



# US 6 Bridges - Design Build Project

## Federal Blvd Slip Ramp to EB US 6 over EB US 6 CD Road

*Structure Type Study*  
(Proposed Structure F-16-ZE)



Prepared for CDOT Region 6  
Project Number: BR 0061-083 (18838)  
July 2012



## Executive Summary

The Project includes improvements and reconstruction along the US 6 (6<sup>th</sup> Avenue) corridor from a western terminus located just east of Sheridan Blvd and an eastern terminus located past the BNSF Railroad Bridge Structure east of the US 6 / I-25 interchange. Included within these limits is the Federal Slip Ramp Bridge to eastbound US 6 over the eastbound US 6 Collector Distributor (CD) Road.

The slip ramp bridge is located just east of Federal Blvd, on the south side, and allows traffic from Federal Blvd and Bryant Street to merge onto eastbound US 6. The bridge spans over the eastbound US 6 CD lanes that are used to move traffic between Federal Blvd and Bryant Street.

The objective of the structure type selection process is to determine an economical structure type that is constructible, and that meets the project goals and requirements. This structure type study evaluates various structure layouts and type options for cost and constructability and will select the recommended structure type.

The bridge width varies due to the ramp entrance and exit curves on each end. A minimum structure width (33'-0') was determined from preferred roadway lane and shoulder requirements for the entrance ramp. Using the US 6 CD alignment and required section in addition to meeting the required 16'-6" minimum vertical clearance requirements, a one span structure with approximately 132'-6" span length is required.

Four structure types, composite steel I-girder, precast prestressed bulb tee girder, cast-in-place post tensioned box girder and adjacent precast prestressed box girder have been evaluated for a one span configuration. Preliminary design of structure types was performed to determine preliminary construction cost estimates. Construction costs for this bridge are estimated to be \$2.3 million.

On the basis of the evaluation contained in the Structure Type Study, the recommended structure type is:

**Precast Prestressed Adjacent Box Girder (BX48" x 78") with a cast-in-place fascia beam at one corner, (132'-6") simple span, 5" concrete deck topping, 3" SMA and 3" average haunch, resulting in a 7'-5" superstructure depth. Substructure is semi-integral vertical wall abutments founded on H-pile pattern with a concrete cap.**

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## 1.0 Introduction

The Project generally includes improvements at the I-25/US 6 interchange, partial closure of the Bryant Street interchange, a diamond interchange at US 6/Federal Boulevard with slip ramps to Bryant Street and a braided ramp from Federal Boulevard to eastbound US 6, improvements to Federal Boulevard between 5<sup>th</sup> and 7<sup>th</sup> Avenues, conversion of 5<sup>th</sup> Avenue to two-way operation east of Federal Boulevard, upgrading portions of the South Platte River Trail to current



Figure 1. US 6 at Bryant look W towards Federal

standards in areas impacted by construction, reconstruction of US 6 with collector-distributor roads/auxiliary lanes from Federal Boulevard to the BNSF Railroad Bridge Structure, in-kind replacement of impacted facilities for Barnum East Park as further defined in the Contract Documents and including adding a bicycle/pedestrian Bridge Structure connecting Barnum Parks South and North, replacement of existing Bridge Structures as further described herein, and overlay of US 6 westerly to Sheridan Boulevard.

The Project includes improvements and reconstruction along the US 6 (6<sup>th</sup> Avenue) corridor from a western terminus located just east of Sheridan Blvd and an eastern terminus located past the BNSF Railroad Bridge Structure east of the US 6 / I-25 interchange. Included within these limits is the Slip Ramp Bridge over the eastbound US 6 CD Road.

A Structure Selection Report (SSR) shall be prepared for each bridge within the project limits. The report will evaluate typical structure options for each bridge and shall evaluate:

- Existing Site Conditions
- Proposed Structure Layout
- Staging
- Geotechnical
- Substructure Alternatives
- Utilities
- Aesthetics requirements
- Environmental
- Structural design criteria
- Construction Cost Estimate

In the SSR, a General Layout shall be prepared for the preferred alignment option. The layout will include both horizontal and vertical alignment and general dimensions of the bridge elements. Areas of temporary and permanent impact required to construct the bridge can be

established. The preferred structure type will be determined by the criteria established in the SSR.

## 2.0 Existing Site Conditions

Federal Blvd. is located just west of the proposed slip ramp location. The existing US 6 has 4 eastbound lanes and 4 westbound lanes. On the north side there is a 3 lane exit ramp for Federal Blvd and the south side has baseball fields. Instead of being a full diamond interchange, the eastbound on-ramp from Federal Blvd to US 6 loops around south of the baseball fields onto US 6.

