hydraulic analysis was carried out using HEC-GeoRAS Version 4 and HEC-RAS version 4.1.0. HEC-GeoRAS was utilized to cut cross sections, assign Manning's n values and determine stream lengths. All other model data was entered directly into HEC-RAS.

Model Development

Manning's n Values. Manning's n values corresponding to present day conditions were determined from site visits and using the high resolution 2000 aerial photography provided by CSU. Manning's n values provided in *Open-Channel Hydraulics* (Ven Te Chow, Ph.D. *Open-Channel Hydraulics.* USA: McGraw-Hill Book Company, 1959) were used as a guideline to determine Manning's n values for the study reach.

Bridges. Data for all road bridges was adopted from the 2006 Fountain Creek Watershed Study by URS. New surveys of all bridges were carried out for that study. Pedestrian bridges have not been included in the hydraulic modeling. Fastening of the bridges to their abutments varies but all are cabled on one side to their abutments. None have been included in the model assuming that they are breakaways or will

fail before peak flows arrive. The effective FIS does not include any of the pedestrian bridges nor do any of the subsequent LOMR/CLOMR models.

Aerial Utility Crossings. In addition to electric lines that are elevated well above flood levels, the study reach contains one aerial gas and water crossing located at station 172+00. The utility lines cross the floodplain between two highway bridges at a ninety degree angle to the bridges making modeling of the structure difficult at best. Survey data for the crossing was not available but rough field measurements indicate that the crossing is elevated above the 100- and 500-year flood levels. Based on review of the situation by Michael Baker Jr. Inc., the utility crossing has not been included in the restudy model. The effective FIS does not include this crossing nor do any of the subsequent LOMR/CLOMR models.

Blocked Obstructions. Where large commercial or industrial buildings are present, multiple blocked obstructions were used to model the structures in the Restudy. Smaller structures, such as homes, were modeled in the Restudy by increasing the Manning's n value in the overbank areas.

According to FEMA requirements, levee elements may not be used as a modeling tool in HEC-RAS unless the embankment is certified as an actual levee. That being the case, normal blocked obstructions were used in this Restudy (instead of levee elements) to "block out" channel flow areas where split flow channels are located adjacent to the main channel. The split flow channels were modeled as disconnected flow areas separated by embankments from the main channel. Without using levee elements or normal blocked obstructions, the resulting top width of the main channel flow would extend beyond the embankment into the split flow channel area. With the normal blocked obstruction method, flow is not shown conveyed beyond the left and/or right obstruction stations, similar to using levee elements.

Drop Structures. The study reach contains numerous drop structures. Survey data for the drops was obtained as part of the 2008 4M Group channel bottom survey. Drops have been included in the modeling with cross sections located at the crest and toe of each.

Boundary Conditions. Starting water surface elevations at the City of Colorado Springs southern corporate boundary, which is immediately upstream of the Army Railroad Spur Bridge (station 50+32), were provided by URS Corporation for the 10-, 50-, 100-, and 500-year events. URS completed a floodplain study of both reaches of Fountain Creek just upstream and downstream of the reach modeled in this Restudy and received approval from FEMA in 2012. The water surface elevations determined by URS were calculated using the HRFC, April 2010 flows and were input into the Restudy HEC-RAS model as the known water surface elevations for the downstream reach boundary conditions at cross section 50+32. The floodplain and floodway limits from the URS study are shown at the upstream and downstream ends of the Restudy reach on the enclosed drawings.

Flow Splits. Split flows were simulated in the study reach at two different locations. The hydraulic models for the flow splits were incorporated into the Fountain Creek HEC-RAS model as separate channel reaches. Inflows to the flow split channel reaches were determined by a combination of flow distribution data as reported by HEC-RAS for the cross section where the split occurs and by including

lateral weir structures in the model to determine the flow spilled to the overflows. Boundary conditions for the split flow channel reaches varied. The flow split modeling is described below.

1. Interstate 25 Split Flow (South Overflow) - A split flow condition exists in the south overbank between the S. Nevada Avenue Bridge and the Highway 24 Bypass bridges for the 500-year event. In this reach, I-25 is elevated on an embankment and creates two independent stream flows, the Fountain Creek main channel and the South Overflow. Inflow to the South Overflow channel reach was determined by flow distribution data as reported by HEC-RAS at cross section 238+42 where the split occurs.

   Flow from the main channel also spills to the South Overflow across the highway divider wall. The highway divider wall was included as a lateral weir in the main channel reach between sections 225+52 and 182+05. The divider wall was also included along the entire length of the South Overflow reach between sections 59+77 and 0+94. Flows were allowed to spill into the South Overflow reach as well as return to the main channel reach along the length of the wall. Only one flow exchange location occurred between the two reaches from the main channel between Sta.'s 216+00 and 210+00 into the South Overflow channel at section 40+40.

   The downstream end of the South Overflow reach is routed to the main channel reach via the Spring Creek culvert and connected in the model at Junction 3 (located between sections 161+91 and 159+13). Due to about a 29-foot drop from the South Overflow to the main channel invert, the South Overflow is not hydraulically connected to the main channel flow and defaulted to using critical depth at the downstream end instead of the main channel water surface elevation at the junction.

2. Las Vegas WWTP Split Flow (North Overflow) - A split flow condition exists on the west side of the Las Vegas Wastewater Treatment Plant along the alignment of the Fountain Mutual Canal. The split exists for 100- and 500-year conditions. A lateral weir was included in the main channel reach between sections 203+52 and 200+53 to simulate the flow split.

   The downstream end of the North Overflow reach is connected to the main channel reach at Junction 2 (located between sections 182+05 and 179+25). The treatment plant is on a fill site and has a steep drop-off on the eastern edge to historic grades. The overflows are contained in a steep swale that outfalls to the main channel about 13 feet above the main channel invert.

<u>Right Overbank Ineffective Flow at Tejon Street Bridge</u>. Cross sections at the Tejon Street Bridge show a ridge of high ground at the right abutment of the bridge that would appear to confine flows to the main channel. Ineffective flow markers were not placed on these cross sections because immediately upstream (50 ft +/-) right bank elevations drop significantly and flooding will extend into the right overbank beyond the abutment.

Floodway Modeling. The one-foot rise floodway for the study reach was initially analyzed by Anderson Consulting Engineers (ACE) in conjunction with the El Paso County DFIRM conversion project. The ACE analysis is documented in the Revisions to Fountain Creek and Upper Fountain Creek Floodplain/Floodway Mapping report, dated June 15, 2012. WHPacific incorporated the proposed ACE floodway encroachment limits into the updated Restudy HEC-RAS model and modified the encroachments as needed to eliminate negative surcharges and water surface elevation rises greater than one foot.

HEC-RAS Model Files. The floodplain and floodway models are included in one HEC-RAS project file. The project filename is ***FountainFPRestudy.prj***. The model reaches, plan names, and descriptions are provided below.

Model Reaches

Fountain Creek Main Channel – Main, NOF to SOF, and Main DS – The Fountain Creek main channel is a 4.6 mile long study reach extending from the upstream side of the Southern Pacific Railroad Army Spur Bridge to the upstream side of the Cimarron Street bridge at the confluence with Monument Creek. The main channel was divided into three reaches (Main, NOF to SOF, and Main DS) in the HEC-RAS model to create junctions (Junction 2 and Junction 3) for the connection of the South Overflow and North Overflow to the main channel.

South Overflow – SOF – The South Overflow is a split flow reach in the right (looking downstream) overbank area between the S. Nevada Avenue Bridge and the Highway 24 Bypass Bridges. The South Overflow is connected to the Fountain Creek main channel at Junction 3. The flow split occurs for the 500-year event only.

North Overflow – NOF – Split flow reach in the left (looking downstream) overbank at the Las Vegas Wastewater Treatment Plant. The North Overflow is connected to the Fountain Creek main channel at Junction 2. The flow split occurs for the 100- and 500-year events only.

Model Plans

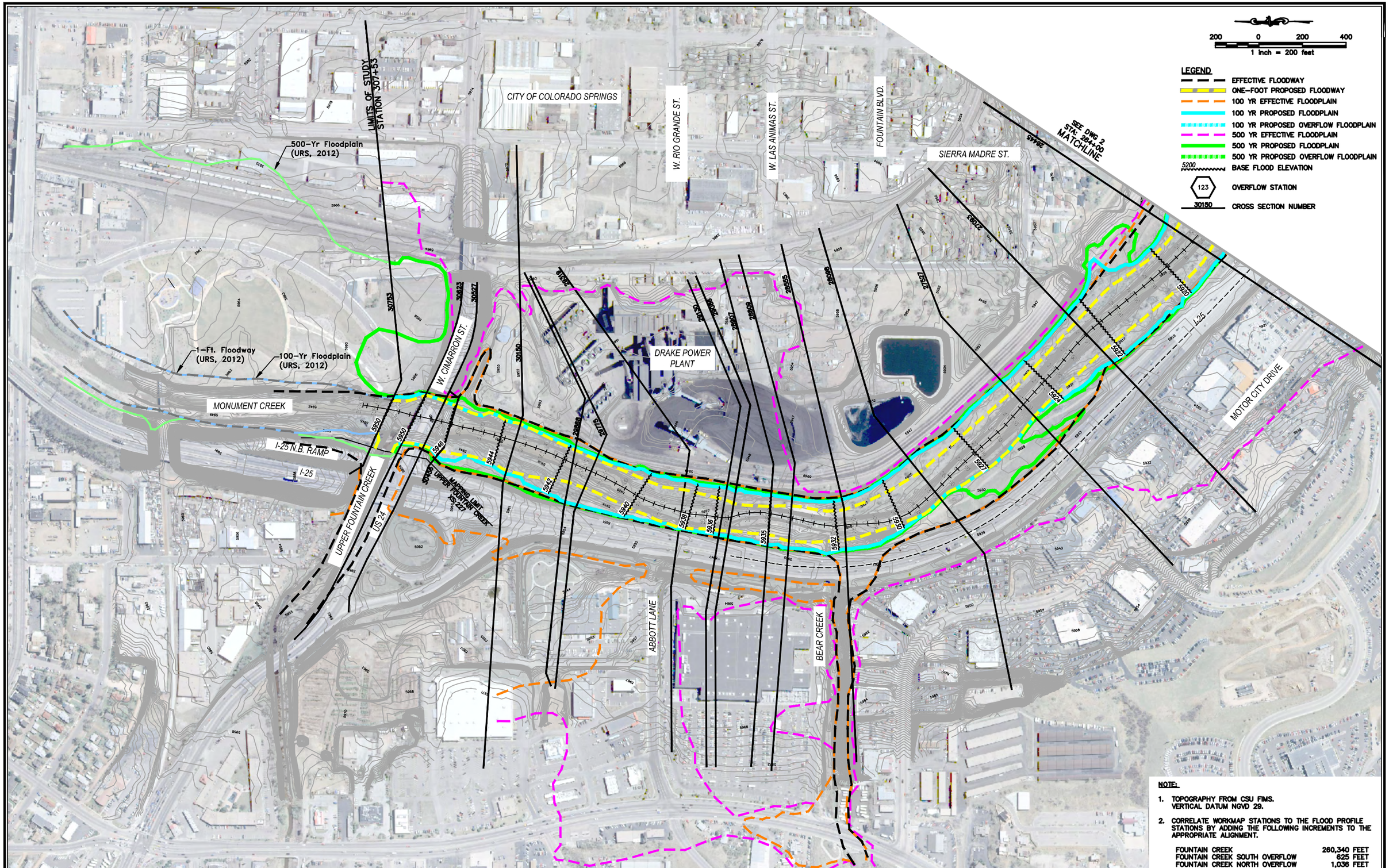
Restudy FC Mar2013 – This model plan simulates the 10-, 50, 100-, and 500-year water surface elevations along the Fountain Creek main channel, South Overflow, and North Overflow.

Restudy FC Mar2013 FW – This model plan simulates the water surface elevations for the floodway encroachment condition for the 100-year storm event.

Modeling Results

Effective FIS and Restudy floodplain boundaries for the 100- and 500-year events, and floodway, are presented in Drawings 1-5. Hand calculations and HEC-RAS model output including tables, cross sections and profiles are presented in **Appendices A to D** in this report.

Floodway Data Tables (FWDTs) were prepared for Fountain Creek for selected cross sections and are included in **Appendix F**. Flood profiles were prepared for Fountain Creek, Fountain Creek South Overflow, and Fountain Creek North Overflow and are included in **Appendix G**. The cross section channel stationing in the FWDTs and the flood profile stationing are measured as the stream distance above the mouth in feet. The channel stationing shown on the workmaps were adjusted by specified increments in order to reflect the stream distance above the mouth. Station correlation tables are provided in **Appendix E** for Fountain Creek, Fountain Creek South Overflow, and Fountain Creek North Overflow that relate the lettered cross sections to the flood profile stationing and the workmap stationing. A note has been added to the workmaps to document the incremental distances.



DESIGN: GGS, LEH, JMB DETAIL: LEH, KHM, RT CHECK: MRG	PROJECT NUMBER: 501007 DATE: JUNE 2013	WHPacific	1536 Cole Blvd, Suite 150 Lakewood, Colorado 80401 Phone: 303.458.5550 Fax: 303.480.9766	CITY OF COLORADO SPRINGS DEPARTMENT OF PUBLIC WORKS/ENGINEERING CITY OF COLORADO SPRINGS, COLORADO	FOUNTAIN CREEK FLOODPLAIN RESTUDY FLOODPLAIN BOUNDARIES	STATION: 308+00 - 264+00	DRAWING NUMBER: 1

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June 18, 2013

Ms. Thuy Patton
Floodplain Mapping Coordinator
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

Ms. Patton,

You recently submitted the report entitled, "Revised Hydraulic Modeling and Flood Hazard Mapping for Upper Fountain Creek", prepared by Anderson Consulting Engineers, Inc., and revised June 13, 2013, along with supporting documentation for our comment and review. Under direction of the FEMA Region VIII office, we have completed a review of the revised hydraulic analysis for Upper Fountain Creek within El Paso County, Colorado. The purpose of this letter is to summarize our review comments and provide corresponding documentation of our review.

The above referenced report provided a hydraulic analysis for Upper Fountain Creek from the confluence with Monument Creek to the upstream limit approximately 2.4 miles above the confluence. Hydraulic analyses were completed using the USACE HEC-RAS Version 4.0. Floodplain mapping data provided included digital workmaps, profiles, and floodplain boundaries. Floodway data tables were not provided for review.

We found the above referenced report and supporting documentation to be reasonable and complete. If you have any questions or comments regarding this letter or review, please contact me at 816-502-9420 x4981.

Sincerely,

Stephanie Bany Porter

Cc: Ms. Dawn Gladwell, Mr. Ryan Carroll, Mr. Dan Bare, Mr. Bob Cope, Mr. Greg Koch, Mr. Travis Rounsaville, Mr. Ben Ackert, Mr. Colin McKernan, Ms. Amanda Banks

REVISED HYDRAULIC MODELING AND FLOOD HAZARD MAPPING FOR UPPER FOUNTAIN CREEK

Prepared for:

Colorado Water Conservation Board
1580 Logan Street, Suite 200
Denver, CO 80203

and

City of Colorado Springs
Department of Public Works
30 S. Nevada Avenue, Suite #502
Colorado Springs, CO 80903

Prepared by:

Anderson Consulting Engineers, Inc.
375 E. Horsetooth Road, Bldg. 5
Fort Collins, CO 80525
(ACE Project No. COCWCB12C)

May 14, 2013

REVISIONS TO FOUNTAIN CREEK AND UPPER FOUNTAIN CREEK FLOODPLAIN/FLOODWAY MAPPING

Prepared for:

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Department of Public Works
30 S. Nevada Avenue, Suite502
Colorado Springs, CO 80903

Prepared by:

Anderson Consulting Engineers, Inc.
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Fort Collins, CO 80525
(ACE Project Nos. COCOCS02 & COCOCS03)

June 15, 2012

ANDERSON CONSULTING ENGINEERS, INC.
Civil • Water Resources • Environmental

June 15, 2012

Mr. Dan Bare
Department of Public Works
City of Colorado Springs
30 S. Nevada Avenue, Suite 502
Colorado Springs, CO 80903

RE: Revisions to Fountain Creek and Upper Fountain Creek Floodplain/Floodway Mapping (ACE Project Nos. COCOCS02 & COCOCS03)

Dear Dan,

Anderson Consulting Engineers, Inc. (ACE) is pleased to inform you that we have completed our revisions to the hydraulic modeling, flood hazard mapping, and floodway analyses for Fountain and Upper Fountain Creeks. ACE was tasked with conducting floodplain and floodway hydraulic analyses and mapping for these two creeks in conjunction with the El Paso County DFIRM conversion project. These tasks were completed under two separate scopes of work.

For Fountain Creek, hydraulic analyses and floodplain mapping were conducted to incorporate abutment protection measures near Circle Drive into an existing model for Fountain Creek created by WHPacific. Floodway analyses were also conducted and floodway mapping was prepared for the 5.2 mile reach of Fountain Creek originally studied by WHPacific between the southern city limit of Colorado Springs and the confluence with Monument Creek. During the course of the floodway analysis and mapping, three areas were identified wherein adjustments to the WHPacific floodplain analyses were warranted; these additional floodplain modeling and mapping adjustments were included in this study.

For Upper Fountain Creek, hydraulic analyses and floodplain/floodway mapping were conducted for a reach of Upper Fountain Creek extending from the confluence with Monument Creek upstream approximately 2.4 miles. A summary of the work conducted for both Fountain Creek and Upper Fountain Creek, and the results of the hydraulic modeling and flood hazard mapping is provided below.

Fountain Creek

Hydrology

The hydraulic model for Fountain Creek utilized discharges presented in the April, 2010 report "Hydrology Report for Fountain Creek, El Paso County, CO" [Michael Baker Jr., 2010]. The report utilized stream gage analyses to define the 10-, 50-, 100-, and 500-year discharges along Fountain Creek. Discharges were adjusted at Cross Sections 22993 and 21000 to account for flows being diverted to the Interstate 25 Divided Flow Path located along the right overbank of Fountain Creek. The discharges defined in the steady state flow data of the hydraulic model are presented in Table 1.

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Phone: (970) 226-0120 • Fax: (970) 226-0121 • www.acewater.com

Table 1. Summary of Fountain Creek Discharges.

Fountain Creek						
Baker Design Point	**Cross Section**	**10-Year Discharge (cfs)**	**50-Year Discharge (cfs)**	**100-Year Discharge (cfs)**	**500-Year Discharge (cfs)**	**Location**
USGS Stream Gage 07105500	30753	7,900	14,300	18,000	29,400	U/S Model Extent
	22993	7,900	14,300	18,000	29,270	
	21000	7,900	14,300	18,000	28,930	
USGS Stream Gage 07105530	14376	11,800	18,800	22,400	32,200	Confluence With Spring Creek

Circle Drive

ACE was originally tasked with updating the WHPacific model for Fountain Creek to reflect an abutment protection project recently constructed in the vicinity of the Circle Drive Bridges. As-built data provided by the City of Colorado Springs were utilized to update the hydraulic model and flood hazard mapping previously created by WHPacific; ACE completed this task without issue. All mapping changes are presented on the flood hazard work maps provided in Appendix A.1, with floodplain mapping revisions in the vicinity of Circle Drive shown on Sheet 4 of the flood hazard work maps. Base flood elevations (BFEs) have been placed in areas where the ACE analysis resulted in modified 100-year flood elevations.

In addition, ACE was tasked to conduct hydraulic modeling in order to delineate a one-foot floodway utilizing the WHPacific hydraulic model that had been updated with the new Circle Drive improvements. During the floodway analyses, three issues were identified with the WHPacific hydraulic model that needed to be corrected in order to produce an accurate and FEMA-compliant model.

Downstream of Nevada Avenue

First, a need was identified for ineffective flow areas on the left overbank of Cross Sections 22993, 22552 and 22497, a short distance downstream of Nevada Avenue. Ineffective flow areas were placed at appropriate locations for these cross sections based on topographic restrictions to flow; corresponding revisions to the flood hazard mapping were made. The new floodplain delineations and resulting floodway are shown on Sheet 2 of Appendix A.2. BFEs were placed in areas where the 100-year flood elevations changed.

Near the Las Vegas Wastewater Treatment Plant

Another area was identified where additional ineffective flow areas were needed, which in turn resulted in changes to an adjacent split flow that was evaluated in the WHPacific model using a non-standard procedure. Based on topographic restrictions to left overbank flows, ineffective flows were added to Cross Sections 20053 through 19829, in the vicinity of the Las Vegas Wastewater Treatment Plant (WWTP).

WHPacific had previously identified a north overbank split flow path through a portion of the WWTP, and computed the flow split based the HEC-RAS flow distribution in the far left portion of Cross Section 20053. Using this methodology, WHPacific determined that the north overflow path would convey approximately 30 cfs during the 100-year event and 301 cfs during the 500-year event. ACE adjustments to the ineffective flow areas resulted in a lower 100-year water surface elevation at Cross Section 20053, relative to that computed by WHPacific. The maximum 100-year flow depth in the area which would contribute to the split flow path was reduced from 0.94 feet to 0.68 feet as shown in the figure included in Appendix A.2. Consequently, the revised 100-year flow which would divert to the north split flow path would be less than 30 cfs which not result in flow depths greater than 1 foot. Therefore, north overbank split flow path at the WWTP was abandoned for the 100-year event, but retained (as described below) for the 500-year event. Sheet 3 in Appendix A.1 displays the resulting floodway and adjusted 100-year floodplain in the vicinity of the WWTP; BFEs have been placed in areas where the 100-year flood elevations have changed.

