I-25 SANTA FE STRUCTURE SELECTION REPORT

Prepared for:

CDOT Region 6
CDOT Region 6 Project # IM 0252-394 (Code 16311)

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FHU Reference No. 08-276-01

October 2009

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1. PROJECT OVERVIEW

INTRODUCTION

The Federal Highway Administration (FHWA), in cooperation with the Colorado Department of Transportation (CDOT), has evaluated improvements to portions of I-25, Alameda Avenue, Santa Fe Drive and Kalamath Street in south-central Denver. Improvements to this portion of I-25, known as the "Valley Highway", was evaluated in the "Valley Highway, Logan to 6th Ave. Environmental Impact Statement" (VHEIS), completed in 2006. The study started from the north end of "T-REX" just south of Broadway and I-25, and extended north to the interchange of US 6 and I-25. The first phase of construction was I-25 over Broadway, termed the "Broadway Viaduct", including reconstruction of the I-25 corridor over Broadway as well as the RTD's Light Rail Train (LRT) and Broadway Station Park-n-Ride.

This report covers structures included in Phase 1 and Phase 2 of the VHEIS, except the Alameda over I-25 and Federal Boulevard over US 6 bridges and associated retaining walls. Phase 1 of the Valley Highway EIS includes reconstruction of the I-25 corridor from the northern limits of the Broadway viaduct, continuing just north of Alameda Avenue, reconstruction of the Santa Fe and Kalamath corridor near I-25, and reconstruction of the I-25 & Santa Fe Interchange. Phase 2 of the Valley Highway EIS includes reconstruction of Alameda Avenue from Lipan to Santa Fe and reconstruction of the partial I-25 Alameda Interchange.

Project Purpose

The purpose of this project is to:

- Provide lane continuity and balance on I-25 from the Broadway Viaduct to north of Alameda Avenue
- Improve connectivity between Santa Fe and I-25, as well as Alameda and I-25
- Correct roadway and bridge deficiencies along all reconstructed corridors to meet current design standards to provide a safer, more efficient, and more reliable transportation system
- Increase safety and reduce congestion and delays related to the deficiencies of the existing corridors and associated interchanges

Proposed Structures

The preferred reconstruction plan set forth by the EIS includes a realignment and reconfiguration of the I-25 / Santa Fe interchange, as well as widening of the I-25 corridor and Alameda Avenue. This preferred plan replaces multiple deficient bridges and adds new bridges which improve connectivity. In addition, new retaining walls and a new box culvert will be a part of the project. The proposed structures are as follows:

Bridges:

I-25 over Santa Fe (Structure No. F-16-XS)

NB Santa Fe to NB I-25 Flyover (Structure No. F-16-XR)

SB Santa Fe over South Platte River (Structure No. F-16-XA)

Alameda over South Platte River (Structure No. F-16-XW)

Alameda to NB I-25 Flyover (Structure No. F-16-XV)

Walls:

I-25 NB & SB Wall 1 (Structure No. Wall-F-16-DW)

I-25 SB Wall 2 (Structure No. Wall-F-16-DX)

Santa Fe SB Wall 1 (Structure No. TBD)

Santa Fe SB Wall 2 (Structure No. TBD)

Ramp 1 Wall 1 & 2 (Structure No. Wall-F-16-DU)

I-25/Ramp 1 Wall & Ramp 1 Wall 3 (Structure No. Wall-F-16-DV)

Ramp 2 Wall (Structure No. Wall-F-16-DS)

Ramp 5S Wall (Structure No. Wall-F-16-EB)

Ramp 5N Wall (Structure No. Wall-F-16-EA)

Construction Funding

Federal Economic Stimulus funds were secured for construction of Phase 1.1 which includes replacement of the Alameda over I-25 Bridge, the Alameda sump cofferdam, and a portion of I-25 north and south of Alameda. CDOT is currently seeking additional funding for the remaining portions of Phase 1 and 2 from highway construction monies generated by the recent State of Colorado "FASTER" legislation; and from other State and Federal funding streams.

Schedule

Construction of the VHEIS Phases 1 and 2 is planned to be completed in five separate construction projects as follows:

Phase 1.1

Replacement of the Alameda Avenue over I-25 Bridge, cofferdam, Alameda outfall CBC and a portion of I-25 north and south of Alameda. Construction is planned for late 2009 thru the end of 2010.

Phase 1.2

Reconstruction of I-25 from the north end of the Broadway Viaduct to the south end of Phase 1.1. Construction schedule is undetermined and is pending funding.

Phase 1.3
Construction of the NB Santa Fe to NB I-25 flyover ramp. Construction schedule is undetermined and is pending funding.

Phase 1.4
Reconstruction of Santa Fe and Kalamath from the South Platte River to Alameda and reconstruction of the I-25 Santa Fe Interchange. Construction schedule is undetermined and is pending funding.

Phase 2
Reconstruction of Alameda Avenue from Lipan to Santa Fe and the I-25 Alameda Partial Interchange. Construction schedule is undetermined and is pending funding.

DESIGN CRITERIA

The bridges will be designed using the following criteria:

- CDOT Bridge Design Manual, current revisions and technical memorandums
- AASHTO LRFD Bridge Design Specifications (4^{th} Edition, with current Interims)
- 2005 CDOT Standard Specifications for Road and Bridge Construction; with current project special provisions and standard special provisions as appropriate
- Live Load: LRFD HL-93 Design Truck or Tandem, and Design Lane Load; and 75 psf sidewalk loading for pedestrians
- 3-inch Hot Mix Asphalt overlay on bridge
- Epoxy reinforcing steel per CDOT requirements (High level road deicing salts)

The retaining walls will be designed using the following criteria:

- CDOT Bridge Design Manual, current revisions and technical memorandums
- AASHTO Standard Specifications for Highway Bridges (16^{th} Edition)
- 2005 CDOT Standard Specifications for Road and Bridge Construction; with current project special provisions and standard special provisions as appropriate
- Allowable Stress Design for Mechanically Stabilized Earth walls, and foundation design
- Load Factor Design for concrete design
- Earth pressure and surcharge, as recommended by Geotechnical Report

AESTHETICS

Bridge Aesthetic Considerations

I-25 Over Santa Fe (Structure No. F-16-XS): It is important to provide elements that visually lighten up the appearance of this structure due to the multi-level high-volume nature of this interchange. A combination of round, 48 inch diameter columns with girders that rise out of the top of the columns provide an uncluttered, clean look. The girders are curved to conform to the highway alignment and the shape of the columns adapt easily to a variety of views and conditions. The bridge rail provides an opportunity for a linear textural enhancement on the outside of its face, which should be carried through as a consistent element on the entire family of bridges in this complex. A rugged flagstone formliner is proposed for the bridge rail inset, with a simple decorative feature above each pier. A dark green (Federal Color No. 14056), vinyl coated woven wire snow fence on top of the barrier is also a consistent visual element required where a mainline or ramp crosses over another interstate roadway. The barrier, deck and piers will receive an enhanced stain of light gray (Federal Color No. 25630) and the girders will be stained dark gray (Federal Color No. 26251) to blend with the nearby Broadway bridge colors.

NB Santa Fe to NB I-25 Flyover (Structure No. F016-XR): Due to the combination of a relatively narrow cross section (39') and overarching profile, this structure appears as a thin ribbon above the interchange. There is a need for only one central line of columns along its alignment, which are round to conform to the multiple opposing angles this bridge passes through. Girders are curved, with a Type 7 bridge rail accented by a contrasting rugged flagstone formliner which is also utilized on other structures in this complex. The dark green (Federal Color No. 14056), woven wire snow fence is included where applicable. This structure will also receive the same stain combination as Structure F-16-XS.

SB Santa Fe over South Platte River (Structure No. F-16-XA): This structure will be viewed from NB Santa Fe and from properties to the west of the South Platte. The girders will be supported by skewed wall piers within the South Platte, mimicking the existing bridge. A Type 7 barrier is repeated with the consistent rugged flagstone formliner inset. An accent feature above each column punctuates the structure and gives it some visual interest. The structure will also receive the same stain combination as Structure F-16-XS.

Alameda over South Platte River (Structure No. F-16-XW): Aesthetics for this bridge will be similar to the Alameda Bridge over I-25, except without the signage on the outside of the curb/deck face. Accent columns and dark green picket-style fence will be repeated here.

Alameda to NB I-25 Flyover (Structure No. F-16-XV): This bridge will be visible to both SB and NB I-25 travelers as it passes over both travelways from Alameda to a NB I-25 lane. Three round columns support the flyover, under a tapered hammerhead pier cap. The barrier and color treatment will be consistent with those on Structure F-16-XS.

Retaining Wall Aesthetic Considerations

All retaining walls supporting fill will be the mechanically stabilized earth design, with 5'x10' rectangular panels, stained light gray (Federal Color No. 25630). Where highly visible to passing traffic, special accent features will be provided to create visual interest and to break up large expanses of wall surfaces.

Retaining wall along the South Platte will utilize formliner textures to break up large expanses of wall surfaces.

EVALUATION PROCESS

The evaluation process for both bridges and retaining walls was developed to insure that the selected alternative provides the highest value for the project. The highest value is a structure that is not only low in initial construction cost, but also is durable, constructible and meets all other project objectives.

Each structure will be evaluated based on criteria specific to the bridge or retaining wall location. However, selected evaluation measures will be based on the following list of relevant criterion associated with this project:

Bridges:

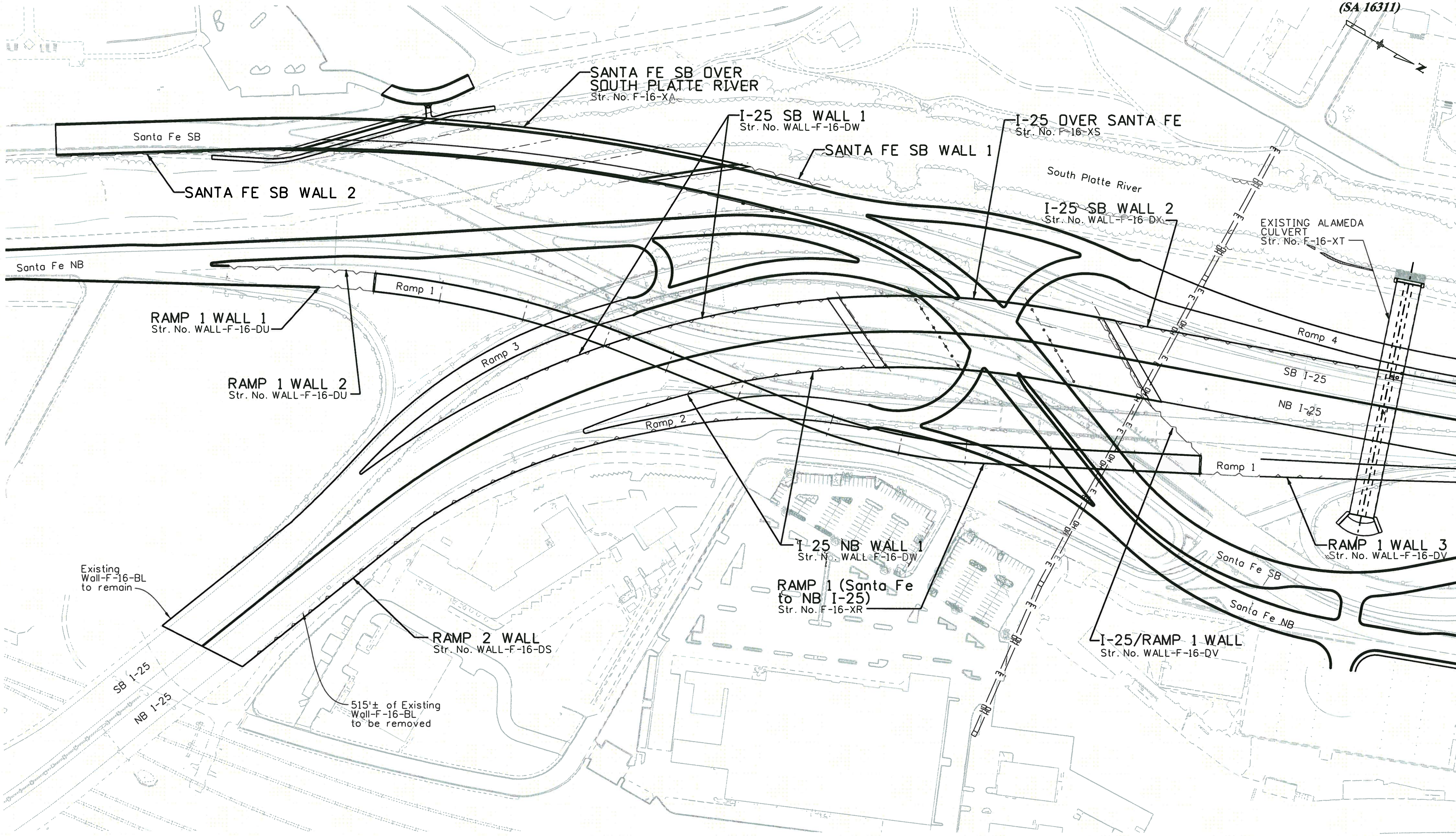
- Least construction cost
- Aesthetics
- Durability and maintainability
- Constructability
- Impact to roadway or hydraulic clearance requirements

Walls:

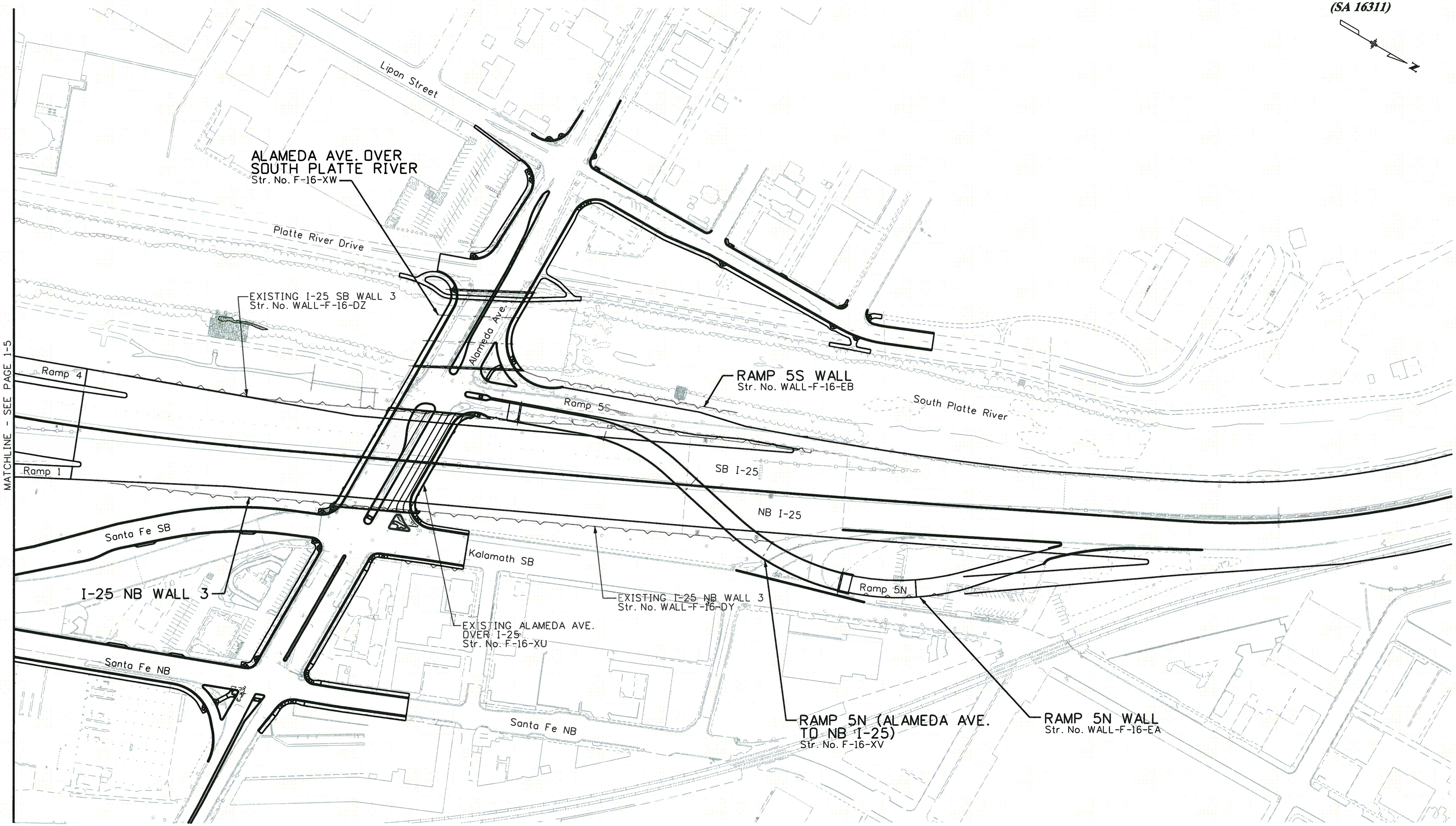
- Least construction cost
- Aesthetics
- Durability and Maintainability
- Constructability
- Proven Experience with Wall Type

Weighting factors will be applied to the construction cost or aesthetics criteria to reflect increased importance for the individual structure being evaluated. Structures which are highly exposed to travelling public will include higher weighting factors for aesthetics, due to their visibility. Structures which are not highly visible will include higher weighting factors on construction cost, to insure an economical structure type is chosen.

Evaluation criteria will be further defined for each structure. An evaluation matrix is provided for each structure being evaluated, with a numerical scoring system applied to each criterion.



Structure Location Map
(1 of 2)



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Structure Location Map
(2 of 2)

2. BRIDGE TYPE SELECTION

SB SANTA FE OVER I-25 (STRUCTURE NO. F-16-XS)

Introduction

The I-25 over Santa Fe Bridge replaces two aging structures: Bridge No. F-16-DT, northbound I-25 over Santa Fe, and Bridge No. F-16-DW, southbound I-25 over Santa Fe. The bridges need to be replaced because they are structurally deficient and functionally obsolete. They also need to be replaced to accommodate the realignment and widening of I-25 and the reconfiguration of the I-25 / Santa Fe Intersection.

The preliminary layout utilized for this report has a combined horizontal and vertical alignment for the northbound and southbound bridge structures. Further modifications to the alignment may utilize a split vertical alignment, such that the slope of the deck is not continuous across the northbound and southbound directions of I-25. This could possibly be accomplished with an offset median barrier. However, if the offset at centerline I-25 is large, two separate structures may be the best choice. None of these modifications affect the selection of the best overall structure type for the proposed bridge structure. Hence it is valid to use the combined horizontal and vertical alignment structure layout for the basis of the structure type selection.

Existing Bridges

The existing bridges are riveted steel plate girders built in 1958, and originally carried 3 lanes of traffic. The structures were widened in 1963 to add one lane to each. In order to accommodate the added lane and the geometry of the roadway below the bridge, large steel straddle bents were incorporated into the widening design.

The bridges are substandard, both functionally and structurally. In 2008, the sufficiency rating for the bridges was 20.2 and 22.8 for the northbound and southbound bridges respectively. Since that time, rehabilitation work has occurred on badly deteriorated columns. However, the overall condition of the bridges is such that replacement is warranted.

In addition, the new alignment of I-25 is such that the bridges can no longer be utilized. Currently, I-25 is a split alignment when it crosses Santa Fe, with the alignments separated by approximately 100 feet. Because the new alignment will be a combined alignment, with the new bridge located roughly between the existing structures, a new structure is needed regardless of the condition of the existing bridges.

Replacement Bridge Layout

The I-25 Bridge over Santa Fe will carry both northbound and southbound I-25. As mentioned in the introduction, a combined alignment with a median barrier between the northbound and southbound directions is utilized for the structure selection. Each direction will carry 4 - 12' lanes of traffic and have 2 - 12' shoulders resulting in a total bridge width of 149'.

The bridge will span over northbound and southbound Santa Fe, as well as a single point urban intersection for ramps connecting I-25 to Santa Fe Drive.

The width of Santa Fe, combined with the geometrics of the single point urban interchange require a longer span than is utilized on surrounding bridges such as the I-25 Broadway viaduct. The piers are set at a skew so as to achieve the minimum possible span length of approximately 240 feet. The resulting configuration satisfies all geometric and sight distance constraints for the intersection below the span.

A vertical clearance of 16'-6" over Santa Fe is required. The profile grade for I-25 must match existing grades on the north end of the Broadway Viaduct, go over Santa Fe and then under the Alameda overpass, again with standard 16'-6" vertical clearance. Because of these profile constraints, the structure depth must be minimized, rendering a single simple span impractical. It is therefore necessary to utilize a three span continuous structure with a 240 foot main span and balancing end spans.

Bridge Superstructure Alternatives

The longer main span that is required limits the possible structure types. Simply erected prestressed concrete girders, prestressed box beams and slab span structures are not feasible at the 240 foot main span length. Segmental bridges require large structures to offset the initial capital cost of specialized equipment. The small overall size of this structure precludes the use of a segmental concrete bridge.

Viable structure types include spliced precast post-tensioned concrete girders, cast-in-place concrete girders and steel girders. Precast concrete girder types include both bulb-T and Colorado U-girders. Cast-in-place concrete structures traditionally utilize box girder cross-sections. Viable steel girder types include fabricated plate girders and box girders.

Aesthetics are an important consideration for all structures in the I-25 / Broadway / Santa Fe / Alameda Interchange. Therefore, Colorado U-Girders are better suited than bulb-T girders. This girder type also matches that utilized for the Broadway Viaduct and will likely be selected for the northbound Santa Fe to northbound I-25 flyover ramp.

Due to the increased fabrication costs, steel box girders are significantly more expensive than steel plate girders. The bridge horizontal alignment also features only large radius curves, where the increased torsional resistance of the steel box is not required. Therefore steel plate girders are better suited than steel box girders. Steel box girders were not considered further in this study.

Given the above considerations, the following structure types are best suited for the I-25 over Santa Fe Bridge:

- Spliced Precast Post-Tensioned Colorado U-Girders (Precast Girder) **(Page 2-6 & 2-8)**
- Cast-in-Place Post-Tensioned Concrete Box Girder (CIP Box Girder) **(Page 2-6 & 2-9)**
- Spliced Steel Plate Girders (Steel Girder) **(Page 2-7 & 2-10)**

The length of the end spans to balance the main span is slightly different for the best suited structure types. For both of the concrete girder types, a span layout of 150' - 240' - 150' is utilized and for the steel plate girder structure, a span layout of 175' - 240' - 175' is utilized.

The best suited structure layouts and cross-sections can be seen on **Pages 2-6 thru 2-10**. These structure types have been studied in detail to determine the best structure for the I-25 over Santa Fe Bridge.

Bridge Substructure

Drilled caissons have proven to be the most economical bridge foundations in the immediate vicinity and were used for the Broadway Viaduct. Drilled caissons will be utilized for the foundations for this structure. More discussion is provided in the Geotechnical Considerations section of this report.

Simple reinforced concrete columns will be utilized for all structure types. A like diameter drilled caisson will be utilized under each column. This eliminates the need for footings, excavation (and possible cofferdams and dewatering) and backfill. One column will be used for each girder line for the Precast Girder alternate. This allows direct support of the girders without costly pier caps and results in a total of eight columns that will be utilized at each bent.

For the CIP Box Girder and Steel Girder structure types, there are 10 webs or girder lines. Placing a column under each web or girder is not necessary and would result in too many columns from an aesthetic standpoint. Therefore, five columns are used at each bent for the CIP Box Girder and Steel Girder structure types. A pier cap is then needed to carry the loads from the webs and girder lines to the columns. This pier cap is integral and within the structure depth for the CIP Box Girder structure type. For the Steel Girder structure type, the cap is not integral and is beneath the superstructure, for the structure type evaluation. An integral cap could be used for the Steel Girder alternate, but it would add additional construction cost and complexity. In the evaluation matrix, construction cost is given a higher weighting factor than aesthetics, so the decision was made to keep the dropped cap in order to give the Steel Girder alternate the highest possible score for the purposes of structure type selection.

The abutments will be simple stub abutments supported on small diameter drilled shafts. They will sit above and behind MSE walls. These walls are a continuation of the walls to each side of I-25 and wrap around the front of the abutments. Conventional CDOT 20 foot long approach slabs are used at each abutment.

Construction Phasing / Constructability

I-25 northbound and southbound will be detoured around the site of the new bridge. Therefore, the construction of the bridge need not be staged to accommodate I-25 traffic phasing. This simplifies construction of the new structure.

However, a temporary configuration of southbound Santa Fe and the ramp from southbound Santa Fe to southbound I-25 will be under the main span of the new bridge during construction. This is to accommodate the overall project staging and traffic phasing. The Precast Girder alternate and the Steel Girder alternate do not require falsework near/over the active roadways. They will require closure of roadways underneath the main span when the main span sections are erected, but these short duration closures can occur at night. The CIP Box Girder alternate will require falsework near and over the active roadways beneath the main span for a significant amount of time. This will reduce horizontal and vertical clearances and affect sight distances. Roadway closures will also be required to erect the falsework. Therefore, due to traffic impacts, the Precast Girder and Steel Girder alternates have a constructability advantage over the CIP Box Girder alternate.

Geotechnical Considerations / Foundations

The preliminary Geotechnical Report provides estimates for the strength level capacities for spread footings at 3300 psf in existing fill, and 5000 psf in the natural gravelly sand. Preliminary estimates for the drilled caisson strength level capacities are 8-13 ksf side resistance and 160 ksf end resistance. Boring logs show bedrock within about 35' of the existing surface.

Due to the low bearing capacities, spread footings would need to be large. Pier footings would also require excavation (and possible cofferdams and dewatering) and backfill. Differential settlement between the footings at the piers (supported on natural soils) and at the abutments (supported on mechanically stabilized earth) are also a concern for this foundation type. Because of these reasons, spread footings are not desirable.

Driven pile foundations would require multiple piles per column and, therefore, footings at each pier. As discussed above, pier footings would also require excavation (and possible cofferdams and dewatering) and backfill. It is desirable to have the wrap-around MSE walls as close as possible to the abutments. Otherwise non-functional areas out of visual sight are created in front of each abutment. This is not desirable from bridge security and urban design perspectives. With the MSE walls close to each abutment, the use of more efficient battered piles is precluded. For these reasons, driven pile foundations are not best suited for this bridge structure.

Drilled caissons are a very economical foundation type for this area, as determined by cost studies of the adjacent Broadway Viaduct. This is due to a good bearing layer being fairly close to the surface. Utilizing a single small diameter drilled caisson for each pier column also precludes the use of footings and the associated excavation and backfill costs. Vertical caissons behind the abutment MSE walls have enough bending capacity to resist horizontal loads. Therefore, drilled caissons are utilized for the I-25 over Santa Fe bridge.

Other Design Considerations

Standard 20' long approach slabs will be used at each abutment. Standard Type 7 bridge railings and a median barrier will also be utilized. Due to the roadways below the structure, 36" chain link fences will be used on top of the exterior barriers.

Roadway drainage may be required on the bridge. If required, cast ductile iron scuppers will be provided, along with piping to get the drainage to the storm sewer system. Every effort will be made to minimize the visual impact of any drainage piping and preserve structure aesthetics.

Bridge Type Evaluation

Construction Cost:

Cost estimates can be found at the end of this report. Cost information was compiled for the appropriate items using the most recent CDOT cost data for a period of 1-3 years depending on the item. The major pay items are included and a 15% contingency is added to account for other miscellaneous items. The cost of the Precast Girder alternate and the CIP Box Girder alternate are nearly the same at approximately $10.5 to $11 million. The cost of the Steel Girder alternate is substantially higher at approximately $13.5 million. The total length of the Steel Girder alternate is greater than the length of the other alternates because of the effort to select the most efficient span layout, as discussed in the Bridge Superstructure Alternatives section. Because of this, the square foot costs are also compared. It is noted that whether total cost or square foot cost is used, the results of the matrix are the same.

Aesthetics:

Refer to the Project Overview for a more complete discussion on the aesthetic theme and treatment for the entire project. This section discusses only those aesthetic elements which may distinguish one alternate from another.

A number of factors influence the aesthetic perception of a bridge including shape, continuity, complexity, color, and texture. Generally, color and texture can be applied to any of the structure types and are therefore not considered here except to note that weathering steel is not considered to be aesthetically acceptable.

With 8 or 10 girder lines for a 149' wide structure, none of the alternates are considered to have a congested look. However, the smooth soffits of the concrete girder alternates are considered more aesthetic than the multiple steel plate girders with stiffeners and transverse cross-frames between girders. The protruding bottom flange of steel girders creates a point of discontinuity in the cross-section, whereas the cross-sections of the concrete alternates have a more continuous simple look. Sloping webs are generally considered to be more aesthetic than vertical webs, giving the box girder alternates some advantage. For this project, a simple continuous look is preferred over an industrial look.

The bent cap of the Steel Girder alternate is below the superstructure and creates discontinuity both in elevation view and in cross-section, which adds to the complexity and visual mass of the structure, especially considering that the bridge provides only minimum vertical clearances. Integral bent caps could be utilized, but it would add cost and construction complexity. The Precast Girder alternate does not have a bent cap since there is a column under each girder line. The CIP Box Girder alternate has an integral bent cap that is low cost and simple to build with typical construction methods.

Given the above considerations, the concrete girder alternates are given "excellent" aesthetic ratings, while the Steel Girder alternate is given a lower "good" aesthetic rating.

Durability and Maintainability:

All of the alternates considered have good durability and a long design life. Every effort has been made to minimize the numbers of bearings and joints, which are high maintenance items. All alternates also have a waterproofing membrane with a stone matrix asphalt wearing course.

The steel girders should be repainted at regular intervals in order to prevent corrosion. However, repainting of steel structures is not typically done in Colorado. This will lead to some corrosion and unsightly rust starting approximately 15 to 25 years after construction is complete. Alternatively, weathering steel could be used; however staining of the piers and abutments is common. Any painting or staining of the concrete girders will also have a finite life, but the coating is purely aesthetic and not required for corrosion protection. The substructures for all alternates are nearly the same with regard to durability and maintainability.

Inspection access is not a major concern for any of the alternates and can be done with a manlift from below the structure. Some maintenance of traffic will be required for inspections. The Steel Girder alternate has a large number of details (welds, bolts, stiffeners, cross-frames etc.) requiring inspection. Inspection of the concrete girders is relatively simple and typically includes only a visual inspection of the concrete surfaces. Inspection doors will be provided for interior inspection of the girders.

Given the above considerations, the concrete girder alternates are given "excellent" durability and maintainability ratings, while the steel girder alternate is given a lower "good" durability and maintainability rating.

Constructability:

All of the alternates are standard structure types that can be built with typical construction techniques. There are multiple contractors in Colorado having experience with these types of structures.

As discussed in the Construction Phasing/Constructability Section above, the Precast Girder alternate and the Steel Girder alternate can be constructed with minimal impact to traffic. The CIP Box Girder alternate will require falsework over active traffic. This will reduce horizontal and vertical clearances and affect sight distances. There is some added complexity in designing and erecting falsework over the roadways below the main span. Additional roadway closures will also be required to erect the falsework.

Due to the impacts on the traffic below, as well as the challenges with designing and erecting the falsework, the Cast-in-Place alternate is given a "Good" constructability rating, while the precast concrete girder alternate and steel plate girder alternate are given "Excellent" constructability ratings.

Clearance:

In the final configuration, all alternates satisfy the AASHTO minimum required vertical clearance requirement of 16'-6" and satisfy sight distance requirements. Because of the effort to minimize span length, all alternates will have a pier or pier cap within 30' of the edge of roadway and will need pier protection or piers that are designed for the impact load. As such, there is no distinction between alternates as far as final clearance is concerned.

For the CIP Box Girder alternate, the falsework under the main span will result in less vertical and horizontal clearances than for the final structure. It is highly likely that a temporary vertical clearance of less than 16'-6" will be required. (Note that the existing northbound structure has a vertical clearance of 15'-5".)

Given the reduced construction clearance, the CIP Box Girder alternate is given a rating of "Good", while the Precast Girder alternate and Steel Girder alternate are given "Excellent" ratings.

Evaluation:

Below is the structure evaluation matrix. Construction cost is given a weighting factor of 3.0, aesthetics are given a weighting factor of 2.0, and all other evaluation categories are given a weighting factor of 1.0.

As can be seen from the matrix, the recommended structure type is Spliced Precast Post-Tensioned Colorado U-Girders.

Summary of Structure Recommendations

The recommended structure type is Spliced Precast Post-Tensioned Colorado U-Girders. We recommend eight girder lines, each supported on its own column at interior bents. The girder and column will be integral and no pier cap is required. Simple stub abutments sitting above and behind wrap-around MSE walls are also recommended. The piers and abutments will be supported on drilled caissons extending down into competent bedrock.

