Central 70 Project
2000 South Holly Street
Denver, CO 80222

June 13, 2016

Lance Kippen
Manager Industry & Public Projects
Union Pacific Railroad
1400 W 52 Avenue
Denver, CO 80221

RE: **30% UPRR Crossing Plans, CDOT Central 70 Project**
Roadway Underpass Grade Separation, 46th Ave, Denver, CO
MP 2.77: Greeley Subdivision (36th Yard)
DOT # 804-266G

Roadway Underpass Grade Separation, Interstate 70 (existing Roadway Overpass), Denver, CO
MP 2.76: Greeley Subdivision (36th Yard)
DOT # 804-269C

Together with the 30% UPRR Trackwork Plans (submitted separately), CDOT is pleased to formally submit the 30% UPRR Crossing Plans for UPRR review and approval. Modifications to the existing grade separated crossings are required as part of the overall Central 70 (formerly I-70 East) reconstruction project. Specifically, the existing 46th Avenue underpass and the existing I-70 viaduct overpass will be removed and replaced with a single underpass for 46th Avenue and I-70 roadways.

As discussed, this project will be constructed under a design-build alternative delivery method. These 30% UPRR Crossing Plans for roadway, sidewalk, drainage, and bridge structure design will be designed to 100% level by the Central 70 design-build Developer and approved by UPRR.

The related 30% UPRR Trackwork Plans (submitted separately) include the temporary shoo-fly tracks, track layout with phasing, crossing material at York Street, and service road design for UPRR approval. The 30% York Street Crossing Plans with warning device design including preemption signal interconnect timing will be submitted independantly under separate cover.

As part of this 30% UPRR Crossing Plan package, applicable proposed roadway, sidewalk, drainage, and bridge structure plans, and drainage memo has been provided for UPRR approval.

This 30% UPRR Crossing Plan package will be included in the Central 70 Project Request for Proposals (RFP). In addition, the following requirements are included in the Central 70 Project RFP:

1. The Developer shall coordinate with UPRR to establish a schedule for the start and anticipated completion of all construction work in accordance to Schedule 10, Section 10 of the RFP.
2. The Developer shall design and construct the new UPRR track bridge and new UPRR Service Road bridge over I-70 as described in Schedule 10, Section 13 of the RFP. Bridge design and construction shall conform to all relevant Railroad standards, and be approved by UPRR, as described in the RFP.

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2000 South Holly Street
Denver, CO 80222

3. The Developer will coordinate with the UPRR, all drainage related issues as related to Construction Work on or across Railroad right-of-way, as described in Schedule 10, Section 8 of the RFP.
4. At the discretion of UPRR, the Developer shall construct temporary and permanent fencing of types in accordance with UPRR standards and requirements at locations described in Schedule 10, Section 10 of the RFP.
5. The Developer shall provide gates in fences at locations and of width and type as approved by the Railroad for maintenance access, as described in Schedule 10, Section 10 of the RFP.
6. Lighting, Intelligent Transportation Systems (ITS) and Electronic Toll Collection (ETC) Systems are proposed along I-70 and included as part of Construction Work and will be designed and constructed by the Developer.
7. The Developer shall perform all Construction Work crossing the UPRR ROW in accordance with plans and specifications that will include UPRR's approval, in accordance to Schedule 10, Section 10 of the RFP.
8. The Developer shall obtain UPRR approval, in writing, in advance of construction activities, on methods and procedures for all Construction Work, in accordance to Schedule 10, Section 10 of the RFP.

I am available to discuss and answer any questions that you may have regarding this submittal. Additionally, our team is available for a review meeting and we can discuss in detail the proposed design.

Sincerely,

Ron Dickey
Central 70 Railroad Manager

Cc: Keith Stefanik, Central 70 Design Manager
Dan Liddle, Atkins

PoDI / NHS	
FHWA PROJECT OF DIVISION INTEREST (PoDI)?	☐ NO ■ YES
NATIONAL HIGHWAY SYSTEM?	☐ NO ■ YES

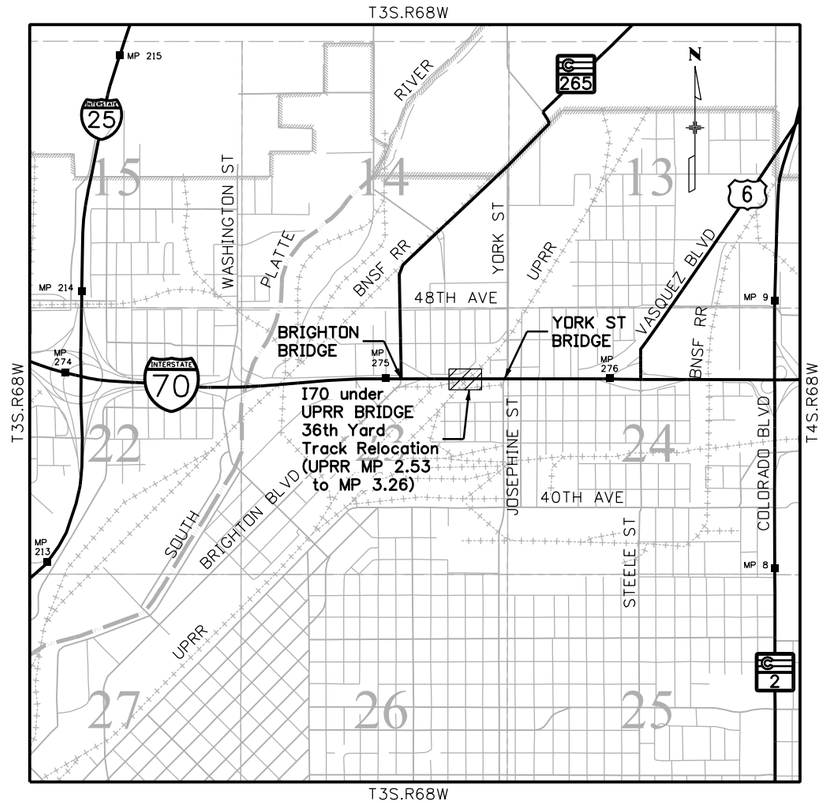
DEPARTMENT OF TRANSPORTATION
STATE OF COLORADO

HIGHWAY CONSTRUCTION BID PLANS OF PROPOSED
FEDERAL AID PROJECT NO. FBR 0704-234
STATE HIGHWAY NO. 70 UNDER UPRR (BRIDGE)
DENVER COUNTY
CONSTRUCTION PROJECT CODE NO. 19631
UPRR MP 2.76: GREELEY SUB; DOT #804-269C/266C

Related Projects:
P. E. UNDER PROJECT:
Project Number FBR 0704-234
Project Code: 19631

R.O.W. Projects:
R.O.W. Project Description

SHEET NO. INDEX OF SHEETS



PROJECT LOCATION MAP

0' 1500' 3000' 6000'

UPRR CROSSING PLANS
30% SUBMITTAL
JUNE 13, 2016

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Unit Information Unit Leader Initials				Phone: 303-757-9934 FAX: 303-757-9907	Void:
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276				Region 1 KJS	

Contract Information	Project No./Code
Contractor: _____	FBR 0704-234
Resident Engineer: _____	19631
Project Engineer: _____	Sheet Number .
PROJECT STARTED: __/__/__ ACCEPTED: __/__/__	
Comments: _____	

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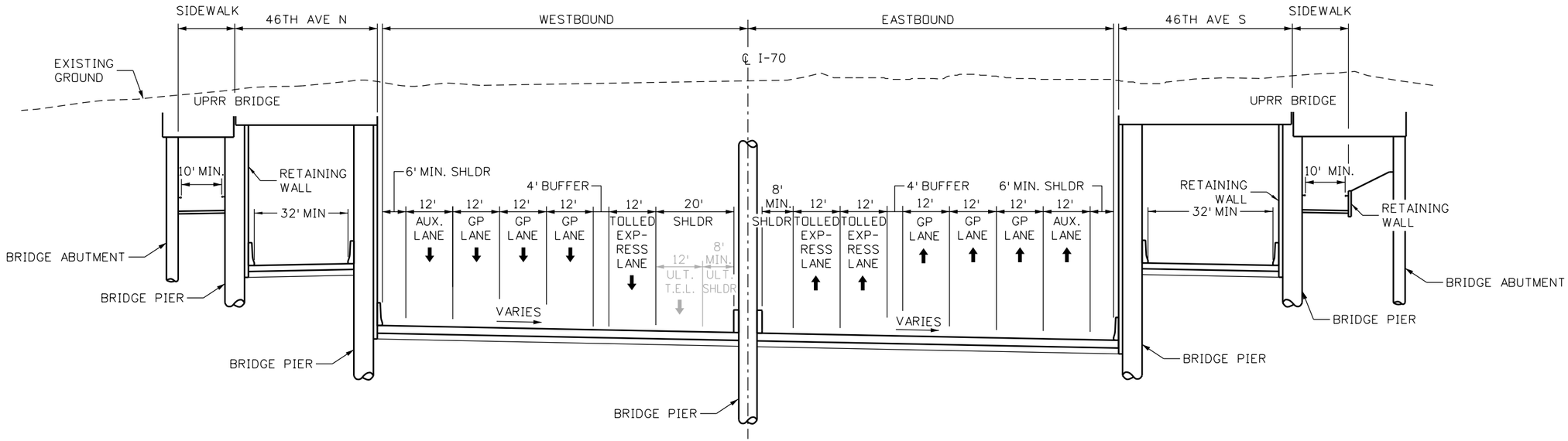
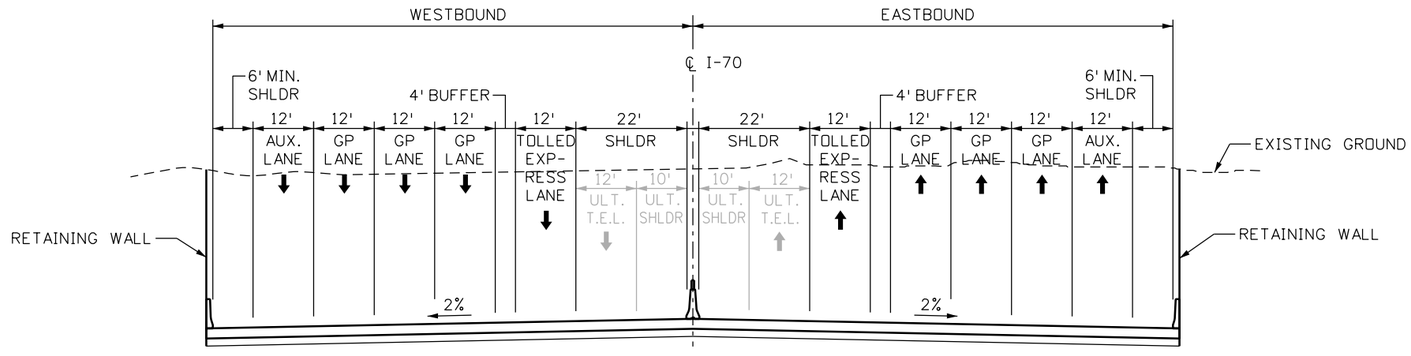


I-70 MAINLINE
UNDER UPRR BRIDGE



I-70 MAINLINE
UPRR TO DAHLIA ST

NOTES:
1. AT LOCATIONS WHERE A CONTINUOUS AUXILIARY LANE IS NOT PROVIDED, PROVIDE A 12' OUTSIDE SHOULDER.
2. THE TOLLED EXPRESS LANE STRIPING INCLUDES A WEAVE LANE AT MOST INGRESS/EGRESS LOCATIONS.

Print Date: 5/10/2016	Sheet Revisions			Colorado Department of Transportation	PRELIMINARY	I-70 MAINLINE TYPICAL SECTIONS	Project No./Code
File Name: 13599DES_Procurement_TypicalSect-02-Section 10B_I-70 Mainline.dgn	Date:	Comments	Init.	2000 South Holly Street Denver, CO 80222 Phone: 303-757-9934 FAX: 303-757-9907	No Revisions:		FBR 0704-234
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Unit Information Unit Leader Initials				Region 1	Void:	Sheet Subset: Rdwy Typl	Subset Sheets: 2 of 17
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276							Sheet Number 2

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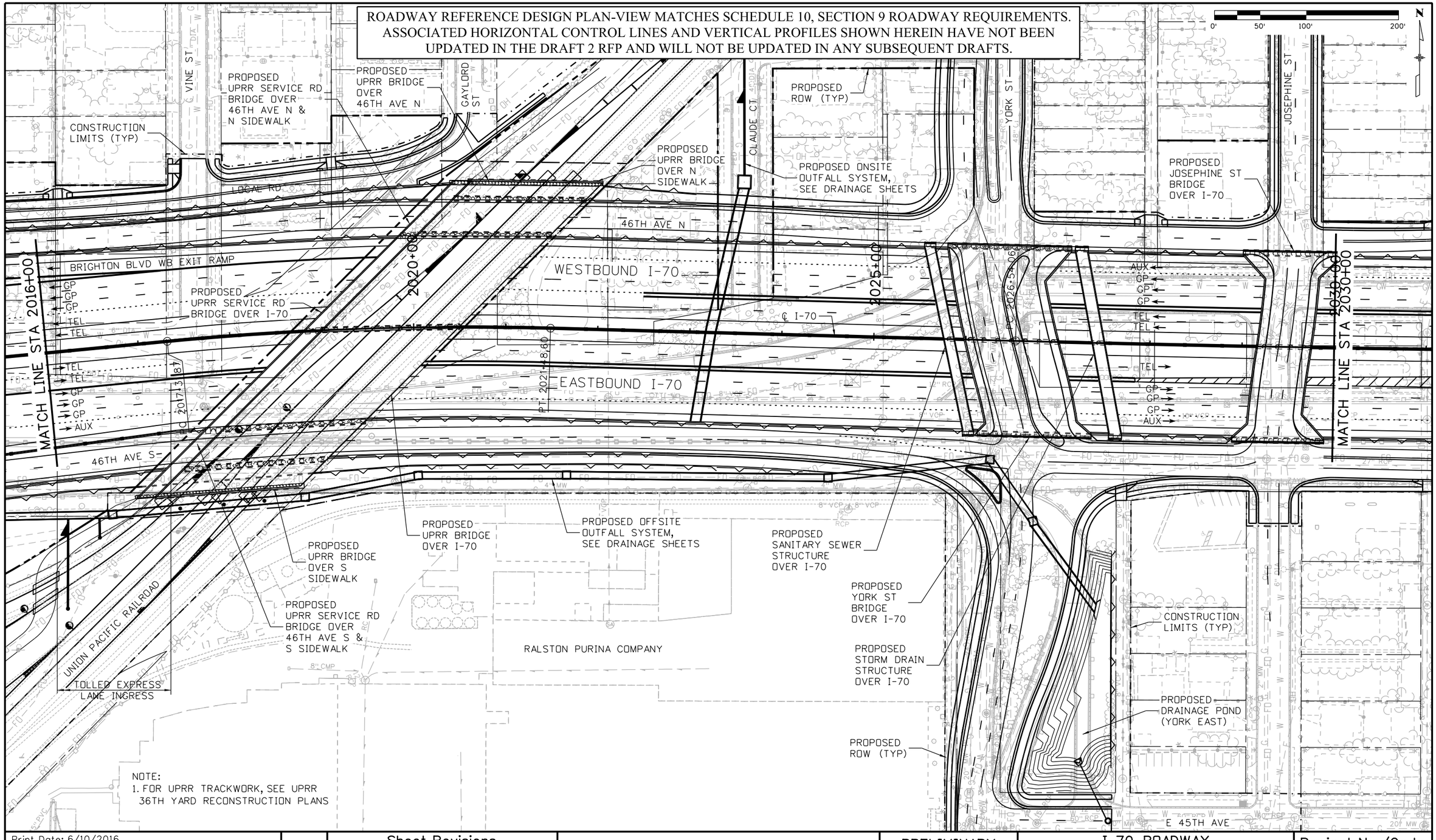
ROADWAY REFERENCE DESIGN PLAN-VIEW MATCHES SCHEDULE 10, SECTION 9 ROADWAY REQUIREMENTS. ASSOCIATED HORIZONTAL CONTROL LINES AND VERTICAL PROFILES SHOWN HEREIN HAVE NOT BEEN UPDATED IN THE DRAFT 2 RFP AND WILL NOT BE UPDATED IN ANY SUBSEQUENT DRAFTS.



NOTE:
1. FOR UPRR TRACKWORK, SEE UPRR 36TH YARD RECONSTRUCTION PLANS

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Unit Information Unit Leader Initials			Void:
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276			

I-70 ROADWAY ROADWAY PLAN STA 2016+00 TO 2030+00			Project No./Code
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Detailer:			
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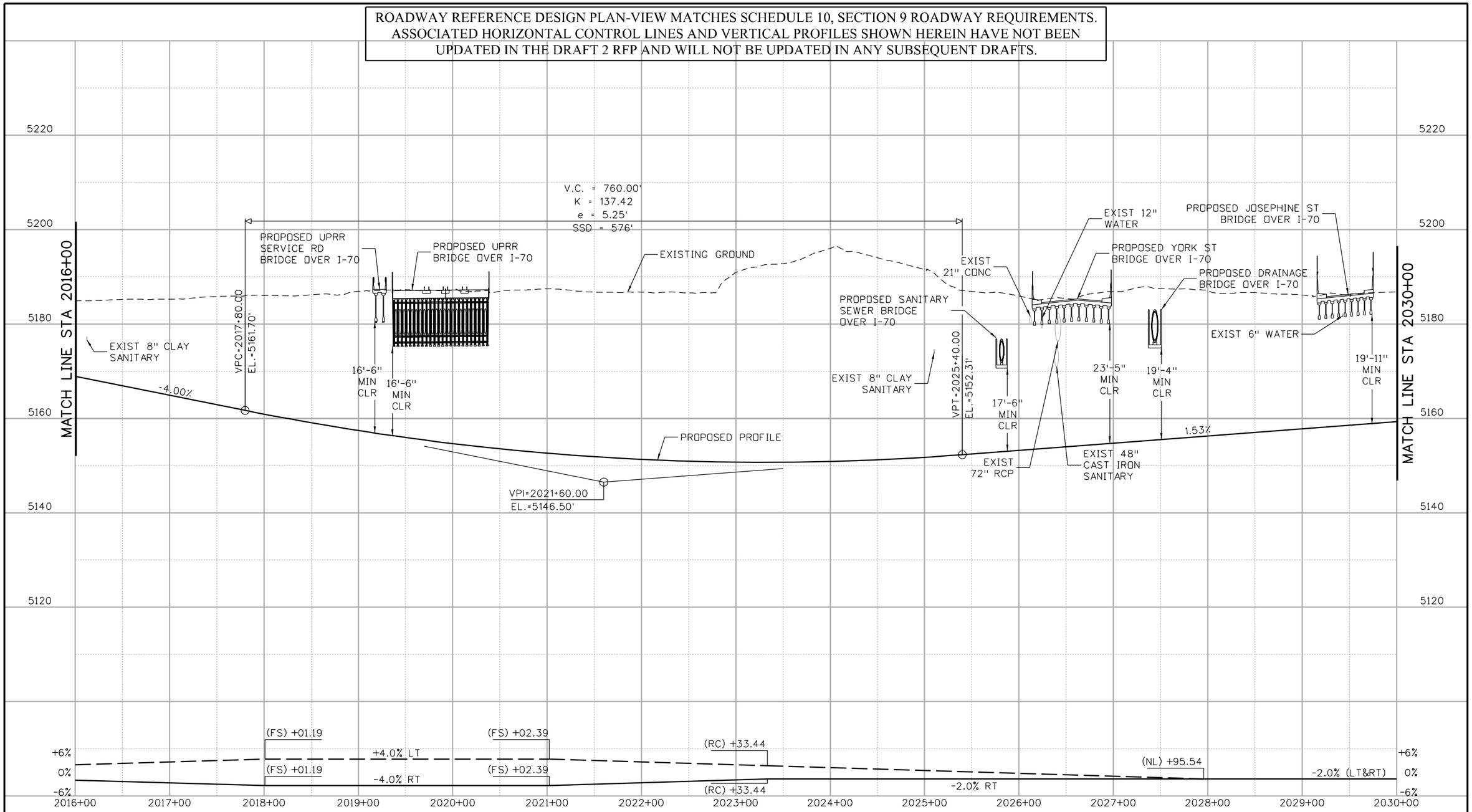

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Unit Information Unit Leader Initials		Region 1 KJS	Void:
ATKINS 7604 Technology Way, Suite 400, Denver, CO 80237, Phone: (303) 221-7275 Fax: (303) 221-7276			

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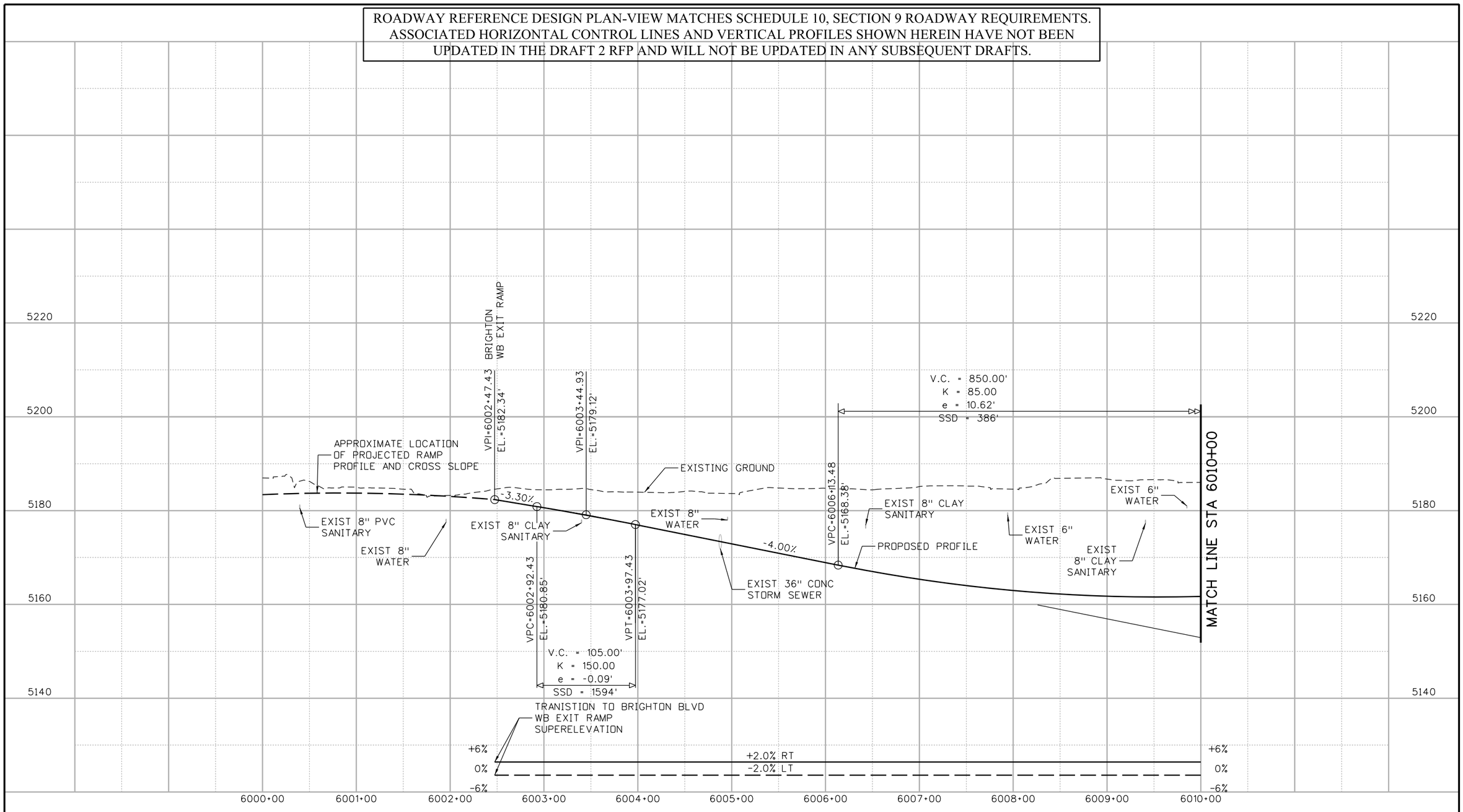

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Unit Information Unit Leader Initials		Region 1 KJS	Void:
ATKINS 7604 Technology Way, Suite 400, Denver, CO 80237, Phone: (303) 221-7275 Fax: (303) 221-7276			

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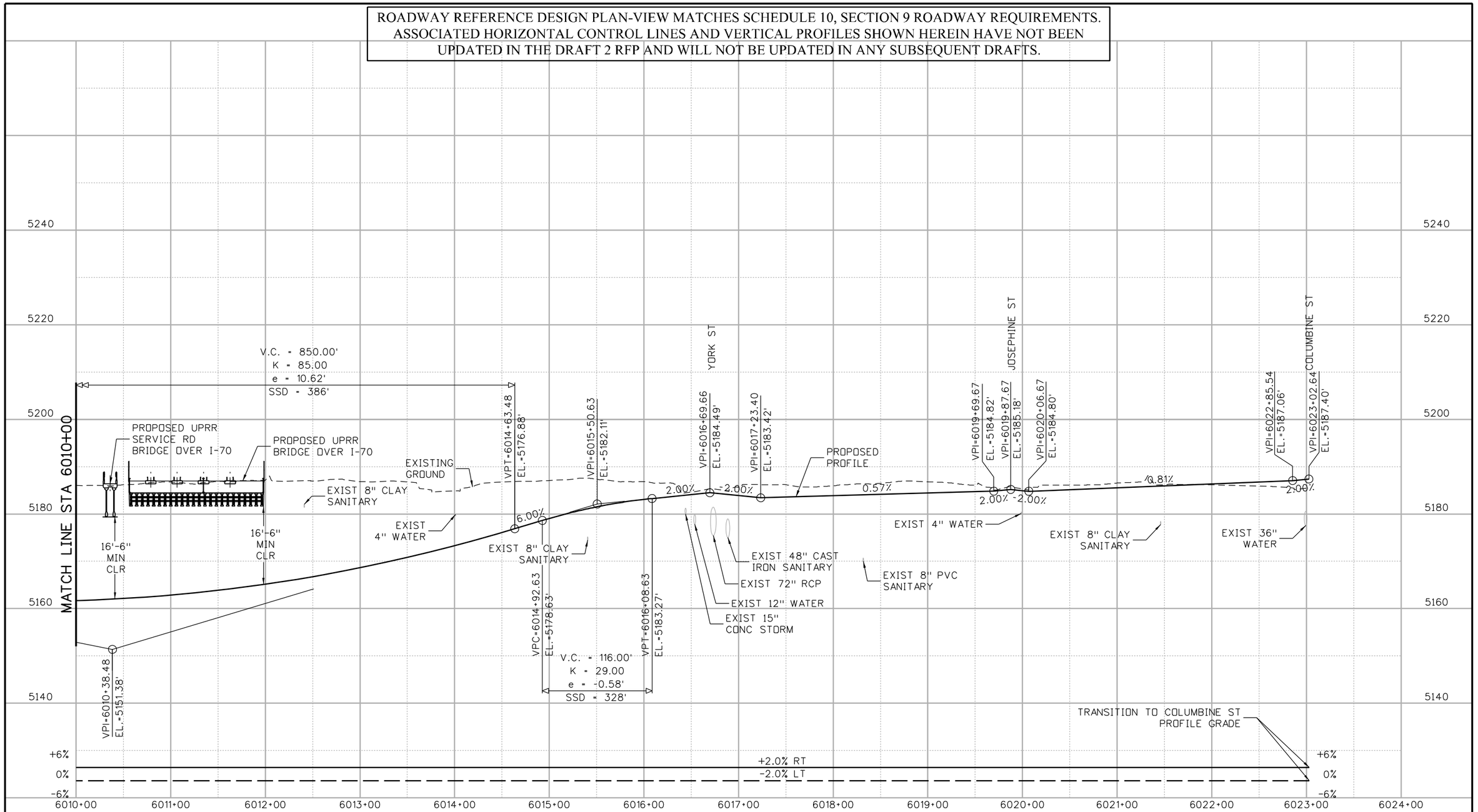

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Region 1 KJS

PRELIMINARY
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46TH AVE N
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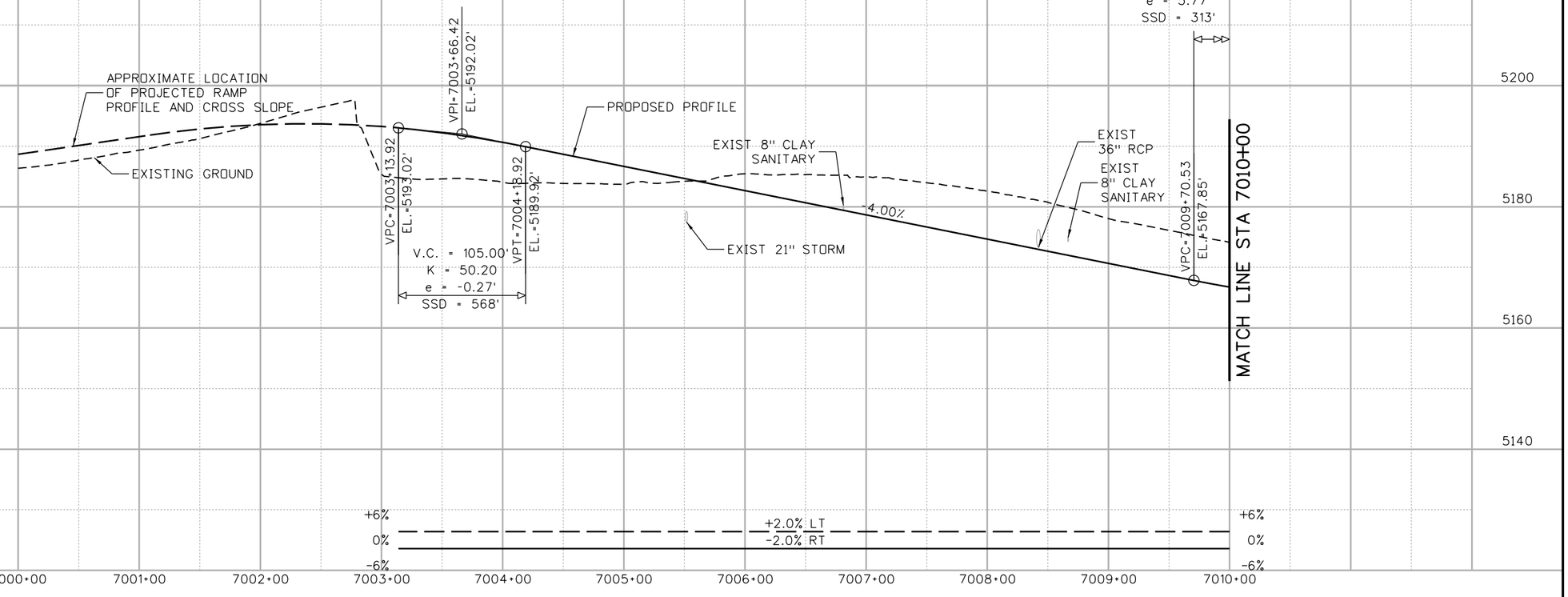

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ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276								

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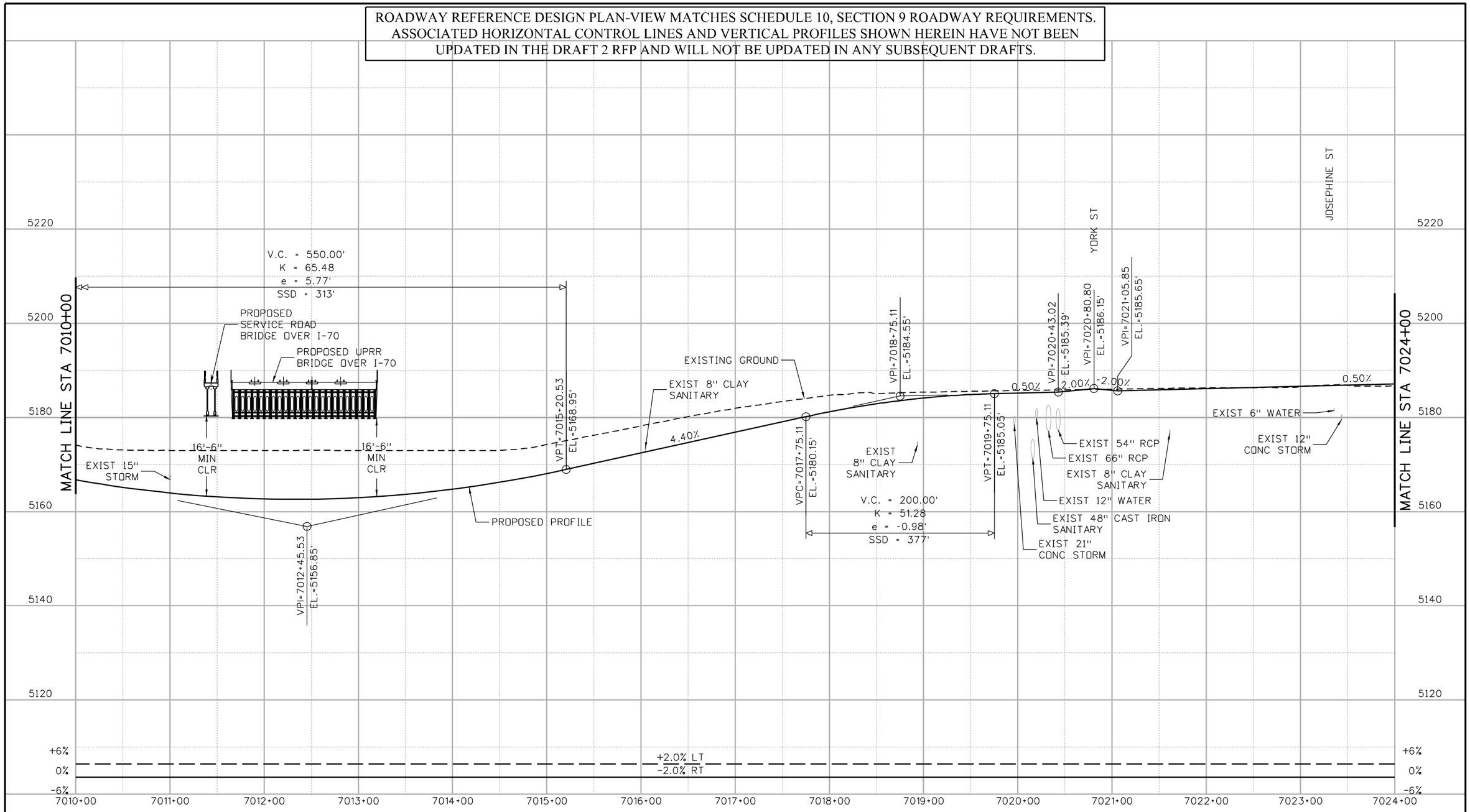