In order to accurately model the 500-year event for the north overbank split flow path, a junction was placed downstream of Cross Section 20053 and the north overflow path geometry modified. The 500-year flow split was then determined utilizing an energy balance computation. Modifications to the north overflow path geometry include the addition of Cross Sections 1084, 1024, and 962, extension of Cross Section 860, and removal of Cross Sections 130 and 75. These changes show that approximately 2,776 cfs is conveyed through the north overflow path during the 500-year event. The resulting 500-year floodplain is shown in Sheet 3 of Appendix A.1.

Downstream Tie-in at the Railroad Spur Crossing

URS was responsible for conducting hydraulic modeling and flood hazard mapping downstream of the railroad spur, near the confluence with Sand Creek, to the El Paso/Pueblo County Line; an effort which commenced prior to the WHPacific modeling effort. As a result, it is incumbent for the downstream end of the WHPacific model to tie to the URS model and mapping, both horizontally and vertically. Inspection of the WHPacific and URS models revealed that this tie-in had not been completed. At the railroad spur, Cross Section 31000 from the URS model was incorporated into the WHPacific model as Cross Section 4600. URS water surface elevations associated with the 100-year, 500-year and 1-foot floodway analyses were imposed as starting water surface elevations (along with the URS floodway encroachments) in the WHPacific model. These modeling modifications did not result in substantive changes to either computed water surface elevations or floodplain mapping shown on the WHPacific mapping.

<u>Upper Fountain Creek</u>

ACE was tasked with updating the Upper Fountain Creek model for the reach between the Monument Creek confluence to a location approximately 0.10 miles upstream of 26th Street. The updated study for Upper Fountain Creek included a field reconnaissance effort, hydraulic modeling of the 10-, 50-, 100-, and 500-year events and the one-foot floodway, and mapping of the 100-, 500-year and one-foot floodway.

A detailed field reconnaissance effort was conducted for this study in June of 2010. The effort included making visual observations of stream corridor conditions and all stream crossings. Photographic

documentation of the stream corridor was completed and is presented in Appendix B.1. During field reconnaissance Manning's n roughness coefficients were also estimated using Cowen's Method. Cowen's method worksheets utilized in quantifying roughness coefficient values are presented in Appendix B.2.

The hydraulic model for Upper Fountain Creek utilized discharges presented in the April, 2010 report "Hydrology Report for Fountain Creek, El Paso County, CO" [Michael Baker Jr., 2010]. For Upper Fountain Creek the report utilized methodologies outlined in WRIR 99-4190 to estimate discharges, at design points located between stream gages, for the 10-, 50-, 100-, and 500-year events. The discharges defined in the steady state flow data of the hydraulic model are presented in Table 2.

Table 2. Summary of Upper Fountain Creek Discharges.

Upper Fountain Creek						
Baker Design Point	**Cross Section**	**10-Year Discharge (cfs)**	**50-Year Discharge (cfs)**	**100-Year Discharge (cfs)**	**500-Year Discharge (cfs)**	**Location**
JUF470	14728	1,360	2,940	3,880	6,820	U/S Model Extent
WFtn1	8768	1,380	2,960	3,920	6,880	U/S Side of Highway 24 Bridge

To the extent possible, ACE was directed to utilize an existing HEC-RAS hydraulic model for Upper Fountain Creek prepared by URS for the U.S. Army Corps of Engineers as part of the Fountain Creek Watershed Study. This model utilized the City of Colorado Springs' 2-foot contour topography for the study reach to determine hydraulic section geometry.

For the reach between 21st Street and 8th Street two studies conducted by CH2MHill were utilized to define channel geometry. First, the CH2MHill LOMR for the Fountain Creek Drainage Improvements Project (Case No. 04-08-0314P) was utilized for the section extending approximately 500 feet downstream of 8th Street to approximately 50 feet downstream of 21st Street. The second source utilized were as-built drawings for the Fountain Creek Restoration at Gold Hill Mesa, dated May 2010, and provided by CH2MHill. The Fountain Creek Restoration at Gold Hill Mesa project was located approximately in the middle third of the Fountain Creek Drainage Improvement Project and therefore superseded the original LOMR submitted by CH2MHill. It is important to note that digital files containing pre-project and as-built condition topography were not submitted to ACE. Therefore, pdf versions of the design drawings were ortho-rectified and utilized for floodplain delineation. The sources utilized for the hydraulic model utilized are summarized in Table 3.

In addition to the analysis of 10-, 50-, 100-, and 500-year flood events, ACE performed an analysis of the 1-foot floodway. Floodplain mapping of the 100-, and 500-year events along with delineation of the 1-foot floodway were conducted based on the results of the hydraulic modeling. Detailed floodplain work maps are presented in Appendix B.3. In addition to floodplain mapping, flood profiles were prepared showing the 10-, 50-, 100-, and 500-year events for Upper Fountain Creek and are presented in Appendix B.4.

Table 3. Summary of Hydraulic Model Sources for Upper Fountain Creek.

Reach	Cross Sections	Source
Downstream Extent to Upstream of Highway 24	15-1432	URS Cross Section Alignment cut on 2-ft Contours
Downstream of 8th Street to Approximately 2100' Upstream of 8th Street	1751-4436	LOMR 04-08-0314P (CH2M Hill, February 2004)
Fountain Creek Restoration at Gold Hill Mesa	4844-8008	Gold Hill Mesa As-Built Drawings (CH2MHill, May 2010)
Approximately 1000' Downstream of Highway 24 to Downstream side of 21st Street	8361-9511	LOMR 04-08-0314P (CH2M Hill, February 2004)
Upstream side of 21st Street to Downstream side of 25th Street	9612-11694	URS Cross Section Alignment cut on 2-ft Contours
25th Street	11744-12080	Effective Fountain Creek Model
Upstream of 25th Street	12234-14031	URS Cross Section Alignment cut on 2-ft Contours

The downstream end of Upper Fountain Creek will confluence with Fountain Creek at a common confluence with Monument Creek. Since the Monument Creek/Fountain Creek system represents the main channel, while Upper Fountain Creek is a relatively small tributary, the downstream boundary condition for the Upper Fountain Creek model was defined using normal depth. The upstream end of the Upper Fountain Creek model resulting from this study was tied to a further upstream model (prepared by URS) by inserting Cross Sections 14846 and 14417 from the URS model into the current ACE model (as Cross Sections 14728 and 14306). Utilization of these common cross sections resulted in 100-year water surface elevations matching within 0.4 feet at the upstream ACE cross section (#14728). It is noted that 0.5 feet is the allowable criteria accepted by FEMA for CLOMR/LOMR submittals. Utilization of these two common cross sections also allowed for seamless tie-ins between the ACE and URS mapping of the 100- and 500-year floodplains, as well as the 1-foot floodway.

A CD containing the HEC-RAS models prepared by ACE for both Fountain Creek and Upper Fountain Creek is enclosed at the end of this letter report. Also, included on the disk are AutoCAD files of the flood hazard mapping for both creeks.

If you have any questions pertaining to the modeling, mapping and other results discussed in this report, please do not hesitate to contact us.

Sincerely,
ANDERSON CONSULTING ENGINEERS, INC.

Jamis D. Darrow, P.E.
Project Engineer II

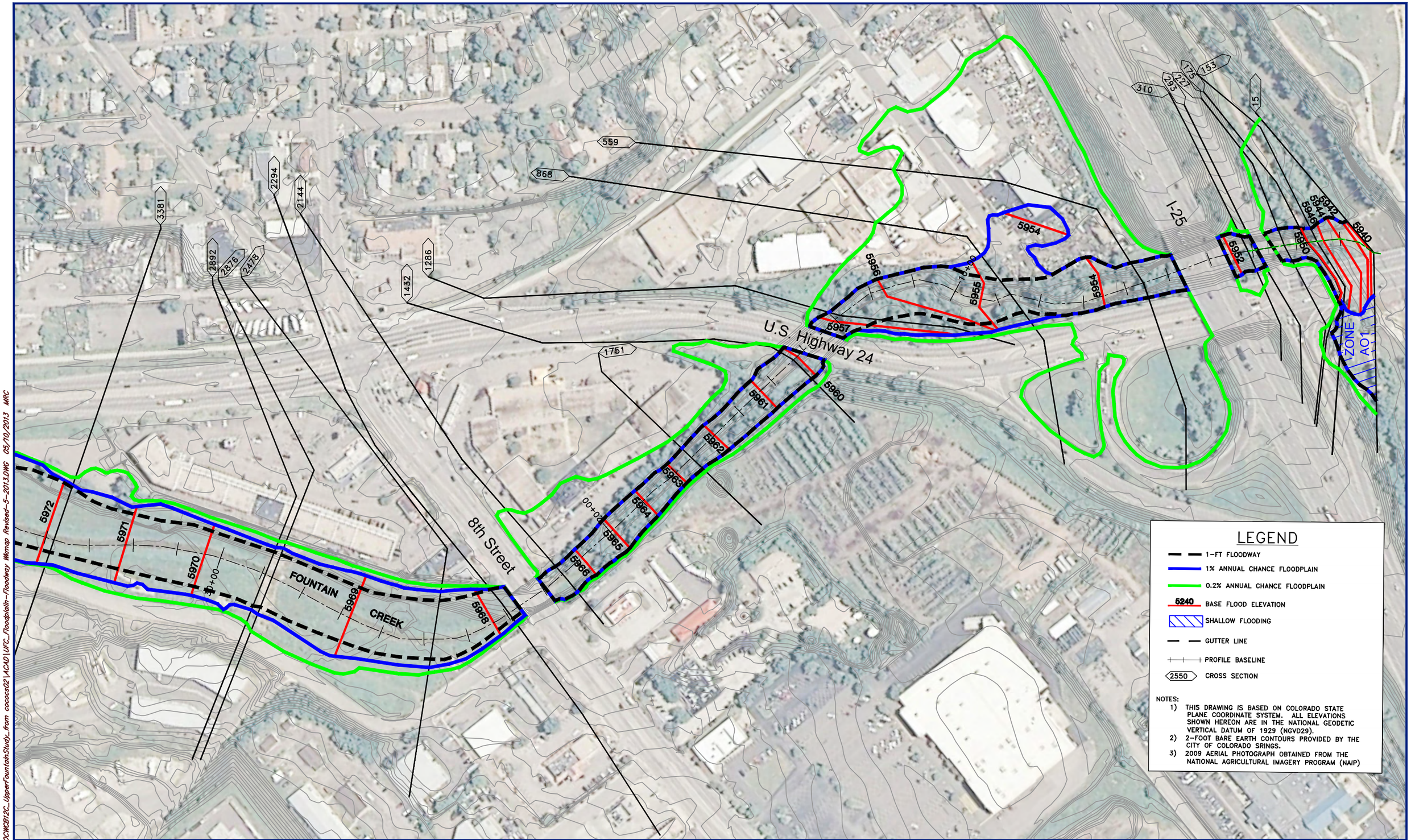
Matt Clark, E.I.T.
Project Engineer

Gregory J. Koch, P.E.
Vice President

Appendices

A. Fountain Creek
   - A.1 Floodplain and Floodway Work Maps
   - A.2 Water Surface Elevation Comparison at Cross Section 20053

B. Upper Fountain Creek
   - B.1 Photographic Documentation
   - B.2 Manning's n Value Documentation
   - B.3 Floodplain and Floodway Work Maps
   - B.4 Graphical Water Surface Profiles



X:\Projects\COCWCB12C_UpperFountainStudy_from cococs02\ACAD\UFC_Floodplain-Floodway Workmap Revised-5-2013.DWG 05/10/2013 MRC

REVISIONS:
REV1
REV2
REV3
REV4
REV5
REV6

1"=200'

0 50 100 200

PROJECT NUMBER:	DRAWN BY:
COCOCS02	JDD/TRR
ACAD FILE: UFC_FP/FW REV.	DESIGNED BY: JDD/TRR
DATE: 05/08/2013	CHECKED BY: GJK

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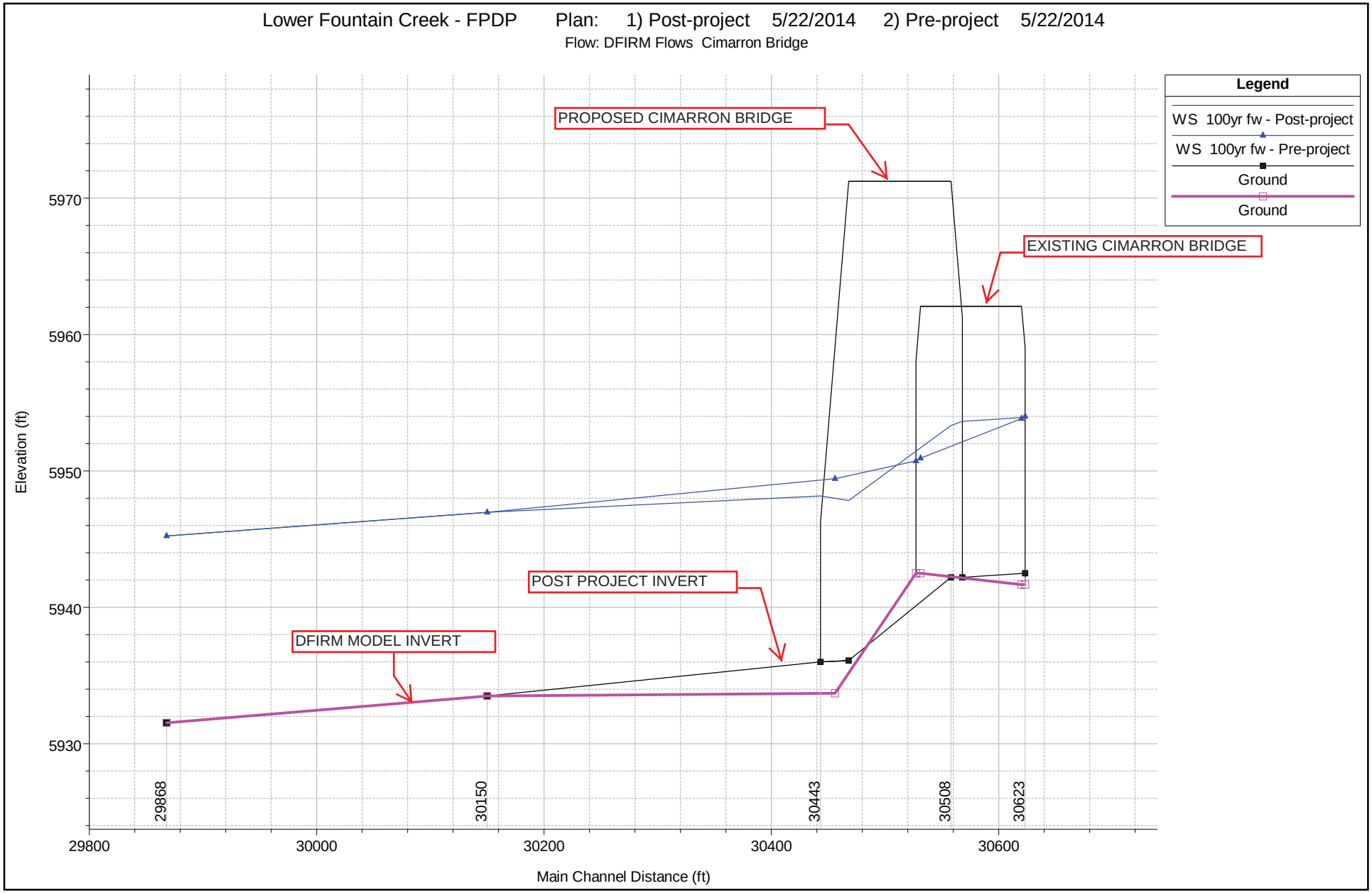
HYDRAULICS AND FLOODPLAIN MAPPING FOR FOUNTAIN CREEK AS PART OF THE EL PASO COUNTY, CO DFIRM CONVERSION PROJECT

UPPER FOUNTAIN CREEK FLOODPLAIN/FLOODWAY WORKMAP

SHEET 1

Appendix B

Lower Fountain Creek Floodplain Hydraulic Analysis Results



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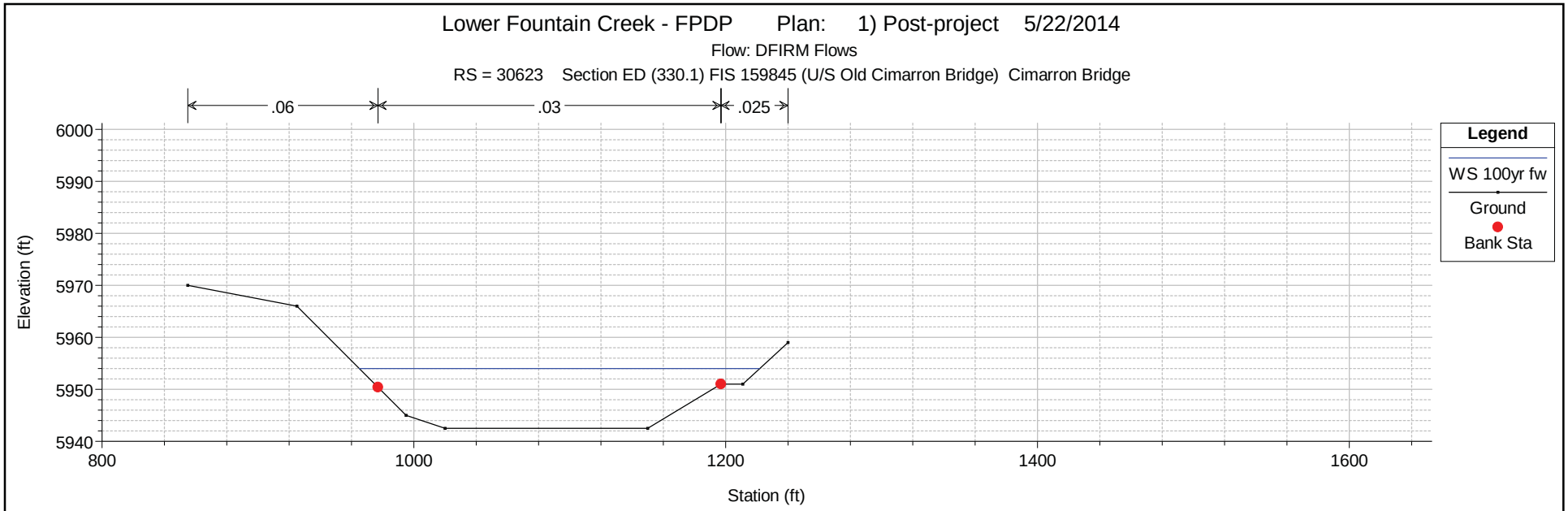

