
ALTERNATIVE EVALUATION REPORT

WESTERN HILLS VIADUCT

TYLIN INTERNATIONAL



DECEMBER 2, 2020



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Bridge Name Abbreviation

SSPL: Short Span Push Launch

CIP: Cast-in-place Segmental

TA: Parallel Twin Arches

EX: Extradosed Bridge

LSPL: Push Launched Long Span Double Decker Truss/Long Span Push Launch

CSB: Cable Stayed Bridge

1 INTRODUCTION

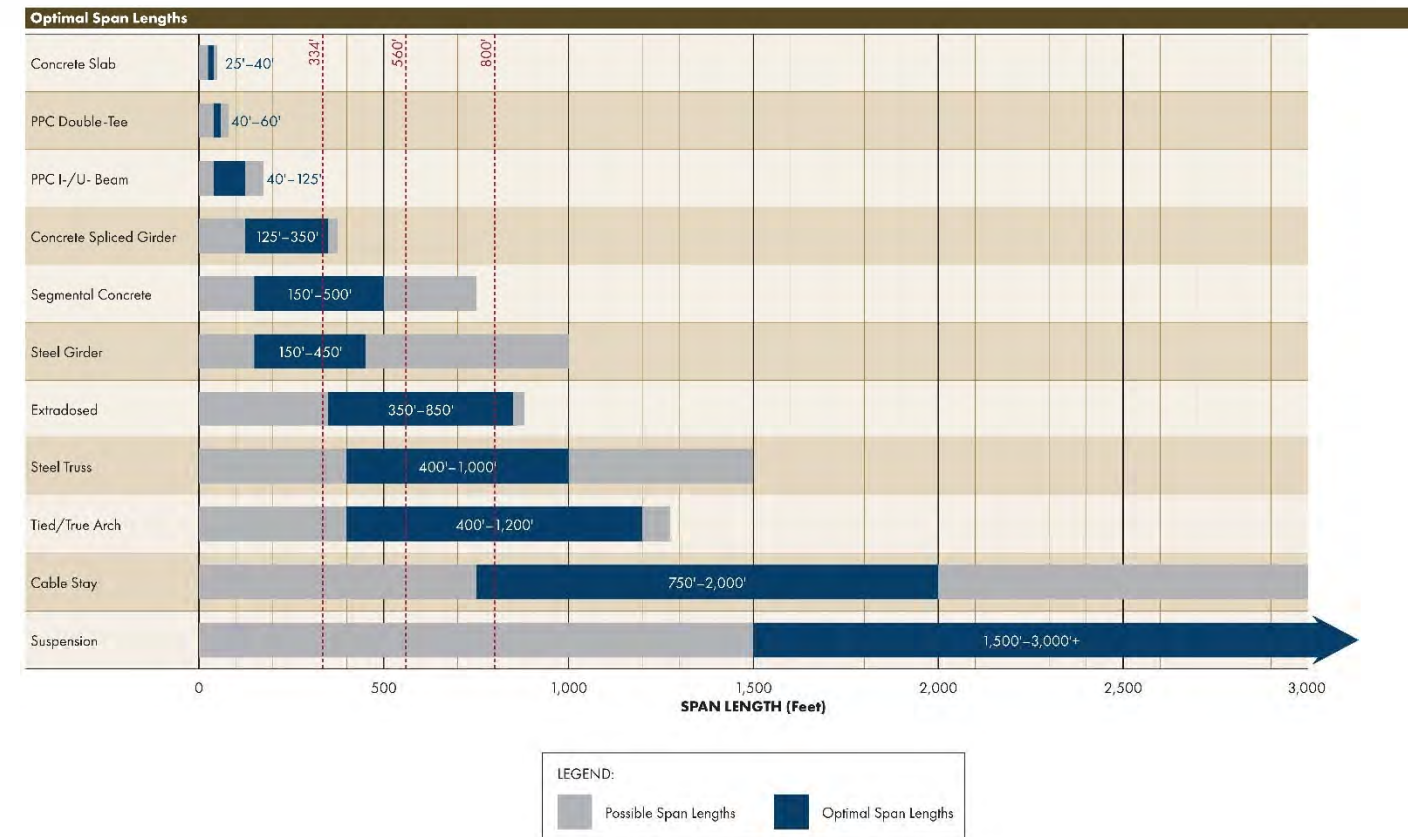
1.1 Introduction

T. Y. Lin International's (TYLI) Design Team has been charged by the City of Cincinnati and Hamilton County to develop an Alternative Evaluations Report for a replacement bridge on a new alignment for the structurally deficient Western Hills Viaduct.

One of the primary challenges is to design a bridge that would span the CSX Queensgate Railyard while limiting interruptions to normal yard operations. Located along the Mill Creek west of downtown Cincinnati, Queensgate Yard is one of the largest rail classification facilities in North America. With a length of approximately five miles and over 70 miles of track, Queensgate is one of the most important hump yards on the CSX system.



The clear span across the railyard is of the order of about 800 feet. While the design team initially looked at bridge types that would span the railyard, because of potential cost constraints the team also looked at additional pier locations within the railyard which would allow shorter and more economical bridge types.



As shown in the chart above, cable-stayed and arch bridges can span the required 800 feet easily. However, this span is at the upper limit for segmental bridges and results in a structure that is very deep at the piers. The design team therefore introduced a pier in a stretch of open ground available near the turntable on the west side of the alignment, reducing the span length to about 560 feet, thus making both the segmental and extradosed bridge feasible for this site.

In order to consider all possibilities, shorter span and potentially more economical options were considered by proposing the placement of a pier in the middle of the yard, just west of the CSX Departure Tracks. A three-span structure over the most active part of the yard was then developed, with a maximum span length of 334 feet.

1.2 Executive Summary

Western Hills Viaduct is a half-mile long viaduct that spans the Mill Creek Valley and the Queensgate Railyard. The viaduct connects Harrison and Westwood Streets to Central Parkway and McMillan Street. It carries more than 55,000 vehicles per day. The viaduct was constructed in 1932 and reaching the end of its design life. It has been classified as structurally deficient and functionally obsolete.

T.Y. Lin International (TYLI) has been charged by the City of Cincinnati and Hamilton County to design a replacement for the Western Hills Viaduct. As a part of that process, the design team has prepared an Alternative Evaluation Report (AER) for review by the various stakeholders. The Design Team has

made an effort that the key information about various alternatives is presented in an easy to navigate format.

The primary purpose for the AER report is as follows:

1. Identify the bridge concept that is in best alignment with the needs and objectives of the City of Cincinnati and Hamilton County and ODOT.
2. The selected design should respect, to the extent possible, the requirements and constraints identified by Duke Energy, CSX Railways and Norfolk Southern.
3. Guided by local and regional planning, the selected design should facilitate connectivity and promote economic vitality through a value driven, purposeful structure of enduring aesthetic quality.
4. The selected design should be durable and maintainable with a strong life-cycle performance.

An ongoing effort is in progress to share pertinent information and solicit feedback from the primary stakeholders CSX Railways, Norfolk Southern and Duke Energy. Significant progress has been made in this regard. Duke Energy is working on shifting its substation to the Chem Pack site north of the existing viaduct. The City and County, supported by the Design Team, have held several meetings with CSX and Norfolk Southern. Their feedback and input are described in section 4 of this report.

The following bridge types were considered for this report:

1. Short-span push-launched steel box-girder (longest span 334 feet)
2. Cast-in-place Segmental Bridge (main span 560 feet)
3. Extradosed Bridge (main span 560 feet)
4. Arch bridge (main span 770 feet)
5. Long span push-launched steel double-deck truss bridge (main span 560 feet)
6. Cable-stayed bridge (main span 770 feet)

The initial alignments developed by the Design Team used a stacked or double-deck solution to thread through the gap between the existing viaduct and the Duke Energy sub-station. However, this is no longer necessary as Duke Energy is planning to move their sub-station to the north side of the existing bridge. This simplified the geometric constraints on the east end of the bridge and facilitated interface with the I-75 interchange.

The City and County held a series of meeting with CSX Railways and Norfolk Southern. The CSX Railways reviewed the sequence and means and methods used for the construction of each bridge alternative and scored various construction steps depending on the level of interruption of rail service. Norfolk Southern was primarily concerned with the use of tower cranes for the construction of the bridge and the risk of a collapsed crane across the tracks. More meetings will be planned with Norfolk Southern to further address their concerns.

Cost estimates were generated for all six types of bridges. These range from \$195 million to \$280 million. All estimates include a 25% contingency and include a railway premium appropriate to the bridge type. Details are shown in section 5 of this report.

The Design Team has included a ranking matrix, shown in section 6 of this report. The matrix includes quantitative criteria such as the cost as well as subjective criteria such as aesthetics. Based on this ranking matrix, the AER report recommends the following top three bridges types:

1. Extradosed Bridge.
2. CIP Segmental Bridge.
3. Parallel Twin Arches.

1.3 Bridge Types

TYLI's Design Team developed several bridge families that were appropriate for the site. A brief introduction is provided below:

1.3.1 Short Span Push Launch

This concept consists of three bridges that are parallel for most of its length. The middle structure carries the I-75 traffic and the north and south bridges carry the local traffic. There is an option for this structure to be built in two stages; the central bridge can be built first and the north and south bridges can follow under an independent contract; the idea being that the City/County can start construction of the first phase with a portion of the money needed for the whole project.

The superstructure consists of a trapezoidal box with a composite concrete deck. The trapezoidal box is launched incrementally using a temporary steel nose, the concrete deck is cast once the structure is launched into position. This concept requires the use of two piers in the most active part of the railyard; the first one is located near the locomotive turn table, the second one, located just west of the departure tracks, is more challenging as it interrupts a railway line and requires relocation of a certain length of that line. The railways are in general amenable to the pier near the turntable but are resistant to any piers that interrupt more active railway tracks.

This concept can also be built more economically using steel plate girders (see section 5). However, the considerable disadvantage of constructing a pier within a heavily congested area of the railroad yard remains.

1.3.2 CIP Segmental Bridge

This concept also consists of three bridges that are parallel for most of its length and they operate in a manner similar to the short-span push-launch alternative. The longest span over the railyard is 560 feet and requires a pier in the railyard near the turntable. Segmental construction is carried out from the top using form travelers. The primary interruption to the rail traffic occurs during launching of the form travelers. The pier inside the railyard is accessed using a trestle and a temporary bridge over the Mill Creek.

As with the short span push launch option, construction of the segmental bridge option can be staged.

1.3.3 Parallel Twin Arches

This concept is a set of two network steel arches that sit side by side and span the entire 800 feet long railyard. The arches are made of structural steel with a concrete deck. The arches are fabricated in an open space on the west side between the rail tracks and Mill Creek, parallel to the axis of the tracks. Once the structural steel of the arch has been erected, the skeleton is swung into position

using self-propelled motorized tractors (SPMTs). A concrete runway is built ahead of the roll-out operation.

An alternative assembly location for the steel skeleton of the arches is at the west end of the project, roughly parallel to the alignment. Transport of the arch across the yard is then straight across the tracks rather than being swung across the rail yard from one end.

The move of a single arch can be carried out in less than a day. This alternative is attractive because it has minimal railway interruption except during the roll-out.

1.3.4 Extradosed Bridge

This concept consists of a pair of extradosed bridges with a main span of 560 feet and side spans of 280 feet. The superstructure comprises longitudinal steel edge girders and steel floor beams that are composite with the concrete deck. The steel edge girder is a built-up box section with an 8-foot depth for the majority of the span tapering to 14 feet deep at the pylons. The steel floor beams are plate girder sections with a maximum depth of 8 feet at midspan. The interstate traffic runs on the lanes between the towers and the local traffic is carried on the north and south sides.

1.3.5 Long Span Push Launch Bridge

This is a double-deck truss with a main span of 560 feet. The bridge is incrementally push-launched over the busy portion of the railyard. The bridge is launched only as a steel skeleton without the concrete decks, which will be cast once the steel trusses are fully built and in final position.

1.3.6 Cable-Stayed Bridge

The twin tower cable-stayed bridge spans 760 feet across the yard. It consists of a steel truss supported by stay-cables. The bridge is a double decked structure with the upper deck carrying local traffic (eastbound and westbound) and the lower deck carrying traffic to and from I-75. Even though the structure spans across the busy portion of the rail yard, its construction will require the temporary, short-term interruption of each of the rail lines in the yard so as to avoid hazards to rail traffic from work overhead.

Two possible basic configurations have been considered for the cable stayed alternative. One uses two towers and spans clear across the busy portion of the yard (Twin Tower option). The other uses a single tower located near locomotive Track F which is within the rail yard (Single Tower option). The Twin Tower option is favored.

1.4 Stakeholders

The two most significant stake holders are Duke Energy with a substation sitting in the path of bridge alignment and the CSX Transportation, whose railyard the bridge will be designed to span.



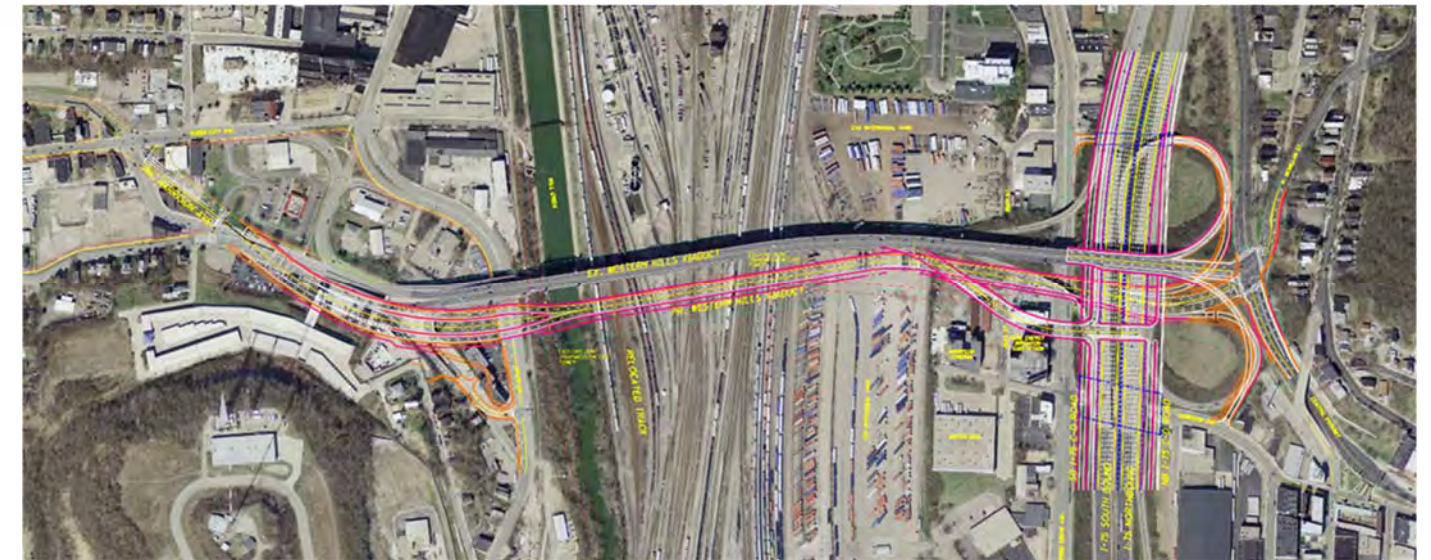
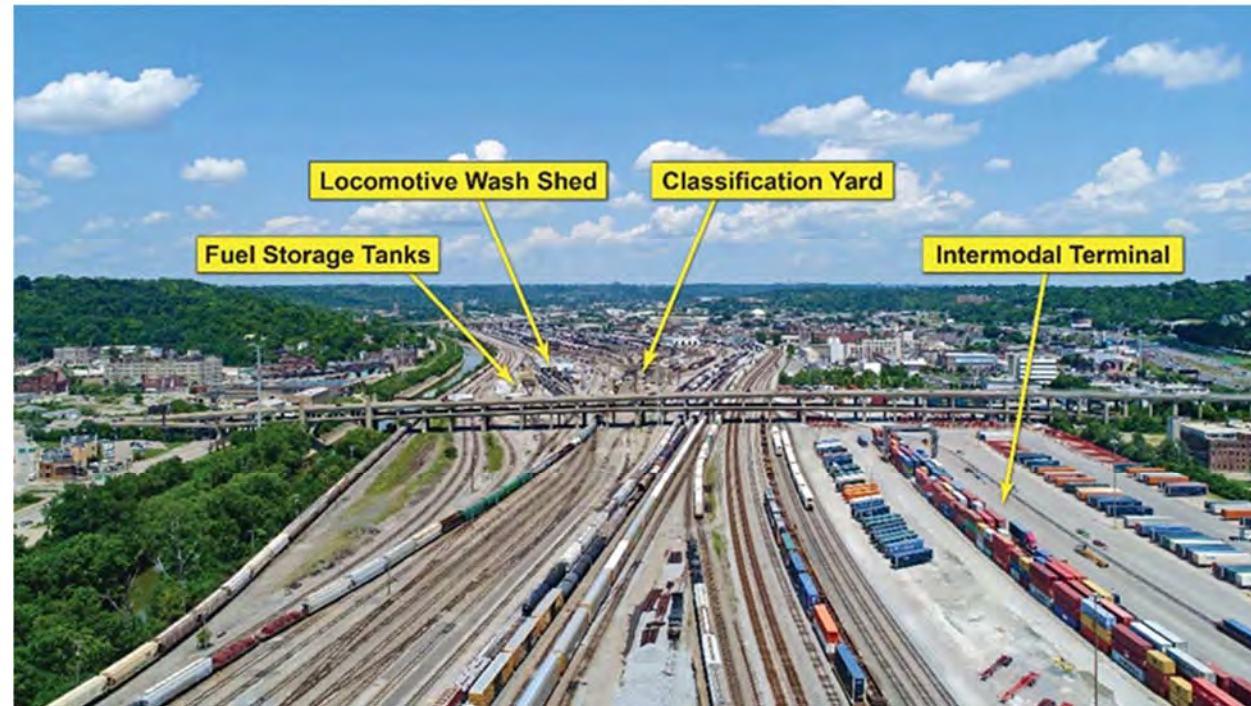
1.4.1 Duke Energy Substation

The substation is located near the eastern end of the proposed alignment. The station sits in the way of the original alignment (modified T). It is being moved to the north of the existing viaduct to the Chem Pack site. The transmission lines will be located to the north side of the existing viaduct.

1.4.2 CSX Railyard

Queensgate Railyard is one of the largest railyards in the country and is owned and operated by CSX Transportation, making them the single most important stake holder in the project. The City and the County Engineers supported by TYLI Design Team have held several meetings with CSX Railway. The various designs developed by the team were discussed with the Railways and their input solicited. All activities that may be impacted by railway operations were marked up with a railway premium and included in the cost estimates.

In addition, the City/County has reached out to Norfolk Southern that owns three tracks going through the railyard. Design documents were submitted for their review and subsequent meetings were arranged to further solicit their input.



On the west end of the alignment, the team came up with the concept of bridge decks at the same level, which allowed a longer weave distance in order to permit turns at Queen City Avenue. This concept was originally developed for the segmental bridge and then also implemented for all other alternatives except for the double deck bridges where implementation of this concept is not possible and a special ramp is required to accommodate the weave distances.

1.6 Environmental Discussion

1.6.1 Introduction

The following is a discussion of the relationship between the current bridge alternatives and alignments within this report and the Environmental Document for the Western Hills Viaduct PID 85388 which was approved on 3/27/2018.

1.6.2 Purpose and Need

As stated in the approved Environmental Document, “the purpose of the proposed project is to improve facility deficiencies and preserve existing connectivity between either side of the Mill Creek Valley, specifically downtown/uptown neighborhoods, Spring Grove Avenue, and IR 75.” The primary need elements are the correction of facility deficiencies and the maintenance of system linkage. The secondary need of the project is community accessibility to incorporate long range plans that involve pedestrian and bicyclist connectivity and access during or after the proposed project has been constructed.

The alternatives presented in this report meet the Purpose and Need in the original Environmental Document but with a potential modification to the Spring Grove Avenue connection. With respect to this connection, three alternates are still under evaluation. The three alternates include: 1) no direct connections from the viaduct to Spring Grove Avenue but indirect access via other routes; 2) a direct connection with ramps leading from the upper deck of a new viaduct per the preferred alternate in the approved 2017 Feasibility Study (see Figure 1 below) ; and 3) a direct connection from the interchange bridge to Harrison Avenue (see Figure 2 below). Final determination of the Spring Grove

1.5 Alignment

The bridge alignment was initially developed along the previously selected alternative labelled modified T, which ran along the south side of the existing bridge and went over the Duke Energy substation. This alignment was primarily developed for a double-decker cable-stayed bridge, the type selected in the previous study.

The TYLI Design Team made two major improvements to the previously selected alignment. In order to avoid the cost associated with the removal of the Duke Energy substation, which amounted to about \$40 million, the team developed a stacked solution that threaded through the space between the substation and the existing viaduct. Although the new alignment was less desirable as compared to the previous alignment, from a roadway geometric standpoint, it did prevent the need to relocate the entire substation at project cost. In the end, a partnered solution was achieved with Duke Energy in which Duke agreed to pay for the substation relocation at its cost, leaving the project to pick up the costs of relocating the transmission lines alone at a cost of \$12.5 million. This consequently also relaxed the constraints on the alignment, resulting in smoother geometry and an easier connection with the I-75 interchange.

connection will be coordinated with the design work of the proposed I-75 interchange, which is part of an ODOT project to reconstruct I-75.