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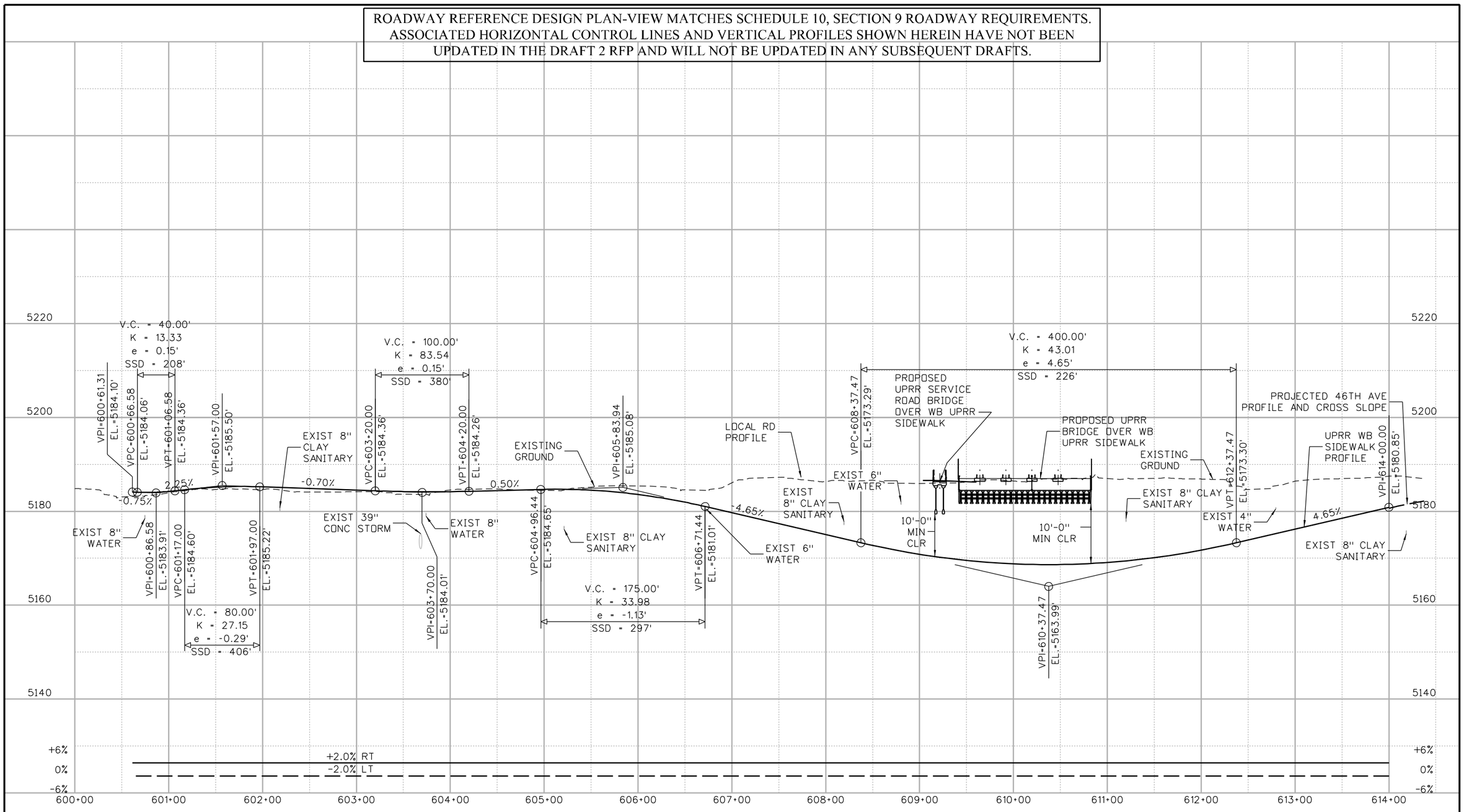

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Unit Information Unit Leader Initials		Region 1 KJS	Void:
ATKINS 7604 Technology Way, Suite 400, Denver, CO 80237, Phone: (303) 221-7275 Fax: (303) 221-7276			

UPRR WB SIDEWALK ROADWAY PROFILE STA 600+00 TO 614+37.34		Project No./Code
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Detailer:		19631
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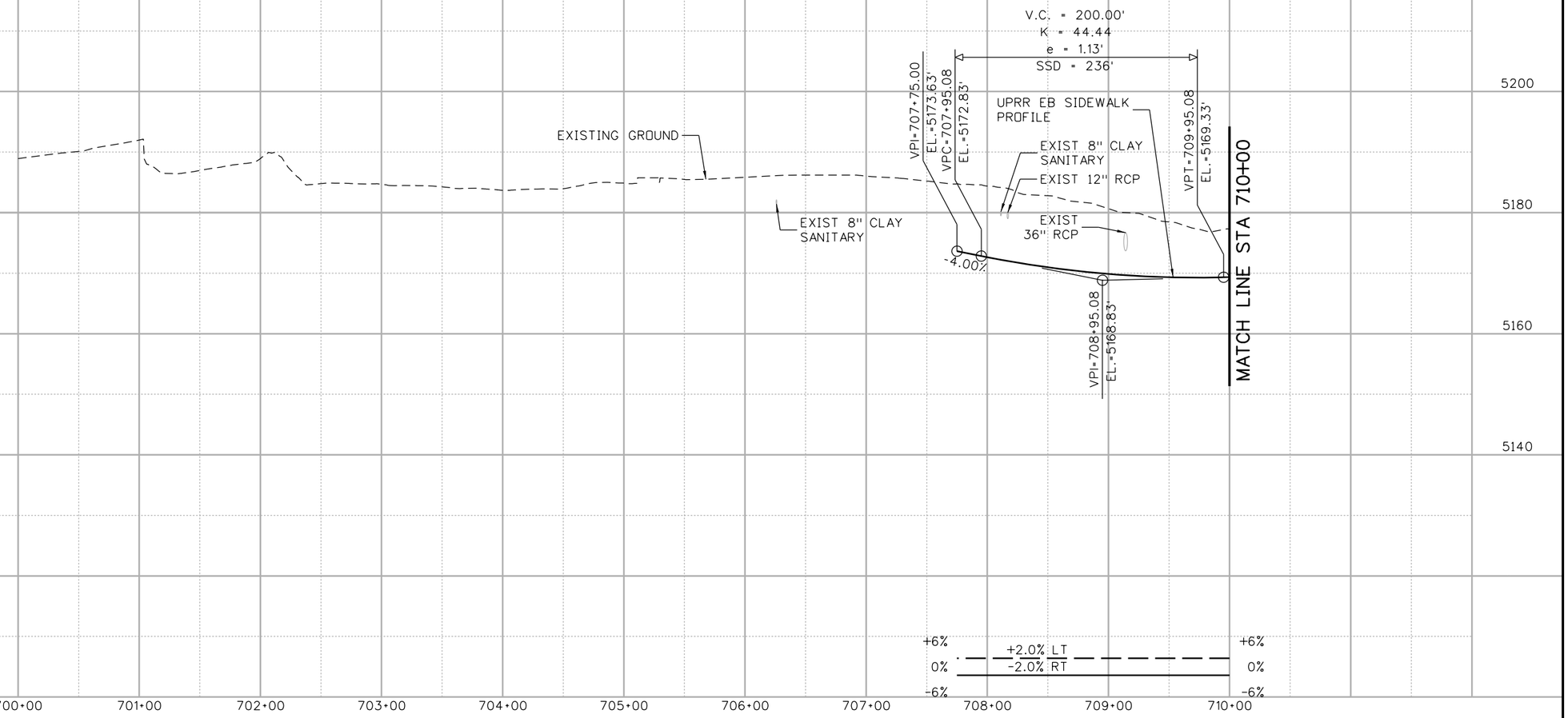

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Unit Information Unit Leader Initials					
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276					

PRELIMINARY	UPRR EB SIDEWALK ROADWAY PROFILE STA 700+00.00 TO 709+00		Project No./Code
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Revised:	Designer:	Structure Numbers	19631
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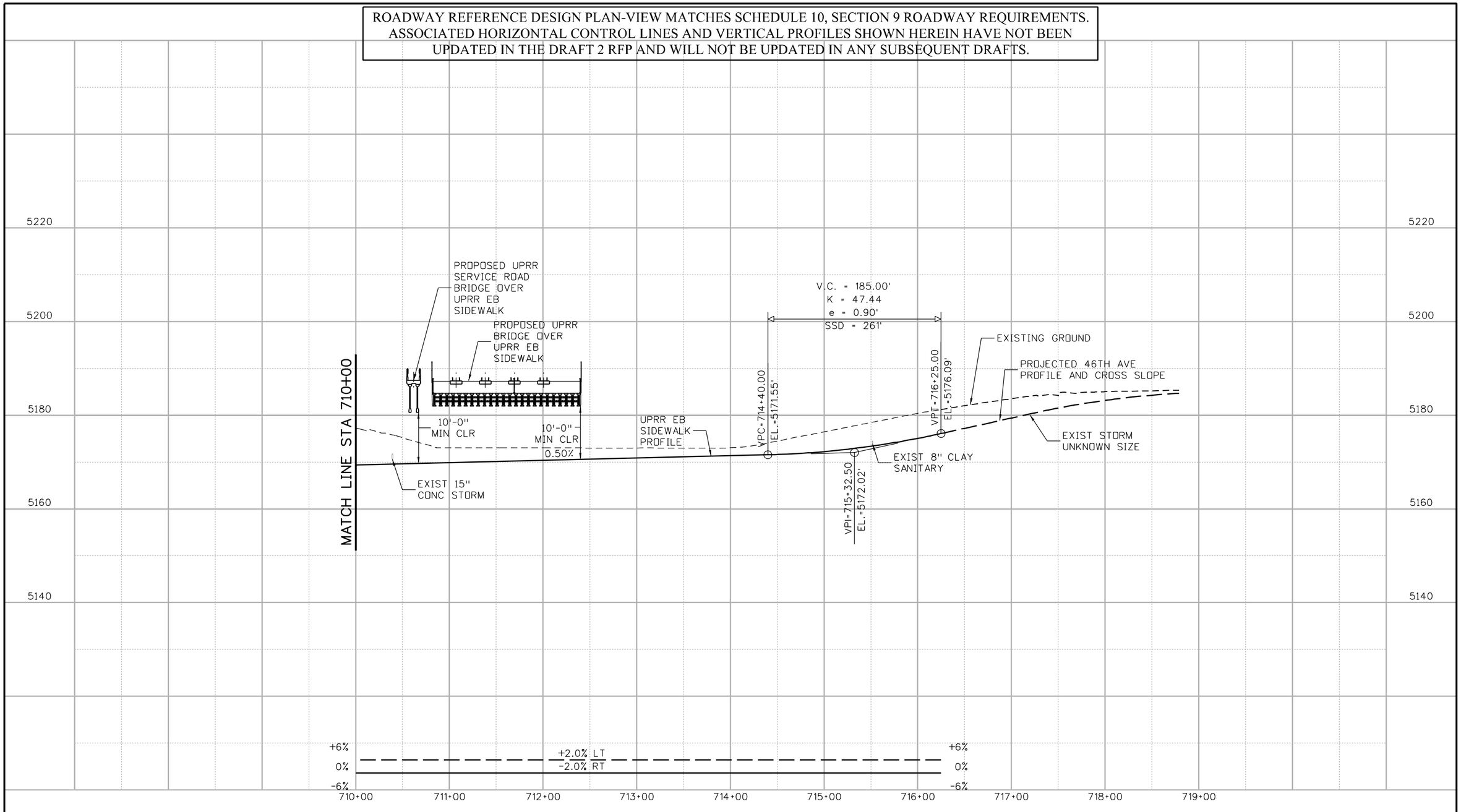

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Unit Information Unit Leader Initials					
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276					

PRELIMINARY	UPRR EB SIDEWALK ROADWAY PROFILE STA 710+00 TO 718+78.92		Project No./Code
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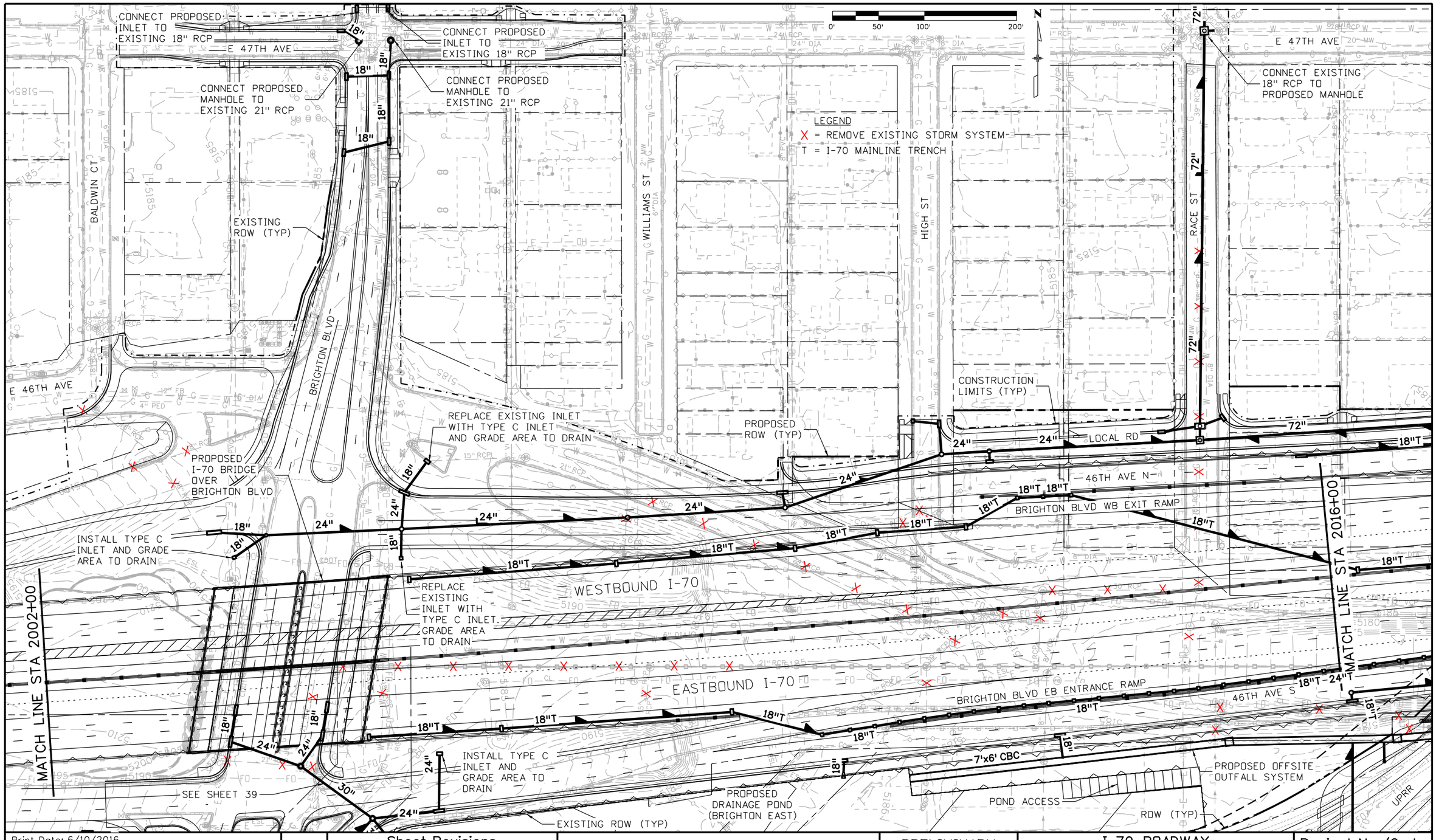

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Unit Information Unit Leader Initials			

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PRELIMINARY

No Revisions:

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Void:

I-70 ROADWAY DRAINAGE PLAN STA 2002+00 TO 2016+00

Designer:

Detailer:

Sheet Subset: Hydr Plan

Structure Numbers

Subset Sheets: 7 of

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19631

Sheet Number 289

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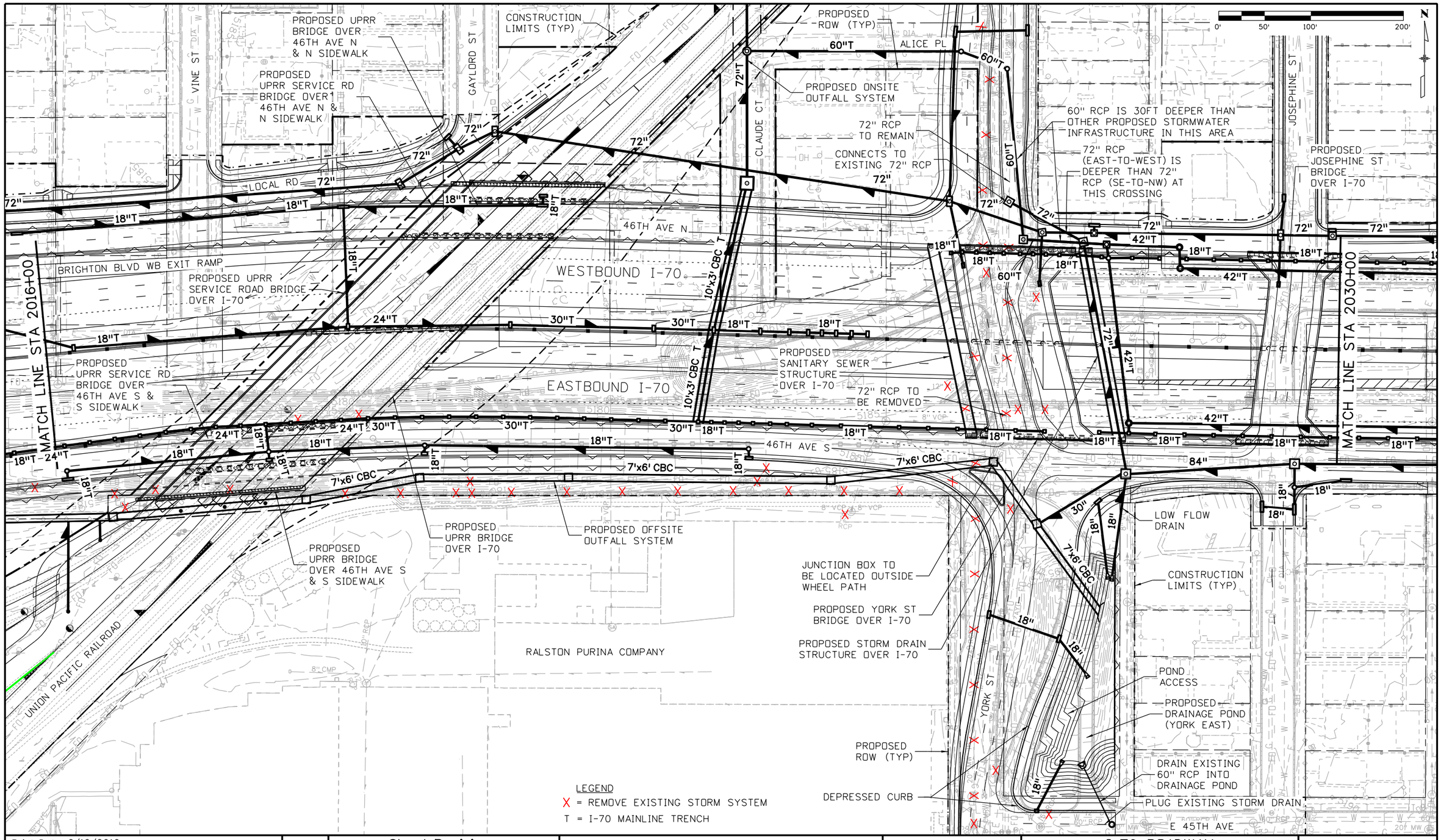

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PRELIMINARY

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I-70 ROADWAY
DRAINAGE PLAN
STA 2016+00 TO 2030+00

Designer:
Detailer:
Sheet Subset: Hydr Plan
Structure Numbers
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FBR 0704-234
19631
Sheet Number 290

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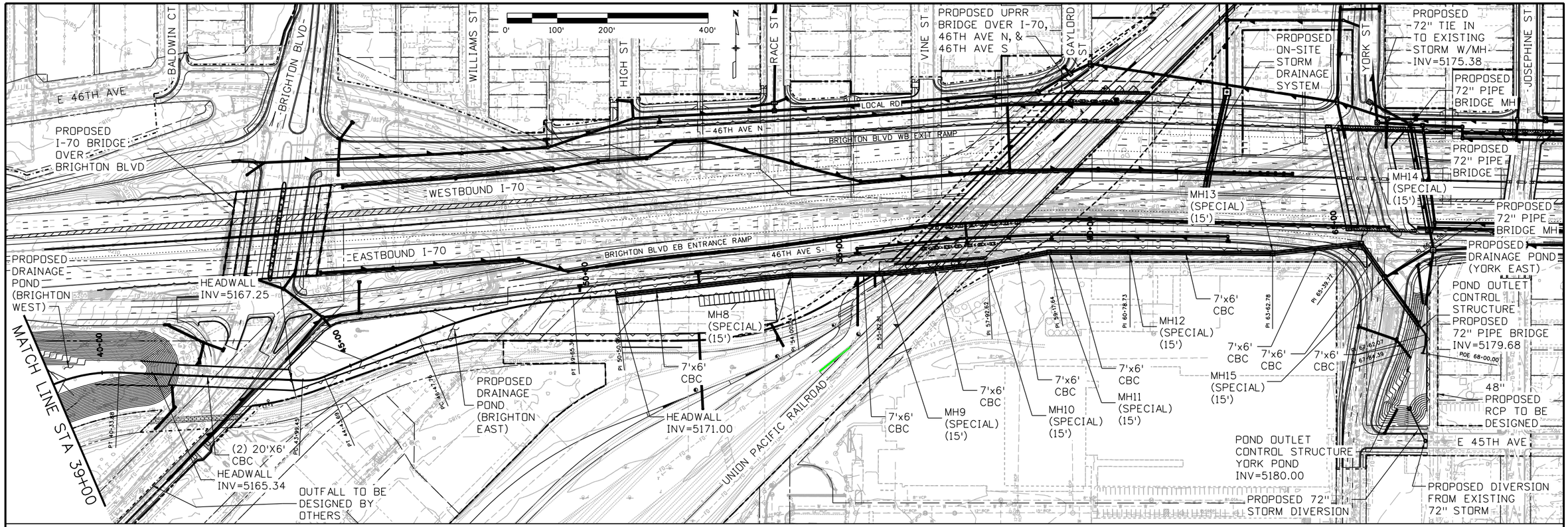

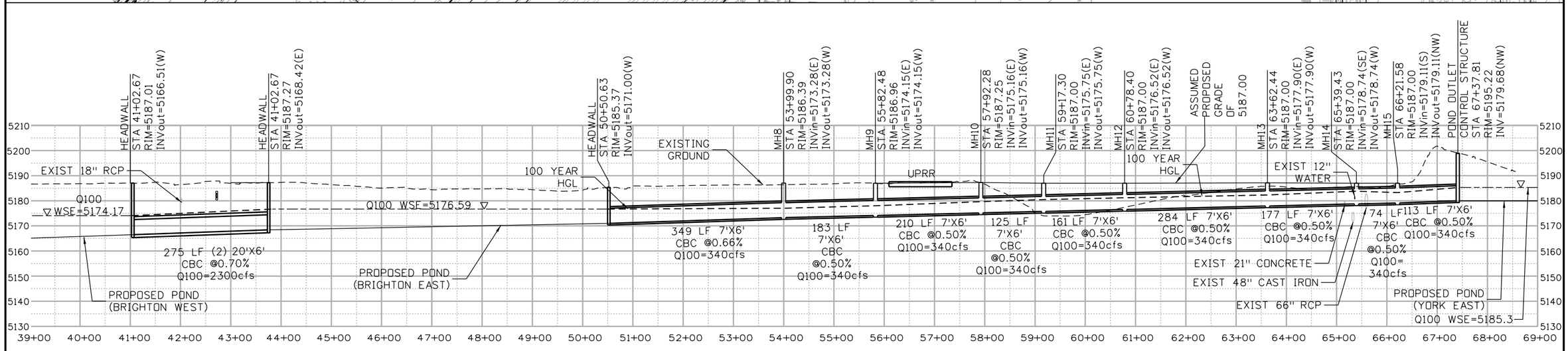

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Horiz. Scale: 1:200 Vert. Scale: As Noted		Region 1 KJS	Revised:
Unit Information Unit Leader Initials			Void:
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276			

I-70 ROADWAY OFFSITE DRAINAGE OUTFALL PLAN AND PROFILE

Designer:		Structure Numbers	
Detailer:			
Sheet Subset: Hydr PnP		Subset Sheets: 57 of	

Project No./Code	
FBR 0704-234	
19631	
Sheet Number	339

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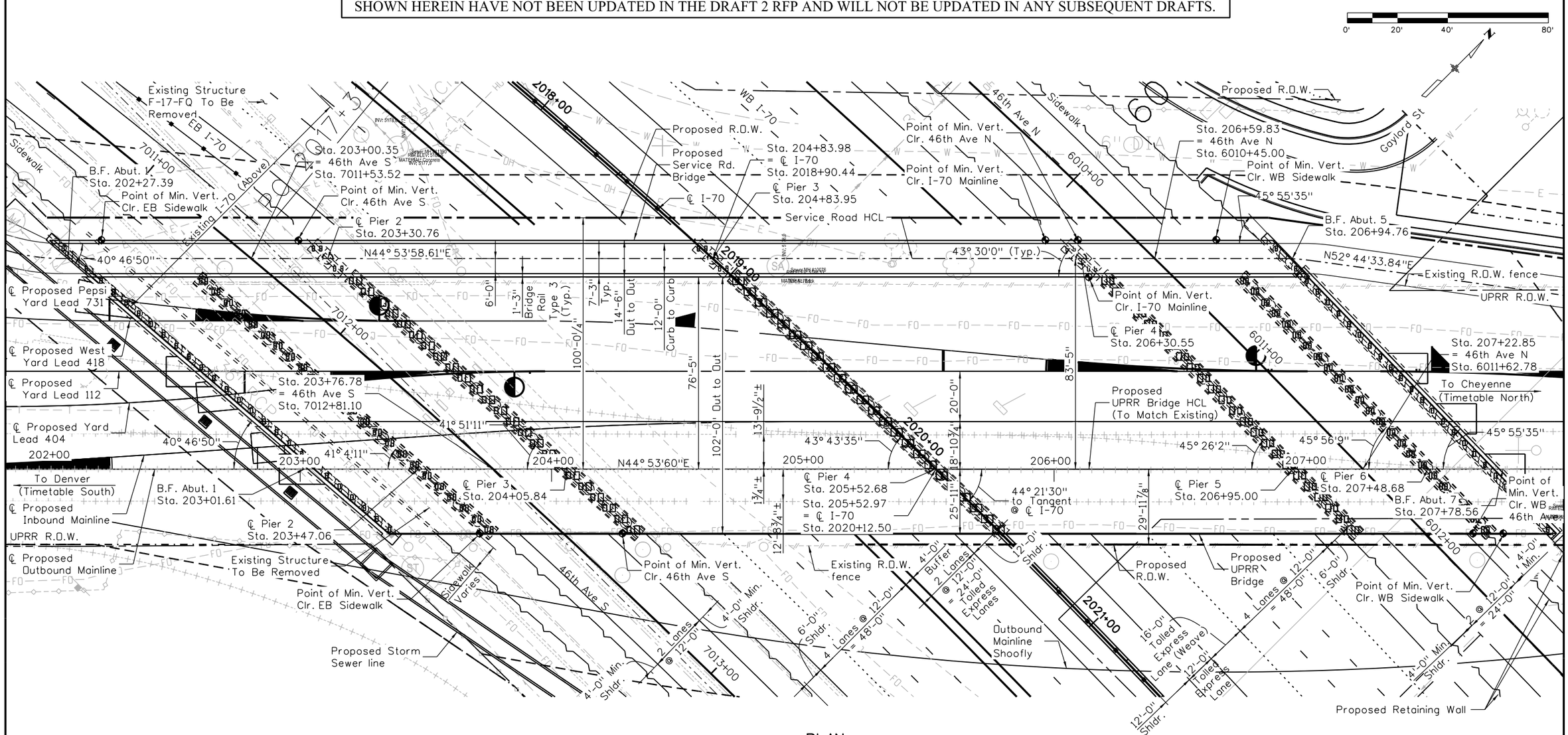
STRUCTURE REFERENCE DESIGN GENERAL LAYOUT AND TYPICAL SECTION MATCHES SCHEDULE 10, SECTION 13 STRUCTURES REQUIREMENTS. RELATION TO THE ASSOCIATED ROADWAY HORIZONTAL CONTROL LINES AND VERTICAL PROFILES SHOWN HEREIN HAVE NOT BEEN UPDATED IN THE DRAFT 2 RFP AND WILL NOT BE UPDATED IN ANY SUBSEQUENT DRAFTS.



PLAN

◆Indicates point of Min. Vert. Clr.

Designed By		Detailed By		Quantities By			
Checked By		Checked By		Checked By			

Print Date: 2/17/2016		Sheet Revisions		
File Name: 13599BRDG_General-Layout01_UPRR.dgn		Date:	Comments	Init.
Horiz. Scale: 1:40	Vert. Scale: As Noted			
Unit Information	Unit Leader Initials			
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Denver, CO 80222
Phone: 303-757-9934 FAX: 303-757-9907
Region 1 KJS

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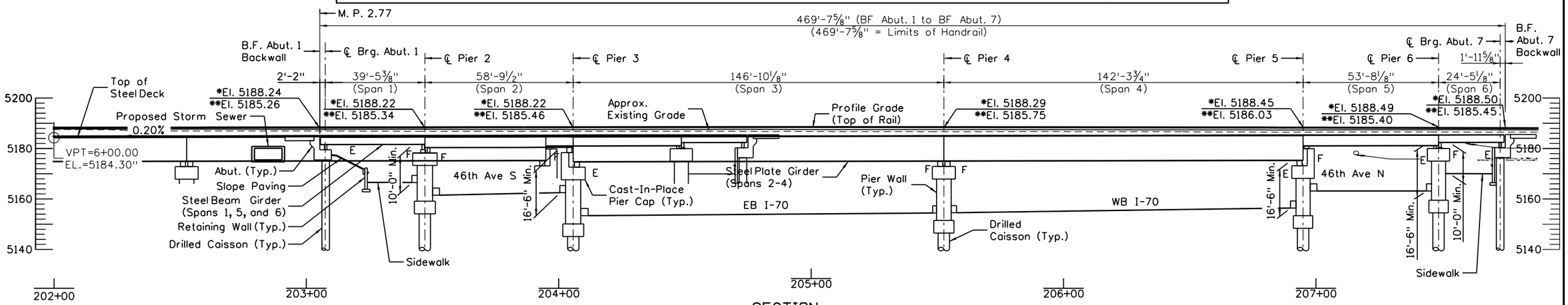
UPRR & SERVICE ROAD OVER I-70
GENERAL LAYOUT
(SHEET 1 OF 2)

Designer:		Structure Numbers	E-17-AEW
Detailer:			E-17-AEX
Sheet Subset:	Bridge	Subset Sheets:	B01 of 03

Project No./Code	
FBR 0704-234	
19631	
Sheet Number	344

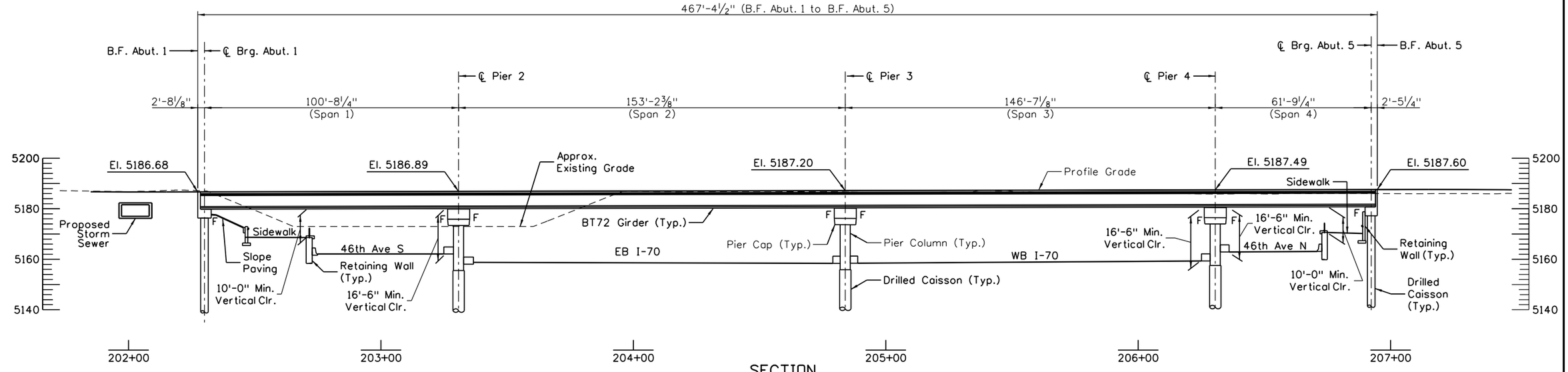
STRUCTURE REFERENCE DESIGN GENERAL LAYOUT AND TYPICAL SECTION MATCHES SCHEDULE 10, SECTION 13 STRUCTURES REQUIREMENTS. RELATION TO THE ASSOCIATED ROADWAY HORIZONTAL CONTROL LINES AND VERTICAL PROFILES SHOWN HEREIN HAVE NOT BEEN UPDATED IN THE DRAFT 2 RFP AND WILL NOT BE UPDATED IN ANY SUBSEQUENT DRAFTS.



SECTION

(Taken along Proposed UPRR Bridge HCL)

* Top of Rail El.
** Top of Steel Deck El.



SECTION

(Taken along Service Road HCL)

See sheet B02 for Exact Location of Min. Vert. Clr.