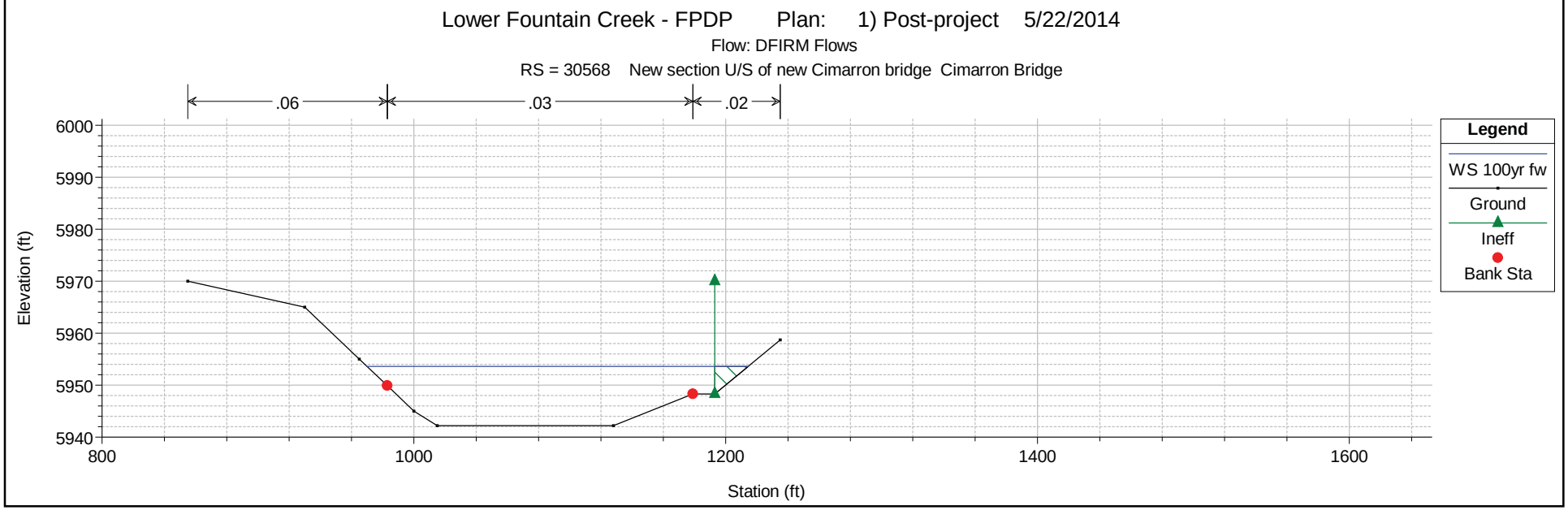

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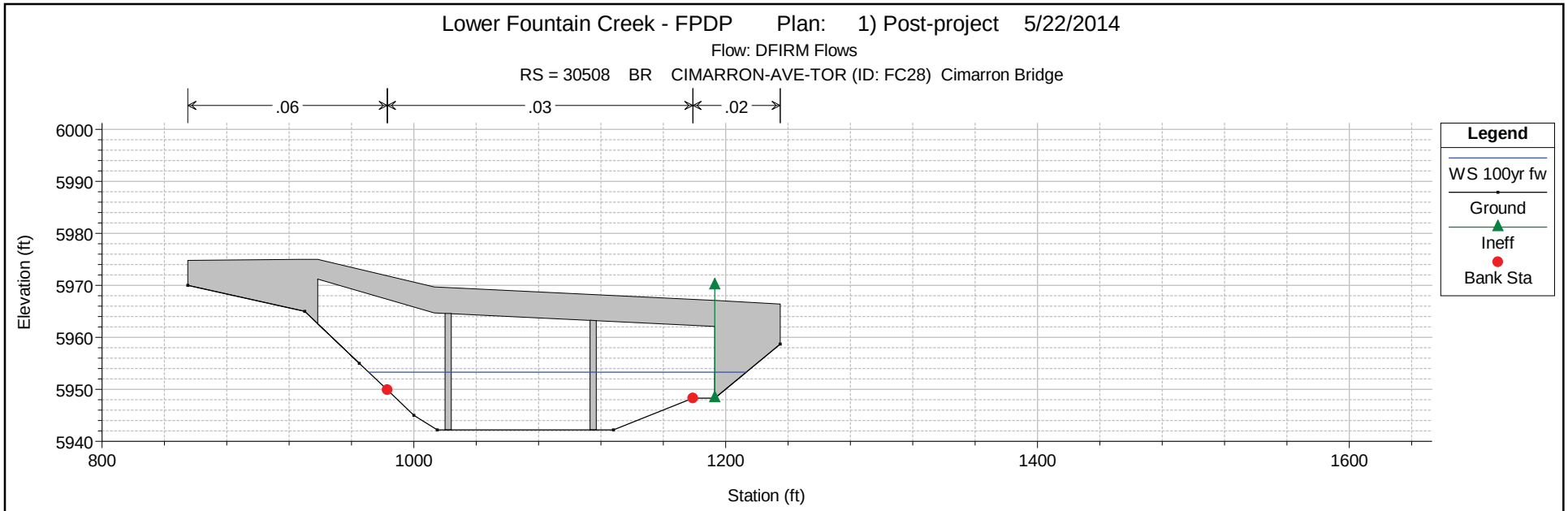
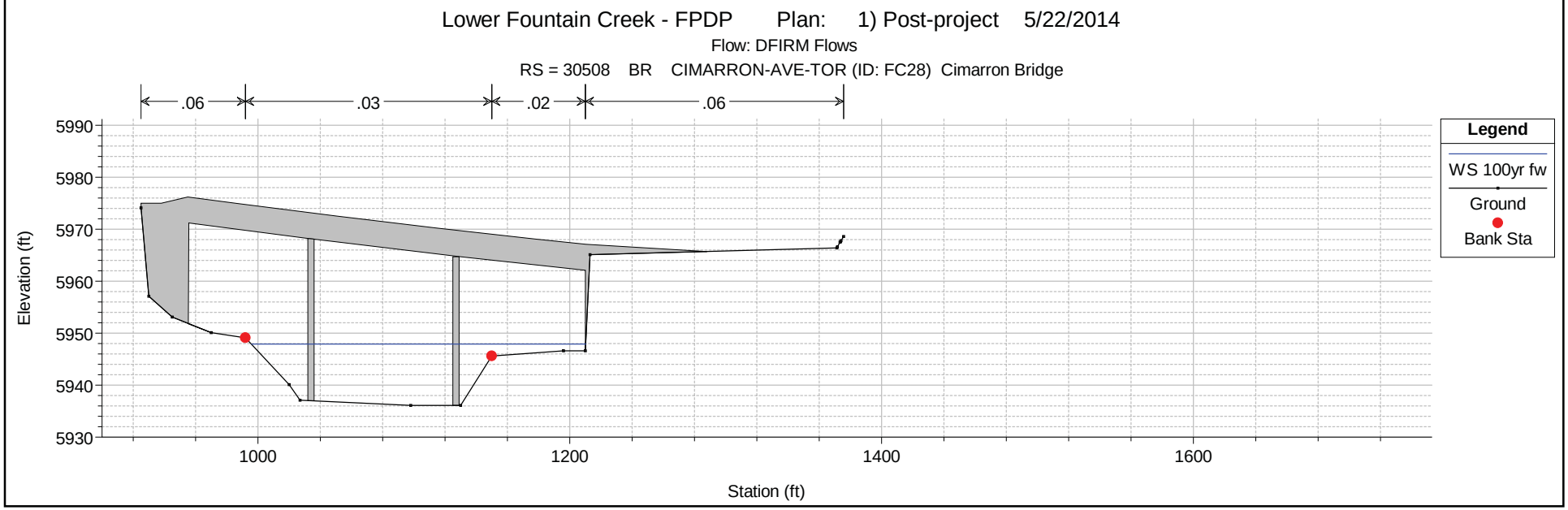
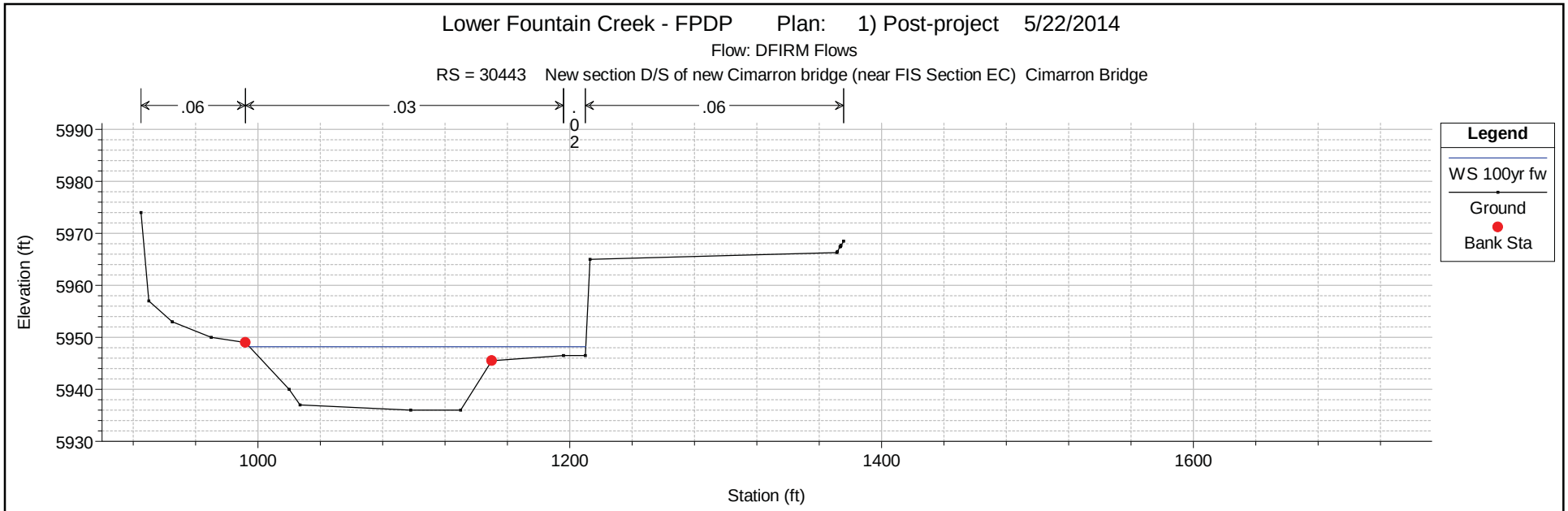
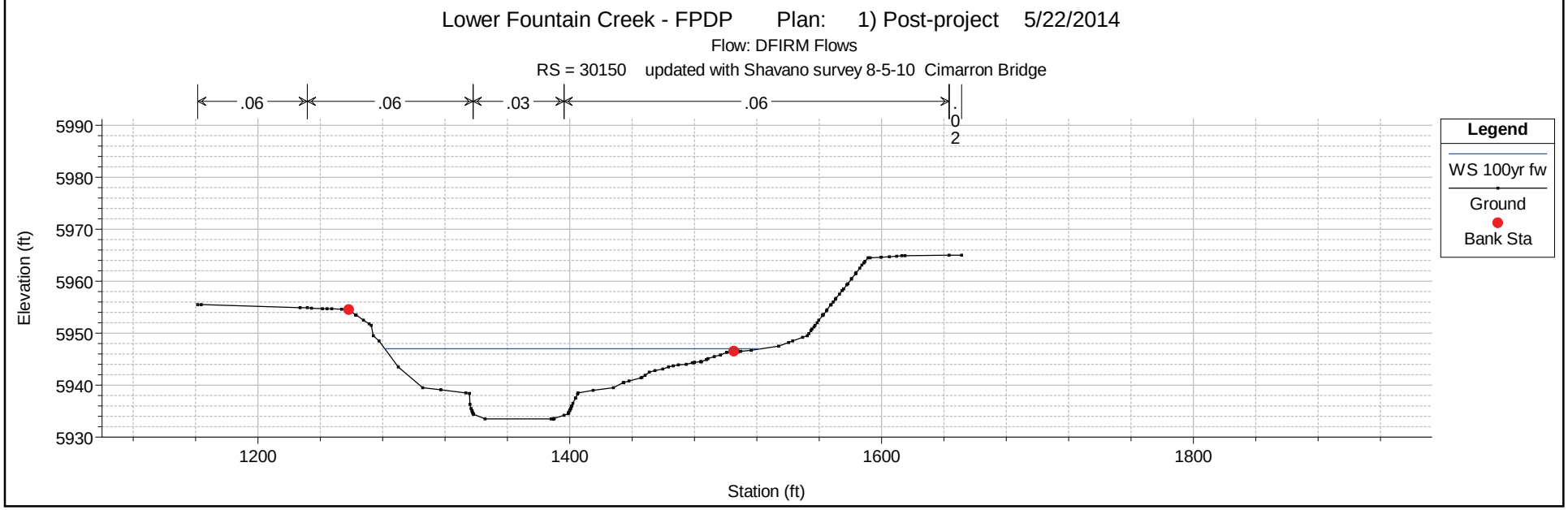




1 in Horiz. = 100 ft 1 in Vert. = 30 ft



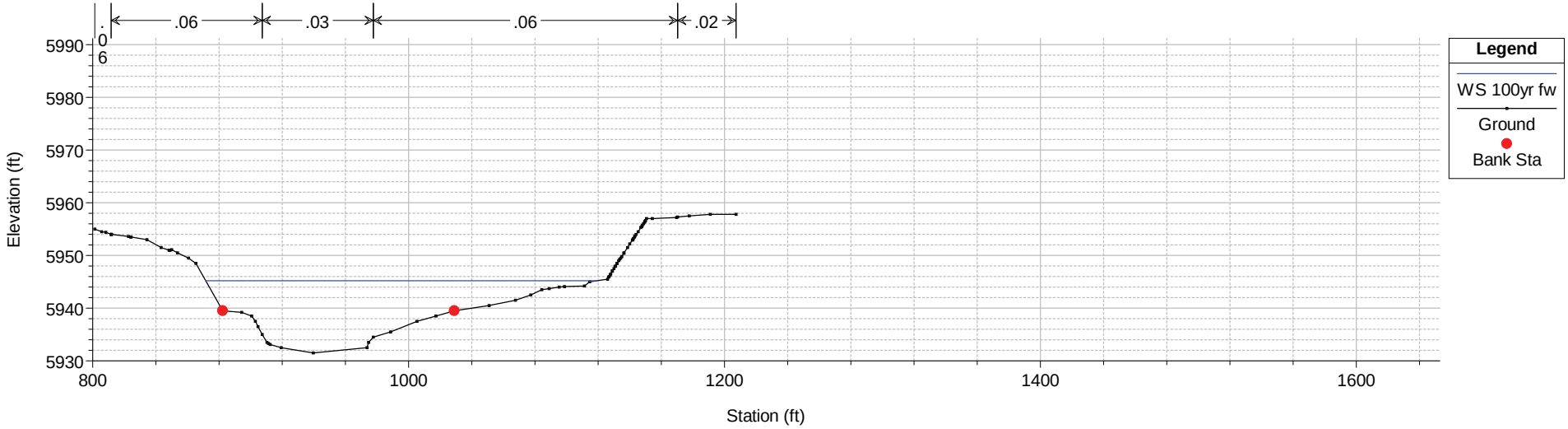


1 in Horiz. = 100 ft 1 in Vert. = 30 ft

Lower Fountain Creek - FPDP Plan: 1) Post-project 5/22/2014

Flow: DFIRM Flows

RS = 29868 updated with Shavano survey 8-5-10 Cimarron Bridge



1 in Horiz. = 100 ft 1 in Vert. = 30 ft

HEC-RAS River: Fountain Reach: Main Profile: 100yr fw

Reach	River Sta	Profile	Plan	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)	
Main	30623	100yr fw	Post-project	18000.00	5942.50	5953.96		5954.96	0.001255	8.09	2273.91	256.57	0.45
Main	30623	100yr fw	Pre-project	18000.00	5941.67	5953.99	5949.69	5955.03	0.002199	8.34	2329.32	250.41	0.44
Main	30568	100yr fw	Post-project	18000.00	5942.20	5953.65	5949.99	5954.84	0.001444	8.75	2078.47	244.87	0.49
Main	30527	100yr fw	Pre-project	18000.00	5942.50	5950.73	5950.73	5953.70	0.007816	13.89	1319.40	228.44	0.97
Main	30508			Bridge									
Main	30456	100yr fw	Pre-project	18000.00	5933.70	5949.43		5950.62	0.004142	8.81	2150.14	249.13	0.42
Main	30443	100yr fw	Post-project	18000.00	5936.00	5948.17		5950.12	0.002556	11.35	1661.87	215.70	0.64
Main	30150	100yr fw	Post-project	18000.00	5933.50	5946.97		5948.70	0.009885	10.56	1708.60	240.15	0.67
Main	30150	100yr fw	Pre-project	18000.00	5933.50	5946.97		5948.70	0.009885	10.56	1708.60	240.15	0.67
Main	29868	100yr fw	Post-project	18000.00	5931.53	5945.24	5942.96	5947.19	0.003234	11.48	1794.51	248.68	0.63
Main	29868	100yr fw	Pre-project	18000.00	5931.53	5945.24	5942.96	5947.19	0.003234	11.48	1794.51	248.68	0.63

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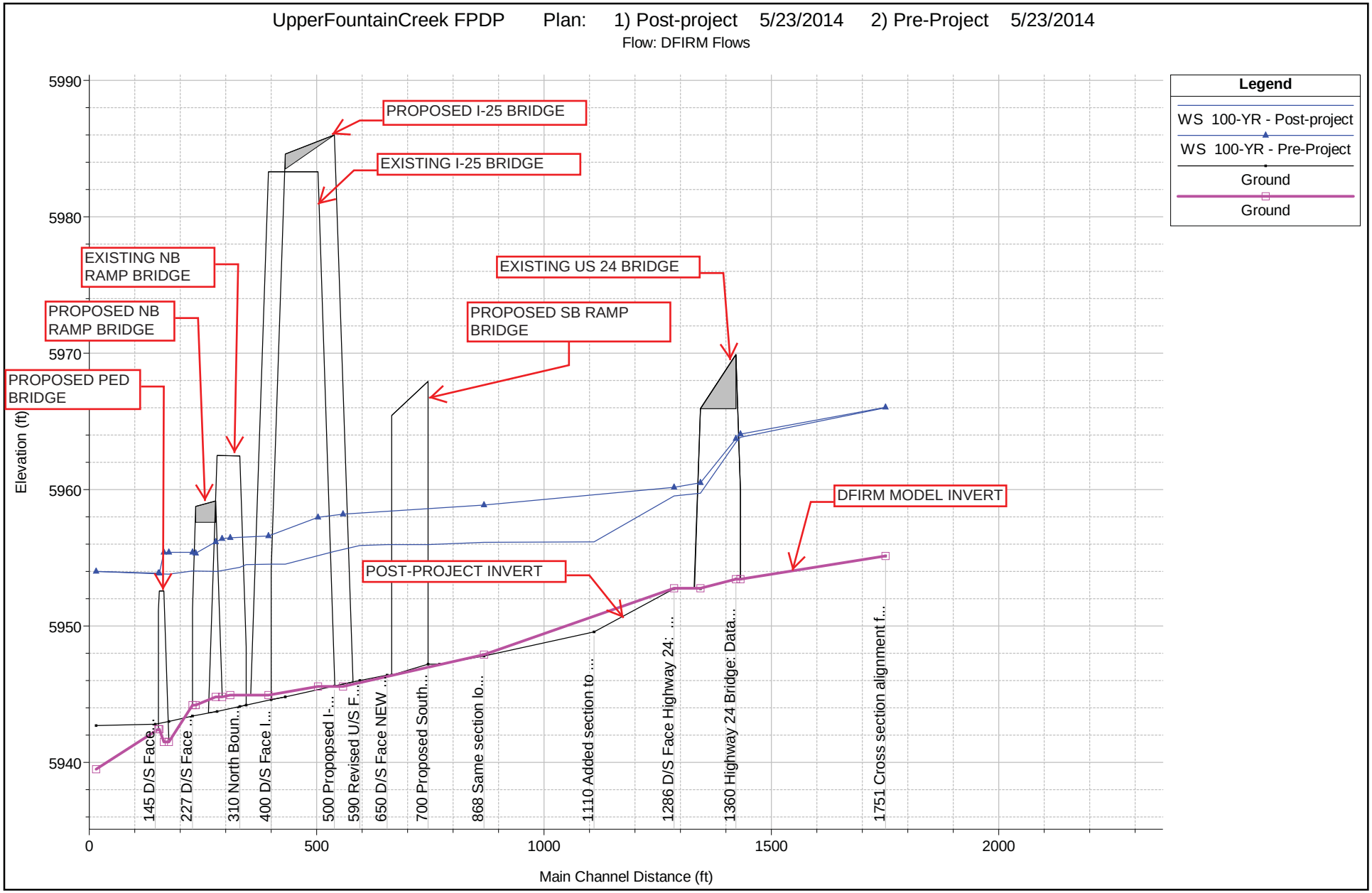
Appendix C

Upper Fountain Creek Floodplain Hydraulic Analysis Results

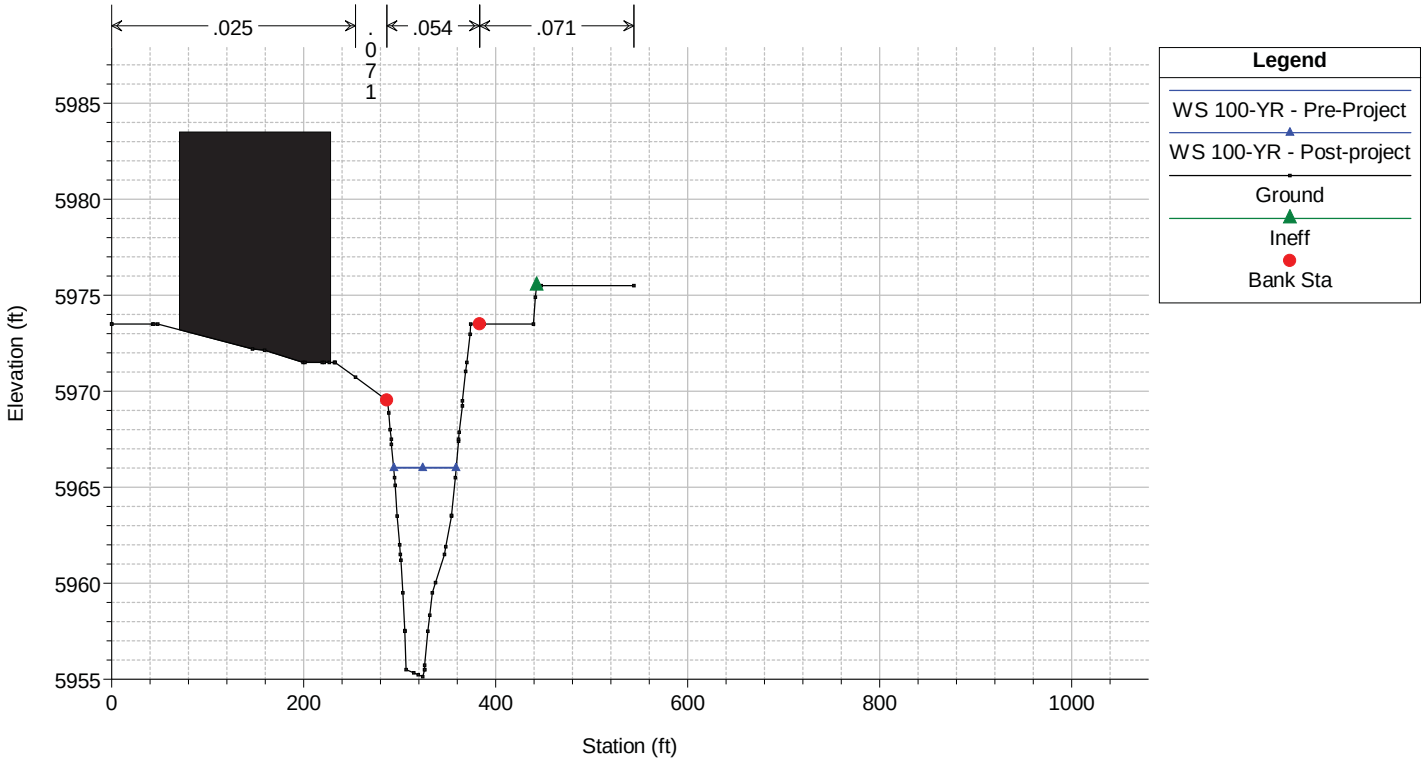


1 in Horiz. = 300 ft 1 in Vert. = 10 ft

UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

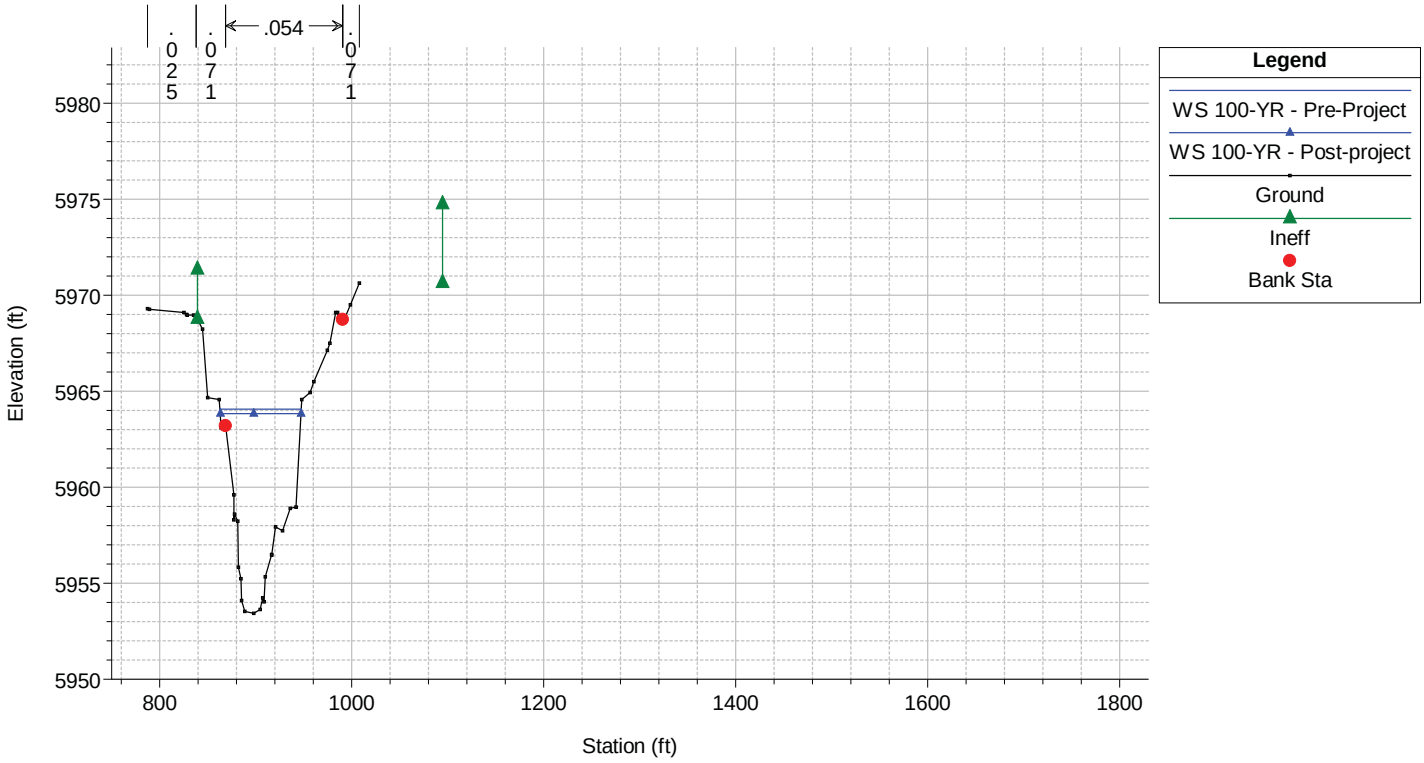
RS = 1751 Cross section alignment from CH2MHill model. Cut on 2006 topo.



UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

RS = 1432 U/S Face Highway 24: Same XS orientation as URS model (ineffect

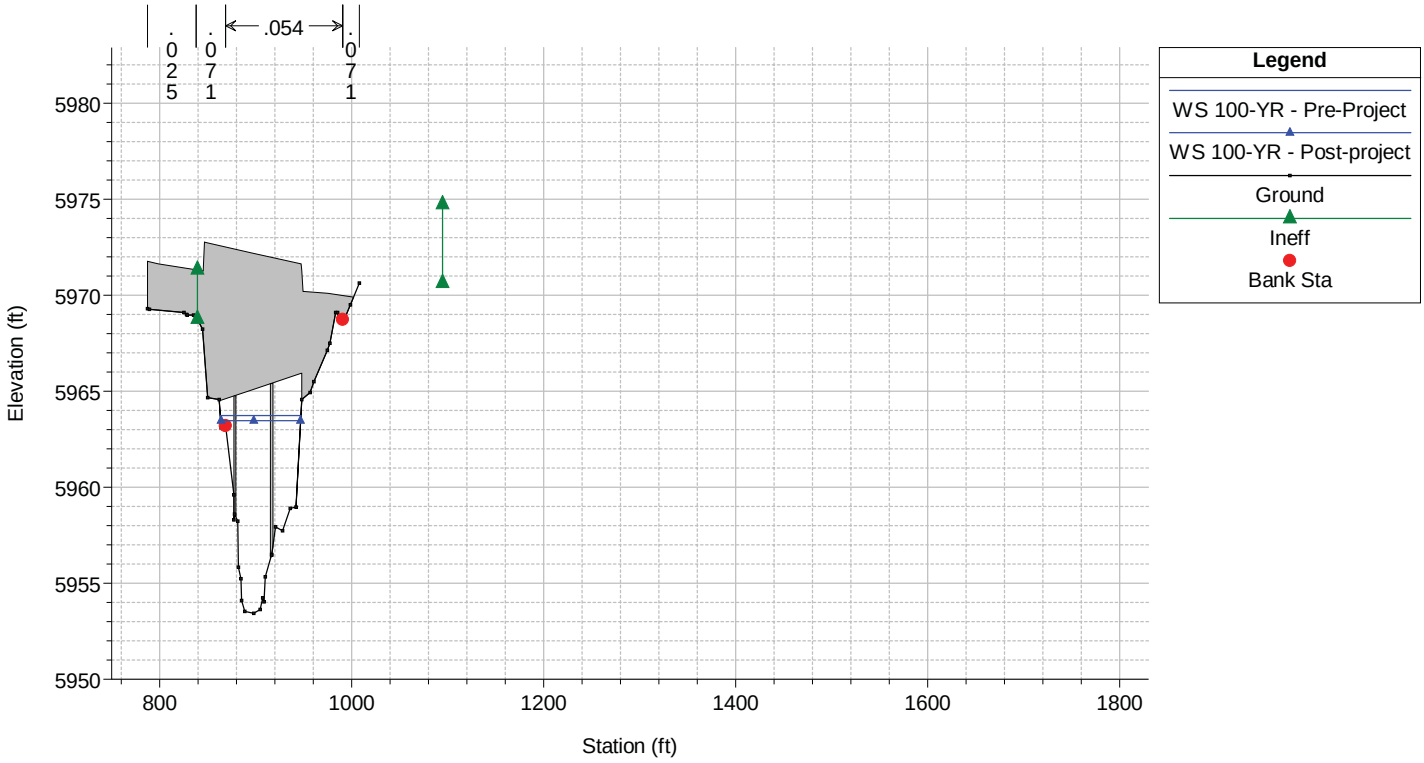


1 in Horiz. = 200 ft 1 in Vert. = 10 ft

UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

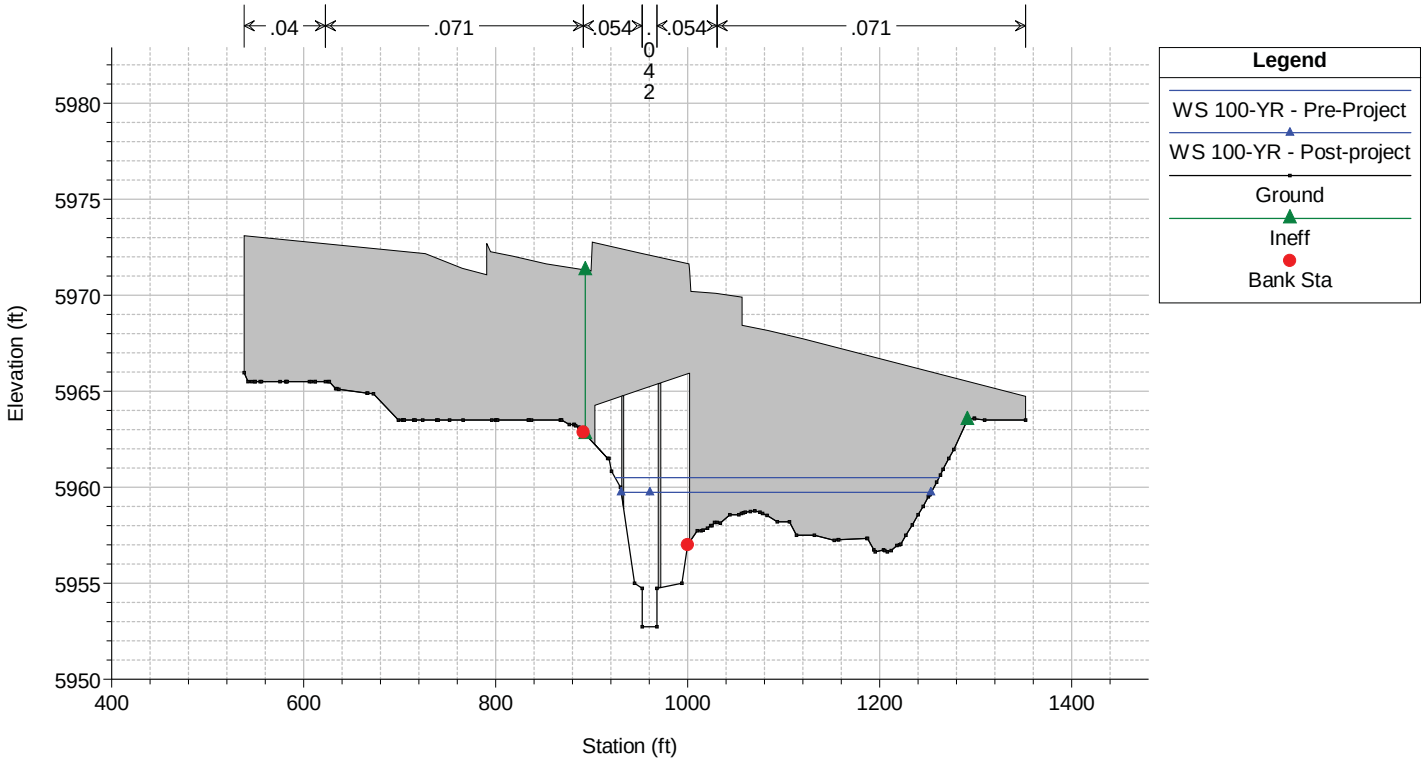
RS = 1360 BR Highway 24 Bridge: Data from URS model



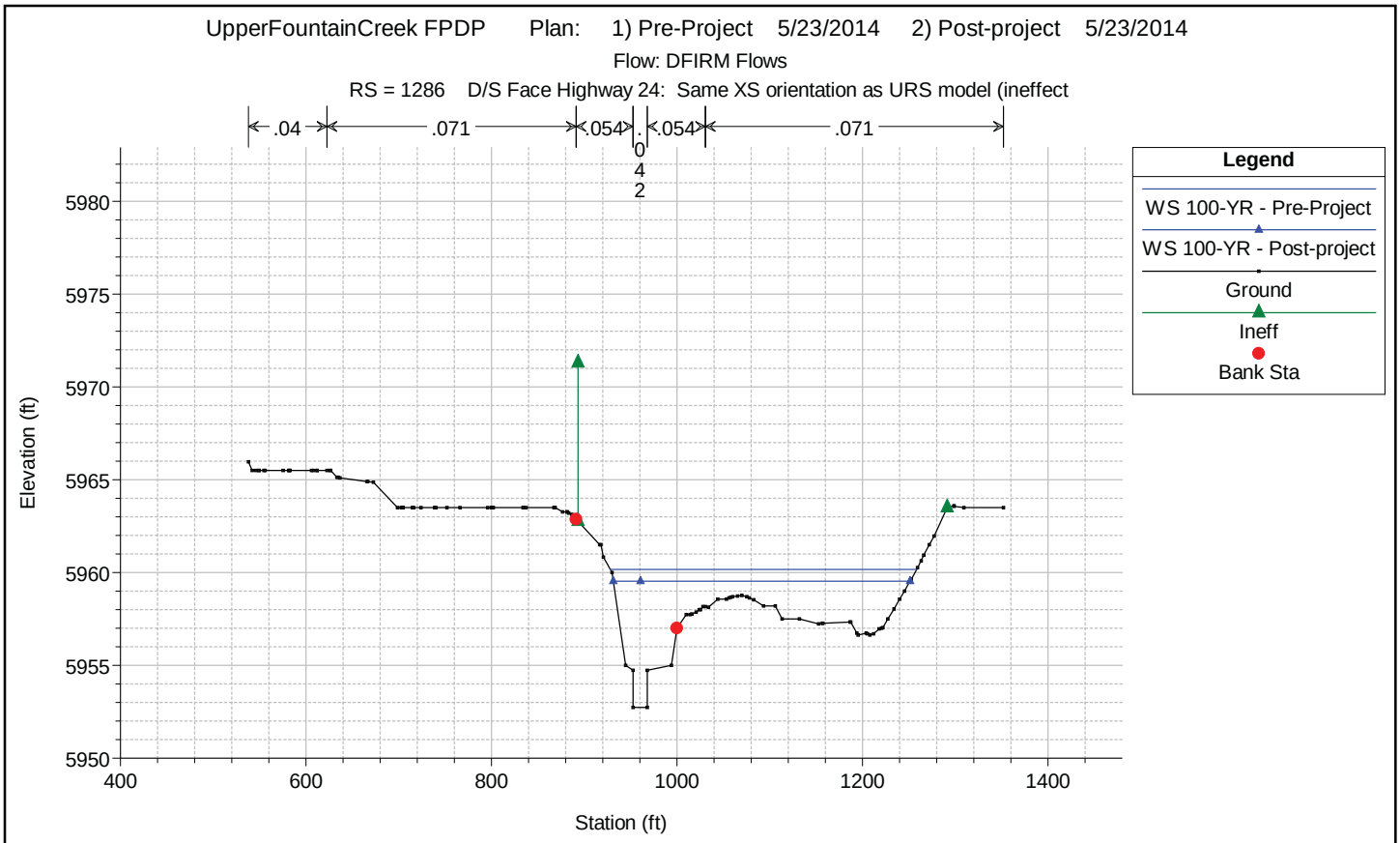
UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

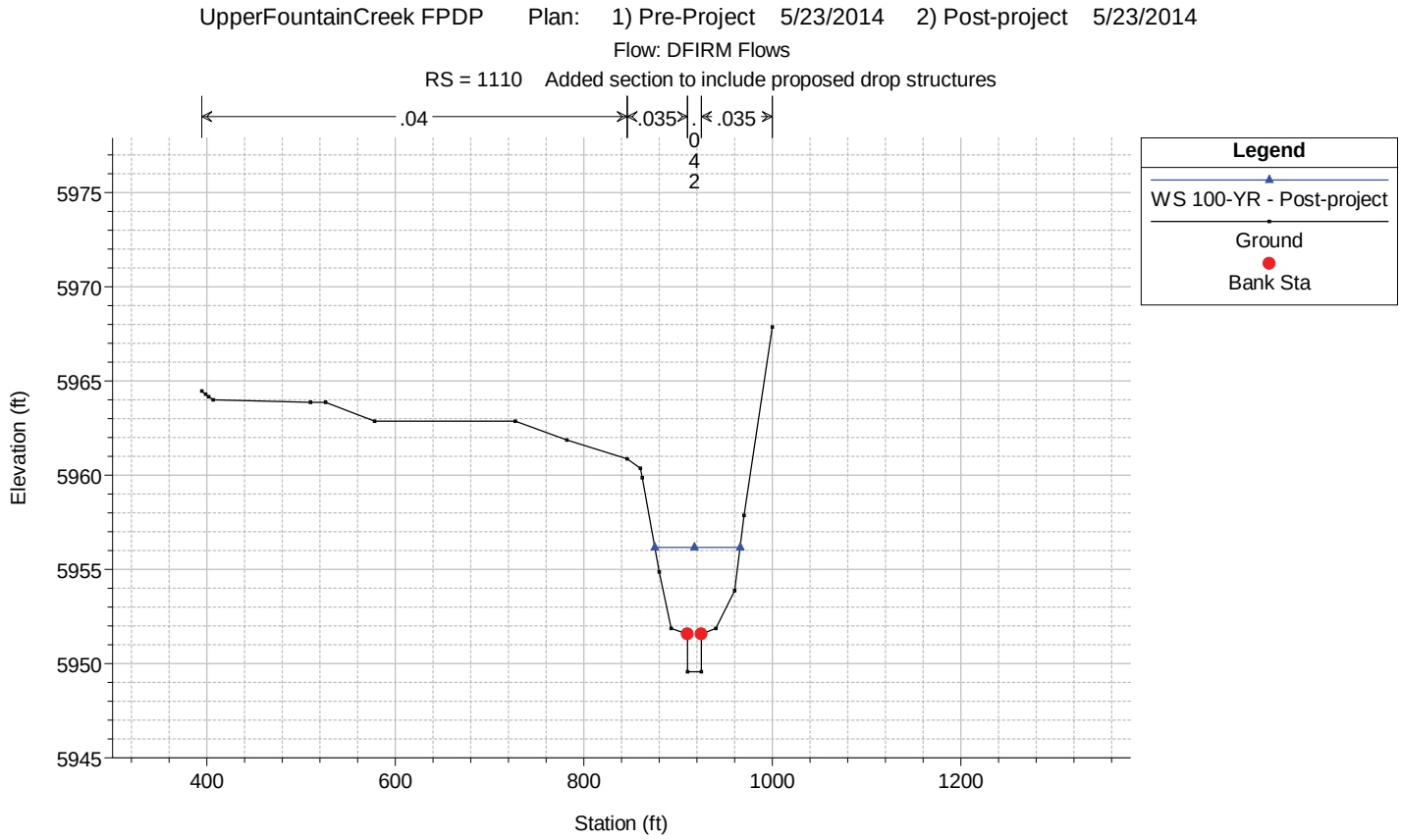
Flow: DFIRM Flows

RS = 1360 BR Highway 24 Bridge: Data from URS model



1 in Horiz. = 200 ft 1 in Vert. = 10 ft





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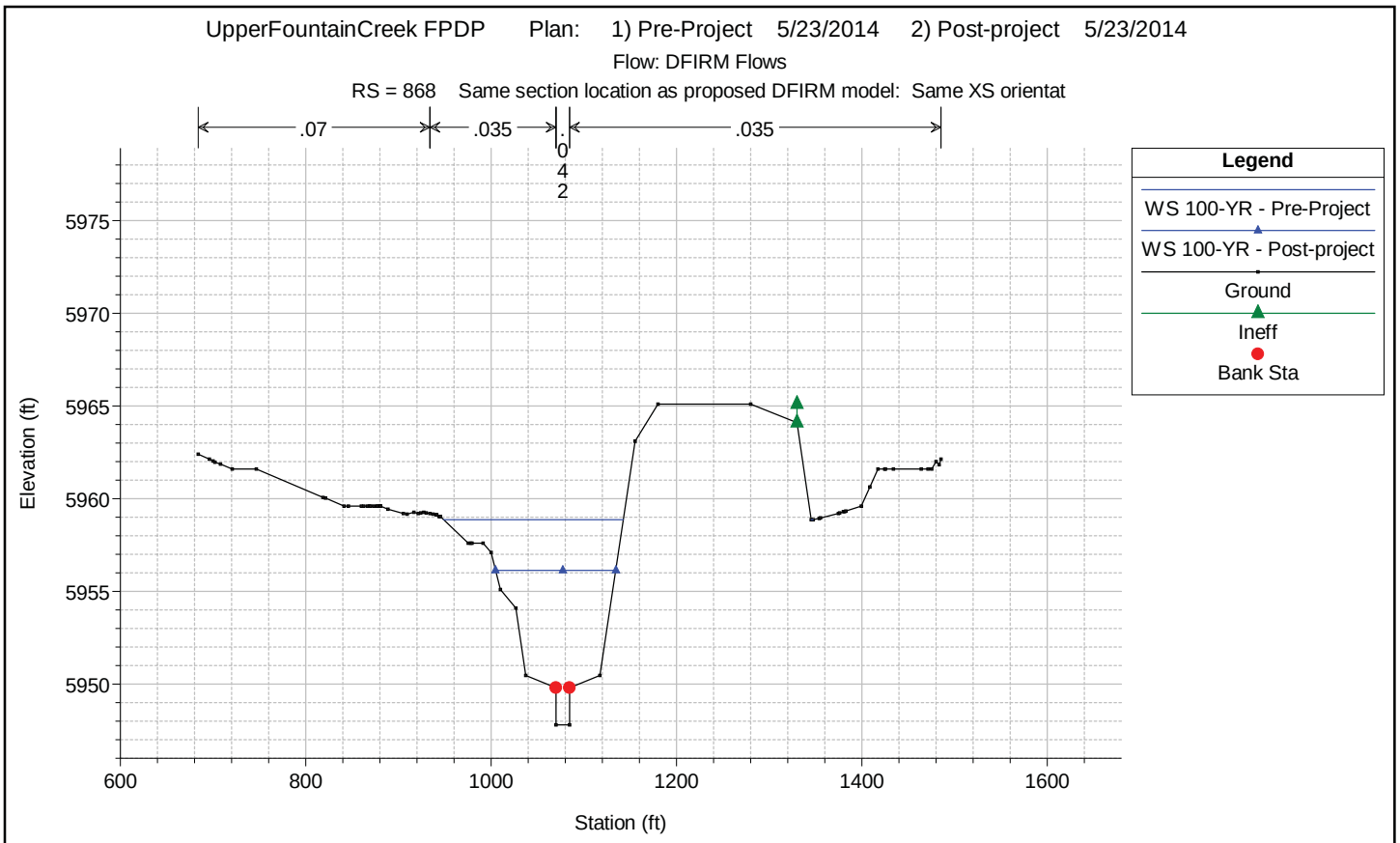
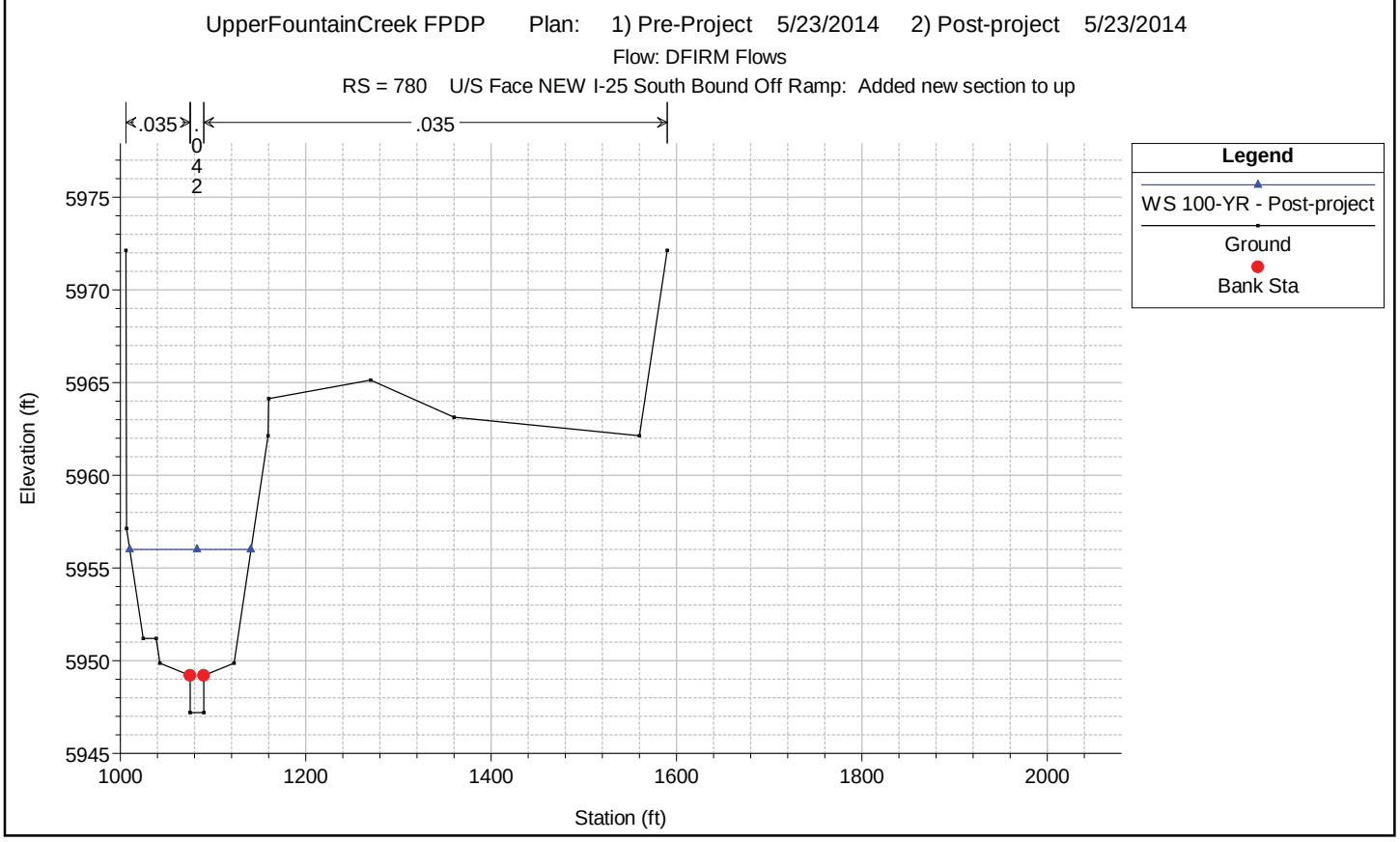