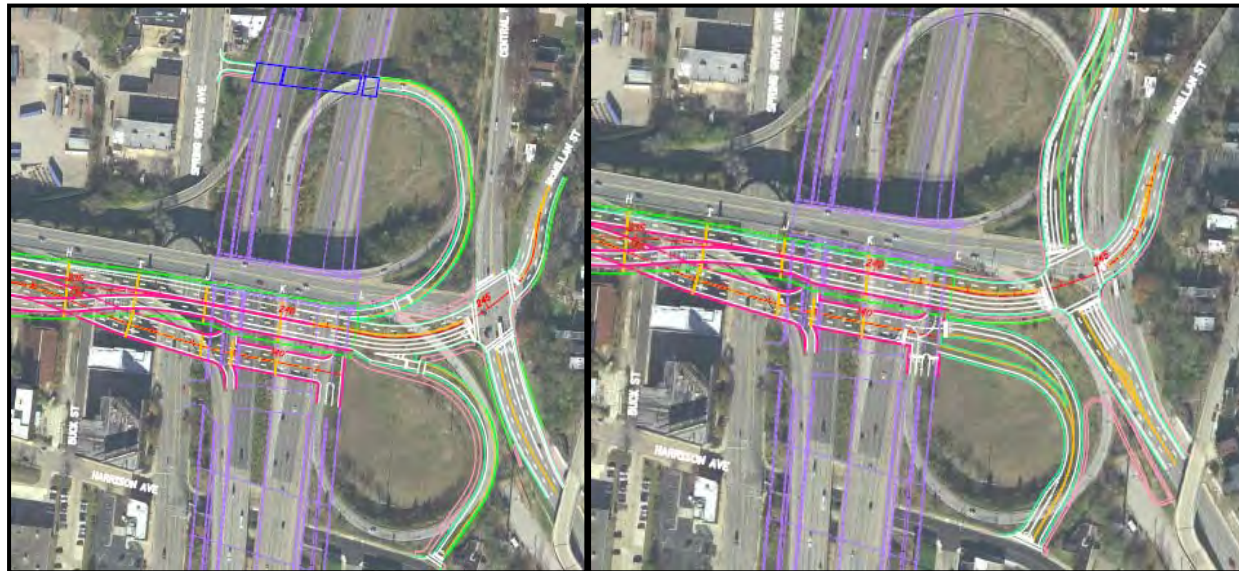


Figure 1

Figure 2

1.6.3 Project Area

The limits of the environmental study within the approved Environmental Document are shown in the figure below. All alternates in this Alternative Evaluations Report are inside of the original study area.



Figure 3 – Environmental Study Area

1.6.4 Environmental Commitments

The environmental commitments listed in the approved Environmental Document are as follows:

General: Coordination of MOT efforts with the public.

ESA: Incorporation of plan notes and performing a Phase II ESA on railroad property.

Cultural Resources:

Recordation of the Western Hills Viaduct and Chem Pack, Inc.

Implementation of a commemorative display.

Ensure SHPO plan review.

Preparation of a draft National Register of Historic Preservation Nomination (NHRP) Form for the West McMicken Historic District.

Minimize effects during construction on the West McMicken Historic District.

Conduct Vibration monitoring during construction in the vicinity of the West McMicken Historic District.

Ecological: Ensure alignments and work areas are designed to minimize tree removal.

Other Resources: Coordination with Greater Cincinnati Waterworks (GCWW) to determine the future disposition of the existing main on the viaduct.

Public Involvement: Plan appropriate activities as needed, including updating the project website.

Waterway Permits: City will obtain 404/401 waterway permits prior to any work below ordinary high water (OHW) and include all Special Provisions for waterway permits in the construction plans.

With respect to the above commitments, the following progress has been made since the approval of the environmental document:

Cultural Resources: The preparation of a draft NHRP Nomination form for the West McMicken Historic District has been completed.

Other Resources: Coordination with GCWW has been ongoing. At this point, GCWW intends to abandon the existing watermain on the viaduct and replace it on a new alignment within or in close proximity to the State Street Right-of-Way.

Public Involvement: Project website has been kept up to date and planning of future public involvement meetings has started.

The new alignments and alternatives presented in this Alternative Evaluation Report do not change or add any additional environmental commitments within the approved environmental document.

1.6.5 Alternate Alignments

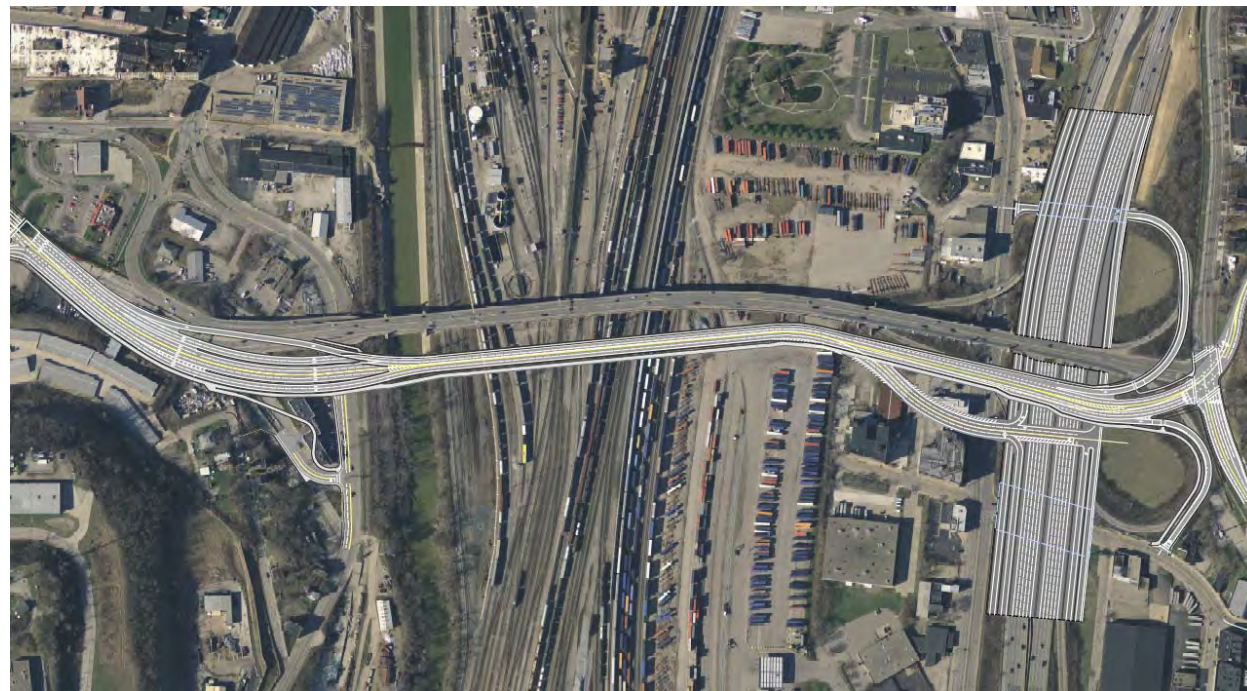
Included in the approved Feasibility Study are several groups of alternates which were studied, those being:

No build

Major reconstruction on existing alignment

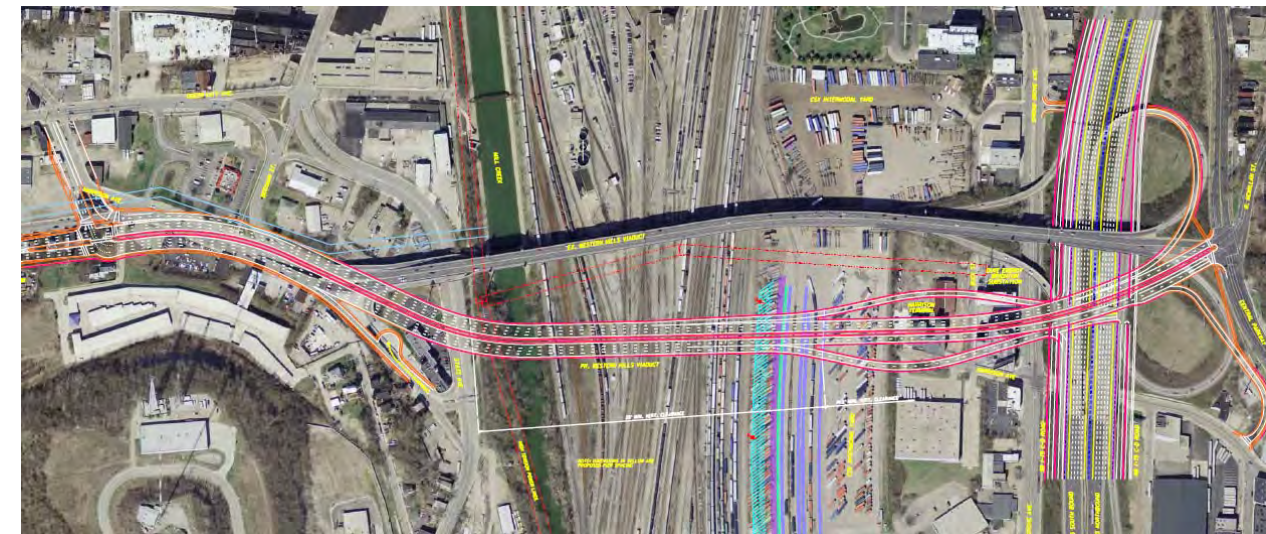
- New single deck structure either on the current alignment or to the north or south of the existing viaduct.
- New double deck structure either on the current alignment or to the north or south of the existing viaduct.

The preferred alignment chosen was a new double deck structure to the south of the existing viaduct. The southern alignment was chosen because it provided the best approach geometry on both the east and western ends of the project with most direct connection to the proposed I-75 interchange. The preferred alternate allowed for the shortest duration of closure since traffic could be maintained on the existing viaduct for the majority of the construction. The double deck configuration allowed for simplified connectivity for local and interstate bound traffic and minimized the footprint within the railroad yards. The preferred alignment, identified as Alternate T Modified, is shown in the figure below.

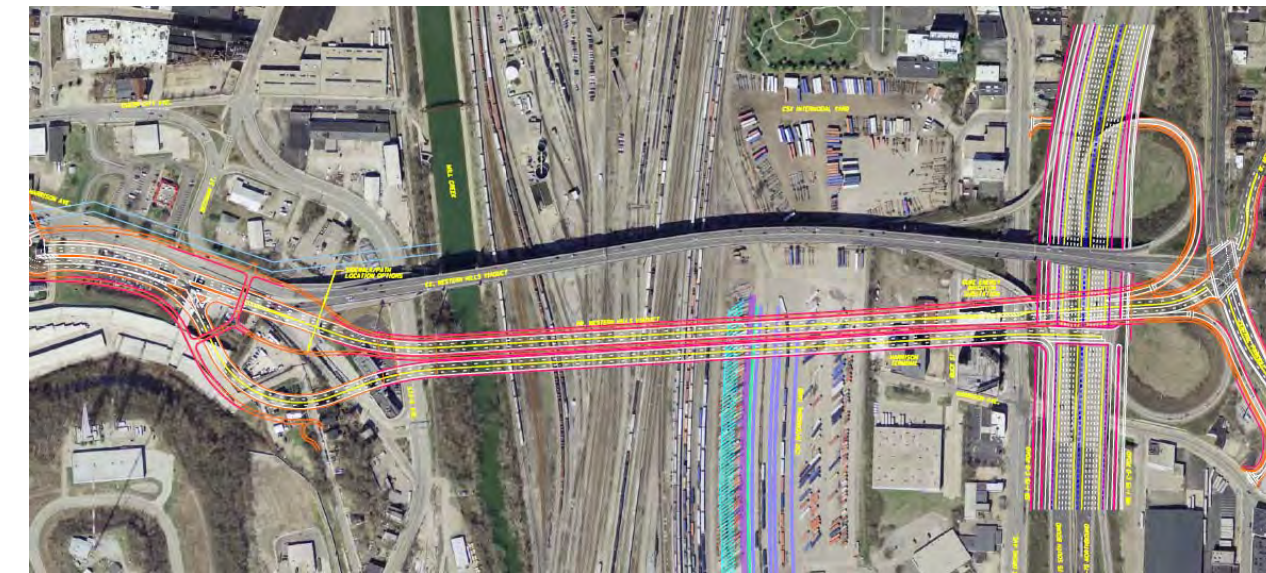


Alternate T Modified

During the preliminary engineering and preparation of the Feasibility Study, a single deck structure south of the existing viaduct was studied but discounted mainly due to the impacts it had on the CSX intermodal yard. Two of the studied alternates are shown in the figures to the right (Alternate F and Alternate R). In Alternate F, the lanes accommodating the interstate traffic are located on the north and south side of the proposed viaduct. In Alternate R, the lanes accommodating the interstate traffic are located on the south side of the viaduct.

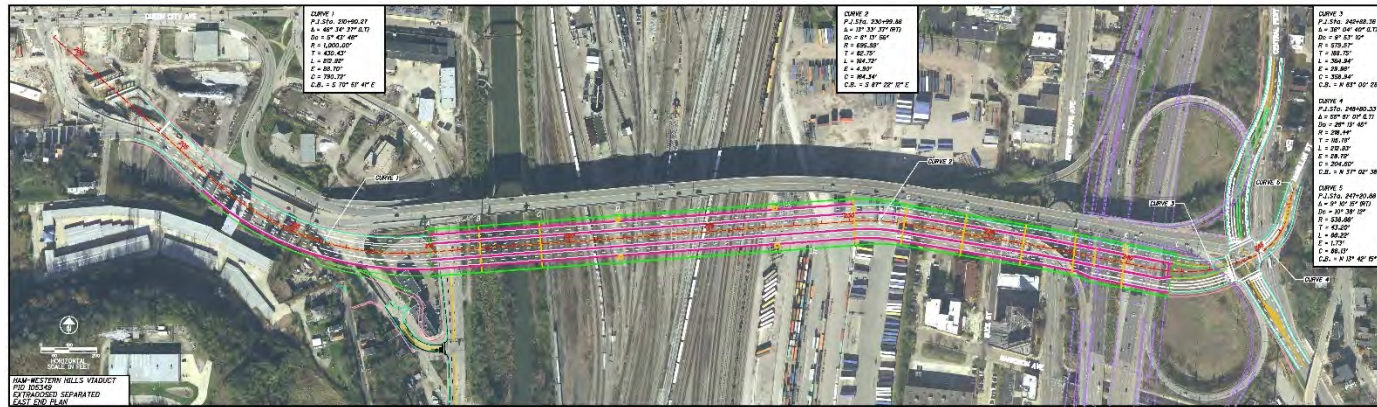


Single Deck - Alternate F



Single Deck - Alternate R

The alignments proposed within this Alternative Evaluation Report differ from the preferred alignment in the approved environmental document. The preferred alternative within this report is a single deck bridge on a southern alignment similar to Alternate T Modified from the Feasibility Study as shown above. The single deck option became possible because of two refinements: 1) shifting the position of the traffic leading to and from the interstate from the outside of the proposed viaduct as in Alternates F and R above to the middle, and 2) shifting the location of the proposed interchange bridge to the north. Using a single deck structure and shifting the alignment resulted in a greatly simplified roadway geometry at the west approach while still maintaining the clearance needed from the intermodal yard. The current alignment with the Spring Grove Avenue ramps is shown below.



Extradosed Alternate

1.7 Preliminary Design Criteria

1.7.1 Bridge Design Criteria

The bridge will be designed in general conformance with the latest edition of the American Association of State Highway and Transportation officials' Standard Specifications for Highway Bridges (AASHTO), including all interims and any exceptions to AASHTO standards listed in the ODOT Bridge Design Manual. (see Appendix A1: Bridge Design Criteria)

1.7.2 Geometric Design Criteria

The geometric design for each structure type alternative conforms to the ODOT Location and Design (L&D) Manual, Volume 1 Roadway Design unless otherwise stated. Below is a summary of key considerations regarding the geometric design criteria for this project.

Lane and Shoulder Widths

The upper (local) deck, bridge approaches and McMillan Street function as urban streets and have 11-foot lanes proposed. The middle deck provides 12-foot lanes. Central Parkway lane widths will be improved from existing 10-foot lanes to 11-foot lanes within the limits of improvement for this project. Both decks on the bridge and its approaches have two-foot shoulder widths to curbs, where present, and four-foot shoulder widths to toe of barrier, where present. McMillan Street has one-foot shoulder widths.

Central Parkway will have 5-foot bike lanes to match existing. A 12-foot separated bike path is proposed south of the eastbound lanes of the new WHV upper deck and an 8-foot sidewalk is proposed north of the westbound lanes of the WHV upper deck. The project will be designed to provide bicycle connectivity between Central Parkway and the South Fairmont neighborhood at the western approach.

Figure 301-5C of the L&D Manual provides curve widening dimensions for given roadway widths, design speeds, and horizontal curve radii. The values in the table suggest curve widening be implemented for certain curves in several structure type alternatives. However, curve widening is not proposed to be included for the WHV structures because truck percentages and design speeds are relatively low, and the relative cost for the additional deck width in most cases is

significant. Truck turning envelopes were established using AutoTurn software and confirmed that two WB-62 trucks can travel side-by-side through each proposed curve on the lower (interstate) deck while maintaining a minimum distance of 2 feet between the trailers. This is true for all structure type alternatives. On the upper (local) deck, a WB-62 truck can travel adjacent to a passenger vehicle while maintaining a minimum distance of 2 feet between the vehicle bodies.

The lane and shoulder widths all meet controlling criteria for design, except the above-mentioned curve widening. For this project required horizontal sight distance is provided in accordance with the ODOT L&D Manual.

Horizontal and Vertical Design and Cross Slope

The proposed curvature on the outer and middle bridge decks and approaches for each structure type alternative meets a 35-mph design speed with the majority of the curves allowing the pavement to remain at normal crown. In some instances, superelevation will be required which can be accomplished utilizing variable deck thickness. McMillan Street has radii equal to or greater than 200 feet that accommodates a design speed of 25 mph with a normal crown.

Vertical curves are designed for each structure type alternative to accommodate a minimum design speed of 35 mph. Bridge decks, approaches, Central Parkway, and McMillan Street all have grades of 6.0percent or less.

Vertical Clearance

The desired vertical clearance requirement is 16.5 feet with a minimum vertical clearance requirement of 15.5 feet, which is consistent with ODOT's proposed design of the interchange with I-75. At this preliminary stage of design, 16.5 feet of vertical clearance is proposed at nearly all locations for each structure type alternative while maintaining ODOT's proposed I-75 mainline profile. The I-75 ramp profiles require slight modifications to tie into the proposed WHV interstate structure. Less than 16.5 feet of clearance is provided for the alternate in which the lower (interstate) deck is located further to the north between the two upper (local) decks. In this alternative, the elevation of the lower (interstate) structure is constrained by the vertical clearance of Ramp CC to the existing WHV structure during construction and a maximum of 16.2 feet of vertical clearance can be attained between southbound I-75 and the WHV interstate deck. This clearance could be improved if ODOT is able to lower the proposed I-75 profile by 4 inches in this location. The specific dimensions of the structural elements will be confirmed during future phases of project development.

(See Appendix A2: Roadway Geometric Criteria)

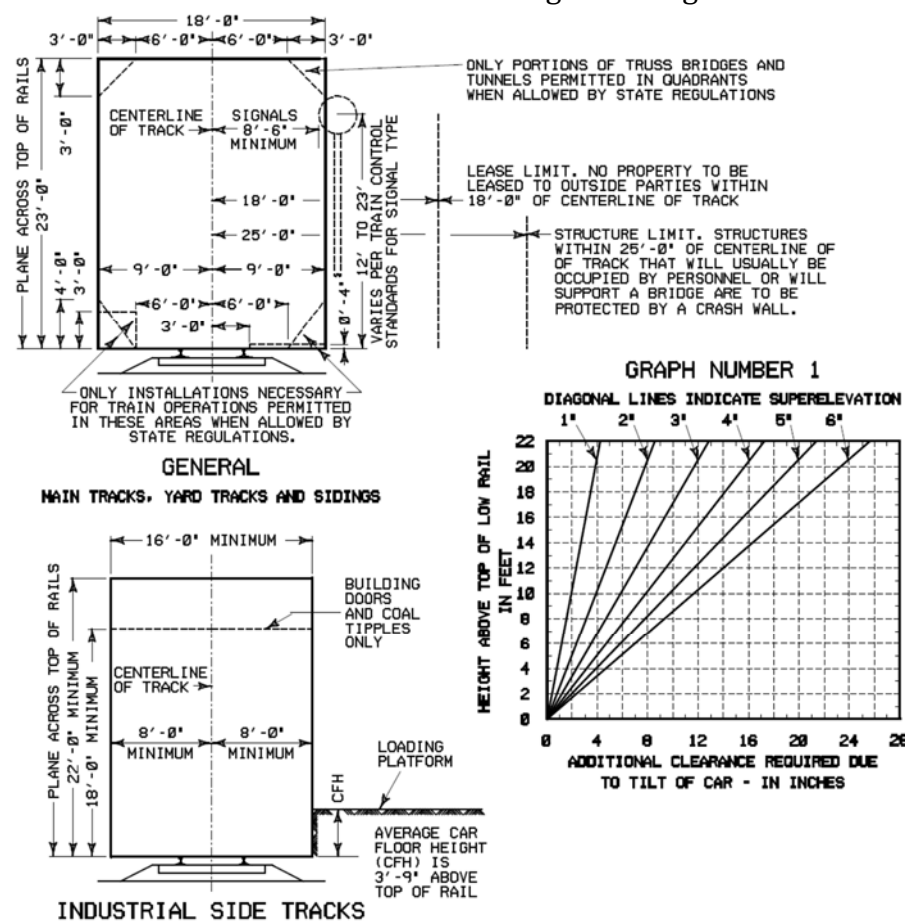
1.7.3 Railway Geometric Clearances

The following geometric clearances are specified in the CSX "Public Project Information for Construction and Improvement Projects that May Involve the Railroad", July 2017.

- A. Horizontal Clearance: Standard horizontal clearance from centerline of the track to the face of the pier or abutment shall typically be 25'-0" or greater, but never less than 18'-0", measured perpendicular to the track. Provisions for future tracks, access roads, other CSXT facilities, and drainage may require the minimum clearance be increased or use of multi-span structures.

The toe of footings shall not be closer than 11'-0" from centerline of the track to provide adequate room for sheeting. Crash-walls are required when face of the pier is closer than 25'-0" from centerline of the track, measured perpendicular to the track. For piers of heavy construction, crash-walls may be omitted. Solid piers with a minimum thickness of 2'-6" and length of 20'-0", single column piers of minimum 4'-0" X 12'-6" dimensions or any other solid pier sections with equivalent cross sections and minimum 2'-6" thickness are considered as heavy construction.

- B. Vertical Clearance: A standard vertical clearance of 23'-0" shall be provided, measured from top of high rail to lowest point of structure in the horizontal clearance area which extends 6'-0" either side of the centerline of track.
- C. Temporary Construction clearances to be used shall be subject to approval by CSXT. Typically, reductions in clearance for construction are not permitted.
- D. For a temporary walkway and handrail system a clearance of 12' shall be provided.
- E. CSXT shall be furnished as-built drawings showing actual clearances as constructed.



1.8 Cost Estimates

The cost estimates are based on concept level design and carry a contingency of 25%. The estimates also include railway premiums; this is the cost associated with idle equipment and labor while waiting for a window to perform a task that can be potentially hazardous to the trains passing underneath the construction. These operations include launching of form travelers for segmental bridges or swinging heavy steel trusses over the rail traffic underneath. This also includes fixed costs such as the permanent and temporary relocation of the tracks and switches and the cost of building overhead trestles to supply material and labor to operations within the railyard without interrupting rail traffic.