Design	INITIAL	DATE	Detail	INITIAL	DATE	Quantities	INITIAL	DATE
Designed By			Detailed By			Quantities By		
Checked By			Checked By			Checked By		

Print Date: 6/10/2016	Sheet Revisions		
File Name: 13599BRDG_General-Layout02_UPRR.dgn	Date:	Comments	Init.
Horiz. Scale: 1:40 Vert. Scale: As Noted			
Unit Information Unit Leader Initials			
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2000 South Holly Street
Denver, CO 80222
Phone: 303-757-9934 FAX: 303-757-9907
Region 1 KJS

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Void:

UPRR & SERVICE ROAD OVER I-70
GENERAL LAYOUT
(SHEET 2 OF 2)

Designer:		Structure Numbers	E-17-AEW
Detailer:			E-17-AEX
Sheet Subset:	Bridge	Subset Sheets:	B02 of 03

Project No./Code	
FBR 0704-234	
19631	
Sheet Number	345

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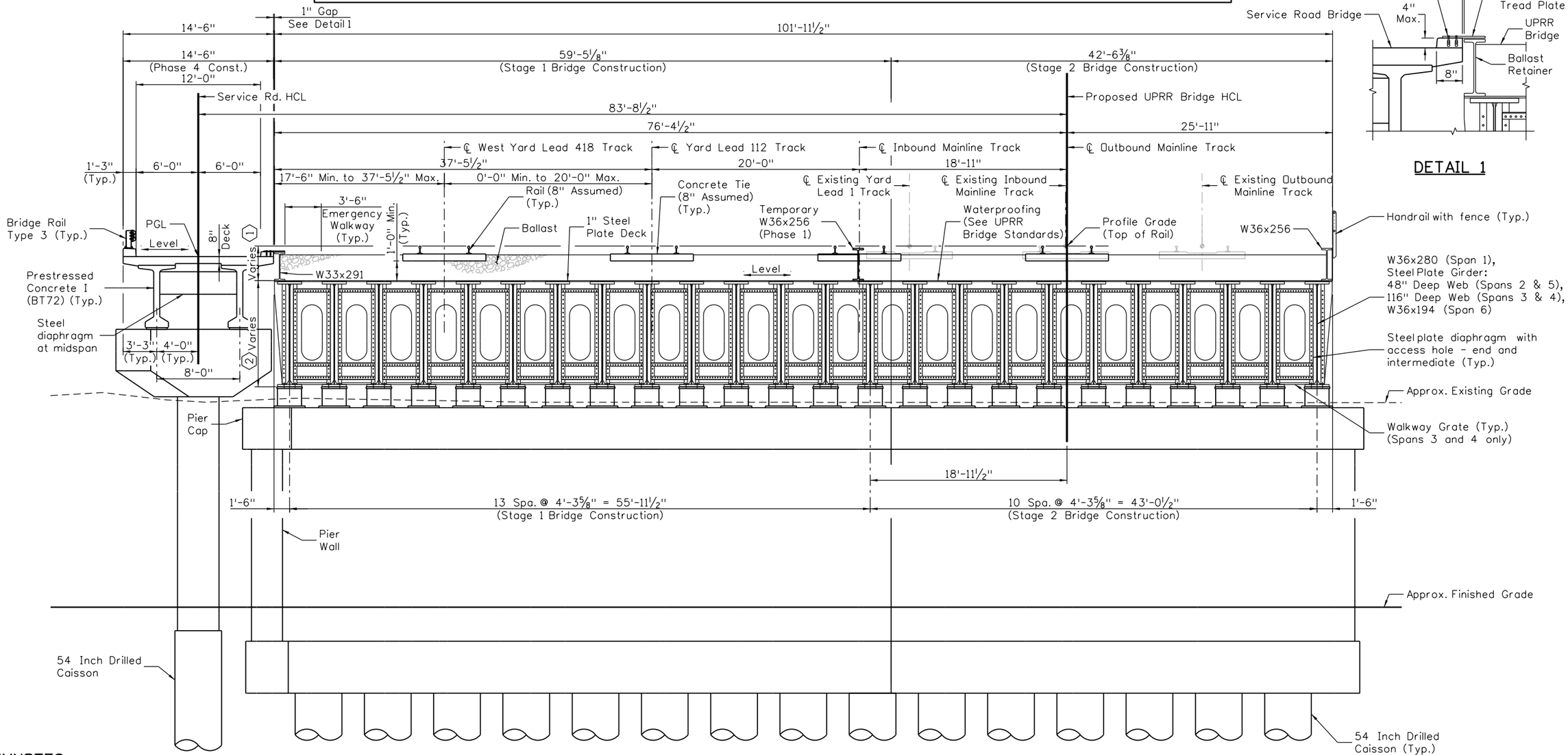
STRUCTURE REFERENCE DESIGN GENERAL LAYOUT AND TYPICAL SECTION MATCHES SCHEDULE 10, SECTION 13 STRUCTURES REQUIREMENTS. RELATION TO THE ASSOCIATED ROADWAY HORIZONTAL CONTROL LINES AND VERTICAL PROFILES SHOWN HEREIN HAVE NOT BEEN UPDATED IN THE DRAFT 2 RFP AND WILL NOT BE UPDATED IN ANY SUBSEQUENT DRAFTS.



DETAIL 1

KEYNOTES:

1. Top of rail to top of deck varies 2'-3⅝" (Sta. 11+89.57) to 3'-9¼" (Sta. 6+13.98).
2. Top of Steel Deck to bottom of girder flange varies:
   Spans 1 = 3'-1½"
   Span 2 = 4'-5"
   Spans 3 & 4 = 10'-2½"
   Span 5 = 3'-5⅜"
   Span 6 = 3'-0½"

TYPICAL SECTION

(Looking Ahead Station)

Allowance for 6 Tracks with Min. Spacing = 15'-0"

Design	INITIAL	DATE
Designed By	AGW	07-14
Checked By	PF	09-14

Detail	INITIAL	DATE
Detailed By	ERS	07-14
Checked By	PF	09-14

Quantities	INITIAL	DATE
Quantities By		
Checked By		

Print Date: 6/13/2016	
File Name: 13599BRDG_Typical-Section01_UPRR.dgn	
Horiz. Scale: 1:10	Vert. Scale: As Noted
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UPRR OVER I-70
TYPICAL SECTION

Designer:	Structure Numbers	E-17-AEW
Detailer:		E-17-AEX
Sheet Subset: Bridge	Subset Sheets: B03 of 03	

Project No./Code
FBR 0704-234
19631
Sheet Number 346

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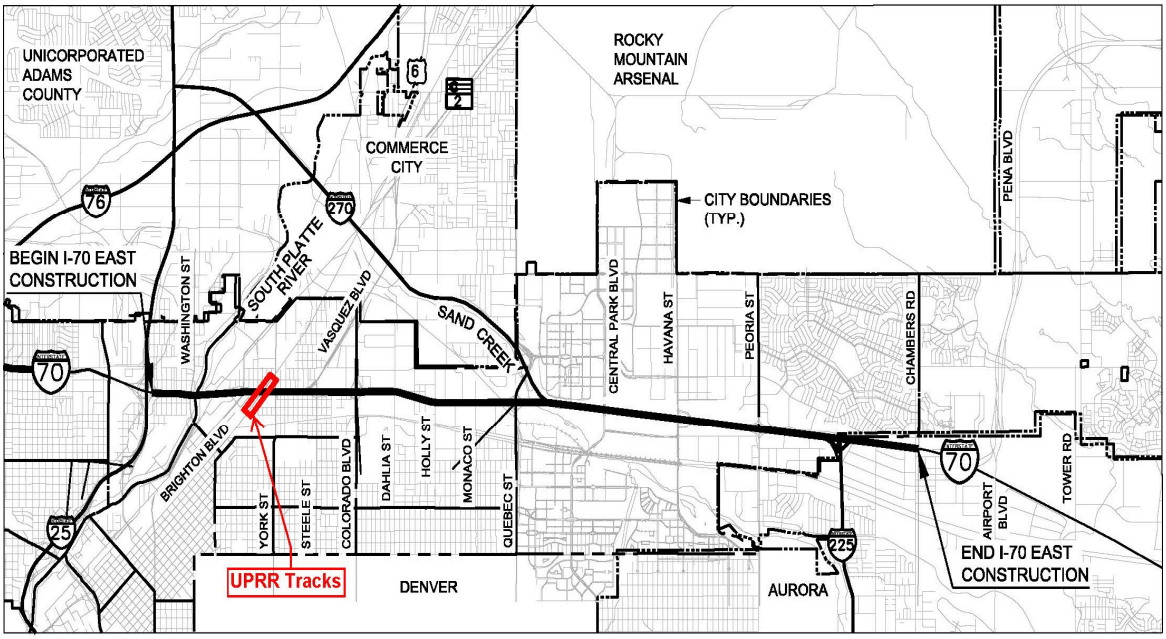
Memo

To:	Lance Kippen		
From:	Jacob Beedle, PE, CFM	**Email:**	Jacob.Beedle@atkinsglobal.com
Phone:	720-475-7089	**Date:**	June 9, 2016
Ref:		**cc:**	Jerry Waterman PE
Subject:	UPRR Preliminary Drainage Memo		

1. Preliminary Technical Summary

The Central 70 project includes construction of 11.7 miles of I-70 from I-25 to Chambers Road. The Central 70 proposed improvements are located within multiple city and county jurisdictions, including the City of Denver, the City of Commerce City, and the City of Aurora, as well as Denver County and Adams County. The purpose of this memo is to discuss the drainage impacts for the Union Pacific Rail Road (UPRR) Tracks within the Central 70 project. The UPRR Tracks, as well as the overall project limits, is shown on Figure 1 below.

Figure 1 Location Map

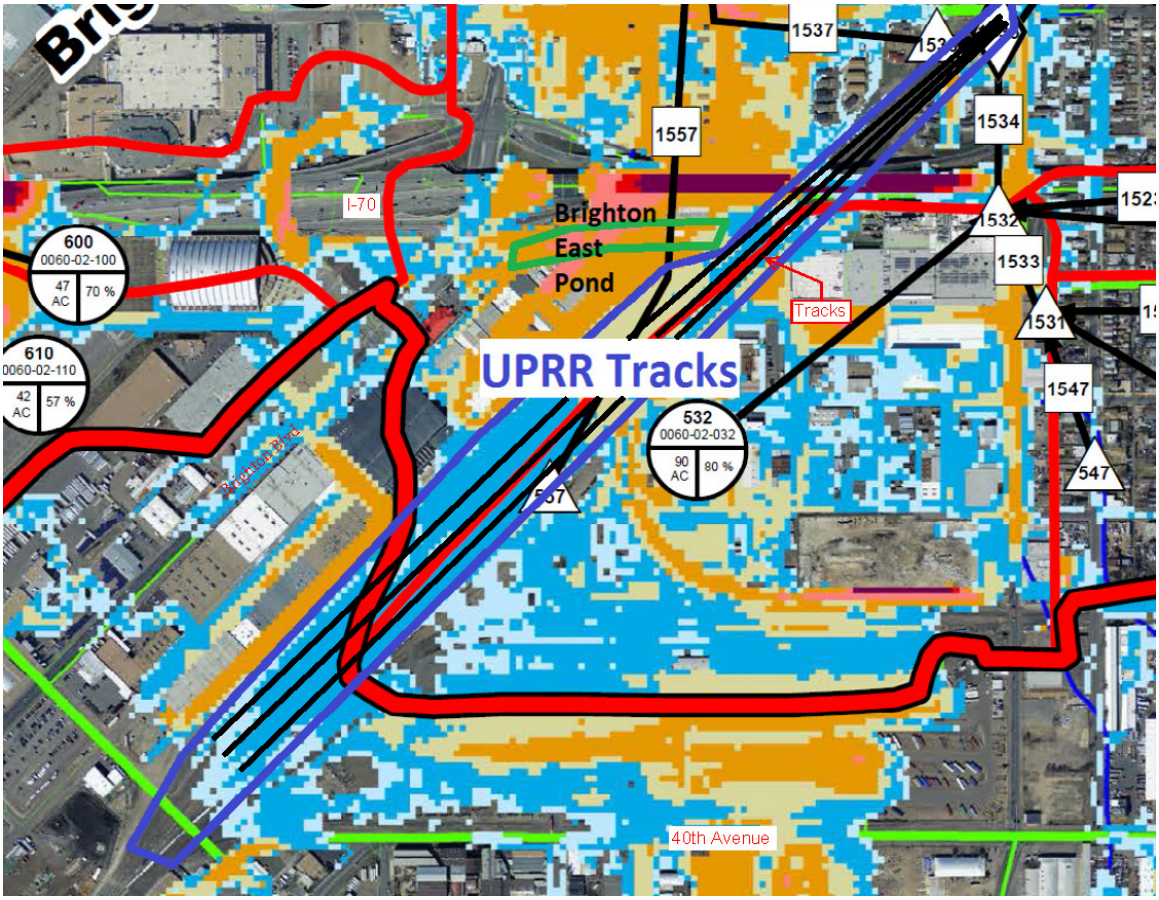


2. UPRR Drainage Impacts

In the existing conditions the inundation of the railyard from the Park Hill and Montclair basins overtops the tracks and flows north-westerly. The drainage design in this area makes use of the overtopping by the placing the Brighton East Pond in the path of the flow, thus capturing the flow before it has a chance to reach the Proposed I-70 Lowered Section. See Figure 2 for flows patterns in the UPRR Tracks.

Memo

Figure 2 MATT Memo Flo2D



The flows will be captured by the Brighton East Pond or the screen drains (defined as raised, precast, steel ballast screens) that will be placed in between the tracks and outlet directly into the pond or the concrete box culvert running underneath the UPRR Tracks. The final design will include walls along the proposed I-70 to direct the flow to the Brighton East Pond. See Appendix C for a detail of the screen drains. See Figure 3 for a profile of the flow conveyed in the culvert. Figure 4 shows the plan view of the drainage system crossing the UPRR. Design of the screen drains is to be completed by the Developer. The Developer will also prepare the required hydraulic analysis to show that the proposed rail improvements will not have an adverse impact on the surrounding areas.

Figure 3 SWMM Profile of Offsite Drainage Concrete Box Culvert

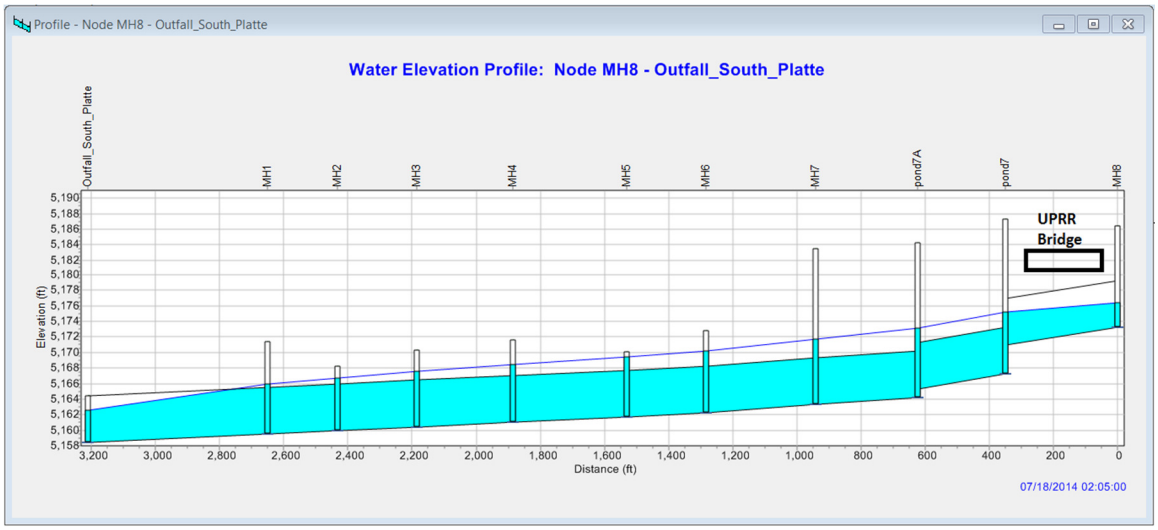
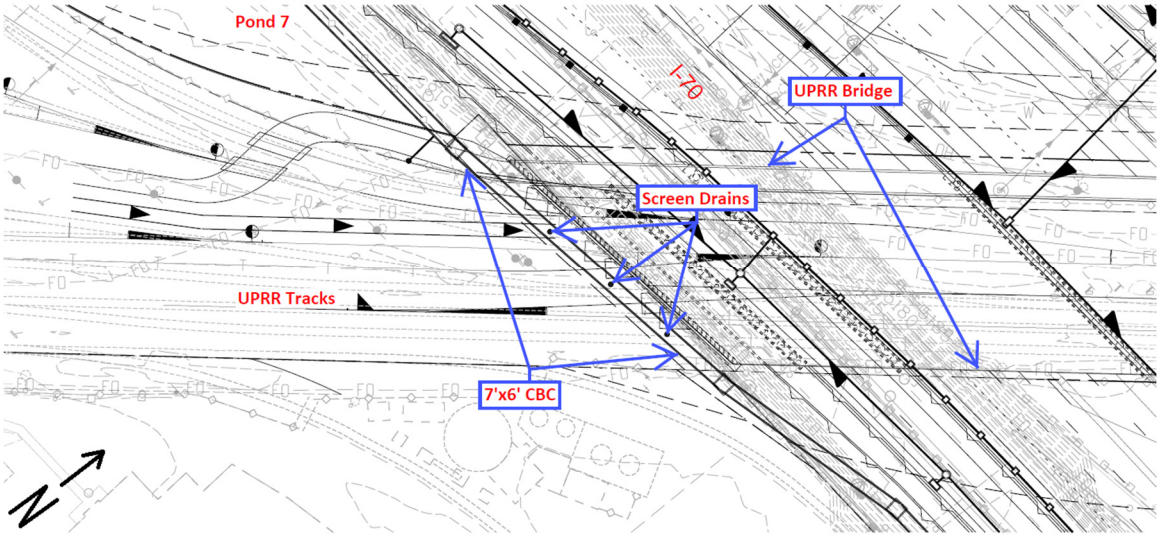


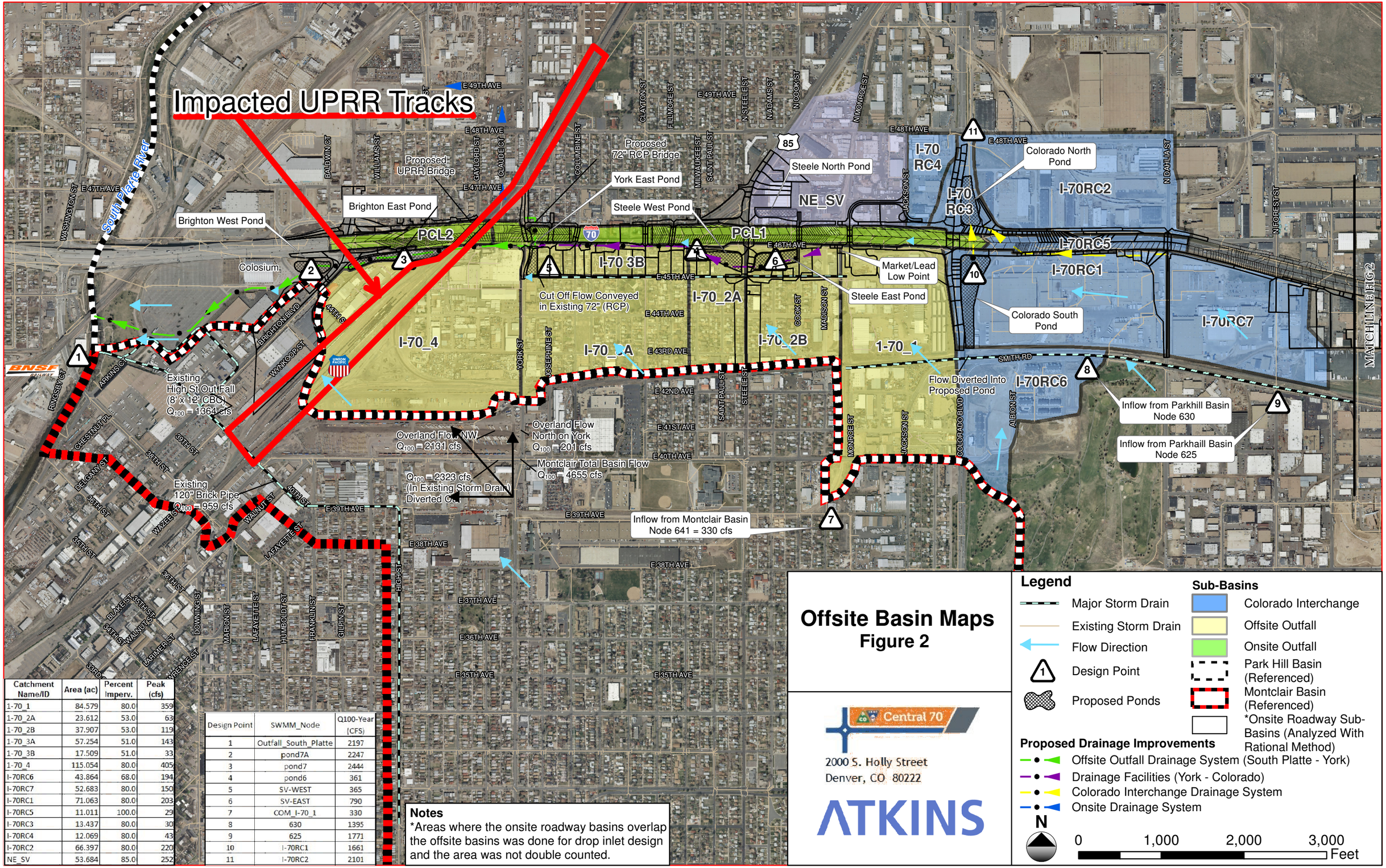
Figure 4 Offsite Drainage Plan View



Flow in the UPRR Tracks north of the bridge will be directed to an area inlet just west of York Street by a ditch on the east side of the tracks.

See Section 3 for the hydrology for the UPRR Tracks and Section 4 for the drainage facility characteristics. See Figure 55 below for an understanding of the Offsite drainage basins in the UPRR Tracks region.

Figure 5 Offsite Basin Map



Catchment Name/ID	Area (ac)	Percent Imperv.	Peak (cfs)
1-70_1	84.579	80.0	359
1-70_2A	23.612	53.0	63
1-70_2B	37.907	53.0	119
1-70_3A	57.254	51.0	143
1-70_3B	17.509	51.0	33
1-70_4	115.054	80.0	405
I-70RC6	43.864	68.0	194
I-70RC7	52.683	80.0	150
I-70RC1	71.063	80.0	203
I-70RC5	11.011	100.0	29
I-70RC3	13.437	80.0	30
I-70RC4	12.069	80.0	43
I-70RC2	66.397	80.0	220
NE_SV	53.684	85.0	252

Design Point	SWMM_Node	Q100-Year (CFS)
1	Outfall_South_Platte	2197
2	pond7A	2247
3	pond7	2444
4	pond6	361
5	SV-WEST	365
6	SV-EAST	790
7	COM_I-70_1	330
8	630	1395
9	625	1771
10	I-70RC1	1661
11	I-70RC2	2101

Notes
*Areas where the onsite roadway basins overlap the offsite basins was done for drop inlet design and the area was not double counted.

Offsite Basin Maps
Figure 2

Central 70
2000 S. Holly Street
Denver, CO 80222
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Legend

- Major Storm Drain
- Existing Storm Drain
- Flow Direction
- Design Point
- Proposed Ponds

Sub-Basins

- Colorado Interchange
- Offsite Outfall
- Onsite Outfall
- Park Hill Basin (Referenced)
- Montclair Basin (Referenced)
- *Onsite Roadway Sub-Basins (Analyzed With Rational Method)

Proposed Drainage Improvements

- Offsite Outfall Drainage System (South Platte - York)
- Drainage Facilities (York - Colorado)
- Colorado Interchange Drainage System
- Onsite Drainage System

N

0 1,000 2,000 3,000 Feet

Memo

3. Hydrology

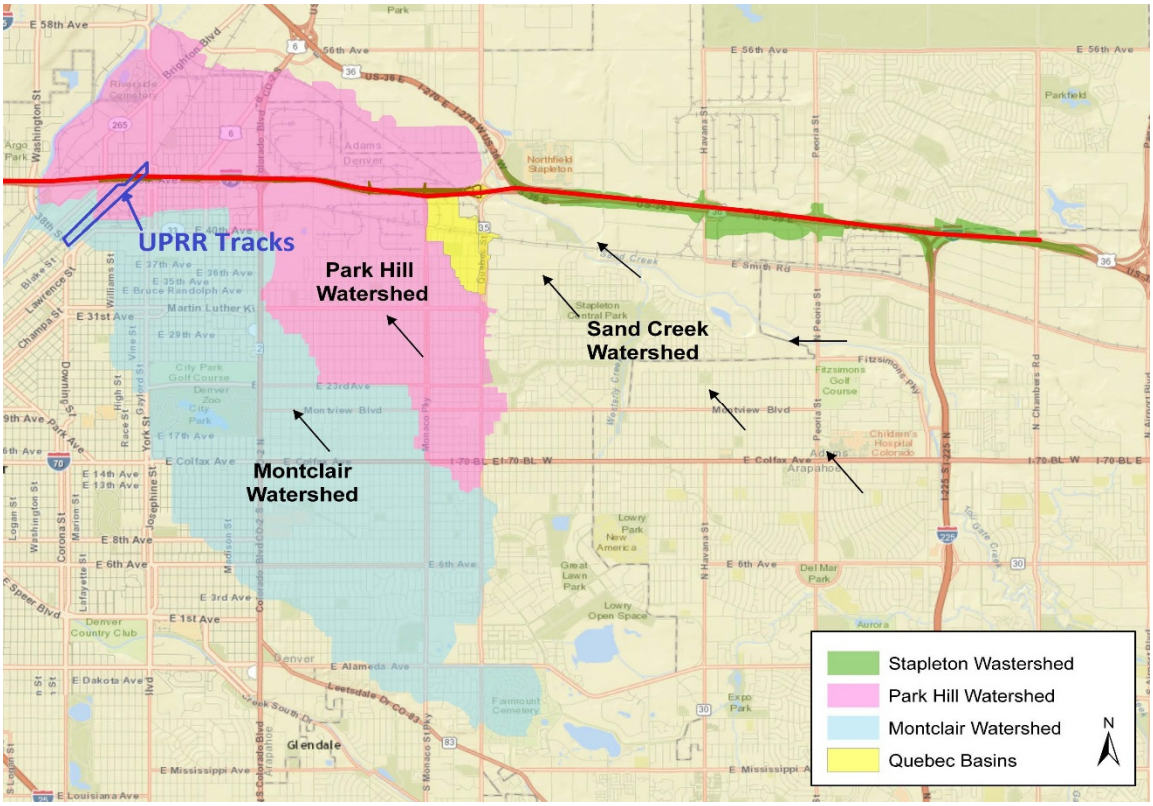
The Central 70 project transects the Montclair and Park Hill Basins. The drainage system for the Central 70 project that is upstream of the project will have to convey these flows away to prevent overflow into the trench. The flows developed for these Basins are discussed in this section.

Montclair Basin: The Montclair Basin impacts the Central 70 Project between York Street and Brighton Boulevard. The Montclair Basin is the largest tributary area impacting the Central 70 Project and was the focal point of the Multi-Agency Technical Team (MATT), which analyzed the flow impacting the Central 70 Project from the Montclair Basin. The *Memorandum for I-70 Partial Cover Lowered Montclair Drainage Basin Hydrologic Analysis (Enginuity, 2014a)* documents the flow impacting the Central 70 Project.

Park Hill Basin: The Park Hill Basin impacts the Central 70 Project between Colorado Boulevard and Monaco Street. The Park Hill Basin is the second largest tributary area impacting the Central 70 Project and was the second focal point of the MATT, which analyzed the flow impacting the Central 70 Project from the Park Hill Basin. The *Memorandum for I-70 Partial Cover Lowered Park Hill Drainage Basin Hydrologic Analysis (Enginuity, 2014b)* documents the flow impacting the Central 70 Project.

The area of interest for this technical memo is located in the City and County of Denver (CCD), along I-70, specifically between Brighton Blvd. and York St. where the UPRR crosses I-70. The UPRR Tracks area is impacted by the Montclair and Park Hill regional watersheds in the existing condition. In existing condition, a total of 2,649 cfs drains to the project area per the MATT Memo for Park Hill (EPA SWIMM Node 557), and this memo is included in **Appendix C** for reference. Figure 66 below shows the Montclair and Park Hill regional watersheds in reference to the project site.

Figure 6 Regional Watershed Map



4. Proposed Drainage Facilities

The proposed condition 100-year flow draining to the UPRR tracks is 3,326 cfs. This flow is designed to flow into the Brighton East pond to the northwest of the tracks. Flow that does not drain into the pond will be captured by the 6 screens drains placed between the tracks just south of the proposed UPRR bridge. See **Appendix C** for an example of a screen drain.

The sub basins draining to the UPRR Tracks are CUHP sub basins 1-70_3A, I-70_3B and 1-70_4 which are shown on the drainage map in **Appendix A**.

A conceptual overview of the proposed roadway and drainage improvements is described below.

- The Central 70 Project between Brighton Boulevard and Colorado Boulevard will be designed to ultimate build out. This section is referred to as the Lowered Section, which lowers the grade of I-70 approximately 42 feet below existing grade. An extensive offsite drainage system is proposed to protect the Lowered Section from the large offsite flows from the Montclair Basin and the Park Hill Basin (impacting the Colorado Boulevard interchange). The proposed system includes seven flood control detention basins and approximately 6,000 feet of larger-diameter culvert.
- To drain the Lowered Section of the Central 70 Project, the Onsite Outfall System is proposed to drain the proposed low point.

4.1. Location and General Discussion

This section discusses the major drainage proposed with the Central 70 Project roadway improvements in the vicinity of the UPRR Tracks.

- The proposed Offsite Outfall System is located to the south of the Central 70 Project within the proposed alignment of 46th Avenue and McFarland Drive. The Offsite Outfall System begins to the east of the historic Market/Lead Railroad low point (near York Street) and conveys flow to the west to discharge into the South Platte River. A series of six flood control detention ponds are proposed to attenuate and capture the large offsite flows impacting the Central 70 Project. The proposed ponds are:
    - Brighton West Flood Control Pond (Station 2000+00)
    - Brighton East Flood Control Pond (Station 2012+00)
    - York East Flood Control Pond (Station 2028+00)
    - Steele West Flood Control Pond (Station 2050+00)
    - Steele East Flood Control Pond (Station 2055+00)
    - Steele North Flood Control Pond (Station 2055+00)

  At the Brighton West Flood Control Pond, the proposed Offsite Outfall System drains to the southwest within McFarland Drive, bisects the parking lot of the Denver Coliseum, enters the north section of Globeville Landing Park, and discharges into the South Platte River.
- The proposed Onsite Outfall System begins at the proposed low point of the Lowered Section of the Central 70 Project and conveys the trench flow to the north along Claude Court and Race Street, where it discharges into the proposed pond located on the south edge of the Riverside Cemetery just north of Brighton Boulevard. The proposed pond outlets into the South Platte River via a stormwater pump station.

4.2. Hydrology and Design Flow Development

The flow draining to the Central 70 Project was calculated using the Colorado Urban Hydrograph Procedure (CUHP2005) software that was developed by the Urban Drainage and Flood Control

District (UDFCD) and routed using Environmental Protection Agency Stormwater Management Model (EPA-SWMM). The proposed facilities conveying offsite flow are designed for the 100-year event.

Table 4-1 below is a summary of the major offsite design points that were used to design the proposed Offsite Outfall System discussed above in Section 3.1.

Table 4-1 Design Points

Design Point	Location	SWMM Node	Q100-Year (CFS)
1	Outlet to South Platte River	Outfall_South_Platte	2268
2	Brighton West Pond	pond7A	2286
3	Brighton East Pond	pond7	2454
4	York East Pond	pond6	361
5	Steele West Pond	SV-WEST	371
6	Steele East Pond	SV-EAST	790
7	Steele North Pond	NE_SV	87
8	Inflow from Montclair Basin (Monroe St and 39th Ave)	COM_I-70_1	683
9	Inflow from Park Hill (Golf Course)	311	1395
10	Inflow from Park Hill (Forest St and Smith Rd)	625	1770

4.3. Information Sources

The studies noted below were reviewed or referenced to develop the offsite flow draining to the Central 70 Project. In addition, the as-built drawings for the existing Central 70 Project corridor were reviewed.

- *Memorandum for I-70 Partial Cover Lowered Montclair Drainage Basin Hydrologic Analysis (Enginuity, 2014a).* This memorandum was created through the MATT to develop the current offsite flow draining to I-70 from the Montclair Basin. The total flow impacting I-70 without removing flow conveyed in existing drainage facilities was referenced from this memorandum and used to design the Offsite Outfall System to protect the proposed lowered section of I-70.
- *The High Street Outfall and 40th Avenue Storm Sewer System, South Platte River to Blake Street, Final Design Report (WHPacific, 2012).* The drainage facility designed in this report is currently designed and ready for construction. The proposed High Street outfall is located in the Globeville Landing Park. Globeville Landing Park is located on a reclaimed landfill. The geotechnical and structural design to stabilize the storm drain using a compaction grouting method was reviewed and a similar method will be incorporated in the I-70 Outfall System designed by the Developer.
- *Memorandum for I-70 Partial Cover Lowered Park Hill Drainage Basin Hydrologic Analysis (Enginuity, 2014b).* Park Hill hydrology analyzed through the MATT was referenced for the offsite flows impacting the proposed Colorado Boulevard and I-70 interchange improvements. No formal report was submitted for this data and the current hydrologic/hydraulic models and figures were received via email from Enginuity.

4.4. Hydraulic Design

4.4.1. Offsite Outfall System (South Platte River to Colorado Boulevard)

For the proposed lowered section of I-70 between Brighton Boulevard and Colorado Boulevard, the Offsite Outfall System was divided into three sections. The first section is from York Street to the South Platte River, the second section is from York Street to Colorado Boulevard, and the third section is at the Colorado Boulevard and I-70 interchange. Below is a conceptual summary of how the Offsite Outfall System will work in the proposed condition. It should be noted that all three sections of the Offsite Outfall System are required to protect the lowered section of I-70 from flooding in the 100-year event.

The purpose of the Offsite Outfall System is to capture and convey the large urban overflows draining north to the Central 70 Project from the Montclair Basin to the south and the local flows from the east. The Montclair Basin flows impacting I-70 are referenced from the *Memorandum for I-70 Partial Cover Lowered Montclair Drainage Basin Hydrologic Analysis* (Enginuity, 2014a). The results of the memorandum show 4,655 cubic feet per second (cfs) draining to I-70 between York Street and the South Platte River. It is important to note that the 4,655 cfs does not take into account the flow leaving the system through the existing 120-inch brick storm drain and the High Street Outfall (8-foot x 12-foot CBC) that is currently designed and is assumed will be built before the Central 70 Project is in place. A minor flow split takes place at York Street, where approximately 201 cfs from the Montclair Basin drains north on York Street to I-70.

The major design points of the proposed Offsite Outfall System impacting the UPRR Tracks are discussed below.

- The York East Pond is located to the east of York Street and to the south of I-70. The York East Pond has three primary functions: (1) to capture the flow draining north on York Street from the south (Montclair Basin), (2) to split flow draining to the north in the existing 72-inch RCP utilizing existing storm drain capacity, and (3) divert low flows to the existing 72” storm drain north of the Lowered Section.

  During final design of the project, design of a storm drain system and depressed curb will be required from the Developer to capture this flow. The flow from the local sub-basins described above is conveyed west in an existing 60-inch RCP located in East 45th Avenue and then will be diverted into the York East Pond. The proposed design takes into account the flow conveyed through the existing 54-inch RCP to 60-inch RCP storm drain facility located in East 45th Avenue, which drains into the York East Pond. The proposed storm drain located in East 46th Avenue will drain into the York East Pond, as well.

  Because of the proposed Lowered Section, the existing 72-inch RCP will be removed and replaced with a bridge structure for the pipe to span the proposed Lowered Section of the Central 70 Project and to redirect the remaining flow draining to the west in the proposed Offsite Outfall System.

  The York East Pond is approximately 1.23 acre-feet in volume and for the 100-year event, 361 cfs drains to the pond. The water surface elevation in the pond for the 100-year event is 5,185.17 feet and it will have two feet of freeboard. The overflow path will be designed (in the final stage) so it drains west through the rail yard and does not drain toward I-70. The total depth of the pond is six feet and the depth of water is five feet. The pond was analyzed in SWMM5 using the orifice function in the software to calculate the water surface elevation and the flow discharging from the pond to the north and west. The outlet structure of the pond will need to be designed in greater detail by the Developer. A digital copy of the SWMM5 model is included in Schedule 29 of the reference documents.

- The drainage facility between the York East Pond and the Brighton East Pond is a 7-foot x 6-foot CBC and is located in the proposed alignment of East 46th Avenue to the north of the existing Nestlé Purina PetCare facility. The proposed 7-foot x 6-foot CBC will cross under the existing and proposed UPRR improvements and continue west to the Brighton West Pond. Screen drains will be placed to capture and track drainage of offsite urban overflow from the Montclair Basin.

- The main purpose of the proposed Brighton East Pond and Brighton West Pond is to capture the Montclair Basin flow that drains to the northwest through the UPRR yard prior to the urban overflow reaching the lowered section of the Central 70 Project. The ponds will also provide detention storage and attenuation of the peak flow. Brighton East Pond is located between the UPRR to the east and Brighton Boulevard to the west. Brighton West Pond is located between Brighton Boulevard to the east and the Denver Coliseum to the west. The two ponds are connected with a dual 20-foot x 6-foot CBC under Brighton Boulevard.

  Brighton East Pond is approximately 23.14 acre-feet in volume and for the 100-year event, 3,326 cfs drains to the pond from the Montclair Basin and local drainage, as discussed above. The water surface elevation in the Brighton East Pond for the 100-year event is 5,176.58 feet. The ponded depth of the Brighton East Pond is 9.33 feet.