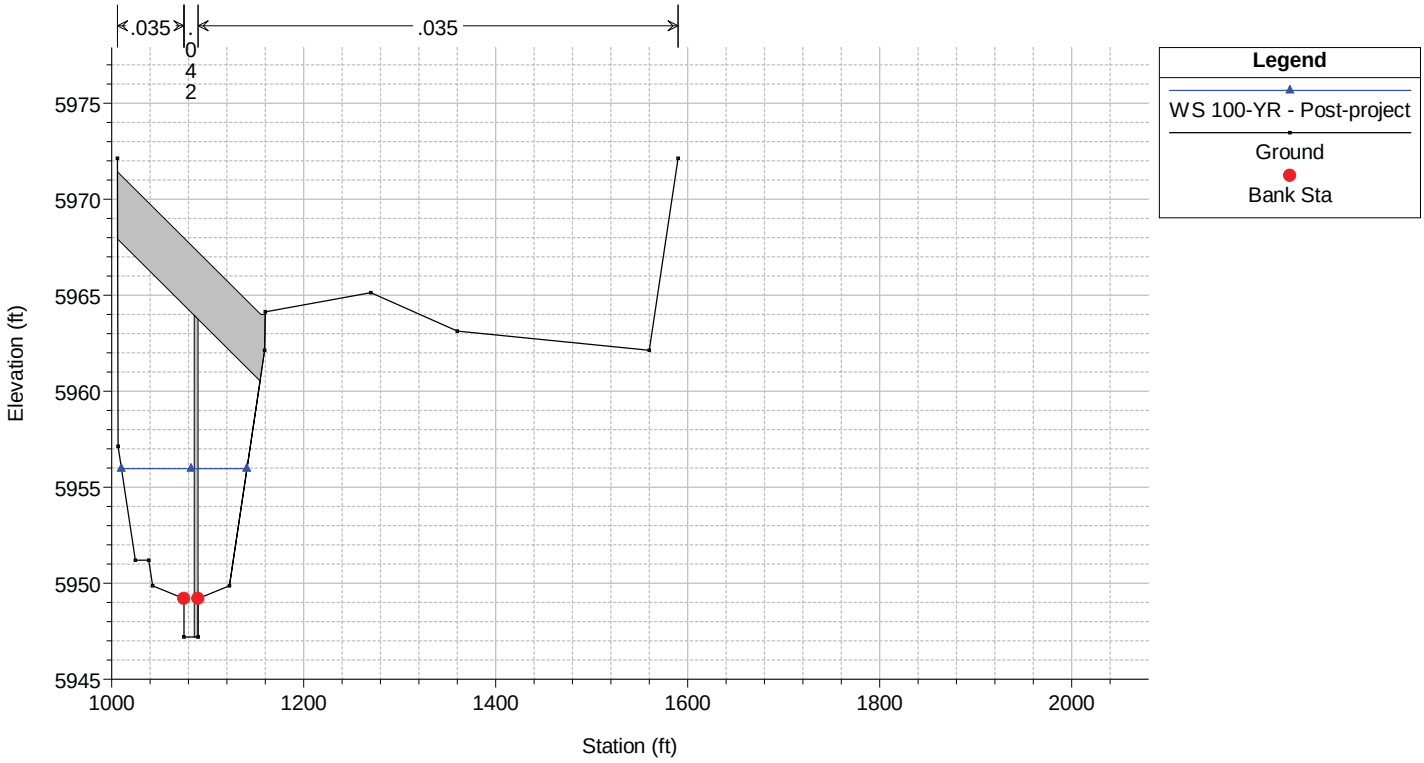


1 in Horiz. = 200 ft 1 in Vert. = 10 ft

UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

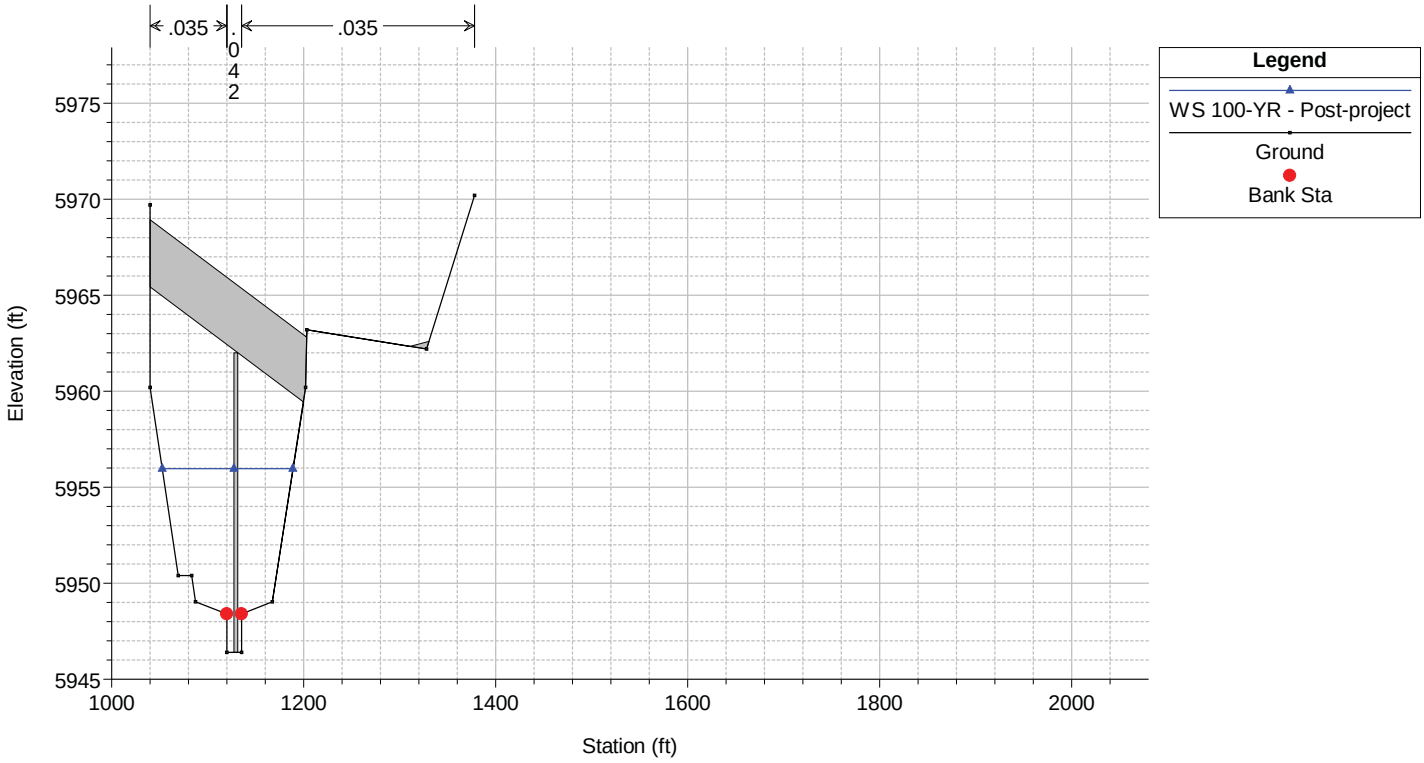
RS = 700 BR Proposed South Bound Off Ramp



UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

RS = 700 BR Proposed South Bound Off Ramp

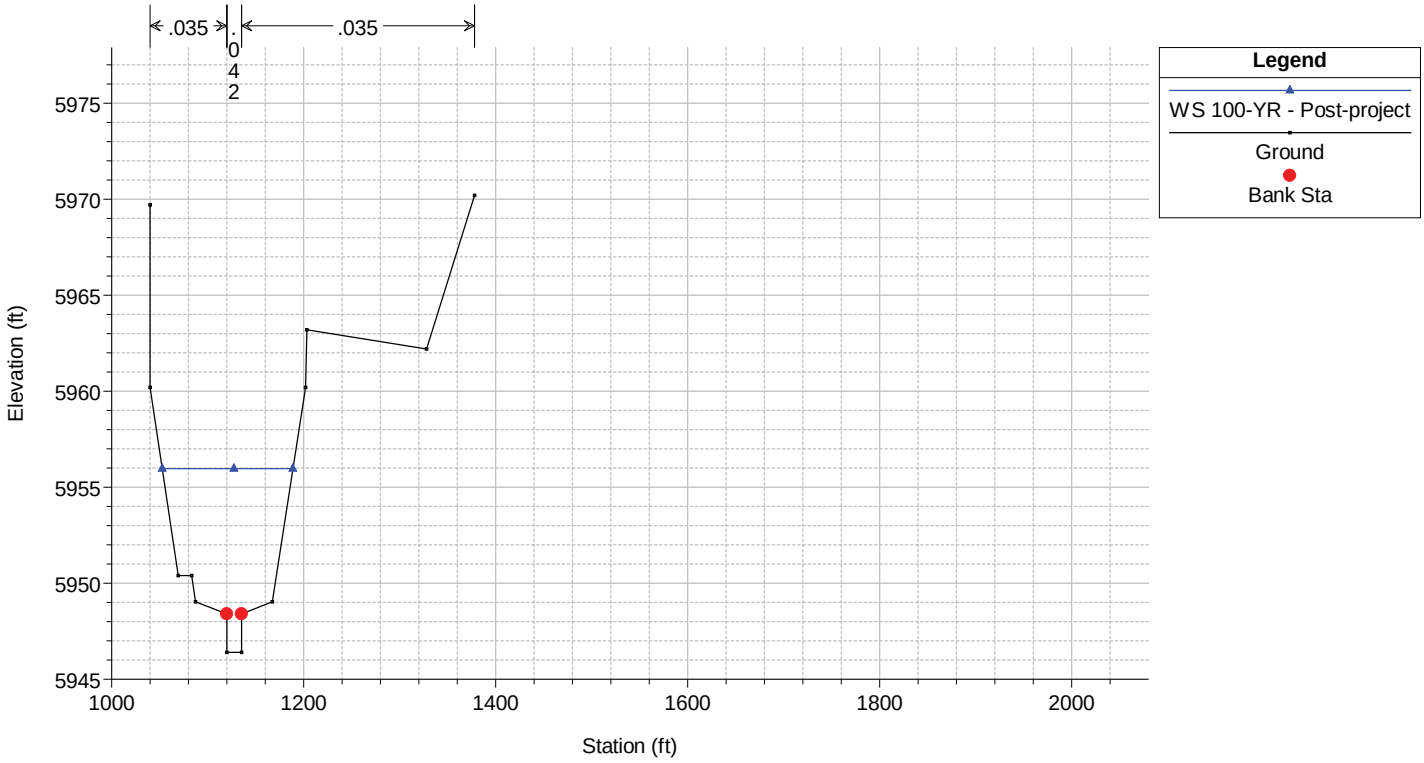


1 in Horiz. = 200 ft 1 in Vert. = 10 ft

UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

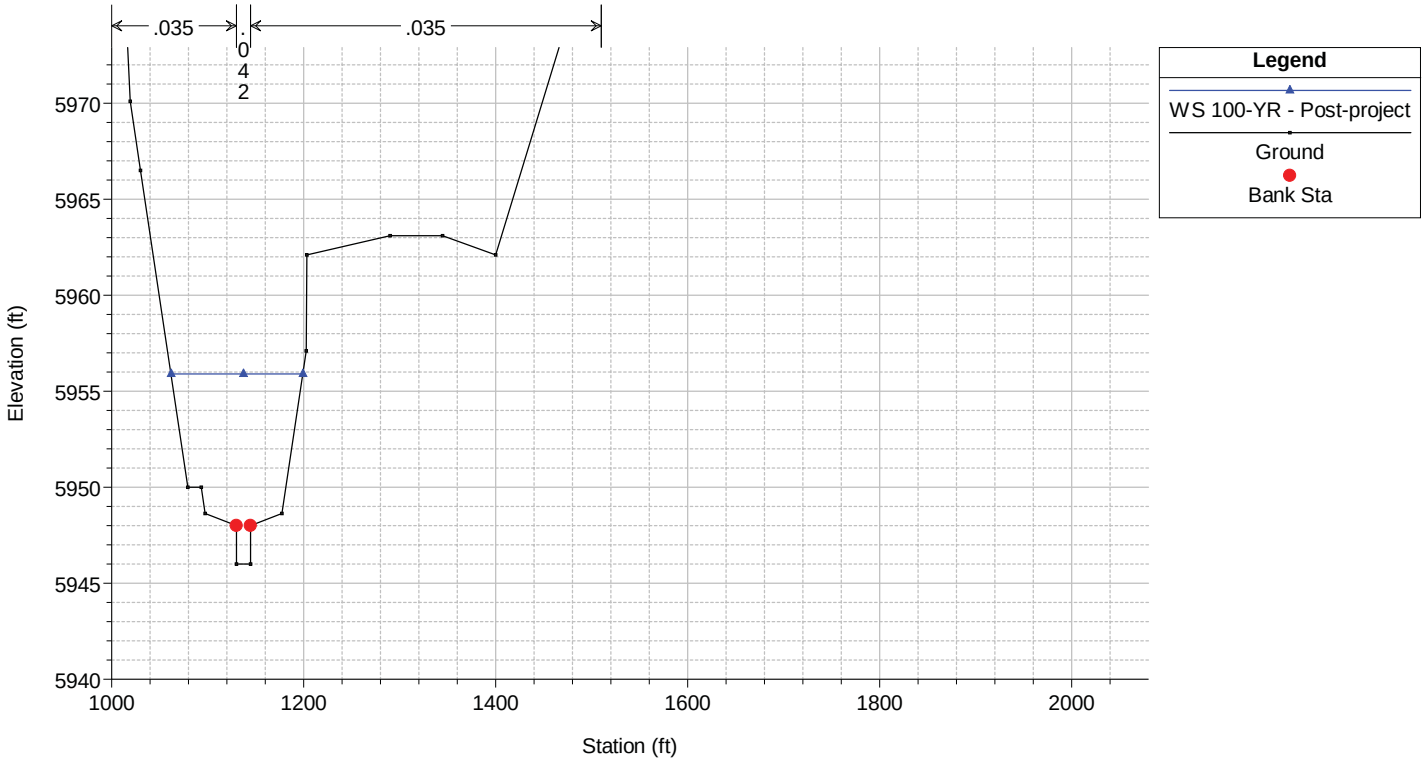
RS = 650 D/S Face NEW I-25 South Bound Off Ramp: Added new section to up



UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

RS = 590 Revised U/S Face New I-25 Bridge: Same XS orientation as URS mod



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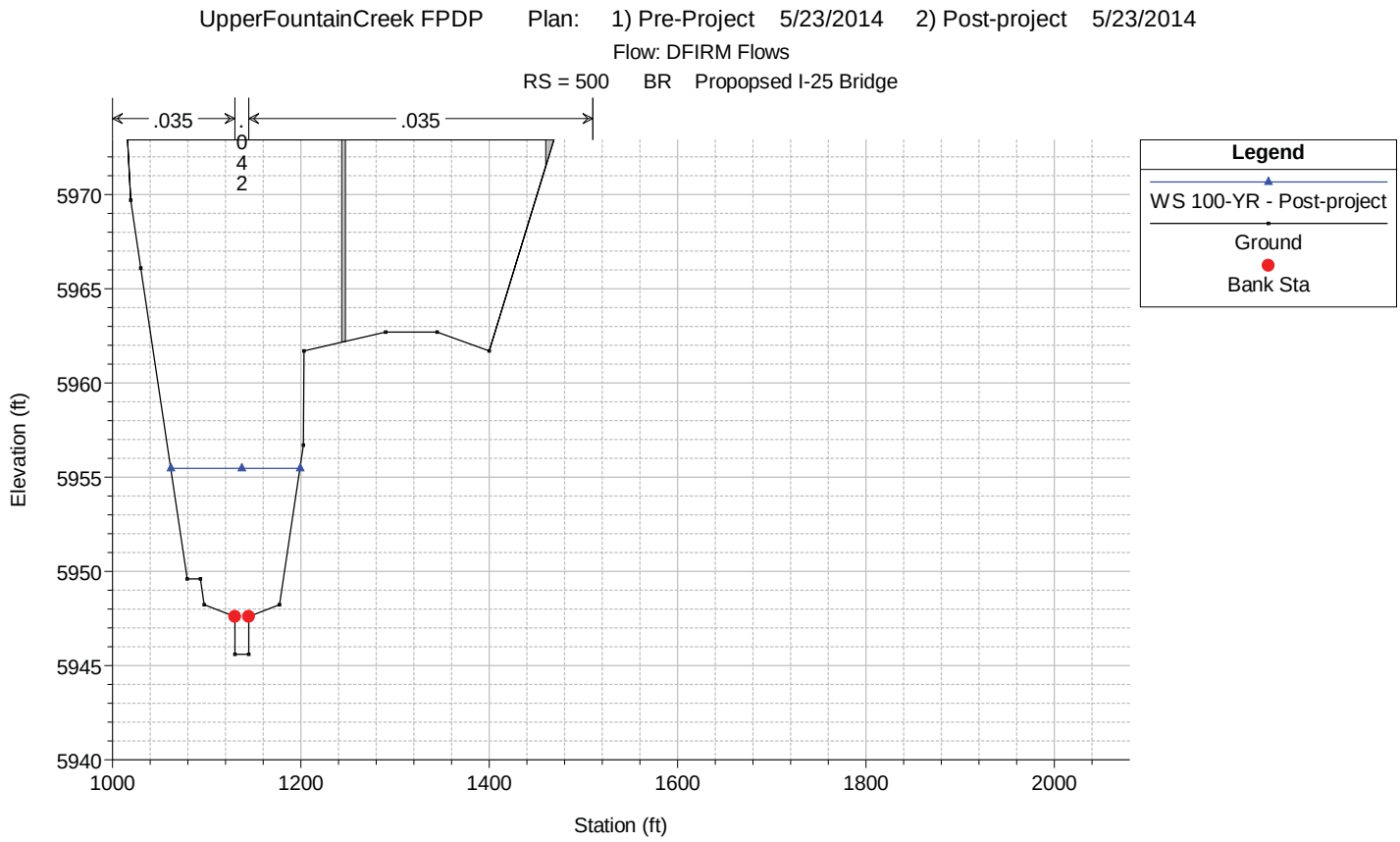
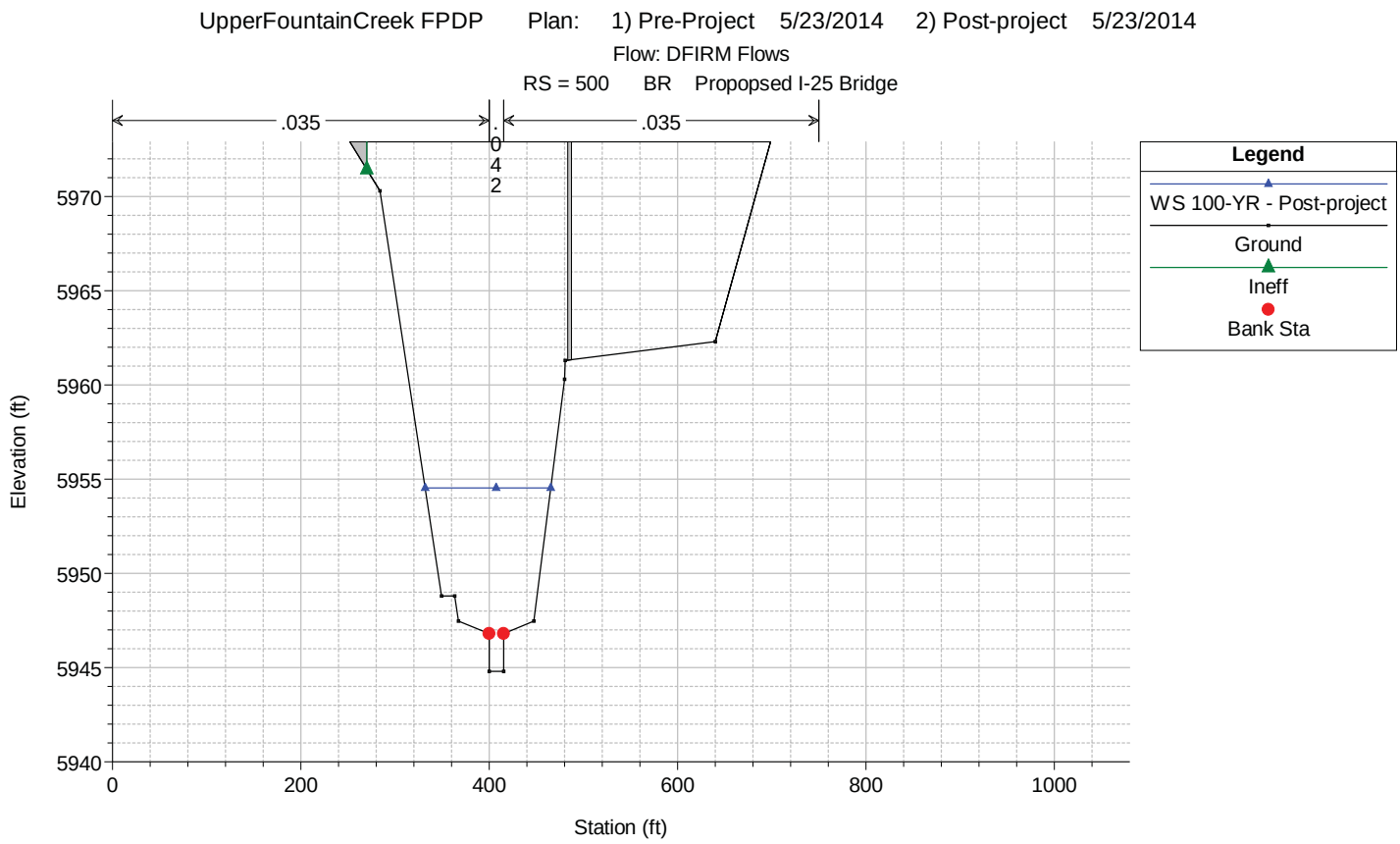