These estimates are based on historical cost data and not a detailed analysis of the cost of equipment, labor and overhead needed for different construction operations. These estimates were prepared by skilled estimators who are current and updated with the construction market conditions. See section 5 for methodology.

1.9 Selection of the Preferred Alternative

Working with the City/County and other stake holders, several suitable bridge types have been developed and evaluated to determine which concept will be the most appropriate considering the various project constraints and priorities. The alternative concepts have been verified with a preliminary analysis model, and further developed into a conceptual design. Planning level cost estimates and schedules have been developed in order to compare the costs of the different structure types and to provide a reasonable idea of how long it will take to construct the project.

Constructability and durability reviews have been performed. Each alternative has been reviewed with a focus on the ease and efficiency with which it can be built and maintained. Potential impacts to construction duration, cost or quality have been identified and incorporated into the selection process.

In order to facilitate the decision-making process, the bridge alternatives are compared in a matrix, where each is scored for several important factors the project must address. These factors, or criterion, include considerations such as costs, aesthetics, durability, railroad preference, constructability, claims potential, traffic operations and drainage.

For each criterion the bridge types were assigned a score between 1 and 10, with 10 being a better score than 1. These scores are then combined using weighting factors expressing the relative importance of each criterion and each bridge type alternative receives a ranking based on these overall scores.

The selection criteria and the scoring of the bridge alternatives involve some subjectivity, but are based primarily on their evaluation as presented in this report. This Alternatives Evaluation Report is produced to quantify the pros and cons of the various alternatives and remove as much of the subjective nature of the selection as possible.

2 BRIDGE STRUCTURE TYPES

2.1 Short Span Push Launch (Steel Girder)

2.1.1 Introduction

In this alternative the new viaduct superstructure consists of steel trapezoidal tub girders with a composite concrete deck. The piers are concrete. To simplify construction and minimize interruption to railyard activities, the steel tubs will be push-launched over the Mill Creek and the most active portion of the yard, touching down only where the piers are located. There are three spans over the more active tracks, ranging in length from 220 to 334 feet, with two piers landing in this critical area.

On the viaduct there are four lanes of traffic in each direction (eastbound and westbound), a pedestrian path along the north side and a shared use path along the south side. At the west approach, just west of State Ave, the traffic is to be all at one level. At the east approach, traffic goes to/from the I-75 interstate at a lower level, and to/from the West McMillan/Central Parkway intersection at an upper level. Whether there will be a direct connection between Spring Grove and the viaduct is yet to be determined.

In order to handle this transition to different levels over the length of the viaduct, separate box girder bridges carry the traffic across, with the center box girder bridge carrying interstate traffic (EB and WB), the north box carrying WB local traffic and the south box carrying EB local traffic. At the east end, the local traffic bridges merge into a single, higher level, bridge over I-75. The bridge carrying traffic to/from the I-75 is beside the higher-level bridge to allow it to be built under separate form and a separate contract. This is possible because Duke Energy will be vacating the substation location thus making space available.

2.1.2 General Description

This alternative includes two different options relating to the construction staging. The project can be constructed all at once (Full Project) as a single project or, with some cost penalty, be built in two distinct stages (Staged Project). The alignments of the two options are essentially the same.

There are three essentially separate bridges in this alternative: a bridge that carries traffic to/from I-75; a bridge that carries eastbound local traffic across the railyard, and a bridge that carries westbound local traffic across the rail yard. Shown on pages 14 through 16.

This alternative could use either steel trapezoidal box girders or steel plate girders. Since the trapezoidal box girders provide greater torsional rigidity and less exposed steel surface to maintain compared to steel plate girders, only the trapezoidal box girders are presented herein. There would be significant savings in construction cost if the plate girders were to be chosen instead. These include about 10% savings in structural steel quantities, savings in steel erection and transport costs, and similar savings in deck concrete materials as well as in the cost of deck construction.

Preliminary estimates indicate that the trapezoidal box girder solution would contain about 11,000 tons of structural steel. Of this, about 450 tons is contained in the bridge over I-75 which is carrying traffic to/from I-75 (i.e. probable ODOT work).

The push-launch technique has been considered for the parts of the bridges over the busy portion of the rail yard because this technique reduces interference between rail and construction operations to a practical minimum in these busy areas. Elsewhere, the structures would be crane-erected in a conventional manner.

The purpose of the Staged Project option is to allow the work to be split into two contracts so that immediately usable infrastructure can be constructed as funding becomes available. Traffic to/from I-75 would be established first, while local traffic would remain on the upper deck of the existing Western Hills Viaduct (WHV). At a later date, when funding becomes available, the remainder of the new WHV would be constructed and the old structure demolished. There are complications inherent in staging the project that would increase the total project cost.

The purpose of investigating this particular (short span) set of options is to attempt to find the lowest-cost, most straightforward solution for the new WHV construction. It is recognized that this scheme has more interfaces with the rail yard operations than any of the others and therefore more interface costs than any of the other alternatives. However, once the work zones at the two critical piers are secured, and access to them has been constructed, the push launch process removes almost all interaction with rail operations during the rest of the construction process.

Push launch is a straightforward technology which is readily available to most contractors, and so is expected to be price competitive. The use of a steel structure rather than concrete has been chosen because steel structures are usually lighter and therefore faster, cheaper and easier to push launch than concrete structures.

These schemes utilize a purpose-built trestle over portions of the rail yard so as to provide unhindered access to the two pier locations that are within the busy, multi-track, portion of the yard. This will minimize the "railway premium" associated with the bridge construction having to work around, or wait for, the railway's operations. The construction of the trestle itself will be subject to considerable disruption from rail operations. The push-launch procedure also greatly reduces this railway premium as most construction operations are not affected by, and do not affect, railway operations. The cost estimates include \$3.2M for construction and removal of the trestle to Pier D and a further \$1.7M to extend the trestle to Pier E. See page 21 & 23.

It was initially anticipated to be able to use large diameter drilled shafts and single, circular, pier shafts at all the piers. This would have eliminated the need for footings below ground with consequent shoring and excavation. However, in the context of the local geotechnical conditions, it does not appear that this type of substructure would be viable for much of the structure length. This alternative therefore shows conventional footings below grade supported on either driven piles or drilled caissons (drilled shafts). See page 17. The choice between driven piles and drilled caissons (drilled shafts) will be more thoroughly explored in final design. Experience has shown driven piles are frequently the more economical choice.

2.1.3 The Push-Launch Procedure

The essential steps in the push-launch method are shown in the Erection Method Schematics on pages 24 through 26.

Generally, the steel structure is assembled in 60-foot long sections on falsework at the west end of the bridge and is then pushed eastward in increments until the steel skeleton for the complete push-launch portion is in place. If necessary, the existing overhead energy transmission lines will need to be raised. The preparation for the push-launch operations is somewhat more complex and is not shown on these sheets. A lightweight launching nose is attached to the front end of the structure being launched. This reduces the bending moment demands during launch.

As each steel section is attached at the west end, the deck formwork is attached to it and launched with it. Stay in place metal formwork would eliminate the need to strip the formwork after the bridge is completed. This eliminates having to install the formwork over live rail operations. It is also possible to have the reinforcing steel installed prior to launch, should that prove desirable.

Once the structural steelwork has been completely launched, the reinforcing steel is placed and then the concrete deck is poured. Delivery of rebar and concrete is via the access trestle for the first bridge to be built and is via this first bridge for the construction of second and third bridges. It is foreseen that the first bridge to be built would be the central bridge, which carries traffic to/from the I-75.

Rebar and concreting operations in this method are safe operations - analogous to typical bridge construction on falsework - that do not need to be interrupted for the passage of trains. Stripping of the falsework can, for the most part, be done without any hazard of dropping material into the yard due to temporary access decks installed between the two tub girders in each section, see page 25. The access decks can be removed by pulling each deck panel longitudinally along the adjacent access decks to a point where they can be safely lowered away from rail operations.

The speed of launch is expected to be about 15 feet per hour meaning that a 60 feet long section would be fully launched within four hours if there are no interruptions. It will take on the order of a half-week cycle to erect steel, attach formwork, and prepare a 60 feet section for launch. So, about 8 hours per week would be consumed with actual launching.

During launching, when the section is being pushed, there is a very low probability hazard of failure, and this only in the leading span where the steelwork is in cantilever. This may be considered, at worst, to be similar in risk level to hoisting loads with a crane - things rarely drop but it is still advisable not to be below. Fortunately, the launching process can be started and stopped at will, so it is easy to work around train movements. One does not need a full four-hour window to launch - eight windows of a half hour each will do as well.

The hazard, if any, is that the launch gear could suffer a failure during launching. This can be greatly mitigated (virtually eliminated) through applying design restrictions and requiring redundant safety features in the design of the push launch process and the launching gear so that the failure of any component would not impair the structural integrity of the whole operation.

Ensuring that redundant critical components are present would require review of the launching details by the design team. It is unlikely to be sufficient to rely on the contractor's system without thorough review by the design team. A proof of concept check from the design team would be necessary.

However, it should be remembered that the railways may choose to take a more subjective view of what constitutes a hazard and therefore may make unexpected restrictions. Nevertheless, it is possible and practical, at a cost, to eliminate any real hazard when the bridge is being launched.

2.1.4 Alignments

Before finalizing the bridge profiles, it is necessary to decide if a maintenance traveler capability is desired for this bridge and whether the maintenance traveler can be allowed to infringe on rail clearances. While it would be feasible to perform inspection and maintenance of the exterior surfaces of the steel tub girders from a snooper truck on the bridge deck, clearances between the three bridges will limit the longitudinal extent that portions of the girders can be accessed with this method. In addition, to reach the surfaces between the two tub girders in a bridge will require a large snooper truck and similar clearance above the tracks as a traveler if temporary infringement on the rail clearances is not allowed. Therefore, it is suggested that the clearance to the underside of structure be established at 27 feet above top of rail thus allowing the normal rail clearance of 23 feet plus 4 feet for the traveler or snooper arm. The railways have requested an over-height clearance of at least 25 feet, which is 2 feet greater than the customary clearance.

It was determined that the Duke Energy substation could be left where it is, undisturbed, and the new WHV threaded to the north of the Duke property as a double deck structure. However, it now appears that Duke Energy will be relocating, and thus more room is available for the new viaduct at this location. Separating the local traffic bridge from the I-75 traffic bridge is desirable from the traffic point of view, it provides an opportunity to more easily stage the project and it will be easier to contractually separate the I-75 traffic bridge from the rest of the work. Accordingly, the alignment near I-75 has been revised to take advantage of this opportunity.

The high-tension line crossing the rail yard will have to be relocated (as with all options).

In order to push-launch, the bridges must be straight in plan and elevation from Pier C to Pier F. Vertical curvature is undesirable but could be tolerated in Span B-C because it is the last span to be erected. Span F-G has vertical and horizontal curvature and so must be crane-erected.

2.1.5 Structure Details

There are fracture-critical considerations relating to non-redundant trapezoidal steel boxes. Current convention suggests that one complete tub must be considered to be ruptured in tension and that the remaining tub(s) must be capable of supporting the structure through transverse diaphragms and torsional behavior. Such system redundant behavior is addressed in AASHTO "Guide Specifications for Analysis and Identification of Fracture Critical Members and System Redundant Members", 1st Edition, 2018. This requires complex analysis to prove the capability.

It is suggested that the tub bottom flanges be fabricated in two halves with a full-length longitudinal bolted splice along the centerline of the tubs. The bolted splice will limit propagation of rupture to half of a tub, thus leaving intact a more viable force path in the undamaged half tub. Such concepts for internal member redundancy are addressed in AASHTO "Guide Specifications for Internal Redundancy of Mechanically-Fastened Built-Up Steel Members", 1st Edition, 2018. The longitudinal joint also allows for easier shipping of the box girders. By truck they can travel flat as wide loads,

whereas if shipped by rail they become narrow enough to travel as normal-width loads. Without the split, shipping of trapezoidal boxes becomes problematic.

The lower level bridge (for traffic to/from I-75) has relatively long deck overhangs, which will require transverse post-tensioning. The upper level bridges (local traffic) are narrower and can have a conventionally reinforced concrete deck which is more economical. Geometry of typical sections are shown on pages 17 through 20.

Should this alternative, or any steel option, advance further in the design development process it is recommended that a cost-benefit study be done relating to the use of metalizing, rather than painting, the exterior surfaces to reduce life-cycle costs from repainting. There is some credible evidence that metalizing of weathering steel, though initially costlier, is in fact more economical in the long run for structures that are intended to have a long service life.

2.1.6 Work Within the Rail Yard

The short spans of the push-launched options have two piers within the main part of the rail yard where their construction will be impacted by rail operations, Piers D and E. The layout of the work zones is shown on page 21.

Pier D places the pier in a location that temporarily blocks the locomotive track south of the existing WHV during pier construction. It appears that this track is not functionally necessary for the operation of the locomotive turntable, since the locomotives can arrive and depart from the north. At the time of the site inspection this track dead-ended a short distance south of the new viaduct location. After pier construction is completed, the locomotive track can be reinstated to its present location and function. Accordingly, there is no apparent impediment to using this space for a permanent pier. A view of this area is shown on page 22.

The next pier east, Pier E, is potentially more problematic. Originally it had been proposed directly on the "Short D" departure track at a location where all the short train assembly tracks converge for train departures, see page 22. Only one track was affected, and it would have had to be temporarily taken out of service during part of the construction period. It would have been returned to service on a somewhat different alignment, once all three pier shafts at Pier E had been constructed. It is however, a very important track that is essential to the functioning of the yard. It was established in consultation with CSX that it would cause very considerable inconvenience to CSX to try to accommodate this original pier location.

Accordingly, the location of Pier E has been revisited. If it is positioned about 33 feet westward it will affect only one piece of CSX's track – a crossover from Track J to Track K. It appears that this track could be permanently relocated to the south before construction starts and could remain permanently in the relocated position without impairing yard operations. The layouts presented incorporate this changed location of Pier E.

A consequence of this relocation is that the available work zone for construction of Pier E becomes narrower – only 37 to 40 feet of width is available. This restriction would increase the cost of the pier construction to some degree but is something which can be practically achieved. Figure 1 and Figure 2 show a suitable method of drilling caissons (drilled shafts) in confined quarters. Figure 3 shows a

method of driving steel sheet pile (required to shore up the footing excavation) without need of a conventional crane or piling rig. It is practical to build the required pier in this location provided the deep foundation elements (driven piles or drilled shafts) are installed from the original ground surface level.

With the combination of the access trestle (see page 23) and the push-launch method, the amount of bridge construction work that would be affected by rail operations is greatly reduced compared to conventional construction. In the 2017 Feasibility Study, Aecom assumed a very low productivity for both labor and equipment for all work within the boundaries of the active rail area. Assuming the contractor will be able to work to within 10 feet of rail centerline with flag-persons present, then the only operations that should be significantly impacted by rail operations are:

- Construction of the trestle
- Removal of the trestle
- Driving steel sheet pile for the foundation excavation shoring
- Some, relatively minor, formwork stripping operations (these are not critical-path operations)
- Actual launching of the bridge



Figure 1: Close Quarters Caisson Drilling without Service Crane

The "Railway Premium" will be significantly less than the \$56 million value reported in the Aecom study for their plate girder option.

Once the piers are built, the only remaining restriction should be during the relatively short time periods when the bridge is being launched, i.e., while it is actually moving. It will be important to establish what operations, if any, during the launching and the deck construction could be considered as hazards to rail operations that would require coordination with the railroad and interruption of rail traffic below. The concrete decks would be poured over live rail traffic just like any bridge built on falsework. The decks can be formed up as the structure is being assembled for launch, so as not to have to install overhang forms above the active rail yard. Conventional stripping platforms would allow the formwork to be stripped independently of rail operations. The trestle allows reinforcement and concrete to be delivered completely unaffected by rail operations.

The intermodal lines on the east side of the yard will need to be interrupted at times to permit crane erection of spans F-G. Some intermodal container and trailer storage will also be affected during construction.



Figure 2: Clam Bucket for Excavating Caisson



Figure 3: Driving Steel Sheet Pile

2.1.7 Other Items

The western-most track (CSX Bypass Track - Track B) is to be relocated to the east as was planned per the 2017 Feasibility Study. This gives the contractor unrestricted access to Pier C, see page 15.

The location of the southern bridge (Eastbound Local) infringes somewhat on the straddle crane turnaround at the north end of the intermodal yard, however, CSX has stated the straddle cranes do not use this location to turn around. (See Appendix C1: Short Span Push Launch – Alignment Plans)

Rail delivery to the site of the new viaduct girders allows use of deeper box sections than could be transported upright by road using normal hauling equipment. It is not known at this time whether the maximum tub widths required (16 feet out to out) are in fact rail transportable in one piece. The tubs could be fabricated with a longitudinal joint down the middle to reduce the shipping width to under 10 feet, which would then be easily transportable by rail.

The methodology described envisions launching from west to east for the push launched sections of the bridge. This minimizes the impact of the assembly operation on the rail operations.

2.1.8 Schedules

The schedules presented on page 27 are for "greenfield" working conditions (i.e., without consideration of the impacts from the rail yard). To the durations shown there has to be added an allowance for construction inefficiencies due to the "Railway Effect".

For this alternative, for the "Full Project" option, the greenfield schedule shows a duration of 43 months. It is estimated that the Railway Effect will add another 6 months to this duration.

2.1.9 Interface with I-75

For the sake of completeness, it has been necessary to make some assumptions about the timing of the interface between WHV construction and the planned reconstruction of I-75. It is unclear at this time whether I-75 will go first, WHV will go first or both will proceed together. This report has

assumed that WHV will proceed to completion before I-75 is reconstructed. In this case it will be necessary to do some work on I-75 near the WHV in order to make the interchange work in the time period before the full reconstruction of I-75 is undertaken. This is discussed more fully in Section 3 of this report.

2.1.10 Items Specific to the Full Project Option

The Full Project Option allows for shortened closures of both local and I-75 traffic access to the WHV, provided that existing I-75 can be closed for 30 hours (30 hours as an estimate, a full closure over a weekend will be required) to allow an accelerated regrading in the vicinity of the WHV. This then permits existing I-75 to pass below the new bridges. Local traffic closure is estimated at about 4 months.

Interruptions to I-75 access are expected to be under 3 months, except for the I-75 SB on-ramp which would be closed for an additional 2 months if a temporary on-ramp is built, or an additional 11 months if not.

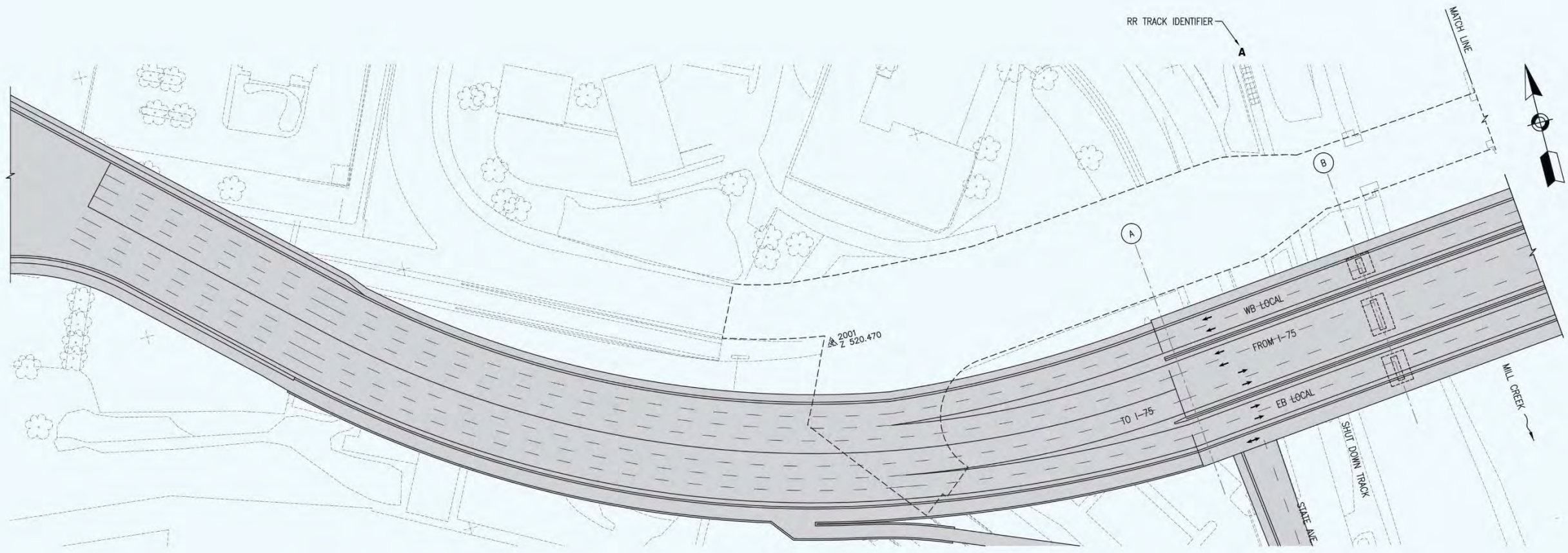
The Full Project Option will be the most economical if sufficient funding is available to construct the entire project at once.

2.1.11 Items Specific to the Staged Option

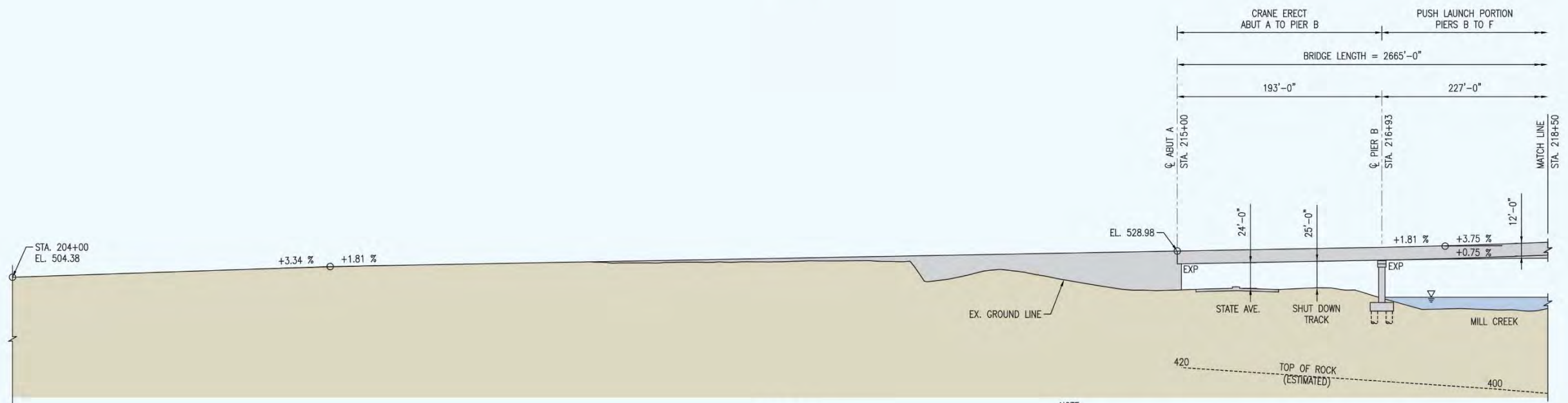
In the Staged Option it is estimated access to I-75 NB would be interrupted for about 9.5 months and access to I-75 SB on-ramp would be closed for a further 3.5 months. Local traffic would be interrupted for about 24 months total - one period of 4 months and a second period of 20 months.