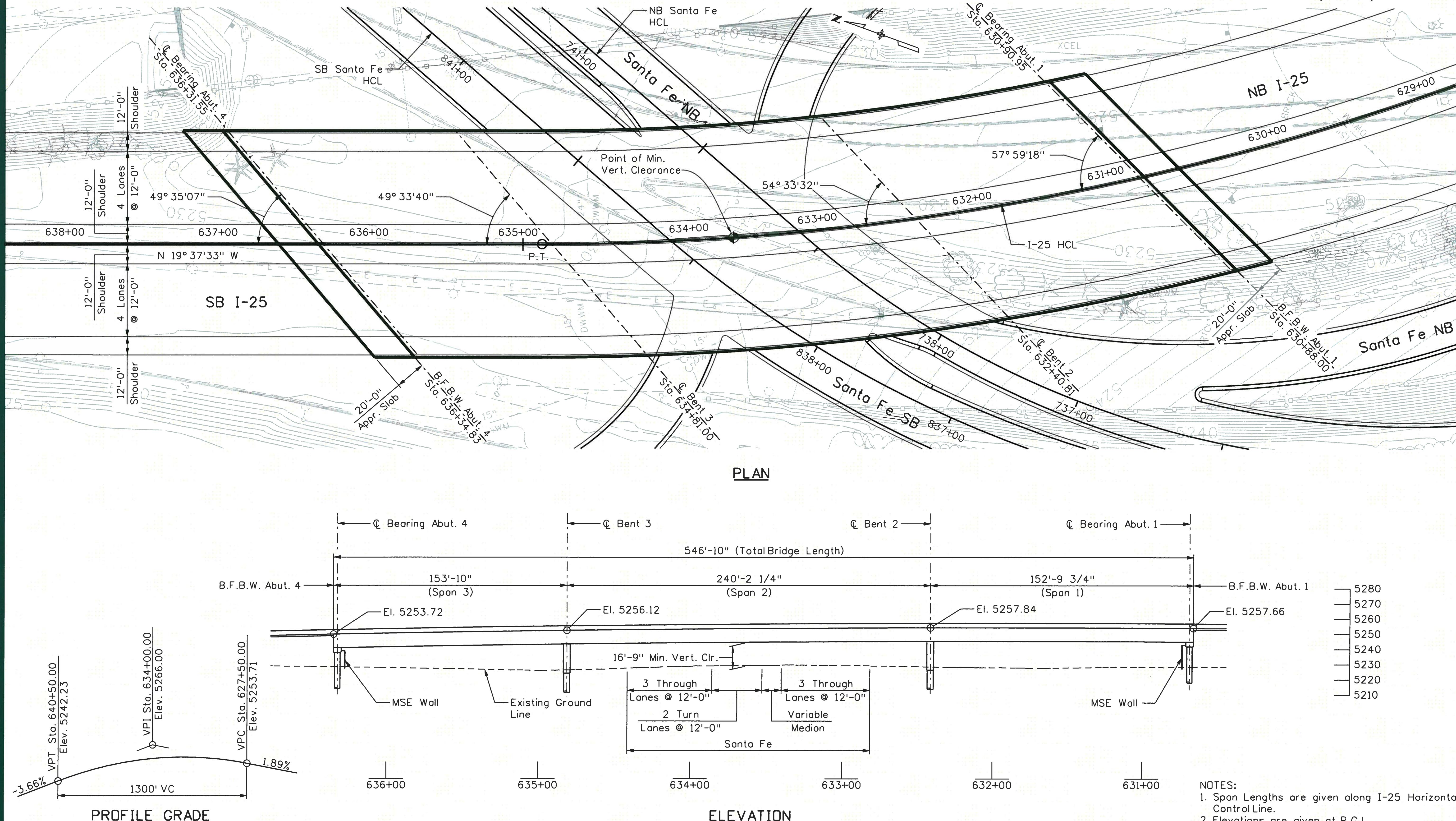
Evaluation Matrix

Superstructure Type	Least Construction Cost	Aesthetics	Durability & Maintainability	Constructibility	Clearance		Construction Cost Weight Factor	Aesthetic Weight Factor	Totals
Spliced Precast Post-Tensioned Colorado U-Girder	3	3	3	3	3		3	2	24
Cast-in-Place Concrete Box Girder	3	3	3	2	2		3	2	22
Spliced Steel Plate Girders	1	2	2	3	3		3	2	15
N/A or Low Importance	0								
Satisfactory	1								
Good	2								
Excellent	3								

	Estimated Cost	% Greater	Rating #
Spliced Precast Post-Tensioned Colorado U-Girder	$10,932,800	2.80%	3
Cast-in-Place Concrete Box Girder	$10,635,000	0.00%	3
Spliced Steel Plate Girders	$13,604,800	27.92%	1

Construction Cost Evaluation

Least Cost	=	3
0-5% Greater	=	3
5-10% Greater	=	2
>15% Greater	=	1



NOTES:
1. Span Lengths are given along I-25 Horizontal Control Line.
2. Elevations are given at P.G.L.

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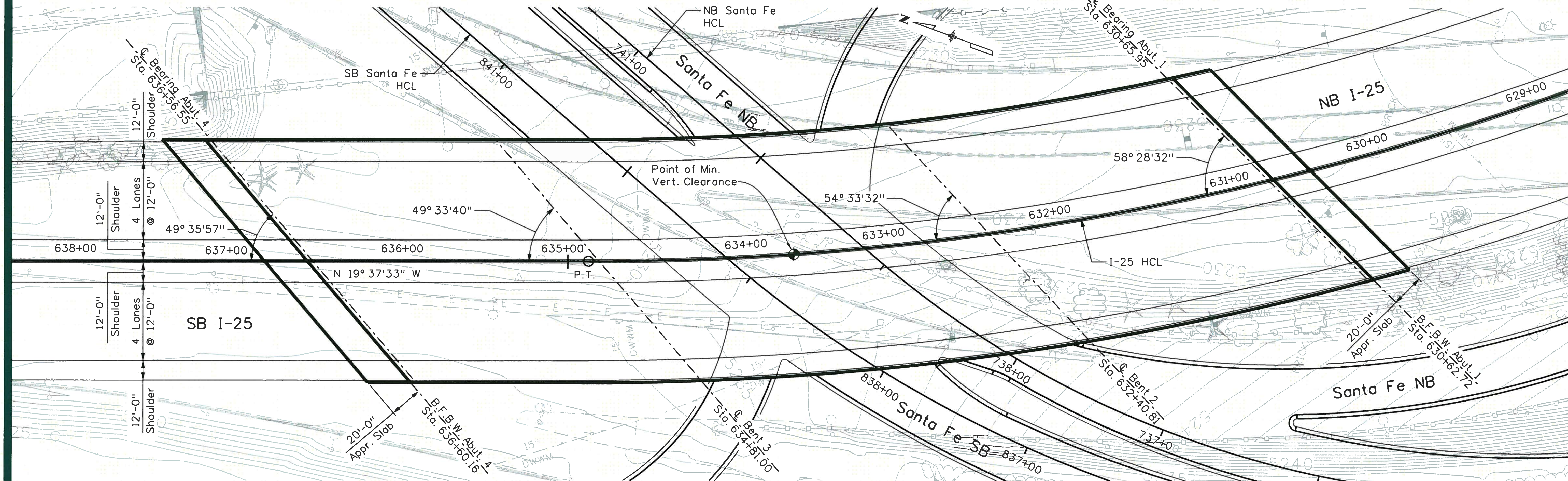
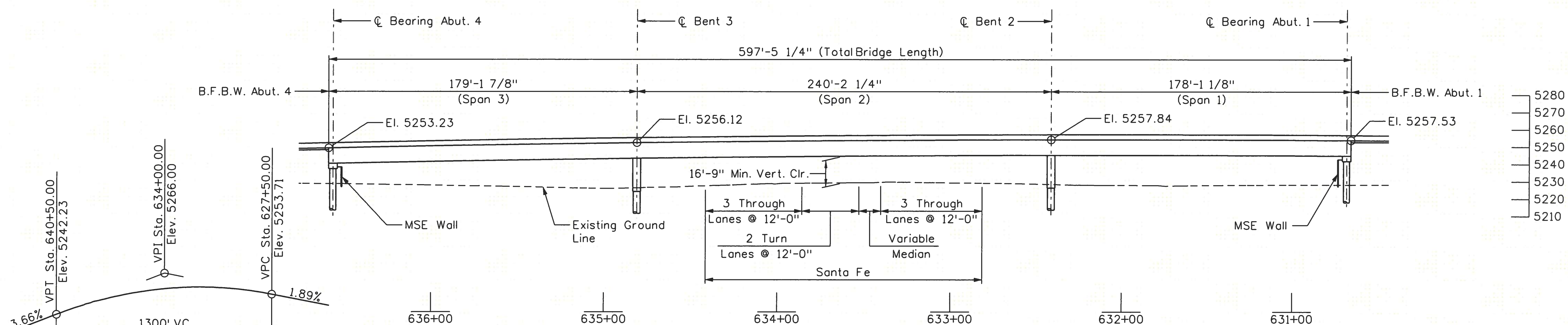
Spliced Precast Post-Tensioned Colorado U-Girder General Layout
Cast-in-Place Post-Tensioned Concrete Box Girder General Layout



PLAN



PROFILE GRADE

ELEVATION

NOTES:
1. Span Lengths are given along I-25 Horizontal Control Line.
2. Elevations are given at P.G.L.

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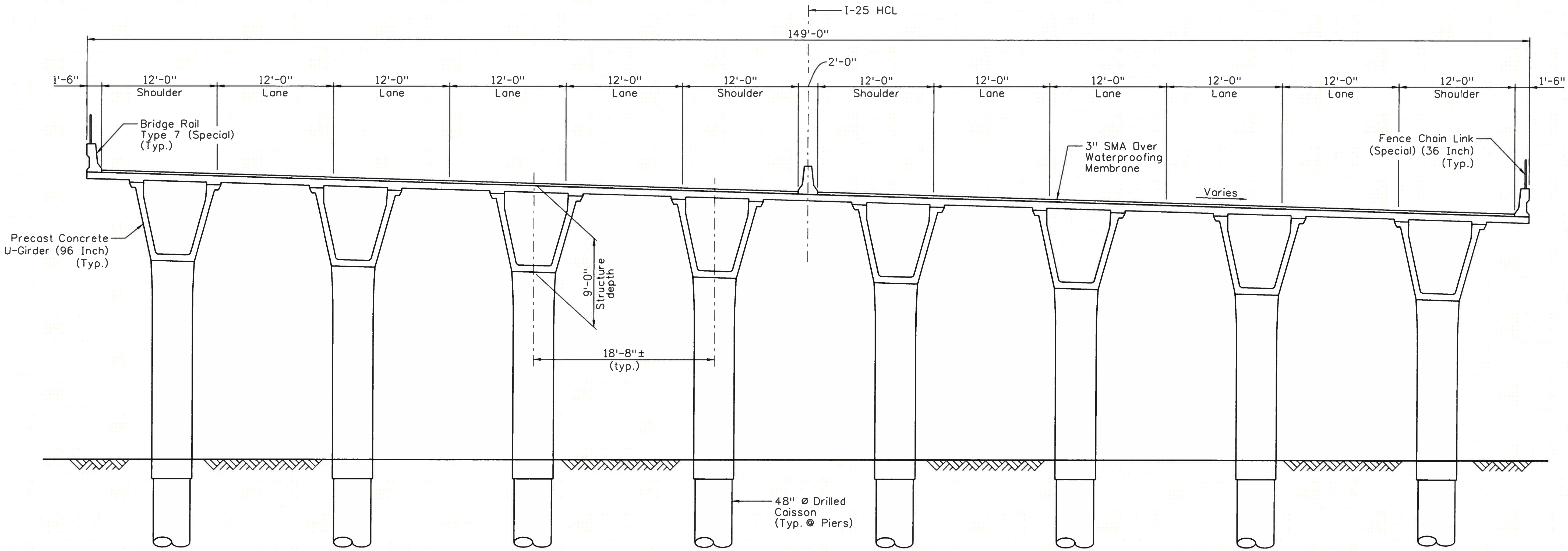
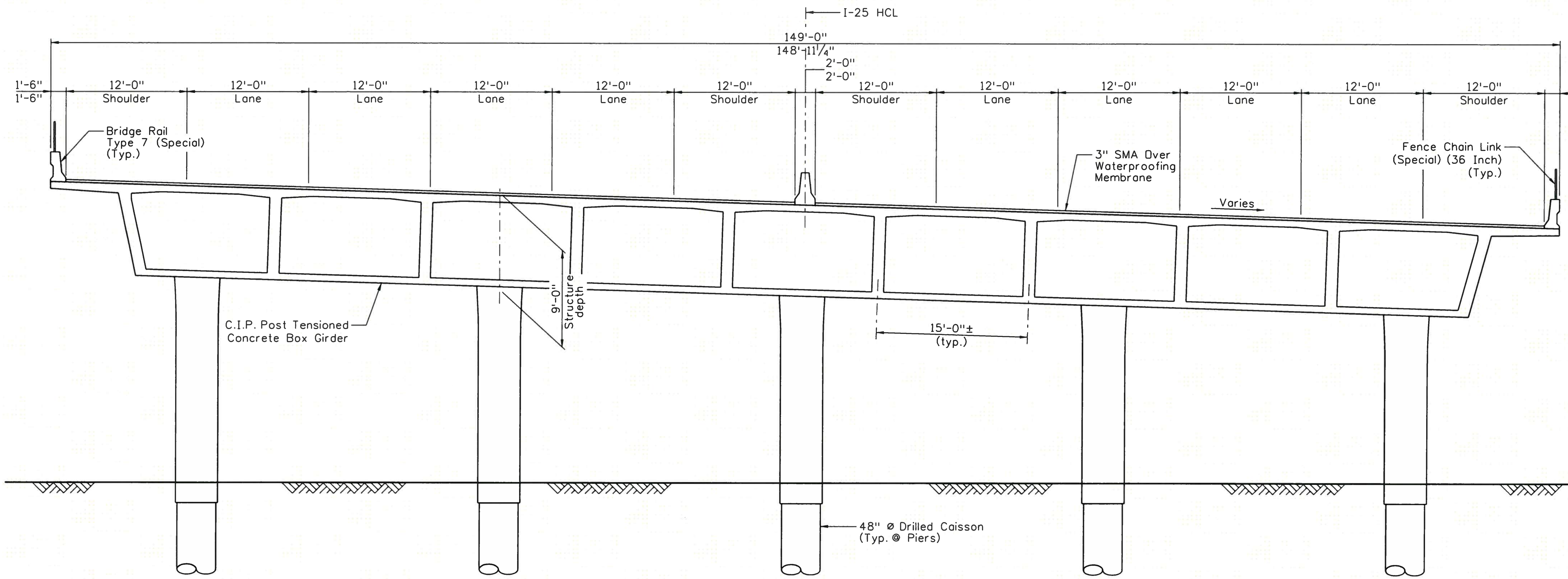
Spliced Steel Plate Girder General Layout



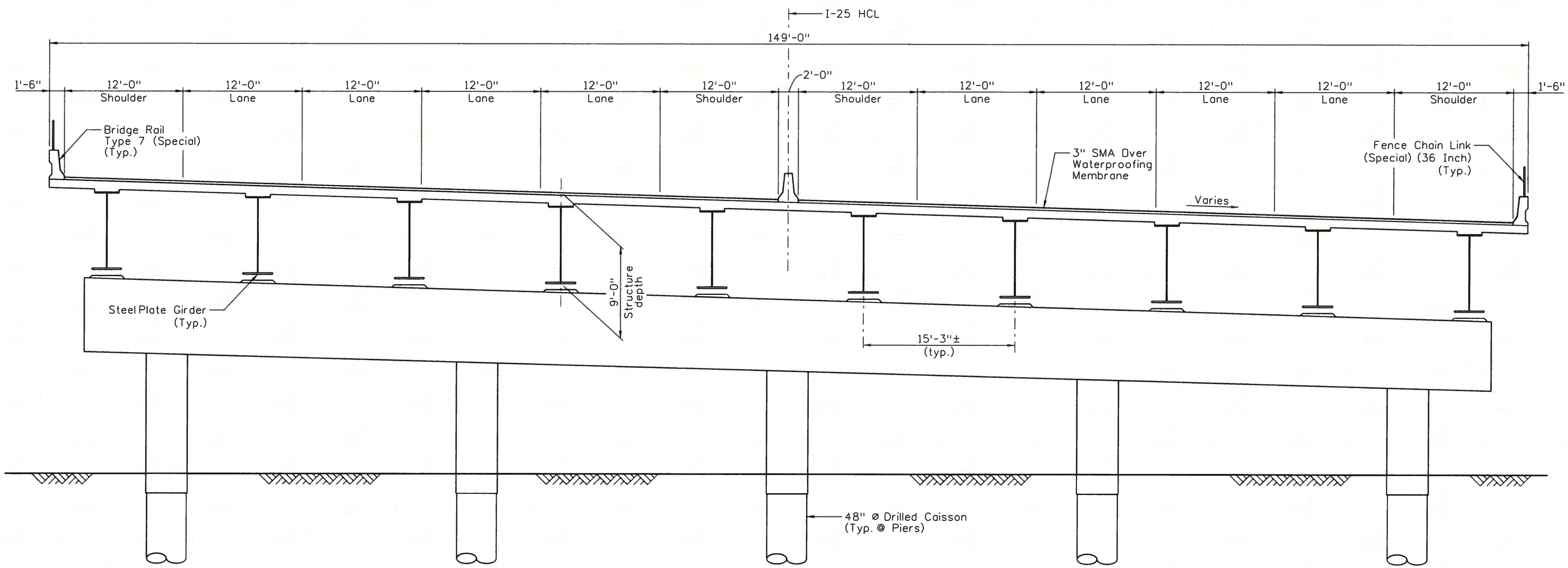
TYPICAL I-25 SECTION
(Looking Ahead Station)

Typical Cross Section - Precast Post-Tensioned Colorado U-Girder



TYPICAL I-25 SECTION
(Looking Ahead Station)

Typical Cross Section - Cast-in-Place Post-Tensioned Concrete Box Girder



TYPICAL I-25 SECTION
(Looking Ahead Station)

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Typical Cross Section - Spliced Steel Plate Girder

I-25 over Santa Fe Drive

Preliminary Opinion of Probable Cost

Colorado U Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	1,560	$ 70.00	$ 109,200
515-00120	Waterproofing (Membrane)	SY	3,300	$ 15.00	$ 49,500
518-01006	Bridge Expansion Device (0-6 inch)	LF	370	$ 850.00	$ 314,500
601-03040	Concrete Class D (Bridge)	CY	3,000	$ 500.00	$ 1,500,000
601-05050	Concrete Class S50	CY	230	$ 850.00	$ 195,500
602-00020	Reinforcing Steel (Epoxy Coated)	LB	925,000	$ 1.10	$ 1,017,500
606-10705	Bridge Rail Type 7 (Special)	LF	1,200	$ 80.00	$ 96,000
607-53136	Fence Chain Link (36 inch)	LF	1,200	$ 35.00	$ 42,000
618-00002	Prestressing Steel Strand	MKFT	17,400	$ 60.00	$ 1,044,000
618-10100	Precast Concrete U Girder (Post-Tensioned)	LF	4,260	$ 800.00	$ 3,408,000
			Subtotal - Superstructure		*$ 7,776,200*
	Substructure				
503-00042	Drilled Caisson (42 Inch)	LF	940	$ 270.00	$ 253,800
503-00048	Drilled Caisson (48 inch)	LF	800	$ 340.00	$ 272,000
601-03040	Concrete Class D (Bridge)	CY	545	$ 450.00	$ 245,250
602-00020	Reinforcing Steel (Epoxy Coated)	LB	145,000	$ 1.10	$ 159,500
			Subtotal - Substructure		*$ 930,550*
202-00400	Removal of Bridge	EACH	2	$ 400,000.00	*$ 800,000*
			Subtotal		$ 9,506,750
	Miscellaneous Items (Not Quantified)			15.0%	$ 1,426,013
	TOTAL				**$ 10,932,800**

Bridge Width 149.00 ft
Bridge Length 540.00 ft
Total Area 81459 sf
Cost per Square Foot
Superstructure $109.78 per sf
Substructure $13.14 per sf
Total $134.21 per sf (Includes Rem. of Bridge & Contin.)

Cast-in-Place Post Tensioned Box Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	1,560	$ 70.00	$ 109,200
515-00120	Waterproofing (Membrane)	SY	3,300	$ 15.00	$ 49,500
518-01006	Bridge Expansion Device (0-6 inch)	LF	370	$ 850.00	$ 314,500
601-05050	Concrete Class S40	CY	6,420	$ 650.00	$ 4,173,000
602-00020	Reinforcing Steel (Epoxy Coated)	LB	1,475,000	$ 1.10	$ 1,622,500
606-10705	Bridge Rail Type 7 (Special)	LF	1,200	$ 80.00	$ 96,000
607-53136	Fence Chain Link (36 inch)	LF	1,200	$ 35.00	$ 42,000
618-00002	Prestressing Steel Strand	MKFT	20,200	$ 60.00	$ 1,212,000
			Subtotal - Superstructure		*$ 7,618,700*
	Substructure				
503-00042	Drilled Caisson (42 Inch)	LF	1,240	$ 270.00	$ 334,800
503-00048	Drilled Caisson (48 inch)	LF	600	$ 340.00	$ 204,000
601-03040	Concrete Class D (Bridge)	CY	425	$ 450.00	$ 191,250
602-00020	Reinforcing Steel (Epoxy Coated)	LB	90,000	$ 1.10	$ 99,000
			Subtotal - Substructure		*$ 829,050*
202-00400	Removal of Bridge	EACH	2	$ 400,000.00	*$ 800,000*
			Subtotal		$ 9,247,750
	Miscellaneous Items (Not Quantified)			15.0%	$ 1,387,163
	TOTAL				**$ 10,635,000**

Bridge Width 149.00 ft
Bridge Length 540.00 ft
Total Area 81459 sf
Cost per Square Foot
Superstructure $107.56 per sf
Substructure $11.70 per sf
Total $130.56 per sf (Includes Rem. of Bridge & Contin.)

Steel I-Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	1,690	$ 70.00	$ 118,300
509-00000	Structural Steel	LB	4,384,000	$ 1.60	$ 7,014,400
515-00120	Waterproofing (Membrane)	SY	3,570	$ 15.00	$ 53,550
518-01004	Bridge Expansion Device (0-4 inch)	LF	370	$ 260.00	$ 96,200
601-03040	Concrete Class D (Bridge)	CY	2,790	$ 500.00	$ 1,395,000
602-00020	Reinforcing Steel (Epoxy Coated)	LB	725,000	$ 1.10	$ 797,500
606-10705	Bridge Rail Type 7 (Special)	LF	1,300	$ 80.00	$ 104,000
607-53136	Fence Chain Link (36 inch)	LF	1,300	$ 35.00	$ 45,500
			Subtotal - Superstructure		*$ 9,624,450*
	Substructure				
503-00042	Drilled Caisson (42 Inch)	LF	650	$ 270.00	$ 175,500
503-00048	Drilled Caisson (48 inch)	LF	700	$ 340.00	$ 238,000
601-03040	Concrete Class D (Bridge)	CY	1,325	$ 450.00	$ 596,250
602-00020	Reinforcing Steel (Epoxy Coated)	LB	360,000	$ 1.10	$ 396,000
			Subtotal - Substructure		*$ 1,405,750*
202-00400	Removal of Bridge	EACH	2	$ 400,000.00	*$ 800,000*
			Subtotal		$ 11,830,200
	Miscellaneous Items (Not Quantified)			15.0%	$ 1,774,530
	TOTAL				**$ 13,604,800**

Bridge Width 149.00 ft
Bridge Length 590.00 ft
Total Area 88864 sf
Cost per Square Foot
Superstructure $124.55 per sf
Substructure $18.19 per sf
Total $153.10 per sf (Includes Rem. of Bridge & Contin.

NB SANTA FE TO NB I-25 FLYOVER (STRUCTURE NO. F-16-XR)

Bridge Layout

The new bridge will be a flyover ramp servicing NB Santa Fe traffic to NB I-25. The ramp will begin south of the proposed I-25 / Santa Fe intersection, cross over both I-25 and Santa Fe Drive, and then merge with NB I-25 north of the intersection. The flyover replaces an existing left entrance ramp from NB Santa Fe as well as a right entrance ramp accessible from both directions of Santa Fe. This layout permits NB Santa Fe traffic to access NB I-25 while reducing potential congestion.

The proposed alignment is a reverse curve consisting of 2012-foot and 1160-foot radii. This alignment reduces span lengths and provides sufficient locations for piers around the numerous roadway crossings. The bridge will be approximately 1760 feet long and carry two lanes of traffic. The bridge length was determined by optimizing bridge and retaining wall costs. The roadway surface will typically contain a 2% cross slope, but transitions from one direction to the other as the curvature of the roadway shifts.

The vertical profile of the bridge was largely determined by the vertical clearances required for I-25 and Santa Fe. In order to clear I-25, the ramp will begin with a 6% grade. Once cresting, the roadway will descend at a 3.46% grade until matching the profile of I-25.

Bridge Superstructure Alternatives

Bridge superstructure alternatives were preliminarily selected to fit the following criteria:

- Accommodate curved alignment
- Prevent shoring on or near roadways
- Minimize number of piers
- Accommodate construction over traffic

Superstructure types which meet the above criteria are:

- Curved steel plate I-girders
- Curved steel box girders
- Spliced curved prestressed concrete tub girders

Each option was developed with a configuration of spans organized in three units. Unit 1 contains four spans with 139-feet end spans and 177-feet interior spans. Unit 2 contains 3 spans using a 158-feet – 197-feet – 150 feet arrangement. Unit 3 contains 4 spans with 136.5-feet end spans and 173.5-feet interior spans. By dividing the bridge into three units, the effects of thermal expansion are reduced. The arrangement also balances moments to minimize structure depth.

The steel plate I-girder alternative is advantageous due to being able to "haunch" the girder depth at the piers, resulting in a minimized structure depth over a majority of the span, while still maintaining an economical structure depth at the piers. Although additional costs are incurred when varying the web depth of a steel girder, the minimized structure depth over the I-25 corridor was necessary to attain sufficient vertical clearance.

Due to the increased fabrication costs, steel box girders are significantly more expensive than steel plate girders. Due to spliced concrete tub girders offering similar aesthetic appeal at a reduced cost, steel boxes were not considered further in the evaluation.

The spliced curved prestressed concrete tub girders alternative is advantageous due to its tapered girder webs, which adds aesthetic appeal. The girders would maintain a constant depth across the entire bridge rather than "haunching" them over the interior supports. Construction of the spliced concrete girder option will require temporary supports during construction that must accommodate maintenance of existing traffic.

Bridge Substructure

Substructure alternatives were determined based aesthetics and constructability. Round concrete column piers were chosen as the most attractive option. The column piers will be located to satisfy offsets from existing roadways.

Stubby concrete abutments supported on H-pile will be utilized at each end of the flyover.

Foundations for these substructure elements are discussed in the Geotechnical Considerations section.

Construction Phasing / Constructability

The ramp structure will be constructed in a single phase. The steel option can be erected with minimal temporary supports during construction. The concrete alternate will utilize vertical shoring towers that do not impact traffic on existing roadways prior to being self supporting. Temporary closures of I-25 and Santa Fe will be required to erect the girders of all options.

Overhead power lines are present, but should not pose a problem for construction.

Geotechnical Considerations

The preliminary Geotechnical Report provides estimates for the strength level capacities for spread footings at 3300 psf in existing fill, and 5000 psf in the natural gravelly sand. Preliminary estimates for the drilled caisson strength level capacities are 8-13 ksf side resistance and 160 ksf end resistance. Boring logs show bedrock within about 35' of the existing surface. Driven piles were also a recommended deep foundation alternative.

Due to the low bearing capacities, spread footings would need to be large. Pier footings would also require excavation (and possible cofferdams and dewatering) and backfill. Differential settlement between the footings at the piers (supporting more load) and at the abutments (supporting less load) are also a concern for this foundation type. Because of these reasons, spread footings are not desirable.

Drilled caissons are a very economical foundation type for this area, as determined by cost studies of the adjacent Broadway Viaduct. This is due to a good bearing layer being fairly close to the surface. Utilizing a multiple small diameter drilled caisson for each pier location will support the viaduct with less effort and cost when compared to a driven pile foundation. However, at the abutments where loads are reduced and flexibility is preferred, driven pile foundation is proposed.

Other Design Considerations

Bridge drainage will be handled by utilizing bridge deck drains along the bridge length, combined with approach slab inlets at each end of the bridge. Drainage will be routed to the piers and abutments and will travel through down spouts before discharging at the base.

No utilities are planned to be supported by the flyover at this time. Ramp lighting will be provided per CDOT ramp lighting criteria.

A 0-6 inch bridge expansion joint will be required at each abutment and two interior expansion piers to accommodate longitudinal movements. Manufactured bearings will be required at all expansion joint locations.

Bridge Type Evaluation

For this particular bridge, evaluation will be based on:

- Least construction cost
- Aesthetics
- Durability and maintainability
- Constructability
- Clearance

Construction cost will include the cost of the new bridge, including superstructure and substructure, as well as additional cost associated with shoring.

Refer to the Project Overview for a more complete discussion on the aesthetic theme and treatment for the entire project. This section discusses only those aesthetic elements which may distinguish one alternate from another. The trapezoidal shape of the box girder alternatives are ranked higher in the aesthetic category due to there aesthetic appeal.

Durability and maintainability will evaluate the proven durability of the structure type, and how easily it is maintained. Due to the increased inspection effort in inspecting the interior of closed girder shapes, the I-girder alternative is found to be more advantageous in this category.

Constructability evaluates not only the construction effort put forth by the contractor, but also impacts to the traveling public (user cost). Alternatives which require a longer timeframe to construct will score lower due to the impacts to maintaining traffic through the extended construction period.

Clearance evaluates the required roadway clearances. All alternatives satisfy the minimum vertical clearance of 16'-6", and also satisfy required roadside clearances, therefore are rated equally.

An evaluation matrix was created to accurately determine the preferred option. Due to the importance of construction cost, a weighting factor of three was applied in the evaluation matrix to the construction cost rating. Due to the high visibility of the flyover to the traveling public, aesthetics were deemed to have higher importance in the selection, therefore a weighting factor of two was used. All other evaluation criteria were left un-weighted, reflecting equal importance.

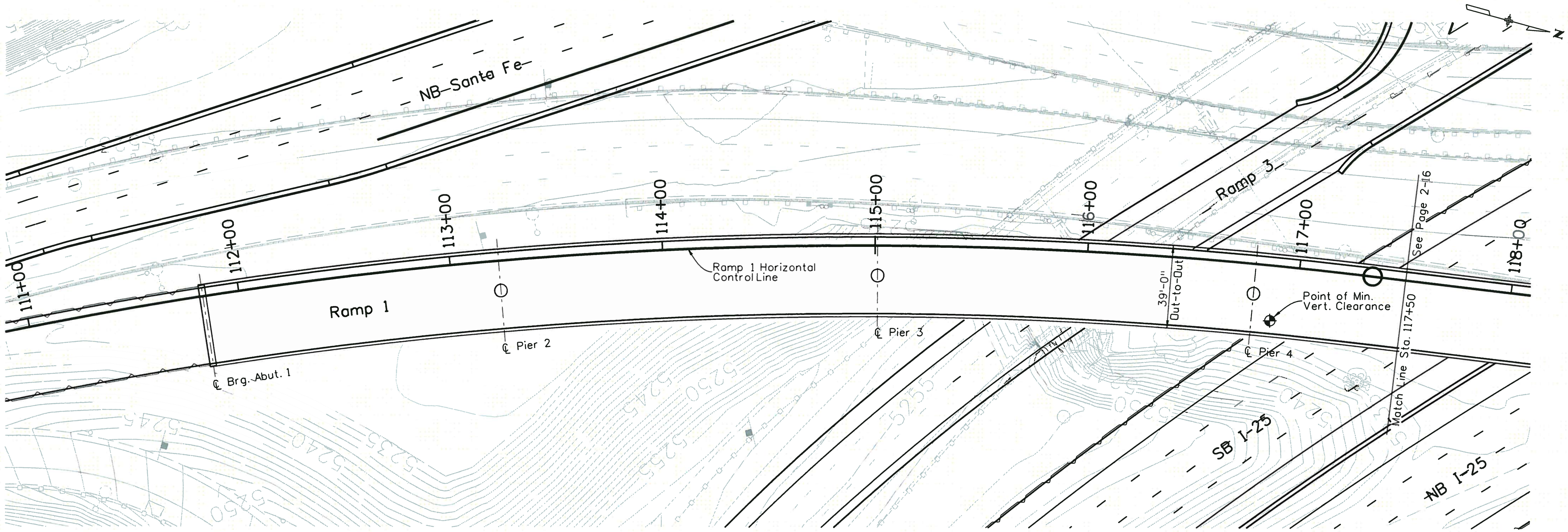
As shown by the evaluation matrix, Colorado U Girders are the recommended alternative for the Santa Fe Bridge over the Platte River.