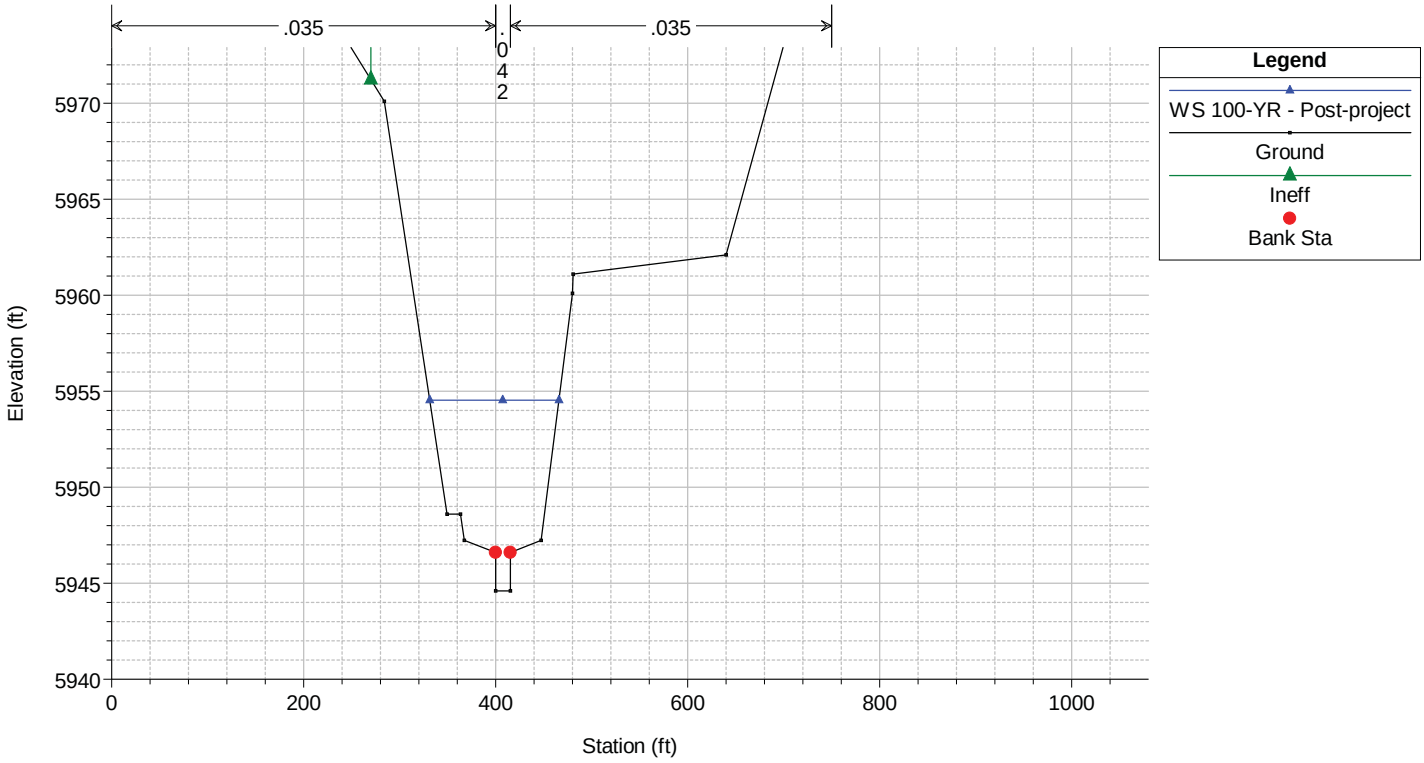


1 in Horiz. = 200 ft 1 in Vert. = 10 ft

UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

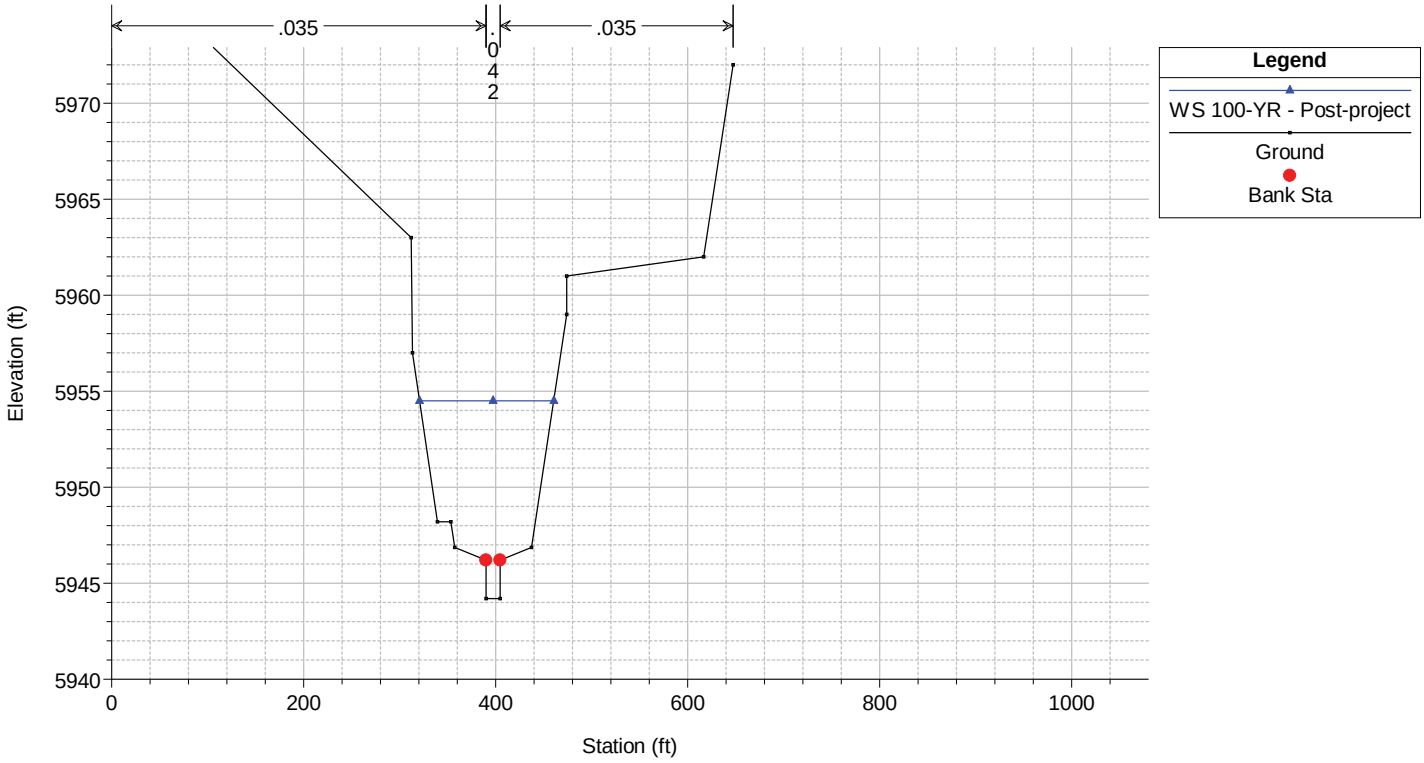
RS = 400 D/S Face I-25 Bridge: Same XS orientation as URS model (ineffec



UpperFountainCreek FPDP Plan: 1) Pre-Project 5/23/2014 2) Post-project 5/23/2014

Flow: DFIRM Flows

RS = 345 U/S Face I-25 North Bound Ramp: Same XS orientation as URS mode



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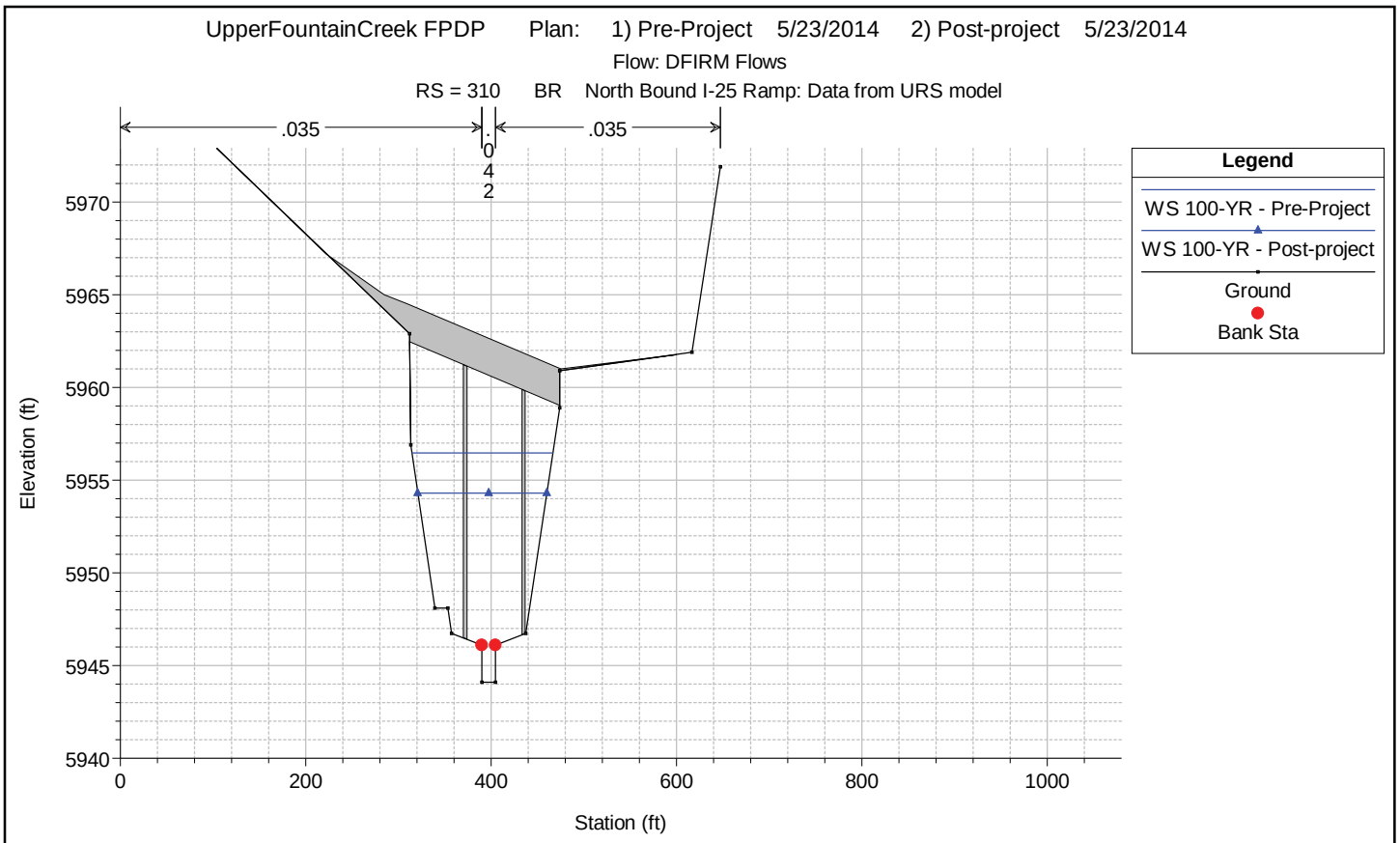