  Brighton West Pond is approximately 15.48 acre-feet in volume and for the 100-year event, 2,274 cfs drains to the pond, which includes discharge from the Brighton East Pond. The water surface elevation in the Brighton West Pond for the 100-year event is 5,174.17 feet. The ponded depth of the Brighton West Pond is 9.95 feet.

  The outlet structures of each pond will need to be designed by the Developer.

- The proposed storm drain that drains the Brighton East Pond and Brighton West Pond is located in McFarland Drive. The Offsite Outfall System is located to the south of the Denver Coliseum and flows under the Denver Coliseum parking lot, continuing into Globeville Landing Park, where it discharges into the South Platte River through a boulder drop structure. The proposed storm drain is designed to cross one foot above the existing 78-inch brick and 77-inch brick sanitary sewer lines located in the Globeville Landing Park. To clear the existing sewer lines, the Offsite Outfall System is designed at a 0.2 percent longitudinal slope. Globeville Landing Park and portions of the Denver Coliseum parking lot are located on a pre-existing landfill. To accommodate the unknown foundation conditions, the proposed Offsite Outfall System will be constructed on a compacted grout foundation similar to the High Street Outfall.

  The outfall system is approximately 2,592 feet. The storm drain starts as a dual 18-foot x 6-foot CBC east of the Denver Coliseum and increases to a dual 20-foot x 6-foot CBC to the west of the Coliseum into Globeville Landing Park. Due to limited clearance over the existing sanitary sewer, a culvert system with a thinner slab thickness is necessary. The 11-foot x 6-foot CBC has a thinner bottom and top slab thickness, so the Offsite Outfall System will transition to a four-cell system (three 11-foot x 6-foot CBCs and one 12-foot x 6-foot CBC) through the park. The existing 78-inch brick and 77-inch brick sanitary sewer lines will be encased in concrete at the proposed crossings. The Offsite Outfall System is designed to convey the 100-year event flow of 2,260 cfs. The Offsite Outfall System was modelled using SWMM5 and are available upon request.

Table 4-2 Summary Water Quality and Detention Ponds

Design Location	Station	Facility Type
Brighton West	2000+00	Flood Control Pond
Brighton East	2012+00	Flood Control Pond
York East	2028+00	Flood Control Pond
Steele West	2050+00	Flood Control Pond
Steele East	2055+00	Flood Control Pond
Steele North	2055+00	Flood Control Pond

4.5. Additional Drainage

4.5.1. York Street Screen Drains

The portion of the UPRR between the bridge and York Street is 2.2 acres. This area is drained by a trackside ditch leading to two screen drains. The ditch is on the southeast side of the UPRR Tracks with the screen drains located approximately 45 feet west of York Street. Screen drains are the type of inlet opening preferred by UPRR.

Inroads analysis was performed at this location using a Type C grate inlet. The flow coming to this inlet in the 100-yr design event is 10.7 cfs. The surface area for drainage of the Type C grate inlet is approximately 7 square feet. The surface area for drainage of the screen drains is approximately 4 square feet. Therefore combining two screen drains provides 8 square feet of surface area for drainage. See Appendix C for the results from the Inroads analysis.

As screen drains are not complete structures they will have to be attached to a custom designed vault. The final design of the screen drain and vault are to be completed by the Developer.

4.5.2. North UPRR Screen Drain

The UPRR Tracks west of York Street is drained by a trackside ditch on the northwest side of the tracks. A screen drain will be placed in this ditch approximately 470 feet northwest of the York Street and 48th Avenue intersection. This screen drain and connecting culvert is placed to utilize a nearby manhole and will require Jacking to access this drainage system. No hydrology has been performed for this screen drain as it is placed solely to capture nuisance flows and reduce the flow heading northeast in the ditch. UPRR will be responsible for daylighting this ditch.

5. Conclusion

The UPRR Tracks will be inundated in the 100-year storm event. This inundation will be conveyed away from the tracks by overflow to the Brighton East pond and the screen drains in between the tracks. This conveyance will prevent the 100-year flood waters from entering the proposed Central 70 Lowered Section.

Memo

Appendix A. Hydrology

A.1. **I-70 East Offsite C.U.H.P. Output**

A.2. **Flow Split Calculations at York Street**

A.3. **Soil Map**

Appendix B. Hydraulics

B.1. **SWMM Map**

B.2. **SWMM Output**

B.3. **Extended Detention Basin Worksheet for Onsite Drainage**

Appendix C. References

C.1. **MATT Memo for Montclair Basin**

C.2. **MATT Memo for Parkhill Basin**

C.3. **Ballast Screen Drain Exhibit**

Memo

Appendix D. **Profiles**

D.1. **UPRR Track Profiles**

D.2. **Offsite Drainage Profiles**

Memo

Appendix A. **Hydrology**

Memo

A.1. I-70 East Offsite C.U.H.P. Output

Summary of Unit Hydrograph Parameters Used By Program and Calculated Results (Version 1.4.4)

		Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment Name/ID	User Comment for Catchment	Ct	Cp	W50 (min.)	W50 Before Peak	W75 (min.)	W75 Before Peak	Time to Peak (min.)	Peak (cfs)	Volume (c.f)	Excess (inches)	Excess (c.f.)	Time to Peak (min.)	Peak Flow (cfs)	Total Volume (c.f.)	Runoff per Unit Area (cfs/acre)
1-70_3A		0.121	0.434	18.6	6.51	9.7	4.35	12.8	144	207,831	2.18	452,719	40.0	170	451,722	2.96
1-70_3B		0.173	0.365	24.1	8.26	12.5	5.83	13.8	35	65,542	2.18	142,770	40.0	44	142,225	2.44
1-70_4		0.085	0.616	13.2	4.62	6.9	3.09	12.9	413	422,492	2.52	1,065,051	40.0	463	1,070,890	3.98

Q_{100} = 1-70_4 + 1-70_3A + 1-70_3B + Node 557*

Q_{100} = 463 cfs + 170 cfs + 44 cfs + 2,649 cfs

Q_{100} = 3326 cfs

*Node 557 is the inflow from the Montclair Watershed

Memo

A.2. Flow Split Calculations at York Street

A.3 Flow Split

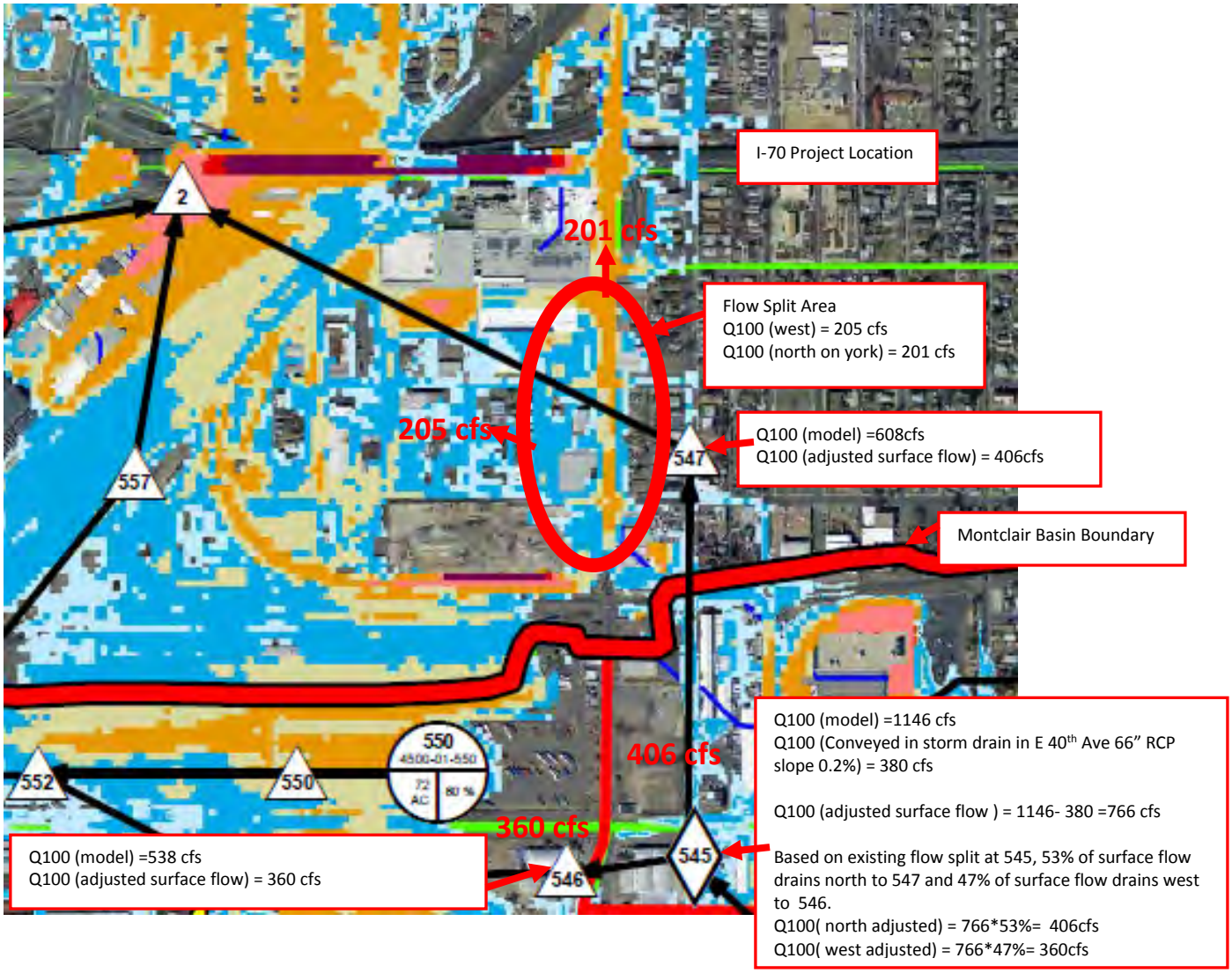
A.3.a York Street Split

Montclair Basin Flow Summary

Flow Description	100-Year Flow (cfs)
Total Montclair Basin Flow	4,655
120” Brick Pipe—Diverted to South Platte River	959
High Street Outfall (8’ x12’ CBC)—Diverted to South Platte River	1,364
***York Street—Flow draining north on York Street to Pond 6**	**201**

Flow split: Between 43rd Avenue and I-70 on York Street

The below snap shot is from the FLO-2D analysis developed by Enginuity for the Montclair Basin (*Memorandum for I-70 Partial Cover Lowered Montclair Drainage Basin Hydrologic Analysis* (Enginuity, 2014a). The snap shot below shows the 100 year flows draining to York Street. The flow split calculation takes into account the 380 cfs conveyed in the existing 66" RCP storm drain in 40th Avenue. Based on a flow master cross section of York Street it is concluded that **201 cfs** is conveyed to the north in York Steet and the remaining **205 cfs** will drain to the west.



WEIR CALCULATION

Project: Flow Split Calculation: Flow draining West between E 43rd Ave and I-70

WEIR Equation $Q = C*L*H^{3/2}$

H = Head above weir crest	0.4	ft
C = Weir Coefficient	3.0	
L = Horizontal length of weir	278	ft
Q = Flow	205	cfs

Worksheet for York street Flow split

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.87700	%
Normal Depth	1.00	ft

Section Definitions

Station (ft)	Elevation (ft)
0+000	1.00
0+000	0.00
0+002	0.17
0+020	0.37
0+039	0.15
0+040	0.00
0+040	1.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+000, 1.00)	(0+002, 0.17)	0.013
(0+002, 0.17)	(0+039, 0.15)	0.017
(0+039, 0.15)	(0+040, 1.00)	0.013

Options

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

Results

Discharge		200.71	ft³/s
Elevation Range	0.00 to 1.00 ft		
Flow Area		29.96	ft²
Wetted Perimeter		42.02	ft

Worksheet for York street Flow split

Results

Hydraulic Radius		0.71	ft
Top Width		40.00	ft
Normal Depth		1.00	ft
Critical Depth		1.17	ft
Critical Slope		0.00444	ft/ft
Velocity		6.70	ft/s
Velocity Head		0.70	ft
Specific Energy		1.70	ft
Froude Number		1.37	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.00	ft
Critical Depth	1.17	ft
Channel Slope	0.87700	%
Critical Slope	0.00444	ft/ft

Flow Split (Existing Storm Drain Diverted Out Flow)

Worksheet for Existing 120" Brick Pipe

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.015	
Channel Slope	0.39000	%
Normal Depth	9.60	ft
Diameter	10.00	ft

Results

Discharge	958.87	ft^3/s
Flow Area	77.49	ft^2
Wetted Perimeter	27.39	ft
Hydraulic Radius	2.83	ft
Top Width	3.92	ft
Critical Depth	7.46	ft
Percent Full	96.0	%
Critical Slope	0.00544	ft/ft
Velocity	12.37	ft/s
Velocity Head	2.38	ft
Specific Energy	11.98	ft
Froude Number	0.49	
Maximum Discharge	962.75	ft^3/s
Discharge Full	894.99	ft^3/s
Slope Full	0.00448	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	96.00	%
Downstream Velocity	Infinity	ft/s

Worksheet for Existing 120" Brick Pipe

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	9.60	ft
Critical Depth	7.46	ft
Channel Slope	0.39000	%
Critical Slope	0.00544	ft/ft

Cross Section for Existing 120" Brick Pipe

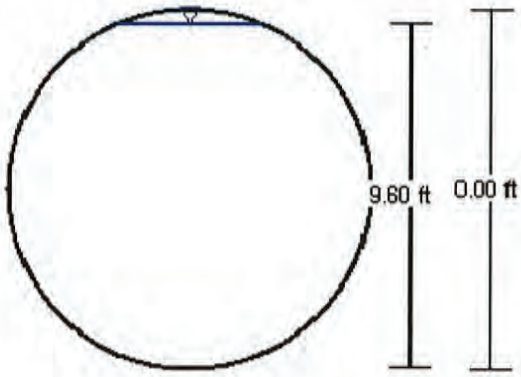
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.015	
Channel Slope	0.39000	%
Normal Depth	9.60	ft
Diameter	10.00	ft
Discharge	958.87	ft³/s

Cross Section Image



V: 1
H: 1

Worksheet for Existing High Street (8'x12' CBC) Q 100

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.30000	%
Normal Depth	7.99	ft
Height	8.00	ft
Bottom Width	12.00	ft

Results

Discharge	1364.35	ft^3/s
Flow Area	95.88	ft^2
Wetted Perimeter	27.98	ft
Hydraulic Radius	3.43	ft
Top Width	12.00	ft
Critical Depth	7.38	ft
Percent Full	99.9	%
Critical Slope	0.00368	ft/ft
Velocity	14.23	ft/s
Velocity Head	3.15	ft
Specific Energy	11.14	ft
Froude Number	0.89	
Discharge Full	1077.35	ft^3/s
Slope Full	0.00187	ft/ft
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	99.88	%
Downstream Velocity	Infinity	ft/s

Worksheet for Existing High Street (8'x12' CBC) Q 100

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	7.99	ft
Critical Depth	7.38	ft
Channel Slope	0.30000	%
Critical Slope	0.00368	ft/ft

Cross Section for Existing High Street (8'x12' CBC) Q 100

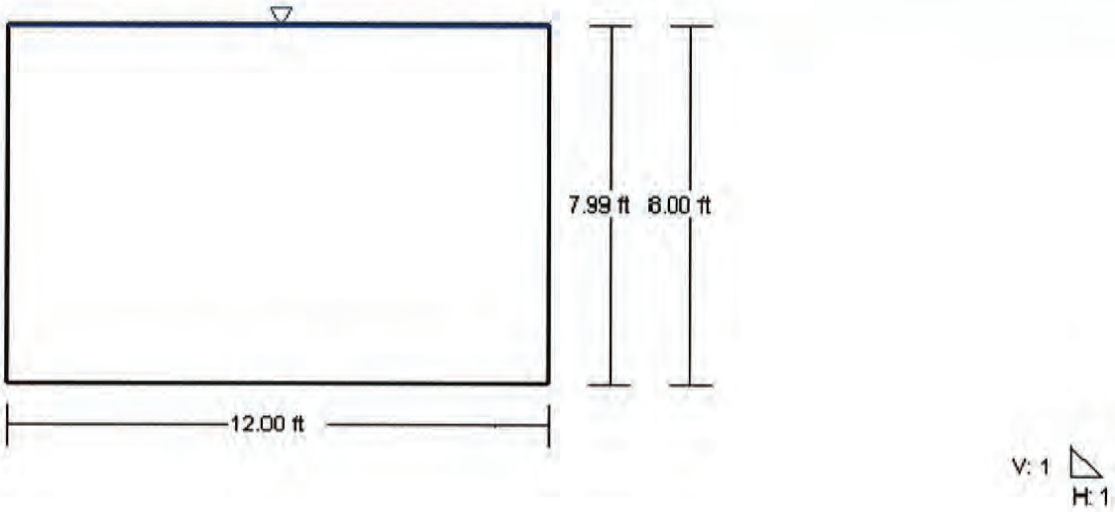
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.30000	%
Normal Depth	7.99	ft
Height	8.00	ft
Bottom Width	12.00	ft
Discharge	1364.35	ft³/s

Cross Section Image



Worksheet for Existing 72" RCP at York St Capacity Calculation

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.52000	%
Normal Depth	5.65	ft
Diameter	6.00	ft

Results

Discharge	328.47	ft³/s
Flow Area	27.61	ft²
Wetted Perimeter	15.92	ft
Hydraulic Radius	1.73	ft
Top Width	2.81	ft
Critical Depth	4.93	ft
Percent Full	94.2	%
Critical Slope	0.00598	ft/ft
Velocity	11.90	ft/s
Velocity Head	2.20	ft
Specific Energy	7.85	ft
Froude Number	0.67	
Maximum Discharge	328.50	ft³/s
Discharge Full	305.38	ft³/s
Slope Full	0.00602	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	94.17	%
Downstream Velocity	Infinity	ft/s

Worksheet for Existing 72" RCP at York St Capacity Calculation

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	5.65	ft
Critical Depth	4.93	ft
Channel Slope	0.52000	%
Critical Slope	0.00598	ft/ft

Cross Section for Existing 72" RCP at York St Capacity Calculation

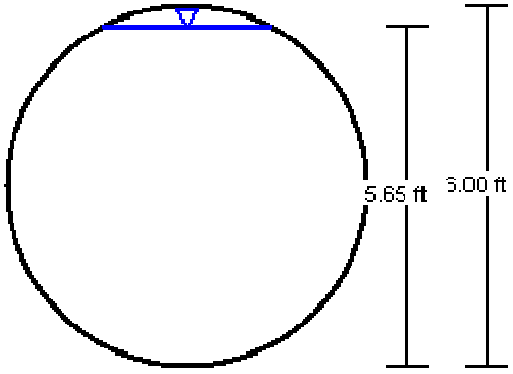
Project Description

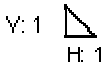
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.52000	%
Normal Depth	5.65	ft
Diameter	6.00	ft
Discharge	328.47	ft³/s

Cross Section Image

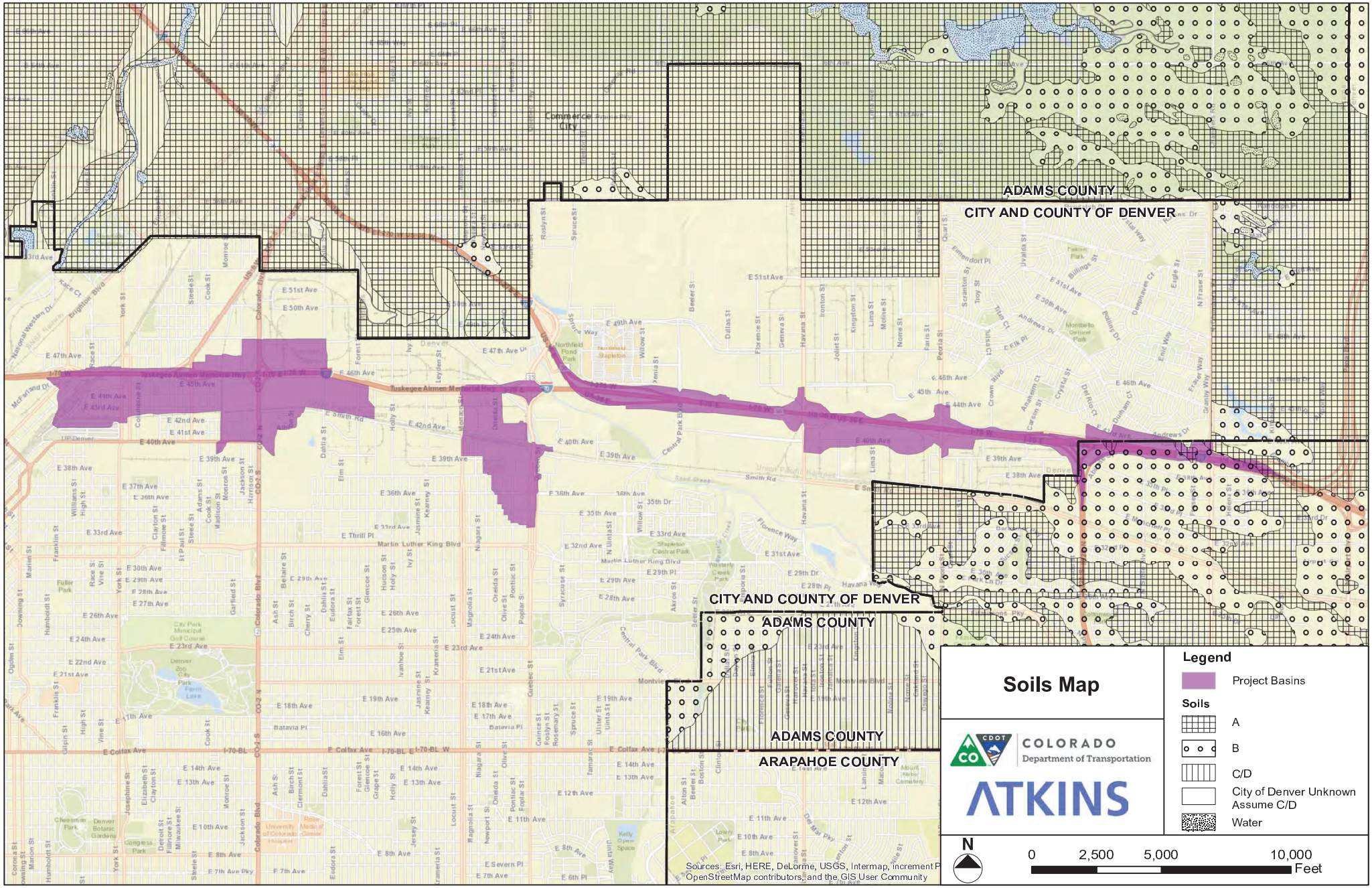




Memo

A.3. **Soil Map**

ATKINS


ADAMS COUNTY
CITY AND COUNTY OF DENVER
CITY AND COUNTY OF DENVER
ADAMS COUNTY
ADAMS COUNTY
ARAPAHOE COUNTY
Soils Map
COLORADO
Department of Transportation
ATKINS
Legend
Project Basins
Soils
A
B
C/D
City of Denver Unknown Assume C/D
Water
N
0
2,500
5,000
10,000
Feet
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P
OpenStreetMap contributors, and the GIS User Community

Memo

Appendix B. **Hydraulics**

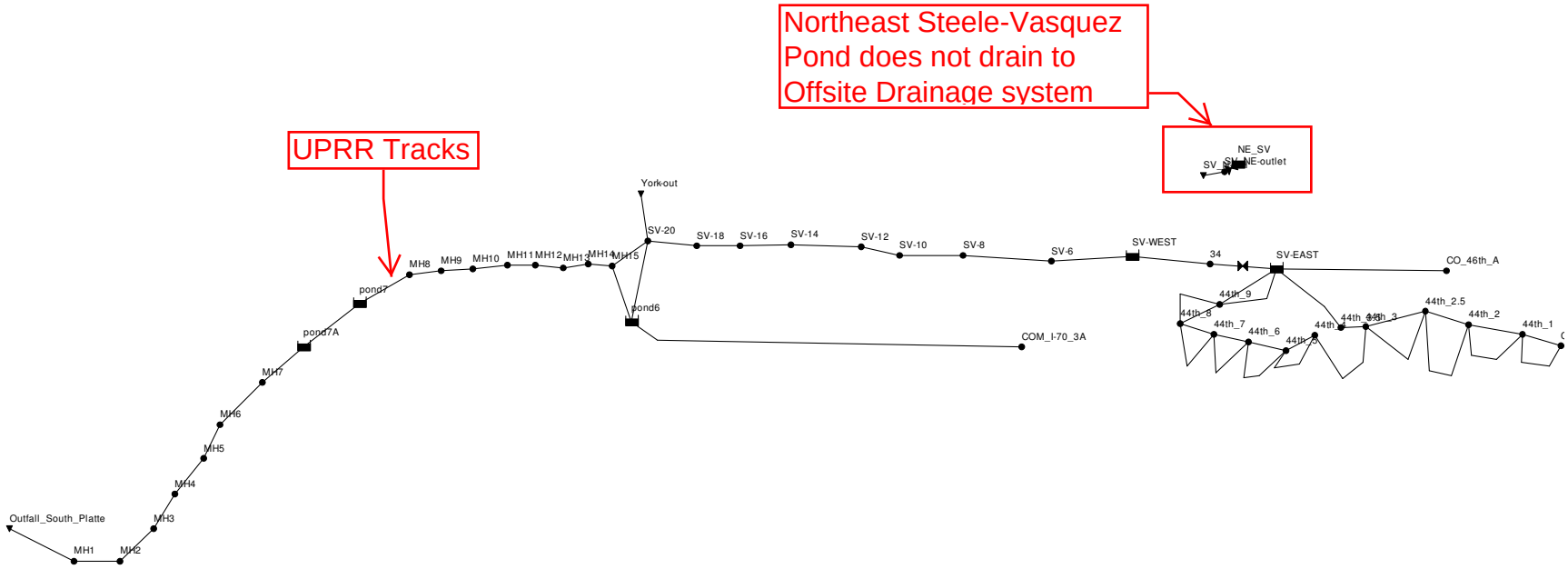
ATKINS

Memo

B.1. **SWMM Map**

Preliminary Model for CDOT I-70 Offsite outfall with ponds SV

07/18/2014 00:05:00



B.2. SWMM Output

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.010)

Preliminary Model for CDOT I-70 Offsite outfall with ponds SV

Model by JRB (Atkins) 3/06/2015

WARNING 02: maximum depth increased for Node 44th_1

WARNING 02: maximum depth increased for Node 44th_2

WARNING 02: maximum depth increased for Node 44th_3

WARNING 02: maximum depth increased for Node 44th_4

WARNING 02: maximum depth increased for Node 44th_2.5

****

Element Count

****

Number of rain gages 0

Number of subcatchments ... 0

Number of nodes..... 48

Number of links..... 58

Number of pollutants 0

Number of land uses 0

****

Node Summary

****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
MH2	JUNCTION	5159.98	8.27	0.0	
MH3	JUNCTION	5160.45	9.86	0.0	
MH4	JUNCTION	5161.03	10.62	0.0	
MH5	JUNCTION	5161.72	8.39	0.0	
MH6	JUNCTION	5162.20	10.59	0.0	
MH7	JUNCTION	5163.29	20.19	0.0	
MH12	JUNCTION	5176.52	10.75	0.0	
MH11	JUNCTION	5175.75	11.25	0.0	
MH10	JUNCTION	5175.16	10.73	0.0	
MH9	JUNCTION	5174.15	12.81	0.0	
MH13	JUNCTION	5177.90	8.00	0.0	
MH15	JUNCTION	5179.11	8.00	0.0	
MH14	JUNCTION	5178.74	8.00	0.0	

MH1	JUNCTION	5159.56	11.89	0.0	
MH8	JUNCTION	5173.28	13.11	0.0	
COM_I-70_3A	JUNCTION	5189.67	5.00	0.0	
COM_I-70_1	JUNCTION	5208.70	16.10	0.0	Yes
34	JUNCTION	5185.81	20.00	0.0	
SV-6	JUNCTION	5184.18	11.37	0.0	
SV-8	JUNCTION	5183.11	17.99	0.0	
SV-10	JUNCTION	5182.16	13.76	0.0	
SV-12	JUNCTION	5181.91	14.51	0.0	
SV-14	JUNCTION	5180.95	10.53	0.0	
SV-16	JUNCTION	5179.00	8.00	0.0	
SV-18	JUNCTION	5177.90	8.00	0.0	
SV-20	JUNCTION	5177.31	7.19	0.0	
CO_46th_A	JUNCTION	5210.00	22.00	0.0	
44th_1	JUNCTION	5206.70	19.00	0.0	
44th_2	JUNCTION	5204.00	18.15	0.0	
44th_3	JUNCTION	5201.30	18.20	0.0	
44th_4	JUNCTION	5199.50	17.96	0.0	
44th_5	JUNCTION	5196.60	14.20	0.0	
44th_6	JUNCTION	5195.60	14.60	0.0	
SV_NE-outlet	JUNCTION	5197.00	5.00	0.0	

44th_2.5	JUNCTION	5202.25	18.25	0.0	
44th_3.5	JUNCTION	5200.92	13.40	0.0	
44th_7	JUNCTION	5194.26	15.74	0.0	
44th_8	JUNCTION	5192.84	16.96	0.0	
44th_9	JUNCTION	5191.78	17.82	0.0	
Outfall_South_ Platte	OUTFALL	5158.45	6.00	0.0	
York-out	OUTFALL	5176.03	6.00	0.0	
SV_N-MH	OUTFALL	5196.00	2.20	0.0	
pond6	STORAGE	5179.68	6.00	0.0	Yes
pond7	STORAGE	5167.25	20.00	0.0	Yes
pond7A	STORAGE	5164.22	20.00	0.0	
SV-EAST	STORAGE	5185.81	18.00	0.0	
SV-WEST	STORAGE	5184.74	10.00	0.0	
NE_SV	STORAGE	5197.00	5.00	0.0	

****

Link Summary

****

Name	From Node	To Node	Type	Length	%Slope	Roughness

OF-2B	pond7	pond7A	CONDUIT	275.0	0.6946	0.0130
OF-1	pond7A	MH7	CONDUIT	317.1	0.2933	0.0130
OF-2	MH7	MH6	CONDUIT	340.8	0.3199	0.0130
OF-3	MH6	MH5	CONDUIT	249.1	0.1927	0.0130
OF-4	MH5	MH4	CONDUIT	354.7	0.1946	0.0130
OF-5	MH4	MH3	CONDUIT	300.0	0.1933	0.0130
OF-6	MH3	MH2	CONDUIT	246.1	0.1910	0.0130
OF-7	MH2	MH1	CONDUIT	219.3	0.1915	0.0130
OF-8	MH1	Outfall_South_Platte	CONDUIT	559.9	0.1983	0.0130
MC-York-2	COM_I-70_3A	pond6	CONDUIT	400.0	2.4983	0.0100
YK5	MH12	MH11	CONDUIT	161.1	0.4780	0.0130
YK6	MH11	MH10	CONDUIT	125.0	0.4719	0.0130
YK7	MH10	MH9	CONDUIT	209.8	0.4814	0.0130
YK8	MH8	pond7	CONDUIT	349.3	0.6528	0.0130
YK1	pond6	MH15	CONDUIT	113.0	0.5044	0.0130
YK2	MH15	MH14	CONDUIT	74.0	0.5000	0.0130
York_bridge	SV-20	York-out	CONDUIT	246.0	0.5203	0.0130
YK3	MH14	MH13	CONDUIT	177.0	0.4746	0.0130
YK4	MH13	MH12	CONDUIT	284.0	0.4859	0.0130

31	MH9	MH8	CONDUIT	182.6	0.4765	0.0130
SV_5	SV-WEST	SV-6	CONDUIT	120.0	0.3000	0.0130
SV_1	CO_46th_A	SV-EAST	CONDUIT	800.0	1.0988	0.0130
SV_3	34	SV-WEST	CONDUIT	283.0	0.3004	0.0130
SV_7	SV-6	SV-8	CONDUIT	290.0	0.3000	0.0130
SV_9	SV-8	SV-10	CONDUIT	248.0	0.3024	0.0130
SV_11	SV-10	SV-12	CONDUIT	56.0	0.0893	0.0130
SV_13	SV-12	SV-14	CONDUIT	290.0	0.2621	0.0130
41	SV-14	SV-16	CONDUIT	509.0	0.3438	0.0130
SV_17	SV-16	SV-18	CONDUIT	300.0	0.3000	0.0130
SV_19	SV-18	SV-20	CONDUIT	175.0	0.3029	0.0130
44th_A	COM_I-70_1	44th_1	CONDUIT	240.0	0.7500	0.0130
44th_B	44th_1	44th_2	CONDUIT	314.0	0.8281	0.0130
44th_C1	44th_2	44th_2.5	CONDUIT	206.0	0.8495	0.0130
44th_3	44th_3.5	SV-EAST	CONDUIT	182.0	6.6686	0.0130
_Diversion						
44th_E_OL	44th_4	44th_5	CONDUIT	107.0	1.5609	0.0160
44th_F	44th_5	44th_6	CONDUIT	32.0	2.5008	0.0130
44th_G	44th_6	44th_7	CONDUIT	57.0	2.0004	0.0130
44th_A_OL	COM_I-70_1	44th_1	CONDUIT	240.0	1.6669	0.0160
44th_E	44th_4	44th_5	CONDUIT	107.0	2.5242	0.0130

44th_B_OL	44th_1	44th_2	CONDUIT	314.0	1.1306	0.0160
44th_C_OL	44th_2	44th_2.5	CONDUIT	206.0	0.8010	0.0160
44th_D_OL	44th_3	44th_4	CONDUIT	164.0	1.2440	0.0160
44th_G_OL	44th_6	44th_7	CONDUIT	57.0	0.3509	0.0160
SV_NEpipe	SV_NE-outlet	SV_N-MH	CONDUIT	150.0	0.5333	0.0130
44th_C2	44th_2.5	44th_3	CONDUIT	112.0	0.8482	0.0130
44th_D	44th_3	44th_3.5	CONDUIT	15.0	1.2001	0.0130
44th_F_OL	44th_5	44th_6	CONDUIT	32.0	1.8753	0.0160
44th_H	44th_7	44th_8	CONDUIT	61.0	2.0004	0.0130
44th_H_OL	44th_7	44th_8	CONDUIT	61.0	0.3279	0.0160
44th_I	44th_8	44th_9	CONDUIT	43.0	2.0004	0.0130
44th_I_OL	44th_8	44th_9	CONDUIT	43.0	0.4651	0.0160
44th_J	44th_9	SV-EAST	CONDUIT	75.0	5.0330	0.0130
44th_J_OL	44th_9	SV-EAST	CONDUIT	75.0	2.3873	0.0160
51	44th_2.5	44th_3	CONDUIT	112.0	0.8929	0.0160
42	SV-20	MH15	CONDUIT	110.0	1.6275	0.0130
52	pond6	SV-20	CONDUIT	110.0	0.1909	0.0130
1	SV-EAST	34	ORIFICE			
NE_SV-out	NE_SV	SV_NE-outlet	ORIFICE			

****

Cross Section Summary

****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
OF-2B	RECT_CLOSED	6.00	120.00	2.31	20.00	2	1996.32
OF-1	RECT_CLOSED	6.00	108.00	2.25	18.00	2	1147.96
OF-2	RECT_CLOSED	6.00	108.00	2.25	18.00	2	1198.89
OF-3	RECT_CLOSED	6.00	120.00	2.31	20.00	2	1051.58
OF-4	RECT_CLOSED	6.00	120.00	2.31	20.00	2	1056.56
OF-5	RECT_CLOSED	6.00	120.00	2.31	20.00	2	1053.23
OF-6	RECT_CLOSED	6.00	120.00	2.31	20.00	2	1046.77
OF-7	RECT_CLOSED	6.00	120.00	2.31	20.00	2	1048.34
OF-8	RECT_CLOSED	6.00	67.50	1.96	11.25	4	537.44
MC-York-2	CIRCULAR	5.00	19.63	1.25	5.00	1	535.15
YK5	RECT_CLOSED	6.00	42.00	1.62	7.00	1	456.96
YK6	RECT_CLOSED	6.00	42.00	1.62	7.00	1	454.06
YK7	RECT_CLOSED	6.00	42.00	1.62	7.00	1	458.60
YK8	RECT_CLOSED	6.00	42.00	1.62	7.00	1	534.03
YK1	RECT_CLOSED	6.00	42.00	1.62	7.00	1	469.44

YK2	RECT_CLOSED	6.00	42.00	1.62	7.00	1 467.37
York_bridge	CIRCULAR	6.00	28.27	1.50	6.00	1 305.49
YK3	RECT_CLOSED	6.00	42.00	1.62	7.00	1 455.35
YK4	RECT_CLOSED	6.00	42.00	1.62	7.00	1 460.71
31	RECT_CLOSED	6.00	42.00	1.62	7.00	1 456.26
SV_5	CIRCULAR	6.50	33.18	1.63	6.50	1 287.16
SV_1	CIRCULAR	2.00	3.14	0.50	2.00	1 23.71
SV_3	CIRCULAR	6.00	28.27	1.50	6.00	1 232.10
SV_7	CIRCULAR	6.50	33.18	1.63	6.50	1 287.16
SV_9	CIRCULAR	6.50	33.18	1.63	6.50	1 288.31
SV_11	CIRCULAR	6.50	33.18	1.63	6.50	1 156.66
SV_13	CIRCULAR	6.50	33.18	1.63	6.50	1 268.39
41	CIRCULAR	6.50	33.18	1.63	6.50	1 307.41
SV_17	CIRCULAR	7.00	38.48	1.75	7.00	1 349.90
SV_19	CIRCULAR	7.00	38.48	1.75	7.00	1 351.57
44th_A	CIRCULAR	4.00	12.57	1.00	4.00	1 124.40
44th_B	CIRCULAR	4.00	12.57	1.00	4.00	1 130.71
44th_C1	CIRCULAR	4.00	12.57	1.00	4.00	1 132.40
44th_3_Diversion	CIRCULAR	4.00	12.57	1.00	4.00	1 370.94
44th_E_OL	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1 10820.66
44th_F	CIRCULAR	4.00	12.57	1.00	4.00	1 227.16

44th_G	CIRCULAR	4.00	12.57	1.00	4.00	1	203.16
44th_A_OL	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1	11181.89
44th_E	CIRCULAR	4.00	12.57	1.00	4.00	1	228.22
44th_B_OL	TRAPEZOIDAL	10.00	2010.00	5.01	401.00	1	58089.64
44th_C_OL	TRAPEZOIDAL	10.00	2010.00	5.01	401.00	1	48893.46
44th_D_OL	TRAPEZOIDAL	10.00	2010.00	5.01	401.00	1	60932.00
44th_G_OL	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1	5130.26
SV_NEpipe	CIRCULAR	2.00	3.14	0.50	2.00	1	16.52
44th_C2	CIRCULAR	4.00	12.57	1.00	4.00	1	132.30
44th_D	CIRCULAR	4.00	12.57	1.00	4.00	1	157.36
44th_F_OL	TRAPEZOIDAL	5.00	520.00	2.55	204.00	1	12331.11
44th_H	CIRCULAR	4.00	12.57	1.00	4.00	1	203.16
44th_H_OL	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1	4959.20
44th_I	CIRCULAR	4.00	12.57	1.00	4.00	1	203.16
44th_I_OL	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1	5906.69
44th_J	CIRCULAR	4.00	12.57	1.00	4.00	1	322.26
44th_J_OL	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1	13381.92
51	TRAPEZOIDAL	5.00	505.00	2.51	201.00	1	8183.90
42	CIRCULAR	2.50	4.91	0.63	2.50	1	52.33
52	CIRCULAR	1.50	1.77	0.38	1.50	1	4.59

****

NOTE: The summary statistics displayed in this report are

based on results found at every computational time step,

not just on results from each reporting time step.