Evaluation Matrix										
Superstructure Type	Least Construction Cost	Aesthetics	Durability & Maintainability	Constructibility	Clearance		Construction Cost Weight Factor	Aesthetic Weight Factor	Totals
Spliced Precast Post-Tensioned Colorado U-Girder	3	3	2	2	3		3	2	22
Steel Plate I-Girder	2	2	3	3	3		3	2	19

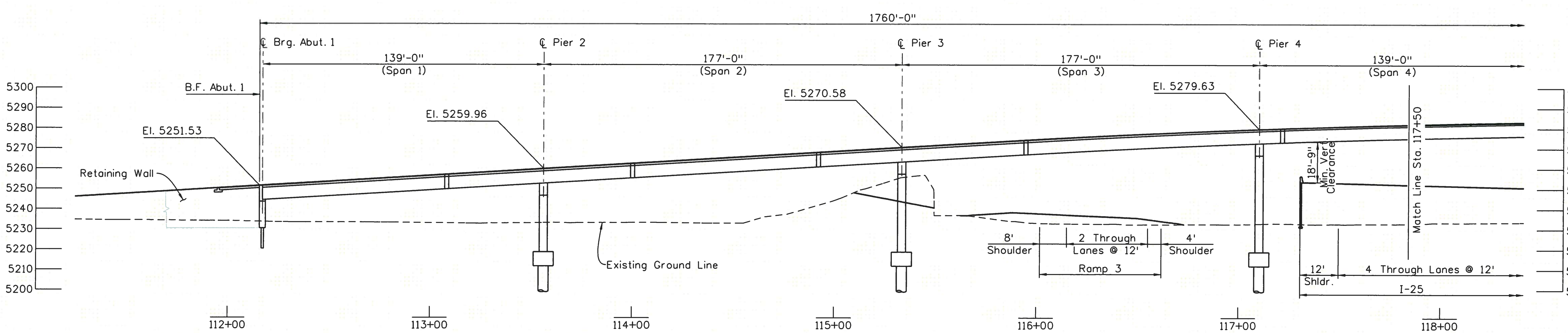
N/A or Low Importance	**0**
Satisfactory	**1**
Good	**2**
Excellent	**3**

	Estimated Cost	% Greater	Rating #
Spliced Precast Post-Tensioned Colorado U-Girder	$9,273,000	0.00%	3
Steel Plate I-Girder	$10,582,000	14.12%	2

Construction Cost Evaluation		
Least Cost	=	3
0-5% Greater	=	3
5-10% Greater	=	2
>15% Greater	=	1



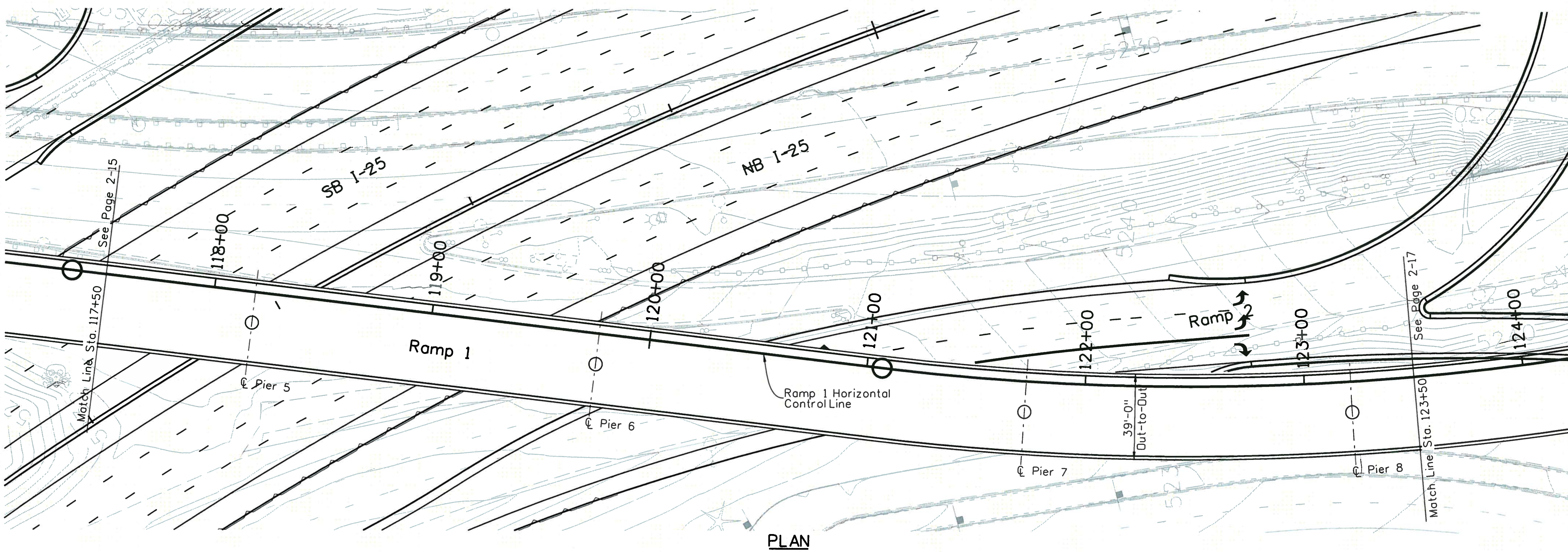
PLAN



LONGITUDINAL SECTION

FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

Ramp 1
(NB Santa Fe to NB I-25 Flyover)



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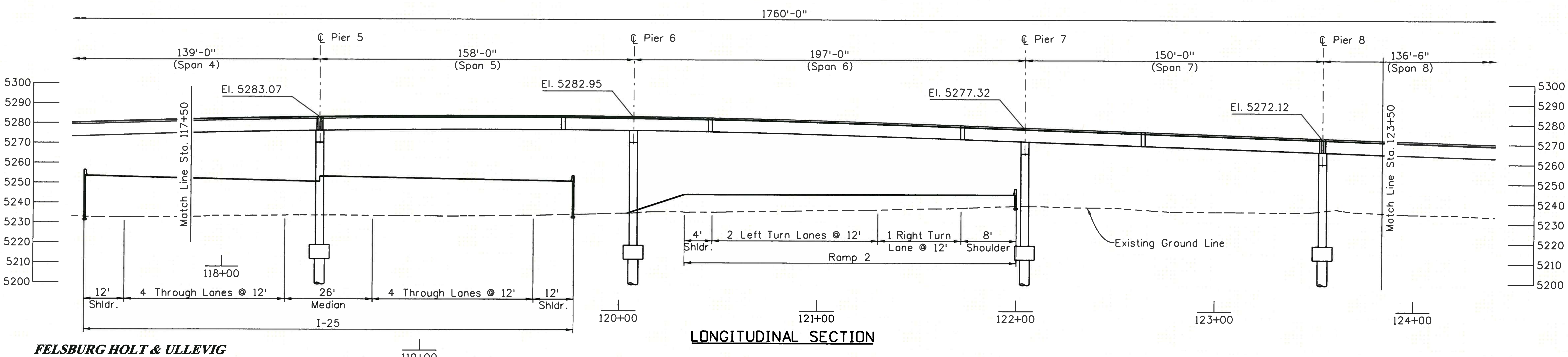
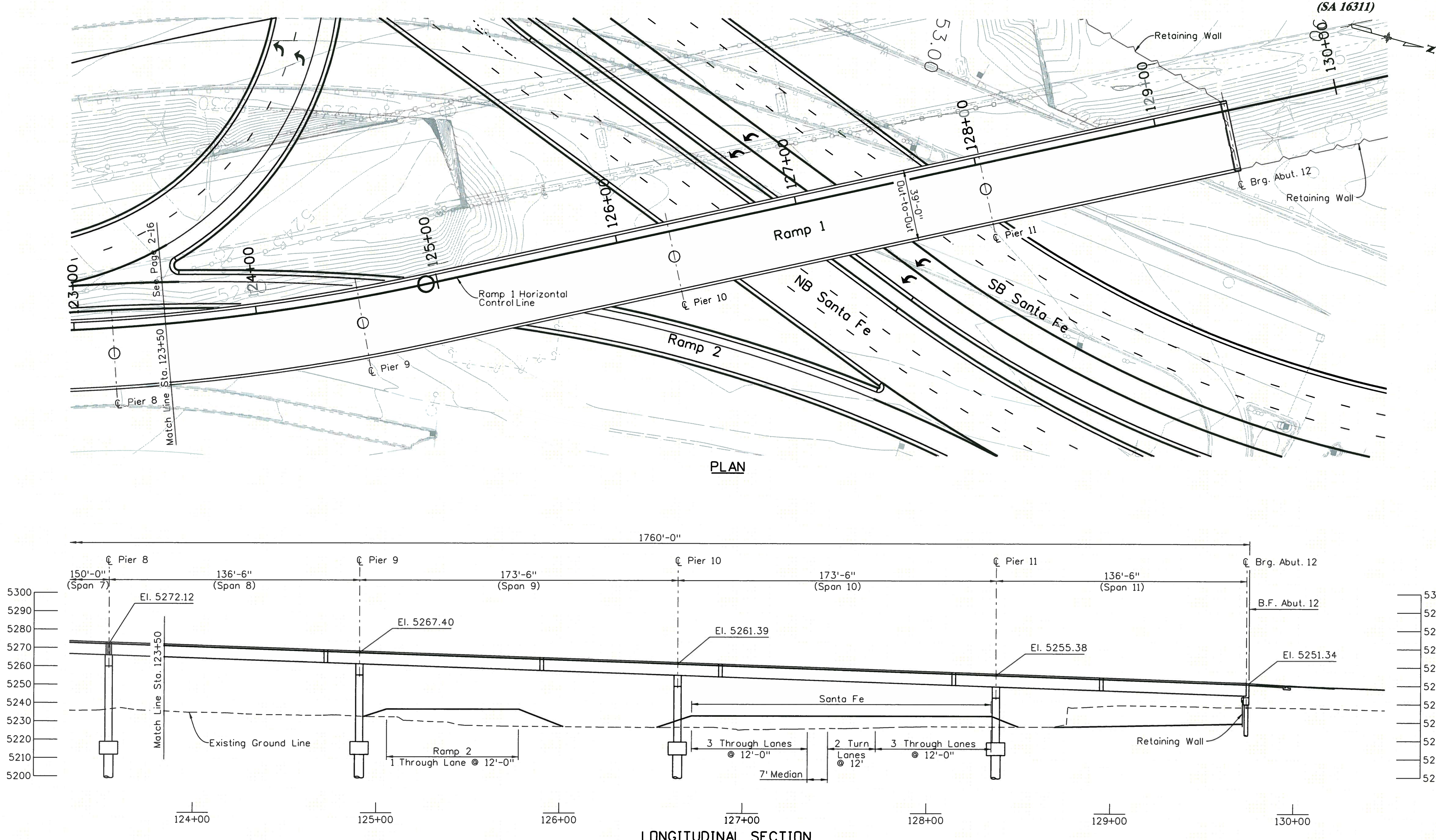


LONGITUDINAL SECTION

FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

Ramp 1
(NB Santa Fe to NB I-25 Flyover)



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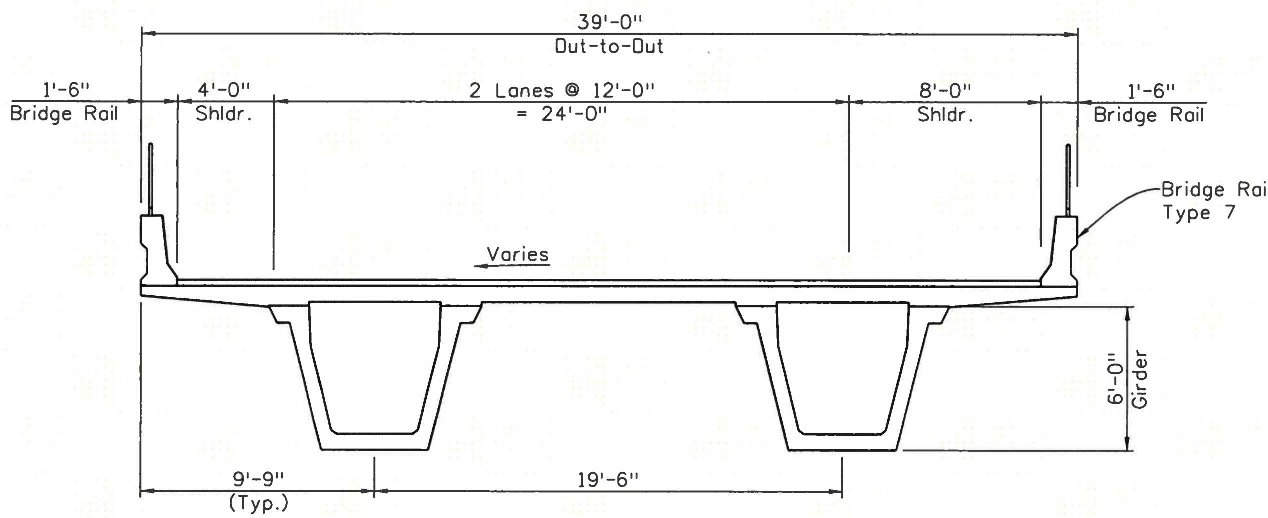
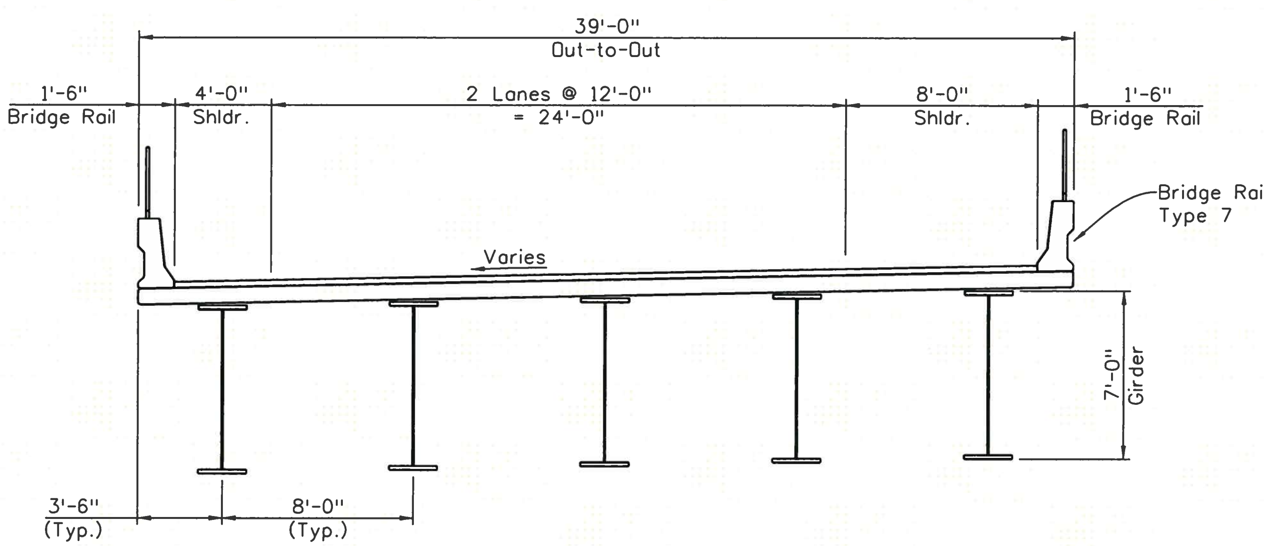
FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

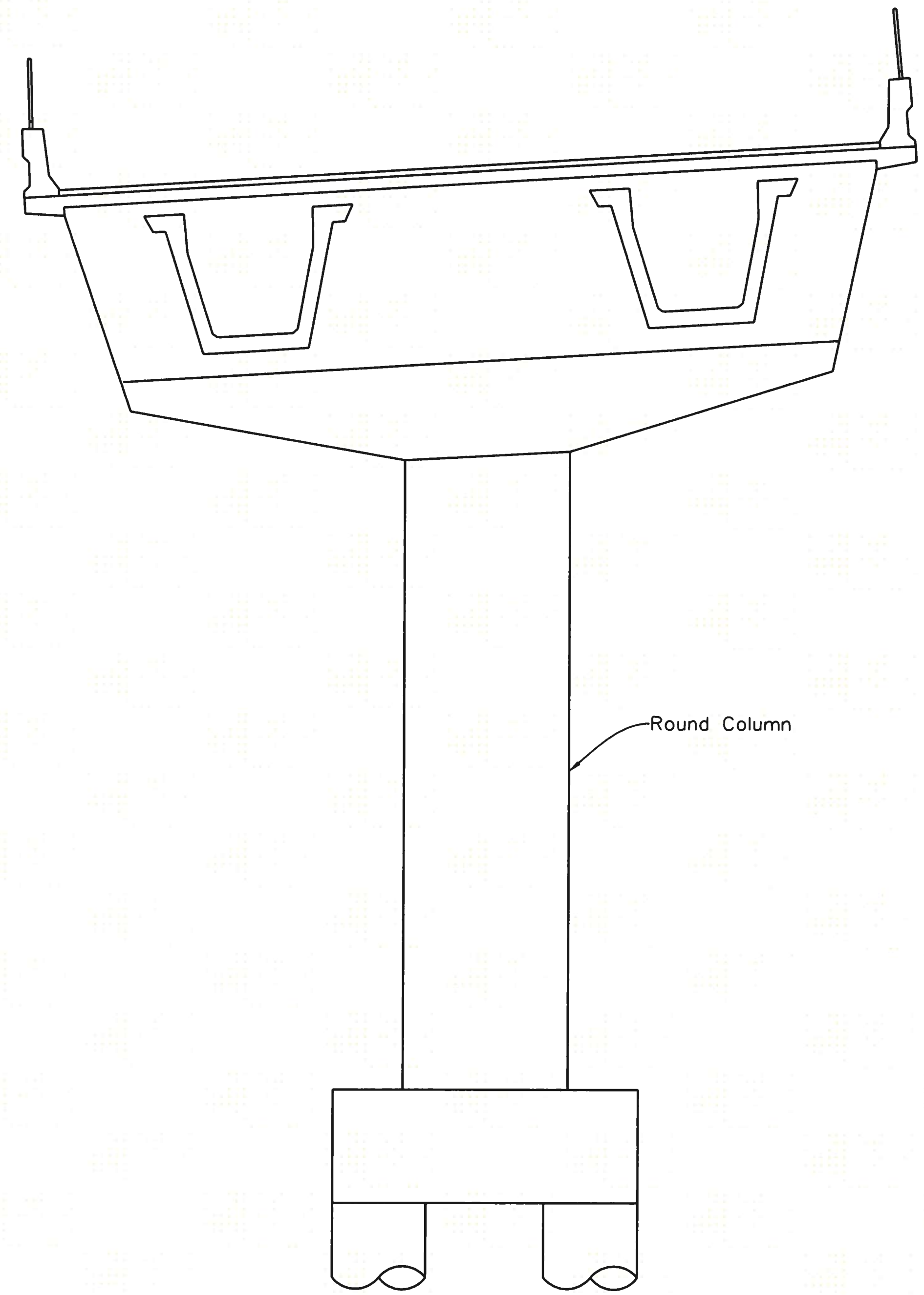
Ramp 1
(NB Santa Fe to NB I-25 Flyover)



COLORADO U GIRDER
(LOOKING NORTH)



STEEL PLATE I-GIRDER
(LOOKING NORTH)



RAMP 1
TYPICAL SECTION AT PIER

Ramp 1 Flyover
Bridge Typical Sections

Ramp 1 Flyover

Preliminary Opinion of Probable Cost

Colorado U Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	1,175	$ 70.00	$ 82,250
512-00101	Bearing Device Type I	EACH	12	$ 1,200.00	$ 14,400
515-00120	Waterproofing (Membrane)	SY	7,040	$ 15.00	$ 105,600
518-01006	Bridge Expansion Device (0-6 inch)	LF	180	$ 850.00	$ 153,000
601-03040	Concrete Class D (Bridge)	CY	2,360	$ 500.00	$ 1,180,000
601-05050	Concrete Class S50	CY	80	$ 850.00	$ 68,000
602-00020	Reinforcing Steel (Epoxy Coated)	LB	625,000	$ 1.10	$ 687,500
606-10705	Bridge Rail Type 7 (Special)	LF	3,520	$ 80.00	$ 281,600
607-53136	Fence Chain Link (36 inch)	LF	3,520	$ 35.00	$ 123,200
618-00002	Prestressing Steel Strand	MKFT	17,500	$ 60.00	$ 1,050,000
618-10100	Precast Concrete U Girder (Post-Tensioned)	LF	3,520	$ 800.00	$ 2,816,000
				Subtotal - Superstructure:	*$ 6,561,550*
	Substructure				
206-01750	Shoring	LS	1	$ 250,000.00	$ 250,000
502-00460	Pile Tip	EA	12	$ 140.00	$ 1,680
502-11274	Steel Piling (HP 12x74)	LF	480	$ 80.00	$ 38,400
503-00048	Drilled Caisson (48 inch)	LF	1,000	$ 340.00	$ 340,000
601-03040	Concrete Class D (Bridge)	CY	1,300	$ 450.00	$ 585,000
602-00020	Reinforcing Steel (Epoxy Coated)	LB	260,000	$ 1.10	$ 286,000
				Subtotal - Substructure:	*$ 1,501,080*
			Subtotal		$ 8,062,630
	Miscellaneous Items (Not Quantified)			15.0%	$ 1,209,395
	TOTAL				**$ 9,272,100**

Bridge Width	39.00	ft
Bridge Length	1757.00	ft
Total Area	68523	sf
Cost per Square Foot		
Superstructure	$110.12	per sf
Substructure	$25.19	per sf
Total	$135.31	per sf

Steel Plate I-Girder Alternative

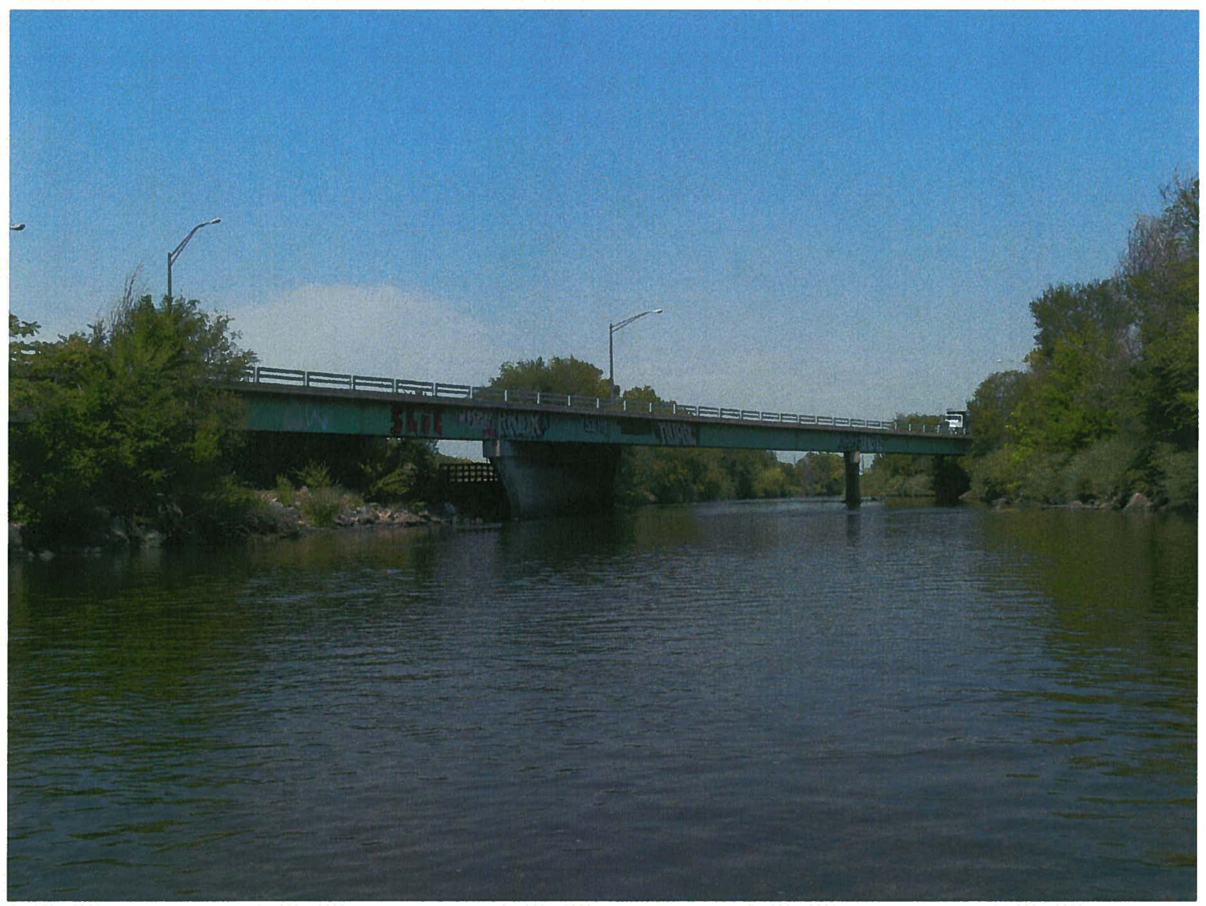
Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	1,175	$ 70.00	$ 82,250
509-00000	Structural Steel	LB	3,083,600	$ 1.60	$ 4,933,760
512-00101	Bearing Device Type I	EACH	40	$ 1,200.00	$ 48,000
512-00102	Bearing Device Type II	EACH	30	$ 3,500.00	$ 105,000
515-00120	Waterproofing (Membrane)	SY	7,040	$ 15.00	$ 105,600
518-01006	Bridge Expansion Device (0-6 inch)	LF	180	$ 850.00	$ 153,000
601-03040	Concrete Class D (Bridge)	CY	2,360	$ 500.00	$ 1,180,000
602-00020	Reinforcing Steel (Epoxy Coated)	LB	625,000	$ 1.10	$ 687,500
606-10705	Bridge Rail Type 7 (Special)	LF	3,520	$ 80.00	$ 281,600
607-53136	Fence Chain Link (36 inch)	LF	3,520	$ 35.00	$ 123,200
				Subtotal - Superstructure:	*$ 7,699,910*
	Substructure				
206-01750	Shoring	LS	1	$ 250,000.00	$ 250,000
502-00460	Pile Tip	EA	12	$ 140.00	$ 1,680
502-11274	Steel Piling (HP 12x74)	LF	480	$ 80.00	$ 38,400
503-00048	Drilled Caisson (48 inch)	LF	1,000	$ 340.00	$ 340,000
601-03040	Concrete Class D (Bridge)	CY	1,300	$ 450.00	$ 585,000
602-00020	Reinforcing Steel (Epoxy Coated)	LB	260,000	$ 1.10	$ 286,000
				Subtotal - Substructure:	*$ 1,501,080*
			Subtotal		$ 9,200,990
	Miscellaneous Items (Not Quantified)			15.0%	$ 1,380,149
	TOTAL				**$ 10,581,200**

Bridge Width	39.00	ft
Bridge Length	1757.00	ft
Total Area	68523	sf
Cost per Square Foot		
Superstructure	$129.23	per sf
Substructure	$25.19	per sf
Total	$154.42	per sf

SB SANTA FE OVER SOUTH PLATTE RIVER (STRUCTURE NO. F-16-XA)

Existing Bridge

The existing Southbound Santa Fe Drive (US 85) bridge, structure number F-16-IK, crosses the South Platte River just south of I-25. The bridge carries the combined traffic of South Kalamath Street, which includes exiting traffic from northbound I-25 turning southbound on South Kalamath Street, as well as exiting traffic from southbound I-25 which merge onto southbound Santa Fe drive just north of the existing bridge location. The bridge was built in 1973 and has four 12-foot lanes, 2-foot shoulders and galvanized steel bridge railing. The bridge follows a horizontal curve, and varies in superelevation across the bridge. The existing bridge utilizes a curved steel plate girder superstructure, supported on concrete wall piers and tall abutments founded on driven steel H-piling. The abutments and piers are skewed to align with South Platte River flows, with skews varying between 65 degrees and 74 degrees. In addition to crossing the South Platte River, the bridge also accommodates the South Platte River Trail on the south side of the river.



Existing structure F-16-IK, looking downstream (northwest)

Replacement Bridge Layout

The replacement bridge will cross the South Platte River west of the existing structure. The bridge was located to accommodate the I-25 Santa Fe reconstruction layout set forth by the Environmental Impact Study, which shifts the Santa Fe / I-25 interchange to the north and west, pushing the proposed Santa Fe alignment to the west. Therefore the north end of the bridge was located approximately 300 feet west of the existing structure to accommodate this alignment shift. However, to avoid 4f environmental actions, the south end of the bridge required avoidance of impacts to Vanderbilt Park, which is just southwest of the existing bridge. It was also desirable to tie into existing southbound alignment shortly south of the proposed bridge, to minimize project footprint. These constraints located the south end of the bridge just west of the existing structure, with the east side of the proposed structure impacting (overlapping) the west portion of the existing bridge. Although this layout requires bridge phasing, avoiding impacts to Vanderbilt Park was a priority set forth in the E.I.S.

The proposed alignment of southbound Santa Fe curves over the river, similarly to the existing bridge. The bridge length is approximately 700 feet, which follows a 4000-foot radius curve. The bridge length was established such that impacts to the existing river channel were minimized and the trail system was maintained. The proposed structure has a constant cross-slope of 2%, which creates a normal crown section when combined with the separated northbound section. Although this cross-slope is opposite direction from the horizontal curve direction, it is necessary to accommodate merging traffic just north of the bridge, and will reduce truck rollover. The bridge will carry five lanes of southbound traffic, and have a 9-foot outside shoulder, 4-foot inside shoulder, and standard CDOT bridge rails. The abutments and piers of the proposed structure align with the South Platte River, which results in a significant skew at each support, however is necessary to accommodate river flows and the existing trail alignment.

The vertical profile of southbound Santa Fe drive was set such that the south end of the proposed bridge matched closely with the south end of existing bridge to accommodate phased construction, and also ties into the existing roadway profile shortly south of the bridge, limiting project footprint. However, during preliminary design it was determined that it was beneficial to raise the profile as much as possible over the river to better accommodate hydraulic flows, as well as accommodate the South Platte River Trail under the bridge. Raising the Santa Fe profile was limited due to Santa Fe crossing beneath I-25 just north of the bridge in the proposed configuration. Therefore to best accommodate river flows and the trail system, a vertical curve was placed on the bridge.

Bridge Superstructure Alternatives

Bridge superstructure alternatives were preliminarily selected to fit the following criteria:

- Accommodate curved alignment
- Reduce shoring requirements in the river
- Minimize structure depth to accommodate hydraulic flows and trail system
- Minimize piers in the channel to:
    - Reduce hydraulic impact from bridge
    - Reduce construction efforts within the river
- Accommodate heavily skewed supports
- Accommodate phased bridge construction

Superstructure types which meet the above criteria are:

- Curved steel plate I-girders
- Curved steel box girders
- Spliced curved prestressed concrete tub girders

A four span bridge alternative was initially evaluated, with 155-feet end spans and 195-feet interior spans. This span layout balances dead load moments between spans, and also aligns the first interior piers along the rivers edge, resulting in only one pier located in the normal flow of the river.

A three span alternative was not investigated, due to the significant increase in required structure depth to span the additional length. Alternatives with more than five spans were also not investigated, due to the significant substructure costs, the added construction required in the river, as well as the tunnel effect which would result for trail users under the shortened south end span.

The steel plate I-girder alternative will utilize a "haunched" girder depth at the piers, resulting in a minimized structure depth over a majority of the span, while still maintaining an economical structure depth at the piers. Although additional costs are incurred when varying the web depth of a steel girder, the haunched girder section was deemed necessary to pass the desired hydraulic flows. The steel I-girder alternative also accommodates the heavily skewed supports the best, not requiring the skewed end sections of a box girder shape. It is also easily inspected, due to it not being a closed section.

Due to the increased fabrication costs, steel box girders are significantly more expensive than steel plate girders. The bridge horizontal alignment also features only large radius curves, where the increased torsional resistance of the steel box is not required. Therefore steel plate girders are better suited than steel box girders, and box girders were not considered further.

The spliced curved prestressed concrete tub girder alternative present many of the same advantages and disadvantages as the steel box girder alternative. The tapered box shapes are aesthetically appealing and permit passing of flood debris more efficiently, but the closed section is more difficult to inspect, requiring access doors for inspection of the inside of the box. The girders would maintain a constant depth across the entire bridge rather than "haunching" them over the interior supports. Construction of the spliced concrete girder option will require temporary supports during construction that must accommodate Platte River flows.

Bridge Substructure

Substructure alternatives were determined based on hydraulic impacts and constructability. Concrete wall piers were chosen to minimize hydraulic impacts and prevent debris collection. Upstream ends of the wall piers will be tapered reduce drag, with downstream ends tapered to be symmetrical. Wall piers minimize the number of concrete pours within the river, and easily accommodate phased bridge construction.

Tall concrete wall abutments will be utilized to reduce end spans, as well as accommodate the South Platte River Trail along the south abutment. This abutment type will mimic the wall pier aesthetics, and can easily accommodate phased construction.

Foundations for these substructure elements are discussed in the Geotechnical Considerations section.

Construction Phasing / Constructability

Bridge construction phasing will be required due to the overlap of existing and proposed bridges at the south end of both structures. Two options were considered, which accommodate required through traffic during construction while building an adjacent structure:

- Construct the proposed bridge in two phases, allowing removal of the existing bridge in its entirety
- Construct a temporary widening of the existing bridge to the east, accommodating a partial removal of the west side of the existing bridge, allowing the proposed bridge to be built in its entirety.

The first option involves phasing the proposed bridge construction. Phase 1 would include the west portion of the bridge, sufficient to carry the 4 lanes of traffic that the existing bridge currently carries. Upon completion of the phase 1 construction, traffic would be shifted on the completed portion of the new bridge. Phase 2 construction would include removal of the existing bridge, and completion of the east side of the proposed bridge.

As stated previously, only the south ends of the bridges conflict, therefore phased bridge construction is only required on the south most span and south abutment. All of the piers and the north abutment could be constructed in there entirety, and all girder sections could be set on all but the south most span. Although this reduces the effort, phased bridge construction still creates issues with diaphragm design, dead load deflections, and deck pour sequencing.