Bryant St lies just to the east of the proposed slip ramp location. The existing interchange is also a partial diamond similar to Federal except there is no entrance ramp to allow access to US 6.

## 3.0 Proposed Structure Layout

### 3.1 Bridge Width

The proposed layout for the slip ramp includes one 15'-0" ramp lane, a 4'-0" outside shoulder, a 6'-0" inside shoulder, additional distance to account for the ramp curvature at the corners, and two 1'-6" Type 7 Bridge Rails. Due to the curvature of the ramp turns, the bridge width varies from about 31'-6" out to out minimum at the north end to 41'-2" maximum at the south end. The typical bridge width at locations without curvature is 33'-0" out to out. To accommodate the varying width, the deck cantilever can be increased at three corners. At the northeast corner, a fascia beam will need to be added which will frame onto the exterior girder and bear on the abutment. Due to the large skew, it was determined that constructing a fascia beam was cheaper than adding additional girders. Figure 2 illustrates the proposed interchange layout.

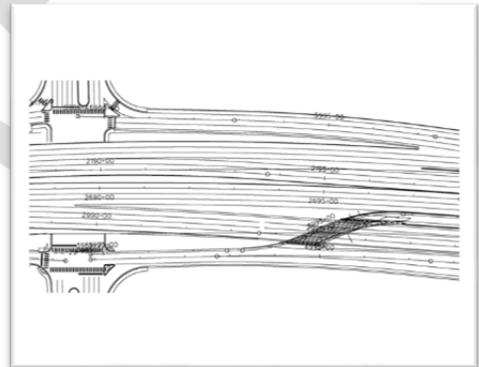


Figure 2. Proposed Slip Ramp

### 3.2 Span Length

The proposed reconstruction of US 6 entails the complete reconfiguration of the access to US 6 at Federal Blvd and Bryant St. It is proposed to close the US 6 interchange access at Bryant St and force access down to Federal Blvd. Part of this new design includes construction of eastbound collector distributor (CD) lanes between Federal Blvd and Bryant St. In addition, an eastbound only frontage road/ramp allows access between Federal Blvd and Bryant St. Due to the configuration of this layout, a slip ramp bridge is required to allow eastbound access from Federal Blvd and the frontage road/ramp over the CD lanes onto eastbound US 6.

The proposed layout for CD lane configuration includes three 12'-0" through lanes, one 12'-0" outside shoulder, one 4'-0" inside shoulder, and room for two roadway barriers. A total bridge

length of 132'-6" from centerline abutment to centerline abutment would be sufficient to span the roadway below. Because the alignment of the frontage road/ramp is almost parallel to the CD lanes, a large 63.5 degrees right ahead skew is required.

Due to the proposed configuration of the frontage road/ramp and the CD lanes, only a single span option with vertical wall abutments was considered. Multiple span options are not practical at this location. The reasons for selecting a one span option include the following:

- **One span option (recommended):** Placing the abutments at the edge of the CD shoulders allows the single span to work.
- **Two or more span options (not recommended):** Due to the location of the frontage road/ramp and US 6, additional spans are not an option.

Based on a single simple span bridge of about 132.5', recommended superstructure depths, according to AASHTO LRFD, Table 2.5.2.6.3-1, are shown in Table 1 below. To calculate the girder depth, it is assumed to use the CDOT 8" minimum deck thickness and a 4" haunch for Bulb Tee Girders, 0.033L (from AASHTO) for Plate Girders and 5" topping with 3" haunch for adjacent box beams.

Girder Type	Ratio	Minimum Depth (ft)	Girder Depth (in)
PC/PS Concrete Bulb Tee	.045	5.96	63
CIP PT Box Girders	.045	5.96	60
Composite Steel Plate Gdr	.040	5.30	54 (web)
Adjacent PC/PS Box Beams	.030	3.98	42

**Table 1 Minimum Superstructure and Girder Depths**

The proposed profile allows for a structure depth of about 7.5', which is sufficient for any of the above options. For the proposed span lengths of this bridge, precast pre-stressed concrete has historically come in significantly cheaper than continuous steel plate girders. For this reason, the steel option will not be considered. Even though the cast-in-place post tensioned box girder is an ideal option for this location, it will not be considered further due to constructability issues as discussed in the Staging section. To allow ease of framing the fascia girder into the exterior girder on the northeast corner, the Bulb Tee Girder will not be considered. Thus, the adjacent box beam option will be the only one considered.