In this option there would be a substantial premium cost associated with the Stage 2 work. Construction of the bridges through the rail yard will be hampered by the live traffic on the lower level (I-75) bridge and by the very restricted working space and access. Frequent night-time lane restrictions would be required on the I-75 traffic bridge to allow for material deliveries etc. In addition, it would be necessary to allow for a second mobilization and for a second construction of the work area at the west end.

If a Staged Option is to be seriously considered, it is recommended that a further detailed study of the matter be undertaken before committing to a staged construction.



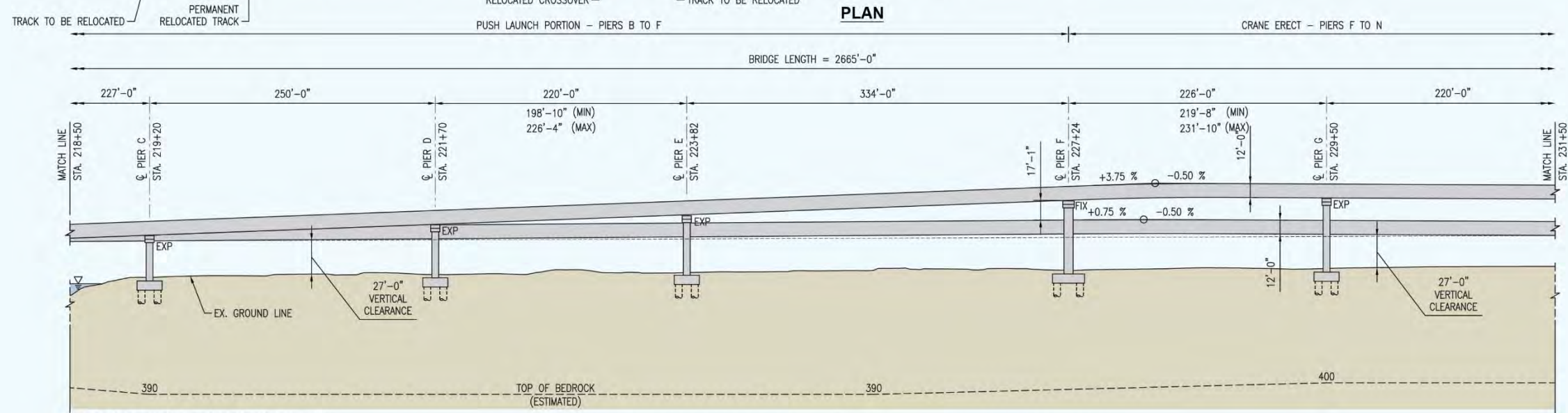
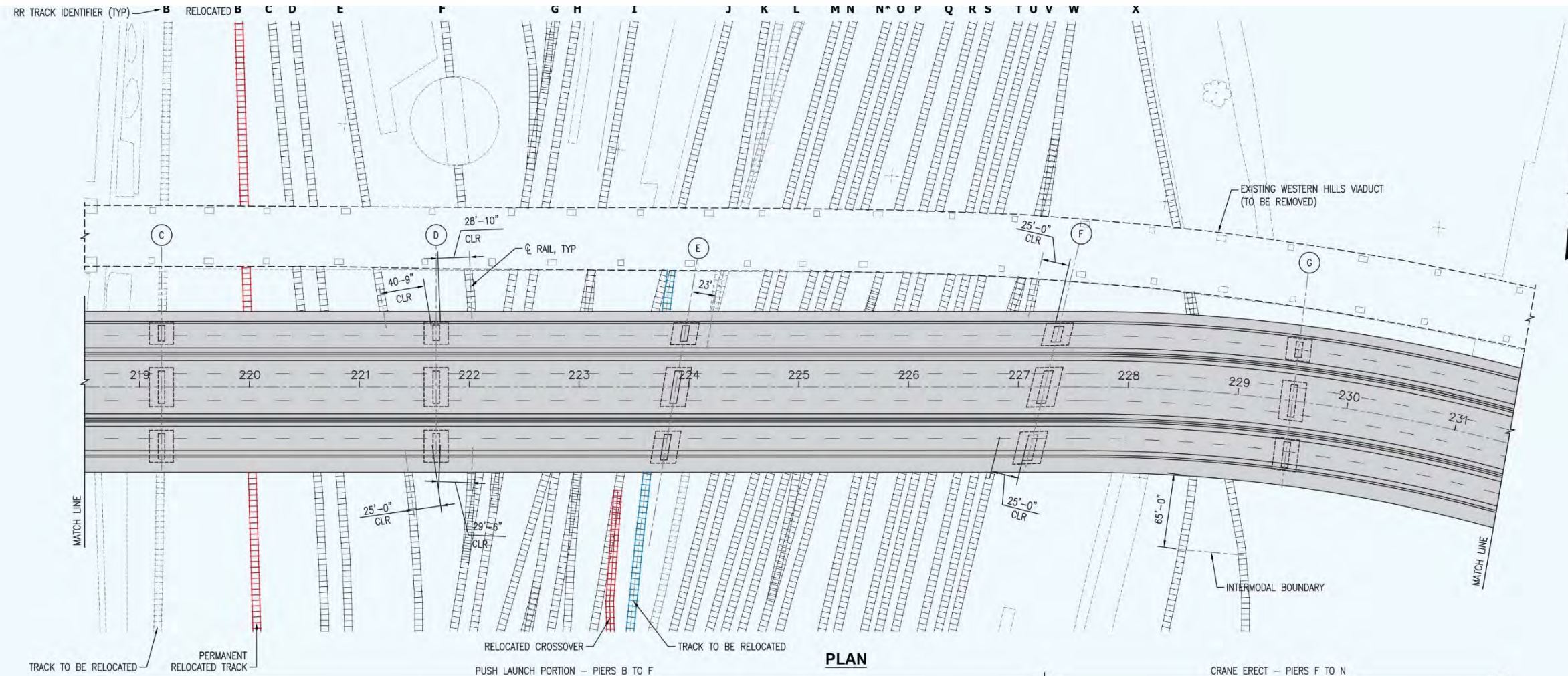
PLAN



PROFILE

NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

Short Span Push Launch
Site Plan 1 of 3

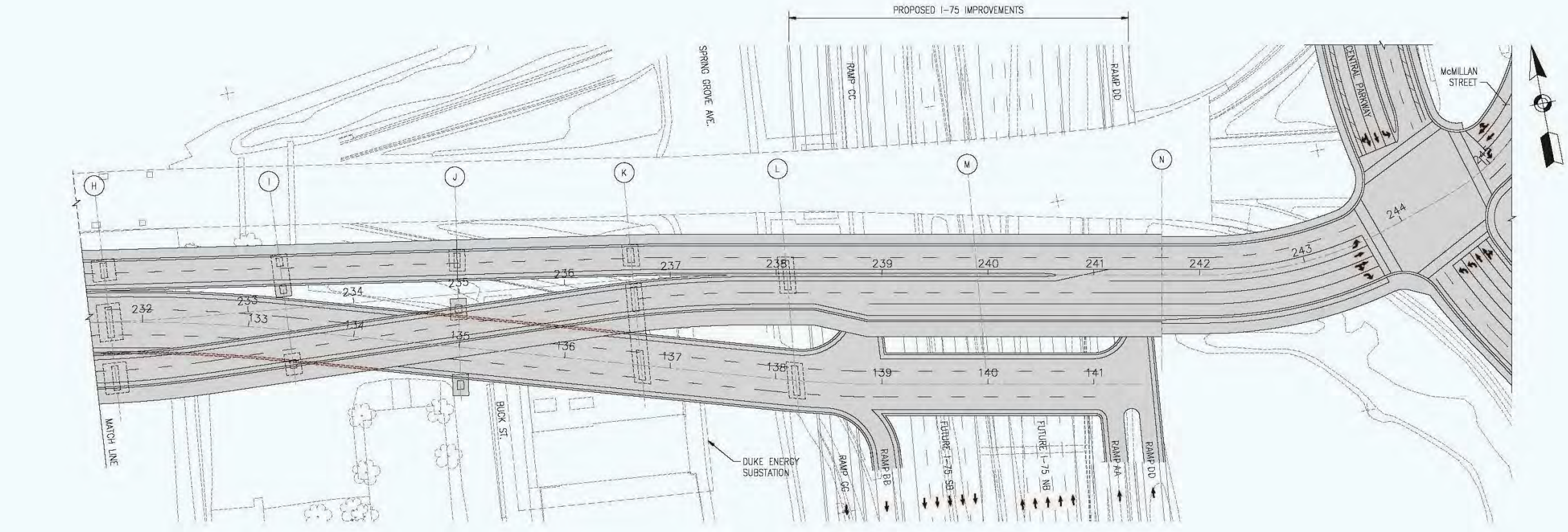


LEGEND - RR TRACK IDENTIFIER

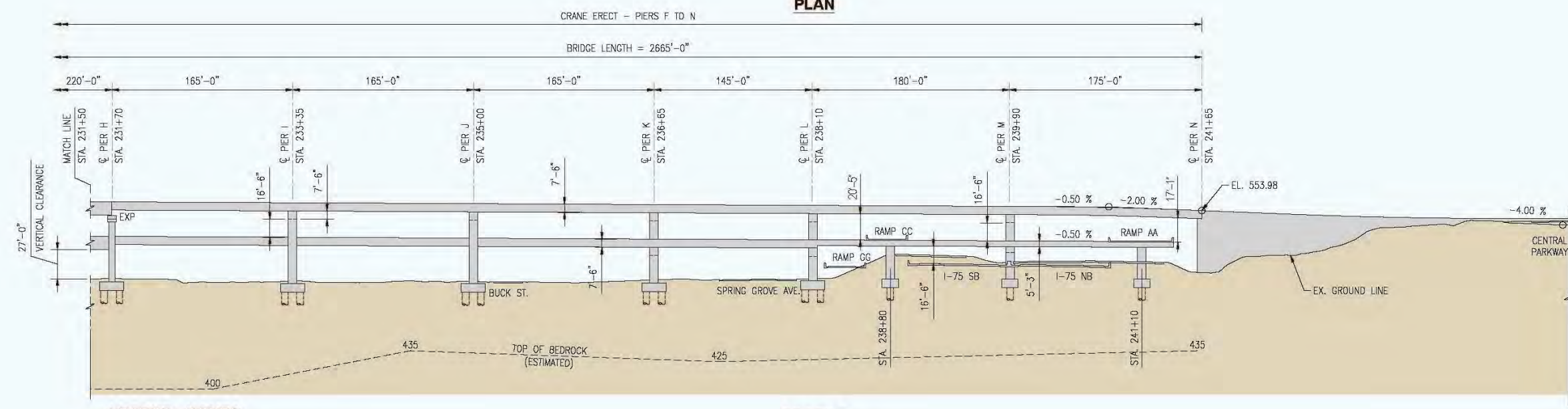
A - CSX (OUT OF SERVICE)	G - CSX LOCOMOTIVE TRACK	M - CSX LONG DEPARTURE TRACK	S - CSX MAIN LINE
B - CSX MAIN LINE	H - CSX WEST OPEN TRACK	N, N* - CSX LONG DEPARTURE TRACK	T - CSX RAMP TRACK
C - CSX RECEIVING TRACK	I - HUMP TRACK	O - NS TRACK	U - CSX RAMP TRACK
D - CSX RECEIVING TRACK	J - CSX EAST OPEN TRACK	P - NS TRACK	V - CSX RAMP TRACK
E - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	Q - NS TRACK	W - INTERMODAL TRACK
F - CSX LOCOMOTIVE TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	R - CSX MAIN LINE	X - GANTRY CRANE TRACK

PROFILE

**Short Span Push Launch
Site Plan 2 of 3**



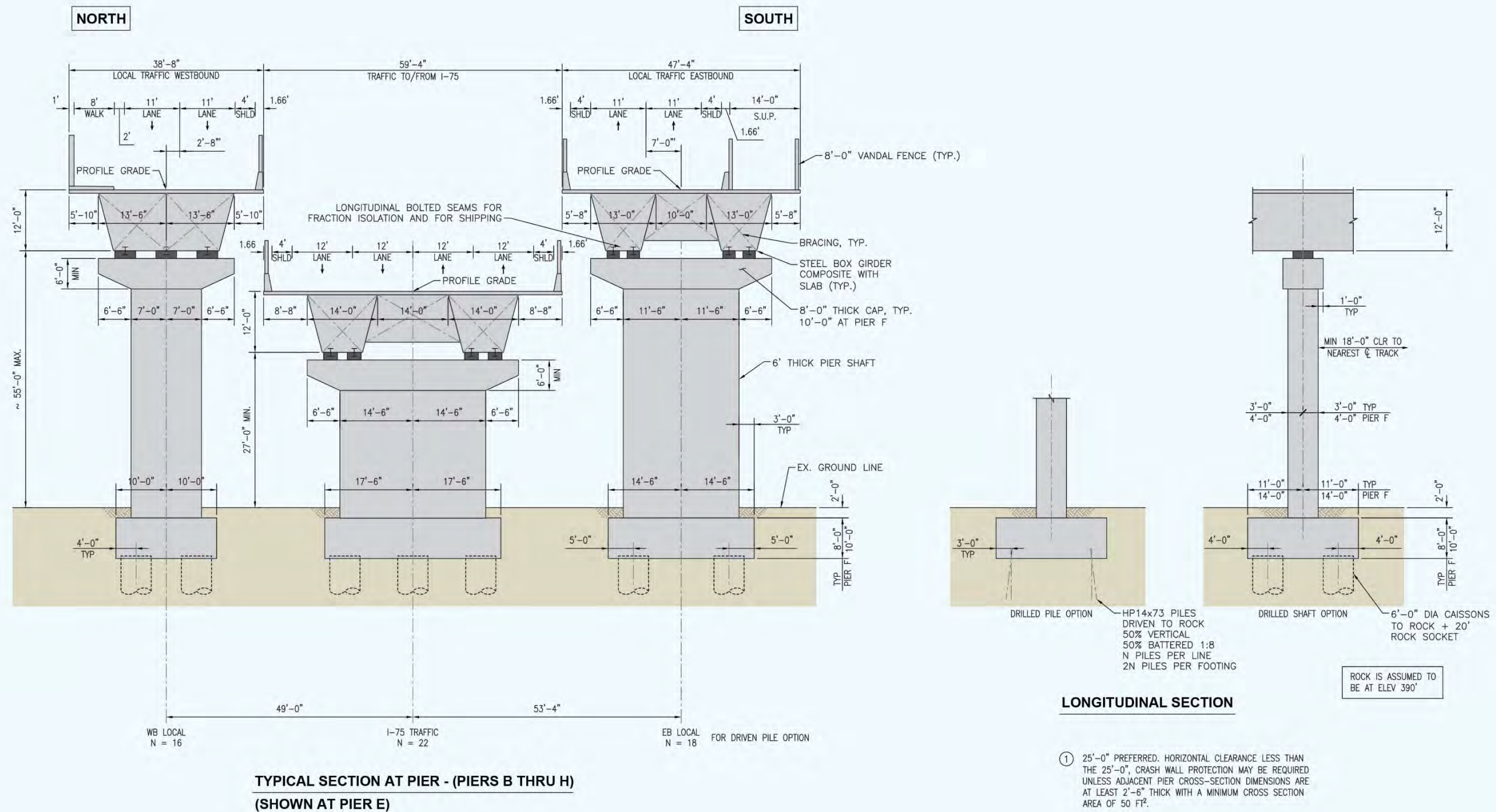
PLAN



PROFILE

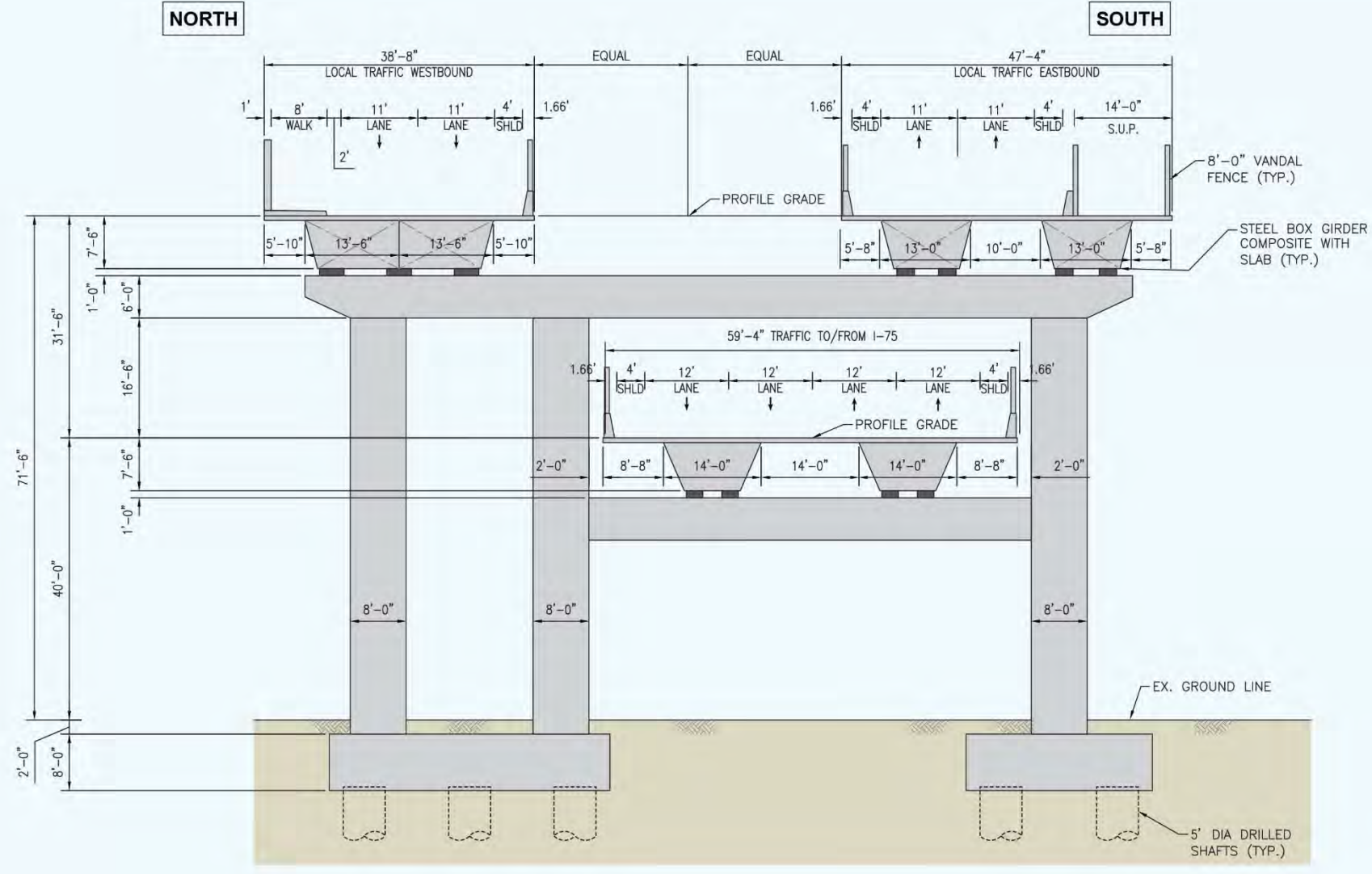
- LEGEND - RAMPS**
- RAMP AA - FUTURE RAMP TO/FROM I-75 NB/WHV
 - RAMP DD - FUTURE RAMP FROM BANK STREET
 - RAMP BB - FUTURE RAMP TO/FROM I-75 SB/WHV
 - RAMP GG - FUTURE RAMP TO FINDLAY STREET