The second option is beneficial, because the entire new bridge can be constructed in one phase. However, further study of this option presented many downfalls. The alignment of the Platte River turns southward just east of the existing bridge, and numerous timber retaining walls are currently supporting the nearby roadway. Constructing a temporary widening in this area would not only result in bridge costs, but also retaining wall removal and reconstruction to support the widened section, and significant impact to the existing trail system. Following completion of the proposed bridge, all of the temporary bridge and wall elements would have to be removed, and the trail system returned to its previous state, resulting in a significant investment with little return. In addition, partial removal of the existing steel girder bridge would require additional evaluation to insure the load capacity of the west side of the bridge is sufficient. Due to these significant drawbacks, this construction scheme was not considered further in the selection report.

Geotechnical Considerations

Preliminary geotechnical results indicate shallow bedrock throughout the South Platte River, which is consistent with the existing bridge as-built plans. The bedrock was found to be non-expansive, however was consistently overtopped with approximately 20 to 30-feet of gravels and cobbles. Due to this significant layer of pervious material, caissons were not recommended due to dewatering efforts, as well as the material not being suitable for auguring without collapse.

Driven steel H-pile was the recommended deep foundation alternative for the bridge structure. Due to shallow bedrock, the H-pile foundation will be a timely foundation solution, and with the immediate surrounding area being commercial and industrial, noise implications of selecting driven H-pile is minimized. No overhead constraints are present in the vicinity of the bridge, which would prevent or hinder the crane heights associated with pile driving. Requiring pile tips is anticipated to penetrate the cobble layer without damaging the steel H-pile. In addition, cofferdams and dewatering will be required to construct the piers.

Hydraulic Considerations

Preliminary hydraulic analysis of the South Platte River was conducted to establish approximate 100-yr storm water elevations utilizing the existing channel. Although the existing bridge over the river does not pass 100-yr flows, it was preferred to raise the profile and minimize structure depth, such that a majority of the proposed bridge would pass the 100-yr storm hydraulic demand. Due to the profile constraints discussed earlier, it was expected that the ends of the structure, near the abutments, may be lower than the 100-yr water elevation. However, the addition of the vertical curve across the bridge brought the superstructure above the desired elevation for a majority of the structure. Although a free-board variance will likely be required, the proposed bridge will result in a hydraulic section which is significantly improved from the existing bridge.

The abutments and piers have been aligned with the South Platte River to minimize hydraulic drag, and also follow the existing trail alignment south of the river. Concrete wall piers are proposed to minimize collection of debris, which will be designed on deep foundation extending beyond scour limits to insure structure stability.

Other Design Considerations

Bridge drainage will be handled by utilizing multiple bridge drains along the west side of the bridge. Storm water will be piped the length of the bridge and tie into the Santa Fe Drive storm drain system.

Conventional CDOT 20-foot approach slabs will be utilized at each end of the bridge. Bridge expansion joints will be added to the ends of each approach slab to accommodate the temperature movement of the bridge. Due to the significant skew, the 0-4 inch joints will be tested to insure sufficient capacity to both translate and shear due to temperature movement. Type 1 bearing devices will be used at each abutment to accommodate this superstructure movement, and to release the temperature movements from being transferred to the abutment.

Bridge Type Evaluation

For the Santa Fe bridge over the Platte River, evaluation will be based on:

- Least construction cost
- Aesthetics
- Durability and maintainability
- Constructability
- Hydraulic Impact

Construction cost will include the cost of the replacement bridge, including superstructure and substructure, as well as additional cost associated with bridge phasing. Bridge costs will also include demolition and removal costs.

Durability and maintainability will evaluate the proven durability of the structure type, and how easily it is maintained. Due to the increased inspection effort in inspecting the interior of closed girder shapes, the I-girder alternative is found to be more advantageous in this category.

Constructability evaluates not only the construction effort put forth by the contractor, but also impacts to the traveling public (user cost). Alternatives which require a longer timeframe to construct will score lower due to the impacts to maintaining traffic through the extended construction period.

Hydraulic impact to the South Platte River will be evaluated on the alternative's superstructure depth, and the superstructure's ability to pass flows without debris collection. Girder alternatives which have a tapered outside section will score better in this category due to the reduction of debris collection, and alternatives with reduced structure depths will score better due to increased freeboard.

An evaluation matrix was created to accurately determine the preferred option. Due to the importance of construction cost, a weighting factor of three was applied in the evaluation matrix to the construction cost rating. Aesthetics were deemed to have minimal importance in the selection, therefore a weighting factor of one was used. All other evaluation criteria were left un-weighted, reflecting equal importance.

As shown by the evaluation matrix, Colorado U Girders are the recommended alternative for the Santa Fe Bridge over the Platte River.

Evaluation Matrix

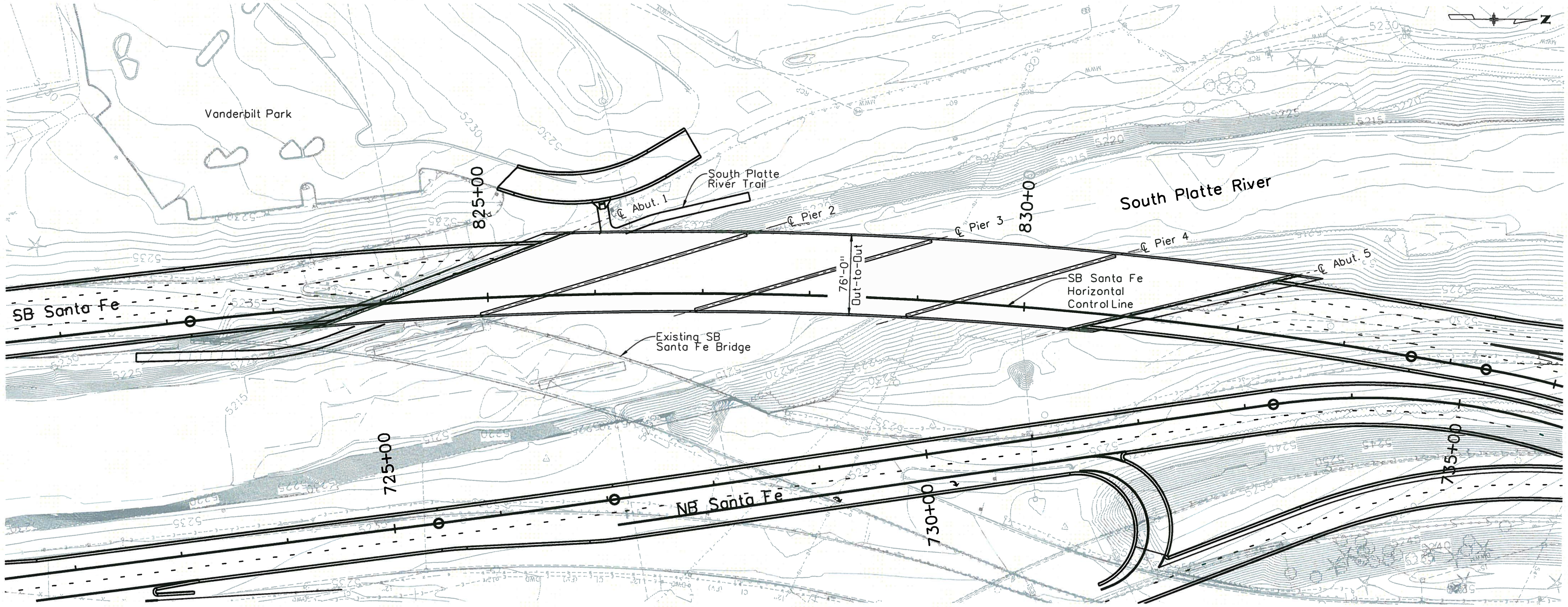
Superstructure Type	Least Construction Cost	Aesthetics	Durability & Maintainability	Constructability	Hydraulic Impacts		Construction Cost Weight Factor	Aesthetic Weight Factor	Totals
Curved Steel Plate I-Girder (haunched web)	2	2	3	3	3		3	1	17
Spliced Curved Prestressed Concrete U Girder	3	3	2	2	2		3	1	18

N/A or Low Importance	**0**
Satisfactory	**1**
Good	**2**
Excellent	**3**

	Estimated Cost	% Greater	Rating #
Curved Steel Plate I-Girder (haunched web)	$9,789,000	13.59%	2
Spliced Curved Prestressed Concrete U Girder	$8,618,000	0.00%	3

Construction Cost Evaluation

Least Cost	=	3
0-5% Greater	=	3
5-15% Greater	=	2
>15% Greater	=	1



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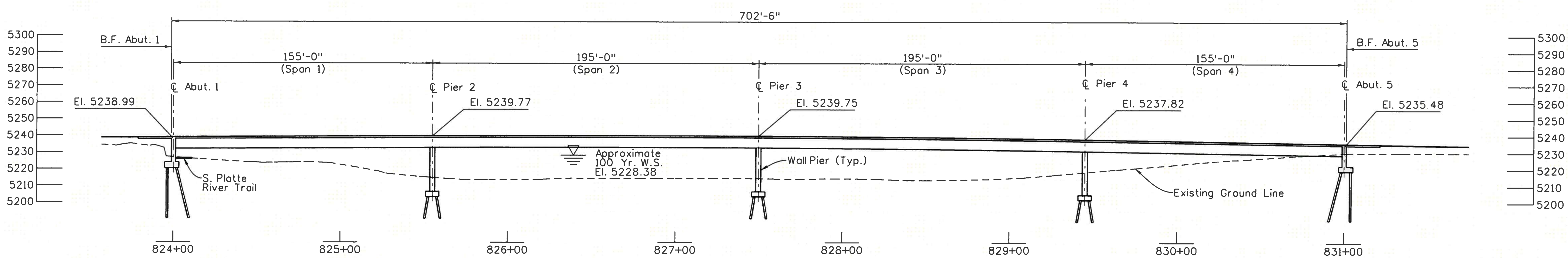
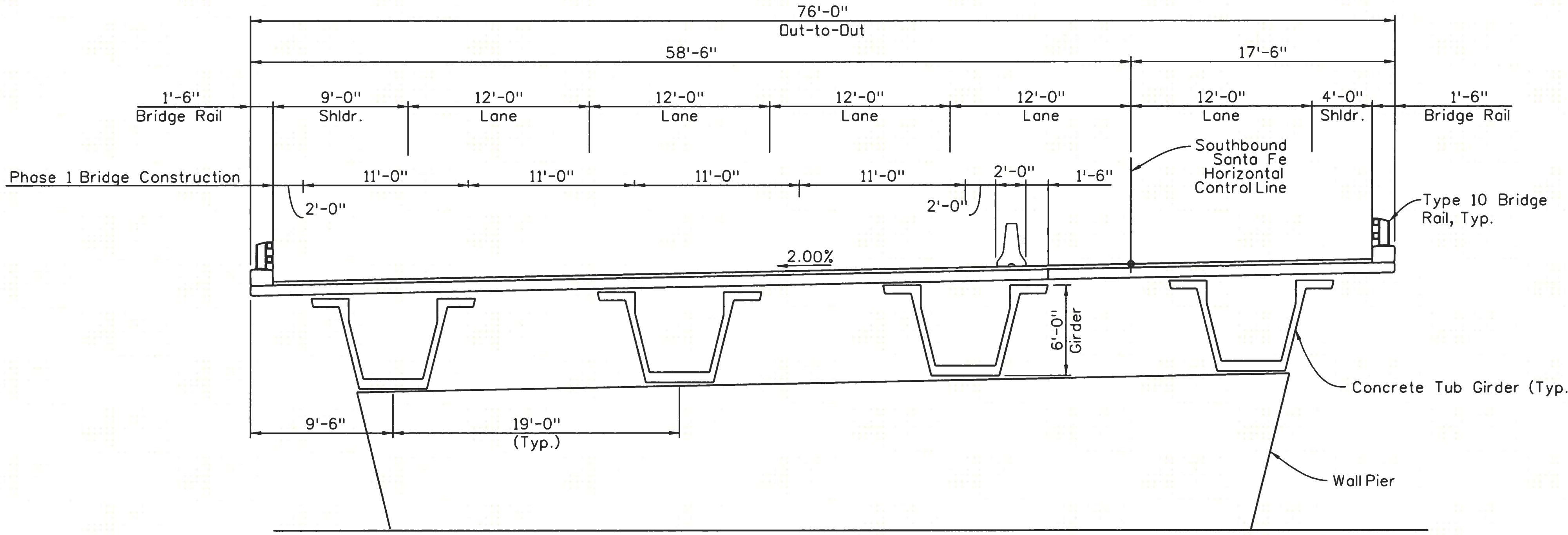
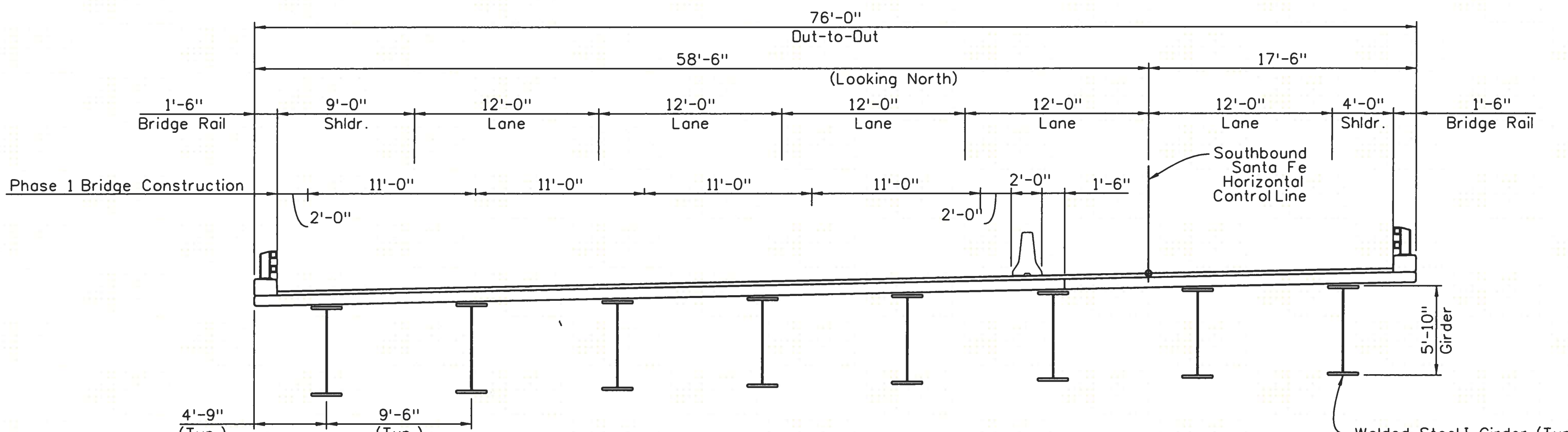


LONGITUDINAL SECTION

SB Santa Fe over South Platte River
Bridge Plan & Profile



CONCRETE TUB GIRDER



WELDED STEEL I-GIRDER
(Looking North)

SB Santa Fe over South Platte River
Bridge Typical Sections

SB Santa Fe over South Platte River

Preliminary Opinion of Probable Cost

Colorado U Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	**979**	$ 70.00	$ 68,538
512-00101	Bearing Device Type I	EACH	**8**	$ 1,200.00	$ 9,600
515-00120	Waterproofing (Membrane)	SY	**5,678**	$ 15.00	$ 85,167
518-01006	Bridge Expansion Device (0-6 inch)	LF	**152**	$ 260.00	$ 39,520
601-03040	Concrete Class D (Bridge)	CY	**1,750**	$ 500.00	$ 875,000
601-05050	Concrete Class S50	CY	**64**	$ 850.00	$ 54,400
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**475,000**	$ 1.10	$ 522,500
606-10705	Bridge Rail Type 7 (Special)	LF	**1,390**	$ 80.00	$ 111,200
618-00002	Prestressing Steel Strand	MKFT	**13,500**	$ 60.00	$ 810,000
618-10100	Precast Concrete U Girder (Post-Tensioned)	LF	**2,745**	$ 675.00	$ 1,852,875
				Subtotal - Superstructure:	*$ 4,428,800*
	Substructure				
206-01750	Shoring	LS	**1**	$ 200,000.00	$ 200,000
502-00460	Pile Tip	EA	**140**	$ 140.00	$ 19,600
502-11274	Steel Piling (HP 12x74)	LF	**3,500**	$ 80.00	$ 280,000
601-03040	Concrete Class D (Bridge)	CY	**3,432**	$ 450.00	$ 1,544,400
602-00000	Reinforcing Steel	LB	**89,853**	$ 1.00	$ 89,853
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**482,932**	$ 1.10	$ 531,225
				Subtotal - Substructure:	*$ 2,665,078*
202-00400	Removal of Bridge	EACH	**1**	$ 400,000.00	*$ 400,000*
			Subtotal		$ 7,493,878
	Miscellaneous Items (Not Quantified)			**15.0%**	$ 1,124,082
	TOTAL				**$ 8,618,000**

Bridge Width	39.00	ft
Bridge Length	1757.00	ft
Total Area	68523	sf
Cost per Square Foot		
Superstructure	$74.33	per sf
Substructure	$44.73	per sf
Total	$125.77	per sf

Steel Plate I-Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	**979**	$ 70.00	$ 68,538
509-00000	Structural Steel	LB	**2,385,000**	$ 1.60	$ 3,816,000
512-00101	Bearing Device Type I	EACH	**18**	$ 1,200.00	$ 21,600
515-00120	Waterproofing (Membrane)	SY	**5,678**	$ 15.00	$ 85,167
518-01004	Bridge Expansion Device (0-4 inch)	LF	**526**	$ 260.00	$ 136,730
601-03040	Concrete Class D (Bridge)	CY	**1,485**	$ 500.00	$ 742,253
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**425,085**	$ 1.10	$ 467,594
606-11030	Bridge Rail Type 10M	LF	**1,480**	$ 150.00	$ 222,000
				Subtotal - Superstructure:	*$ 5,559,882*
	Substructure				
206-01750	Shoring	LS	**1**	$ 100,000.00	$ 100,000
502-00460	Pile Tip	EA	**134**	$ 140.00	$ 18,760
502-11274	Steel Piling (HP 12x74)	LF	**3,350**	$ 80.00	$ 268,000
601-03040	Concrete Class D (Bridge)	CY	**3,432**	$ 450.00	$ 1,544,400
602-00000	Reinforcing Steel	LB	**89,853**	$ 1.00	$ 89,853
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**482,932**	$ 1.10	$ 531,225
				Subtotal - Substructure:	*$ 2,552,238*
202-00400	Removal of Bridge	EACH	**1**	$ 400,000.00	*$ 400,000*
			Subtotal		$ 8,512,120
	Miscellaneous Items (Not Quantified)			**15.0%**	$ 1,276,818
	TOTAL				**$ 9,789,000**

Bridge Width	39.00	ft
Bridge Length	1757.00	ft
Total Area	68523	sf
Cost per Square Foot		
Superstructure	$93.31	per sf
Substructure	$42.83	per sf
Total	$142.86	per sf

ALAMEDA OVER SOUTH PLATTE RIVER (STRUCTURE NO. F-16-XW)

Existing Bridge

The existing Alameda Avenue bridge, structure number F-16-XW, crosses the South Platte River just west of I-25. The bridge was originally constructed in 1911, and was widened in 1957. In 1965, the portion of the bridge which was constructed in 1911 was demolished and reconstructed. The bridge currently carries six through lanes, one turn lane and a sidewalk along the north side. The bridge follows a straight alignment, and is in a normal crown across the bridge. The existing bridge utilizes a steel plate girder superstructure, supported on concrete column piers and tall abutments founded on driven steel H-piling. The abutments and piers are skewed 27 degrees to align with South Platte River flows. In addition to crossing the South Platte River, the bridge also accommodates the South Platte River Trail on the west side of the river.

Existing structure F-16-BI, looking upstream (south)

Replacement Bridge Layout

The proposed replacement structure will be 142'-0" wide, carrying five eastbound lanes, four westbound lanes, a 10'-6" wide sidewalk on the south side of the bridge, and an 8'-6" sidewalk on the north side. A raised concrete median will be required for Alameda; together with Modified Type 10 Bridge Rails which incorporate pedestrian fencing along each edge of the bridge. It has been assumed that the pedestrian railing style will be similar to that required by the City and County of Denver on recent projects involving CDOT and CCD joint facilities.

The Alameda Avenue vertical profile was set such that hydraulic demands from the Platte River were accommodated, including required freeboard. Structure depth was minimized to insure that the Alameda profile could tie into existing Alameda Avenue features shortly west of the bridge, including S. Platte River drive just west of the bridge. Keeping the existing and proposed roadway profiles close was also necessary to accommodate phased bridge construction.

The allowable structure depth which accommodates hydraulic demands was found to be 3'-1", requiring a multi-span structure to span the approximately 180 foot bridge length. The west abutment was shifted approximately 5 feet further west from existing, to allow for additional room for the trail system to pass beneath the structure on the west side of the Platte River. The east abutment will remain in the same location as the existing to maximize hydraulic width, yet not encroach on the west ramps of the Alameda and I-25 interchange.

Bridge Superstructure Alternatives

Bridge superstructure alternatives were preliminarily selected to fit the following criteria:

- Minimize structure depth to accommodate hydraulic flows and trail system (3'-1" max structure depth)
- Minimize piers in the channel to:
  - Reduce hydraulic impact from bridge
  - Reduce construction efforts within the river
- Accommodate phased bridge construction
- Accommodate flared bridge ends

Superstructure types which meet the above criteria are:

- Side-by-Side precast box girder (24" deep girder)
- Cast-in-place concrete (30" deep section)
- Rolled Steel I-Beam (W24x146)

Each bridge was evaluated using a three span arrangement combined with the previously defined layout criteria. The precast concrete girder option was analyzed using three 60-ft spans, resulting in economical girder production. However, this alternative results in overlap in proposed and existing pier foundations, requiring existing foundation elements be incorporated with proposed foundation elements. The steel girder alternative was analyzed using a 59-ft – 71-ft – 53-ft arrangement, to balance the spans and also avoid the existing pier locations.

The cast-in-place (CIP) alternative will accommodate the flared ends of the bridge better than other alternatives; however will require significant shoring in the Platte River to accommodate construction. The Platte River will need to be diverted under one span to accommodate shoring beneath the span being constructed. Following the completion of one portion of the span, the river will have to be diverted under the completed span to accommodate shoring to finish the construction of the bridge. Since the bridge is being built in three phases, this alternative is not feasible due to the significant shoring effort in the Platte River, and was not considered further. However, consideration for the northeast corner of the bridge being built cast-in-place will still be investigated as a part of the girder alternatives.

The prestressed precast box girder alternative is the most flexible system when accommodating bridge phasing, due to the accommodation of deck joint locations. The exterior girders can be cast with a tapered edge, improving hydraulic performance of this alternative. The precast girder alternative will require minimal shoring in the Platte, and is the fastest constructed of the alternatives. The large flared end section on the northeast corner will be constructed utilizing cast-in-place post tensioned concrete, anchored into the exterior girders of the first phase of construction. Post tensioning ducts will be provided through the 5 exterior girders. The shoring for construction will be limited to the east span, requiring minimal shoring in the river.

The rolled steel I-Beam alternative will accommodate the constrained structure depth requirement, however does not accommodate a tapered upstream profile to reduce debris collection. Also, the span lengths coupled with the limited structure depth demands a heavy girder section which is closely spaced, making this alternative economically prohibitive. This alternative will accommodate the flared ends better than the prestressed girder alternative, due to the framing flexibility of a steel alternative.

Bridge Substructure

Substructure alternatives were determined based on hydraulic impacts and constructability. Round concrete column piers were chosen to minimize hydraulic impacts yet allow better lighting under the bridge for the trail system. The column piers will be located to accommodate the 3-phase bridge construction.

Tall concrete wall abutments will be utilized to reduce end spans, as well as accommodate the South Platte River Trail along the south abutment.

Foundations for these substructure elements are discussed in the Geotechnical Considerations section.

Construction Phasing / Constructability

The bridge replacement has been divided into three phases, starting from the north side, continuing in order toward the south. Bridge phasing will match the phasing scheme of the Alameda over I-25 bridge, just to the east.

Due to the north and south abutments being constructed near interchanges, construction will require shoring to accommodate existing abutment removal and reconstruction of the proposed abutment. Shoring is anticipated at the existing abutments as each phase of the bridge is removed, to retain backfill behind the existing abutments.

The South Platte River Trail will temporarily be detoured during construction.

Geotechnical Considerations

Preliminary geotechnical results indicate shallow bedrock throughout the South Platte River, which is consistent with the existing bridge as-built plans. The bedrock was found to be non-expansive, however was consistently overtopped with approximately 20 to 30-feet of gravels and cobbles. Due to this significant layer of pervious material, caissons were not recommended due to dewatering efforts, as well as the material not being suitable for auguring without collapse.

Driven steel H-pile was the recommended deep foundation alternative for the bridge structure. Due to shallow bedrock, the H-pile foundation will be a timely foundation solution, and with the immediate surrounding area being commercial and industrial, noise implications of selecting driven H-pile is minimized. No overhead constraints are present in the vicinity of the bridge, which would prevent or hinder the crane heights associated with pile driving. Requiring pile tips is anticipated to penetrate the cobble layer without damaging the steel H-pile.

Hydraulic Considerations

Preliminary hydraulic analysis of the South Platte River was conducted to establish approximate 100-yr storm water elevations utilizing the existing channel. The bridge superstructure options were selected to satisfy required free-board at the bridge, as well as minimize debris collection. The abutments and piers have been aligned with the South Platte River to minimize hydraulic drag, and also follow the existing trail alignment south of the river.

Other Design Considerations

Bridge drainage will be handled by utilizing bridge drains on the west end of the bridge, tying into the roadway storm sewer system.

Utilities will be accommodated by spacing girders to provide utility openings in two different locations across the bridge. Utilities crossing the bridge will include Level 3 Fiber Optic, Xcel Electric and Qwest utilities, in similar arrangement to Alameda over I-25.

Conventional approach slabs are not feasible due to the adjacent intersections just east and west of the bridge. Expansion joints will be provided at each abutment location to separate bridge movement from the proposed concrete pavement.

A 0-4 inch bridge expansion joint will be added at each abutment to allow for temperature movements, and will minimize temperature forces being induced into the tall abutments.

Bridge Type Evaluation

For this particular bridge, evaluation will be based on:

- Least construction cost
- Aesthetics
- Durability and maintainability
- Constructability
- Impact to South Platte River

Construction cost will include the cost of the replacement bridge, including superstructure and substructure, as well as additional cost associated with bridge phasing. Bridge phasing costs will include demolition and removal costs, and costs for phasing bridge construction.

Durability and maintainability will evaluate the proven durability of the structure type, and how easily it is maintained. Due to the increased inspection effort in inspecting the interior of closed girder shapes, the I-girder alternative is found to be more advantageous in this category.

Impact to the South Platte River will be evaluated on the alternative's superstructure depth, and the superstructure's ability to pass flows without debris collection. Girder alternatives which have a tapered outside section will score better in this category due to the reduction of debris collection.

Constructability evaluates not only the construction effort put forth by the contractor, but also impacts to the traveling public (user cost). Alternatives which require a longer timeframe to construct will score lower due to the impacts to maintaining traffic through the extended construction period.

An evaluation matrix was created to accurately determine the preferred option. Due to the importance of construction cost, a weighting factor of three was applied in the evaluation matrix to the construction cost rating. All other evaluation criteria were left un-weighted, reflecting equal importance.

Evaluation Matrix

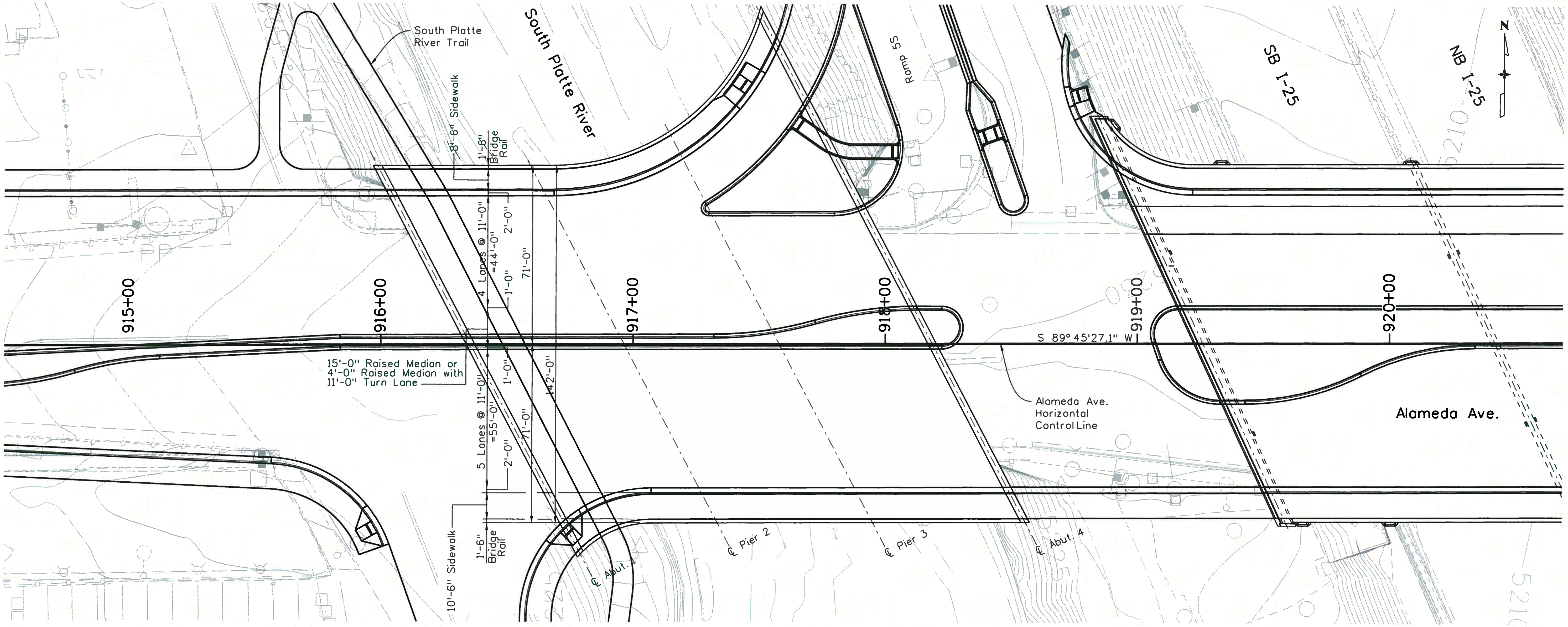
Superstructure Type	Least Construction Cost	Aesthetics	Durability & Maintainability	Constructability	Hydraulic Impacts	Construction Cost Weight Factor	Aesthetic Weight Factor	Totals
Prestressed Box Girder (BX24x68)	3	2	3	3	3	3	0	18
Rolled Steel I-Beam (W24x146)	3	1	2	1	2	3	0	14

N/A or Low Importance	**0**
Satisfactory	**1**
Good	**2**
Excellent	**3**

	Estimated Cost	% Greater	Rating #
Prestressed Box Girder (BX24x68)	$4,505,000	0.00%	3
Rolled Steel I-Beam (W24x146)	$4,619,000	2.53%	3

Construction Cost Evaluation

Least Cost	=	3
0-5% Greater	=	3
5-15% Greater	=	2
>15% Greater	=	1



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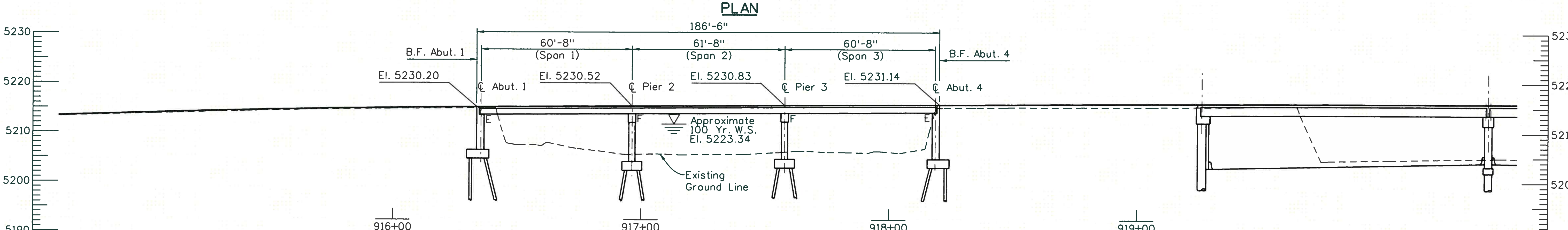