Framing in a fascia girder on the northeast corner will have a large effect on the final girder selection. Due to the load from the fascia beam, the minimum girder depth shown above is not sufficient to meet the required deflection criteria of zero negative camber at final. Based on preliminary girder runs, the proposed girder size needs to be increased to a BX48"x78" deep.

## 4.1 Staging

A preliminary assessment of reconstructing US 6 between Federal Blvd. and Bryant St entails several stages of construction. Current phasing plans show the CD road and retaining walls being constructed before the bridge in Stage 5 and the new lanes carrying traffic during Stage 6. The bridge is scheduled to be built in Stage 7. CDOT will not allow falsework for cast-in-place structures to be above active traffic during construction. Due to this rule, the cast-in-place PT bridge option is ruled out. During the design build process, the phasing can be re-evaluated and costs compared to the adjacent precast box girders. It is anticipated that any of the bridge options can be constructed in a single stage.

## 5.0 Geotechnical

A preliminary assessment of the foundation types has not been performed on the project at this time, except for the Federal Blvd bridge replacement just west of the proposed slip ramp bridge. Based on Federal Blvd geotechnical report, deep foundations such as drilled caissons and H-pile are acceptable options for the foundations. At this location, bedrock is estimated to be approximately 55' below the existing grade on US 6. Estimated foundation lengths at vertical wall abutments will be approximately 55' for H-pile and 60' for caissons.

At the Federal Blvd bridge location, the general geology consists of medium stiff to very stiff clay overlaying medium dense to very dense well graded sand overlaying very hard claystone bedrock. Bedrock was encountered between 5,171 feet above mean sea level (amsl) (83 feet below ground surface [bgs]) to the north and 5,173 feet amsl (84 feet bgs) to the south. Soil and bedrock characteristics were consistent among borings. Groundwater was encountered in the borings during drilling between 5,194 feet amsl (28 feet bgs) to the east in TH14 and 5,224 feet amsl (32 feet bgs) to the west in TH3.

## 6.0 Substructure Alternatives

Competent bedrock exists approximately 55' below the existing US 6 pavement. The depth of rock indicates typical deep foundations such as piles and drilled caissons would be the recommended foundation type. Vertical wall abutments will be required due to the configuration of the slip ramp. It is anticipated that the vertical walls will be founded on a pile pattern with concrete cap.

## 7.0 Utilities

There are no known utilities proposed to be located on the bridge. At the bridge site, there is an existing buried XCEL line and buried electric for lights which are to be removed, and a CDOT ITS which is to remain.

## 8.0 Aesthetics

At this time, there are no plans to develop special aesthetic details for the US 6 Bridge project. Minor aesthetic treatment, such as colors and form liner patterns, should be developed prior to the

completion of the final design. The developed details should be aesthetically pleasing with distinctive color; texture and material treatments which help break down scale and create a sense of place. The series of bridges on the project should share common elements while maintaining its own unique identity. Components that create identity include character, detailing, color and materials. The developed architectural details should integrate well with the characteristics of the surrounding area. Possible areas where architectural treatments may be applied include barriers, abutment walls, wingwalls, columns and girders.

## 9.0 Environmental

This section discusses the potential for soil and groundwater contamination to be encountered in the project area. Areas of contaminated soil and groundwater must be identified so they can be avoided, if reasonably possible. Encountering soil and groundwater contamination during construction without prior knowledge may affect a project in terms of worker safety, cost, schedule, and agency and public relations.

A *Modified Environmental Site Assessment* (MESA) was performed in support of the Valley Highway EIS process (FHU, 2005h). The MESA was prepared based on the American Society for Testing and Materials (ASTM) *Standard Practice for Environmental Site Assessments* (ASTM, 2000), CDOT guidance (CDOT, 2002d), and through consultation with CDOT and CDPHE (FHU, 2003b). The purpose of the MESA is to identify recognized and potential environmental conditions in the project area that could adversely affect the project, to aid in effectively screening and evaluating the feasibility of system alternatives and aid in the right-of-way process.