**Short Span Push Launch
Site Plan 3 of 3**



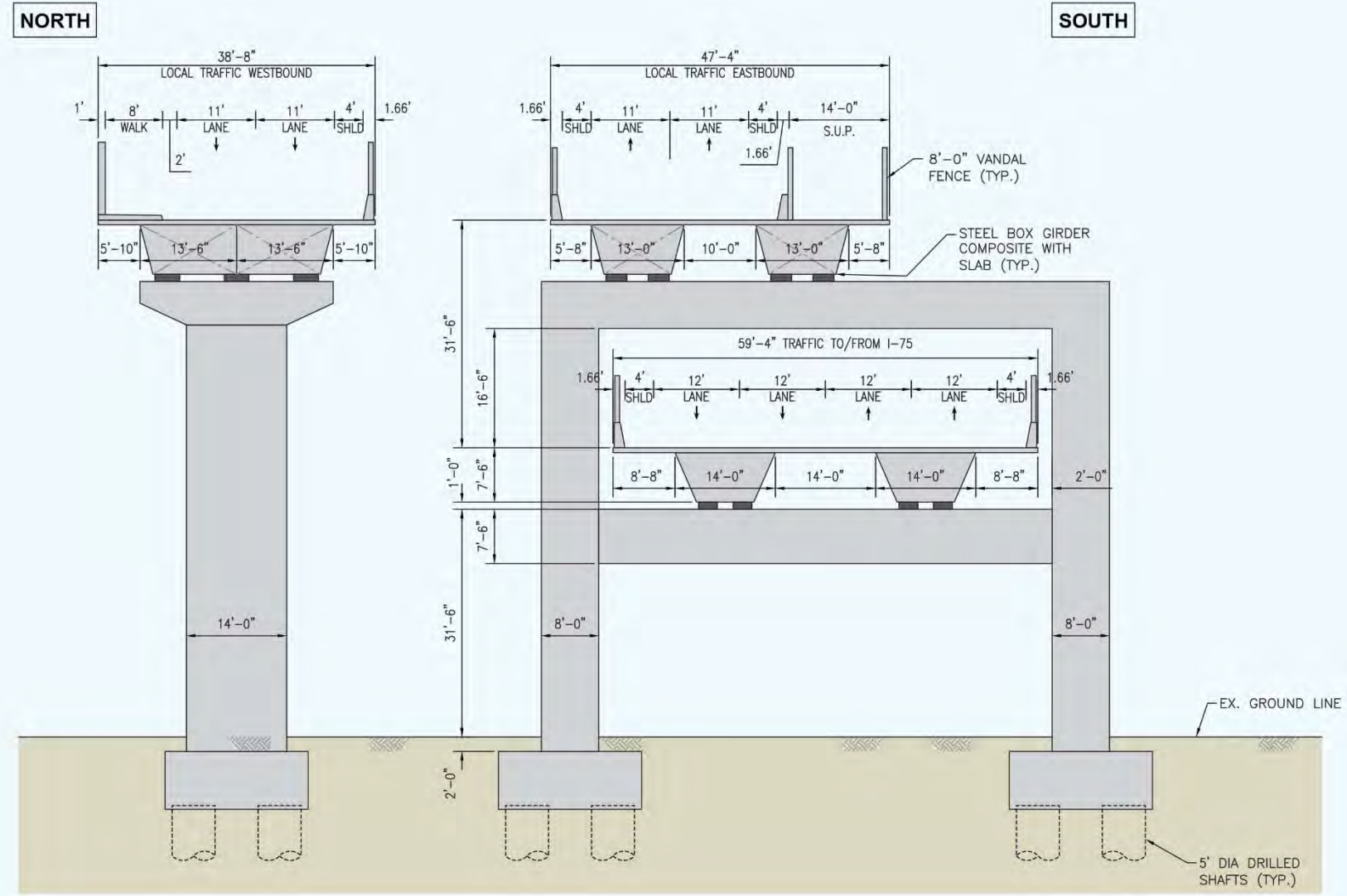
**TYPICAL SECTION AT PIER - (PIERS B THRU H)
(SHOWN AT PIER E)**

**Short Span Push Launch
Typical Sections 1 of 4**



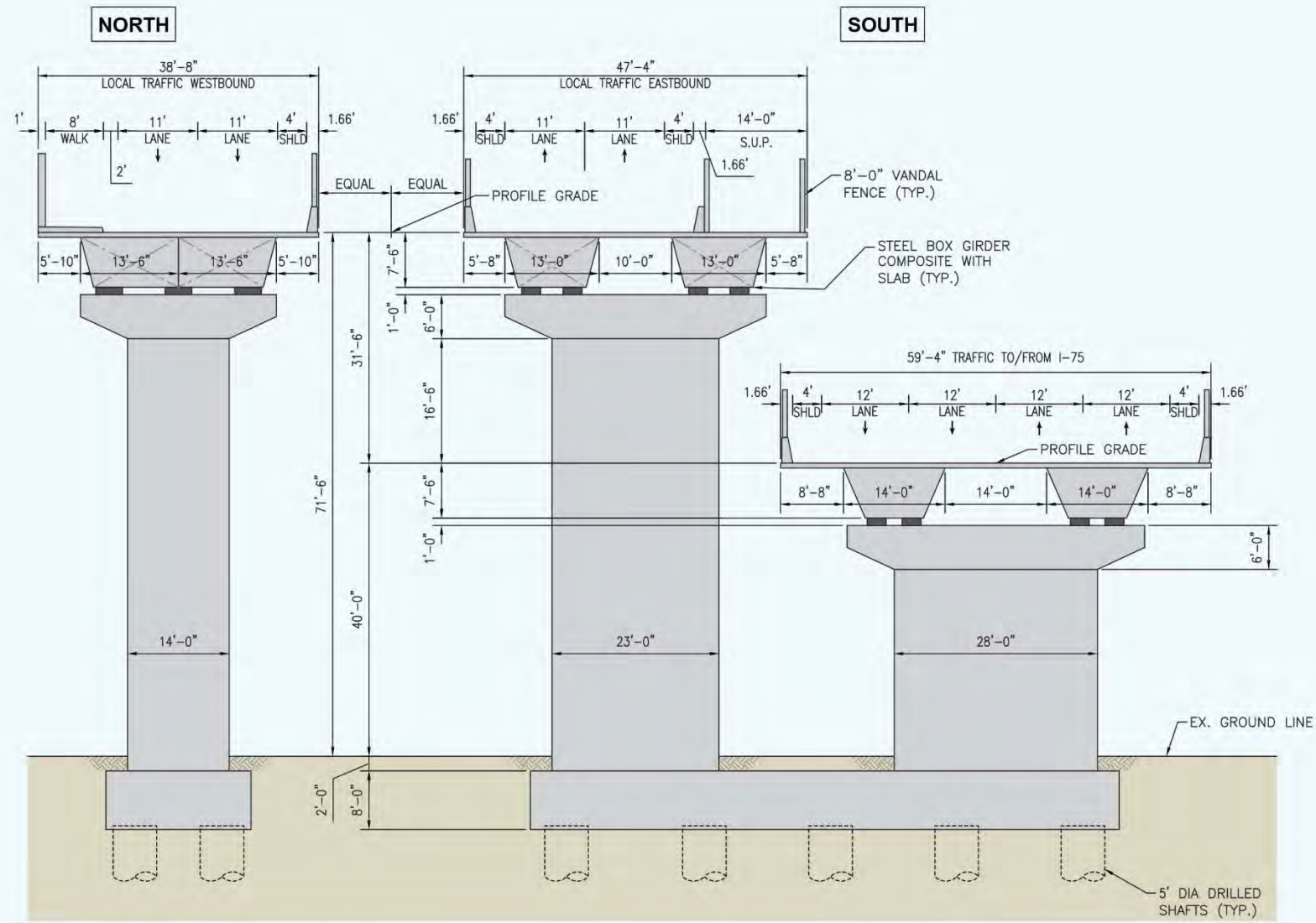
SECTION @ PIER I

Short Span Push Launch
Typical Sections 2 of 4



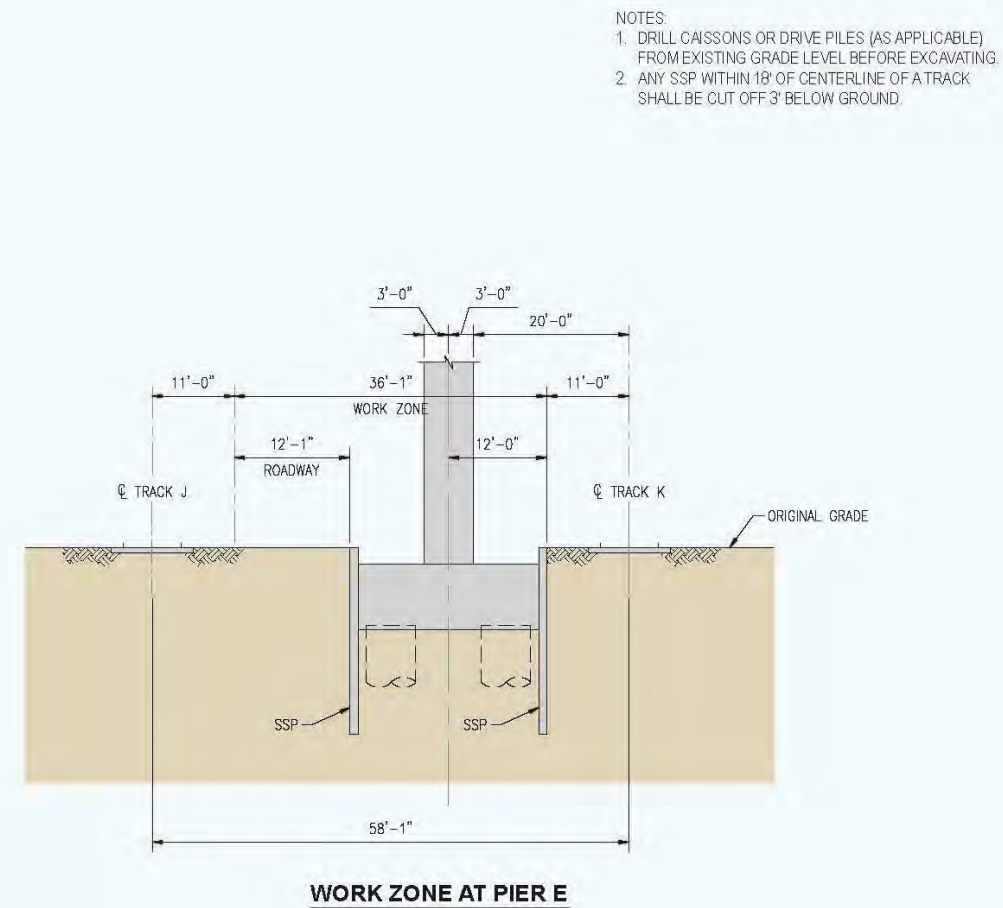
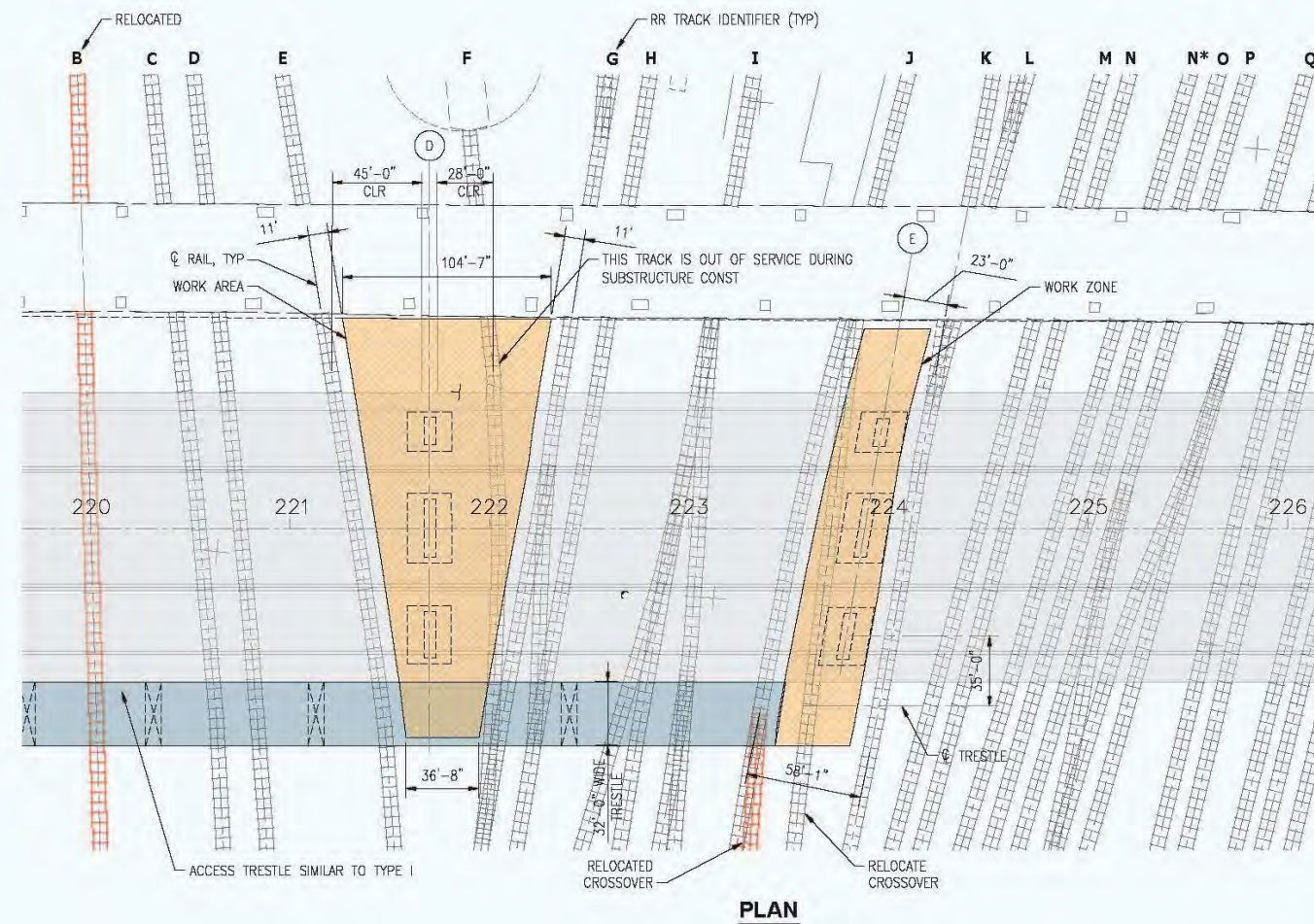
SECTION @ PIER J

Short Span Push Launch
Typical Sections 3 of 4



SECTION @ PIER K

Short Span Push Launch
Typical Sections 4 of 4

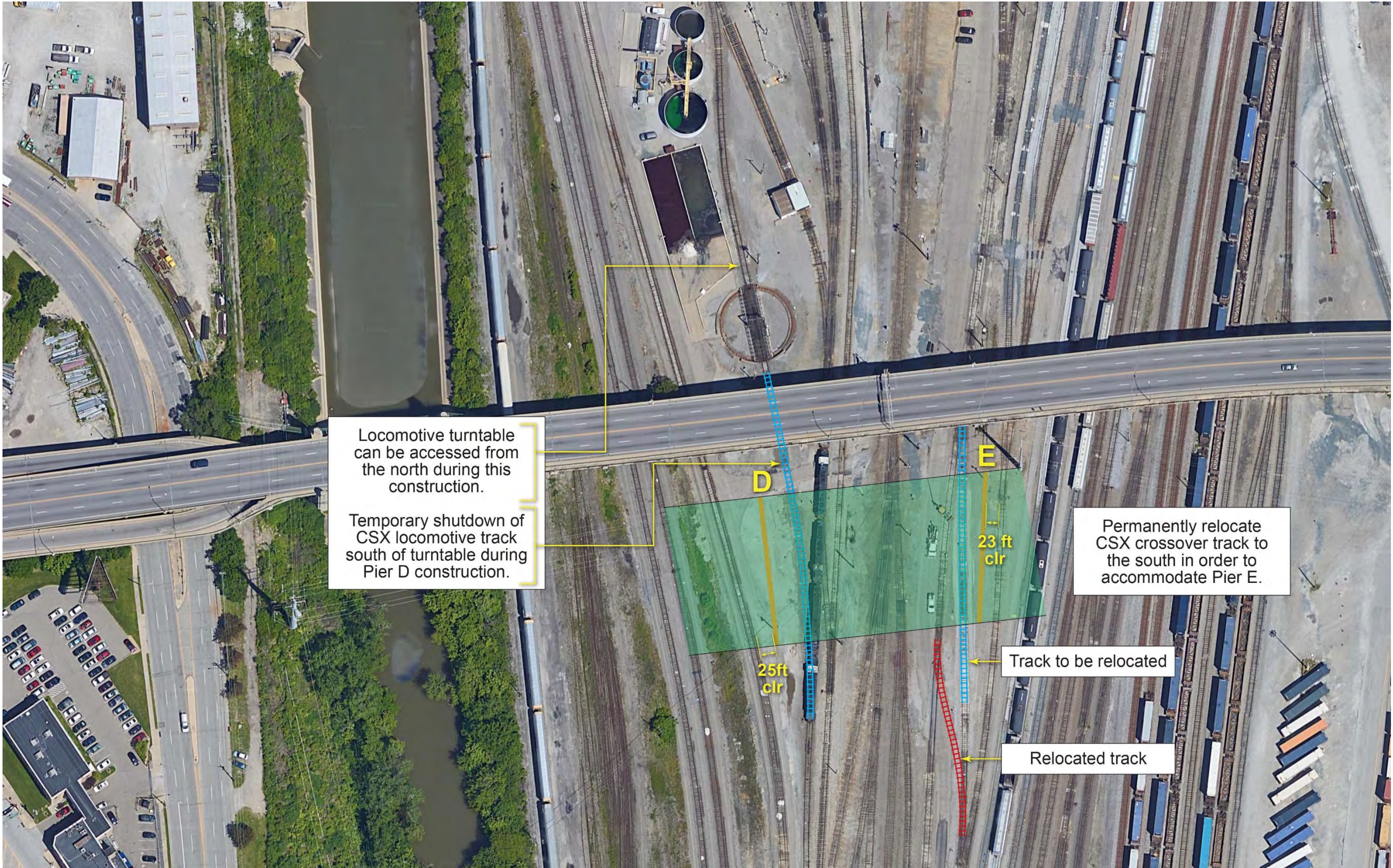


NOTES:
1. DRILL CAISSONS OR DRIVE PILES (AS APPLICABLE) FROM EXISTING GRADE LEVEL BEFORE EXCAVATING.
2. ANY SSP WITHIN 18' OF CENTERLINE OF A TRACK SHALL BE CUT OFF 3' BELOW GROUND.

LEGEND - RR TRACK IDENTIFIER

A - CSX (OUT OF SERVICE)	I - HUMP TRACK	Q - NS TRACK
B - CSX MAIN LINE	J - CSX EAST OPEN TRACK	R - CSX MAIN LINE
C - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	S - CSX MAIN LINE
D - CSX RECEIVING TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	T - CSX RAMP TRACK
E - CSX RECEIVING TRACK	M - CSX LONG DEPARTURE TRACK	U - CSX RAMP TRACK
F - CSX LOCOMOTIVE TRACK	N, N* - CSX LONG DEPARTURE TRACK	V - CSX RAMP TRACK
G - CSX LOCOMOTIVE TRACK	O - NS TRACK	W - INTERMODAL TRACK
H - CSX WEST OPEN TRACK	P - NS TRACK	X - GANTRY CRANE TRACK

**Short Span Push Launch
Pier E & D Work Zones**



Locomotive turntable can be accessed from the north during this construction.

Temporary shutdown of CSX locomotive track south of turntable during Pier D construction.

Permanently relocate CSX crossover track to the south in order to accommodate Pier E.