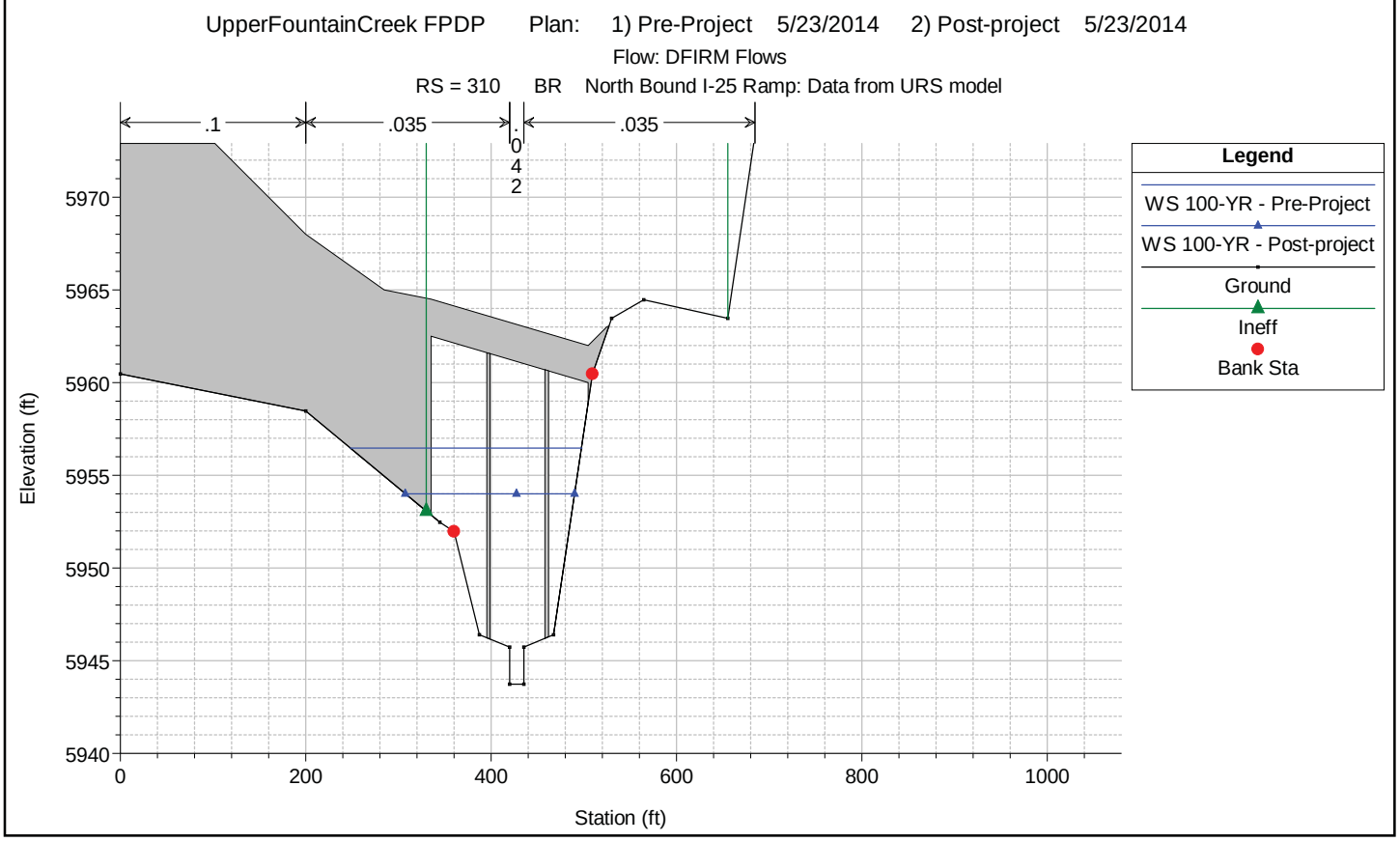

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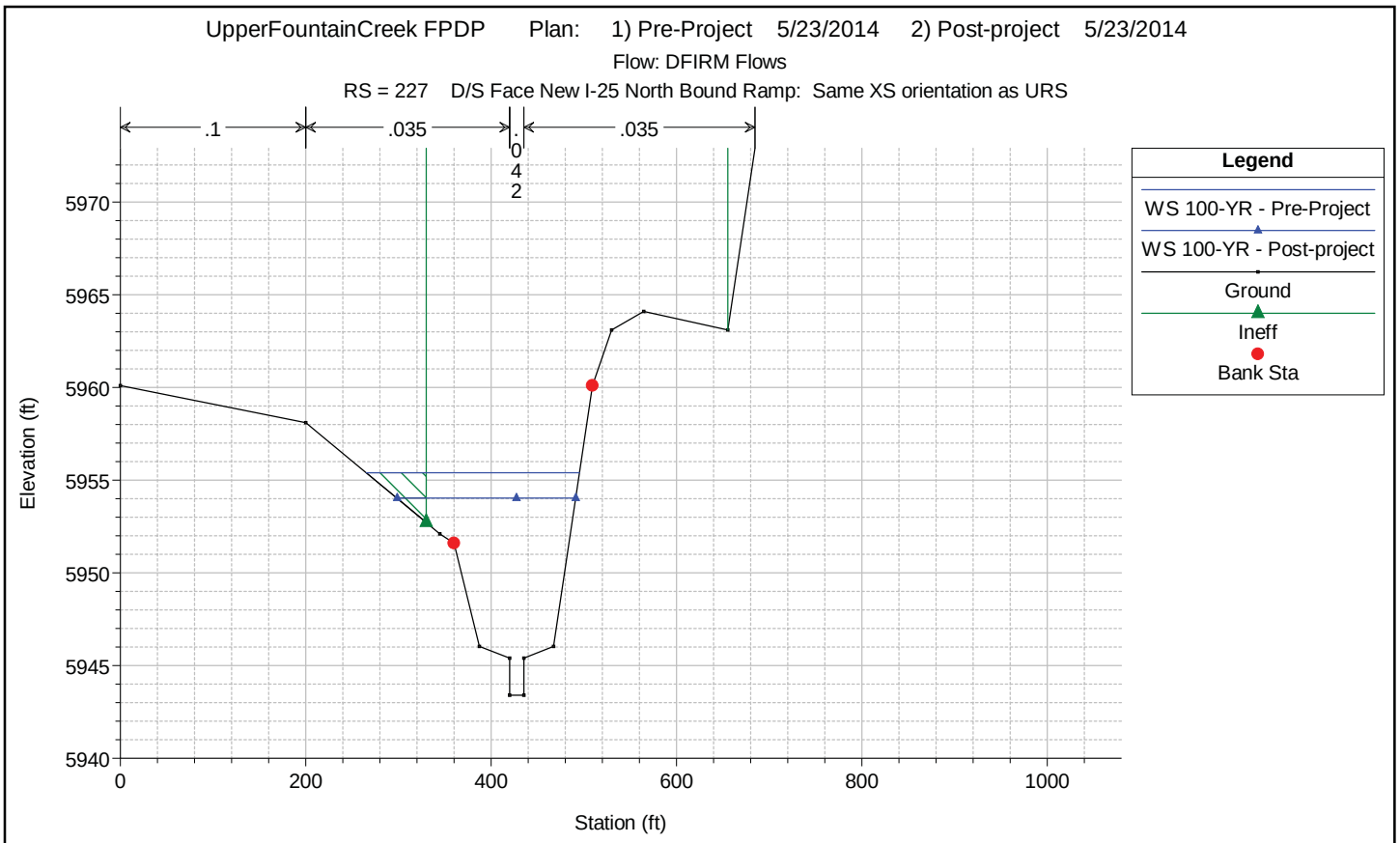
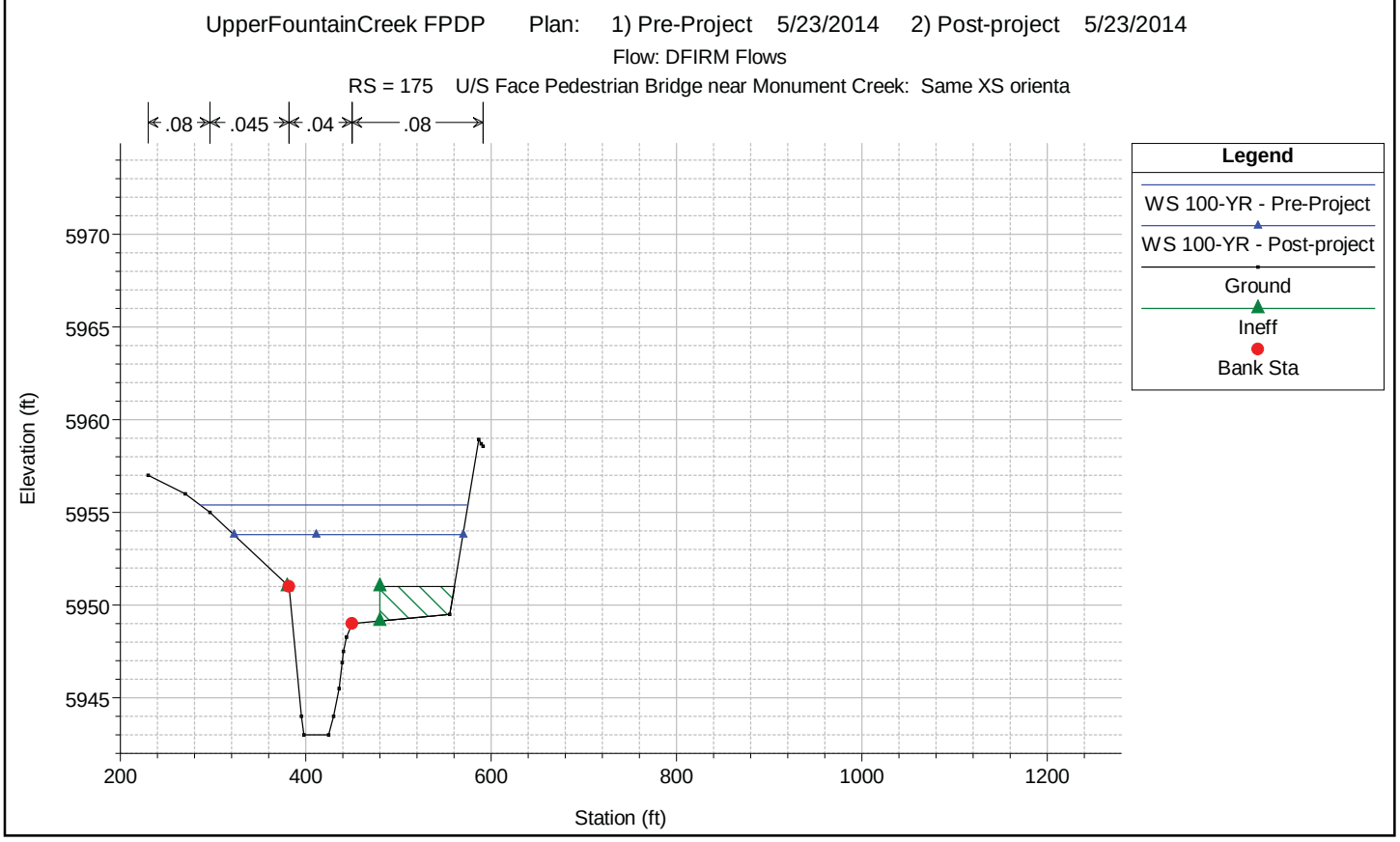
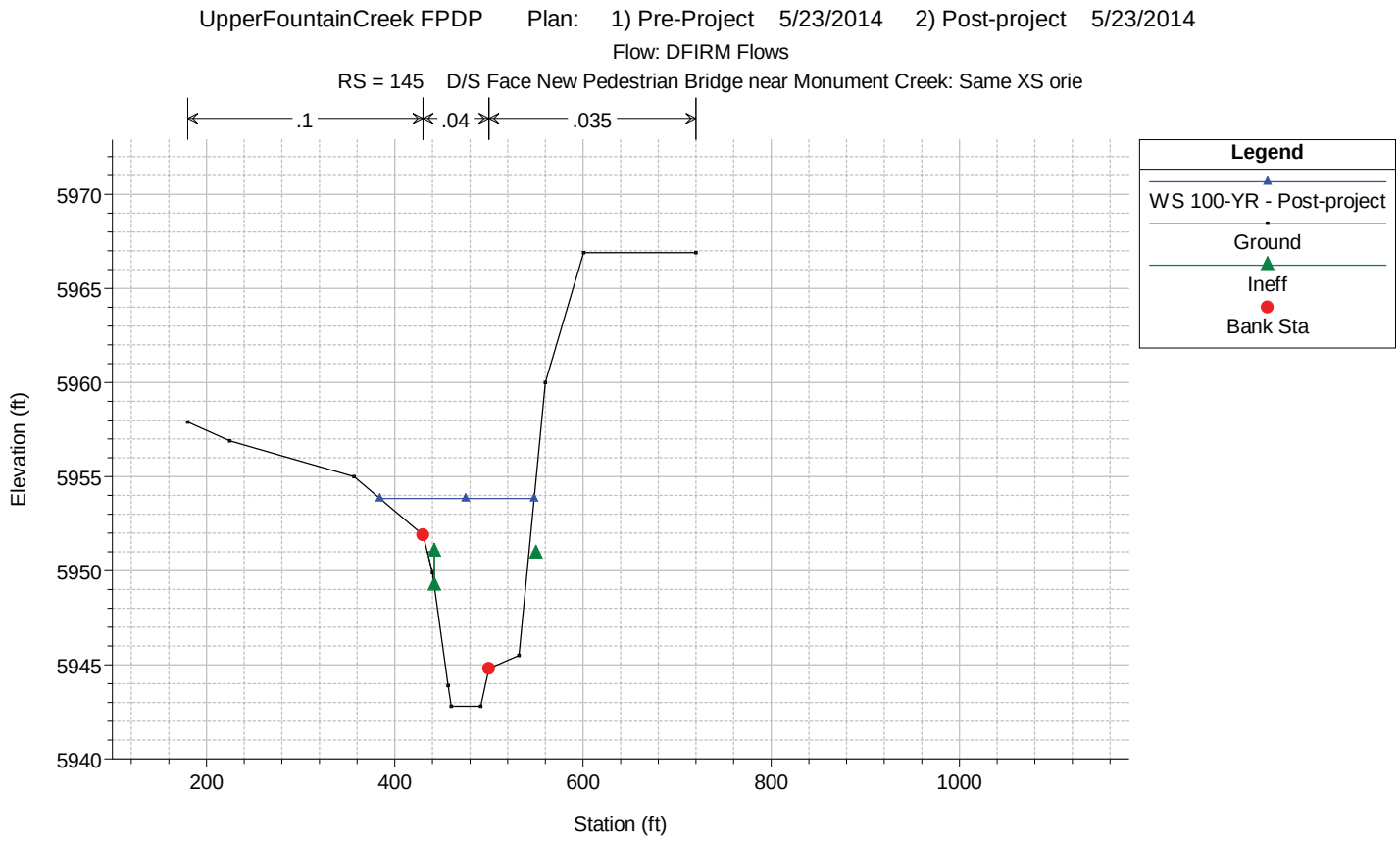
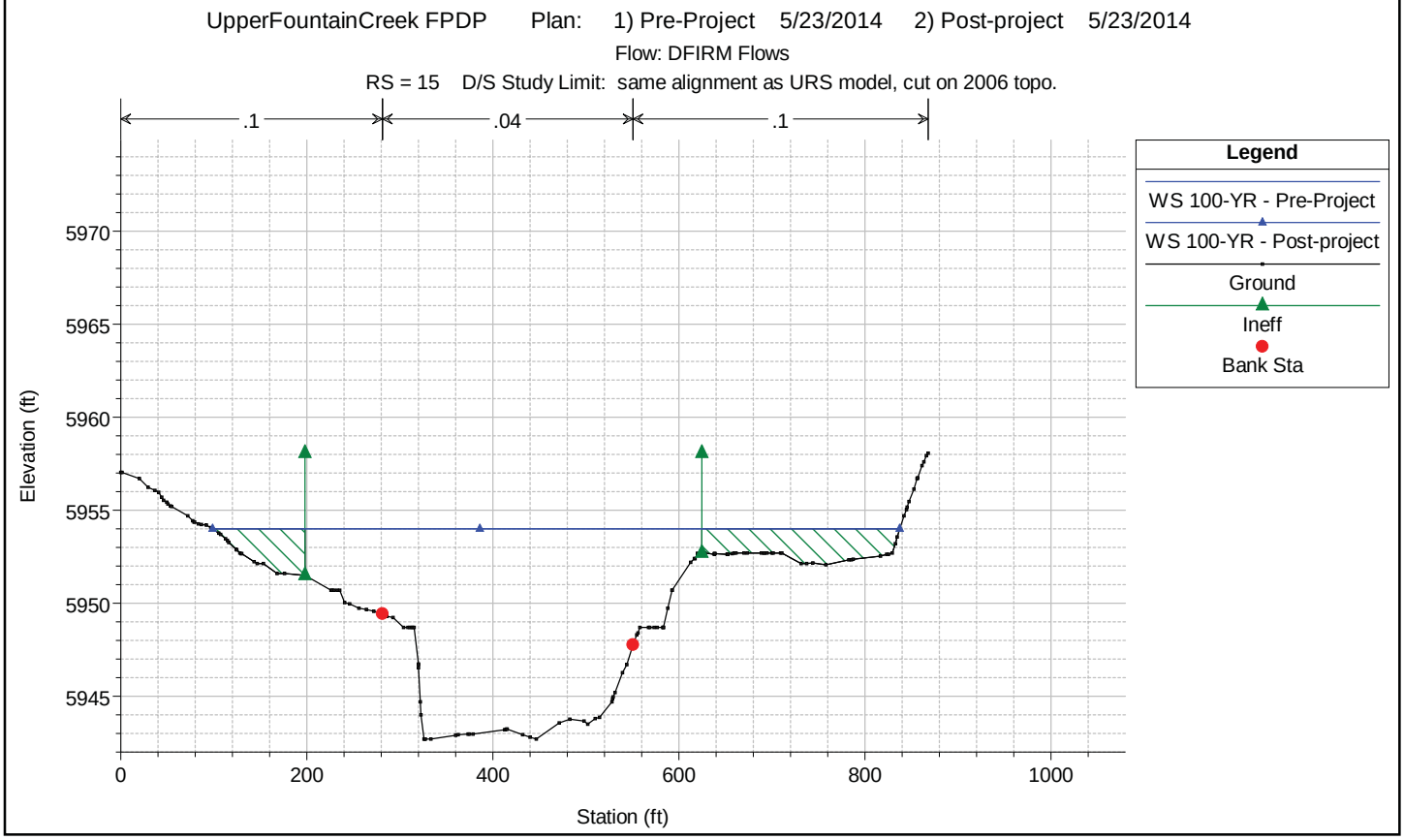




1 in Horiz. = 200 ft 1 in Vert. = 10 ft





1 in Horiz. = 200 ft 1 in Vert. = 10 ft

HEC-RAS River: UpperFountain Reach: Main Profile: 100-YR

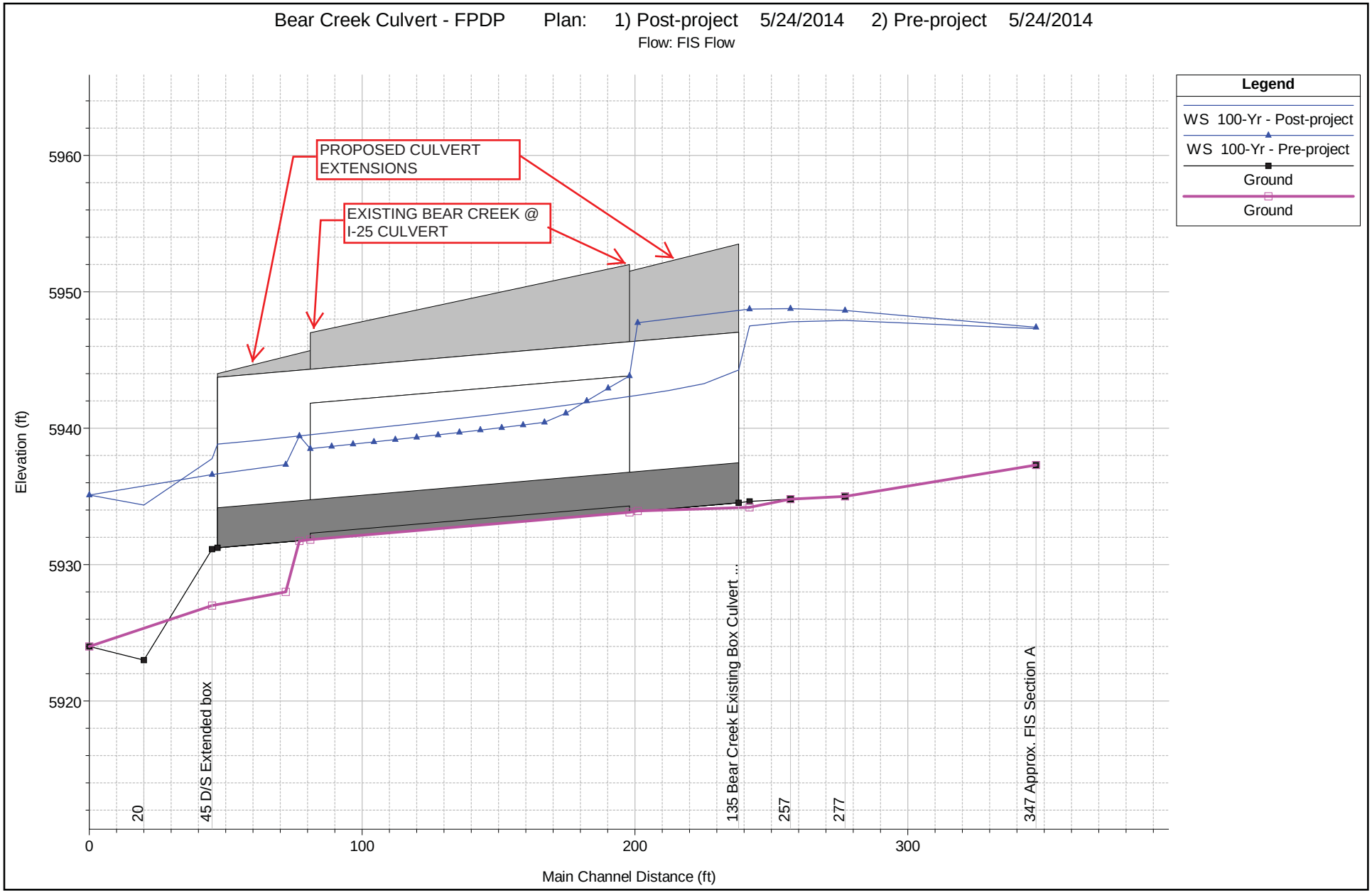
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	1751	100-YR	Post-project	3920.00	5955.12	5965.99	5963.92	5967.28	0.009895	9.10	430.95	65.13	0.62
Main	1751	100-YR	Pre-Project	3920.00	5955.12	5966.04	5963.92	5967.30	0.009719	9.04	433.68	65.28	0.62
Main	1432	100-YR	Post-project	3920.00	5953.43	5963.83	5961.01	5964.67	0.006251	7.34	536.76	83.96	0.50
Main	1432	100-YR	Pre-Project	3920.00	5953.43	5964.07	5961.02	5964.85	0.005594	7.09	556.93	84.59	0.47
Main	1360			Bridge									
Main	1286	100-YR	Post-project	3920.00	5952.75	5959.53	5959.31	5960.25	0.009935	8.14	750.86	319.80	0.67
Main	1286	100-YR	Pre-Project	3920.00	5952.76	5960.17	5959.26	5960.52	0.008053	5.67	912.84	333.75	0.52
Main	1110	100-YR	Post-project	3920.00	5949.56	5956.16	5956.16	5958.09	0.012822	12.04	353.56	90.44	0.83
Main	868	100-YR	Post-project	3920.00	5947.80	5956.12	5953.82	5956.73	0.002853	6.63	632.83	129.63	0.40
Main	868	100-YR	Pre-Project	3920.00	5947.91	5958.87	5954.97	5959.24	0.002359	5.11	923.19	244.19	0.33
Main	780	100-YR	Post-project	3920.00	5947.20	5956.01	5953.15	5956.46	0.001778	5.44	735.00	130.94	0.32
Main	700			Bridge									
Main	650	100-YR	Post-project	3920.00	5946.40	5955.96	5952.35	5956.30	0.001210	4.74	837.24	136.08	0.27
Main	590	100-YR	Post-project	3920.00	5946.00	5955.92	5951.95	5956.22	0.001028	4.47	883.04	137.55	0.25
Main	559	100-YR	Pre-Project	3920.00	5945.56	5958.20	5951.67	5958.55	0.002011	4.79	903.62	480.10	0.29
Main	500			Bridge									
Main	400	100-YR	Post-project	3920.00	5944.60	5954.53	5950.55	5954.84	0.001040	4.50	873.11	134.48	0.25
Main	345	100-YR	Post-project	3920.00	5944.20	5954.50	5950.15	5954.77	0.000864	4.20	936.21	139.85	0.23
Main	310			Bridge									
Main	310	100-YR	Pre-Project	3920.00	5944.92	5956.47	5951.04	5956.86	0.001556	5.02	787.03	131.51	0.31
Main	293	100-YR	Pre-Project	3920.00	5944.80	5956.38	5951.10	5956.82	0.002007	5.28	742.09	101.68	0.34

HEC-RAS River: UpperFountain Reach: Main Profile: 100-YR (Continued)

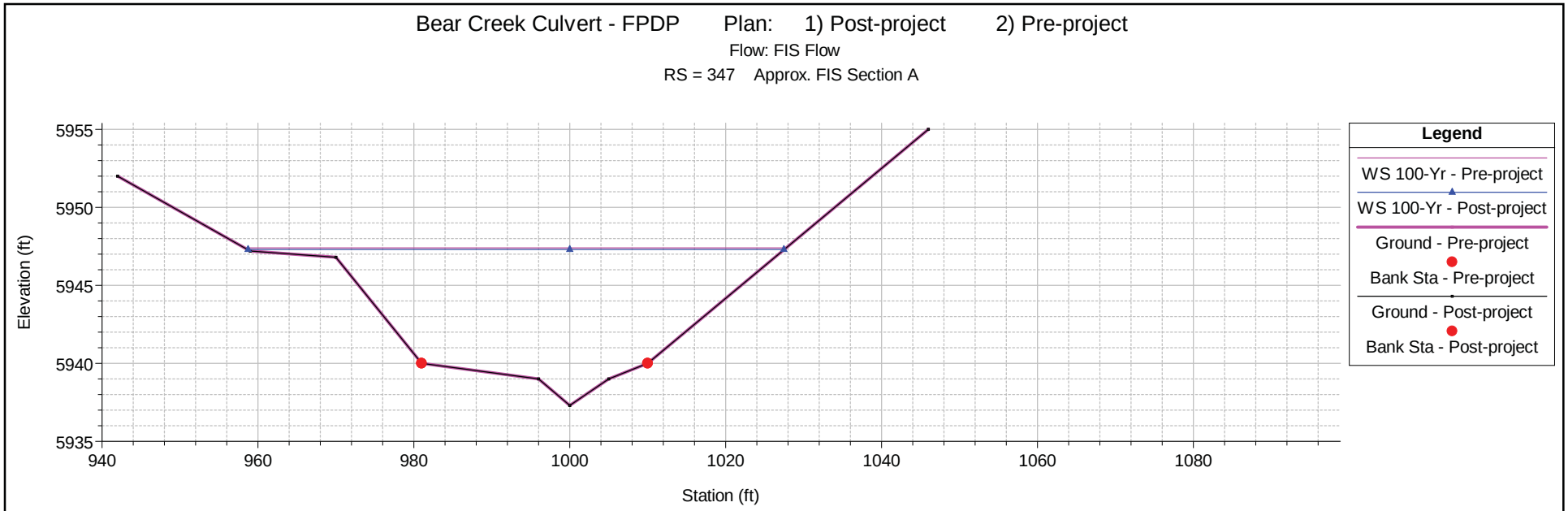
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	227	100-YR	Post-project	3920.00	5943.40	5954.02	5949.39	5954.27	0.000755	4.08	992.94	192.74	0.27
Main	227	100-YR	Pre-Project	3920.00	5944.20	5955.40	5950.49	5955.89	0.002304	5.61	699.01	97.64	0.37
Main	175	100-YR	Post-project	3920.00	5943.00	5953.78	5949.85	5954.18	0.001281	5.49	1054.29	246.88	0.33
Main	175	100-YR	Pre-Project	3920.00	5941.50	5955.40	5949.08	5955.72	0.001363	4.53	898.59	304.93	0.29
Main	153	100-YR	Pre-Project	3920.00	5942.42	5953.86	5950.52	5954.16	0.001663	5.51	1454.18	565.49	0.31
Main	145	100-YR	Post-project	3920.00	5942.80	5953.85	5948.28	5954.11	0.000708	4.10	996.66	164.03	0.25
Main	15	100-YR	Post-project	3920.00	5942.70	5953.99	5945.50	5954.02	0.000073	1.43	3199.77	739.06	0.08
Main	15	100-YR	Pre-Project	3920.00	5939.50	5953.99	5942.27	5954.00	0.000028	0.95	6240.35	859.84	0.05