LONGITUDINAL SECTION

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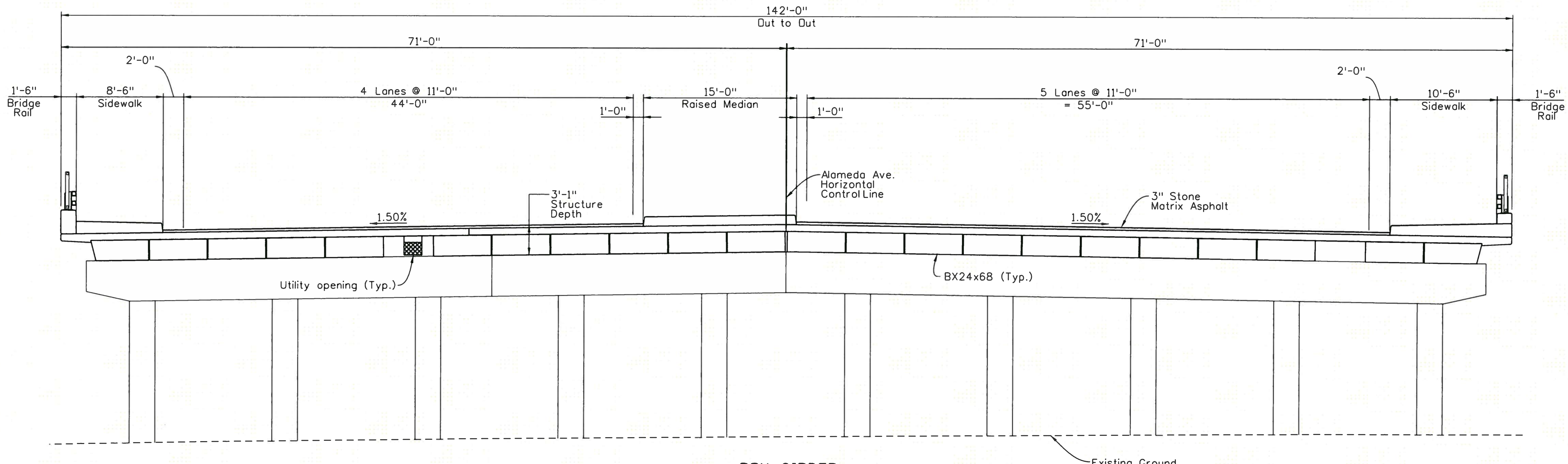
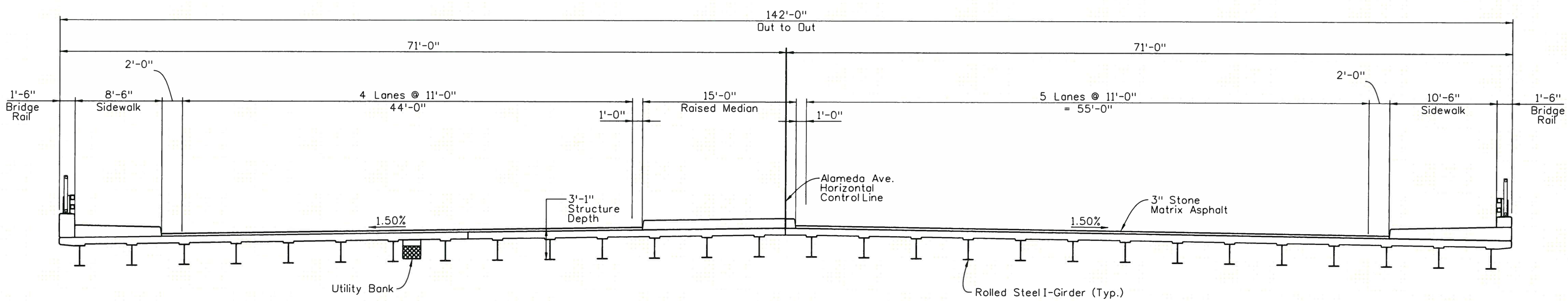
Alameda Avenue over South Platte River
Bridge Plan & Elevation



BOX GIRDER
(Looking East)



ROLLED STEEL I-GIRDER
(Looking East)

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Alameda Avenue over South Platte River
Bridge Typical Section

Alameda over South Platte River

Preliminary Opinion of Probable Cost

Box Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	**461**	$ 70.00	$ 32,273
512-00101	Bearing Device Type I	EACH	**44**	$ 1,200.00	$ 52,800
515-00120	Waterproofing (Membrane)	SY	**2,826**	$ 15.00	$ 42,395
518-01004	Bridge Expansion Device (0-4 inch)	LF	**203**	$ 260.00	$ 52,780
601-03040	Concrete Class D (Bridge)	CY	**957**	$ 500.00	$ 478,492
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**287,095**	$ 1.10	$ 315,805
606-11030	Bridge Rail Type 10M	LF	**366**	$ 150.00	$ 54,900
618-01992	Prestressed Concrete Box (Depth Less Than 32 Inches)	SF	**22,814**	$ 50.00	$ 1,140,700
				Subtotal - Superstructure:	$ *2,170,145*
	Substructure				
206-01750	Shoring	LS	**1**	$ 10,000.00	$ 10,000
502-00460	Pile Tip	EA	**200**	$ 140.00	$ 28,000
502-11274	Steel Piling (HP 12x74)	LF	**5,000**	$ 80.00	$ 400,000
601-03040	Concrete Class D (Bridge)	CY	**1,465**	$ 450.00	$ 659,030
602-00000	Reinforcing Steel	LB	**74,689**	$ 1.00	$ 74,689
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**158,951**	$ 1.10	$ 174,846
				Subtotal - Substructure:	$ *1,346,565*
202-00400	Removal of Bridge	EACH	**1**	$ 400,000.00	$ *400,000*
			Subtotal		$ 3,916,710
		Miscellaneous Items (Not Quantified)		**15.0%**	$ 587,507
	TOTAL				**$ 4,505,000**

Bridge Width	142 ft
Bridge Length	183 ft
Total Area	25986 sf
Cost per Square Foot	
Superstructure	$96.04 per sf
Substructure	$59.59 per sf
Total	$173.36 per sf

Rolled Steel I-Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	**461**	$ 70.00	$ 32,273
509-00000	Structural Steel	LB	**822,914**	$ 1.60	$ 1,316,663
512-00101	Bearing Device Type I	EACH	**56**	$ 1,200.00	$ 67,200
515-00120	Waterproofing (Membrane)	SY	**2,826**	$ 15.00	$ 42,395
518-01004	Bridge Expansion Device (0-4 inch)	LF	**203**	$ 260.00	$ 52,780
601-03040	Concrete Class D (Bridge)	CY	**848**	$ 500.00	$ 423,894
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**254,336**	$ 1.10	$ 279,770
606-11030	Bridge Rail Type 10M	LF	**366**	$ 150.00	$ 54,900
				Subtotal - Superstructure:	$ *2,269,874*
	Substructure				
206-01750	Shoring	LS	**1**	$ 10,000.00	$ 10,000
502-00460	Pile Tip	EA	**200**	$ 140.00	$ 28,000
502-11274	Steel Piling (HP 12x74)	LF	**5,000**	$ 80.00	$ 400,000
601-03040	Concrete Class D (Bridge)	CY	**1,465**	$ 450.00	$ 659,030
602-00000	Reinforcing Steel	LB	**74,689**	$ 1.00	$ 74,689
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**158,951**	$ 1.10	$ 174,846
				Subtotal - Substructure:	$ *1,346,565*
202-00400	Removal of Bridge	EACH	**1**	$400,000.00	$ *400,000*
			Subtotal		$ 4,016,439
		Miscellaneous Items (Not Quantified)		**15.0%**	$ 602,466
	TOTAL				**$ 4,619,000**

Bridge Width	142 ft
Bridge Length	183 ft
Total Area	25986 sf
Cost per Square Foot	
Superstructure	$100.45 per sf
Substructure	$59.59 per sf
Total	$177.75 per sf

ALAMEDA TO NB I-25 FLYOVER (RAMP 5N) (STRUCTURE NO. F-16-XV)

Bridge Layout

The Ramp 5N alignment connects Alameda traffic to NB I-25 via a flyover beginning on the northwest corner of the Alameda/I-25 interchange, continuing over I-25 and connecting to NB I-25 via a ramp on the east side of I-25. This alternative was the preferred concept set forth by the EIS. The alignment and profile were established based on design speed, sight distance and vertical clearance over I-25. Due to the significant clear span demands of the bridge, the vertical profile was set using a structure depth of 8'-0".

The vertical profile of the ramp flyover was set such that the minimum vertical clearance was achieved for the I-25 ultimate roadway section. Due to the I-25 profile climbing to the north from Alameda, the ramp profile must also climb to attain sufficient vertical clearance. Starting from Alameda, the ramp profile quickly climbs to a 6% grade heading north to attain sufficient clearance over I-25. Once sufficient vertical clearance was attained, the alignment turns northeast and continues to climb until the median of I-25, where the vertical profile crests and the horizontal curve reverses to align with NB I-25.

Bridge Superstructure

Due to the radius of the roadway alignment, coupled with the span length and structure depth demands, only curved steel plate I-girders are viable for the superstructure. Curved Steel Box Girders were considered, and removed from consideration due to constructability issues with the heavier girder sections being erected over I-25 and the increased cost to fabricate box girders.

Currently, spliced post-tensioned Colorado U-Girders can no be fabricated to meet the radius of the roadway alignment, therefore were not considered. Segmental concrete construction was also removed from consideration due to the significant shoring efforts required within the I-25 corridor.

Bridge Substructure

Substructure alternatives were determined based on constructability and aesthetic continuity. Single round column piers were chosen to minimize impacts to I-25 and match the aesthetic theme of the corridor. Stubby concrete abutments will be utilized at each end, reducing bridge cost.

Foundations for these substructure elements are discussed in the Geotechnical Considerations section.

Construction Phasing / Constructability

Although steel I-girder bridges are a common construction type, the complex geometry of the bridge combined with crossing the I-25 corridor create a challenge. Span 1 and span 4 are both near grade and offer the most accessible construction staging area for steel girder erection. It's assumed that both span 1 and span 4 would be constructed first, with cantilever girder portions extending beyond the piers. This stage of the girder erection will not require lane closures of I-25, however Span 1 erection will likely require a partial shoulder closure for SB I-25 traffic.

The second stage of girder erection will include completion of Span 2, which will require nighttime closure of SB I-25 traffic. Traffic will be detoured onto the SB off ramp to Alameda Ave, and utilize Santa Fe Drive to reconnect to SB I-25. The girder segments will include a cantilever portion of Span 3.

The third stage of girder erection will complete span 3, and will require nighttime closure of NB I-25. Traffic will be detoured to Santa Fe Drive, and will reconnect to I-25 at 6th Avenue.

Following the completion of the steel girder erection, lane closures and detours should be limited to formwork installation and the deck pour. No falsework or shoring towers are anticipated during the bridge construction.

Geotechnical Considerations

Preliminary geotechnical results indicate shallow bedrock consistently through the bridge limits. The bedrock was found to be non-expansive, and capable of 160 ksf tip resistance for caisson foundations.

Caisson foundations are the recommended deep foundation alternative for the piers and abutments. Due to shallow bedrock, the caisson foundation will be a timely foundation solution and will be more viable than driven H-pile in the median of I-25. No overhead constraints are present in the vicinity of the bridge, which would prevent or hinder caisson drilling. Dewatering is anticipated due to the high water table present near the South Platte River.

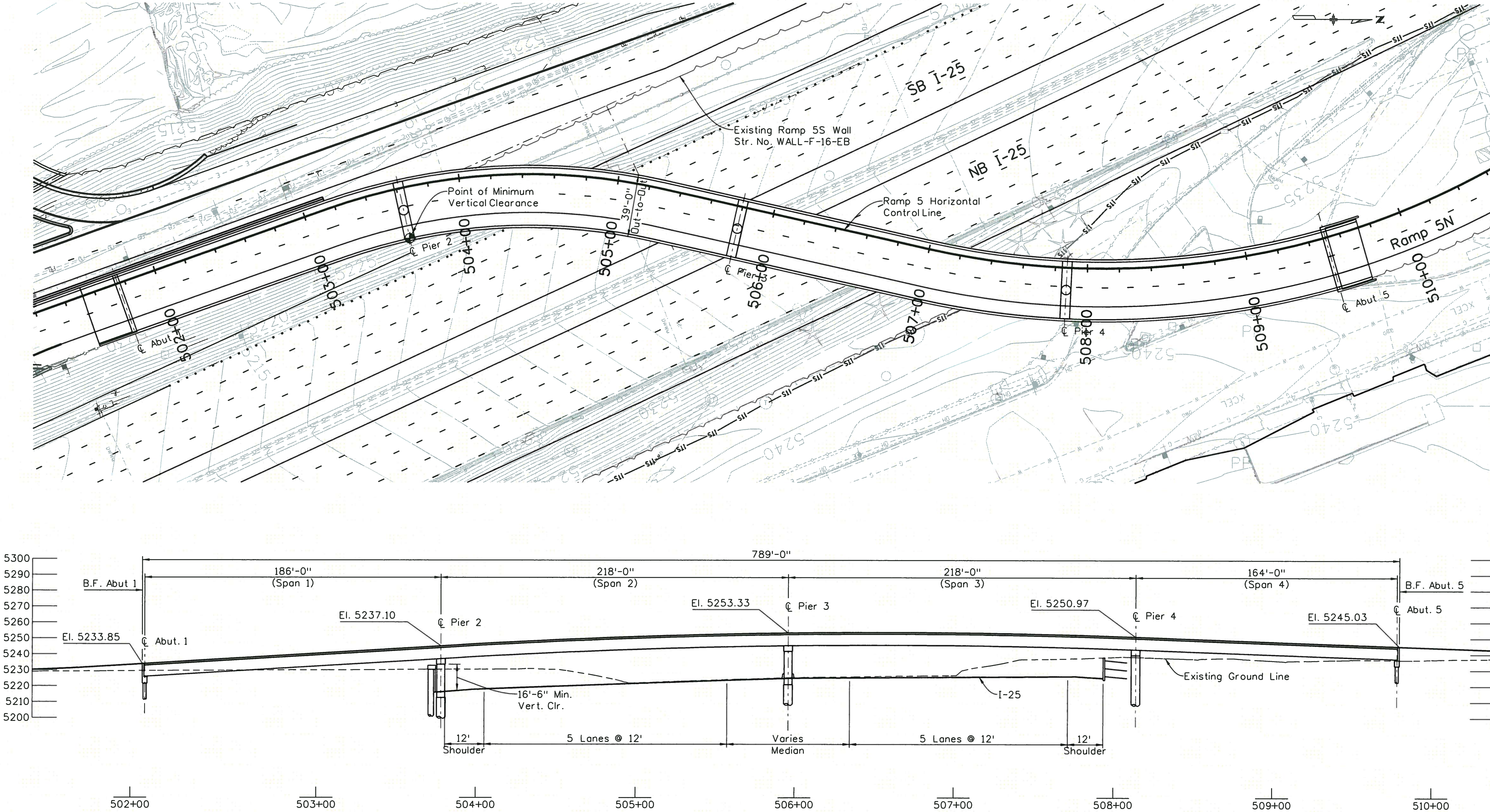
Other Design Considerations

Bridge drainage will be handled by utilizing approach slab inlets and bridge drains, which will tie into the projects storm drainage system.

Conventional CDOT 20-foot approach slabs will be utilized at each end of the bridge. Bridge expansion joints will be added to the ends of each approach slab to accommodate the temperature movement of the bridge.

Bridge Type Recommendation

The recommended bridge type is a curved steel plate I-girder bridge. **Page 2-34 and 2-35** show the preliminary bridge layout and typical bridge section. **See Page 2-36** for a preliminary cost estimate.



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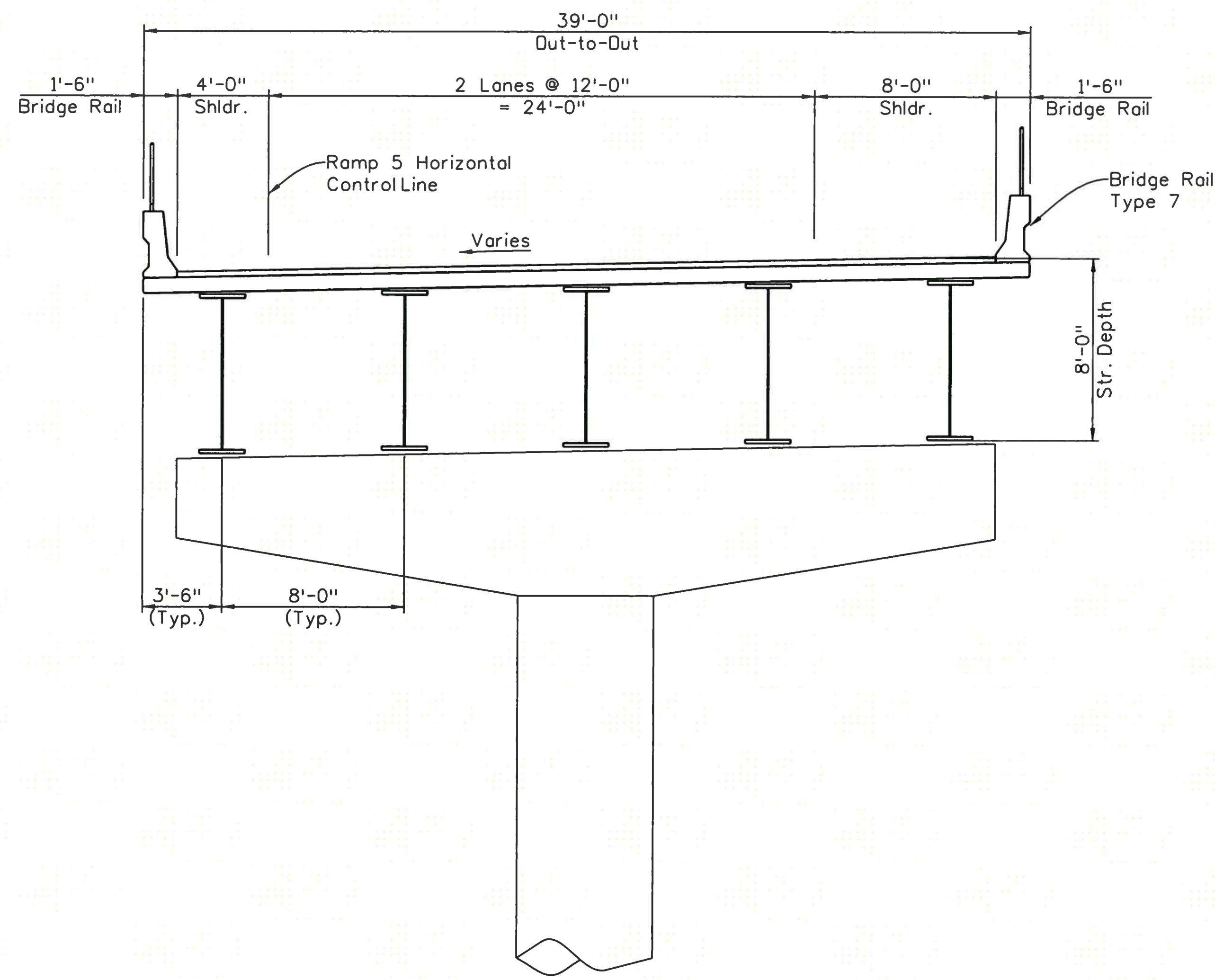
Ramp 5 Flyover Bridge Plan & Profile



TYPICAL BRIDGE SECTION
(Looking East)

Ramp 5 Flyover
Bridge Typical Section

Ramp 5N Flyover

Preliminary Opinion of Probable Cost

Steel Plate I-Girder Alternative

Item	Item Description	Unit	Quantity	Unit Costs	Total Costs
	Superstructure				
403-09210	Stone Matrix Asphalt	TON	**539**	$ 70.00	$ 37,728
509-00000	Structural Steel	LB	**1,685,970**	$ 1.80	$ 3,034,746
512-00101	Bearing Device Type I	EACH	**10**	$ 1,200.00	$ 12,000
515-00120	Waterproofing (Membrane)	SY	**3,144**	$ 15.00	$ 47,160
518-01004	Bridge Expansion Device (0-4 inch)	LF	**84**	$ 260.00	$ 21,840
601-03040	Concrete Class D (Bridge)	CY	**863**	$ 500.00	$ 431,593
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**248,556**	$ 1.10	$ 273,411
606-11030	Bridge Rail Type 7 (Special)	LF	**1,652**	$ 80.00	$ 132,160
607-53136	Fence Chain Link (36 inch)	LF	**1,652**	$ 35	$ 57,820
				Subtotal - Superstructure:	*$ 4,048,457*
	Substructure				
502-00460	Pile Tip	EA	**18**	$ 140.00	$ 2,520
502-11274	Steel Piling (HP 12x74)	LF	**720**	$ 80.00	$ 57,600
503-00048	Drilled Caisson (48 inch)	LF	**360**	$ 340.00	$ 122,400
601-03040	Concrete Class D (Bridge)	CY	**662**	$ 450.00	$ 297,883
602-00000	Reinforcing Steel	LB	**14,622**	$ 1.00	$ 14,622
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**98,421**	$ 1.10	$ 108,263
				Subtotal - Substructure:	*$ 603,288*
			Subtotal		$ 4,651,746
	Miscellaneous Items (Not Quantified)			**15.0%**	$ 697,762
	TOTAL				**$ 5,349,600**

Bridge Width	39.00	ft
Bridge Length	786.00	ft
Total Area	30654	sf
Cost per Square Foot		
Superstructure	$151.88	per sf
Substructure	$22.63	per sf
Total	$174.52	per sf (Includes Contingency)

3. RETAINING WALL TYPE SELECTION

INTRODUCTION

The purpose of this section is to select retaining wall types for the various retaining walls listed below, in accordance with Colorado Department of Transportation (CDOT) Staff Bridge policies 5.1 through 5.8. The walls will be evaluated based on the wall attributes as well as site specific considerations in an effort to select the wall type that best meets the evaluation criteria. Acceptable alternative wall types, if any, will also be identified for the wall.

RETAINING WALL/SOUND WALL DESCRIPTION AND LOCATIONS

The reconstruction of the I-25/Santa Fe interchange will require numerous retaining walls to support ramp and roadway fill, as well as retain grade along the Platte River.

The proposed retaining walls are as follows:

Retaining Walls Information Table

Wall Name	Structure Number	Approximate Wall Length (ft)	Wall Height Range Min/Max (ft)	Approximate Exposed Wall Area (ft^2)	Cut/Fill
I-25 NB Wall 1	WALL-F-16-DW	535	5.0 / 25.5	11,090	Fill
I-25 SB Wall 1	WALL-F-16-DW	700	5.0 / 32.0	16,102	Fill
I-25 SB Wall 2	WALL-F-16-DX	580	5.0 / 24.0	9,274	Fill
I-25/Ramp 1 Wall	WALL-F-16-DV	396	15.0 / 23.0	7,377	Fill
Santa Fe SB Wall 1	TBD	170	7.0 / 11.0	1,515	Cut
Santa Fe SB Wall 2	TBD	467	7.0 / 17.0	4,030	Cut
Ramp 1 Wall 1 & 2	WALL-F-16-DU	410	5.0 / 18.0	3,884	Fill
Ramp 1 Wall 3	WALL-F-16-DV	254	5.0 / 26.0	5,138	Fill
Ramp 2 Wall	WALL-F-16-DS	1,157	5.0 / 36.0	20,640	Fill
Ramp 5N Wall	WALL-F-16-EA	200	5.0 / 12.0	1,524	Fill
Ramp 5S Wall	WALL-F-16-EB	455	5.0 / 19.0	7,535	Cut
Total		**5,324**		**88,109**	

Retaining wall locations are detailed on **Pages 1-5 & 1-6** of the report. Plan and Elevations for the retaining walls are located on **Pages 3-7 through 3-22**. The only cut retaining walls will support Ramp 5S and Santa Fe Drive above the Platte River. The remaining walls will support fill from the ramps and I-25.

GEOTECHNICAL CONSIDERATIONS

A geotechnical investigation is currently being conducted by Ground Engineering. Preliminary foundation recommendations from current borings indicate that mechanically stabilized earth wall (MSE) are appropriate for retaining walls supporting fill, while deep foundation alternatives are appropriate for both cut and fill retaining walls.

ALTERNATIVES

The Colorado Department of Transportation Bridge Design Manual Subsection No. 5.5 Wall Selection Factors and Procedure lists 24 different retaining walls to compare. Most of these can be eliminated directly, as they are clearly inappropriate for this particular location and project. They may be unjustifiably expensive, require more width than can be accommodated everywhere, are not suitable for the walls on this site, or are simply not needed for the foundation conditions.

The alternatives that are applicable for the retaining walls supporting fill include cast-in-place concrete retaining walls supported on deep foundation (CIP) and metal reinforced mechanically stabilized earth walls (MSE). Retaining walls lining the South Platte River will encounter partial submersion within the river, therefore wall alternatives must be capable of sustaining scour and hydrostatic pressures. The alternatives that are applicable for the retaining walls along the South Platte River include cast-in-place concrete retaining walls on deep foundation and side-by-side drilled caisson walls with concrete facing.

ATTRIBUTES

Appearance

Aesthetics of the retaining walls on this project are an important issue due to the fact that the retaining walls will be visible to travelers, commuters, and residents alike. All retaining wall systems can be pleasing by using various finishing patterns (Form Liner), colors, and landscaping features on the faces of the walls. The architectural treatment finish for these walls has been determined by PKM, as approved by the project team, and is discussed in further detail in the Project Overview section. Each of these wall types has been rated 5 to reflect this equality of expectation.

Schedule

Cast-in-place retaining walls require more time to build than the mechanical stabilized earth walls due to the fact that forms have to be placed, reinforcing steel to be tied, and the concrete should be cured before any backfilling and compacting can occur. The mechanical stabilized earth wall will require less time and less labor to construct, due to backfilling occurring simultaneously with wall facing. Side-by-side Caisson walls with concrete facing will be similar construction time as CIP walls. However, significant shoring efforts will be required along Ramp 5S and walls along Santa Fe Drive, which will delay the start of CIP wall construction.

Design Life

It is our understanding that the mechanical stabilized earth wall proprietors believe that the components of their retaining walls will provide as long of a life and satisfactory service as the cast-in-place walls or caisson walls with concrete facing. Each of the wall types has been rated 5 to reflect this equality of expectation.

Standard Design

Cast-in-place walls consist of reinforcing steel, concrete, and backfill. The same constituents are used for, buildings, cast-in-place concrete box culverts, and concrete substructures. Every experienced contractor has performed this type of construction and is familiar with its requirements.

Caisson walls have been used as a top-down retaining wall solution for many years. A caisson drilling sub-contractor is required, however the design requirements are standard.

As mechanically stabilized earth walls have been successfully installed in projects around the state over the years, standards have emerged for suppliers and contractors for MSE wall construction. Specialty suppliers and sub-contractors are confident in this type of construction.

Proven Experience

We know from a historical basis that reinforced concrete, with an adequate mix design and structural design, is capable of long satisfactory service. Current design may include air entrainment for freeze-thaw resistance, use of fly ash or silica fume in mixes for reduced permeability, and epoxy-coating reinforcing steel for resistance to corrosion.

Caisson retaining walls are faced with the same proven concrete and reinforcing used in CIP walls, and utilize durable concrete caissons embedded in the soil behind the facing.

Mechanical stabilized earth walls have been installed in Colorado projects for a number of years creating a proven track record. Several local specialty sub-contractors and suppliers are experienced in their construction.

Serviceability

The mechanically stabilized earth walls, which have frequent joints in their facing, can generally articulate to permit relative movement without distress. Since the movement is divided up among many joints, each joint movement is minimized so that the displacement of the wall is less visible. Cast-in-place wall joints are less frequent than those in mechanical stabilized earth walls, but if the joints move to accommodate differential settlement of the foundation, they are more visible. The cast-in-place wall on deep foundation and caisson retaining walls are much less likely to have differential settlement and therefore, the wall joint movement will be less visible.

Constructability

A successful structure must not only serve its structural purpose, it must install confidence in the observer that it is able to do so. A structure that appears unsound is not satisfactory.

In recent years successful construction of mechanically stabilized earth walls which perform well and appear sound has been a common occurrence in this area. Many experienced contractors are available in Colorado that have built mechanically stabilized earth walls. The quality of this type of construction is assured by well-defined and established construction specifications. Many standard details have been developed over the years to aid in the design and construction of this type of wall. For this reason, they have been rated 5 in constructability.

Constructability of CIP walls utilized for cut conditions include the limits of excavation and backfill required for wall construction. Often the excavation limits encroach on existing features such as existing roadways, utilities, or ROW. Shoring is necessary for areas without construction space to excavate the wall, increasing the relative cost of this wall type. Side-by-Side Caisson retaining walls do not require excavation behind the retaining wall, therefore are rated higher for constructability in areas which have adjacent roadways close to the wall alignment.

Probable Construction Cost

The cost comparisons developed for this report are based on a square foot basis, which are intended to show relative costs for alternative comparison purposes. Mobilization, contingencies, and construction engineering are not included. Cost estimates were developed to be comparative, and do not include Bridge Rails or concrete paving which will be required for all wall alternatives.

The below summary was developed using recent project pricing, which was collected from retaining wall projects with similar maximum wall heights, bedrock depth and project constraints. Due to construction constraints, the C.I.P. wall unit price increases when used in cut conditions, due to required shoring to accommodate construction and backfilling.

- M.S.E. Retaining Wall with Precast Panel Facing = $60 / SF
- C.I.P. Retaining Wall on Deep Foundation (Fill) = $120 / SF
- C.I.P. Retaining Wall on Deep Foundation (Cut) = $140 / SF
- Side-by-Side Caisson with C.I.P. Facing = $180 / SF

OTHER CONSIDERATIONS

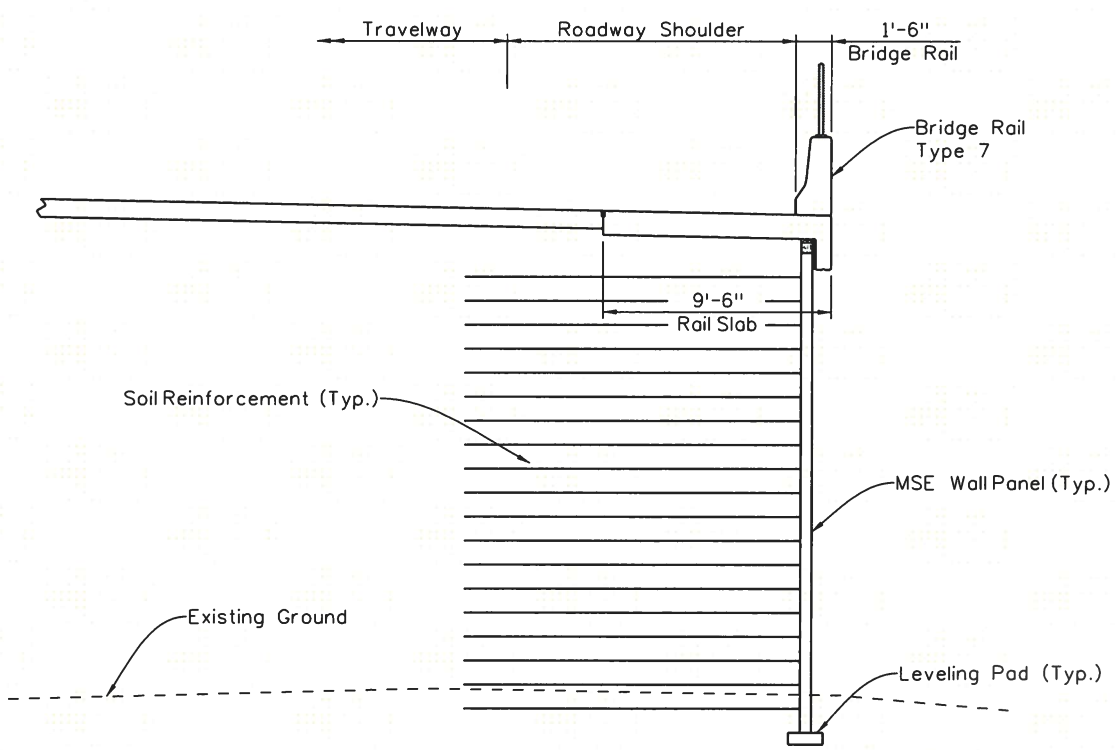
In locations of ramp retaining walls, typically retaining walls are on each side, as shown in the MSE wall typical section **(Page 3-5)**. We recommend the use of Type 7 Bridge Rail on CDOT standard rail slabs adjacent to the travel way, with conventional concrete pavement between rail slabs. However, the rail slab/pavement joint won't match the striping line, creating a longitudinal rail slab joint extending into the middle of a travel lane. If it is determined that this undesirable longitudinal joint location is unacceptable, it is an option to use reinforced concrete paving full width. Similar construction was previously utilized for the I-225/Alameda interchange ramp retaining walls. The final decision regarding the ramp paving will be made during final design.

SUMMARY

A Retaining Wall Decision Matrix was constructed comparing the wall alternatives. The matrix lists each attribute along with the corresponding score for each of the wall types. The mechanically stabilized earth wall alternative has the higher score for fill walls, and is therefore the recommended alternative for this project for all retaining walls supporting fill. The Side-by-Side Caisson wall scored the highest for cut walls near roadways, due to the lack of required shoring, therefore is the recommended wall type for the retaining walls in cut which are adjacent to roadways. The Cast-in-Place retaining walls scored the highest for cut walls when shoring is not required, therefore is the recommended wall type for any cut walls which are not adjacent to roadways.