Several areas of known contaminated soil and groundwater are located in the project area. Chlorinated solvent and petroleum contaminated soil and groundwater are located in the vicinity of the Broadway and I-25 interchange. Petroleum contaminated soil and groundwater is also present east of the I-25 and US 6 interchange. The I-25 and US 6 interchange is located west of the Union Pacific Burnham Shops (the former Denver & Rio Grande rail yard), the Rio Grande LUST site, and the former Lake Archer. Three closed and one active LUST sites and the active Union Pacific–Burnham Shops ERNS spill are located in the vicinity of the interchange. The I-25 interchange is also located near the Lake Archer reservoir with potential soil and groundwater contamination and methane concerns. The fill material for the Lake Archer reservoir is unknown but may have included municipal and industrial debris. A diesel-contaminated groundwater plume is located west of the I-25 interchange. Landfill debris, contaminated soil and groundwater, and methane may be encountered in the area of the I-25 and US 6 interchange.

## 10.0 Design Criteria

### 10.1 Design Specifications

- CDOT Staff Bridge Design Manual – May 2009
- CDOT Staff Bridge Technical Memorandums
- “AASHTO LRFD Bridge Design Specifications”, 6<sup>th</sup> Edition

- CDOT Standard Specifications for Road and Bridge Construction, 2011

## 11.0 Construction Cost Estimate

In determining initial construction cost, major construction items will be quantified and priced using standard unit costs established from CDOT's Cost Data book. Below is a list of the estimated bridge costs for the superstructure type options. These construction costs do not include costs for roadway, traffic control, design, construction management or contingency.

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# Federal Blvd Slip Ramp Bridge — Structure Type Study

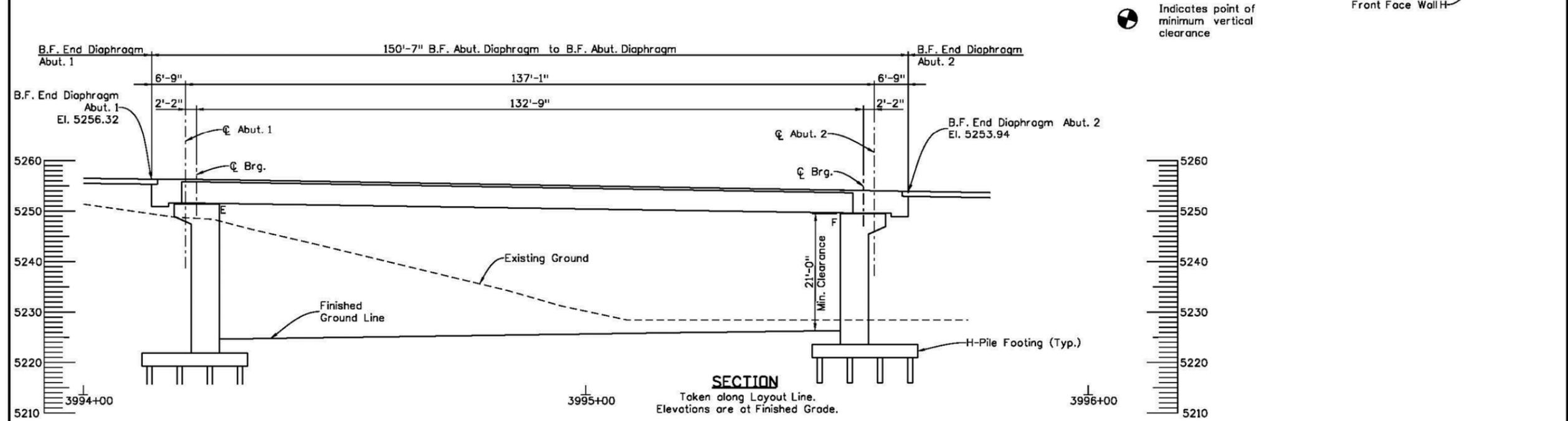
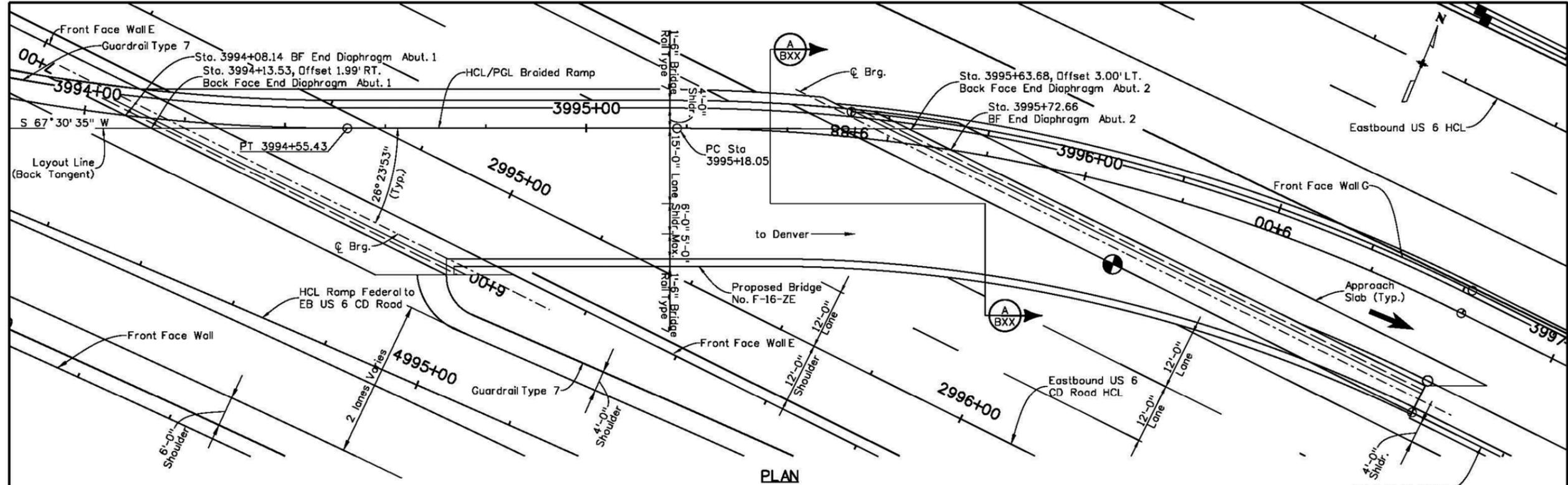
Table 2. Estimated Construction Cost