Track to be relocated

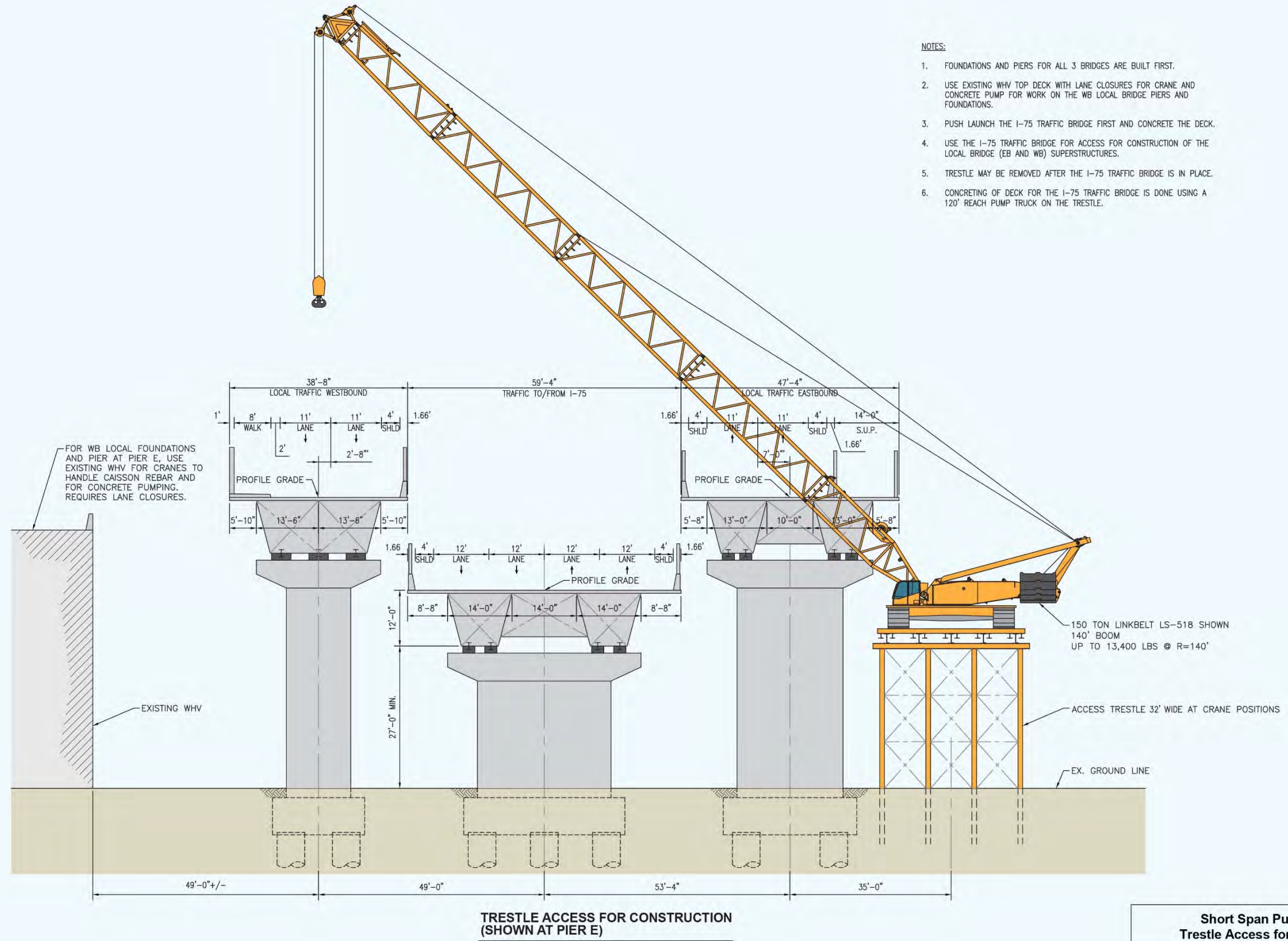
Relocated track

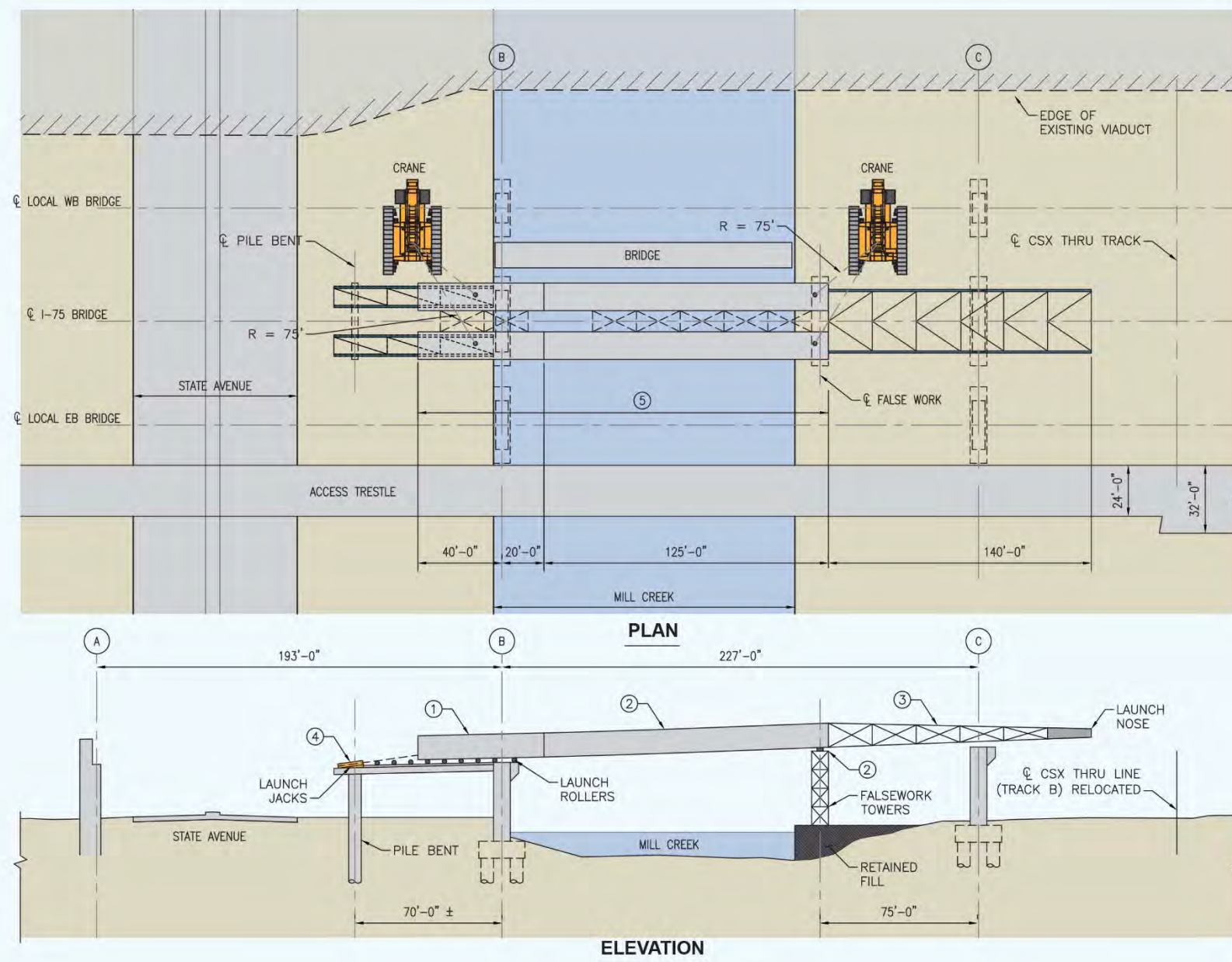
D

E

25ft
clr

23 ft
clr



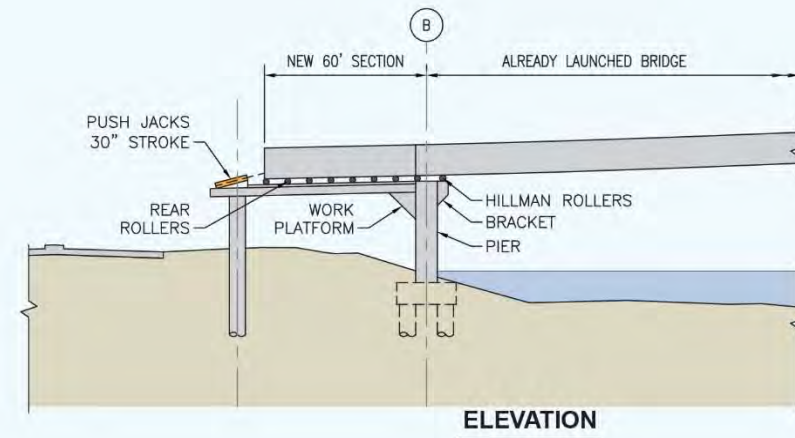


NOTE:

FOR THE FIRST BRIDGE TO BE LAUNCHED, IT IS POSSIBLE TO PLACE THE REBAR AND THE P/T, AS WELL AS THE FORMWORK, ON THE SECTIONS AS THEY ARE ERECTED (PRIOR TO LAUNCH). FOR THE SECOND AND THIRD BRIDGES IT IS BETTER TO USE THE FIRST BRIDGE AS ACCESS FOR THIS WORK AND TO DO IT AFTER LAUNCH IS COMPLETE.

CONSTRUCTION NOTES:

1. THE PUSH-LAUNCH PORTION OF THESE BRIDGES IS FROM PIER B TO PIER F. FROM PIER F TO PIER G, THE BRIDGE IS CURVED IN PLAN AND/OR ELEVATION AND THEREFORE THIS SPAN IS TO BE CRANE ERECTED. FROM PIER A TO PIER B WILL BE CRANE ERECTED AFTER PUSH LAUNCH IS COMPLETED FOR ANY ONE BRIDGE.
2. FROM PIER G TO EAST OF I75 THE BRIDGES WILL BE CRANE ERECTED.
3. THE FIRST BRIDGE TO BE CONSTRUCTED IS THE I-75 TRAFFIC BRIDGE. THE TRESTLE WILL BE USED TO PROVIDE CONSTRUCTION ACCESS TO THIS BRIDGE WHICH WILL THEN BE USED FOR CONSTRUCTION ACCESS TO THE LOCAL TRAFFIC BRIDGES. THE TRESTLE CAN BE REMOVED AFTER THE I-75 BRIDGE IS COMPLETED FROM PIER A TO PIER G.
4. ALL FOUNDATIONS AND PIERS AT LINES A THRU E WILL BE CONSTRUCTED AT THE SAME TIME AND BEFORE ANY PUSH LAUNCHING IS COMMENCED USING THE TRESTLE AS ACCESS FOR WORKERS AND MATERIALS AS REQUIRED.

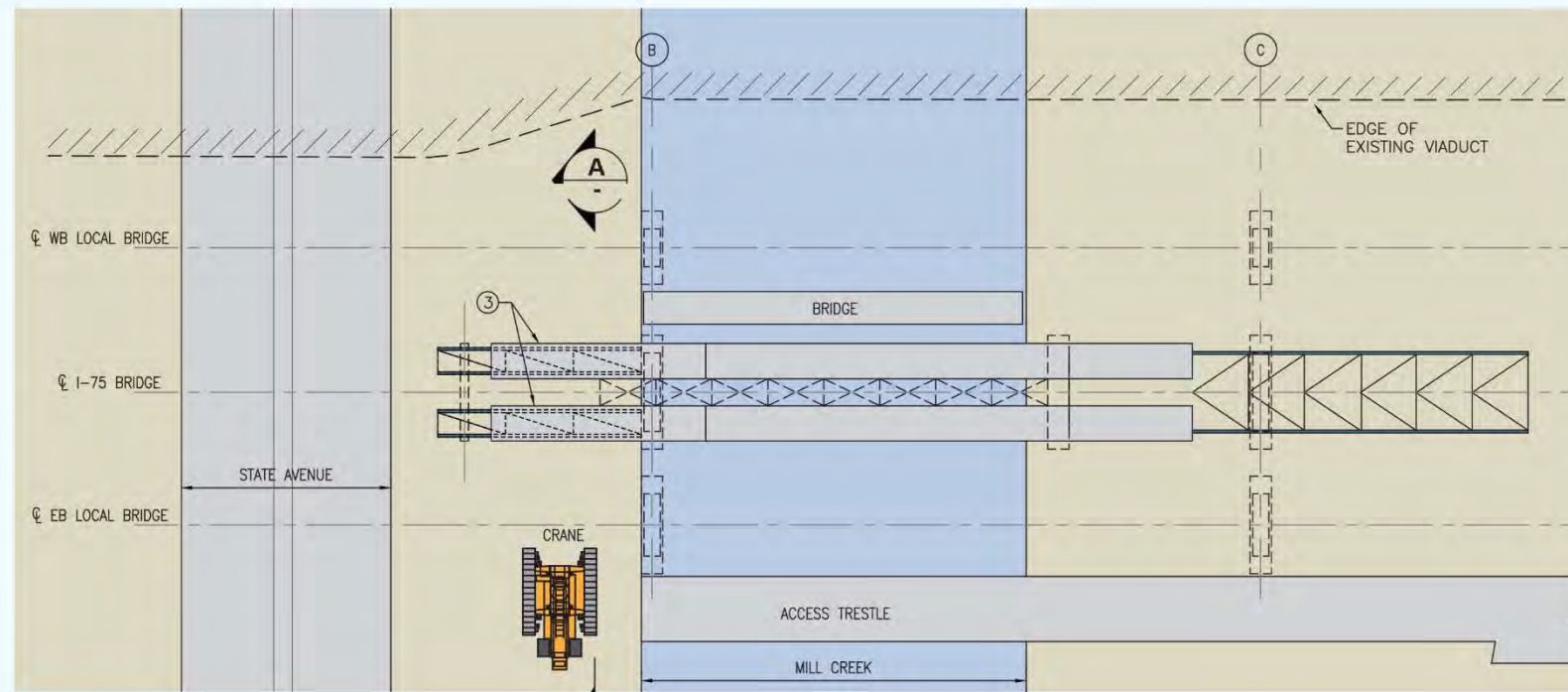


PUSH LAUNCH OF TRAPEZOIDAL STEEL BOX SHEET 1

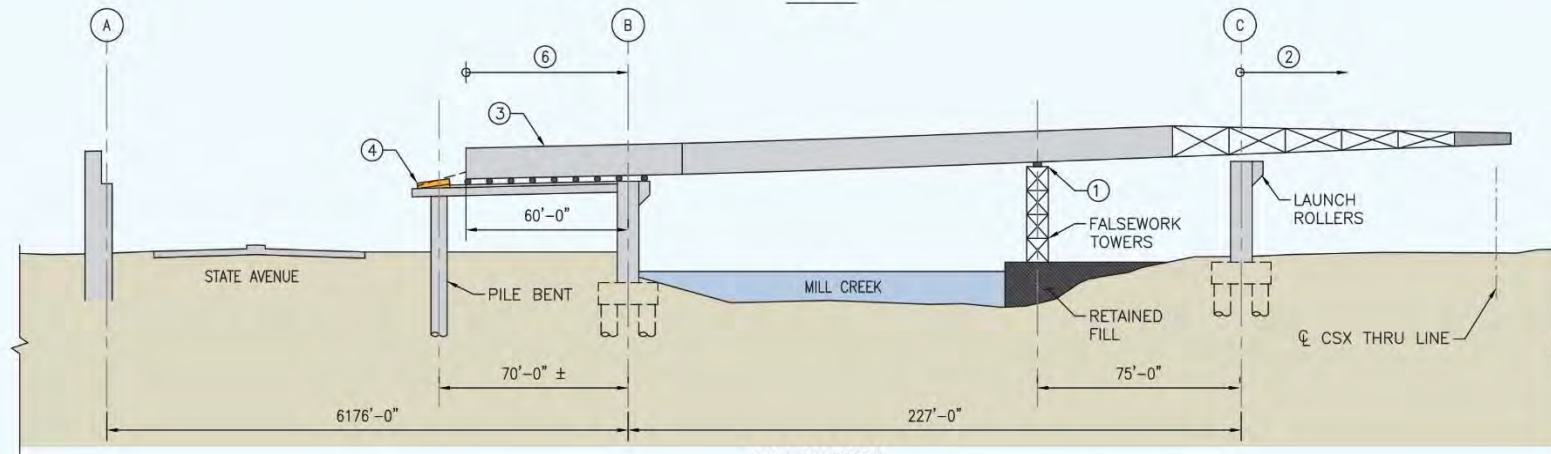
WHV TRAPEZOIDAL BOX ERECTION STEPS:

1. ERECT TWO 60' LONG TUBS CANTILEVERING 20' BEYOND PIER B. INSTALL DIAPHRAGMS AND BRACING, MAX PER TUB - 60 TON APPROX.
2. ERECT TWO 125' LONG TUBS. CONNECT TO TUBS FROM STEP 1 AND REST EAST ENDS ON FALSEWORK TOWERS - APPROX 125 TON EACH.
3. ERECT 140' LONG LAUNCH NOSE AND CONNECT TO TUBS FROM STEP 2.
4. INSTALL LAUNCH JACKS AT WEST END.
5. INSTALL FORMWORK AND STRIPPING ACCESS PLATFORMS ON THE TUBS THAT HAVE BEEN ERECTED.

**Short Span Push Launch
Erection Methods 1 of 3**



PLAN



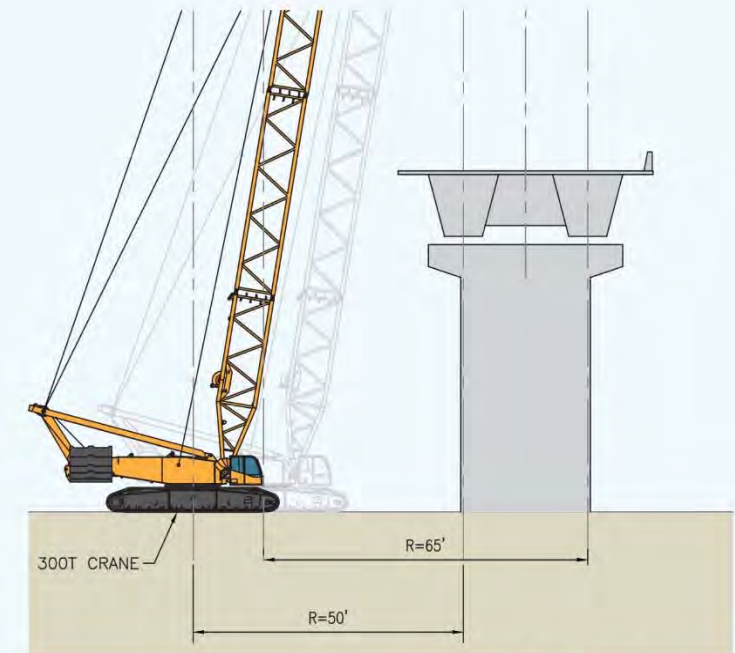
ELEVATION

PUSH LAUNCH OF TRAPEZOIDAL STEEL BOX SHEET 2

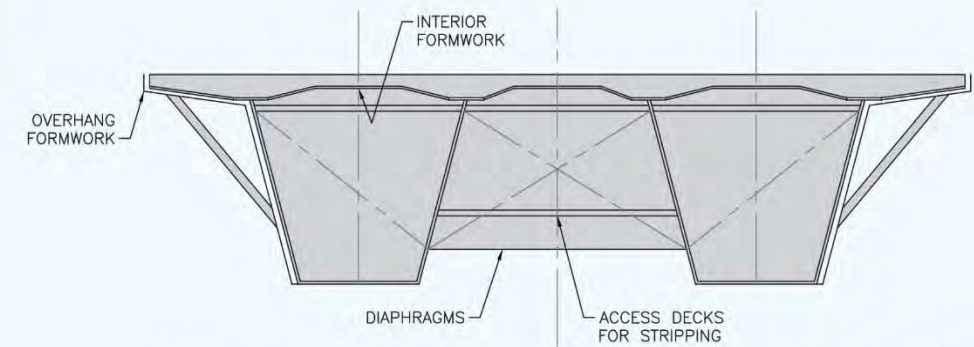
WHV TRAPEZOIDAL BOX ERECTION STEPS:

1. UNLOAD FALSEWORK TOWERS SO THAT THE STRUCTURE SPANS FROM PIER B TO PIER C.
2. LAUNCH AHEAD 40'.
3. ERECT TWO 60' TUB SECTIONS WEST OF PIER B.
4. RELOCATE LAUNCH GEAR TO WEST END OF NEWLY ERECTED TUBS.
5. INSTALL FORMWORK AND STRIPPING ACCESS PLATFORMS ON THE TUBS THAT HAVE BEEN ERECTED.
6. LAUNCH AHEAD 60'

REPEAT STEPS 3 TO 6 UNTIL BRIDGE IS FULLY LAUNCHED.

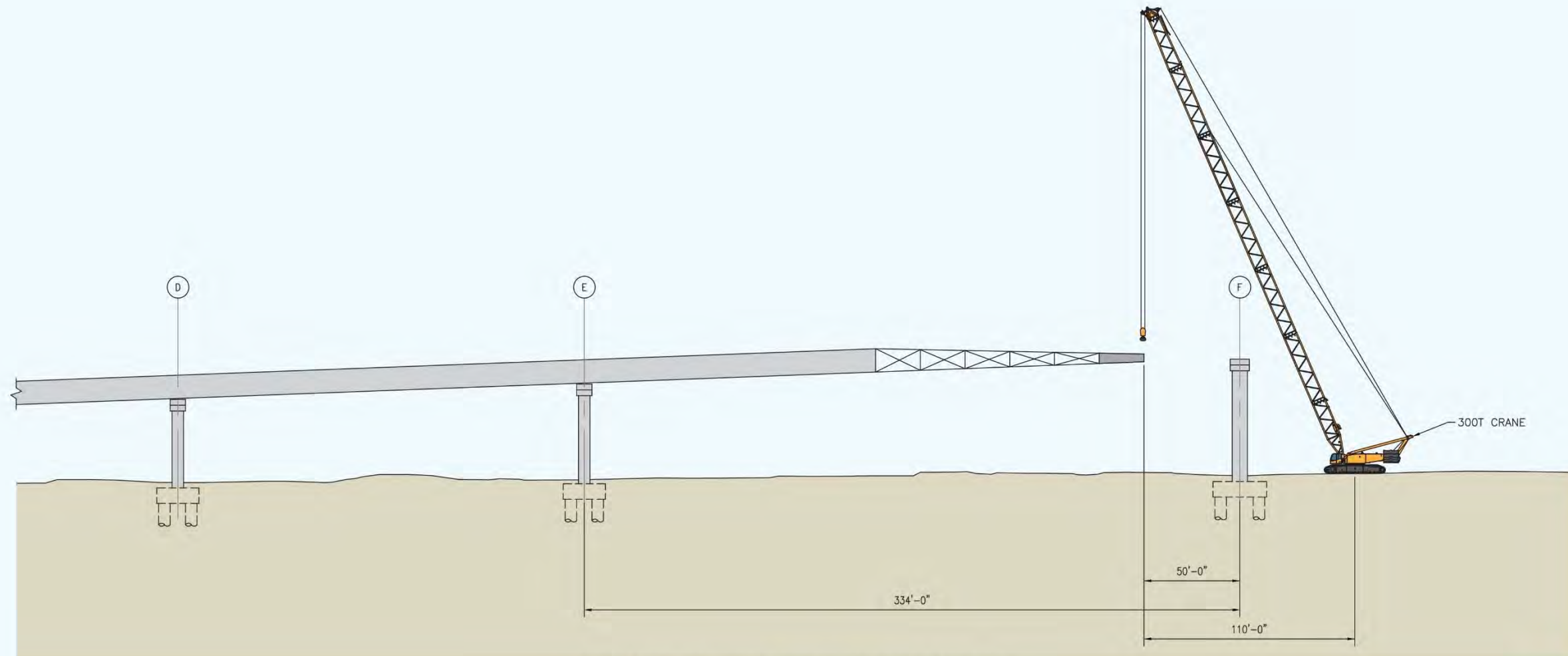


SECTION A AT PIER B



PRIOR TO LAUNCH, INSTALL FORMWORK & STRIPPING ACCESS DECKS

**Short Span Push Launch
Erection Methods 2 of 3**

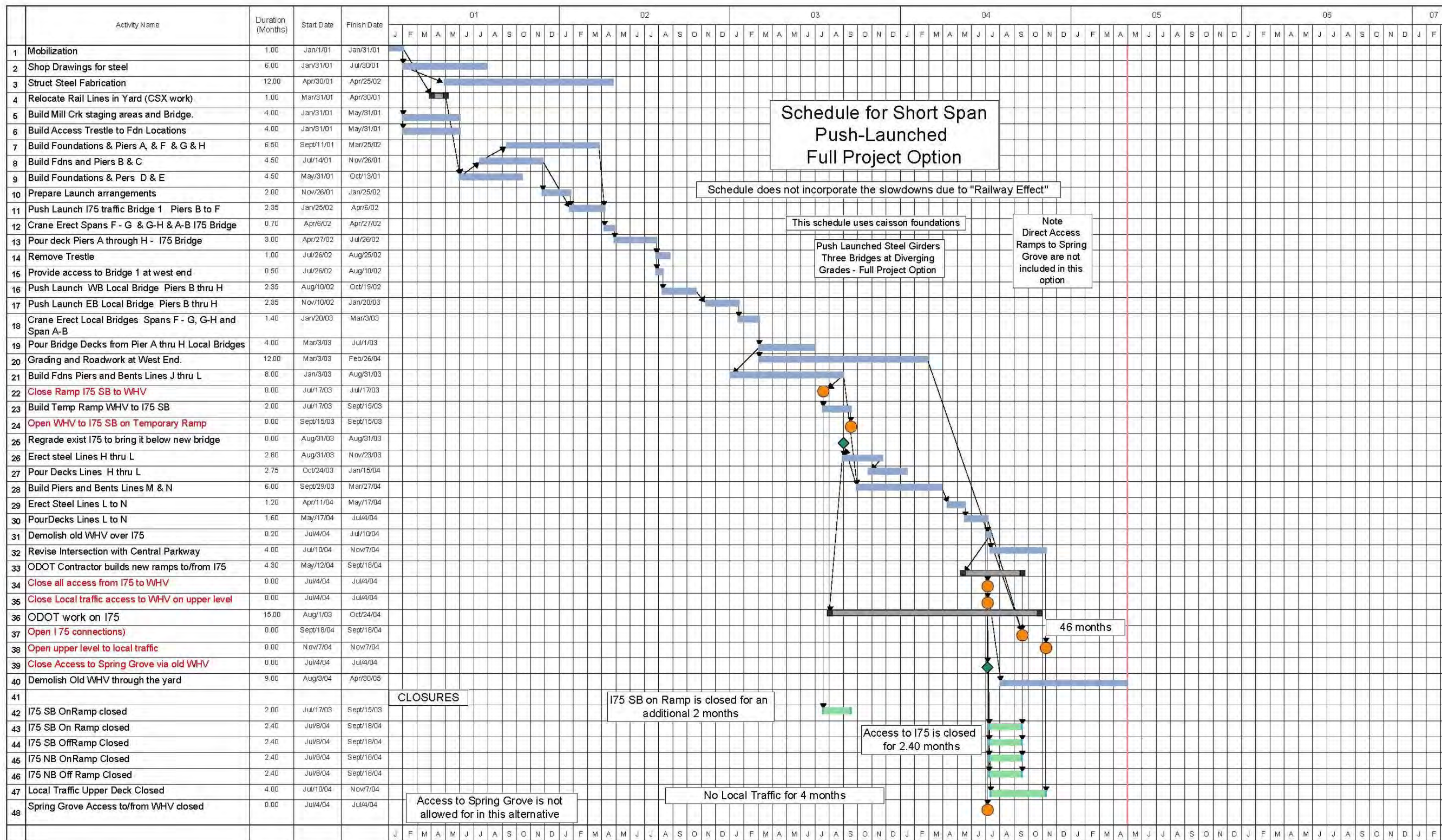


PUSH LAUNCH OF TRAPEZOIDAL STEEL BOX SHEET 3

COMPLETION OF PUSH LAUNCH:

1. LAUNCH BRIDGE UNTIL NOSE IS 50' SHORT OF PIER F.
2. HOOK ON CRANE TO TIP OF NOSE.
3. LIFT BY APPROX. 35 TONS.
4. ADVANCE BRIDGE WHILE BOOMING UP CONTROLLING THE REACTION TO THE CRANE AS BRIDGE ADVANCES.
5. WHEN NOSE REACHES PIER E, SET IT DOWN ONTO THE LAUNCH ROLLERS.
6. DISCONNECT CRANE.
6. LAUNCH UNTIL BOX GIRDER REACHES PIER F.