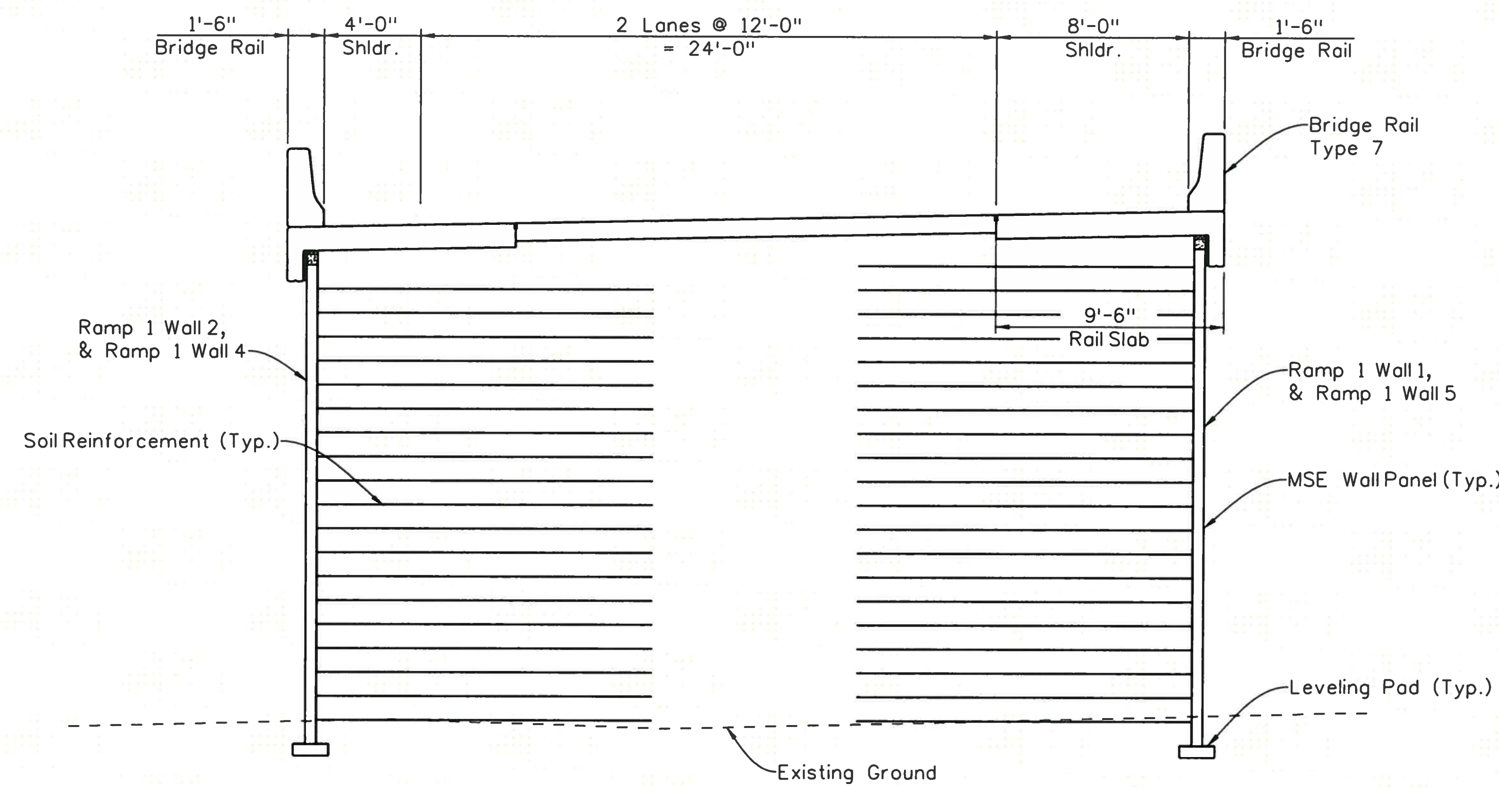
Retaining Wall Decision Matrix

		Fill Walls				**Cut Walls Near Roadways**				**Other Cut Walls**			
Attribute	Weight	Mechanically Stabilized Earth		Cast-in-Place on Spread Footing		Cast-in-Place on Deep Foundation		Side-by-Side Caisson Walls with CIP Facing		Cast-in-Place on Deep Foundation		Side-by-Side Caisson Walls with CIP Facing	
	%	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Appearance	10	5	50	5	50	5	50	5	50	5	50	5	50
Schedule	10	5	50	3	30	3	30	4	40	4	40	4	40
Design Life	10	5	50	5	50	5	50	5	50	5	50	5	50
Standard Design	10	4	40	5	50	5	50	4	40	5	50	4	40
Proven Experience with Wall Type	10	4	40	5	50	5	50	5	50	5	50	5	50
Serviceability	10	5	50	4	40	5	50	5	50	5	50	5	50
Constructability	15	4	60	4	60	2	30	4	60	4	60	4	60
Probable Construction Cost	25	4	100	3	75	3	75	2	50	3	75	2	50
Total Score	**100**		**440** *(Recommended Alternative)*		**405**		**385**		**390** *(Recommended Alternative)*		**425** *(Recommended Alternative)*		**390**



TYPICAL SECTION
(MSE WALL OPTION)

I-25 NB Wall 1
I-25 SB Wall 1
I-25 SB Wall 2
Ramp 2 Wall
Ramp 5N Wall



RAMP 1
TYPICAL SECTION
(MSE WALL OPTION)

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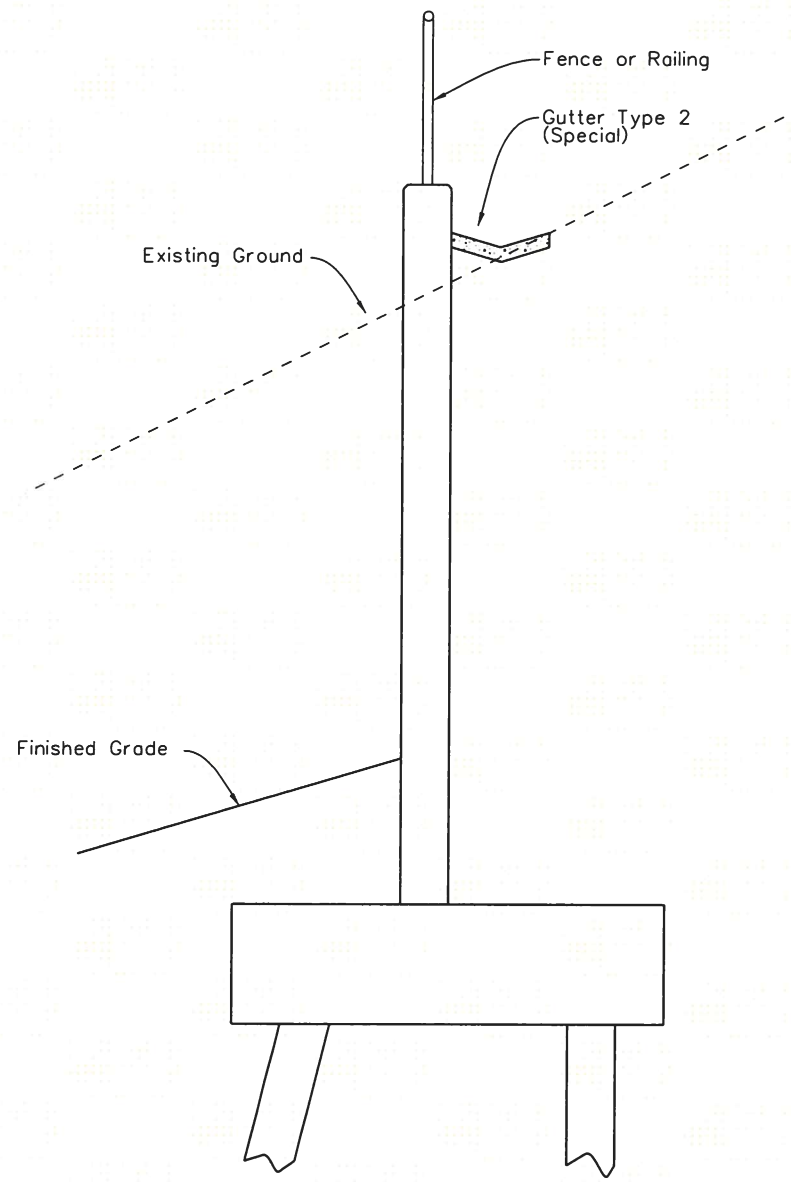
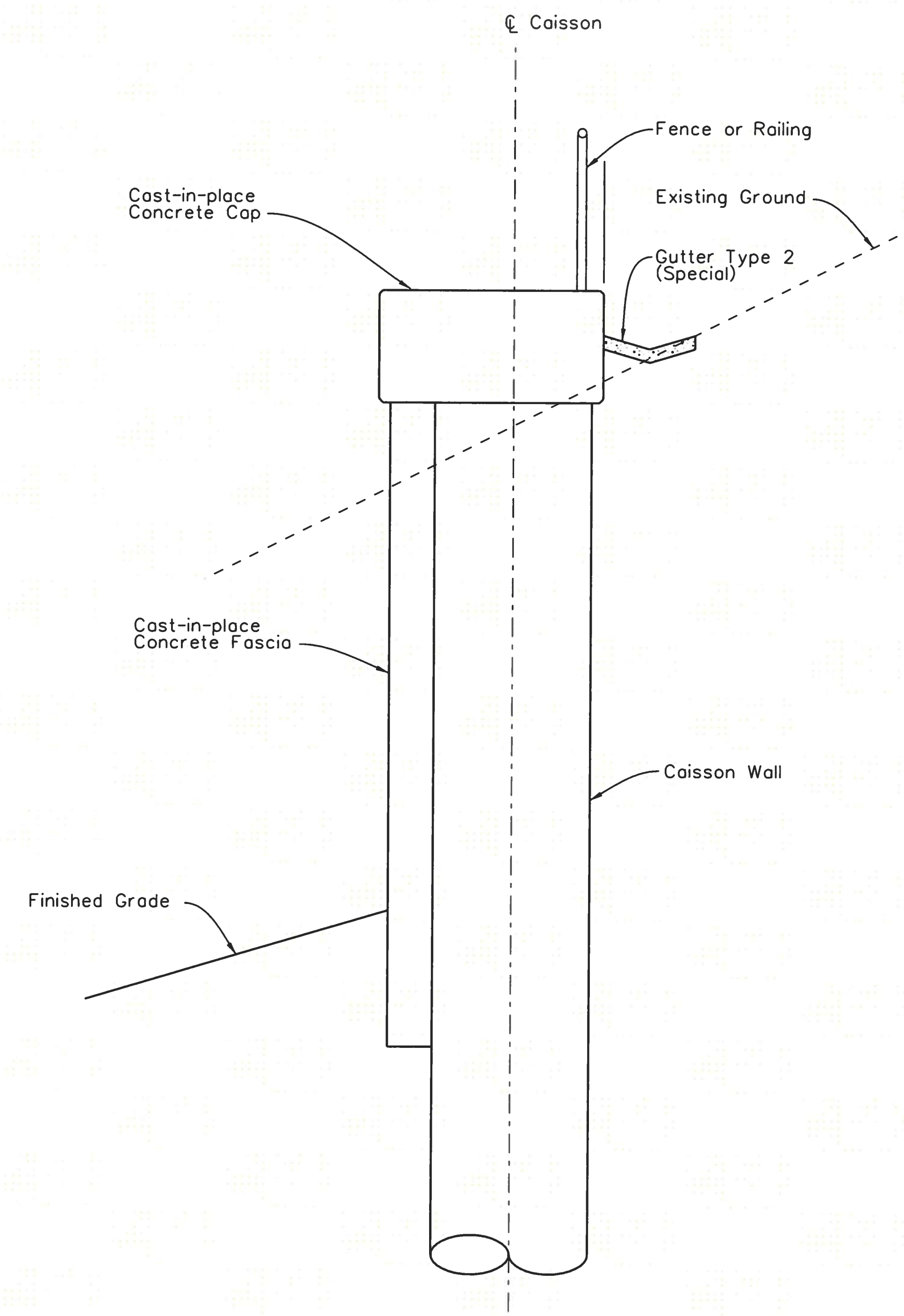


CAST-IN-PLACE RETAINING WALL SECTION

Santa Fe SB Wall 1



TYPICAL CAISSON RETAINING WALL SECTION

Ramp 5S Wall
Santa Fe SB Wall 1

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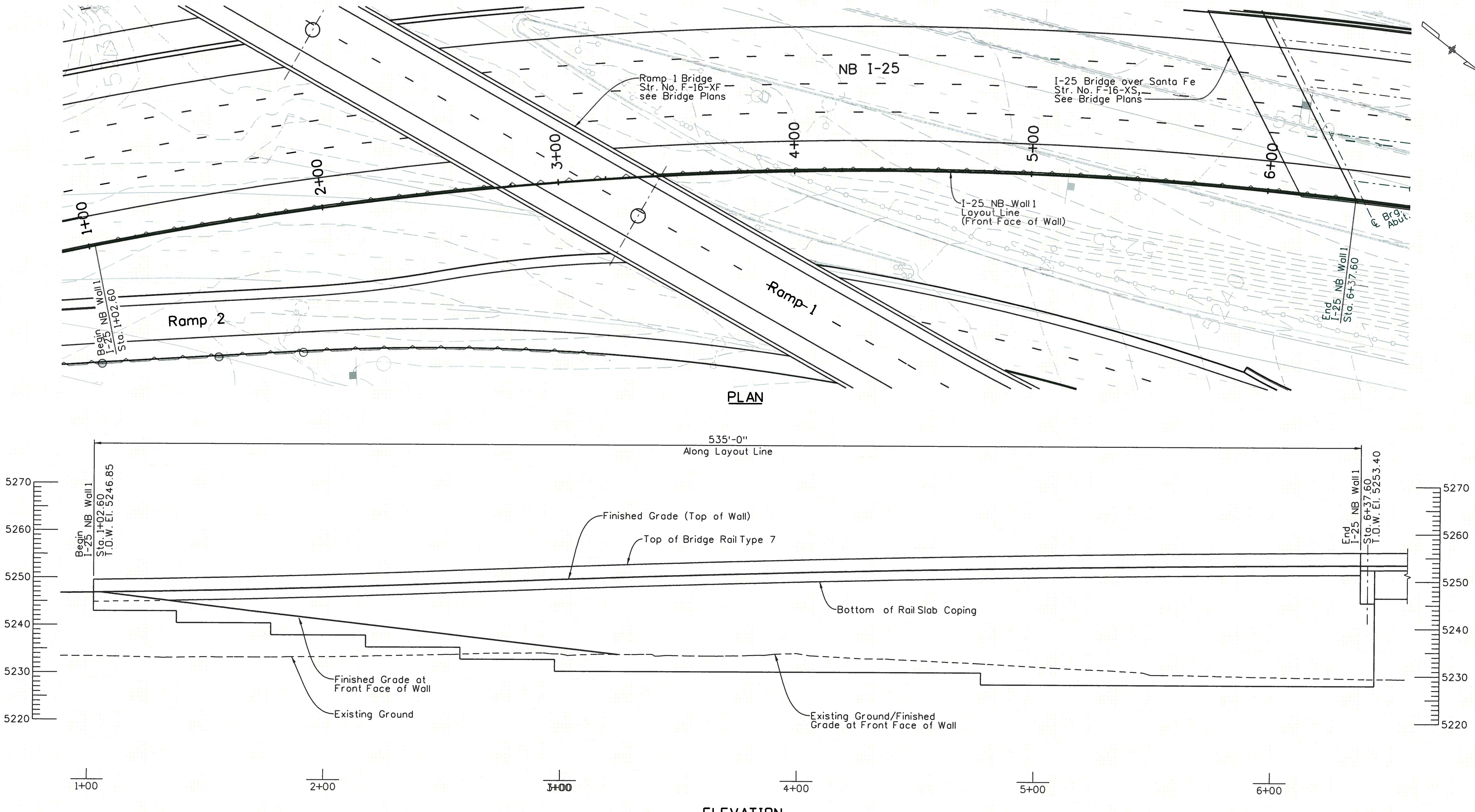
Cut Retaining Wall Typical Sections



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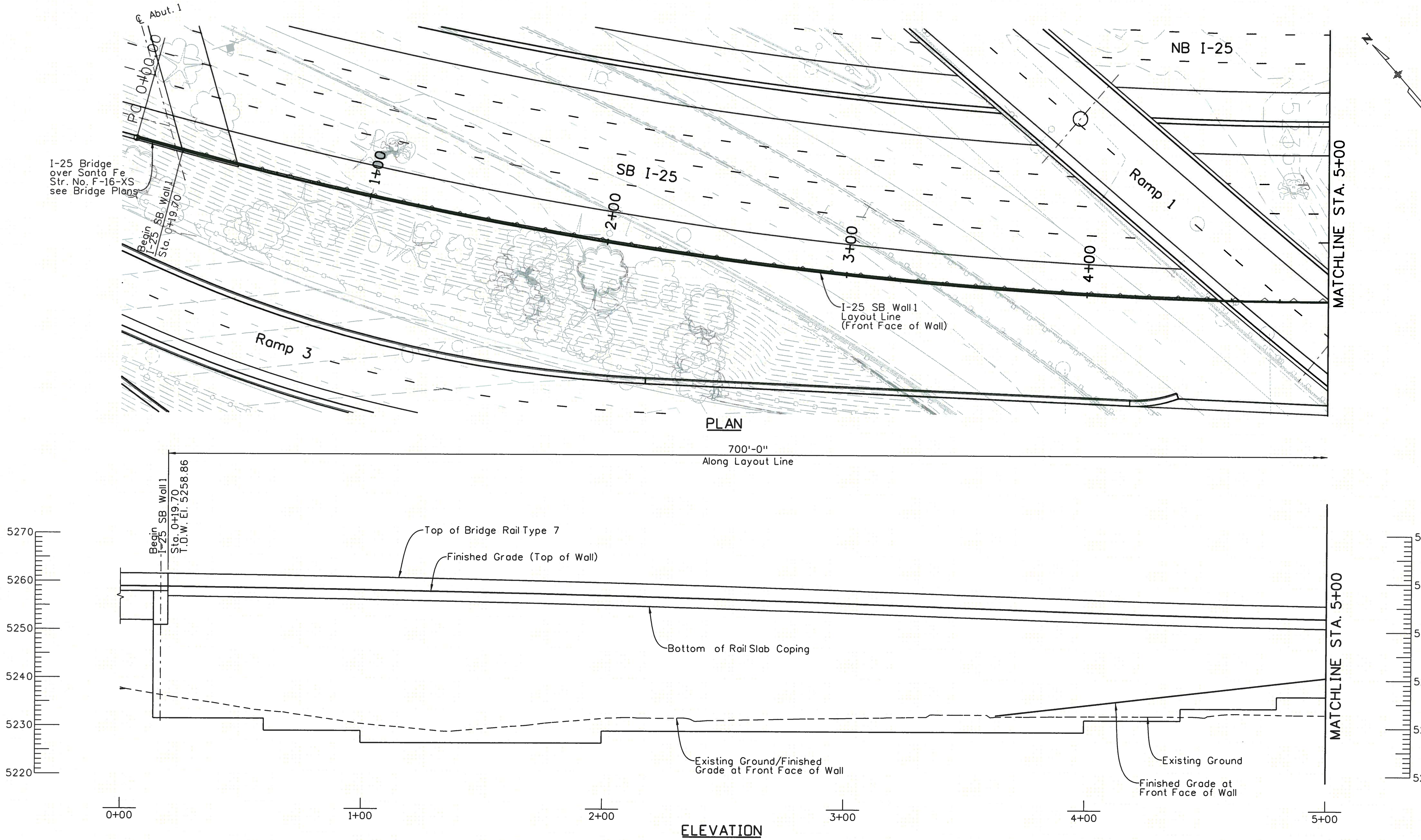
I-25 NB Wall 1



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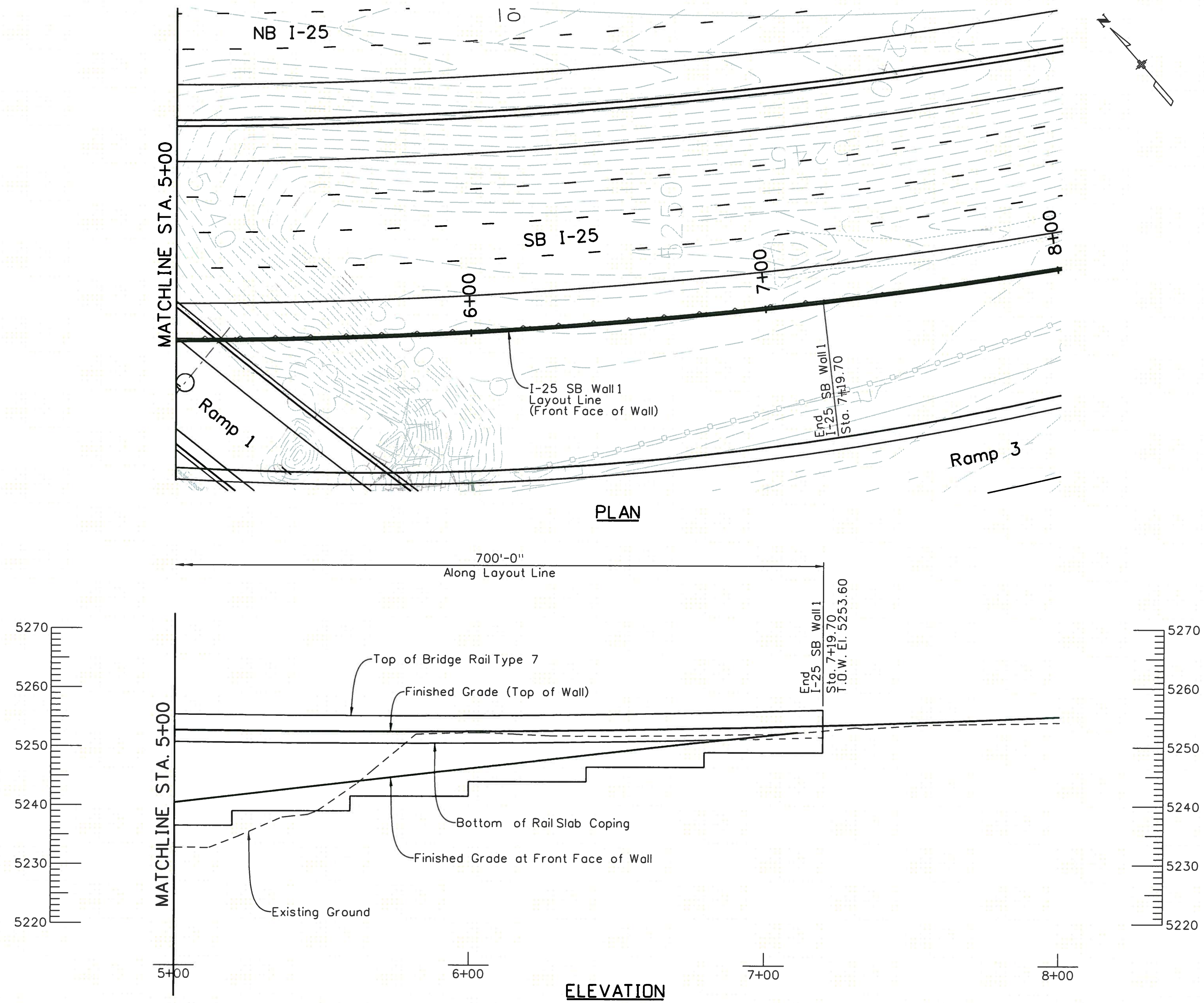
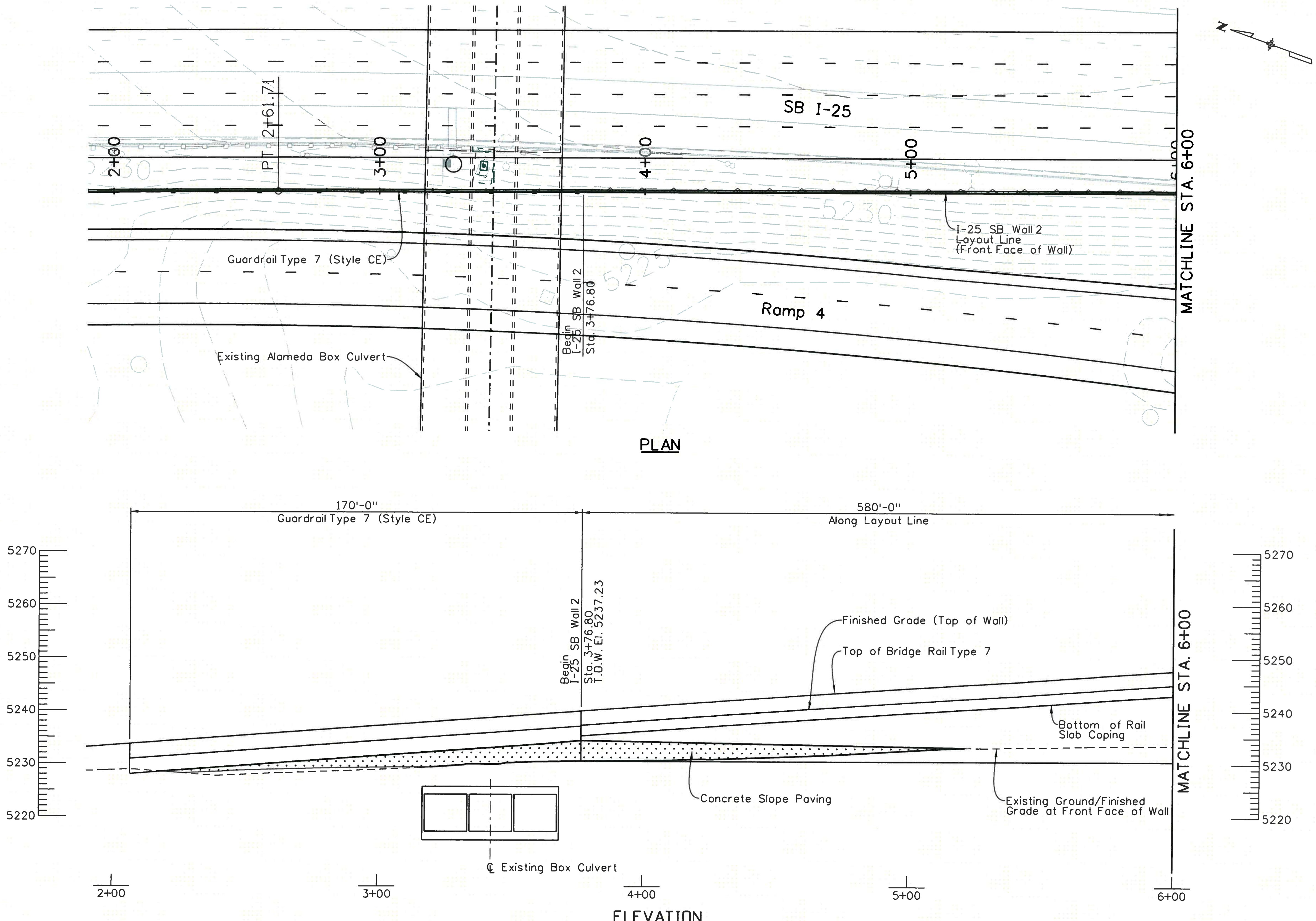
I-25 SB Wall 1
(Sheet 1 of 2)



I-25 SB Wall 1
(Sheet 2 of 2)



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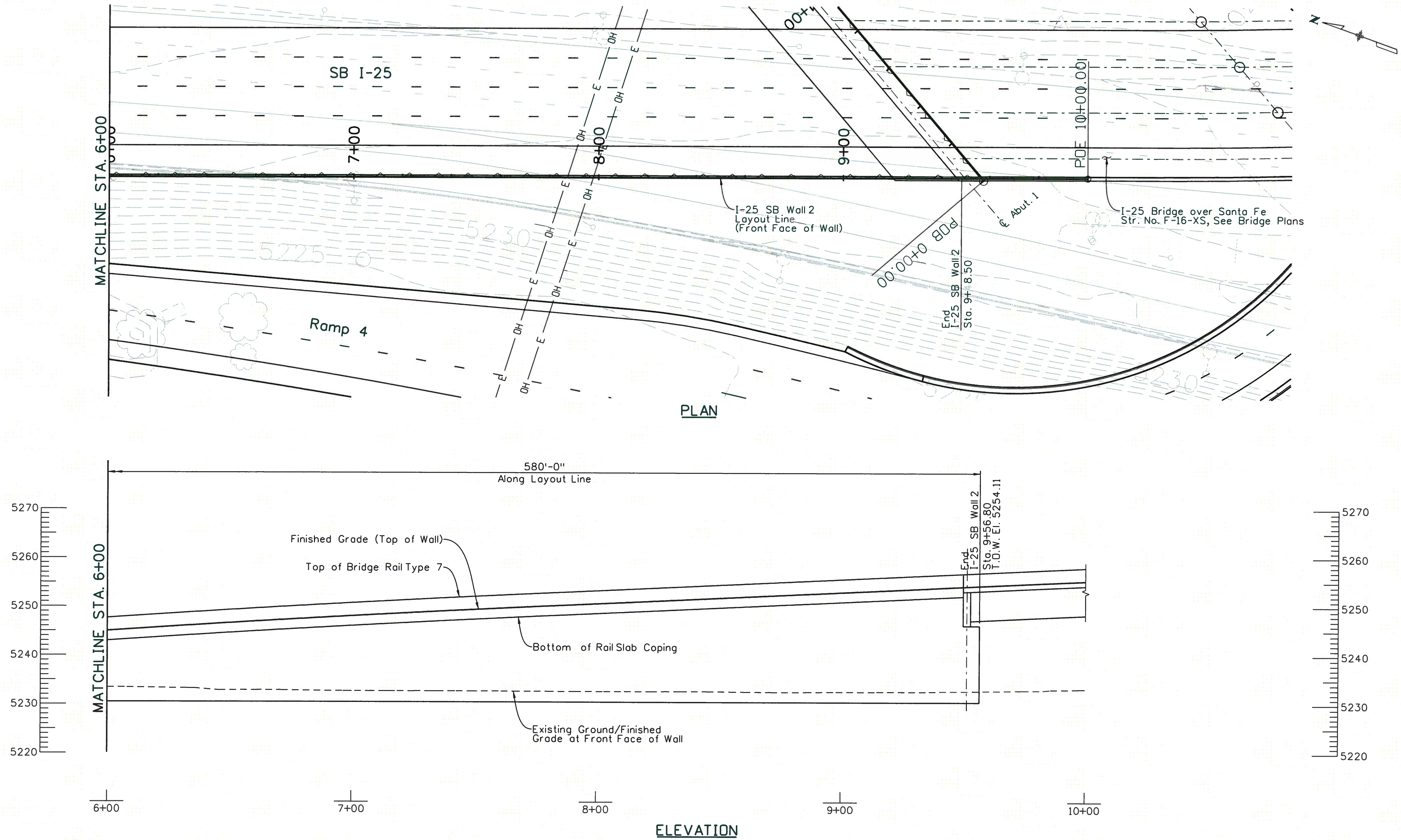
I-25 SB Wall 2
(Sheet 1 of 2)