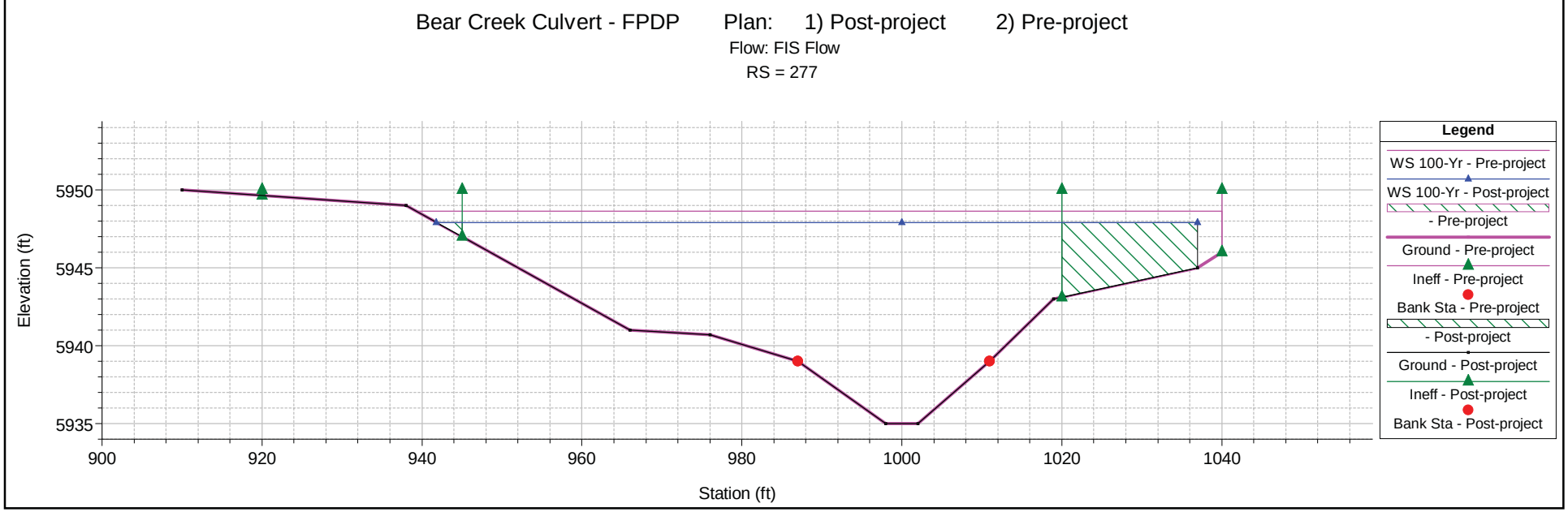
Appendix D

Bear Creek Floodplain Hydraulic Analysis Results

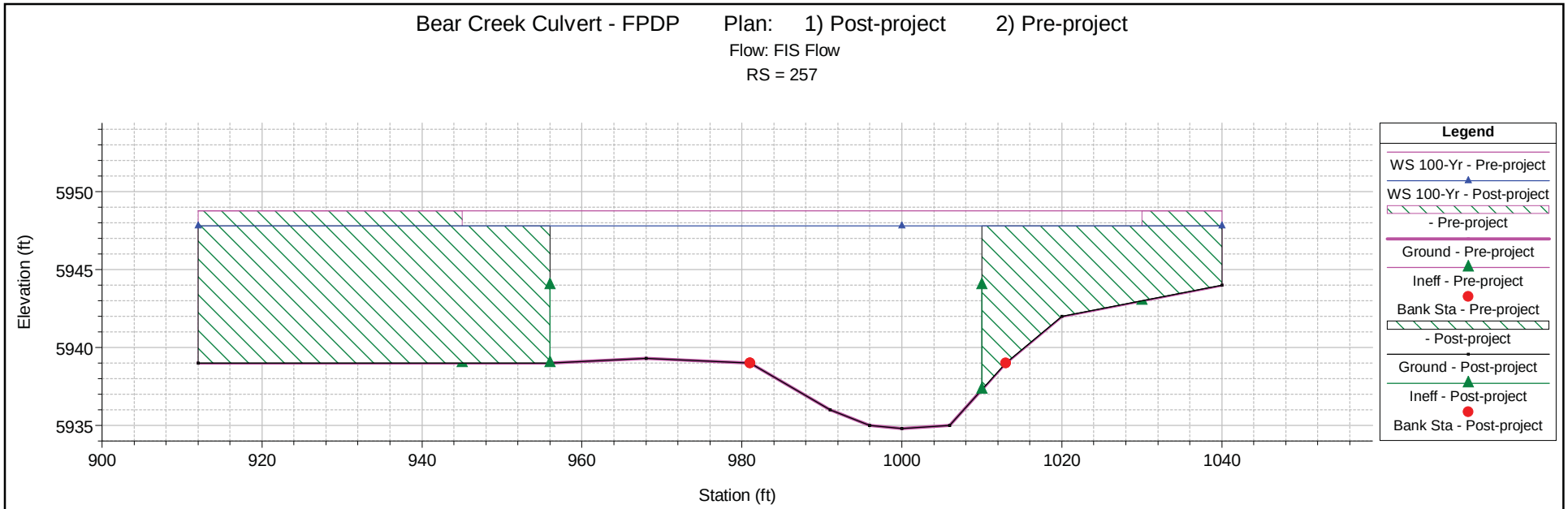


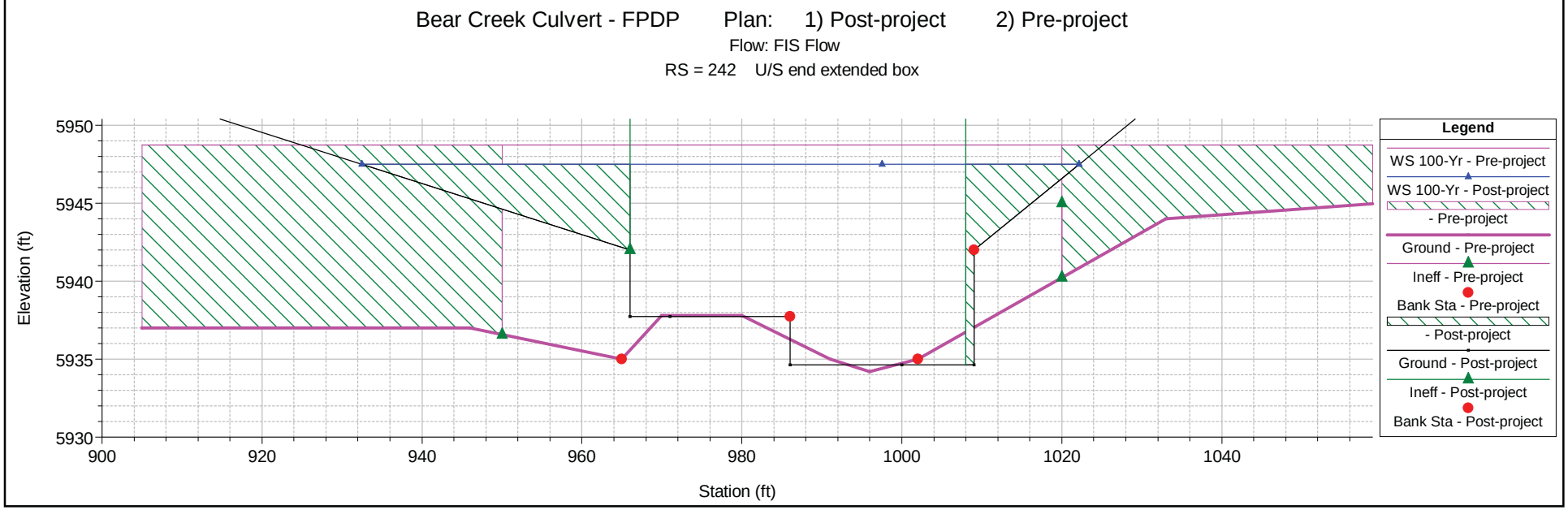
1 in Horiz. = 50 ft 1 in Vert. = 10 ft



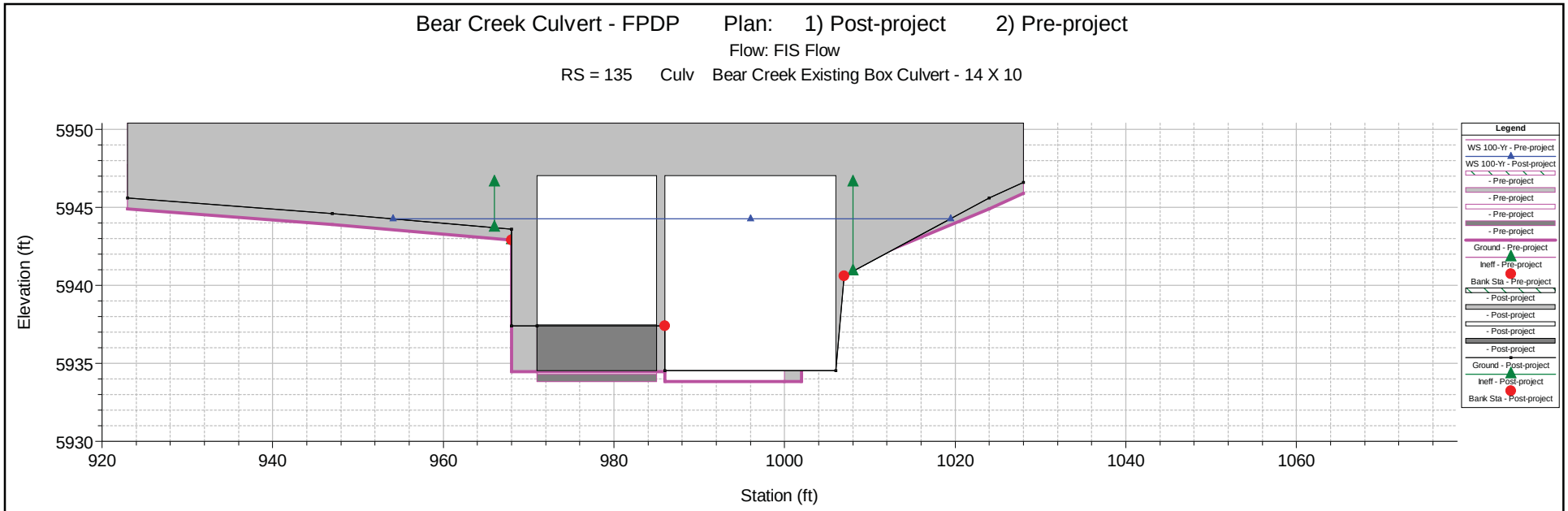


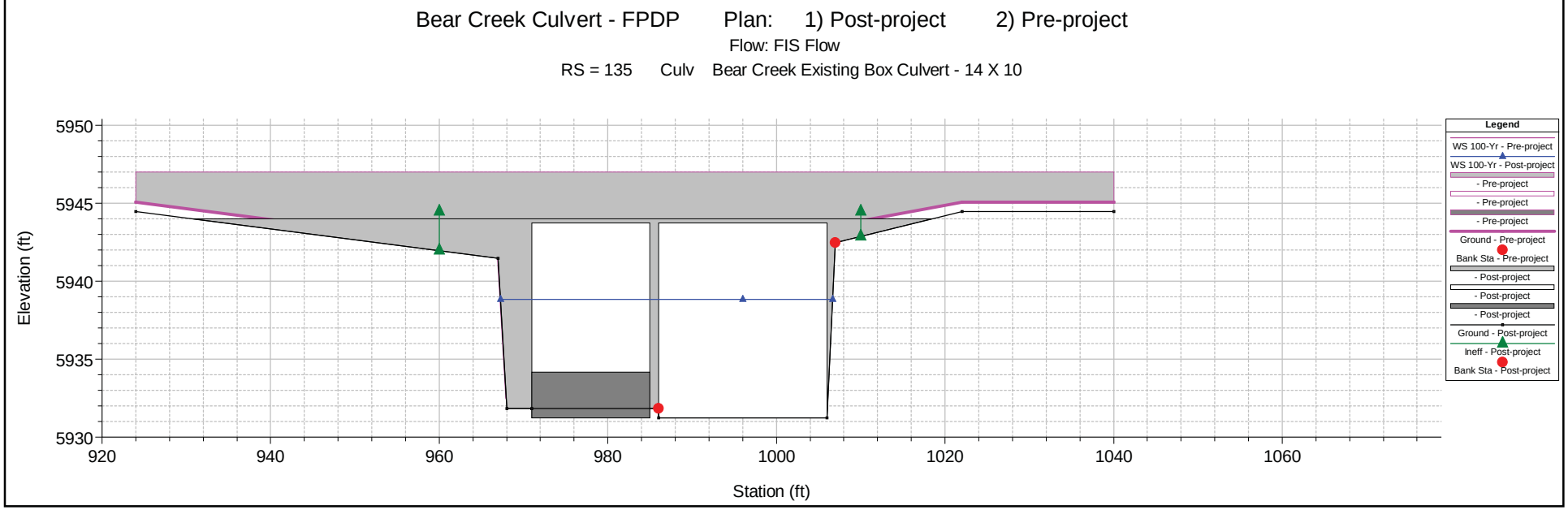
1 in Horiz. = 20 ft 1 in Vert. = 10 ft



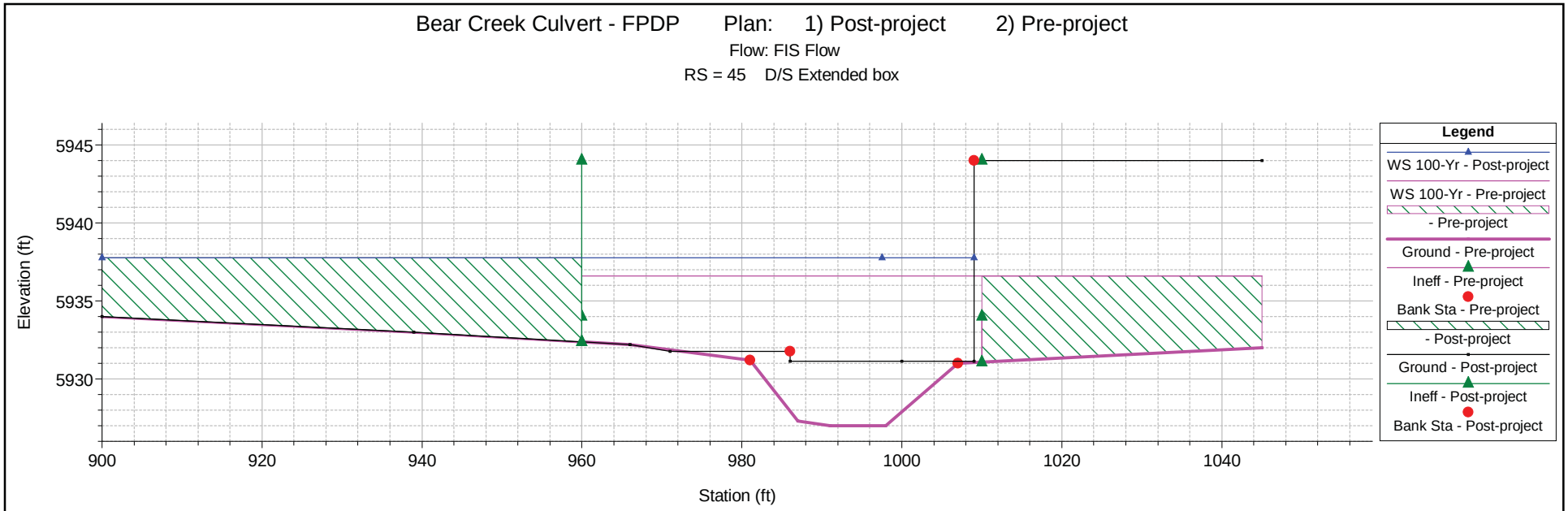


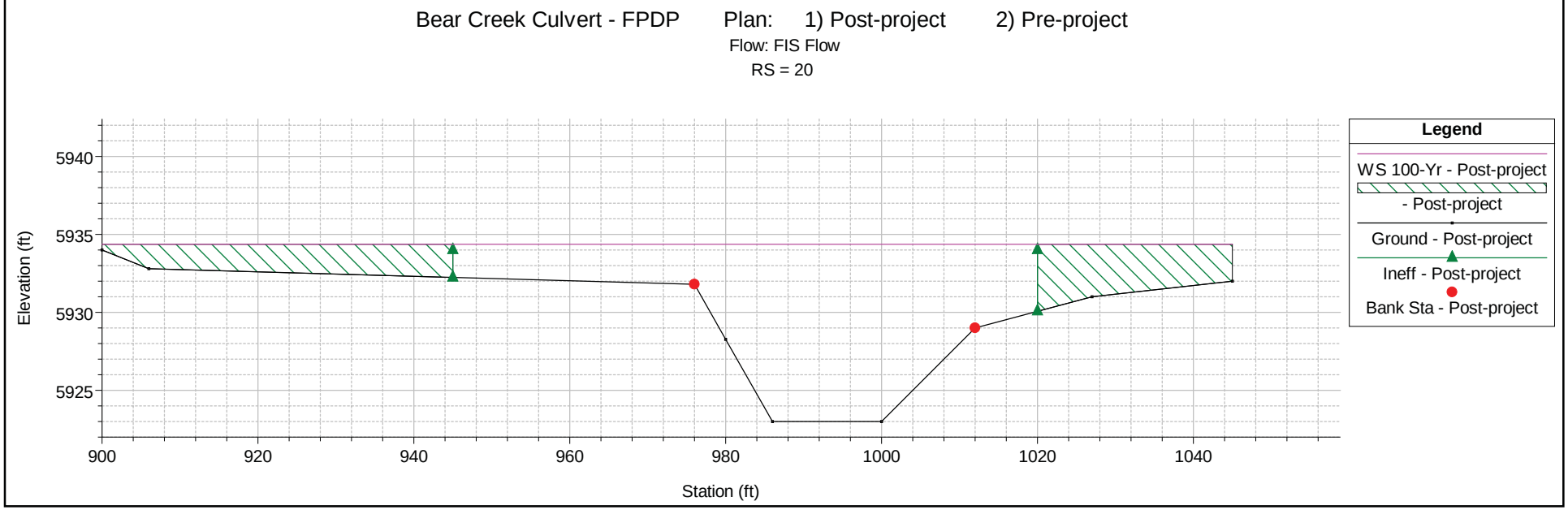
1 in Horiz. = 20 ft 1 in Vert. = 10 ft





1 in Horiz. = 20 ft 1 in Vert. = 10 ft





1 in Horiz. = 20 ft 1 in Vert. = 10 ft

HEC-RAS River: Bear Creek Reach: Lower Profile: 100-Yr

Reach	River Sta	Profile	Plan	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)	
Lower	347	100-Yr	Post-project	4140.00	5937.30	5947.28	5947.28	5949.94	0.006899	14.10	347.43	68.78	0.87
Lower	347	100-Yr	Pre-project	4140.00	5937.30	5947.41	5947.28	5949.94	0.006486	13.80	355.83	69.50	0.84
Lower	277	100-Yr	Post-project	4140.00	5935.00	5947.92	5944.66	5948.76	0.001396	7.64	571.79	95.21	0.40
Lower	277	100-Yr	Pre-project	4140.00	5935.00	5948.62	5944.83	5949.22	0.000961	6.60	716.45	100.68	0.34
Lower	257	100-Yr	Post-project	4140.00	5934.80	5947.80	5943.10	5948.73	0.000952	6.44	556.27	128.00	0.33
Lower	257	100-Yr	Pre-project	4140.00	5934.80	5948.75	5942.63	5949.14	0.000452	4.54	867.00	128.00	0.23
Lower	242	100-Yr	Post-project	4140.00	5934.63	5947.50	5943.05	5948.70	0.000358	9.43	478.32	89.70	0.46
Lower	242	100-Yr	Pre-project	4140.00	5934.20	5948.75	5941.39	5949.14	0.000451	5.47	857.59	155.00	0.27
Lower	201	100-Yr	Pre-project	4140.00	5933.92	5947.75	5941.96	5949.01	0.002303	9.03	458.55	105.00	0.43
Lower	135			Culvert									
Lower	77	100-Yr	Pre-project	4140.00	5931.75	5939.44	5939.44	5943.25	0.002677	15.67	264.17	34.75	1.00
Lower	72	100-Yr	Pre-project	4140.00	5928.00	5937.34	5937.34	5942.25	0.007124	12.14	278.76	56.52	0.75
Lower	45	100-Yr	Post-project	4140.00	5931.15	5937.76	5937.76	5940.79	0.002796	15.37	303.42	109.00	1.05
Lower	45	100-Yr	Pre-project	4140.00	5927.00	5936.59	5936.59	5939.77	0.008724	15.53	333.04	145.00	0.95
Lower	20	100-Yr	Post-project	4140.00	5923.00	5934.36	5933.27	5935.76	0.004726	9.79	440.10	145.00	0.57
Lower	0	100-Yr	Post-project	4140.00	5924.00	5935.10	5930.81	5935.39	0.001033	6.02	1169.77	150.00	0.34
Lower	0	100-Yr	Pre-project	4140.00	5924.00	5935.10	5930.81	5935.39	0.001033	6.02	1169.77	150.00	0.34