Summary of Approximate Quantities										Date: 7/16/2012	
US 6 Bridges											
Braided Ramp over EB CD Road											
CONTRACT ITEM NO.	CONTRACT ITEM	UNIT	Approximate Quantities	2007 AVE UNIT COST	2008 AVE UNIT COST	2010 AVE UNIT COST	Estimated UNIT COST	Estimated TOTAL COST			
<b>Braided Ramp</b>	<b>Structure dimensions (length by width)</b>	150.54	33.00								
206-00000	Structure Excavation	CY	7,050	\$ 17.33	\$ 7.96	\$ 7.79	\$ 8.00	\$ 56,400.00			
206-00100	Structure Backfill (Class 1)	CY	8,450	\$ 35.66	\$ 28.20	\$ 16.68	\$ 20.00	\$ 169,000.00			
206-00360	Mechanical Reinforcement of Soil	CY	8,100	\$ 17.58	\$ 25.20	\$ 17.57	\$ 18.00	\$ 145,800.00			
403-09210	Stone Matrix Asphalt	TON	135	\$ 71.70	\$ 71.32	\$ 81.73	\$ 80.00	\$ 10,800.00			
502-11274	Steel Piling (HP 12x74)	LF	2,475	\$ 51.99	\$ 77.73	\$ 48.44	\$ 75.00	\$ 185,625.00			
513-00600	Bridge Drain	EACH	4	\$ 3,714.29	\$ 10,893.33	\$ 3,000.00	\$ 3,500.00	\$ 14,000.00			
515-00120	Waterproofing (Membrane)	SY	810	\$ 10.20	\$ 15.41	\$ 13.71	\$ 12.00	\$ 9,720.00			
518-01004	Bridge Expansion Device (0-4 Inch)	LF	220	\$ 186.87	\$ 267.88	\$ 154.74	\$ 160.00	\$ 35,200.00			
601-03040	Concrete Class D (Bridge)	CY	2,325	\$ 473.70	\$ 432.91	\$ 396.97	\$ 400.00	\$ 930,000.00			
601-40300	Structural Concrete Coating	SY	1,000	\$ 7.95	\$ 7.55	\$ 9.09	\$ 10.00	\$ 10,000.00			
602-00020	Reinforcing Steel (Epoxy Coated)	LB	350,000	\$ 1.02	\$ 0.99	\$ 0.79	\$ 1.15	\$ 402,500.00			
606-10700	Bridge Rail Type 7	LF	470	\$ 83.69	\$ 95.69	\$ 74.52	\$ 100.00	\$ 47,000.00			
613-00100	1 inch Electrical Conduit	LF	250	\$ 5.65	\$ 10.31	\$ 11.08	\$ 10.00	\$ 2,500.00			
613-00200	2 inch Electrical Conduit	LF	500	\$ 9.30	\$ 14.96	\$ 9.56	\$ 10.00	\$ 5,000.00			
618-01996	Prestressed Concrete Box (Depth Greater Than 48 Inches)	SF	3,738	#N/A	#N/A	#N/A	\$ 80.00	\$ 299,040.00			
<b>Subtotal of accounted construction items</b>								<b>South Bound Bridge:</b>	<b>\$ 2,322,585</b>	<b>\$468</b>	