Short Span Push Launch
Erection Methods 3 of 3



2.2 CIP Segmental

2.2.1 Introduction

The alignment considered in this alternative is side by side bridges across the rail yard with a weave at the east end to separate the I-75 traffic from the local traffic. In this alignment, there are three parallel bridges across the rail yard - a center bridge for the I-75 traffic and two other bridges (north and south) which together carry the local traffic. The weave starts east of the intermodal terminal tracks.

Two options are considered in this alternative:

- The Full Project Option in which the entire WHV project is built at once and
- The Staged Option

The purpose of the Staged Option is to allow the work to be split into multiple contracts so that immediately usable infrastructure can be constructed without waiting for the full funding for the complete project. Traffic to and from I-75 would be established first, while local traffic would remain on the upper deck of the existing Western Hills Viaduct (WHV). At a later date, when funding becomes available, the remainder of the new WHV would be constructed and the old structure demolished. There are complications inherent in staging the project that would increase the total project cost.

The Full Project Option is the most suitable and economical if full funding for the project can be secured.

The plans and profiles for the Full Project Option are shown on pages 32 through 34. The plans and profiles for the Staged Option are essentially identical.

2.2.2 Structure Description and Selection Considerations

There are four structure types making up the new WHV in this alternative:

- The main span over the rail yard (Piers C to F) is a long span (560 feet) cantilever cast-in-place concrete bridge. There are three bridges side by side in this portion. The total length of bridge to be built by the cantilever cast-in-place method is about 1120 feet per bridge.
- The approach spans (Piers A to C and Piers F to G) are conventional, relatively long-span, cast-in-place on falsework concrete bridges. These spans form part of the cantilever cast-in-place structural system. It is possible to make these spans continuous with the central 1120 feet of long-span structure in order to offset the disadvantageous effects of the short backspans (320 feet) and avoid the need for ballast.
- The approach spans from Pier G to Pier K are conventional, short span, cast-in-place on falsework concrete bridges.
- The bridges crossing I-75 are precast concrete girders or steel girders with cast-in-place concrete decks. These spans are precast concrete or steel because there is no clearance for falsework for the lower level bridge and because the upper level bridge can be built faster and more easily than by using cast-in-place concrete. Steel girders are assumed in this report.

The cantilever cast-in-place main span, at 560 feet, is at the upper end of the economically plausible span range for this type of construction. Physical constraints of the site limit the available length for the backspans to about 320 feet, which is short for a mainspan of 560 feet. Short backspans may experience uplift at the end piers (Piers C and F) due to live loads in the mainspan and adding extra dead load (ballast) to the backspans to preclude the uplift is common. However, to avoid adding extra weight in the backspan, the adjacent approach spans at each end could be made with a shear connection to the backspan so the weight of the approach span compensates for the potential backspan uplift at the piers. In addition, the depth at the midspan could likely be reduced as a consequence. The backspan at the east end (Pier E to Pier F) is curved in plan, which is not a problem for cantilever cast-in-place construction.

The mainspan slopes downward at 4% from a high point at centerline span so as to facilitate drainage. The vertical profile is also an aesthetic benefit.

A longer span (760' +/-) cantilever cast-in-place structure that could span the whole rail yard was also considered. The longer span structure, although offering less interference with railway operations, is structurally problematic because of having backspans that are too short, and also is expected to be more expensive. It is not recommended and therefore is not discussed further at this stage of the project.

It was determined that the planned location of Pier D (see page 37), although within the rail yard, need not interfere greatly with rail operations during construction and will not interfere at all once construction is complete. Therefore, this appears to be a good compromise between economy and avoiding interaction with rail yard operations.

2.2.3 The Cast-in-Place Segmental Construction Procedure

Cast-in-place segmental construction is a relatively simple method of building concrete bridges that is widely and successfully practiced in the USA. It does not require any great expense in purpose-built equipment. It does not require highly specialized expertise.

In this form of construction, the bridge structure is built in segments, frequently about 16 feet long, starting at a main pier and progressing outwards in both directions as a balanced double cantilever. Two such cantilevers are built until they meet at the midspan and are then joined together to create a continuous bridge. Many of the details of how this happens are discussed in the next section. Page 42 shows a typical sequence and schedule for the construction of one balanced cantilever.

Cast-in-place segmental construction requires more space on the ground than some of the other alternates. The footings are larger, the pier is thicker, and room must be created to install and remove the pier table falsework and also to install the travelers and the formwork for the cast-in-place segments. The important steps that affect rail operations are illustrated on pages 39 & 40 and are discussed in more detail in the following section.

Figure 4 shows a similar, long span, cantilever cast-in-place bridge under construction.



Figure 4: CIP Traveler

2.2.4 Work Within the Rail Yard

It is feasible to place the westerly main pier (Pier D) as shown close to the locomotive turnaround track (Track F that passes over the turntable) but it will be necessary to refrain from using this track south of the existing WHV structure for certain time periods when the extra space is needed for construction (see page 37).

The turntable can still be used during any of the interruptions, but locomotives would have to come and go only from the north. This restriction is seen as manageable. The functionality of the locomotive turnaround is not impaired.

This alternative utilizes a purpose-built trestle over portions of the rail yard so as to provide unhindered access to the one pier location (Pier D) that is within the busy, multi-track, portion of the yard. This is done in order to minimize the "railway premium" associated with the bridge construction activities having to work around, or wait for, the railway's operations. The construction of the trestle itself will be subject to considerable disruption from rail operations. The cost estimates allow \$3.2M for construction and removal of the trestle to Pier D. It is proposed to construct the access trestle at least 25 feet above track level to provide access for workers and materials to the work zone, the details of the trestle are shown on page 37. This trestle would be able to support cranes and concrete placing booms as required. Equipment operating at grade level (e.g. pile drivers

or augers and cranes) would be walked in over the rails. Once within the work zone, they can operate uninhibited by rail operations.

Use of the south end of the locomotive track (Track F) would have to be halted for two periods. The first period is about 8 months long which permits the construction of the Pier D footings and all of the pier columns (5.4 months) and then, overlapping with this, construction of the pier table and setting up the travelers for the first bridge (about 4 months). After the first CIP bridge (the central bridge – for I-75 traffic) is built and can be accessed for material deliveries and construction equipment, there will be another interruption of about 5 months to build the pier tables and set up the form travelers for the two local traffic bridges. These two local bridges would be built essentially simultaneously. In the Full Project Option, once the center bridge is constructed and accessible, the trestle could be removed. In the Staged Option, the center bridge is opened to I-75 traffic as soon as it is complete. At some later time (Stage 2) the second and third cantilever cast-in-place bridges will be built adjacent to live traffic on the center bridge. Access for this construction would be via the lower deck of the existing WHV and also using frequent lane closures of the center bridge. As well, frequent lane closures will be required on the upper deck of the existing WHV. Closures can usually be restricted to off-peak traffic hours.

In the case of the Staged Option, the second interruption to Track F would take place only after the project remobilizes (Stage 2) for construction of the local traffic bridges. This time the interruption would be of the order of 6 months to build pier tables and set up travelers for the second and third bridges, which would, again, be built essentially simultaneously.

The work zone for Pier D (see page 37) is constrained to a trapezoidal plot of land about 260 feet long and 35 feet to 120 feet wide. The work zone should also continue under the existing structure to allow for material storage etc. It is practical, but tight, to work within this space to construct conventional footings supported on driven steel piles or caissons (drilled shafts).

The work zone has been defined herein as approaching no closer to centerline of the nearest track than 10 feet. This is understood to be the normal CSX minimum horizontal clearance requirement. It is presumed that a flagperson will need to be present during all construction activities, but that work done within this zone will not be slowed down by rail activity if the 10 foot setback is respected.

The easterly main pier (Pier E) is easily accessible via the intermodal yard and is not considered an issue from the access point of view.

During pier table forming operations and also during the setup of the form travelers, it will be necessary to interrupt rail traffic on the rail line(s) immediately below the first cantilever segment (see pages 39 & 40). The interruption is anticipated to be for a total of 36 hours in blocks at least 4 hours long for each traveler/formwork set that is to be erected. There will be a total of 9 such interruptions applying to different rail lines. Note that Pier E disrupts only one rail line unlike Pier D, which disrupts 2. Page 33 illustrates which rail lines would be affected by this work.

The pier table is too small to permit both travelers in a set to be erected simultaneously. It will be necessary to erect one traveler, construct one segment, move that traveler ahead and then erect the

second traveler and its formwork. Setting the forms and travelers will require interruption of use for the closest rail line while work is carried out overhead.

Once the forms are ready and the initial segments have been built, segment casting can start. Segments are typically about 16 feet long. Each cantilever would consist of 15 segments. The casting of the 15 segments in a single cantilever is expected to require about 22 weeks to complete.

The casting of the two cantilevers in any one bridge would be done more or less simultaneously from the pier tables to the east (Pier E) and to the west (Pier D) to meet at midspan over the rail yard.

A further interruption to rail traffic will be necessary in order to remove the form travelers and segment formwork after each bridge is connected at midspan. The interruption would affect several tracks near midspan for three periods of three shifts each after each bridge is closed at midspan. It is possible to move the location of this interruption, at some extra cost, by walking the form travelers back towards the piers and then taking them down within the original work zones. This operation would still affect some tracks, but only those that were affected when the forms were first set up.

For cast-in-place segmental construction, the potential hazards to rail operations are confined to the short time periods when the form travelers are being advanced, i.e., when they are not securely tied down. With the large and heavy segments required to achieve a 560 feet span it is expected that the time period between form traveler advances will be of the order of 1½ to 2 weeks for any given traveler. The zone of hazard is only immediately below the form traveler (40 feet +/- long) that is being moved, i.e., it is confined to a small portion of the length of the bridge. The elapsed time taken by the actual advancement of the form traveler is of the order of 4 hours until it is tied down again. Since it is not desirable to interrupt this operation, it is preferable to create a time window when it can take place without interruption. Two to four tracks would be affected by each form traveler advance.

There are 3 parallel bridges and each one has 30 segments which are within the footprint of the busy part of the yard. There will therefore be $30 \times 3 = 90$ launches of the form travelers that will have an impact on railroad operations. At 4 hours per launch, this represents 360 hours of potential interruption in about two years of work over the yard.

The form traveler and its formwork are, from the risk point of view, analogous to any falsework once the traveler is tied down and is not being moved. Therefore, there is no perceived hazard to rail operations from placing rebar, pouring concrete or prestressing the segments.

A detailed schedule on pages 41 and 42 shows the various steps necessary to construct one complete cantilever, including its foundations.

In the Full Project Option, once the midspan connection is made, the center bridge can be used as access, the trestle can be removed and work on the north and south bridges can commence.

Light cranes will be necessary on the cantilevering deck to transport and place rebar and post-tensioning. Concrete delivery would be via pump along the deck from the piers to placing booms

at the form travelers. Materials would be delivered via the trestle or via the first bridge to be completed.

In the Staged Option there are some complications to consider, since the second and third bridges will have to be built while live traffic (to/from I-75) is on the adjacent bridge. This will slow down the work and make it more costly as compared to the Full Project Option.

2.2.5 Other Items

The high-tension line crossing the rail yard will have to be relocated (as with all options).

The western-most line (CSX Bypass Track - Track B) is shown to be relocated to the east as planned in the previous feasibility study. The relocation of Track B is necessary for the Construction of Pier C. Access from the east bank of the Mill Creek is needed to build Pier C.

The location of the southern bridge (Eastbound Local) infringes somewhat on the straddle crane turnaround at the north end of the intermodal yard, however. CSX has stated that the straddle cranes do not use this location to turn around. (See Appendix C2 – Cast-in-place – Alignment Plans)

Since deck replacement is not possible for this alternative, a CIP concrete overlay would be provided and is included in the cost estimate. It is anticipated that the overlay would need to be replaced about every 15 years throughout the service life of the bridge to protect the deck from deterioration. In the case of deck deterioration, a partial replacement of the deck may be possible. The upper 2" of the deck would be hydro-demolished and replaced with UHPC.

2.2.6 Schedule and Staging Considerations

The schedules presented are for "greenfield" working conditions (i.e. without consideration of the impacts from the rail yard). To the durations shown there has to be added an allowance for construction inefficiencies due to the "Railway Effect".

For this alternative, for the Full Project or Staged Option, the greenfield schedule shows a duration of 47 months. It is estimated that the Railway Effect will add another 6 months to this duration.

2.2.7 Interface with I-75

For the sake of completeness, it has been necessary to make some assumptions about the timing of the interface between WHV construction and the planned reconstruction of I-75. It is unclear at this time whether I-75 will go first, WHV will go first, or both will proceed together. This report has been based on the assumption that WHV will proceed to completion before I-75 is reconstructed. In this case it will be necessary to do some work on I-75 near the WHV in order to make the interchange work in the time period before the full reconstruction of I-75 is undertaken. This is discussed more fully in Section 3 of this report.

2.2.8 Items Specific to the Full Project Option

The Full Project option allows for shortened closures of both local and I-75 traffic access to the WHV, provided that existing I-75 can be closed for 30 hours (30 as an estimate, a full closure over a weekend will be required) to allow an accelerated regrading in the vicinity of the WHV. This then permits existing I-75 to pass below the new bridges. Local traffic closure is estimated at about 4 months.

Interruptions to I-75 access are varied. Estimated closure times are as follows:

- The off-ramp from I-75 SB need only be closed for about 2.5 months.
- The on-ramp to I-75 SB must be closed for about 27 months unless a temporary (and substandard) on-ramp is constructed which would shorten the closure by 23 months.
- The I-75 NB off-ramp must be closed for 11 months.
- The I-75 NB on-ramp must be closed for about 4 months.

The schedule for the Full Project Option includes consideration of measures at the I-75 interface that can be taken to reduce road closure times to a minimum and which are discussed in detail in Section 3. These include a suggested temporary on-ramp to I-75 SB, see page 133.

2.2.9 Items Specific to the Staged Option

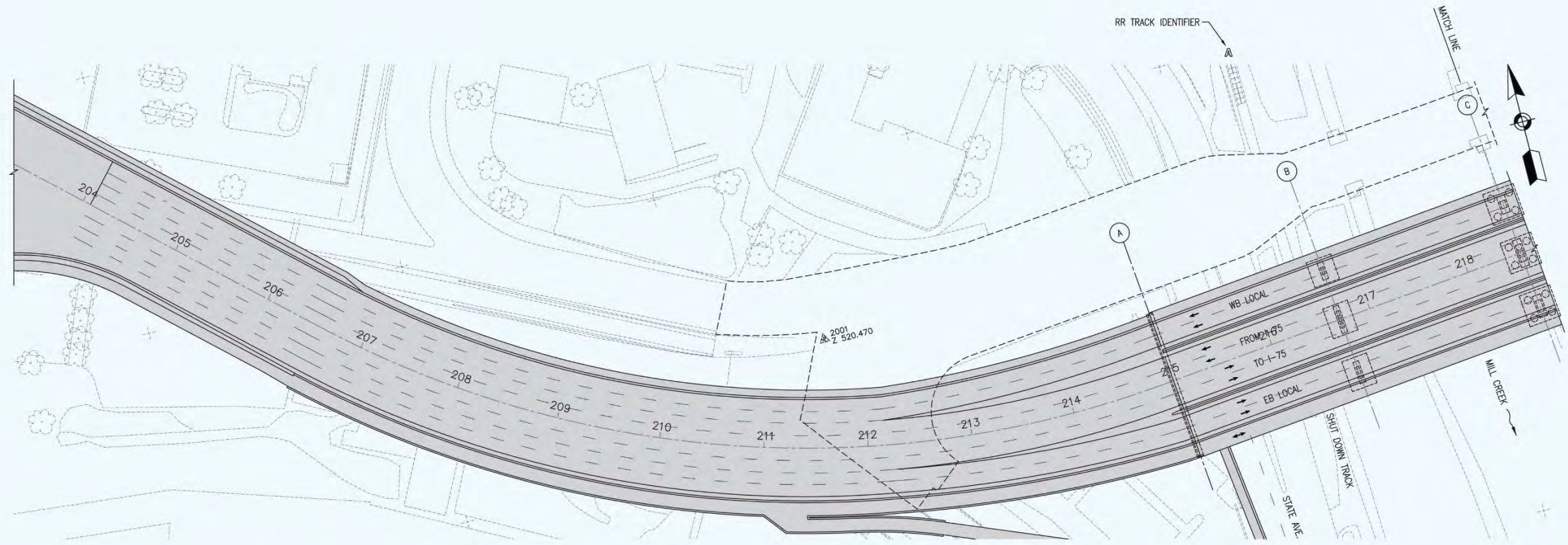
In the Staged Option it appears as if access to I-75 NB would be interrupted for about 9.5 months and access to I-75 SB on-ramp would be closed for a further 3.5 months. Local traffic would be interrupted for about 24 months total - one period of 4 months and a second period of 20 months.

In this option there would be a substantial premium cost associated with the Stage 2 work. Construction of the bridges through the rail yard will be hampered by the live traffic on the lower level (I-75) bridge and by the very restricted working space and access. Frequent night-time lane restrictions would be required on the I-75 traffic bridge to allow for material deliveries etc. In addition, it would be necessary to allow for a second mobilization and for a second construction of the work area at the west end.

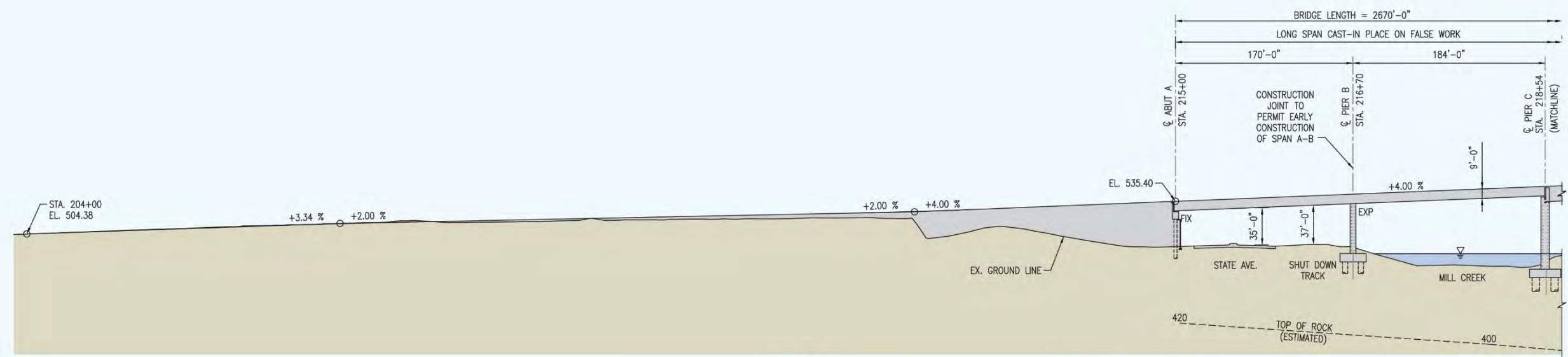
If a staged option is to be seriously considered, we recommend that a further detailed study of the matter be undertaken before committing to a staged construction.

The Staged Option scheduling is predicated on the staging details shown in Section 3. Following this methodology creates a situation where traffic closures are required for extended periods compared to the Full Project Option. It is conceivable that a different approach to the final geometry and to the staging sequence could reduce these closure times. However, it is premature to conclude such an outcome could be achieved. If the Staged Option is favored, then the possibility for such an improvement should be studied in more detail.

It appears that the workflow in this option can be adjusted such that there is little to no benefit to be achieved from implementing a temporary ramp connection to I-75 SB.