****

****

Analysis Options

****

Flow Units ..... CFS

Process Models:

  Rainfall/Runoff ..... NO

  RDII ..... NO

  Snowmelt ..... NO

  Groundwater ..... NO

  Flow Routing ..... YES

  Ponding Allowed ..... NO

  Water Quality ..... NO

Flow Routing Method ..... DYNWAVE

Starting Date JUL-18-2014 00:00:00

Ending Date JUL-18-2014 06:00:00

Antecedent Dry Days 0.0

Report Time Step 00:05:00

Routing Time Step ..... 1.00 sec

Variable Time Step ..... YES

Maximum Trials 8

Number of Threads 1

Head Tolerance ..... 0.005000 ft

**********	Volume	Volume
Flow Routing Continuity	acre-feet	10^6 gal
**********	---------	---------
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.000	0.000
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	371.320	121.000
External Outflow	371.219	120.967
Flooding Loss	0.000	0.000

Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.052	0.017
Continuity Error (%)	0.013	

****

Time-Step Critical Elements

****

Link 44th_D (20.61%)

Link SV_11 (1.06%)

****

Highest Flow Instability Indexes

****

Link 1 (1)

****

Routing Time Step Summary

****

Minimum Time Step : 0.50 sec

Average Time Step : 0.94 sec

Maximum Time Step : 1.00 sec

Percent in Steady State : 0.00

Average Iterations per Step : 2.02

Percent Not Converging : 0.20

****

Analysis begun on: Wed May 04 12:08:17 2016

Analysis ended on: Wed May 04 12:08:19 2016

Total elapsed time: 00:00:02

B.3. Extended Detention Basin Worksheet for Onsite Drainage

Design Procedure Form: Extended Detention Basin (EDB)

Designer: MNJ
Company: Atkins
Date: February 22, 2016
Project: I-70 East
Location: South Platte Directly - "Onsite" Pond located north of Brighton Blvd. and Race Ct.

1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area, I_a — I_a = 100.0 %

B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$) — i = 1.000

C) Contributing Watershed Area — Area = 27.600 ac

D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm — d_6 = ____ in

E) Design Concept (Select EURV when also designing for flood control)

Choose One
- (●) Water Quality Capture Volume (WQCV)
- ( ) Excess Urban Runoff Volume (EURV)

F) Design Volume (1.2 WQCV) Based on 40-hour Drain Time
($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area * 1.2)$) — V_{DESIGN} = 1.380 ac-ft

G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume
($V_{WQCV\ OTHER} = (d_6 * (V_{DESIGN}/0.43))$) — $V_{DESIGN\ OTHER}$ = ____ ac-ft

H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired) — $V_{DESIGN\ USER}$ = ____ ac-ft

I) Predominant Watershed NRCS Soil Group

Choose One
- ( ) A
- ( ) B
- ( ) C / D

J) Excess Urban Runoff Volume (EURV) Design Volume
For HSG A: EURVA = (0.1878i - 0.0104)*Area
For HSG B: $EURV_B$ = (0.1178i - 0.0042)*Area
For HSG C/D: $EURV_{C/D}$ = (0.1043i - 0.0031)*Area

EURV = ____ ac-ft

2. Basin Shape: Length to Width Ratio
(A basin length to width ratio of at least 2:1 will improve TSS reduction.)

L : W = 2.0 : 1

3. Basin Side Slopes

A) Basin Maximum Side Slopes
(Horizontal distance per unit vertical, 4:1 or flatter preferred)

Z = 4.00 ft / ft

4. Inlet

A) Describe means of providing energy dissipation at concentrated inflow locations:

Forebay

Design Procedure Form: Extended Detention Basin (EDB)

Designer: MNJ
Company: Atkins
Date: February 22, 2016
Project: I-70 East
Location: South Platte Directly - "Onsite" Pond located north of Brighton Blvd. and Race Ct.

5. Forebay

A) Minimum Forebay Volume (V_{FMIN} = 3% of the WQCV) — V_{FMIN} = 0.035 ac-ft

B) Actual Forebay Volume — V_F = 40.000 ac-ft

C) Forebay Depth (D_F = 30 inch maximum) — D_F = 30.0 in

D) Forebay Discharge

i) Undetained 100-year Peak Discharge — Q_{100} = 128.00 cfs

ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$) — Q_F = 2.56 cfs

E) Forebay Discharge Design

Choose One
- ○ Berm With Pipe
- ◉ Wall with Rect. Notch
- ○ Wall with V-Notch Weir

F) Discharge Pipe Size (minimum 8-inches) — Calculated D_P = in

G) Rectangular Notch Width — Calculated W_N = 8.3 in

6. Trickle Channel

A) Type of Trickle Channel

Choose One
- ◉ Concrete
- ○ Soft Bottom

F) Slope of Trickle Channel — S = 0.0050 ft / ft

7. Micropool and Outlet Structure

A) Depth of Micropool (2.5-feet minimum) — D_M = 2.5 ft

B) Surface Area of Micropool (10 ft^2 minimum) — A_M = 65 sq ft

C) Outlet Type

Choose One
- ◉ Orifice Plate
- ○ Other (Describe):

D) Depth of Design Volume (EURV or 1.2 WQCV) Based on the Design Concept Chosen Under 1.E. — H = 2.50 feet

E) Volume to Drain Over Prescribed Time — WQCV = 1.150 ac-ft

F) Drain Time (Min T_D for WQCV= 40 hours; Max T_D for EURV= 72 hours) — T_D = 40 hours

G) Recommended Maximum Outlet Area per Row, (A_o) — A_o = 2.46 square inches

H) Orifice Dimensions:
i) Circular Orifice Diameter or — $D_{orifice}$ = 1 - 3 / 4 inches
ii) Width of 2" High Rectangular Orifice — $W_{orifice}$ = inches

I) Number of Columns — n_c = 1 number

J) Actual Design Outlet Area per Row (A_o) — A_o = 2.41 square inches

K) Number of Rows (nr) — n_r = 7 number

L) Total Outlet Area (A_{ot}) — A_{ot} = 18.0 square inches

M) Depth of WQCV (H_{WQCV}) (Estimate using actual stage-area-volume relationship and V_{WQCV}) — H_{WQCV} = feet

N) Ensure Minimum 40 Hour Drain Time for WQCV — $T_{D\,WQCV}$ = hours

Design Procedure Form: Extended Detention Basin (EDB)

Designer: MNJ
Company: Atkins
Date: February 22, 2016
Project: I-70 East
Location: South Platte Directly - "Onsite" Pond located north of Brighton Blvd. and Race Ct.

8. Initial Surcharge Volume

A) Depth of Initial Surcharge Volume (Minimum recommended depth is 4 inches): D_{IS} = 30.0 in

B) Minimum Initial Surcharge Volume (Minimum volume of 0.3% of the WQCV): V_{IS} = 150.3 cu ft

C) Initial Surcharge Provided Above Micropool: V_s = 162.5 cu ft

9. Trash Rack

A) Type of Water Quality Orifice Used

Choose One
- ○ Circular (up to 1-1/4" diameter)
- ◉ Circular (greater than 1-1/4" diameter) OR Rectangular (2" high)

B) Water Quality Screen Open Area: $A_t = Aot * 38.5*(e^{-0.095D})$: A_t = 588 square inches

C) For 1-1/4"", or Smaller, Circular Opening (See Fact Sheet T-12):

i) Width of Water Quality Screen and Concrete Opening ($W_{opening}$): $W_{opening}$ = inches

ii) Height of Water Quality Screen (H_{TR}): H_{TR} = inches

iii) Type of Screen, Describe if "Other"

Choose One
- ○ S.S. Well Screen with 60% Open Area*
- ○ Other (Describe):

D) For Circular Opening (greater than 1-1/4" diameter) OR 2" High Rectangular Opening (See Fact Sheet T-12):

i) Width of Water Quality Screen Opening ($W_{opening}$): $W_{opening}$ = 1.2 ft

ii) Height of Water Quality Screen (H_{TR}): H_{TR} = 4.8 ft

iii) Type of Screen, Describe if "Other"

Choose One
- ◉ Aluminum Amico-Klemp SR Series (or equal)
- ○ Other (Describe):

v) Cross-bar Spacing: 2.0 inches

vi) Minimum Bearing Bar Size: 1-1/4 inch x 3/16 inch

Design Procedure Form: Extended Detention Basin (EDB)

Designer: MNJ
Company: Atkins
Date: February 22, 2016
Project: I-70 East
Location: South Platte Directly - "Onsite" Pond located north of Brighton Blvd. and Race Ct.

10. Overflow Embankment	
A) Describe embankment protection for 100-year and greater overtopping:	Overflow will overtop pond to surrounding, vegetated area.
B) Slope of Overflow Embankment (Horizontal distance per unit vertical, 4:1 or flatter preferred)	Z_E = _____ ft / ft
11. Vegetation	Choose One: ○ Irrigated ◉ Not Irrigated
12. Access	
A) Describe Sediment Removal Procedures	Annual, local maintenance with vacuum trucks.

Notes:

Appendix C. References

Memo

C.1. MATT Memo for Montclair Basin

Memorandum

To: I-70 PCL Drainage Multi Agency Technical Team (MATT)
- Urban Drainage and Flood Control District (UDFCD)
- Colorado Department of Transportation (CDOT)
- City and County of Denver (CCD)
- Regional Transportation District (RTD)
- Atkins
- Stantec

From: Don Jacobs P.E. – Enginuity Engineering Solutions (Enginuity)

Date: August 1, 2014

Re: I-70 PCL **Montclair** Drainage Basin Hydrologic Analysis

1.0 Contents of this Memorandum

This memorandum was prepared by Enginuity Engineering Solutions documenting the Multi Agency Technical Team's (MATT) investigation of the Montclair drainage basin hydrology in Denver, Colorado. A list of individual MATT participating members is located in the appendix (see meeting minutes) and includes the Urban Drainage and Flood Control District (UDFCD), the Colorado Department of Transportation (CDOT), the City and County of Denver (CCD), and the Regional Transportation District (RTD). Organizational contents of this memorandum are listed below:

2.0 Background and Purpose

CDOT has identified the Partial Covered Lowered Alternative (PCL) as the preferred alternative for improvements to I-70 East through Denver. A portion of this alternative includes rebuilding I-70 below grade between Brighton Boulevard and Colorado Boulevard, where the existing viaduct currently stands. While lowering the highway at this location provides several enhancements to the community such as reconnecting the Elyria and Swansea neighborhoods, it also presents drainage challenges that must be addressed from a design standpoint.

The proposed lowered portion of the I-70 project crosses two major drainage basins in Denver – the Montclair and Park Hill basins. This memorandum specifically addresses the Montclair basin. Flood

potential in the lower Montclair drainage basin has been documented by several previous studies, including studies by the City and County of Denver and the Regional Transportation District. These studies have defined flow rates and rough flooding limits around the I-70 area both upstream and downstream of the interstate. Currently, this flood potential does not pose a significant risk to the highway due to its elevated design on a viaduct. However, proposed lowering of alignment below grade will introduce the potential for flood waters to enter the highway if not accounted for in the project's drainage design.

To address this potential drainage issue, the MATT was formed during the fall of 2013 to collectively investigate the Montclair basin's hydrology and other inter-agency coordination issues. While the Montclair basin hydrology has been documented in several previous studies (see below for more information), all of the previous analyses were performed from a regional planning standpoint, and there was a general presumption that the previously published flow rates could potentially be overly conservative from a design standpoint. Specific factors such as conservative impervious values, existing inadvertent detention that may exist within the basin, CUHP model discretization, and limited accounting for floodplain flow routing were to be investigated.

Overall goal of this analysis: to perform a technical review of the previous Montclair basin hydrologic analysis and modify the modeling, if necessary, in order to provide C-DOT with a mutually agreed upon off-site 100-year design flow rate for the I-70 PCL project.

Previous analysis that were used as the initial basis of this project:

- 2005 CCD Storm Drainage Master Plan (SDMP)
- 2008 CCD Ferril Lake Stormwater Detention Design
- 2009 CCD Storm Drainage Master Plan
- 2010 CCD Sanitary and Storm Drainage Master Plan FasTracks Interface
- 2014 CCD Storm Drainage Master Plan (in progress, scheduled for completion in October 2014)
- 2008 RTD Draft East Corridor Drainage Master Plan
- 2011 RTD Eagle P3 Drainage Adverse Impact Analysis
- 2013 RTD North Metro FLO-2D Drainage Analysis
- 2011-2014 RTD/CCD/UDFCD 40th Avenue/High Street Outfall Design
- 2012 UDFCD Park Hill (North of Smith Road) Drainage Outfall Systems Plan

This memorandum documents the hydrologic analysis performed by Enginuity in the Montclair basin for the I-70 PCL project's conceptual design. The analysis was a collaborative effort between MATT members with bi-weekly technical meetings held from September 2013 thru February 2014. Hydrology related meeting minutes are included in the appendix.

3.0 General Approach – Base Model Hydrology

General Hydrologic Conditions

The Montclair basin is a fully developed, urbanized watershed containing a total tributary drainage area of approximately 9.4 square miles. It encompasses drainage planning basins 4500-01, -03, and -04. The basin generally drains to the northwest and discharges to the South Platte River between Globeville Landing Park and Riverside Cemetery. Its upstream boundary is located to the southeast at the Fairmont Cemetery. Land use varies within the basin from primarily residential in the upper reaches to commercial and industrial in the lower reaches. City Park, an approximate 320 acre urban park containing the Denver Zoological Gardens, the Denver Museum of Nature & Science, and the City Park Golf Course, is located near the center of the drainage basin.

There is an extensive system of existing storm sewer pipes serving the basin including a 10' x 10' RCBC primary outfall. A second large (12' x 8' RCBC) outfall associated with the RTD Eagle P3 project in conjunction with UDFCD and CCD is currently under construction. These two outfalls combined were designed to convey the 5-year event. Surcharged flows in excess of the storm sewers' capacity are conveyed overland via the network of City streets. There is historical evidence that a drainage channel once existed in the Montclair basin, but it has since been obliterated by development during the early 20th century. Without a formal drainage channel, periodic flooding occurs throughout the basin with significant surface runoff. These areas of urban flooding are not recognized by FEMA as jurisdictional floodplains, but they pose a significant drainage design issue for the I-70 PCL project as they drain towards the highway.

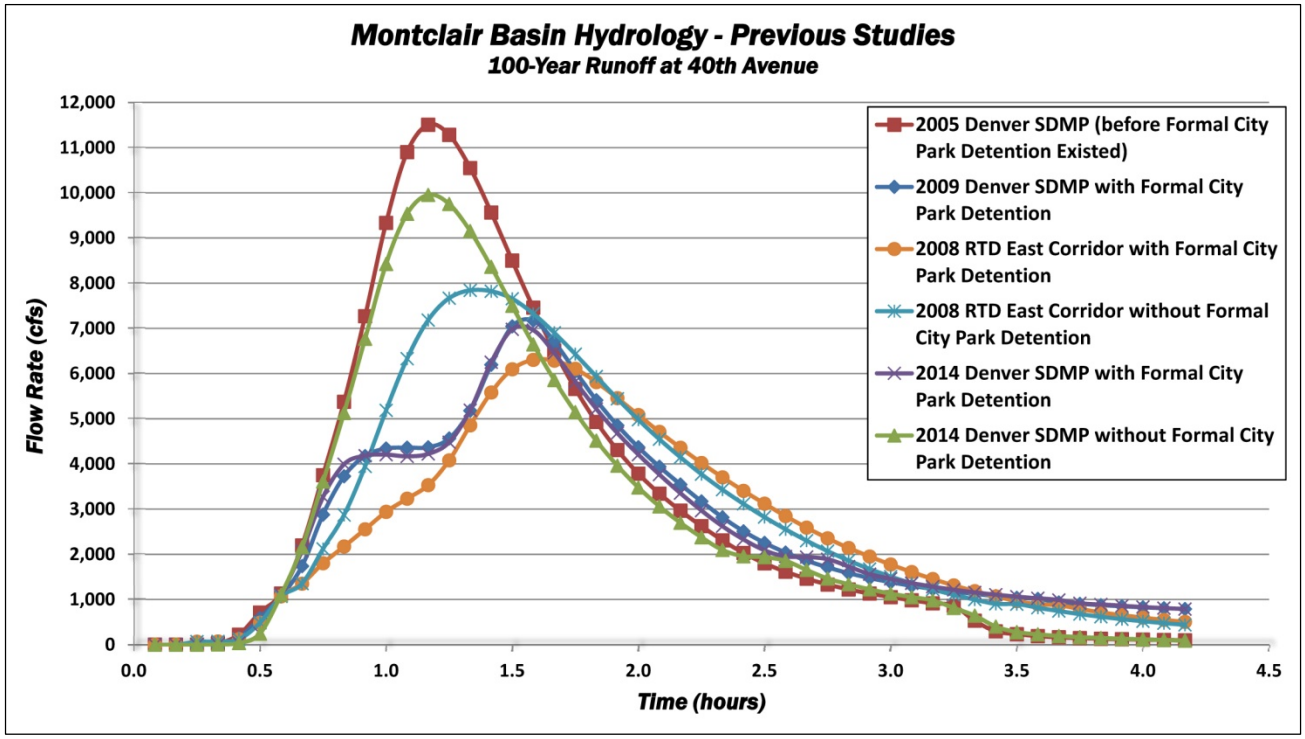
Previous Studies and Flow Rates

With numerous previous studies encompassing different portions of the Montclair drainage basin for a variety of purposes, the MATT began by investigating hydrologic results and flow rates published in the previous studies. In order to adequately compare these studies, Enginuity modified the previous CUHP/SWMM models as necessary to provide comparative results at a common location using identical assumptions. For the purpose of consistency when comparing previous studies, the following assumptions were used:

- The location for comparing flow rates produced by the Montclair basin is at 40th Avenue and represents a combined flow rate across several streets and pipes. **All comparative flow rates published in this memorandum are at 40th Avenue** and are represented as "Design Point 2" in the modeling. Once water crosses 40th Avenue, it branches into several different directions and is conveyed by various underground pipes and multiple streets. These diversions downstream (north) of 40th Avenue are accounted for in the accompanying *I-70 PCL MATT Park Hill Basin Hydrology* technical memorandum.

- **Comparative Flow rates throughout this study represent the total 100-year runoff from the basin (pipe flow plus surface flow).** For the sake of simplicity, underground pipe conveyances are not separated from the surface flow conveyances in the comparative flow rate analysis in this memorandum (DP 2). More detailed separated pipe and surface flow rates can be obtained from the updated SWMM modeling in this memorandum, but they are not used for the comparative analysis herein. These pipe conveyances should be accounted for as part of the future I-70 conceptual design.

Considering the assumptions listed above, runoff hydrographs from previous studies are depicted in the graph below:



The "City Park Detention" referenced in the graph above refers to formalized detention constructed in 2008 at Ferril Lake, which consists of approximately 124 acre-feet of detention volume and was designed for the 5-year event. While not all of the previous studies originally analyzed the basin with and without formalized detention at Ferril Lake, Enginuity added this variation to the previous models for comparative purposes and to provide the MATT with a clear understanding of the expected benefits of the existing 5-year Ferril Lake facility.

General background of the previous studies (all utilize CUHP 2000 and UDSWMM 2000):

- 2005 Denver SDMP: the first major study of the basin; utilized detailed CCD topography and GIS data; basin delineation based on pipe infrastructure; estimated % impervious values based on UDFCD land use table; delineated 57 individual sub-basins.

- 2008 RTD East Corridor: more "basic" analysis delineating 5 individual sub-basins; basin delineation based on topography; estimated % impervious values based on UDFCD land use table.

- 2009 Denver SDMP: modified 2005 model to account for City Park detention; revised % impervious calculations to be based on measured impervious values for each land use utilizing the City's GIS pervious layer; other minor modeling parameter modifications.

- 2014 Denver SDMP: modified 2009 model's routing and basin delineations to account for various surface split-flows identified using FLO-2D; routing elements account for both pipe and surface flow splits instead of pipe only; other minor modifications to account for newly constructed projects.

See the original technical documentation for each of these studies for additional information, maps, and results.

Determination of Base Hydrologic Model

The MATT reviewed results from previous modeling and decided to move forward with the 2014 Denver SDMP CUHP/UDSWMM analysis as the "Base Model" for the I-70 PCL analysis. This model was selected due to the fact that it is the latest model available, incorporates both surface and pipe flow routing, and provides a significant level of additional detail over the RTD analysis. A CUHP-UDSWMM routing schematic map representing this model is located in the appendix, which includes a summary of 100-year peak flow rates for each design point. The model has been modified by Enginuity for the purposes of this study, by combining several design points into a single point at 40th Avenue to represent the total flow for the basin. The total flow is represented by Design Point "2" in the revised model, with a 100-year peak flow rate of 6,979 cfs.

The base model was then utilized to perform a series of sensitivity analyses accounting for potential modifications to modeling parameters that the group had identified as potentially more accurate, and also accounting for physical features observed within the basin that were not previously accounted for in the model. The results of this sensitivity analysis are discussed in the following section.

4.0 Hydrologic Modeling Sensitivity Analysis

The MATT investigated the following potential modifications to the base CUHP/UDSWMM modeling and performed a sensitivity analysis on each:

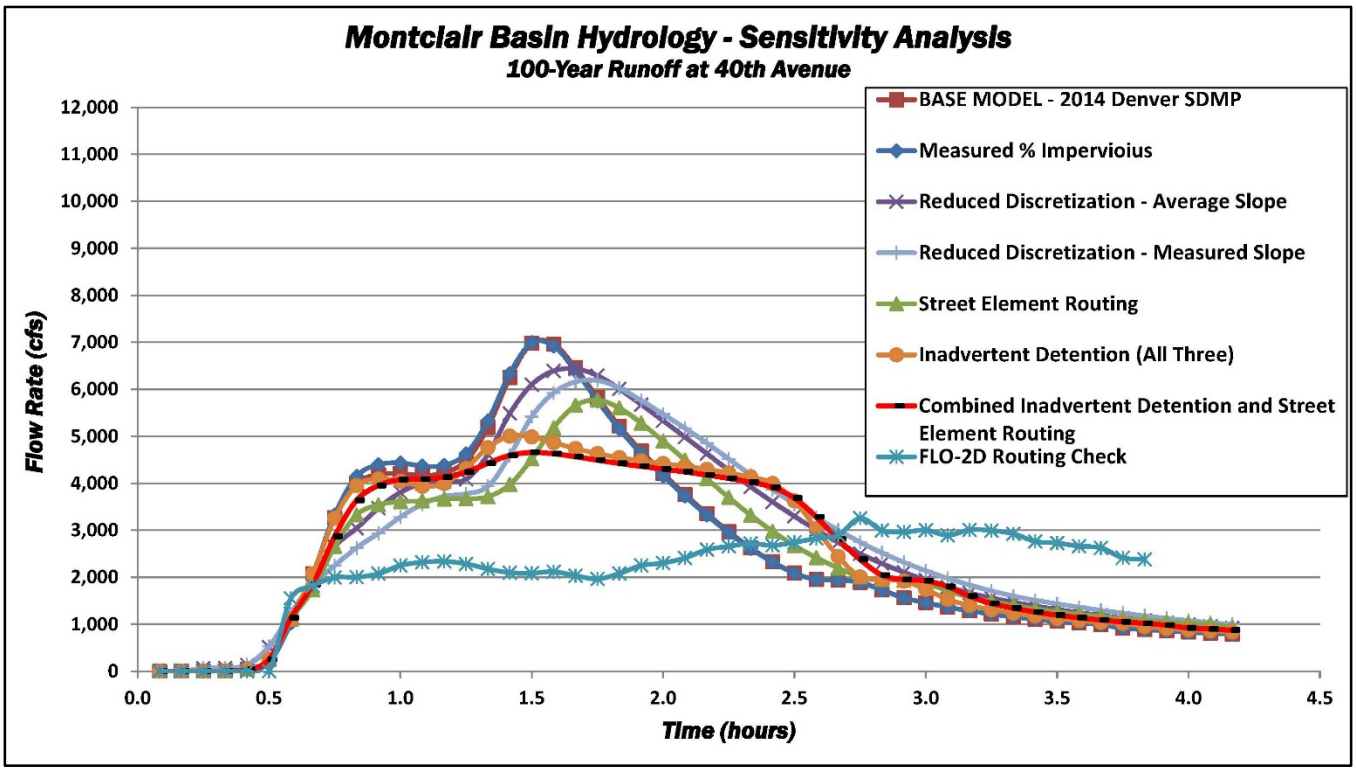
1. Accounting for **loss of surface runoff to the 36th Street** drainage basin.
2. Utilizing direct **measured impervious values** instead of land use based values.
3. Reducing the model's **discretization** by subdividing the basin into fewer sub-basins.
4. Modifying the **street routing elements** in UDSWMM to better represent flow occurring down multiple streets during the 100-year event.
5. Accounting for **inadvertent detention** that occurs within the basin.

The following table and graph summarize peak runoff rates and hydrographs for the various modeling modifications investigated by the MATT. The subsequent subsections further discuss the sensitivity analysis performed for each potential modification.

Montclair Basin Hydrology – Sensitivity Analysis
100-Year Runoff at 40th Avenue

Model or Potential Modification*	Q100 (cfs)	Change from Base Model	Comment
2014 CCD Master Plan	**6979**	0%	**Base Model, CUHP 2000, UDSWMM 2000**
Loss of surface runoff to 36th Street Basin	6598	-5%	Straight subtraction of peak flow acquired from FLO-2D model
Measured % Impervioius	6991	0.2%	1% increase in total % Impervious
Reduced Discretization - Weighted Average Slope	6432	-8%	59 sub-basins to 5 sub-basins
Reduced Discretization - Measured Basin Slope	6188	-11%	59 sub-basins to 5 sub-basins
Multiple Street X-section Routing Elements	5793	-17%	Adjusted trapazoidal bottom width and side slopes
Inadvertent Detention in City Park below Ferril Lake	5644	-19%	45.5 acre-feet assumed Inadvertent Detention
Inadvertent Detention in City Park Golf Course	5619	-19%	41.8 acre-feet assumed Inadvertent Detention
Inadvertent Detention in City Park Ball Fields	6825	-2%	18.2 acre-feet assumed Inadvertent Detention
Inadvertent Detention - all 3 combined	5005	-28%	105.5 acre-feet assumed Inadvertent Detention (total)
Check: FLO-2D Routing for Basin Below Colfax Avenue	3255	-53%	Accounts for all inadvertent detention throughout the lower basin. Includes pipe flow. Includes flow lost to 36th Street. **Low-end check only.**
Modification Combinations			
Multiple Street X-section Routing Elements & Inadvertent Detention (all 3 locations)	4422	-37%	Combination requested by MATT on 12/16/2013
Multiple Street X-section Routing Elements & Inadvertent Detention (Golf Course and Duck Pond only)	4655	-33%	Combination requested by Matt on 2/19/2014 and adopted in agreement with Denver Parks Department

* All models represent total peak runoff produced by the basin, existing pipe outfalls are not considered. All models account for existing detention at City Park in Ferril Lake and also Crestmore Park.
Red = changes recommended by MATT



4.1. Loss of Water to 36th Street Basin

FLO-2D analysis performed in the 2014 Denver SDMP indicated that there is potential for some flood waters to exit the Montclair basin and enter the 36th Street basin during large storm events. The location for this potential trans-basin flow to the west would occur across Lafayette Street in the lower portion of the basin between 31st Avenue and 36th Avenue. See the Montclair-Park Hill Basin Depth map in the appendix for a depiction of this trans-basin flow location.

As part of the MATT analysis, modifications to the 2014 SDMP FLO-2D analysis were made in order to track the trans-basin flow into the 36th Street basin. The modeling results produced a trans-basin flow of 381 cfs from Montclair to 36th Street during the 100-year event. The MATT determined this amount of flow loss to be negligible and decided not to account for it in the Montclair basin hydrology.

4.2. Measured Impervious Values

As part of the MATT analysis, the impervious values for each sub-basin were directly measured utilizing CCD's impervious layer in GIS. While the exact measured values differed from the 2014 SDMP base model for individual sub-basins, the cumulative basin-wide percent impervious value only differed by 1% and produced a negligible change in runoff values. Based on this result, the MATT decided not to modify the base model's impervious values.

4.3. Reduced Discretization

It is generally understood that the more a large basin is subdivided for CUHP/SWMM analysis (discretized), higher resulting flow rates can be expected. Often times during CUHP/SWMM model development, engineers will model a basin utilizing different levels of discretization, and compare the results in order to "calibrate" the model based on the original basis of development for CUHP itself.

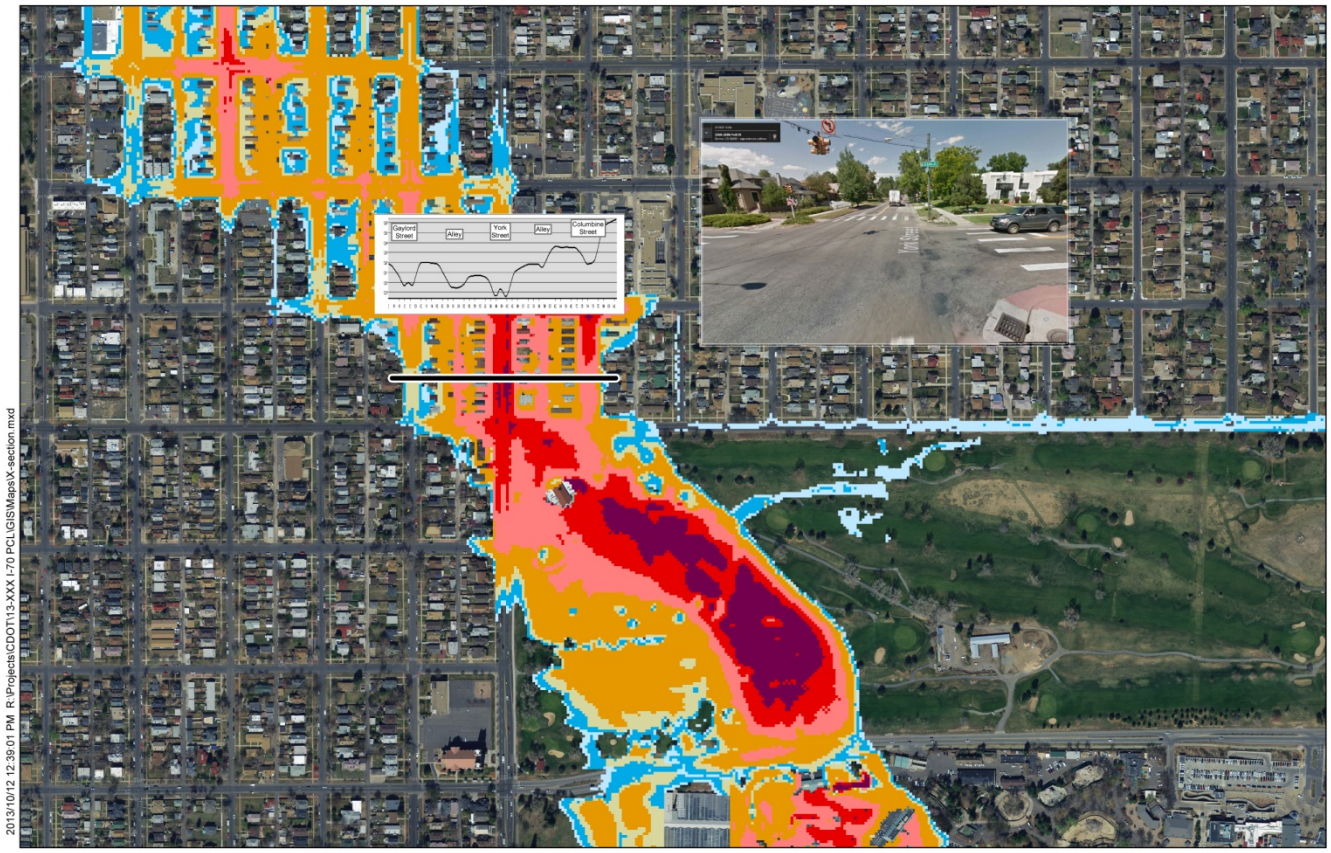
The MATT checked the sensitivity of the Montclair model by reducing the discretization from 59 sub-basins in the base 2014 SDMP model to a 5 sub-basin model. The result was an 8% to 11% decrease in peak flow rates at 40th Avenue depending on the method used to calculate sub-basin slopes. The MATT determined that this difference between the two approaches was acceptable, and did not warrant

modification to the base model. The MATT decided to continue with the more conservative, 59 sub-basin approach in the 2014 SDMP without further modification to account for discretization.