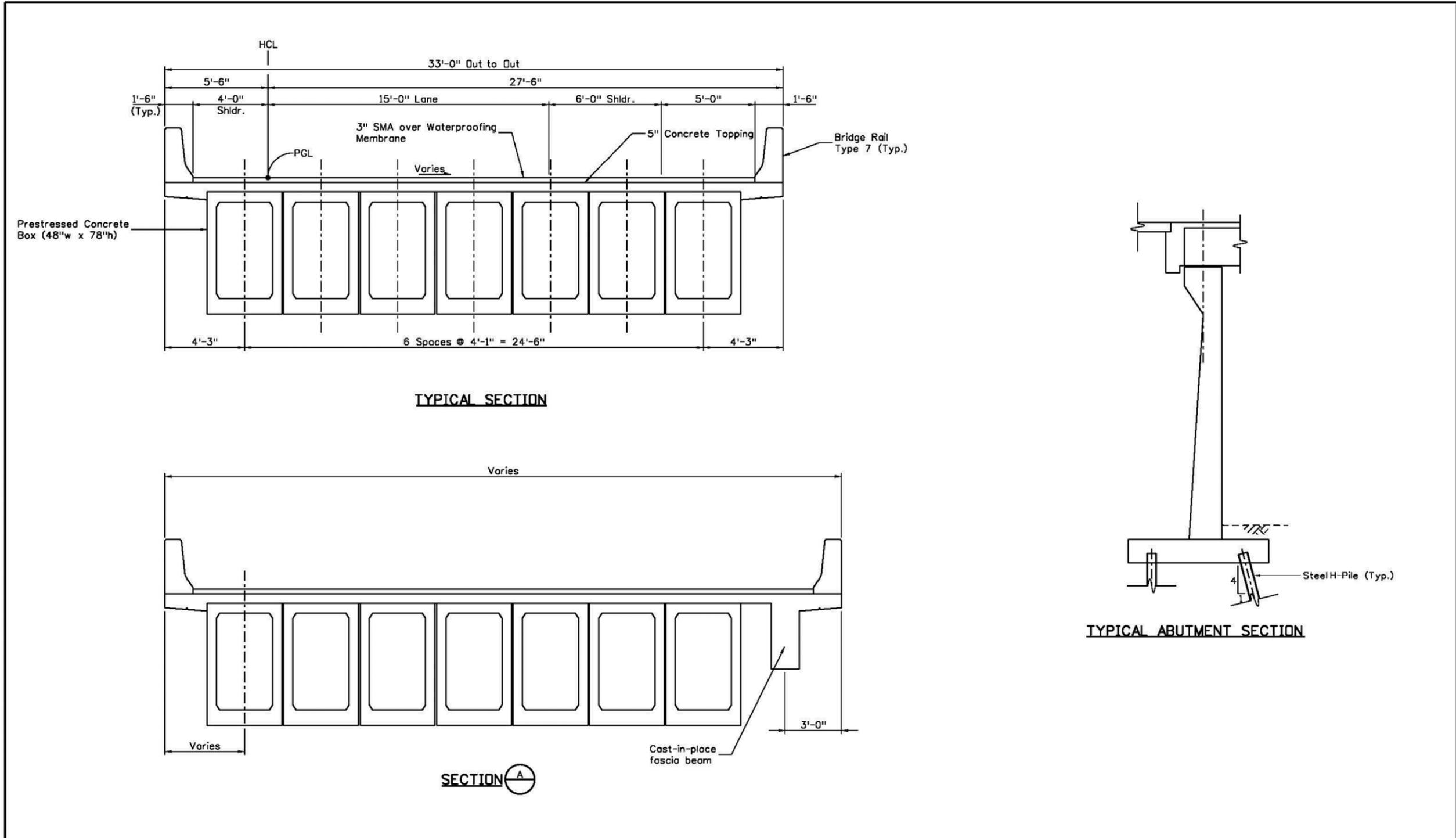
**APPENDIX A**

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Horiz. Scale: 1:20	Unit Information	Unit Leader Initials				Date: 09-19-12	Designer: H. REED	Structure: F-16-ZE
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