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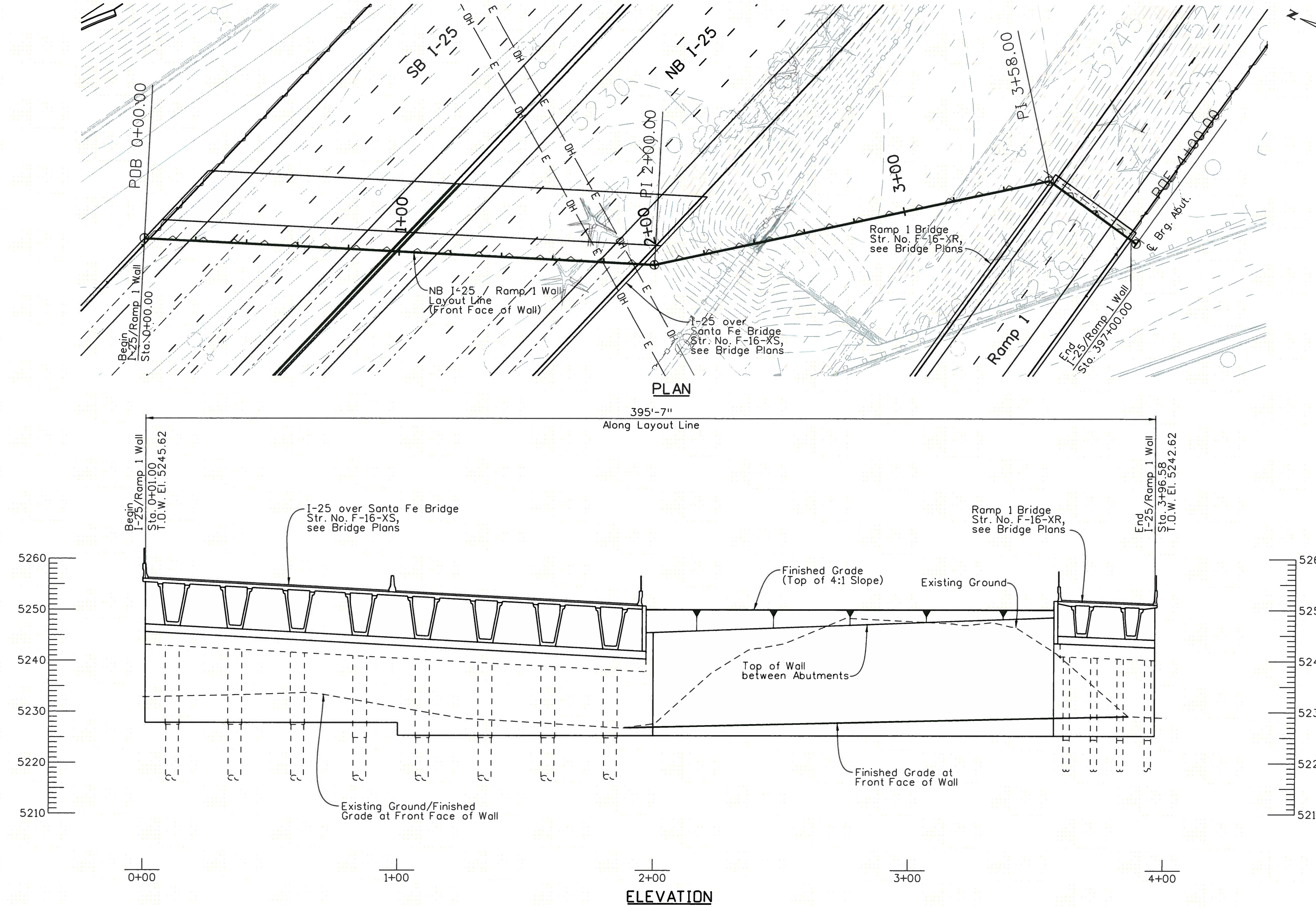
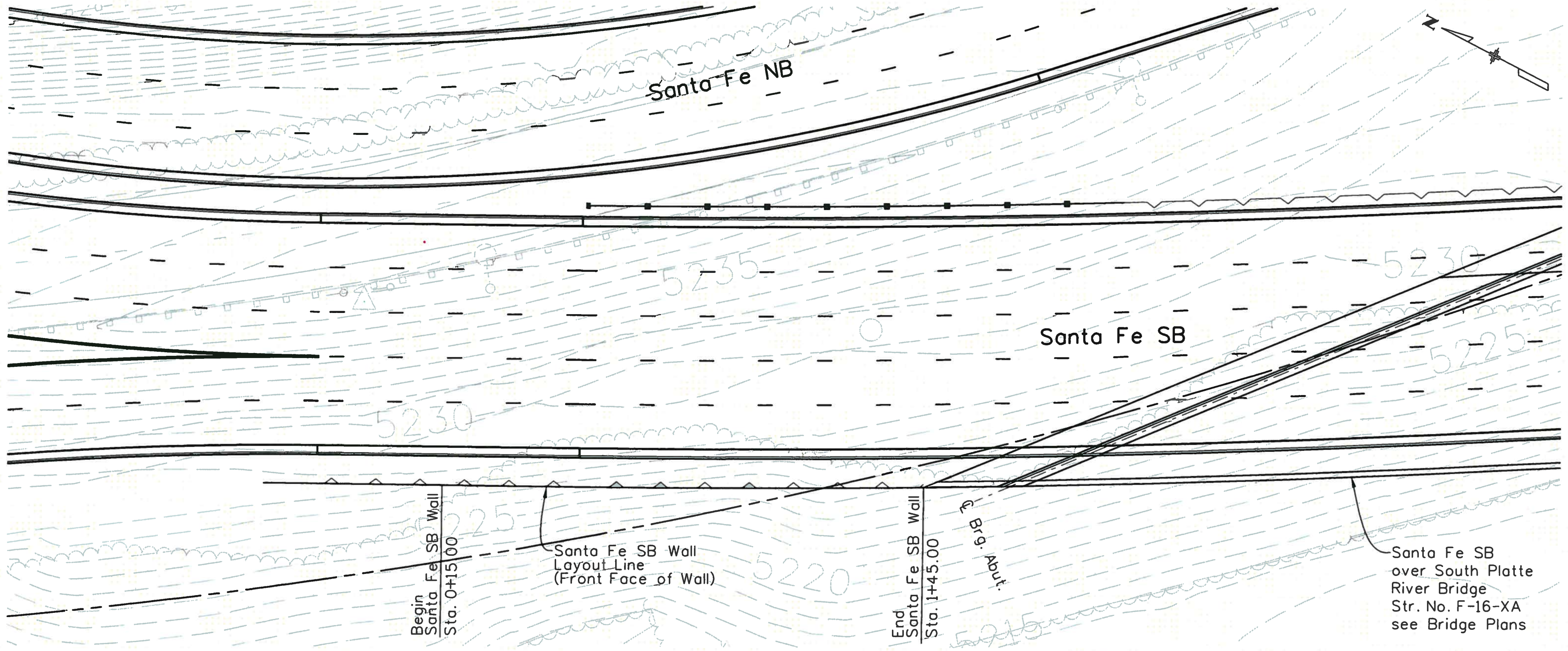
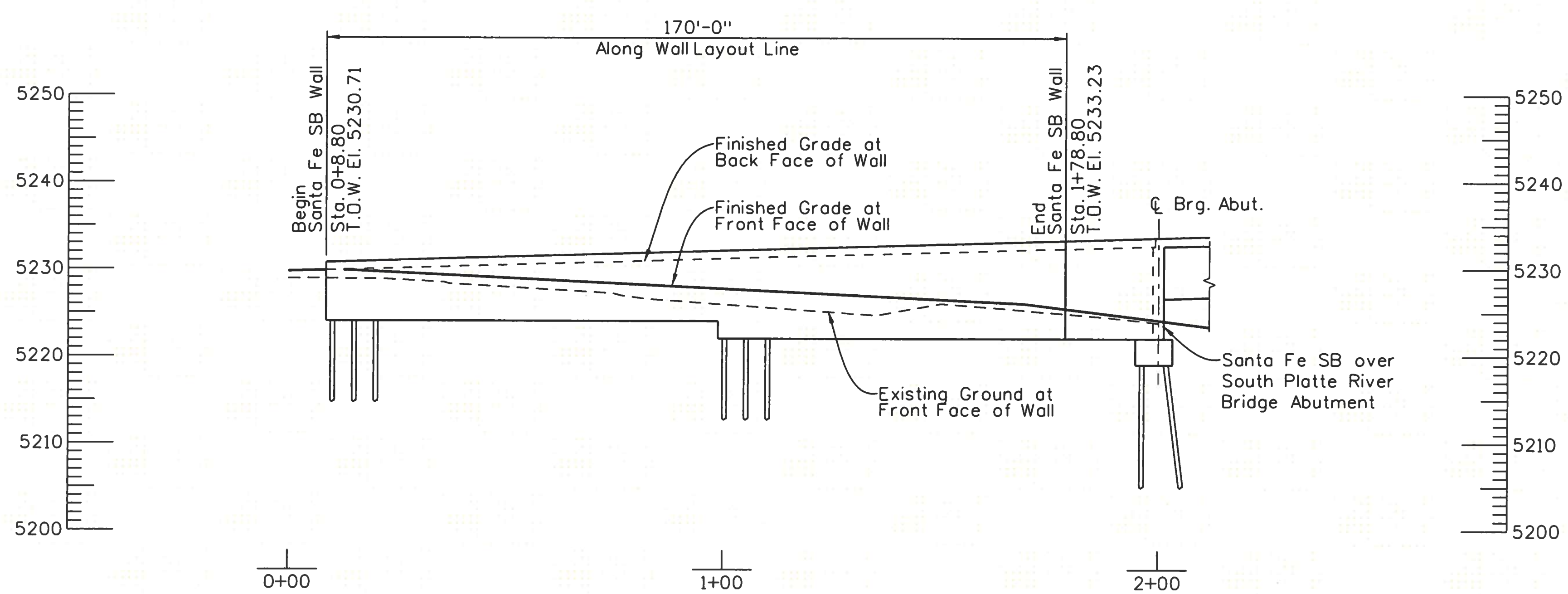
I-25 SB Wall 2
(Sheet 2 of 2)



I-25 / Ramp 1 Wall



PLAN



ELEVATION

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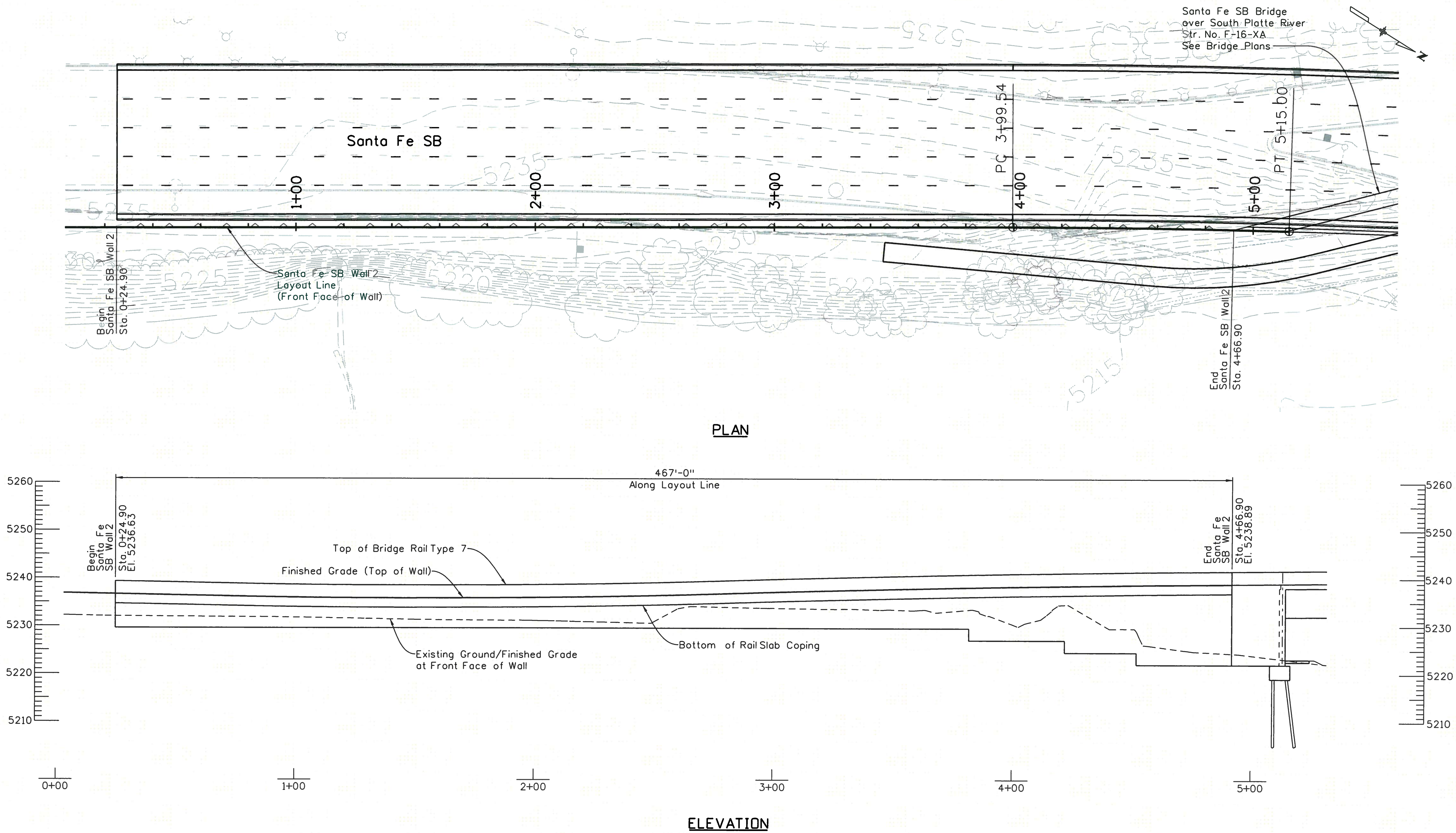
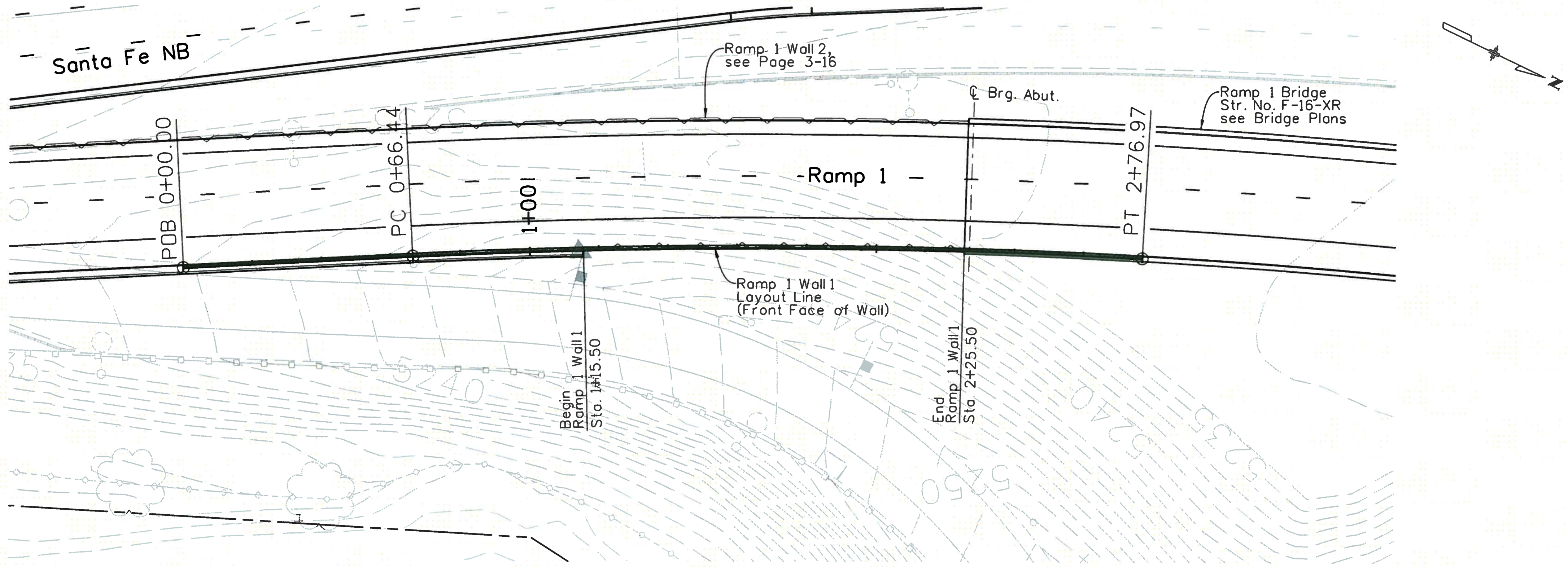
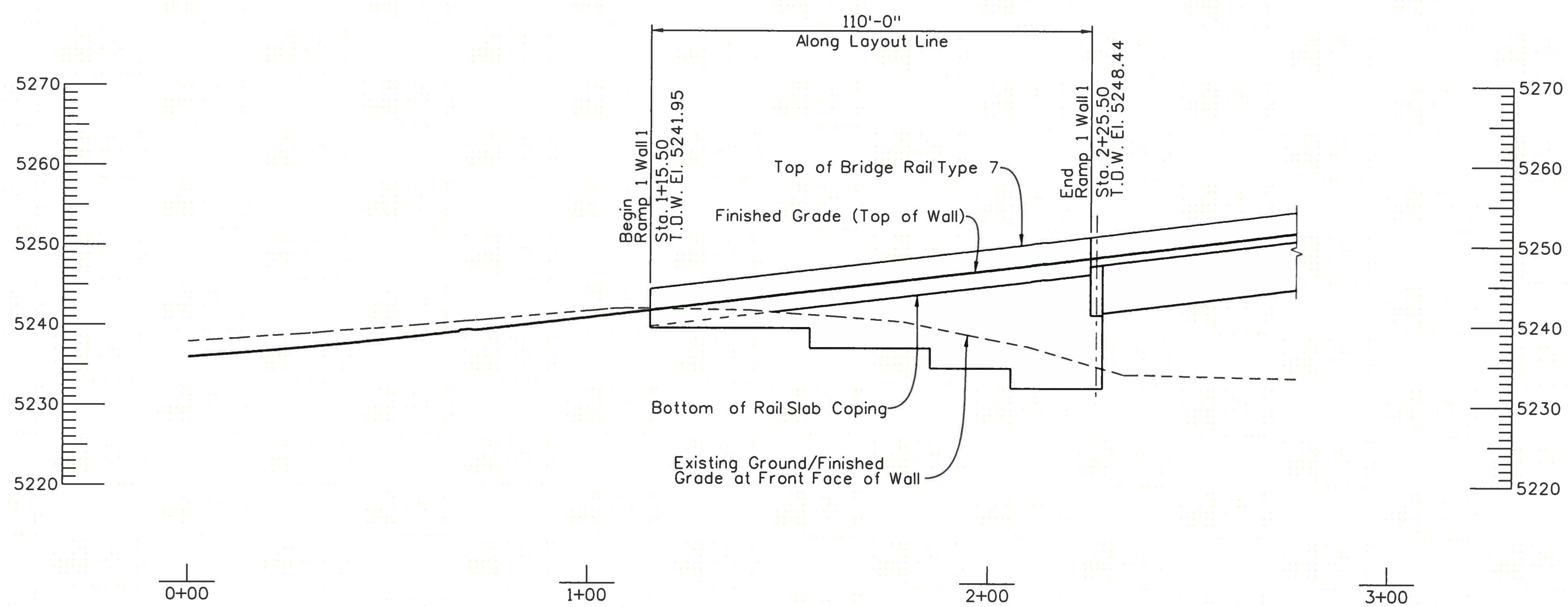
Santa Fe SB Wall 1


Santa Fe SB Bridge
over South Platte River
Str. No. F-16-XA
See Bridge Plans
N
Santa Fe SB
1+00
2+00
3+00
PC 3+99.54
4+00
5+00
PT 5+15.00
Begin Santa Fe SB Wall 2 Sta. 0+24.90
Santa Fe SB Wall 2 Layout Line (Front Face of Wall)
End Santa Fe SB Wall 2 Sta. 4+66.90
PLAN
467'-0"
Along Layout Line
Begin Santa Fe SB Wall 2 Sta. 0+24.90 El. 5236.63
End Santa Fe SB Wall 2 Sta. 4+66.90 El. 5238.89
Top of Bridge Rail Type 7
Finished Grade (Top of Wall)
Bottom of Rail Slab Coping
Existing Ground/Finished Grade at Front Face of Wall
5260
5250
5240
5230
5220
5210
0+00
1+00
2+00
3+00
4+00
5+00
ELEVATION



PLAN



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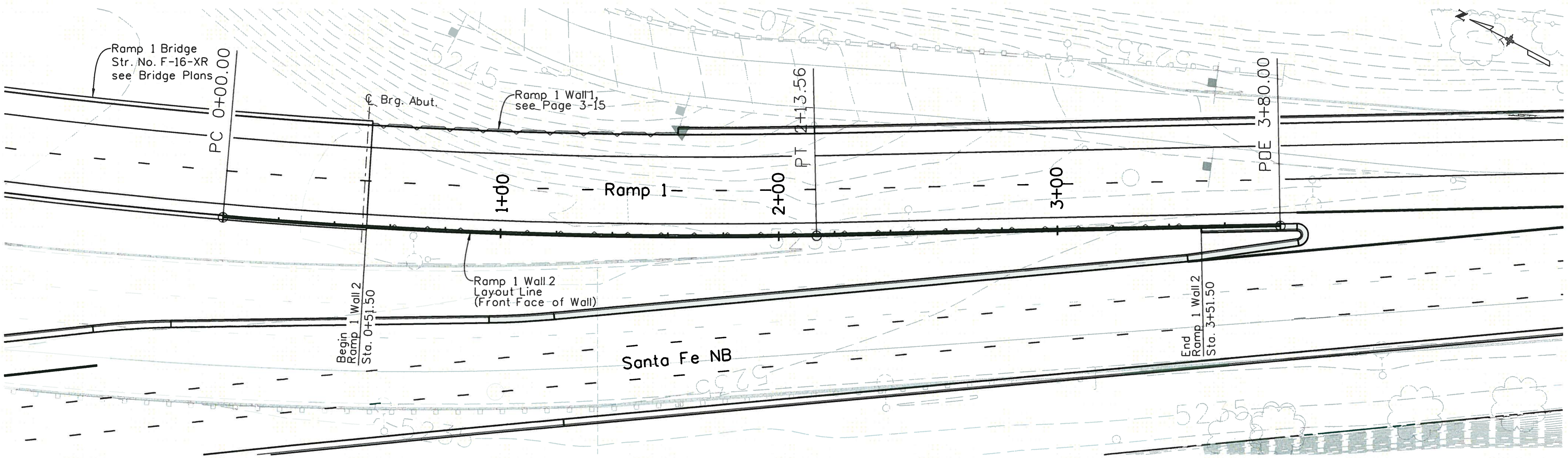
Ramp 1 Wall 1



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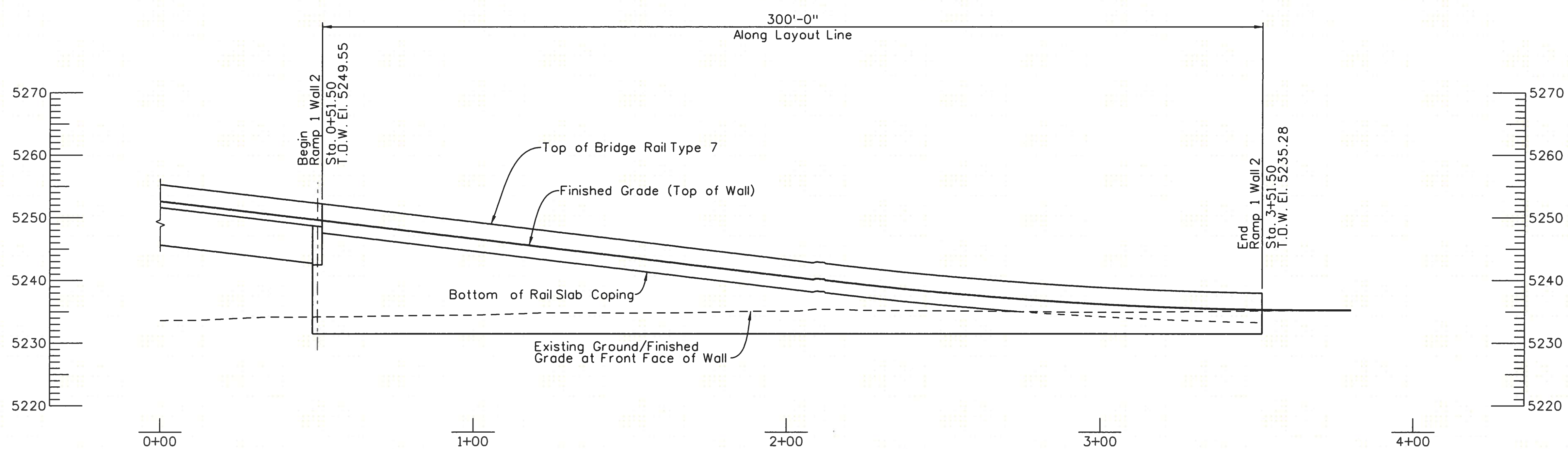
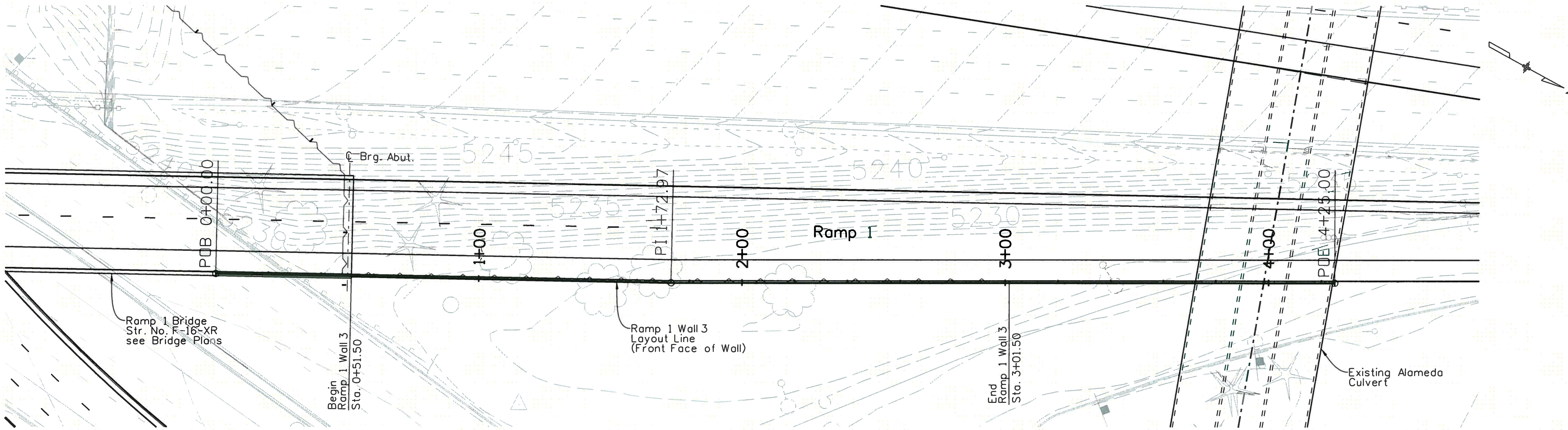


ELEVATION

Ramp 1 Wall 2



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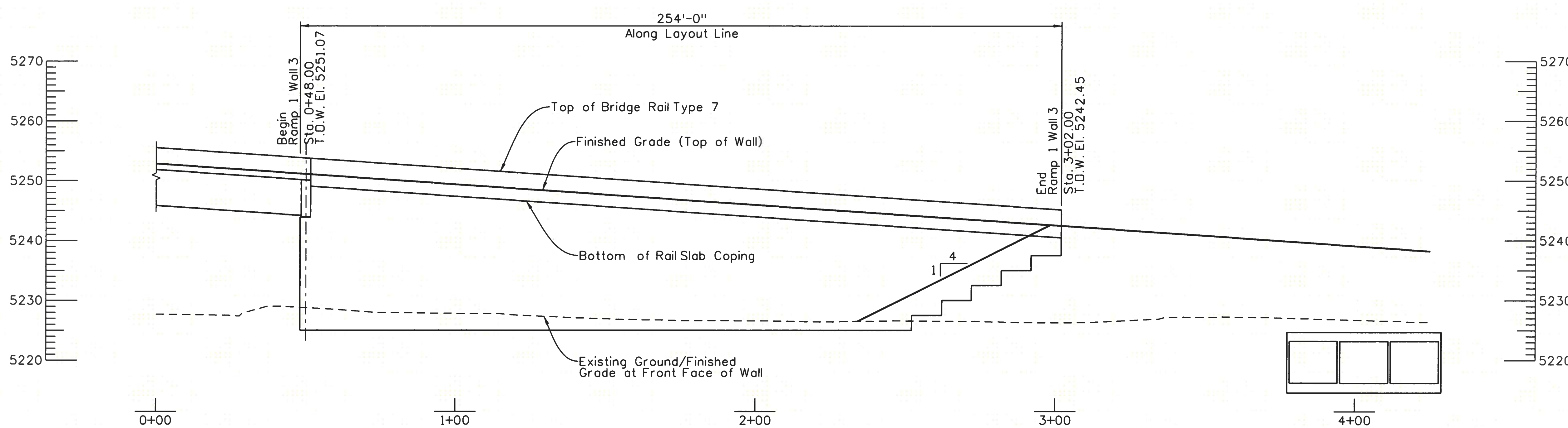
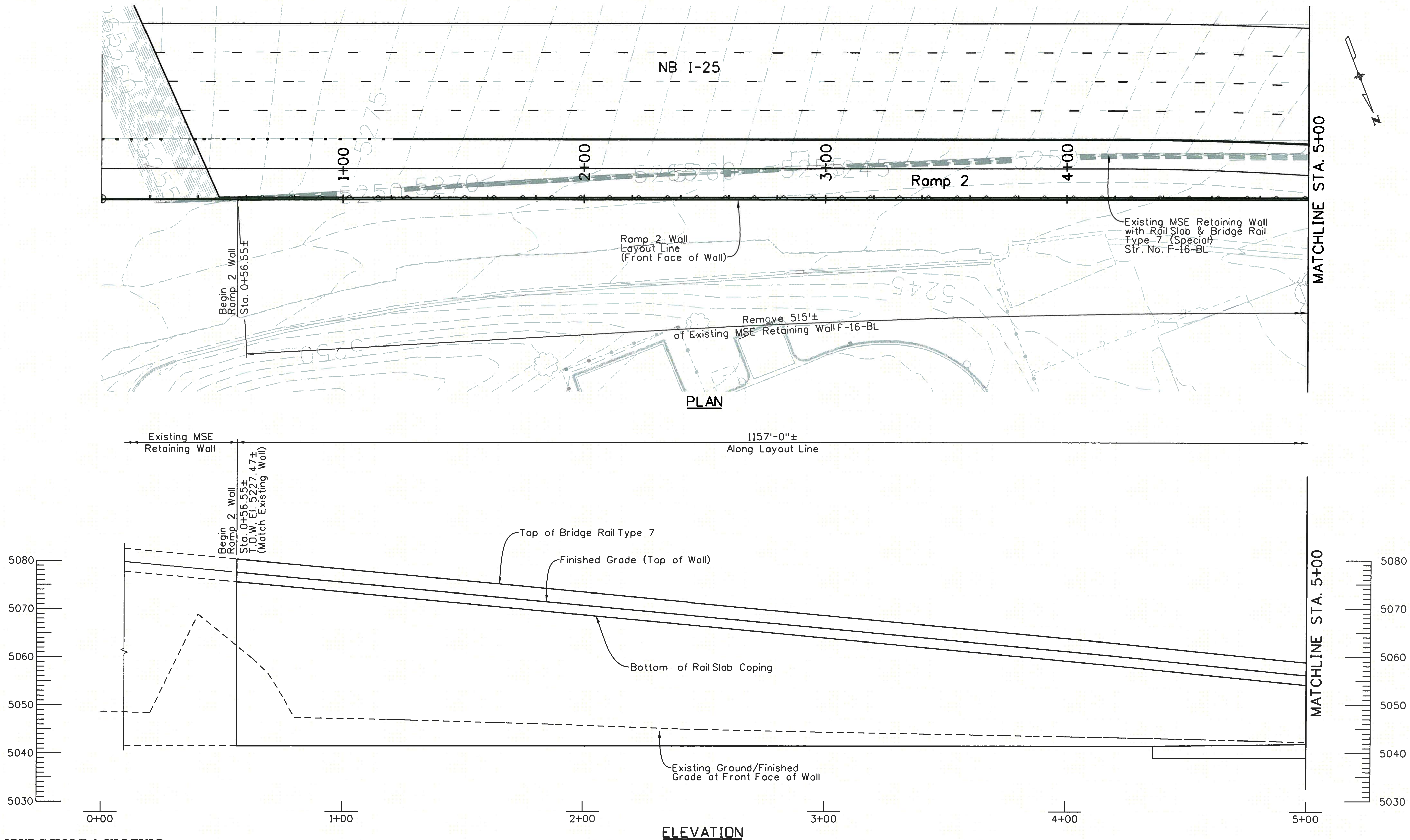


ELEVATION

FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

Ramp 1 Wall 3



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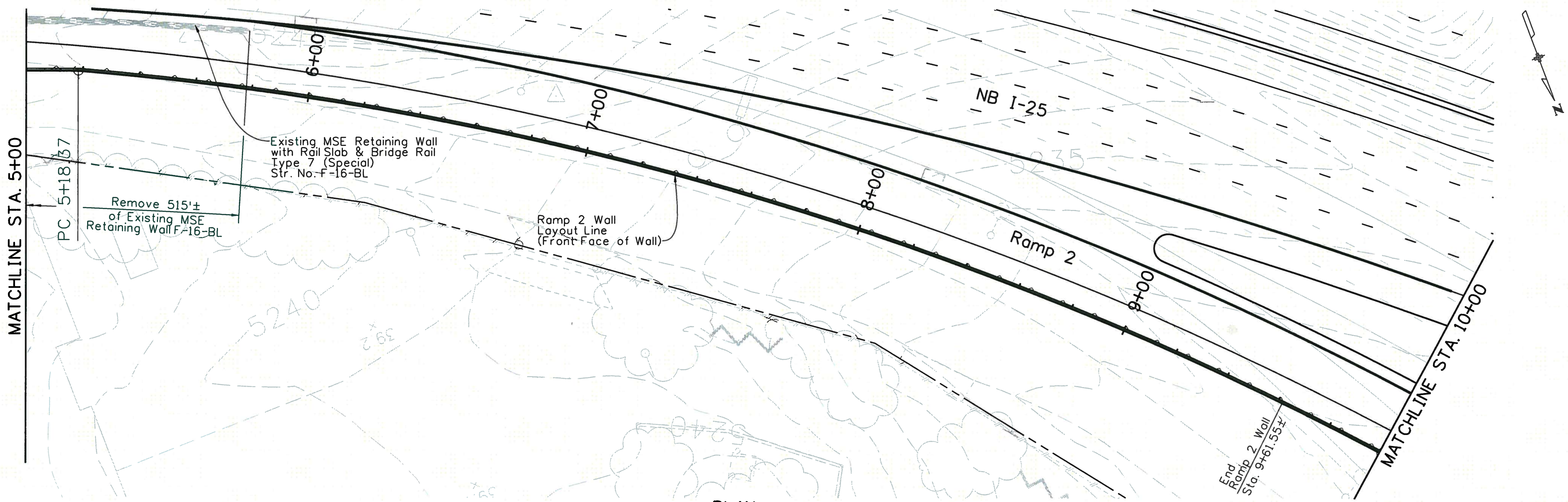
FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