4.4. Multiple Street SWMM Routing Elements.

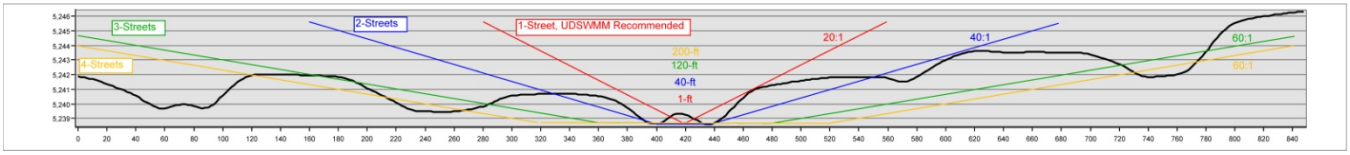
The street routing elements in the 2014 SDMP base UDSWMM model were input as recommended in the UDSWMM User's Manual. The recommended cross section is a 1-foot bottom width trapezoidal section, with 20:1 side slopes. The UDSWMM model can only accept trapezoidal shaped cross sections to represent surface flow. This standard cross section is intended to represent a street's gutter section, and can be thought of as an "inverted street crown." While this recommended cross section provides a good representation for water flowing down a single street, portions of the Montclair basin experience widespread flooding with water flowing down multiple streets, alleys, and around structures. In order to better represent the nature of this 100-year flood routing, the MATT developed several wider cross sections to be utilized in the SWMM model depending on the nature of the street flow at individual locations. The nature of the street flow was determined using FLO-2D surface modeling results from the 2014 SDMP.

A representative section located just north of 26th Avenue across the basin's primary flow path was utilized to depict the nature of street flow through the basin during the 100-year event. The following figure shows the typical nature of flow and a typical cross section within the basin, a larger version of this image is available in the appendix:



The following figure illustrates four different routing cross sections used in the MATT UDSWMM analysis representing a varying number of streets conveying the runoff. The typical ground cross section north of 26th Avenue is shown in the background in black. A larger version of this image is available in the appendix.

- Flow traveling down one street (UDSWMM User's Manual recommendation) in red. 1-foot bottom width, 20:1 side slopes.
- Flow traveling down two streets in blue. 40-foot bottom width, 40:1 side slopes.
- Flow traveling down three streets in green. 120-foot bottom width, 60:1 side slopes.
- Flow traveling down four+ streets in yellow. 200-foot bottom width, 60:1 side slopes.



When comparing these cross sections to actual ground cross sections where flow occurs down multiple streets, the MATT believes these routing element representations are conservative, with actual flooding being realistically wider, slower, and more shallow than the trapezoidal sections used in the UDSWMM model.

Several velocity checks were completed to ensure the revised trapezoidal x-section routing elements are still considered to be conservative. Results indicate that velocities calculated in SWMM for a representative trapezoidal routing element are in fact higher (more conservative) than other methods of determining flow velocities in the area. Velocity calculations performed for comparison purposes are listed below:

Velocity Check for 6000 cfs, 0.05 ft/ft longitudnal slope, 0.02 Manning's n

Manning's Velocity for Irregular Section (3-Streets):	6.8 fps
Manning's Velocity for Trapezoidal Section:	7.6 fps
EPASWMM Velocity for Irregular Section (3-Streets):	7.4 fps
EPASWMM Velocity for Trapezoidal Section:	7.8 fps (used in revised modeling)
FLO-2D Computed Velocity:	3 to 7 fps

Revision of the UDSWMM street flow routing elements resulted in a 17% decrease in peak flow rates from the base model. The MATT recommended incorporating these revisions into the I-70 hydrology to better represent 100-year flow conditions within the basin. See the UDSWMM routing map in the appendix for specific locations where the routing elements were modified to better represent street flow conditions.

4.5. Inadvertent Detention

Three areas of significant inadvertent detention were identified within the basin that could have a significant impact on peak flow rates aimed at the I-70 project. Inadvertent detention is referred to as naturally occurring detention storage that exists within low-lying and depressed areas; these areas have not been designed, constructed, or maintained for the purposes of stormwater detention. Inadvertent detention is not typically accounted for in design hydrology due to the fact it cannot be relied upon for future storage of flood waters. As a general practice, it is typically assumed that areas of inadvertent storage could be modified in the future resulting in a reduction or elimination of the storage that currently occurs. However, the three areas identified in the Montclair basin are located on CCD publically owned property, where assurances can potentially be provided to maintain the existing inadvertent detention storage volumes in perpetuity.

The MATT investigated inadvertent volumes and the impact they have on the basin's hydrology at the following locations:

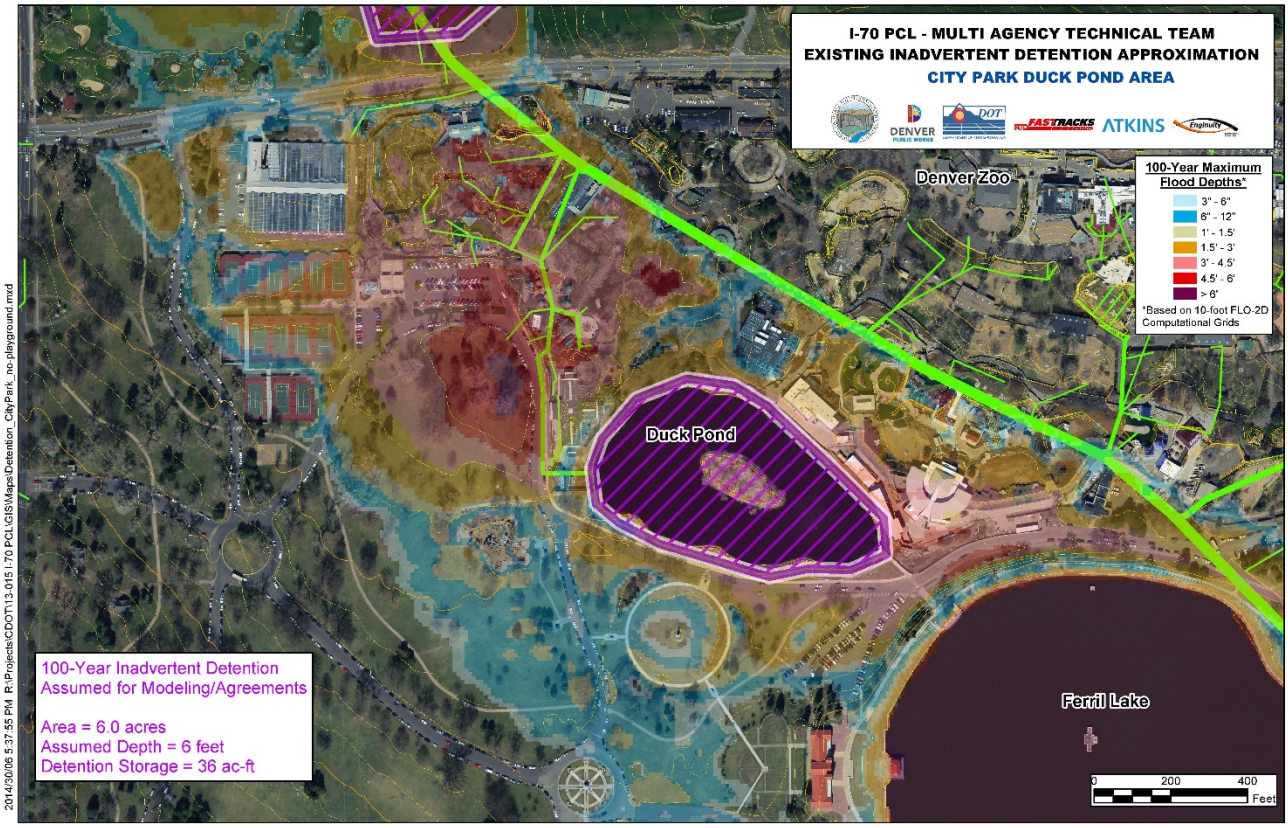
1. City Park below (north of) Ferril Lake (Duck Pond area). Assume 45.5 acre-feet including the playground area, or 36.0 acre-feet without the playground area.

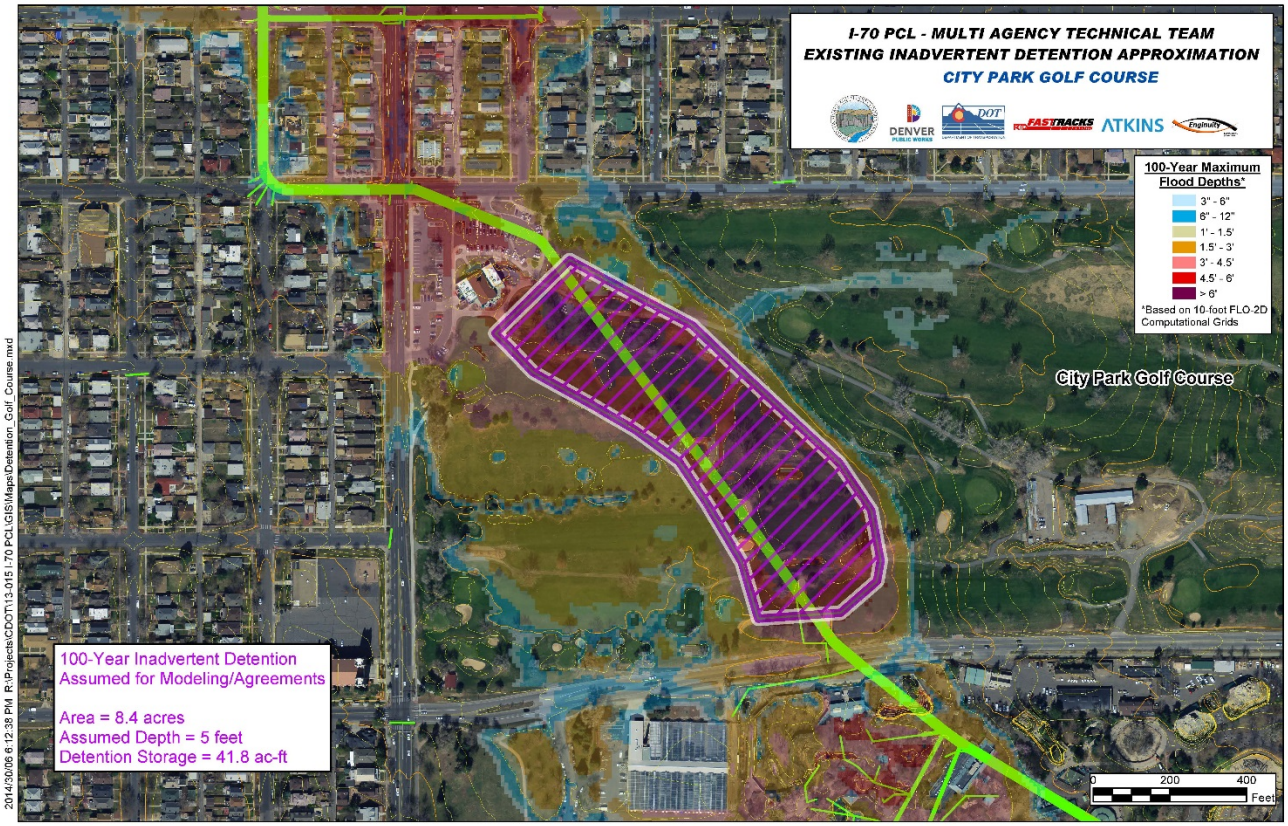
2. City Park Golf Course between 23rd and 26th Avenues. Assume 41.8 acre-feet.

3. City Park Ball Fields west of Colorado Boulevard and south of 23rd Avenue. Assume 18.2 acre-feet.

See the appendix for mapping of these three areas and assumed inadvertent detention volume calculations. These inadvertent detention volumes are considered by the MATT to be conservative, with actual 100-year inadvertent detention volumes being significantly larger than the assumed values.

The addition of these inadvertent detention volumes into the UDSWMM model results in significantly reduced flow rates at 40th Avenue. If all three areas are accounted for, a 28% reduction in 100-year peak flow rates is realized. See the table at the beginning of this section for specific results from each individual area. After coordination with the Denver Parks Department, the MATT recommended accounting for two of the three inadvertent detention areas in the I-70 hydrology. A legal agreement has been finalized with the Denver Parks Department assuring future actions will not adversely impact the natural and formal storage currently occurring at these two locations. The two locations where inadvertent detention has been accounted for in both the modeling and the agreement with the Parks Department includes the Duck Pond area of City Park and the City Park Golf Course. Both areas are depicted in the figures below:





4.6. FLO-2D Routing

As a "low end check" of the overall hydrologic results for the basin, runoff values from the 2014 SDMP FLO-2D model were included in the sensitivity analysis documentation. The routing of flood conveyances utilizing FLO-2D is not a methodology approved by UDFCD because it accounts for every square foot of inadvertent detention within the basin, and it is generally considered to lack enough conservatism when determining peak flow rates for design purposes. However, the FLO-2D results have been included in the sensitivity analysis tables and graphs as a simple reference point, allowing the MATT to further understand the various modeling results and help make final modeling recommendations.

4.7. Technical Peer Review of Analysis

UDFCD contracted with an independent 3rd party, CH2M Hill, to conduct a peer review of the sensitivity analysis and a general review of the CUHP/SWMM modeling for the Montclair Basin. The review was completed on May 9, 2014 and the results are provided in the Appendix. The review did not recommend any significant changes to the modeling approach or analysis.

5.0 Revised I-70 PCL Hydrology Results and Final MATT Recommendations

Recommendations

After reviewing the previous hydrologic studies performed for the Montclair drainage basin and further performing a sensitivity analysis of various modeling parameter modifications, the MATT has recommended the following modifications be made to the base 2014 SDMP CUHP/SWMM model for I-70 design purposes:

- Revise UDSWMM routing elements to more accurately represent flow occurring down multiple streets.

- Account for inadvertent detention at the following two locations: City Park Duck Pond (36.0 acre-feet), and City Park Golf Course (41.8 acre-feet). The Inadvertent Detention Memorandum of Understanding (MOU) between CCD Public Works and Denver Parks and Recreation has been finalized ensuring future maintenance of the flood storage volumes.

Results

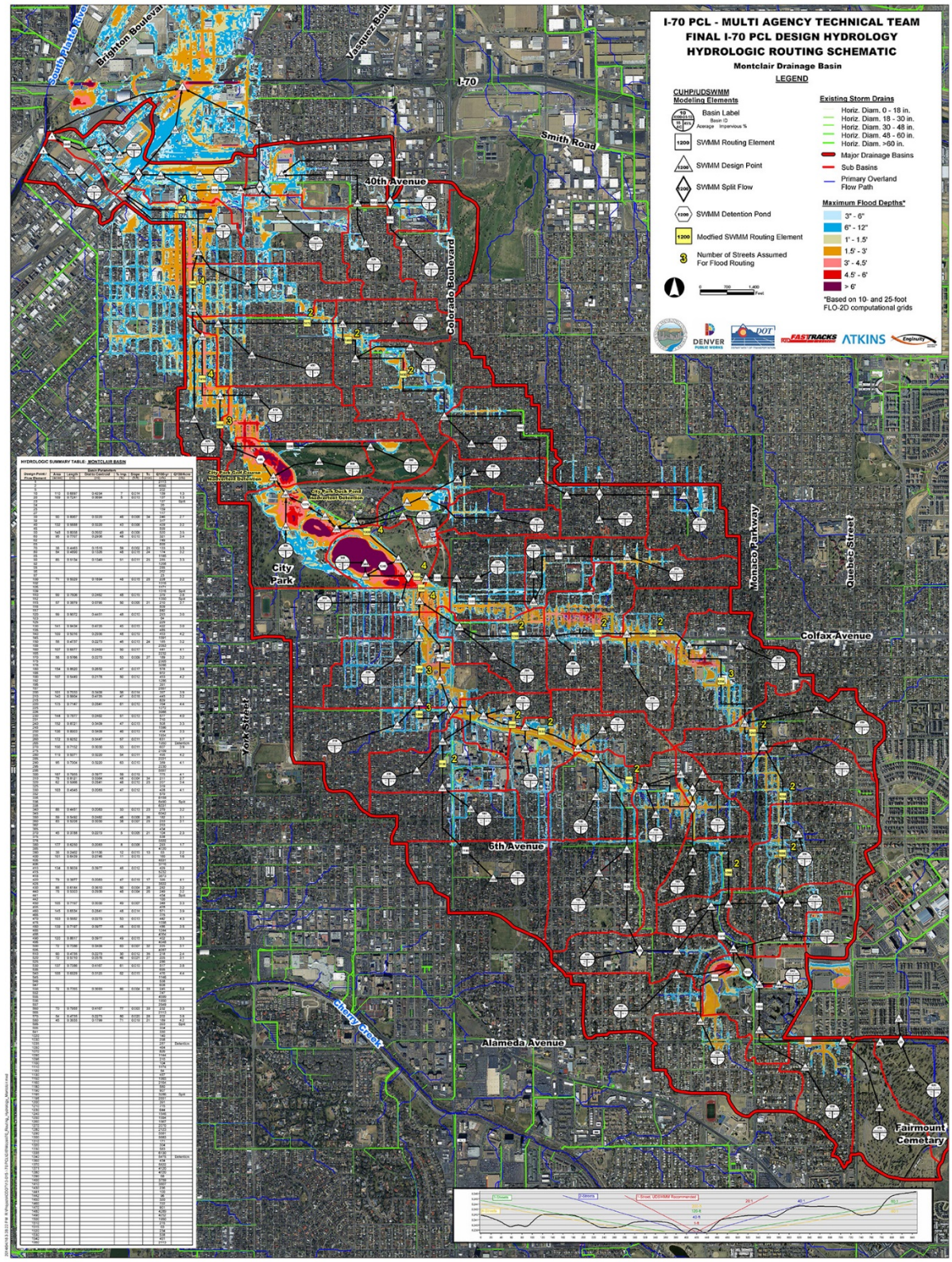
Incorporating the MATT recommendations into the CUHP/SWMM hydrologic modeling, a revised total basin 100-year peak flow rate of 4,655 cfs is calculated at 40th Avenue. From this value, the I-70 design team can account for existing and soon-to-be completed pipe outfalls serving the basin by subtracting their capacities from the total peak flow rate. Based on CCD's GIS data and recent construction plans, the following two main outfalls should be accounted for:

- Existing 120" BRICK @ 0.39% serving 40th Street and 40th Avenue with a calculated Manning's full flow capacity of 897 cfs.

- Currently under construction High Street Outfall (UDFCD, Denver, RTD) serving 40th Avenue and the East Corridor rail alignment with a design capacity of 906 cfs (based on construction plans dated January 2013). The latest construction plans or as-builts for this project should be referenced to verify this number.

Accounting for the two storm drain outfalls serving the Montclair basin, the 100-year design flow rate at 40th Avenue (surface flow) is 2,852 cfs (4,655 minus 897 minus 906). This peak flow rate can be further revised during the design process to account for the complex flood routing and split flows that occur between 40th Avenue and I-70.

This flood routing between 40th Avenue and I-70 has already been preliminarily completed for the RTD North Metro project and was incorporated into the 2014 SDMP Base modeling for the Montclair and Park Hill Basins. The revised MATT CUHP/SWMM Park Hill basin model includes the storm drain outfalls listed above and combines flows from both the Montclair and Park Hill basins in the vicinity of I-70. **Please refer to the accompanying *I-70 PCL MATT Park Hill Basin Hydrology* technical memorandum for a more detailed determination of peak flow rates anticipated at I-70.**



This image represents the Montclair basin's SWMM Routing diagram, a larger version is available in the appendix.

6.0 Appendix

All supporting maps, figures, tables, and hydrologic models used during the MATT analysis are provided in electronic format only. All supporting documentation can be found on the attached DVD.

The supporting documents are organized in the same general order to match the layout of this memorandum. Supporting documents include:

01. Figures/Maps/Tables:

- A. Background Montclair Mapping
    - i. Montclair/Park Hill Basin FLO-2D Flooding Depth Analysis
    - ii. 2011-07-07 Flooding Video at 36th Avenue and High Street
    - iii. 2008 RTD East Corridor CUHP-SWMM Routing Diagram
    - iv. 2014 SDMP Base Model CUHP-SWMM Routing Diagram
- B. Hydrology Sensitivity Analysis
    - i. Impervious Value Sensitivity Analysis
    - ii. Reduced Discretization Sensitivity Analysis
    - iii. Multiple Street SWMM Routing
    - iv. Inadvertent Detention
- C. Final Hydrologic Mapping for I-70 PCL
    - i. Final MATT I-70 PCL CUHP-SWMM Routing Diagram

02. Hydrologic Models CUHP-UDSWMM:

- A. Previous Models Modified by Enginuity for Comparative Purposes
    - i. 2008 RTD East Corridor (with and without Ferril Detention)
    - ii. 2014 Denver SDMP with Ferril Detention
    - iii. 2014 Denver SDMP without Ferril Detention
- B. Sensitivity Analysis
    - i. Base 2014 Denver SDMP
    - ii. Measured Imperviousness
    - iii. Reduced Discretization
    - iv. Multiple Street X-section Routing
    - v.a. Inadvertent Detention City Park Duck Pond

- v.b. Inadvertent Detention City Park Golf Course
- v.c. Inadvertent Detention City Park Ball Fields
- v.d. Inadvertent Detention Combined (all 3)

- C. Final Hydrology Revised for I-70 PCL
  - i. Combined Inadvertent Detention and Multiple Street Routing

03. Peer Review of Analysis

04. MATT Meeting Minutes

Memo

C.2. MATT Memo for Parkhill Basin

Memorandum

To: I-70 PCL Drainage Multi Agency Technical Team (MATT)
- Urban Drainage and Flood Control District (UDFCD)
- Colorado Department of Transportation (CDOT)
- City and County of Denver (CCD)
- Regional Transportation District (RTD)
- Atkins
- Stantec

From: Don Jacobs P.E. – Enginuity Engineering Solutions (Enginuity)

Date: August 1, 2014

Re: I-70 PCL **Park Hill** Drainage Basin Hydrologic Analysis

1.0 Contents of this Memorandum

This memorandum was prepared by Enginuity Engineering Solutions documenting the Multi Agency Technical Team's (MATT) investigation of the Park Hill drainage basin hydrology in Denver, Colorado. A list of individual MATT participating members is located in the appendix (see meeting minutes) and includes the Urban Drainage and Flood Control District (UDFCD), the Colorado Department of Transportation (CDOT), the City and County of Denver (CCD), and the Regional Transportation District (RTD). Organizational contents of this memorandum are listed below:

2.0 Background and Purpose

CDOT has identified the Partial Covered Lowered Alternative (PCL) as the preferred alternative for improvements to I-70 East through Denver. A portion of this alternative includes rebuilding I-70 below grade between Brighton Boulevard and Colorado Boulevard, where the existing viaduct currently stands. While lowering the highway at this location provides several enhancements to the community such as reconnecting the Elyria and Swansea neighborhoods, it also presents drainage challenges that must be addressed from a design standpoint.

The proposed lowered portion of the I-70 project crosses two major drainage basins in Denver – the Montclair and Park Hill basins. This memorandum specifically addresses the Park Hill basin. Flood potential

in the lower Park Hill drainage basin has been documented by several previous studies, including studies by the City and County of Denver, UDFCD, and the Regional Transportation District. These studies have defined flow rates and rough flooding limits around the I-70 area both upstream and downstream of the interstate. Currently, some of the identified flood potential in the Park Hill basin does not pose a significant risk to the highway due to its elevated design on a viaduct, except for an area just east of Colorado Boulevard, where I-70 is currently at-grade. However, proposed future lowering of alignment below grade will introduce the potential for flood waters from the Park Hill basin to enter the highway if not accounted for in the project's drainage design.

To address this potential drainage issue, the MATT was formed during the fall of 2013 to collectively investigate the Park Hill basin's hydrology and other inter-agency coordination issues. While the Park Hill basin hydrology has been documented in several previous studies (see below for more information), all of the previous analyses were performed from a regional planning standpoint, and there was a general presumption that the previously published flow rates could potentially be overly conservative from a design standpoint. Specific factors such as conservative impervious values, existing inadvertent detention that may exist within the basin, CUHP model discretization, and limited accounting for floodplain flow routing were to be investigated.

Overall goal of this analysis: to perform a technical review of the previous Park Hill basin hydrologic analysis and modify the modeling, if necessary, in order to provide C-DOT with a mutually agreed upon off-site 100-year design flow rate for the I-70 PCL project.

Previous analysis that were used as the initial basis of this project:

- 2005 CCD Storm Drainage Master Plan (SDMP)
- 2009 CCD Storm Drainage Master Plan
- 2010 CCD Sanitary and Storm Drainage Master Plan FasTracks Interface
- 2011 CCD Sand Creek and Upper Park Hill Basins Final Drainage Study
- 2012 UDFCD Park Hill (North of Smith Road) Drainage Outfall Systems Plan
- 2014 CCD Storm Drainage Master Plan (in progress, scheduled for completion in October 2014)
- 2008 RTD Draft East Corridor Drainage Master Plan
- 2011 RTD Eagle P3 Drainage Adverse Impact Analysis

This memorandum documents the hydrologic analysis performed by Enginuity in the Park Hill basin for the I-70 PCL project's conceptual design. The analysis was a collaborative effort between MATT members with bi-weekly technical meetings held from September 2013 thru February 2014. Hydrology related meeting minutes are included in the appendix.

3.0 General Approach – Base Model Hydrology

General Hydrologic Conditions

The Park Hill watershed encompasses a total area of approximately 5.75 square miles near its outfall at the South Platte River. Flow from the basin generally travels from south to north and enters the South Platte River approximately 2,500 feet downstream of Brighton Boulevard, east of York Street. The majority of the watershed is located within the City and County of Denver and is fully developed. Topography within the basin is generally mild with grades ranging from 0.5% to 2%.

During larger storm events, runoff is conveyed through the basin primarily by the streets as surface flow, with several storm drain pipes also conveying water to the north. Most of the basin lacks a formal drainageway, or even a low lying area, to convey water. Throughout the basin, there are numerous surface features such as railroad embankments, local roadways, major highways, and underpasses, that split surface runoff in at least two directions. These surface flow "splits" combined with several storm drainage pipes conveying water in various directions creates a relatively complex drainage basin with sometimes difficult to determine primary flowpaths.

Previous Studies and Flow Rates

With numerous previous studies encompassing different portions of the Park Hill drainage basin for a variety of purposes, the MATT began by investigating hydrologic results and flow rates published in the previous studies.

General background of the previous studies:

- 2005 Denver SDMP: the first major study of the basin (CUHP 2000 and UDSWMM 2000); utilized detailed CCD topography and GIS data; basin delineation based on pipe infrastructure; estimated % impervious values based on UDFCD land use table; delineated 25 individual sub-basins above I-70 spanning Denver basins 0060-02, 0060-01 and 4400-02.

- 2008 RTD East Corridor: more "basic" analysis delineating 18 individual sub-basins and only extending down to Smith Road; basin delineation based on topography; estimated % impervious values based on UDFCD land use table. Utilized CUHP 2000 & UDSWMM 2000.

- 2009 Denver SDMP: modified 2005 model to account for 38th & Holly detention; revised % impervious calculations to be based on measured impervious values for each land use utilizing the City's GIS pervious layer; other minor modeling parameter modifications. Utilized CUHP 2000 and UDSWMM 2000.

- 2011 CCD Sand Creek and Upper Park Hill Basins Final Drainage Study: refined the SDMP analysis and incorporated FLO-2D modeling in the upper basin to develop several pipe conveyance alternatives south of Smith Road. Updated modeling to CUHP 2005 and EPASWMM 5.

- 2012 UDFCD Park Hill (North of Smith Road) Drainage Outfall Systems Plan: studied the lower portion of the basin near the outfall to the South Plate River and developed design alternatives to eliminate flooding north of Brighton Boulevard. Additional FLO-2D modeling was developed for the lower basin north of Smith Road to determine primary flow paths and estimate flood routing parameters. Updated modeling to CUHP 2005 and EPASWMM 5.

- 2014 Denver SDMP: combined modeling and documented results from the previous studies listed above – 2009 SDMP, 2011 Sand Creek, and 2012 OSP. Also linked results from the neighboring Montclair Basin, where trans-basin flows occur between the two basins. Modeling included a mix of both CUHP 2000 and UDSWMM 2000 as well as CUHP 2005 and EPASWMM 5 depending on the location.

See the original technical documentation for each of these studies for additional information, maps, and results.

Determination of Base Hydrologic Model

The MATT reviewed results from previous modeling and decided to move forward with the 2014 Denver SDMP CUHP/SWMM analysis as the "Base Model" for the I-70 PCL analysis. This model was selected due to the fact that it is the latest model available and incorporates all previous analyses. A CUHP-UDSWMM routing schematic map representing this model is located in the appendix, which includes a summary of 100-year peak flow rates for each design point.

The base model was then modified for the I-70 project based on a series of sensitivity analyses performed by the MATT for the Montclair Basin. The sensitivity analysis accounted for potential modifications to modeling parameters that the group had identified as potentially more accurate, and also accounting for physical features observed within the basin that were not previously accounted for in the model. The results of this sensitivity analysis are discussed in the following section.

4.0 Hydrologic Modeling Sensitivity Analysis

In the Montclair basin, the MATT investigated several potential modifications to the base CUHP/UDSWMM modeling and performed a sensitivity analysis on each. After the sensitivity analysis was completed and modeling revisions were recommended, the MATT also recommended applying the same modifications to the Park Hill hydrologic modeling. Please refer to the accompanying *I-70 PCL MATT Montclair Basin Hydrology* technical memorandum for full documentation of the sensitivity analysis.

The location for comparing flow rates from a sensitivity analysis standpoint is at Smith Road and Dahlia Street. This location is represented as "Design Point JUNCT_630" in the modeling. Once water reaches Smith Road, it branches into several different directions and is conveyed by various underground pipes and multiple streets and railroad corridors. These diversions along and downstream (north) of Smith Road are accounted for in the Hydraulic modeling, and can be utilized by the I-70 designers to determine 100-year peak flow rates expected to reach I-70.

The following table summarizes comparative peak runoff rates and hydrographs for the modeling sensitivity analysis investigated by the MATT. In this basin, the MATT only made one modification to the base 2014 SDMP CUHP/SWMM models, which was to utilize the larger and more accurate multiple-street cross sections in the SWMM models. Again, see the Montclair basin memorandum for more information on this determination.

Park Hill Basin Hydrology – Sensitivity Analysis
100-Year Runoff at Smith Road and Dahlia Street

Model or Potential Modification*	Q100 (cfs)	Change from Base Model	Comment
2014 CCD Master Plan	**2733**	0%	**Base Model, CUHP-UDSWMM 2000, CUHP 2005, EPASWMM 5.0**
Multiple Street X-section Routing Elements	2600	-5%	Adjusted trapezoidal bottom width and side slopes
Inadvertent Detention in Park Hill Golf Course	NA		Not analyzed due to inability to reach agreement with Golf Course

* All models represent total peak runoff at Smith Road and Dahlia Street, Design Point JUNCT_630 for comparative purposes. All models account for existing detention at 38th & Holly.
Red = changes recommended by MATT

5.0 Revised I-70 PCL Hydrology Results and Final MATT Recommendations

Recommendations

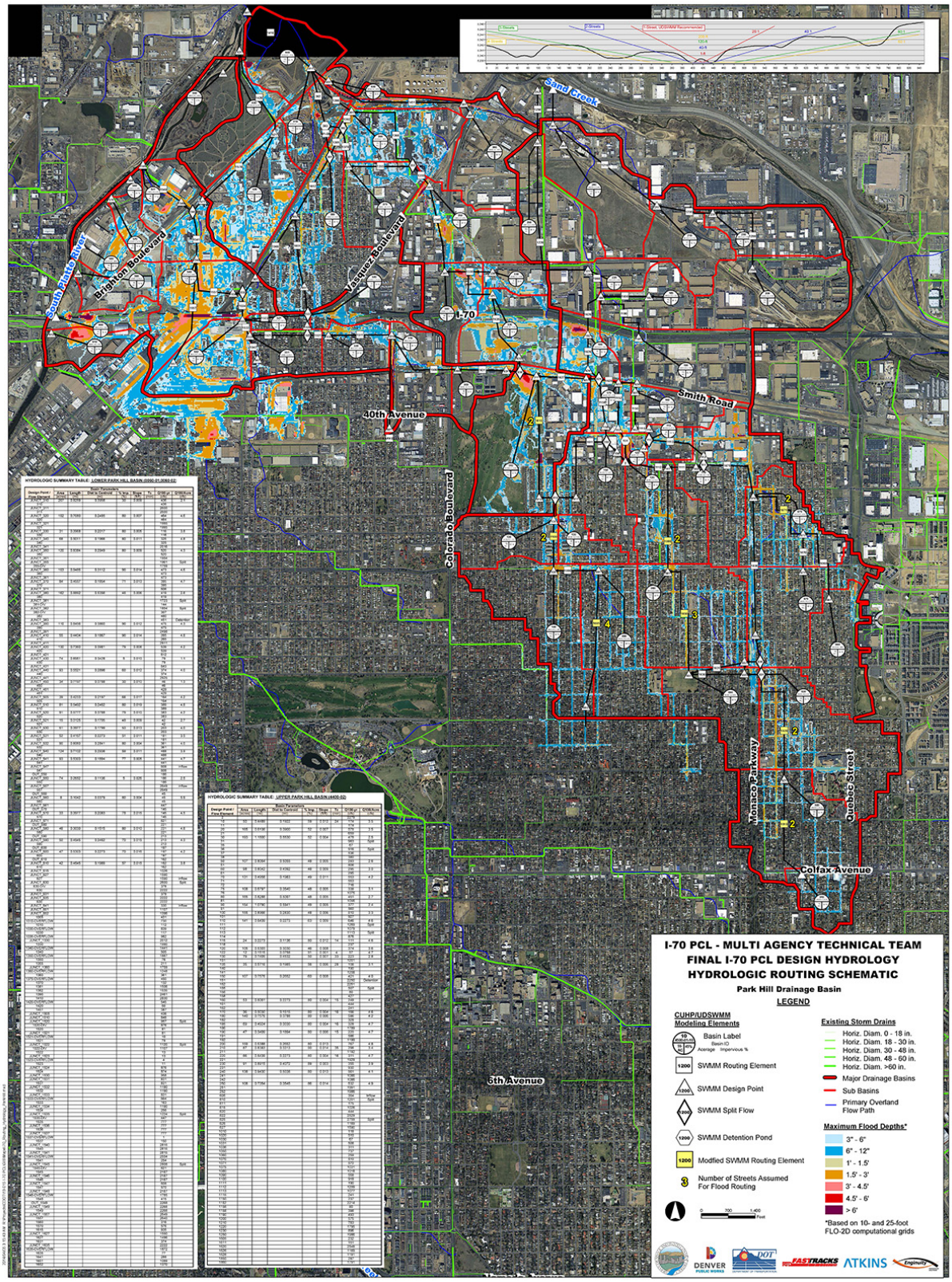
After reviewing the previous hydrologic studies performed for the Montclair and Park Hill drainage basins and further performing a sensitivity analysis of various modeling parameter modifications, the MATT has recommended the following modifications be made to the base 2014 SDMP CUHP/SWMM model for I-70 design purposes:

- Revise UDSWMM routing elements to more accurately represent flow occurring down multiple streets.

Results

Incorporating the MATT recommendations into the CUHP/SWMM hydrologic modeling for both the Monclair and Park Hill basins, revised 100-year peak flow rate were calculated at various points along I-70 and are summarized in the following table. This table includes runoff from both the Montclair and Park Hill basins. See the SWMM routing schematic in the Appendix for additional information and design point locations.

100-year Storm Peak Discharge Summary Based on MATT Hydrology* - Existing Conditions		
Design Point	Peak Discharge (cfs)	Location (Source)
557	2,649	I-70/Race (Montclair main stem)
1532	1,190	I-70/York (Montclair east + local basins)
1522	1,120	I-70/Steele (Montclair & Park Hill Market Lead + local basins)
321	1,995	I-70/Colorado (Park Hill main stem)
* Assumes High Street outfall is completed and accounts for inadvertent detention at the Duck Pond and City Park Golf Course		



This image represents the Park Hill basin's SWMM Routing diagram, a larger version is available in the appendix.

6.0 Appendix

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The supporting documents are organized in the same general order to match the layout of this memorandum. Supporting documents include:

01. Figures/Maps/Tables:

- A. Background Montclair Mapping
    - i. Montclair/Park Hill Basin FLO-2D Flooding Depth Analysis
    - ii. 2008 RTD East Corridor CUHP-SWMM Routing Diagram
    - iii. 2014 SDMP Base Model CUHP-SWMM Routing Diagram
- B. Hydrology Sensitivity Analysis
    - i. Multiple Street SWMM Routing
- C. Final Hydrologic Mapping for I-70 PCL
    - i. Final MATT I-70 PCL CUHP-SWMM Routing Diagram

02. Hydrologic Models CUHP-UDSWMM:

- A. Previous Models
    - i. 2014 Denver SDMP
- B. Final Hydrology Revised for I-70 PCL
    - i. Multiple Street Routing

03. Peer Review of Analysis

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C.3. Ballast Screen Drain Exhibit

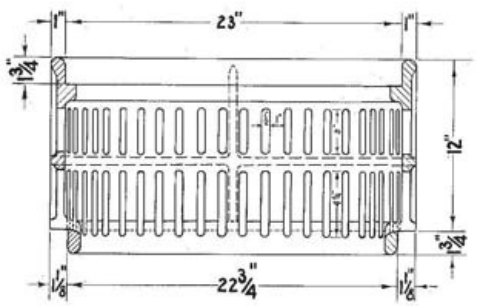
BALLAST SCREENS

Neenah Foundry offers a variety of cast iron ballast screens. Select from the list below to find the ballast screen that is a perfect fit for your needs.

R-7516 Round Ballast Screen -

R-7516

Round Ballast Screen



Used where positive drainage must be assured

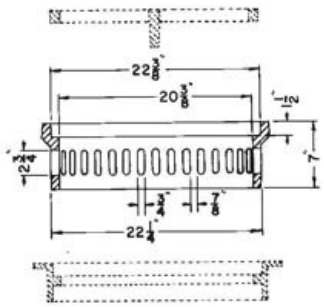
Used where positive drainage must be assured

- Designed to fit R-2504 standard catch basin frame with grate fitting top recess of ballast screen.
- Also compatible with R-1713 frames and lids.
- Can be double or triple stacked as needed.

R-7516-C Round Ballast Screen -

R-7516-C

Round Ballast Screen

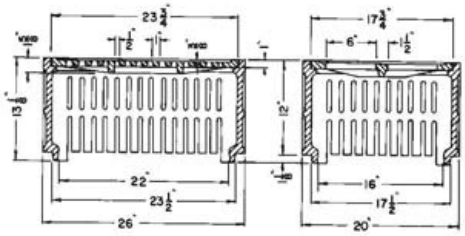


- Designed to fit in lid opening of R-5901-E slab type frame. Frame is designed to fit 24" corrugated metal pipe. When specified, top cover grate and frame can also be furnished.
- Can be double or triple stacked as needed.

R-7516-D Rectangular Ballast Screen -

R-7516-D

Rectangular Ballast Screen



- Can be double or triple stacked as needed.

Back to Top

Design Log

==========

InRoads Storm & Sanitary Design Log

Drainage File: S:\I70Data\13599\Hydraulics\Drainage_Draft_RFP\Draft_RFP2_supplemental\Inroads_Files\46th\WB Drainage_100yr_Brighton-Colorado.sdb

Design File: S:\I70Data\13599\Hydraulics\Drawings\Reference_Files\Procurement\13599HYDR_46th Drainage.dgn

Display Log: S:\I70Data\13599\Hydraulics\Drawings\Reference_Files\Procurement\design.log

Date: Thursday, June 09, 2016 11:50:19 AM

==========

Designing inlet IN17

   WARNING: Pipe Too large for valid connection to inlet.

  Results:

Gutter Flow:	10.6762 cfs	Flow From:	Area
Status:	Fixed		
Inlet Length:	2.9200 ft	Inlet Width:	2.9200 ft
Flow Downstream:	3.2015 cfs	Bypass To:	7.4747 cfs
Percent Cap:	29.9877 %	Capacity:	3.2015 cfs
Spread:	2.3430 ft		
Depth in Gutter:	1.1715 ft	Assigned Bypass:	IN15

Designing pipe P17

  Results:

Total Flow:	3.2015 cfs	Flow From:	Upstream
Status:	Fixed	Slope:	0.0050 ft/ft
Pipe Width:	24.0000 in	Pipe Height:	24.0000 in
Depth of Flow:	0.6060 ft	Flow Status:	Partial
Critical Depth:	0.6200 ft	Capacity:	15.9965 cfs
Velocity:	3.9745 ft/s		
Froude Number:	1.0597	Flow Regime:	SuperCritical

   WARNING: Pipe Too large for valid connection to inlet.

Designing inlet IN15

   WARNING: Pipe Too large for valid connection to inlet.

  Results:

Gutter Flow:	7.4747 cfs	Flow From:	Upstream
Status:	Fixed		
Inlet Length:	2.9200 ft	Inlet Width:	2.9200 ft
Flow Downstream:	10.6762 cfs		
Percent Cap:	100.0000 %	Capacity:	7.4755 cfs
Spread:	1.0038 ft		
Depth in Gutter:	0.5019 ft	Assigned Bypass:	N/A

Designing pipe P14

  Results:

Total Flow:	10.6762 cfs	Flow From:	Upstream
Status:	Fixed	Slope:	0.0050 ft/ft
Pipe Width:	24.0000 in	Pipe Height:	24.0000 in
Depth of Flow:	1.1940 ft	Flow Status:	Partial
Critical Depth:	1.1700 ft	Capacity:	15.9965 cfs
Velocity:	5.4517 ft/s		
Froude Number:	0.9625	Flow Regime:	Critical

   WARNING: Pipe Too large for valid connection to inlet.

HGL/EGL Computations:

  Table A:

Struct_ID	D (in)	Q (cfs)	L (ft)	V (ft/s)	d (ft)	dc (ft)	V^2/2g (ft)	Sf (ft/ft)	Dn_Soffit (ft)	EGLdn (ft)	HGLdn (ft)	Tot_Loss (ft)	EGLup (ft)	HGLup (ft)	Rim_Elev. (ft)
Outfall	-	-	-	-	-	-	-	-	-	-	-	-	-	5180.66	-
(Alternate HGL and EGL Used)													5181.51	5181.05	
P14	24	10.68	36.85	5.45	1.19	1.17	0.46	0.0050	5181.47	5181.51	5181.05	0.18	5181.70	5181.23	-
IN15	-	-	-	-	-	-	-	-	-	5181.70	5181.23	0.23	5181.92	5181.46	5185.00
P17	24	3.20	5.91	1.02	-	-	0.02	0.0002	5181.74	5181.92	5181.46	0.00	5181.92	5181.91	-
IN17	-	-	-	-	-	-	-	-	-	5181.92	5181.91	-	5181.92	5181.91	5185.00

Table B:

LOSSES								-|LOSS_COEFFICENTS							
Str_ID	Hf	Hb	Hstr	Hc	He	Hj	Total	Dstr	Ko	CD	Cd	Cq	Cp	Cb	K
Outfall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P14	0.18	-	-	-	-	-	0.18	-	-	-	-	-	-	-	-
IN15	-	-	0.23	-	-	-	0.23	1.60	1.118	1.000	0.437	1.000	1.000	1.000	0.488
P17	0.00	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-
IN17	-	-	-	-	-	-	-	2.16	-	-	-	-	-	-	-

Memo

Appendix D. **Profiles**

ATKINS

Memo

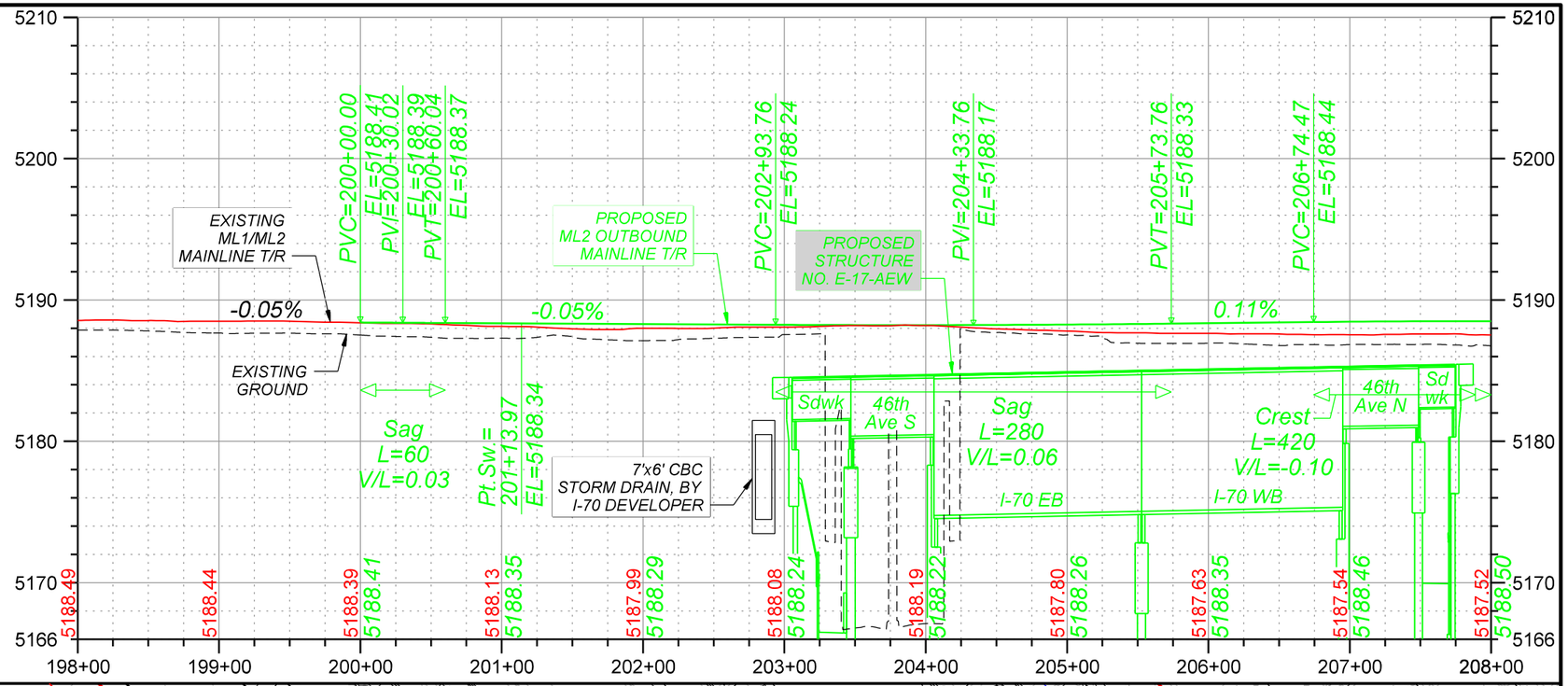
D.1. UPRR Track Profiles

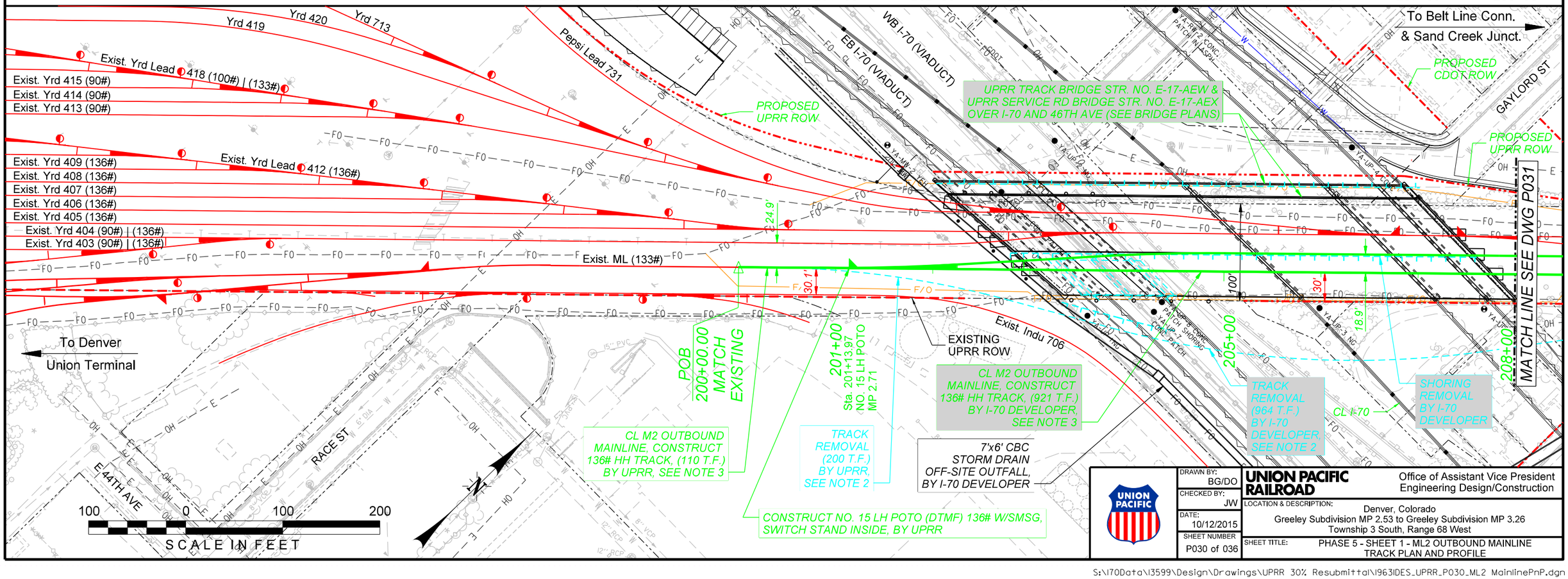
- 30% SUBMITTAL -

MAY 26, 2016

NOTES:

1. SEE TRACK GEOMETRY SHEETS FOR MAINLINE AND YARD TRACK GEOMETRY.
2. SHOOFLY AND TEMPORARY TRACK REMOVAL OUTSIDE THE 13' CLEAR POINT TO BE PERFORMED BY I-70 DEVELOPER UNLESS OTHERWISE STATED.
3. NEW TRACK CONSTRUCTION OUTSIDE THE 13' CLEAR POINT TO BE COMPLETED BY I-70 DEVELOPER UNLESS OTHERWISE STATED.





DRAWN BY:	BG/DO
CHECKED BY:	JW
DATE:	10/12/2015
SHEET NUMBER	P030 of 036

UNION PACIFIC RAILROAD — Office of Assistant Vice President Engineering Design/Construction

LOCATION & DESCRIPTION: Denver, Colorado
Greeley Subdivision MP 2.53 to Greeley Subdivision MP 3.26
Township 3 South, Range 68 West

SHEET TITLE: PHASE 5 - SHEET 1 - ML2 OUTBOUND MAINLINE TRACK PLAN AND PROFILE

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Default
6/2/2016

S:\I70Data\I3599\Design\Drawings\UPRR 30% Resubmittal\I963IDES_UPRR_P030_ML2 MainlinePnP.dgn

- 30% SUBMITTAL -

MAY 26, 2016

PVI=208+84.47
EL=5188.67

PVT=210+94.47
EL=5188.03

PVI=216+64.27
EL=5186.30

PROPOSED ML2 OUTBOUND MAINLINE T/R

CL YORK ST. CROSSING

EXISTING ML2 OUTBOUND MAINLINE T/R

-0.30%

-0.30%

Crest
L=420
V/L=-0.10

EXISTING GROUND

EXISTING 4" WATER

EXISTING 15" STORM

EXISTING 78" STORM

EXISTING 8" WATER

EXISTING 48" STORM

EXISTING 12" WATER

EXISTING 36" WATER

Pt.Sw.= 216+94.27
EL=5186.21

5210
5200
5190
5180
5170
5166

208+00 209+00 210+00 211+00 212+00 213+00 214+00 215+00 216+00 217+00 218+00 219+00

5187.52 5188.50
5187.47 5188.44
5187.36 5188.27
5187.36 5188.01
5187.33 5187.71
5187.34 5187.41
5187.30 5187.10
5187.22 5186.80
5186.67 5186.49
5186.20
5185.94

NOTES:

1. (ML02-X) SEE TRACK GEOMETRY SHEETS FOR MAINLINE AND YARD TRACK GEOMETRY.
2. SHOOFLY AND TEMPORARY TRACK REMOVAL OUTSIDE THE 13' CLEAR POINT TO BE PERFORMED BY I-70 DEVELOPER UNLESS OTHERWISE STATED.
3. NEW TRACK CONSTRUCTION OUTSIDE THE 13' CLEAR POINT TO BE COMPLETED BY I-70 DEVELOPER UNLESS OTHERWISE STATED.
4. REMOVE TEMPORARY CROSSING PANELS AND INSTALL CONCRETE CROSSING PANELS PER STD DETAIL 0302A. SEE CROSSING DETAIL SHEETS FOR ADDITIONAL INFORMATION.

72" RCP STORM DRAIN ON-SITE OUTFALL, BY I-70 DEVELOPER

PROPOSED CDOT ROW

PROPOSED UPRR ROW

EXISTING UPRR ROW

CL M2 OUTBOUND MAINLINE CONSTRUCT 136# TRACK (921 T.F.) BY I-70 DEVELOPER, SEE NOTE 3

CL M2 OUTBOUND MAINLINE, SHIFT TRACK, (380 T.F.) BY UPRR

TEMPORARY CROSSING REMOVAL BY UPRR

MATCH LINE SEE DWG P030

208+00

210+00

ML2-01

Mainline 2
Curve (ML2-01)
Dc = 3°30'00"
S/L = 33'
R = 1,637.28'
363 T.F.

210+94.47 PSC

211+27.47 PT

TRACK REMOVAL (964 T.F.) BY I-70 DEVELOPER

NEW SIGNAL BUNGALOW BY UPRR, SEE YORK ST CROSSING PLANS

TRACK REMOVAL (382 T.F.) BY UPRR

PCS 214+90.19

PT 215+00

215+23.19

Sta. 214+92.00 York St. Crossing Panels
Concrete Crossing Panels
DOT 804-422R
M.P. 2.98

INSTALL CONCRETE CROSSING PANELS (152' TOTAL LENGTH) (10' W) BY UPRR, SEE NOTE 4

EOT 216+64.27 MATCH EXISTING

PROPOSED CDOT TEMPORARY EASEMENT

Yrd Lead 112

Exist. ML2

ML1

Exist. Yrd 425 (133#)

Indu 701

Indu 702

Yrd 039

To Belt Line Conn. & Sand Creek Junct.

To Denver Union Terminal

CL I-70

GAYLORD ST

E 47TH AVE

CLAUDE CT

YORK ST

YORK LANE

ALICE PL

JOSEPHINE ST

E 47TH AVE

100 0 100 200
SCALE IN FEET

DRAWN BY:	BG/DO
CHECKED BY:	JW
DATE:	10/12/2015
SHEET NUMBER	P031 of 036

UNION PACIFIC RAILROAD

Office of Assistant Vice President
Engineering Design/Construction

LOCATION & DESCRIPTION:
Denver, Colorado
Greeley Subdivision MP 2.53 to Greeley Subdivision MP 3.26
Township 3 South, Range 68 West

SHEET TITLE: PHASE 5 - SHEET 2 - ML2 OUTBOUND MAINLINE TRACK PLAN AND PROFILE

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Default
6/2/2016

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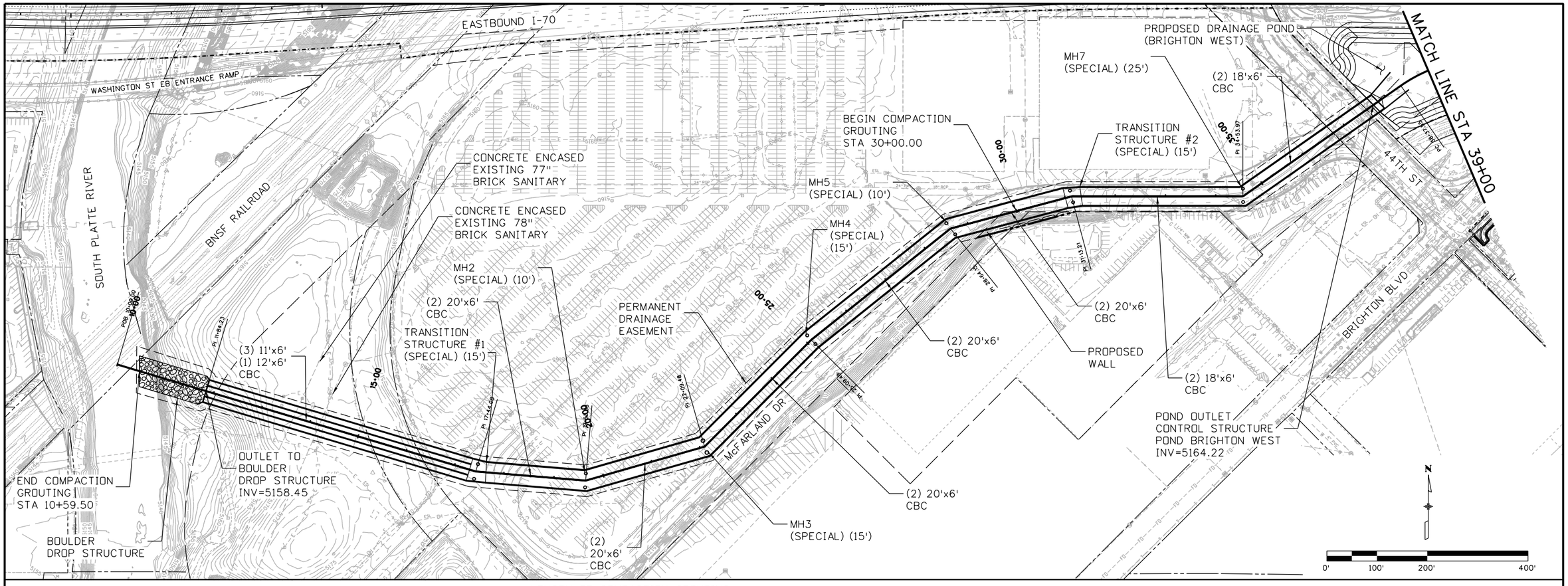
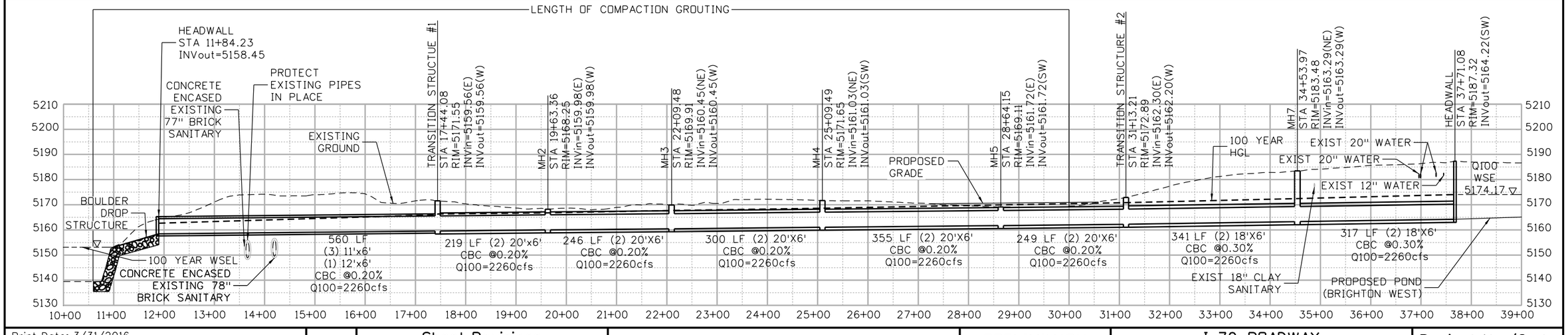
D.2. Offsite Drainage Profiles





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Horiz. Scale: 1:200 Vert. Scale: As Noted			
Unit Information Unit Leader Initials			
ATKINS 7604 Technology Way, Suite 400 Denver, CO 80237 Phone: (303) 221-7275 Fax: (303) 221-7276			

Colorado Department of Transportation
2000 South Holly Street
Denver, CO 80222
Phone: 303-757-9934 FAX: 303-757-9907
Region 1 KJS

PRELIMINARY
No Revisions:
Revised:
Void:

I-70 ROADWAY OFFSITE DRAINAGE OUTFALL PLAN AND PROFILE

Designer:
Detailer:
Sheet Subset: Hydr PnP
Structure Numbers
Subset Sheets: 56 of 58

Project No./Code
FBR 0704-234
19631
Sheet Number

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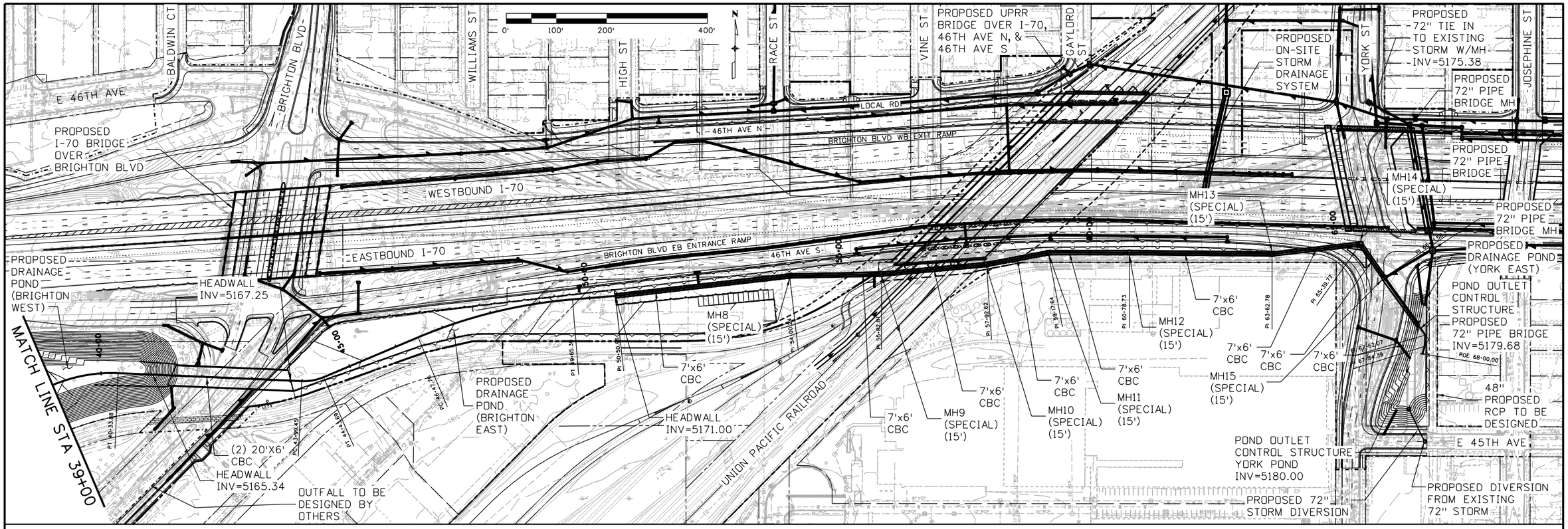

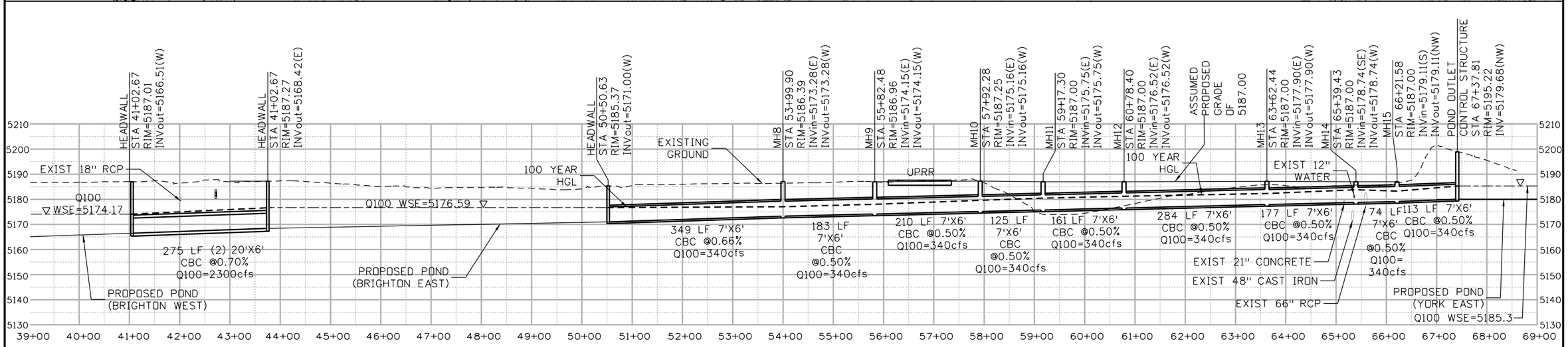

Print Date: 3/31/2016	Sheet Revisions	Colorado Department of Transportation	PRELIMINARY
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Horiz. Scale: 1:200 Vert. Scale: As Noted		Phone: 303-757-9934 FAX: 303-757-9907	Revised:
Unit Information Unit Leader Initials		Region 1 KJS	Void:
ATKINS 7604 Technology Way, Suite 400, Denver, CO 80237, Phone: (303) 221-7275 Fax: (303) 221-7276			

I-70 ROADWAY OFFSITE DRAINAGE OUTFALL PLAN AND PROFILE			Project No./Code
Designer:	Structure Numbers		FBR 0704-234
Detailer:			19631
Sheet Subset: Hydr PnP	Subset Sheets: 57 of 58		Sheet Number

jone6773 6:24:04 PM S:\1700data\13599\Hydraulics\Drawings\Procurement Plans\13599HYDR_Procurement_Plan 57_Off-site Outfall.dgn

Colorado Department of Transportation
2000 South Holly Street
Denver, CO 80222
Phone: 303-757-9923 FAX: 303-757-9053
Region 1 Right of Way SLK

Sheet Revisions		
Date	Description	Initials

Sheet Revisions		
Date	Description	Initials

Sheet Revisions		
Date	Description	Initials

LUND PARTNERSHIP
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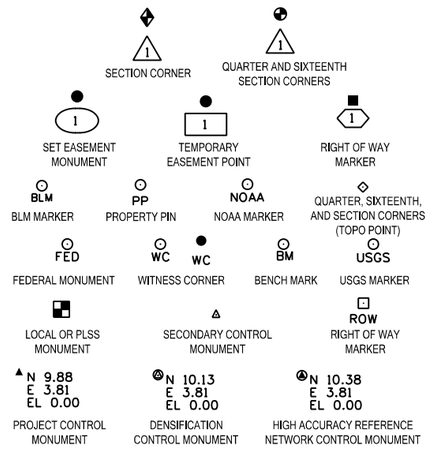
CIVIL ENGINEERING & SURVEYING

Project Control Diagram				
Title Sheet				
Project Number: FBR 0704-234				
Project Location: I-70 (EAST CORRIDOR)				
Project Code	Last Mod. Date	Subset	Sheet No.	
19631	10-16-2014	3.01 OF 3.03	3.01	



Note: For a complete listing of symbololgy used within this set of plans, please refer to the M-100-1 Standard Symbols of the Colorado Department of Transportation M&S Standards Publication dated July 2012. Existing features are shown as screened weight (gray scale). Proposed or new features are shown as full weight without screening.

Typical Control Monument Cap
Not to Scale

▲ CM-MP - Control Point Monuments set by CDOT. They are CDOT Type 2 monuments, a 3¼" dia. aluminum control monument cap (as shown) on a 3' x¾" dia. aluminum security rod on a 3' x¾" dia. smooth aluminum rod.

General Notes:

1. This Project Control Diagram is not a boundary survey of the adjoining property and is prepared for the Colorado Department of Transportation purposes only.

2. This control diagram is subject to change and may not be the most current set. It is the user's responsibility to verify with CDOT that this set is the most current. The information contained on the attached drawing is not valid unless this copy bears an original signature of the Professional Land Surveyor hereon named.

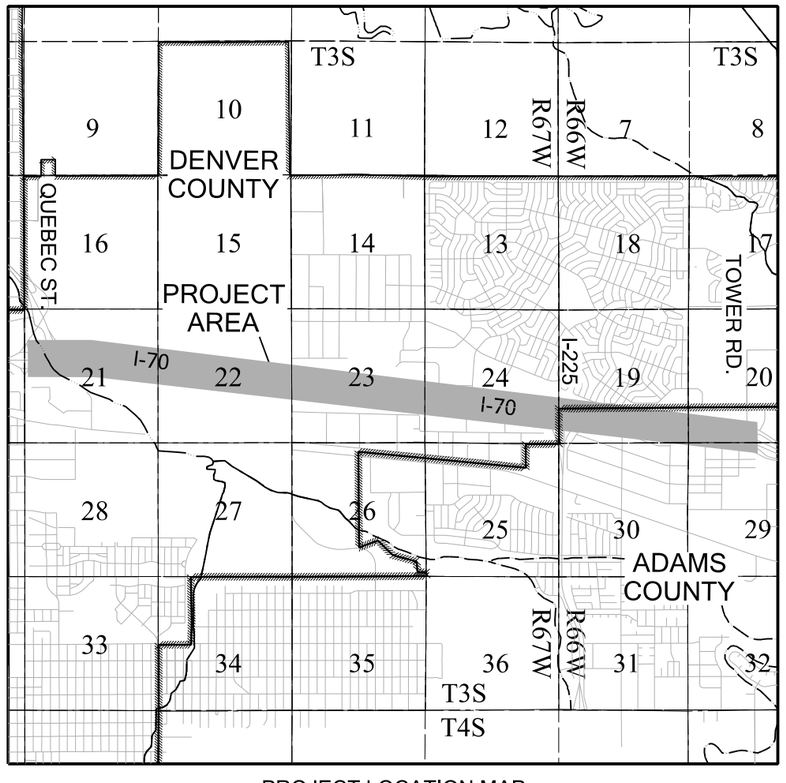
3. Refer to the M-629-1 Survey Monuments of the Standard Plans dated July, 2012 found in The Colorado Department of Transportation, M & S Standards for typical survey monument descriptions.