Ramp 2 Wall (Sheet 1 of 3)



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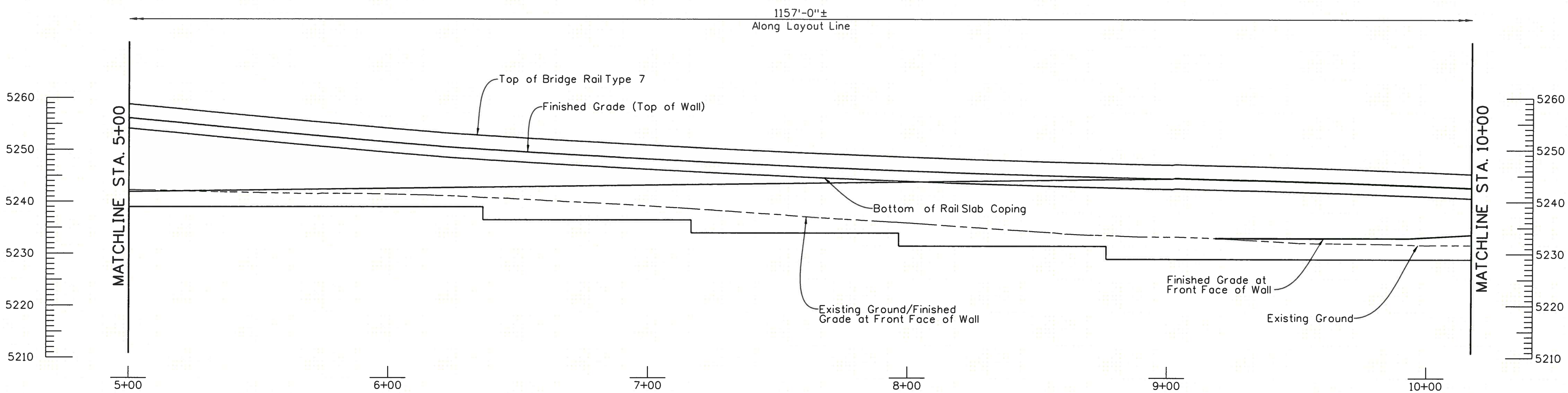

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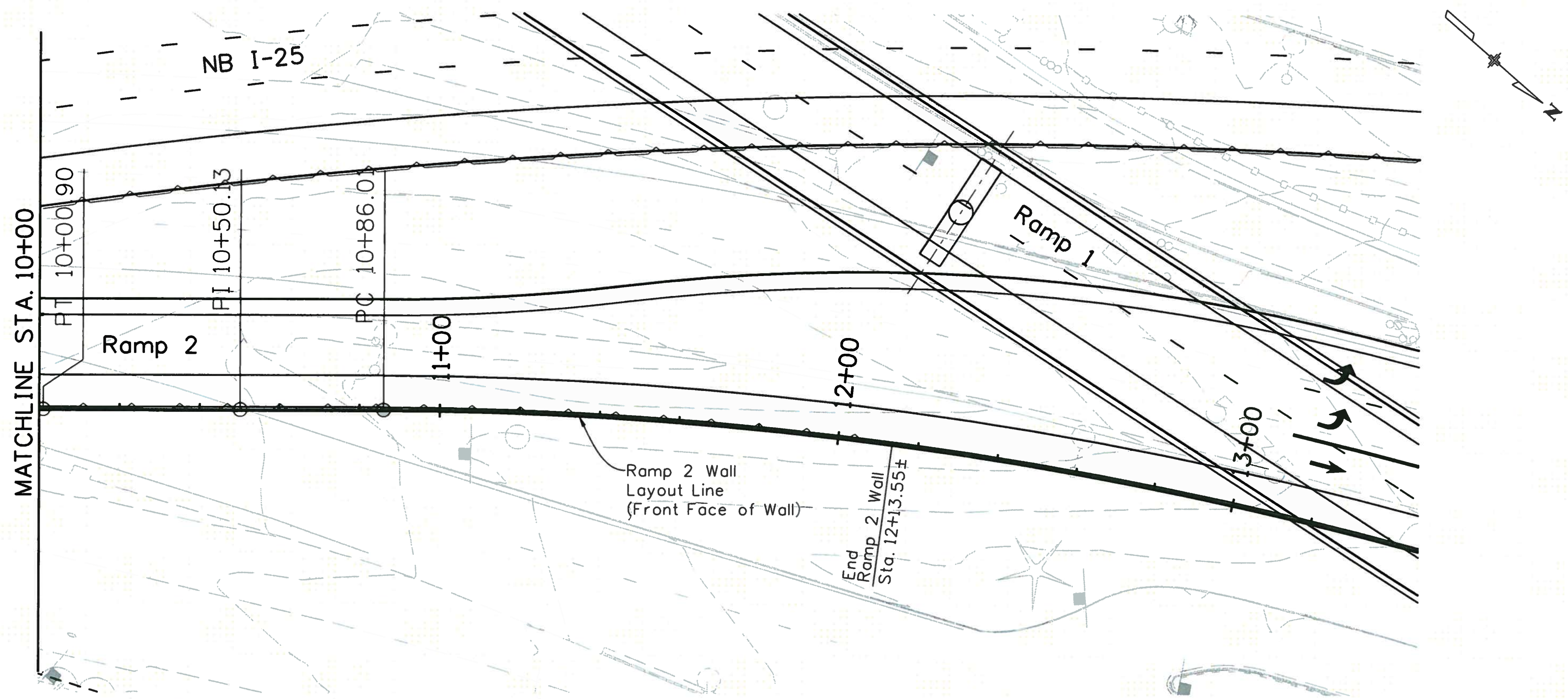
FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

Ramp 2 Wall (Sheet 2 of 3)



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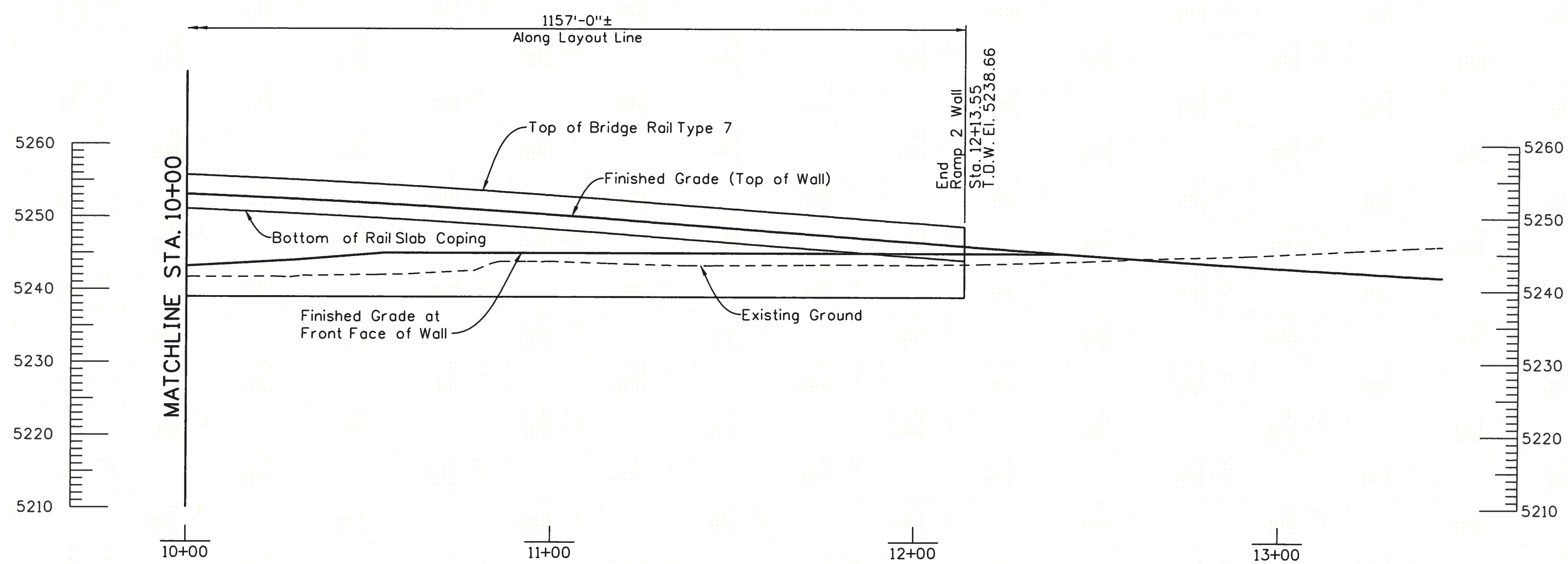
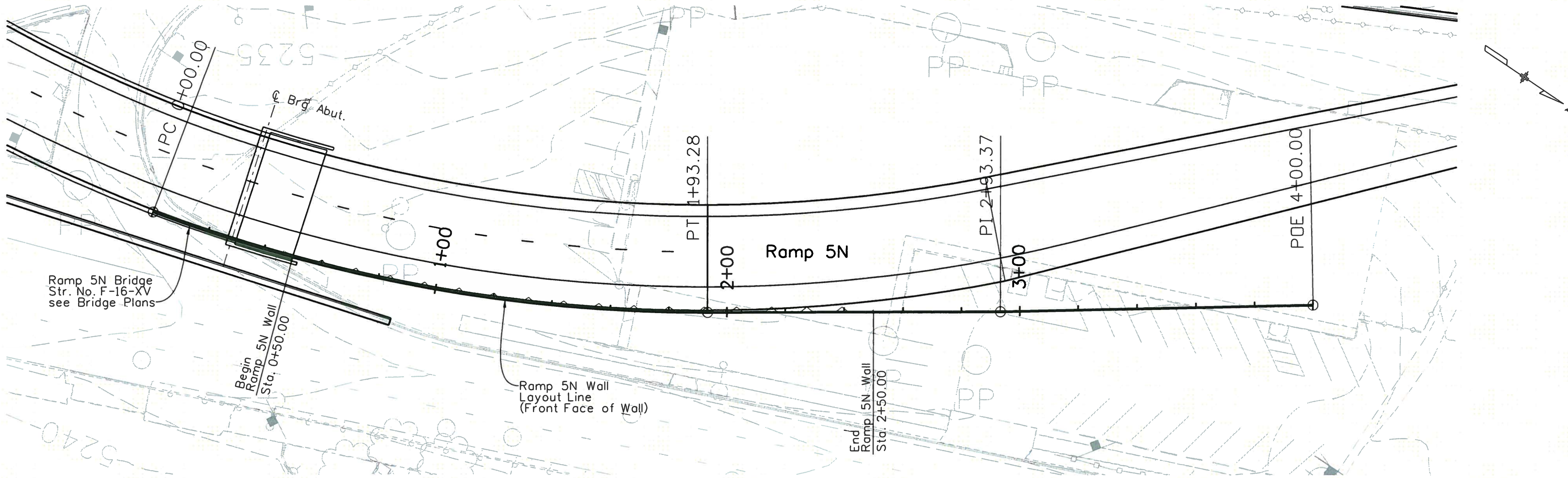


ELEVATION

FELSBURG HOLT & ULLEVIG
FIGG BRIDGE ENGINEERS
HARTWIG & ASSOCIATES, INC.
SUMMIT ENGINEERING GROUP, INC.

Ramp 2 Wall
(Sheet 3 of 3)



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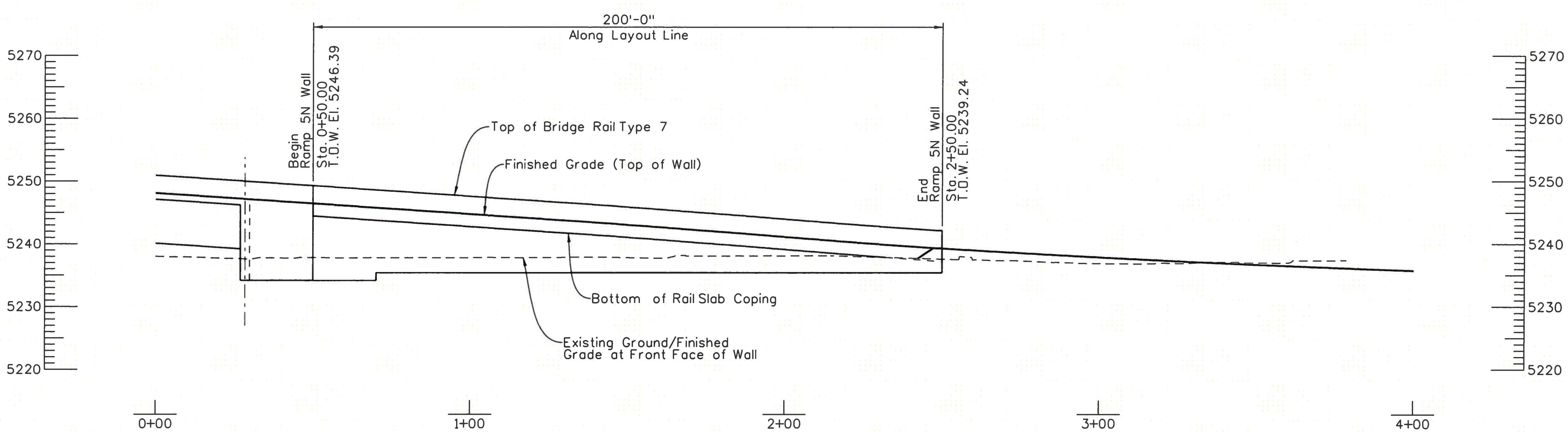

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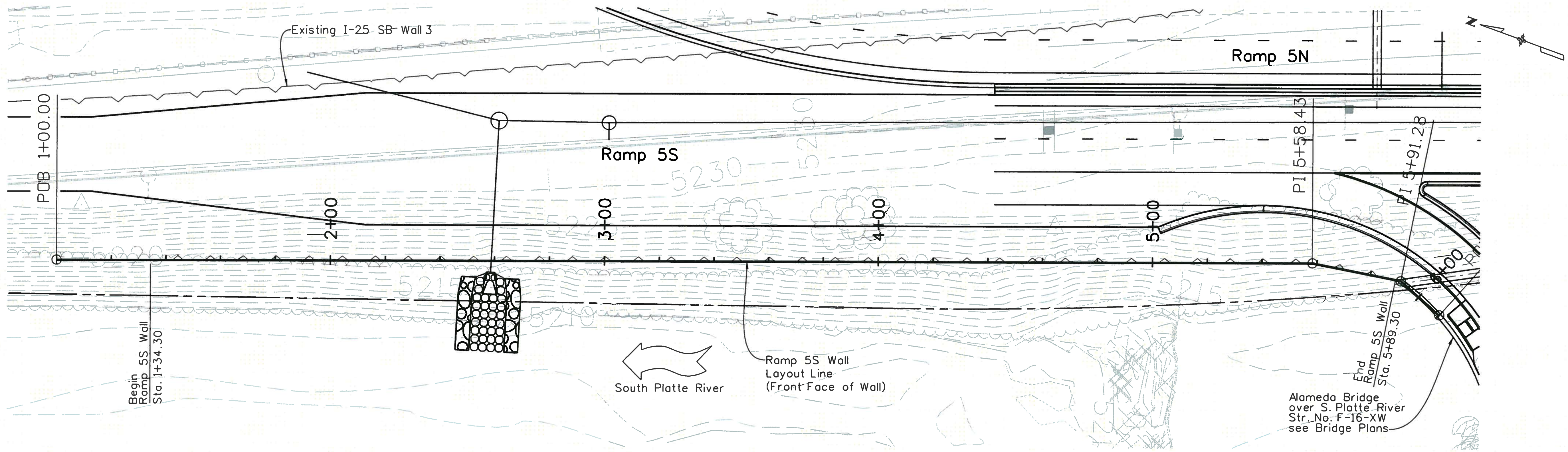

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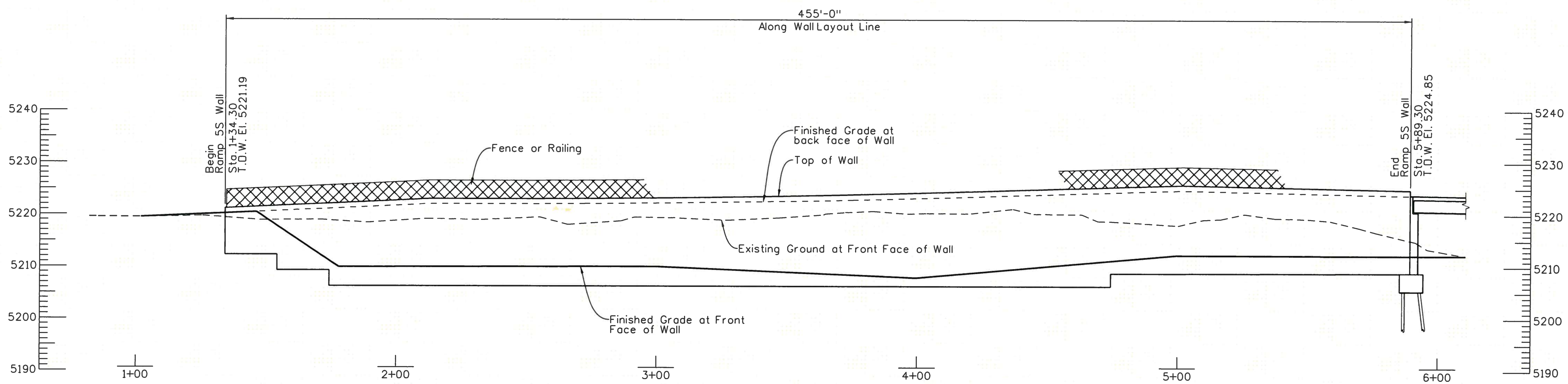
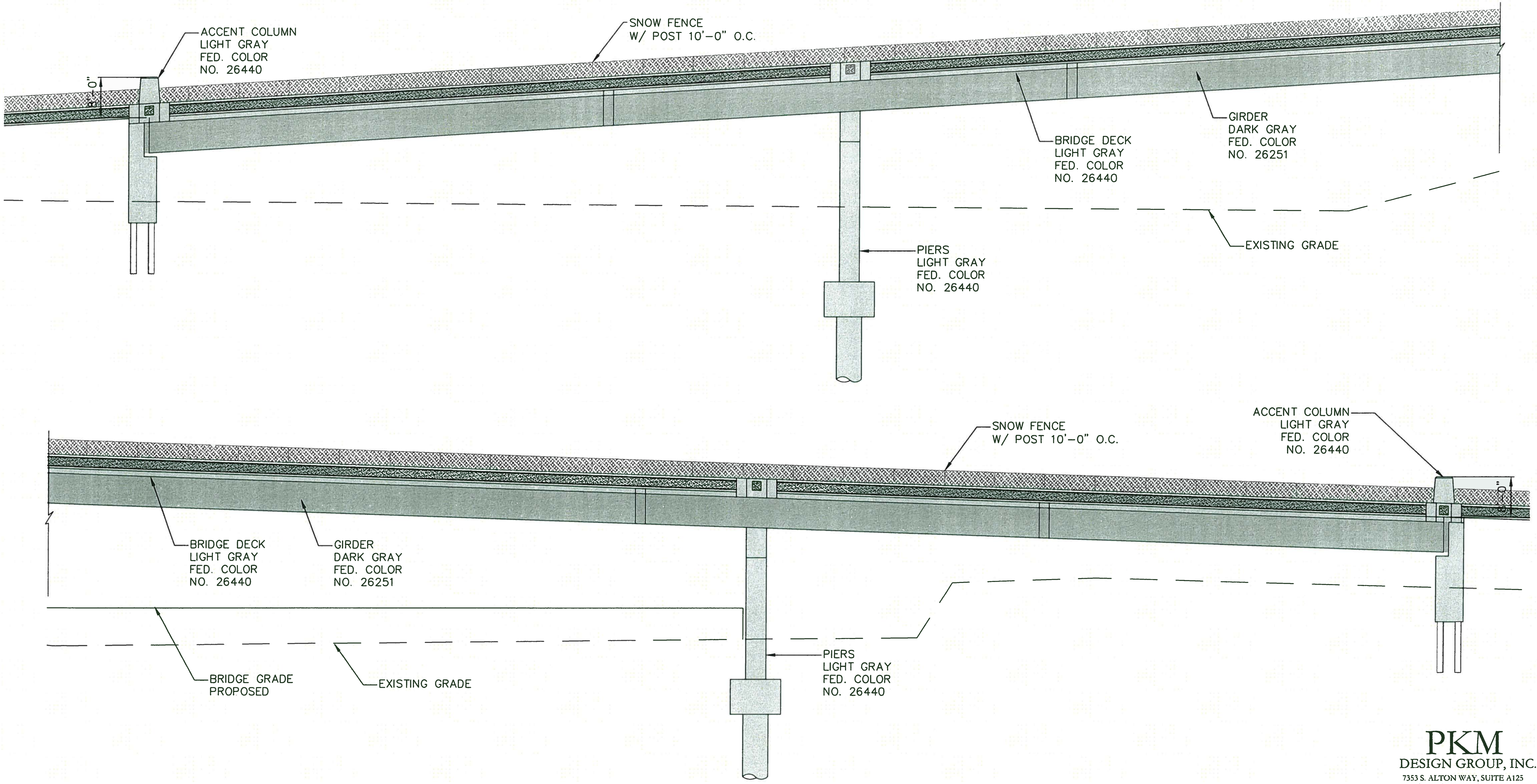


ELEVATION

Ramp 5S Wall

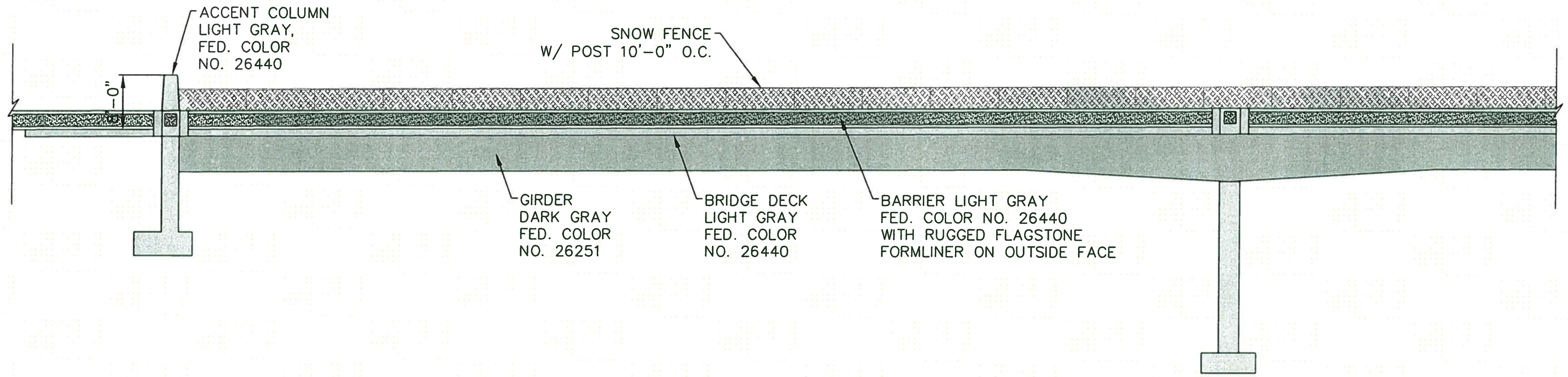
4. PRELIMINARY AESTHETIC PLANS

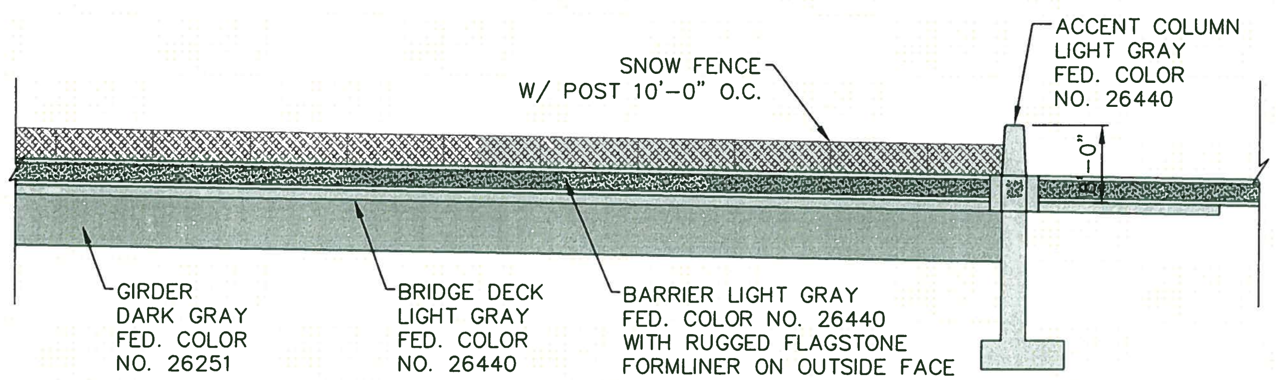


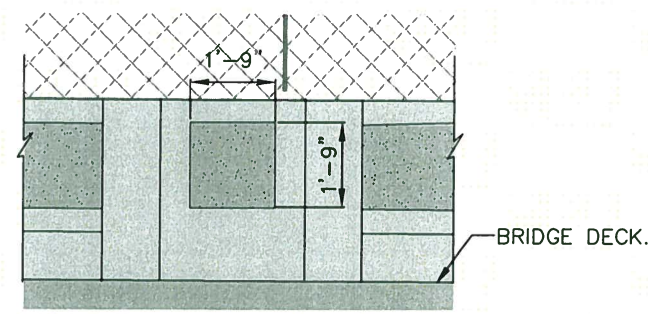
F-16-XR PH 3

SCALE = 1" = 20'

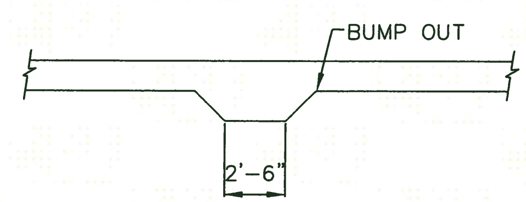
PKM
DESIGN GROUP, INC.
7353 S. ALTON WAY, SUITE A125
CENTENNIAL, CO. 80112
PH. (303) 804-0080
FAX(303) 804-0070



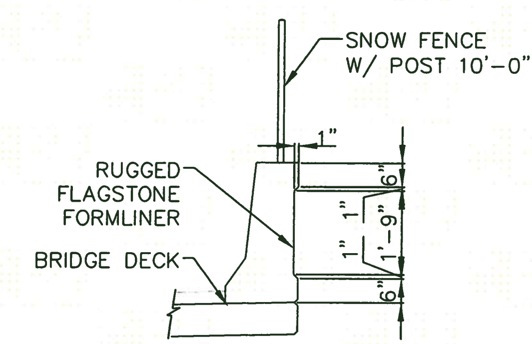




TEXTURED INSET AT COLUMNS AND ABOVE PIERS



BARRIER ACCENT DETAILS

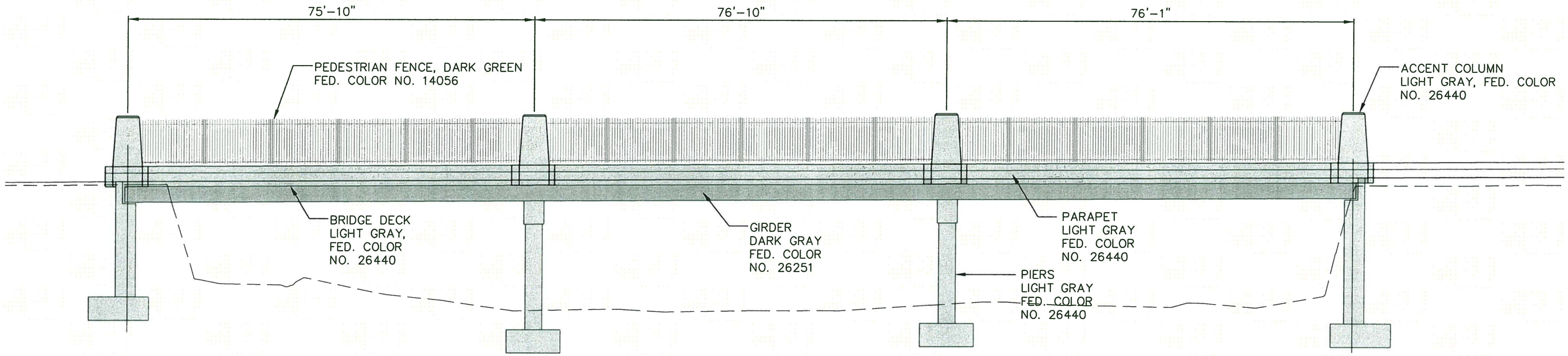


TYPE 7 BARRIER CROSS SECTION

F-16-XA_SSR PH 4

SCALE = 1" = 10'

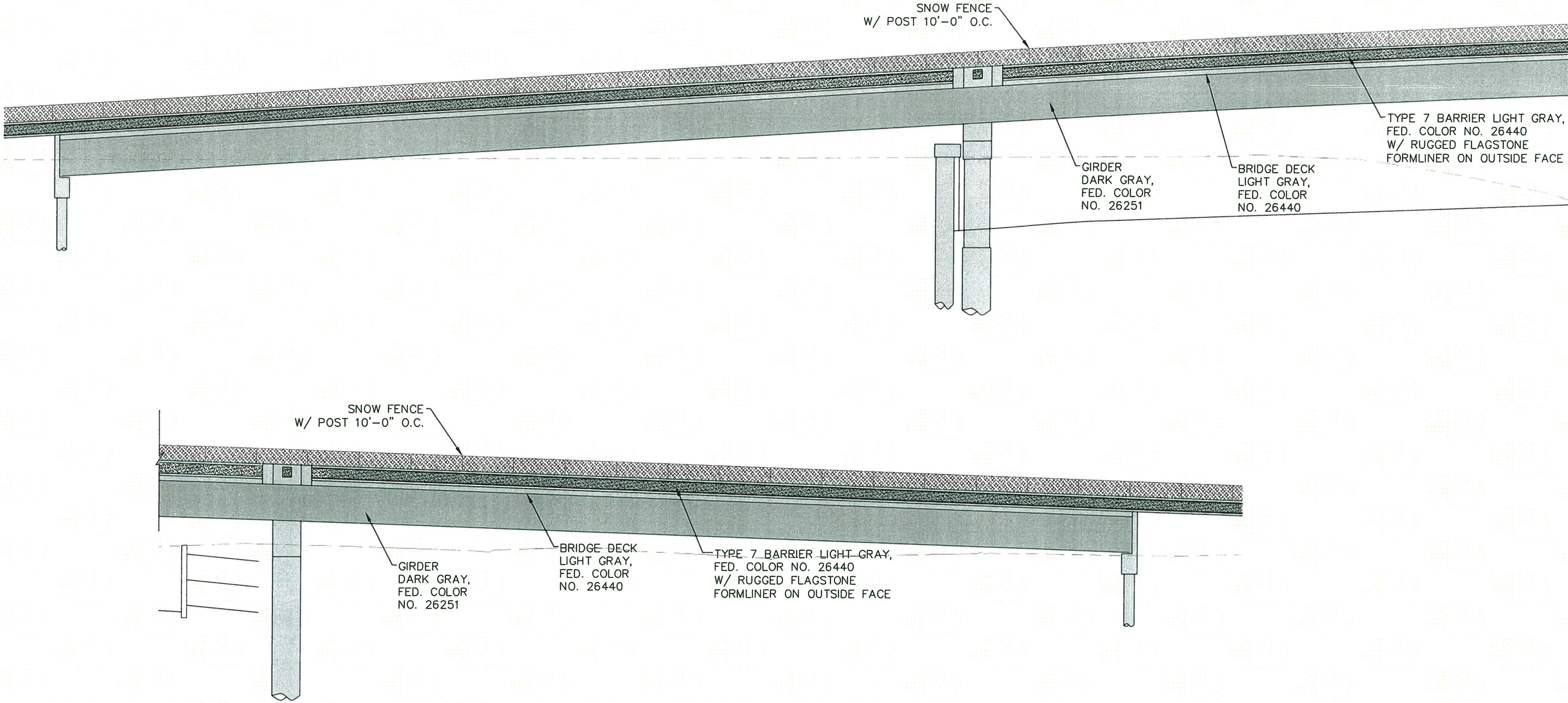
PKM
DESIGN GROUP, INC.
7353 S. ALTON WAY, SUITE A125
CENTENNIAL, CO. 80112
PH. (303) 804-0080
FAX(303) 804-0070



ALAMEDA OVER
SOUTH PLATTE RIVER
F-16-XW PH 5

SCALE = 1" = 8'

PKM
DESIGN GROUP, INC.
7353 S. ALTON WAY, SUITE A125
CENTENNIAL, CO. 80112
PH. (303) 804-0080
FAX(303) 804-0070



F-16-XV - PH 5

SCALE = 1" = 10'

PKM
DESIGN GROUP, INC.
7353 S. ALTON WAY, SUITE A125
CENTENNIAL, CO. 80112
PH. (303) 804-0080
FAX(303) 804-0070