NOTICE: According to Colorado law you must commence any legal action based upon any defect in this survey within three years after you first discover such defect. In no event may any action based upon any defect in this survey be commenced more than ten years from the date of the certification shown hereon.

DEPARTMENT OF TRANSPORTATION STATE OF COLORADO

PROJECT CONTROL DIAGRAM
PROJECT NO. FBR 0704-234

Interstate Highway 70 - MP 278.50 to 283.90
Sections 21, 22, 23, 24, Township 3 South, Range 67 West, and
Sections 29 & 30, Township 3 South, Range 66 West,
of the 6th Principal Meridian
City and County of Denver and Adams County



PROJECT LOCATION MAP

SCALE:
0' 3000' 6000' 12000'
1" = 6000'
Lineal Units = U.S. Survey Feet

N

SHEET NO.	INDEX OF SHEETS	
3.01	(1)	Title Sheet
3.02	(1)	Coordinate Tables
3.03	(1)	Plan Sheets
	(3)	Total Sheets

BASIS OF BEARINGS: Bearings used in the calculations of coordinates are based on a grid bearing of N 86°24'06" W between NGS point "Pena" (PID# AE5246), being a stainless steel rod in monument box, to NGS point "B 394" (PID# KK1294), being a 3¼" brass cap in concrete abutment stamped "B 394 -1983".

The survey data was obtained from a Global Positioning System (GPS) survey based on the Colorado High Accuracy Reference Network (CHARN).
Said grid bearing is NAD 83 (1992) Universal Transverse Mercator (UTM) Zone 13 North.

BASIS OF ELEVATION: Project elevations are based on NGS point "Pena" (PID# AE5246) being a stainless steel rod in monument box, having a published NAVD 88 elevation of 5414.53 ft.
Elevations shown herein were GPS derived through completion of a static GPS network survey.

COORDINATE DATUM: Project coordinates are modified Universal Transverse Mercator (UTM) Zone 13 North NAD '83/(1992) coordinates. The combined elevation/scale factor used to modify the coordinates from UTM to project coordinates is 1.0006504025.
The resulting project coordinates are truncated by 14,000,000' in the Northing and 1,000,000' in the Easting after converting from UTM coordinates to project coordinates. Units are US Survey Feet.

Project Coordinates Northing US Survey Feet =
(UTM Coordinate Northing in sft * 1.0006504025 - 14,000,000).

Project Coordinates Easting US Survey Feet =
(UTM Coordinate Easting in sft * 1.0006504025 - 1,000,000).

The horizontal positional accuracy tolerance for this project control diagram meets the CDOT Class "A" primary tolerance as defined in the CDOT survey manual chapter 5, paragraph 5.5.2 and 5.5.3.

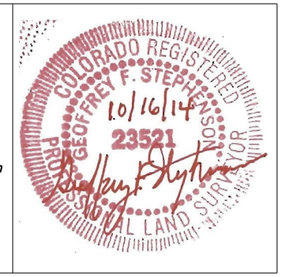
The vertical accuracy tolerance for this project control diagram meets the minimum vertical accuracy tolerance as defined in the CDOT survey manual chapter 5, paragraph 5.8.6.

The CDOT survey manual can be viewed at
HTTP://WWW.COLORADODOT.INFO/BUSINESS/MANUALS/SURVEY

SURVEYOR STATEMENT (PROJECT CONTROL DIAGRAM)

I, Geoffrey F. Stephenson, a professional land surveyor licensed in the State of Colorado, do hereby state to the Colorado Department of Transportation that this Project Control Diagram was prepared and the field survey it represents was performed under my responsible charge, and based upon my knowledge, information and belief is in accordance with applicable standards of practice defined by the Colorado Department of Transportation publications. This statement is not a guaranty or warranty, either expressed or implied.

PLS No. 23521



Colorado Department of Transportation
2000 South Holly Street
Denver, CO 80222
Phone: 303-757-9923 FAX: 303-757-9053
Region 1 Right of Way SLK

Sheet Revisions		
Date	Description	Initials

Sheet Revisions		
Date	Description	Initials

Sheet Revisions		
Date	Description	Initials

LUND PARTNERSHIP
12265 W. Bayaud Avenue, Suite 130
Lakewood, Colorado 80228
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CIVIL ENGINEERING & SURVEYING

Project Control Diagram
Monument Coordinate Tables
Project Number: FBR 0704-234
Project Location: I-70 (EAST CORRIDOR)

Project Code	Last Mod. Date	Subset	Sheet No.
19631	10-16-2014	3.02 of 3.02	3.02

NATIONAL GEODETIC SURVEY CONTROL POINTS - HELD FIXED (U.S. SURVEY FEET)

	GEODETIC COORDINATES - NAD 83 (1992)		ELLIPSOID		NAD 83 (1992) UTM ZONE 13 NORTH		PROJECT COORDINATES		NAVD (88)	
POINT NO.	LATITUDE	LONGITUDE	HEIGHT (sft)	POINT NO.	NORTHING (sft)	EASTING (sft)	NORTHING (sft)	EASTING (sft)	ELEVATION	DESCRIPTION
1.032179	39° 45' 43.73379" N	104° 46' 45.95074" W	5354.1	1.032179	14440200.14	1702401.11	449592.08	703508.35	5412.48	CDOT Type 2 Monument (MP 1.032179)
A 452	39° 46' 34.52572" N	104° 52' 33.44121" W	5205.5	A 452	14445285.37	1675268.46	454680.62	676358.06	5263.07	NGS Stainless Steel Rod
B 394	39° 46' 47.04085" N	104° 56' 26.22144" W	5205.0	B 394	14446532.63	1657100.23	455928.69	658178.01	5261.82	3 1/2" Brass Cap stamped "B 394 1983"
J 392	39° 45' 14.29570" N	104° 53' 00.96536" W	5255.7	J 392	14437167.54	1673130.87	446557.51	674219.08	5313.08	NGS Stainless Steel Rod
P 402	39° 49' 03.80069" N	104° 50' 48.07161" W	5202.5	P 402	14460396.77	1683466.20	469801.85	684561.13	5260.53	NGS Stainless Steel Rod
PENA	39° 46' 20.23261" N	104° 47' 26.65207" W	5356.2	PENA	14443884.24	1699215.28	453278.57	700320.46	5414.53	NGS Stainless Steel Rod
PRAIRIE 2	39° 47' 07.71211" N	104° 53' 57.95125" W	5195.4	PRAIRIE 2	14448633.78	1668669.08	458031.21	669754.39	5252.74	3 1/2" Brass Cap stamped "PRAIRIE 2 2006"
T 451	39° 45' 41.12654" N	104° 47' 29.57430" W	5346.6	T 451	14439928.28	1698996.41	449320.04	700101.44	5404.88	NGS Stainless Steel Rod
U 451	39° 46' 02.45124" N	104° 48' 01.50098" W	5336.5	U 451	14442079.51	1696499.34	451472.67	697602.75	5394.75	NGS Stainless Steel Rod
V 451	39° 46' 10.41689" N	104° 48' 45.19598" W	5303.3	V 451	14442877.84	1693087.02	452271.52	694188.21	5361.43	NGS Stainless Steel Rod
W 451	39° 46' 12.81341" N	104° 49' 33.72846" W	5289.0	W 451	14443112.59	1689298.45	452506.43	690397.18	5347.02	NGS Stainless Steel Rod

SECONDARY PROJECT CONTROL POINTS - ADJUSTED SURVEY DATA (U.S. SURVEY FEET)

	GEODETIC COORDINATES - NAD 83 (1992)		ELLIPSOID		NAD 83 (1992) UTM ZONE 13 NORTH		PROJECT COORDINATES		NAVD (88)	
POINT NO.	LATITUDE	LONGITUDE	HEIGHT (sft)	POINT NO.	NORTHING (sft)	EASTING (sft)	NORTHING (sft)	EASTING (sft)	ELEVATION	DESCRIPTION
1301	39° 46' 36.34178" N	104° 54' 10.66076" W	5206.8	1301	14445459.70	1667680.73	454855.06	668765.40	5264.06	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1301"
1302	39° 46' 52.44083" N	104° 54' 00.07996" W	5175.9	1302	14447088.96	1668504.69	456485.39	669589.89	5233.19	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1302"
1304	39° 46' 48.28869" N	104° 53' 00.04777" W	5194.2	1304	14446674.66	1673190.13	456070.81	674278.37	5251.71	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1304"
1305	39° 46' 32.36356" N	104° 52' 59.25273" W	5214.7	1305	14445063.97	1673254.27	454459.07	674342.56	5272.16	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1305"
1308	39° 46' 25.16998" N	104° 51' 57.91002" W	5235.3	1308	14444343.07	1678042.91	453737.71	679134.32	5292.95	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1308"
1310	39° 46' 33.63580" N	104° 50' 47.77231" W	5268.5	1310	14445208.14	1683515.57	454603.34	684610.53	5326.38	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1310"
1313	39° 46' 15.43945" N	104° 49' 46.72737" W	5292.4	1313	14443376.26	1688283.36	452770.26	689381.42	5350.36	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1313"
1315	39° 45' 59.24148" N	104° 49' 43.01321" W	5281.4	1315	14441738.45	1688576.39	451131.39	689674.64	5339.38	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1315"
1317	39° 46' 23.20913" N	104° 49' 27.78396" W	5295.2	1317	14444164.99	1689760.37	453559.51	690859.40	5353.24	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1317"
1318	39° 46' 14.03826" N	104° 48' 58.53873" W	5296.3	1318	14443241.97	1692044.83	452635.89	693145.34	5354.43	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1318"
1320	39° 46' 21.90904" N	104° 48' 36.24754" W	5322.4	1320	14444041.70	1693783.01	453436.14	694884.65	5380.57	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1320"
1322	39° 45' 52.10277" N	104° 47' 32.59993" W	5338.7	1322	14441037.93	1698757.65	450430.42	699862.53	5396.94	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1322"
1323	39° 46' 09.68511" N	104° 47' 37.30434" W	5348.7	1323	14442815.47	1698386.33	452209.11	699490.97	5406.96	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1323"
1325	39° 45' 48.80606" N	104° 46' 58.65836" W	5346.2	1325	14440710.76	1701407.89	450103.03	702514.49	5404.62	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1325"
1327	39° 45' 25.20505" N	104° 46' 18.89897" W	5374.3	1327	14438331.32	1704517.57	447722.05	705626.20	5432.73	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1327"
1328	39° 46' 01.68312" N	104° 47' 16.96413" W	5340.1	1328	14442009.80	1699975.86	451402.92	701081.53	5398.44	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1328"
1330	39° 46' 21.97229" N	104° 51' 15.45992" W	5257.6	1330	14444024.81	1681356.59	453419.24	682450.15	5315.39	Set 2 1/2" Aluminum Cap on #5 rebar stamped "L.P.I. 1330"

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Land Survey Control Diagram
Title Sheet

Project Number: FBR 0704-234
Project Location: I-70 (East Corridor)
South Platte River to Tower Rd.

Project Code:	Last Mod. Date	Subset	Sheet No.
19631	11-24-15	4.01 to 4.03	4.01

DEPARTMENT OF TRANSPORTATION
STATE OF COLORADO

SUPPLEMENTAL LAND SURVEY CONTROL DIAGRAM

Interstate 70 MP 274.5 to 285.8
Sections 19, 20, 28, & 29, Township 3 South, Range 66 West
Sections 19, 20, 21, 22, 23, & 24, Township 3 South, Range 67 West
& Sections 23 & 24, Township 3 South, Range 68 West
of the 6th Principal Meridian
City & County of Denver and Adams County

GENERAL NOTES:

1. This Supplemental Land Survey Control Diagram (SLSCD) was produced by utilizing existing control as established and listed in the Land Survey Control Diagram (LSCD) produced for CDOT Project No. NH 0361-070 and filed in the records of the City & County of Denver under Reception No. L013566. The information contained in the LSCD produced for CDOT Project No. NH 0361-070 has been approved by the CDOT Region Survey Coordinator for re-use on Project Number: FBR 0704-234, Project Code: 19631.

2. This SLSCD is not a Land Survey Plat, Boundary Survey or Right of Way Plat and does not address matters of title.

3. This SLSCD is subject to change and may not be the most current diagram. It is the user's responsibility to verify with CDOT that this diagram is the most current. The information contained on this SLSCD is not valid unless this copy bears an original signature of the Professional Land Surveyor hereon named.

4. Primary Horizontal Control Tolerance meets CDOT Class A (+/- 0.07' with 95% certainty).

5. Secondary Horizontal Control Tolerance meets CDOT Class B (+/-0.13' with 95% certainty).

6. BASIS OF BEARINGS: All bearings are grid bearings of the UTM System, Zone 13 North, NAD 1983 (1992) determined by a fast static GPS survey. The line between point MCDONNELL and point W410, monumented as shown in the Land Survey Control Diagram at CDOT Project No. NH 0361-070, bears N14°20'15.6"W.

7. BASIS OF ELEVATION: Elevations are NAVD '88 Datum established by digital differential levels by CDOT crews as part of a First Order Class II leveling project. Elevations identified with an asterisk (*) are National Geodic Survey (NGS) published values. Elevations followed by (B) were derived from the differential level loops, all other elevations were GPS derived (Geiod '99). On June 25, 2009, the NGS "Blue Booked" Level Project L26455 as a Second Order Class I Vertical Control.

8. Elevations on control points established by digital differential levels were measured with an accuracy exceeding 0.018' times the square root of the distance leveled in miles

9. To convert Project Specific Coordinates to UTM GRID:

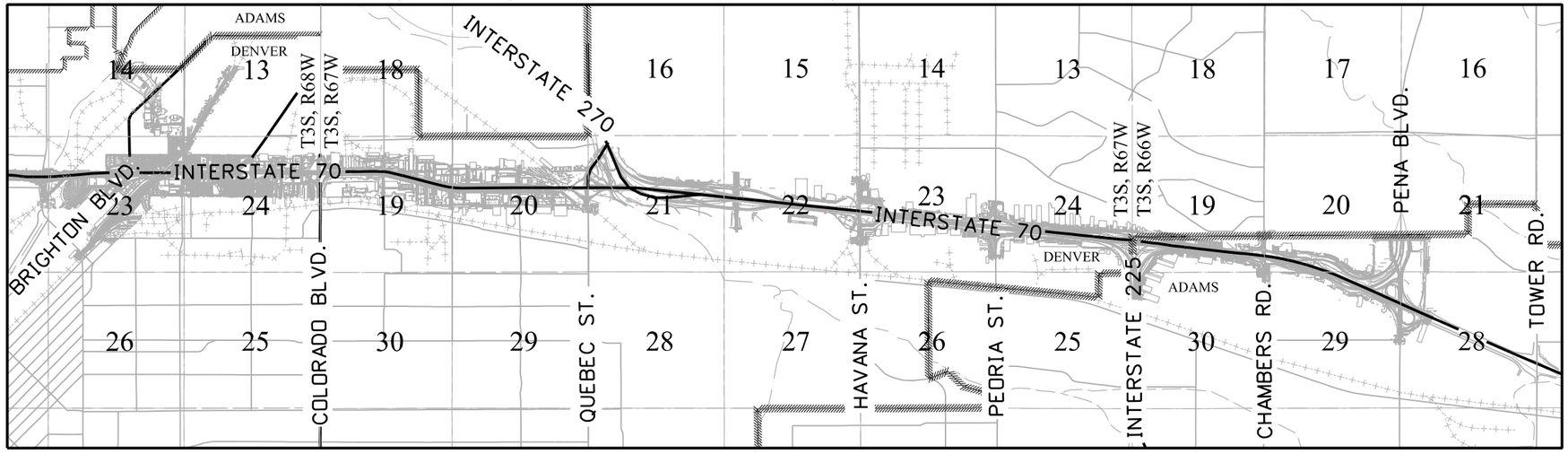
Project Northing - (442,527.62+14,000,000)x(0.999350021) = 14,433,140.28 - UTM Grid
Project Easting - (641,175.35+ 1,000,000)x(0.999350021) = 1,640,108.62 - UTM Grid

10. To convert UTM GRID to Project Specific Coordinates:

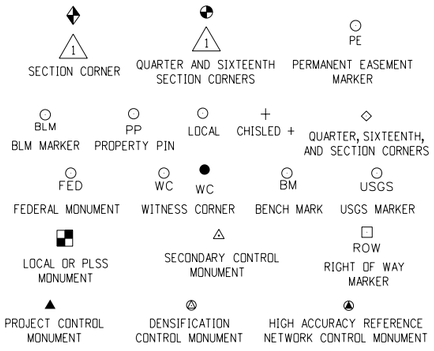
UTM GRID (survey feet) N (14,433,140.28x1.000650402)-(14,000,000) = 442,527.620 - Project Northing
UTM GRID (survey feet) E (1,640,108.62x1.000650402)-(1,000,000) = 641,175.350 - Project Easting

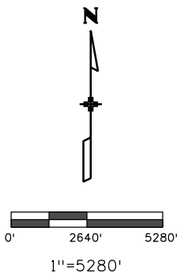
SHEET NO. / INDEX OF SHEETS

SHEET NO.	INDEX OF SHEETS
4.01-4.03	(3) Title Sheet / Key Sheets
4.04-4.46	(43) Plan Sheets
4.47-4.60	(14) Monument Coordinate Tables
	(60) Total Sheets



PROJECT LOCATION MAP





Note: For a complete listing of symbology used within this set of plans, please refer to the M-100-1 Standard Symbols of the Colorado Department of Transportation M&S Standards Publication dated July 2012.

NOTICE: According to Colorado law you must commence any legal action based upon any defect in this survey within three years after you first discover such defect. In no event may any action based upon any defect in this survey be commenced more than ten years from the date of the certification shown hereon.

SURVEYOR STATEMENT (LAND SURVEY CONTROL DIAGRAM)

I, Lee Pennell, a professional land surveyor licensed in the State of Colorado, do hereby state to the Colorado Department of Transportation this Supplemental Land Survey Control Diagram was prepared and the field survey it represents was performed under my responsible charge and, based upon my knowledge, information and belief is in accordance with applicable standards of practice defined by Colorado Department of Transportation publications. This statement is not a guaranty or warranty, either expressed or implied.

PLS No. 38027

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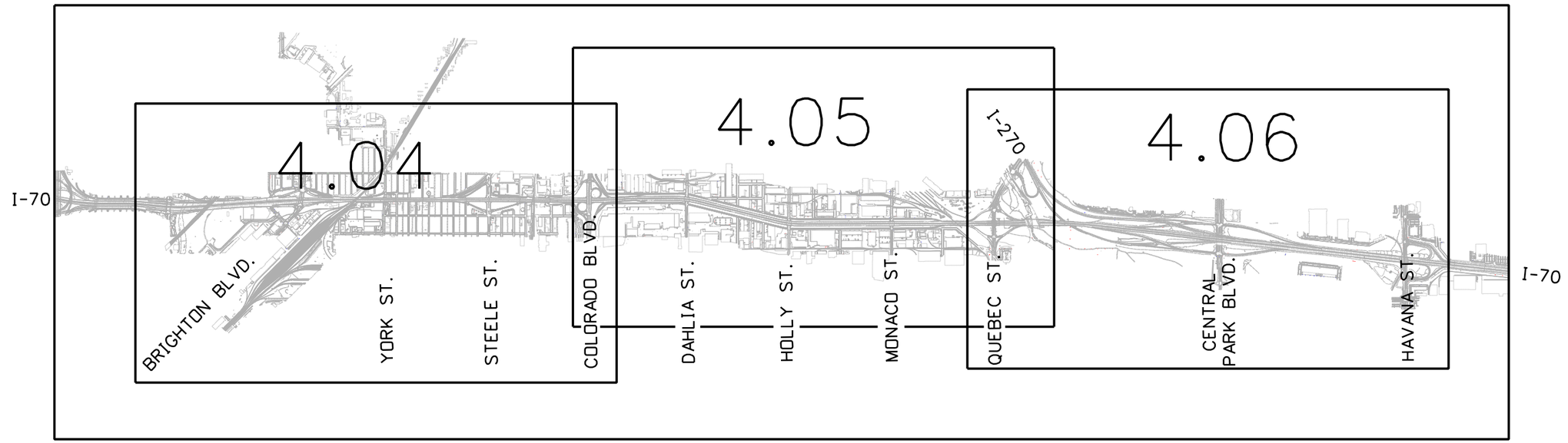
0' 1500' 3000'

Land Survey Control Diagram
Key Sheet

Project Number: FBR 0704-234
Project Location: I-70 (East Corridor)
South Platte River to Tower Rd.

Project Code:	Last Mod. Date	Subset	Sheet No.
19631	11-24-15	4.01 to 4.03	4.02

1"=800' SHEETS (4.04-4.06)



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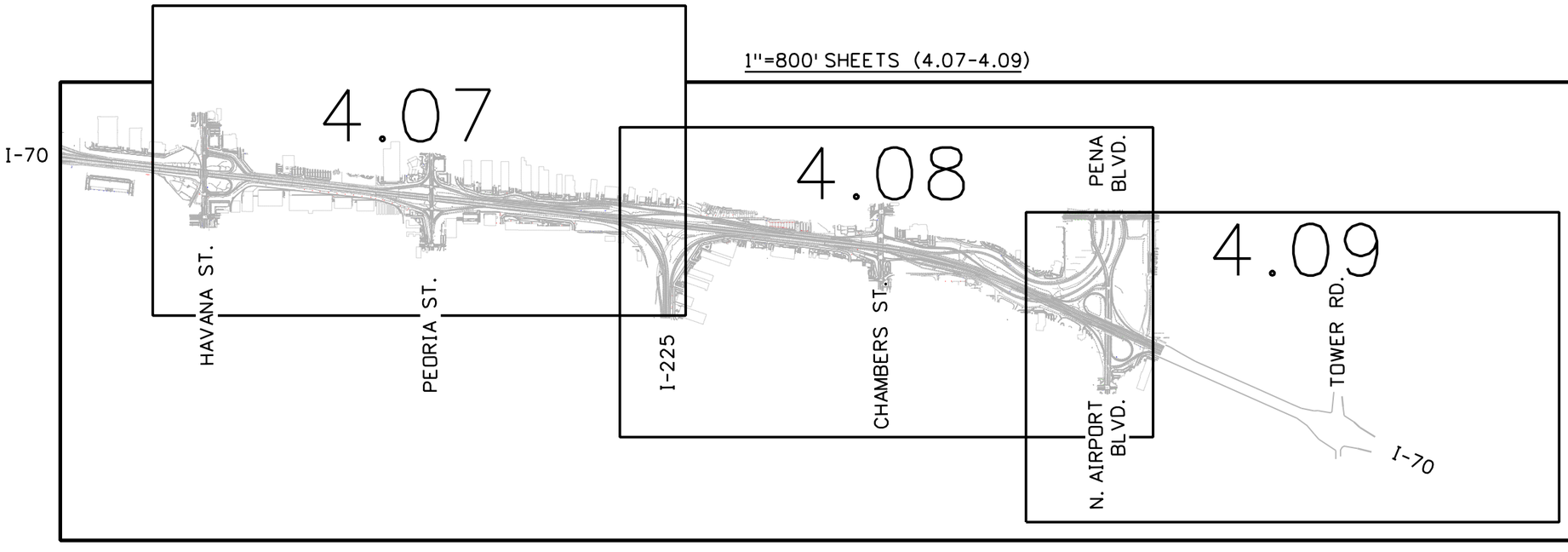

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0' 400' 800'

Land Survey Control Diagram
Plan Sheet

Project Number: FBR 0704-234
Project Location: I-70 (East Corridor)
South Platte River to Tower Rd.

Project Code:	Last Mod. Date	Subset	Sheet No.
19631	11-24-15	4.04 to 4.46	4.04

ARGO

N89° 57'31"E SECTION LINE 2636.82' | N89° 51'14"E 1327.11' | N89° 50'41"E 1327.16' | S89° 51'45"E 48TH AVE. 1327.13' | S89° 52'17"E 1327.21' | S89° 44'25"E SECTION LINE 2649.58'

1146 | 630 | 793 | 104 | 105 | 107 | 870

WASHINGTON ST. | N00° 02'23"E 1317.72' | SOUTH PLATTE RIVER | BRIGHTON BLVD. | SECTION LINE | VASQUEZ BLVD. | N00° 08'22"E 1323.84' | N00° 06'38"E 2642.21'

577 | 581 | 591 | 595 | 517 | 519 | 527 | 520 | B394

1145 | F452 | E595 | E452

INTERSTATE-70 | 47TH AVE. | 45TH AVE. | 44TH AVE. | 43RD AVE. | 39TH AVE. | 38TH AVE. | 37TH AVE.

NW 1/4 SEC. 23 T3S, R68W, 6TH P.M. | NE 1/4 SEC. 23 T3S, R68W, 6TH P.M. | NW 1/4 SEC. 24 T3S, R68W, 6TH P.M. | NE 1/4 SEC. 24 T3S, R68W, 6TH P.M.

N00° 02'18"E 1318.82' | UPRR | BRIGHTON BLVD. | 38TH ST. | TOWNSHIP LINE | 767 | WC

791 | 687 | WC 790 | 789 | 810 | 796 | 872

SECTION LINE N00° 04'05"E 2634.98' | SW 1/4 SEC. 23 T3S, R68W, 6TH P.M. | SE 1/4 SEC. 23 T3S, R68W, 6TH P.M. | N00° 04'58"E 2644.21' YORK ST. | SW 1/4 SEC. 24 T3S, R68W, 6TH P.M. | STEELE ST. | COLORADO BLVD.

S89° 50'05"E 1321.71' | SECTION LINE | S89° 51'38"E 2652.13'

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Land Survey Control Diagram
Monument Coordinate Tables

Project Number: FBR 0704-234
Project Location: I-70 (East Corridor)
South Platte River to Tower Rd.

Project Code:	Last Mod. Date	Subset	Sheet No.
19631	11-24-15	4.47 to 4.60	4.47

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PROJECT CONTROL *(NH 0361-070) (Δ1:*=NGS published elevation, B=benched elevation, blank=GPS derived elevation(Geoid 1999))

Point No.	Latitude	Longitude	Ellipsoid Height	Convergence Angle	Northing (UTM-13N)	Easting (UTM-13N)	Point No.	Northing(ft) (Project)	Easting(ft) (Project)	Elevation NAVD '88	Δ1	Adjusted Elevation '88	Description
ARGO	39°47'04.34115"N	104°58'53.46470"W	5090.18	0°00'42.6"	14448277.49	1645608.81	ARGO	457674.68	646679.12	5146.34		5146.37	(PID AE5245) NGS Deep Rod in Logo Box "ARGO 1995"
B394	39°46'47.04085"N	104°56'26.22144"W	5205.13	0°02'16.8"	14446532.63	1657100.23	B394	455928.68	658178.01	5261.82	*	5261.82	(PID KK1294) NGS Standard Disc in Concrete "B 394 1983"
E 452	39°46'43.6"N	104°57'18.6"W					E 452	455578.86	654086.13		B	5204.61	(PID DJ8150) Stainless Steel Rod in Range Box
F 452	39°46'46.0"N	104°58'01.9W					F 452	455815.08	650704.76		B	5187.31	(PID DJ8148) Stainless Steel Rod in Range Box
C 452	39°46'36.9"N	104°54'46.0"W					C 452	454905.86	666004.82		B	5276.12	(PID DJ8152) Stainless Steel Rod in Range Box
R452	39°45'50.5"N	104°47'06.2"W					R452	450274.08	701922.84		B	5405.01	(PID DJ8163) NGS Standard Disc in box culvert headwall "R 452 2002"
T451	39°45'41.1"N	104°47'29.6"W					T451	449320.01	700101.46		B	5404.88	(PID DJ8160) Stainless Steel Rod in Logo Box "T 451 2002"
V451	39°46'10.4"N	104°48'45.3"W					V451	452271.52	694188.23		B	5361.43	(PID DJ8158) Stainless Steel Rod in Logo Box "V 451 2002"
W451	39°46'12.8"N	104°49'33.7"W					W451	452506.39	690397.13		B	5347.02	(PID DJ8227) Stainless Steel Rod in Logo Box "W 451 2002"
Y 451	39°46'17.5"N	104°50'50.2"W					Y 451	452969.37	684420.55		B	5325.32	(PID DJ8156) Stainless Steel Rod in Logo Box "Y 451 2002"
Z 451	39°46'22.8"N	104°51'40.1"W					Z 451	453499.49	680522.66		B	5303.45	(PID DJ8155) Stainless Steel Rod in Logo Box "Z 451 2002"

* For complete listing of Control Points and network parameters refer to the Land Survey Control Diagram produced under CDOT Project No. NH 0361-070 and filed in the City & County of Denver, CO at Reception No. L013566

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Secondary Control Monumentation (Double-Based RTK Horizontal & Vertical positions)

Point No.	Northing(ft)	Easting(ft)	Elevation(ft)	Description
517	456117.13	652886.27	5185.59	CDOT Type 5s
519	456156.17	655529.12	5206.45	CDOT Type 5s
577	456755.52	651134.22	5182.77	3.25" Aluminum Cap CDOT 1994 1.00470018 LP1
581	456756.86	651467.83	5182.10	3.25" Aluminum Cap CDOT 1994 1.00470019 LP1
591	456697.40	651725.75	5182.47	3.25" Aluminum Cap CDOT 1994 1.00470020 LP1
595	456197.13	651726.64	5184.48	3.25" Aluminum Cap CDOT 1994 1.00460020 LP1
934	456052.29	661359.28	5249.83	CDOT Type 5s
1166	454400.73	674417.89	5272.52	CDOT Type 5s
1168	457466.90	669462.40	5253.03	CDOT Type 5s

NOTE: For information on Control Points 1301 to 1330 see Project Control Diagram, Sheets 3.01-3.03, by Lund Partnership.

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Land Survey Control Diagram
Monument Coordinate Tables

Project Number: FBR 0704-234
Project Location: I-70 (East Corridor)
South Platte River to Tower Rd.

Project Code:	Last Mod. Date	Subset	Sheet No.
19631	11-24-15	4.47 to 4.60	4.48

XXX XXX XXX WC

FOUND ALIQUOT MONUMENT COORDINATE TABLE-SOUTH PLATTE RIVER TO HAVANA STREET

Point No.	Northing(ft)	Easting(ft)	Description
104	457394.22	652902.52	NE Corner S23, T3S, R68W, 6th P.M. - 3.25" Aluminum Cap on 2 3/8" Pipe in Range box "LS 13155"
105	457391.03	654229.64	W 1/16 Corner on the N line of S24, T3S, R68W. 6th P.M. - Chisled + in Stone in Range Box
107	457388.05	655556.84	N 1/4 Corner S24, T3S, R68W. 6th P.M. - 2" Aluminum Cap "PLS 14112" in Range Box
520	456064.22	655553.62	Center-North 1/16 Corner S24, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "LS 17488" in Range Box
527	456070.45	652899.10	N 1/16 Corner on the W line of S24, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap ILLEGIBLE in Range Box
630	457387.23	650248.26	N 1/4 Corner S23, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "PLS 23521" in Range Box
687	454746.92	652895.74	W 1/4 Corner S24, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "PLS 23521" in Range Box
767	454734.24	658281.20	79.9' W.C. W 1/4 Corner S19, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 28291"
768	454746.45	660687.32	Center 1/4 Corner S19, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap ILLEGIBLE
789	452113.79	647606.51	SW Corner S23, T3S, R68W. 6th P.M. - Chisled X on Stone
790	452123.66	647606.66	10' W.C. SW Corner S23, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "WC 10 LS 24961"
791	454748.77	647609.64	W 1/4 Corner S23, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "PLS 24961"
793	457390.62	651575.36	E 1/16 Corner on the N line of S23, T3S, R68W. 6th P.M. - 3" Aluminum Cap "PLS 33204" in Range Box
796	452102.71	652891.92	1' W.C. SW Corner S24, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "WC 1 LS 13155"
810	452105.52	651570.22	E 1/16 Corner on the S line of S23, T3S, R68W. 6th P.M. - No. 6 Rebar
870	457376.04	658206.40	NE Corner S24, T3S, R68W. 6th P.M. - 2" Aluminum Cap in Range Box ILLEGIBLE
872	452095.20	655544.11	S 1/4 Corner S24, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "LS 38033" in Range Box
927	457394.52	660686.36	N 1/4 Corner S19, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 16406"
928	457423.86	665968.77	N 1/4 Corner S20, T3S, R67W. 6th P.M. - 2.5" Aluminum Cap "PLS 2149"
929	456078.90	662008.83	NE Center 1/16 Corner S19, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 14592" in Range Box
930	454760.31	663329.09	W 1/4 Corner S20, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap ILLEGIBLE
932	454769.57	665965.25	Center 1/4 Corner S20, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 14112"
935	457428.07	668608.20	NE Corner S20, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 23519"
936	456104.45	668610.54	N 1/16 Corner on the W line of S20, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 24942"
937	454779.31	668614.21	E 1/4 Corner S20, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap on Concrete Barrier "PLS 23516"
938	453454.58	668618.75	S 1/16 Corner on the E line of S20, T3S, R67W. 6th P.M. - Axle in Range Box
939	454779.04	669939.72	Center-West 1/16 Corner S21, T3S, R67W. 6th P.M. - No. 8 Rebar
940	454779.02	671264.78	Center 1/4 Corner S21, T3S, R67W. 6th P.M. - 2.5" Aluminum Cap "PLS 23501"
942	457404.24	662008.29	E 1/16 Corner on the N line of S19, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 14592" in Range Box
944	457414.27	663333.50	NE Corner S19, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap in Range Box "PLS 17488"
997	454753.45	662038.30	30' WC W E 1/16 S19 - 2.5" Aluminum Cap 2013 LS 16116
1037	456091.58	664649.08	NW Center 1/16 Corner S20, T3S, R67W. 6th P.M. - Axle
1049	456086.40	663331.41	N 1/16 Corner on the E line of S20, T3S, R67W. 6th P.M. - Axle in Range Box
1145	456067.60	647610.53	N 1/16 Corner on the W line of S23, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "PLS 23521"
1146	457385.32	647611.44	NW Corner S23, T3S, R68W. 6th P.M. - 3.25" Aluminum Cap "LS 164?1"
1170	452143.50	679219.87	SE Corner S22, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 11434" in Range Box
1173	457450.40	679197.41	NE Corner S22, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 11434" in Range Box
1188	452128.59	673914.41	SW Corner S22, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "URS PLS 31928" in Range Box
1189	457439.90	676558.19	N 1/4 Corner S22, T3S, R67W. 6th P.M. - 2.5" Aluminum Cap "PLS 11434" in Range Box
1190	457427.95	671262.71	N 1/4 Corner S21, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 20683" in Range Box
1191	458769.21	668594.81	S 1/16 Corner on the W line of S16, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 36053" in Range Box
1193	454778.82	673916.31	E 1/4 Corner S21, T3S, R67W. 6th P.M. - 2.5" Aluminum Cap "PLS 35597"
1195	454778.89	672590.52	Center-East 1/16 Corner S21, T3S, R67W. 6th P.M. - No. 8 Rebar
1276	454987.95	676563.94	200' WC Center Quarter Corner S22 3.25" Aluminum Cap "URS CORP PLS 20683 2004"
1279	454797.05	679208.70	E 1/4 Corner S22, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 9872" in Range Box
1282	457429.50	673918.80	NW Corner S22, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "PLS 20683"
1359	452136.03	676568.28	S 1/4 Corner S22, T3S, R67W. 6th P.M. - 3.25" Aluminum Cap "ZBS INC. PLS 11434 1992"