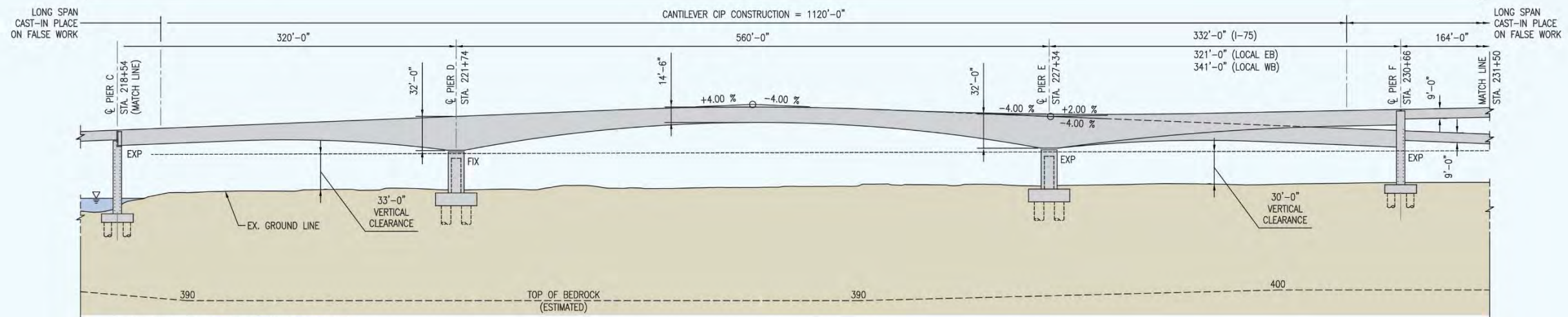
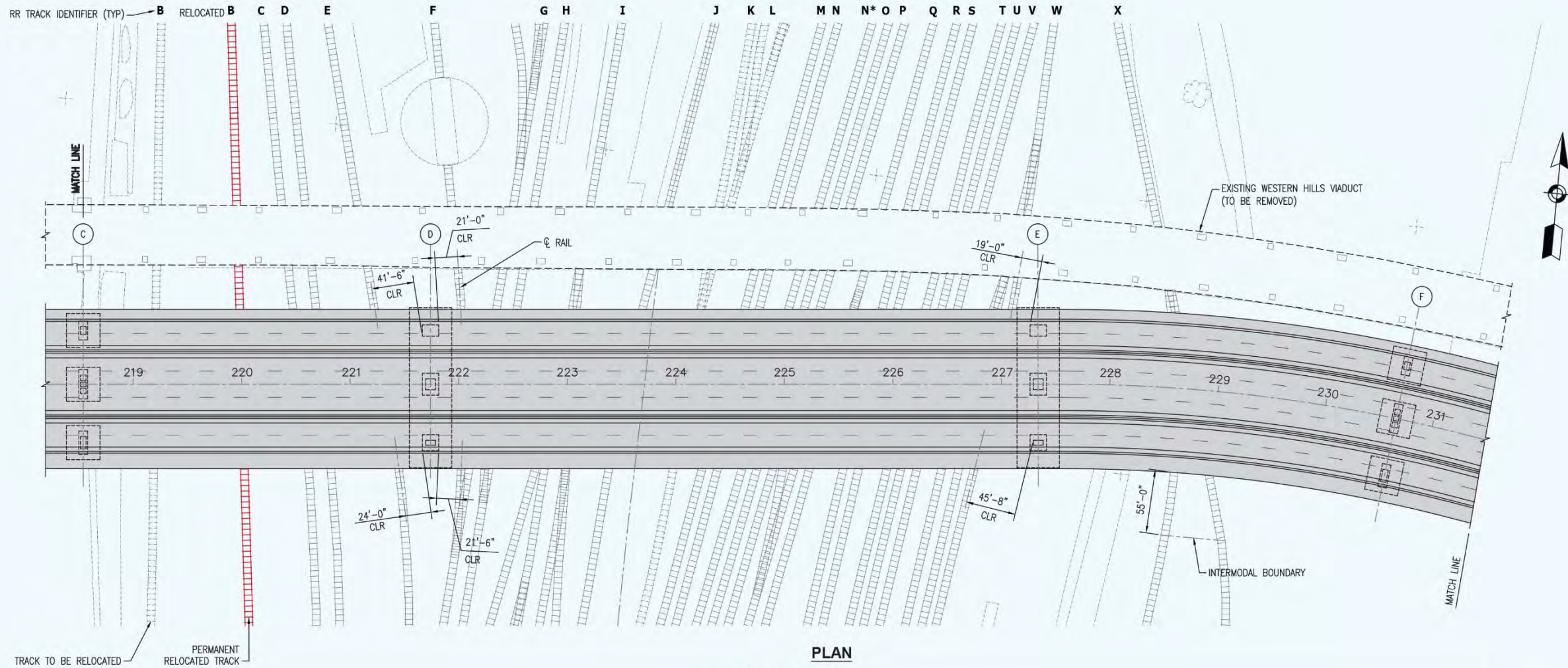
PLAN



PROFILE

NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

CIP Segmental
Site Plan 1 of 3



LEGEND - RR TRACK IDENTIFIER

- A - CSX (OUT OF SERVICE)
- B - CSX MAIN LINE
- C - CSX RECEIVING TRACK
- D - CSX RECEIVING TRACK
- E - CSX RECEIVING TRACK
- F - CSX LOCOMOTIVE TRACK

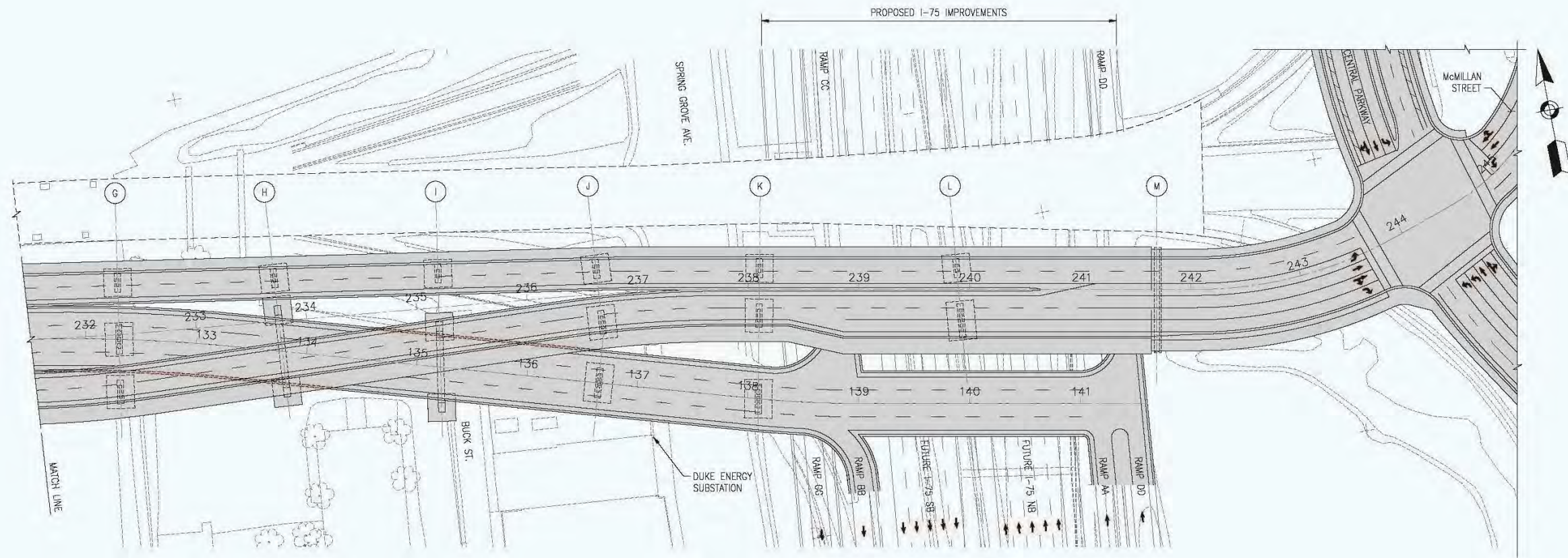
- G - CSX LOCOMOTIVE TRACK
- H - CSX WEST OPEN TRACK
- I - HUMP TRACK
- J - CSX EAST OPEN TRACK
- K - CSX BYPASS TRACK
- L - CSX SHORT DEPARTURE TRACKS (3)

- M - CSX LONG DEPARTURE TRACK
- N, N* - CSX LONG DEPARTURE TRACK
- O - NS TRACK
- P - NS TRACK
- Q - NS TRACK
- R - CSX MAIN LINE

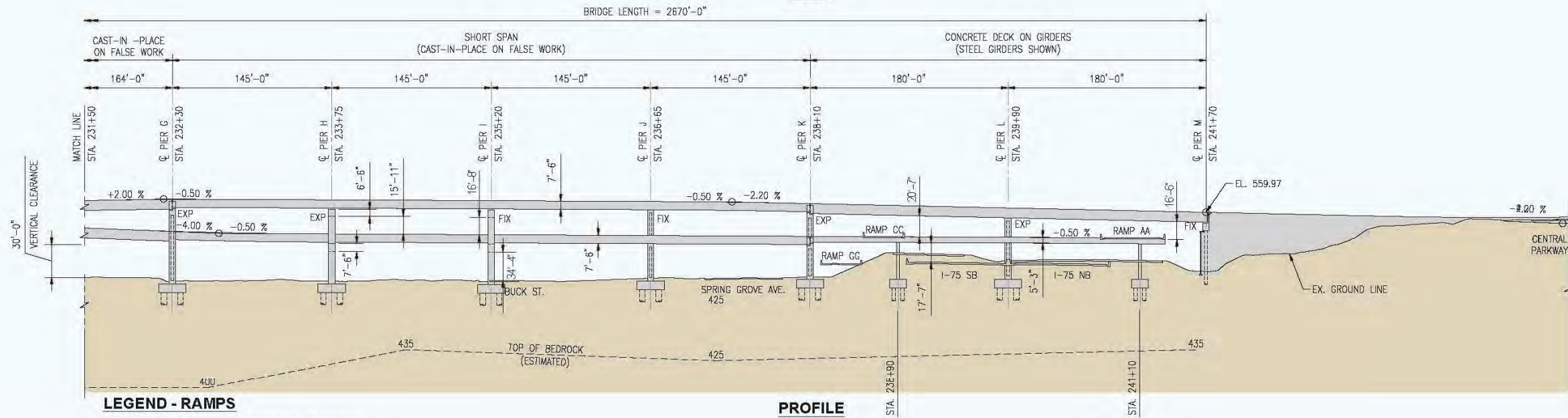
PROFILE

- S - CSX MAIN LINE
- T - CSX RAMP TRACK
- U - CSX RAMP TRACK
- V - CSX RAMP TRACK
- W - INTERMODAL TRACK
- X - GANTRY CRANE TRACK

CIP Segmental
Site Plan 2 of 3



PLAN

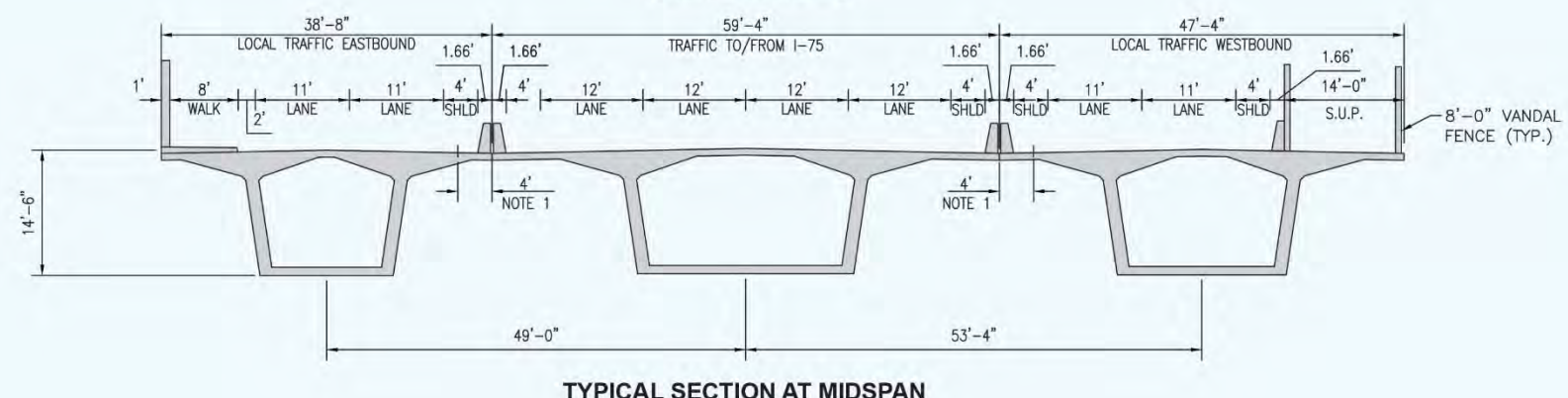
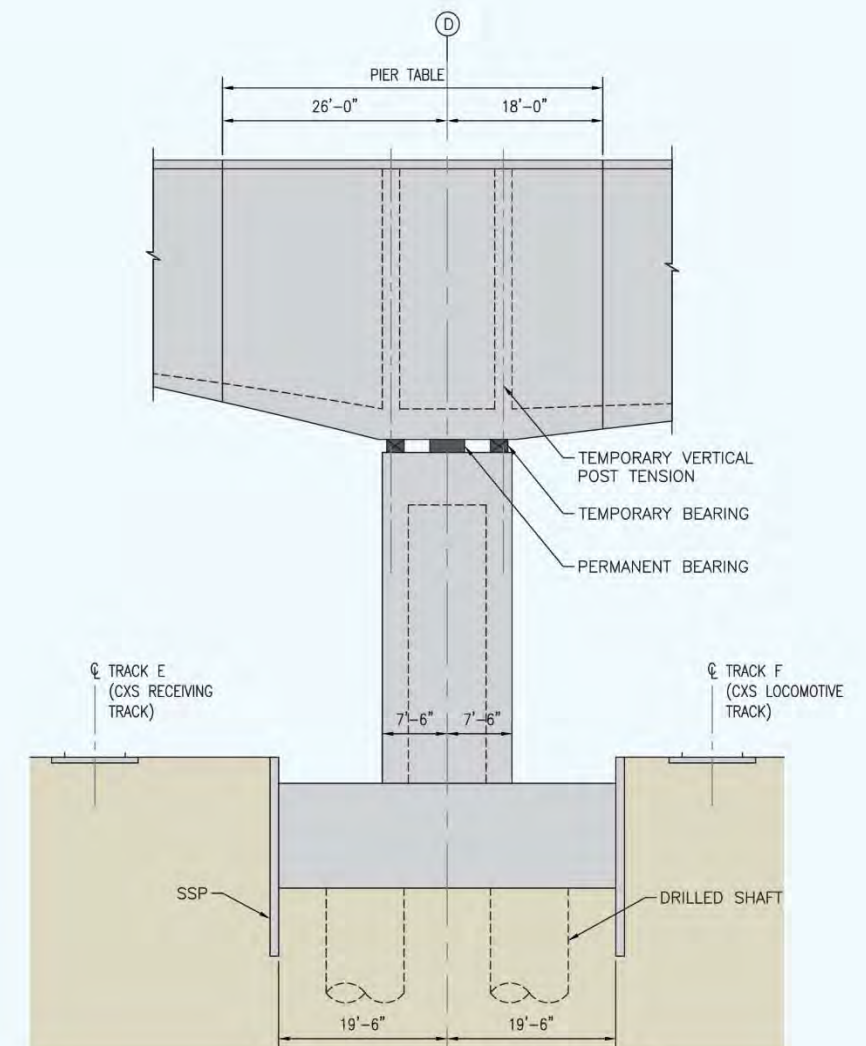
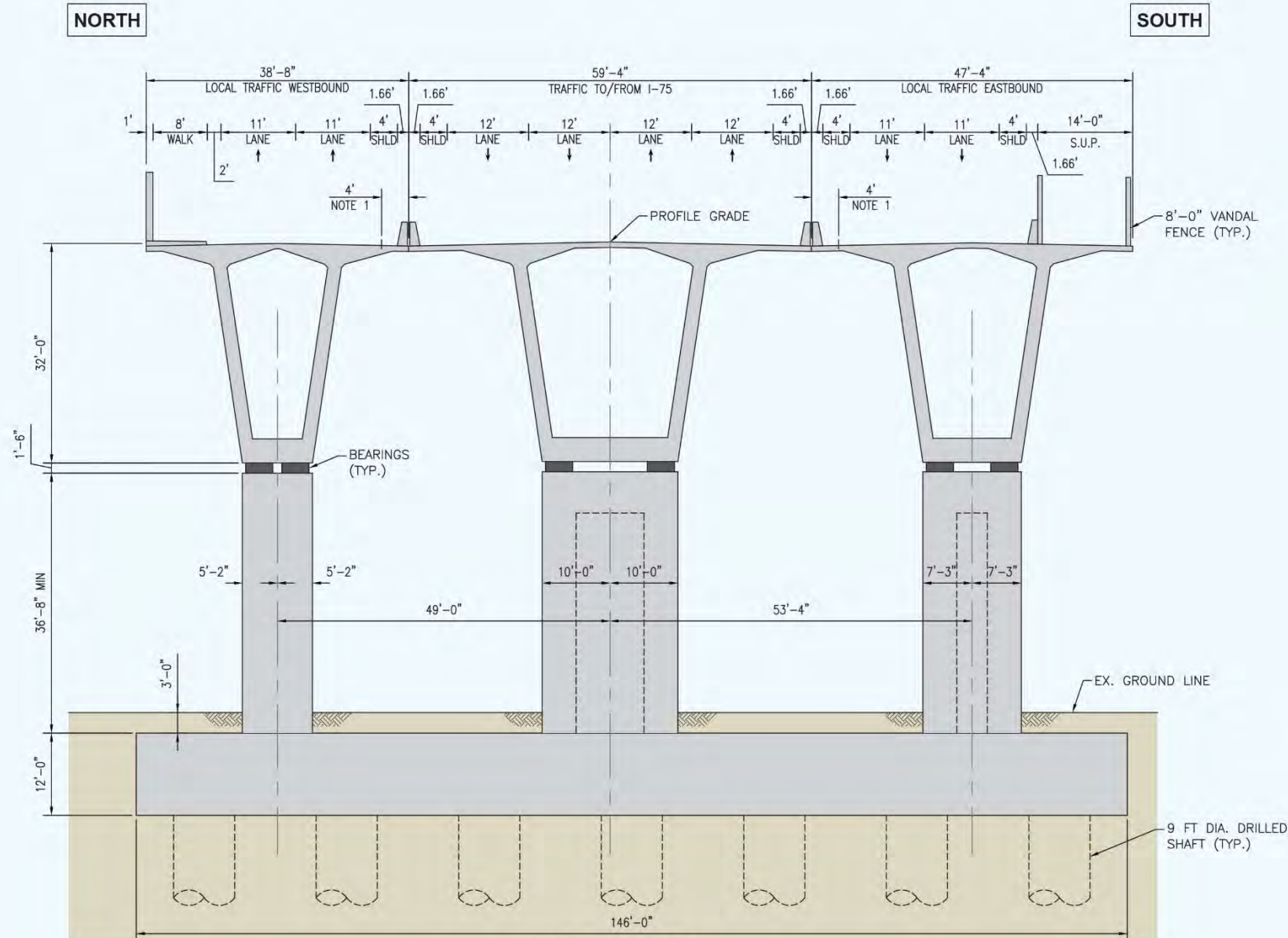


PROFILE

LEGEND - RAMPS

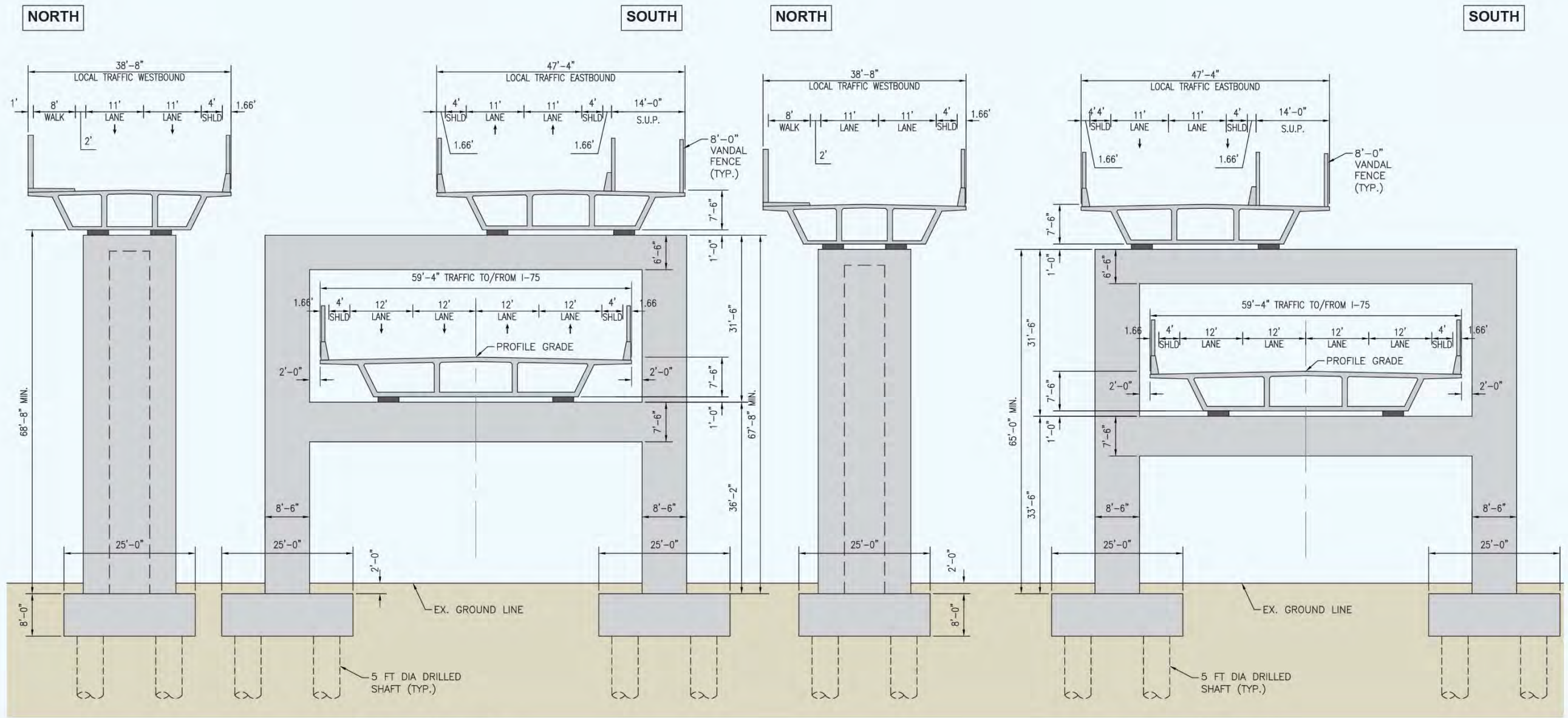
- RAMP AA - FUTURE RAMP TO/FROM I-75 NB/WHV
- RAMP DD - FUTURE RAMP FROM BANK STREET
- RAMP BB - FUTURE RAMP TO/FROM I-75 SB/WHV
- RAMP GG - FUTURE RAMP TO FINDLAY STREET

CIP Segmental
Site Plan 3 of 3



NOTE:
1. APPROXIMATE 4' OF DECK OVERHUNG TO BE OMITTED DURING CONSTRUCTION OF THE LOCAL BRIDGES TO ACCOMMODATE SUSPENSION OF THE FORM TRAVELERS POUR THESE PORTIONS OF THE DECK AFTER CANTILEVER CONSTRUCTION IS COMPLETE.

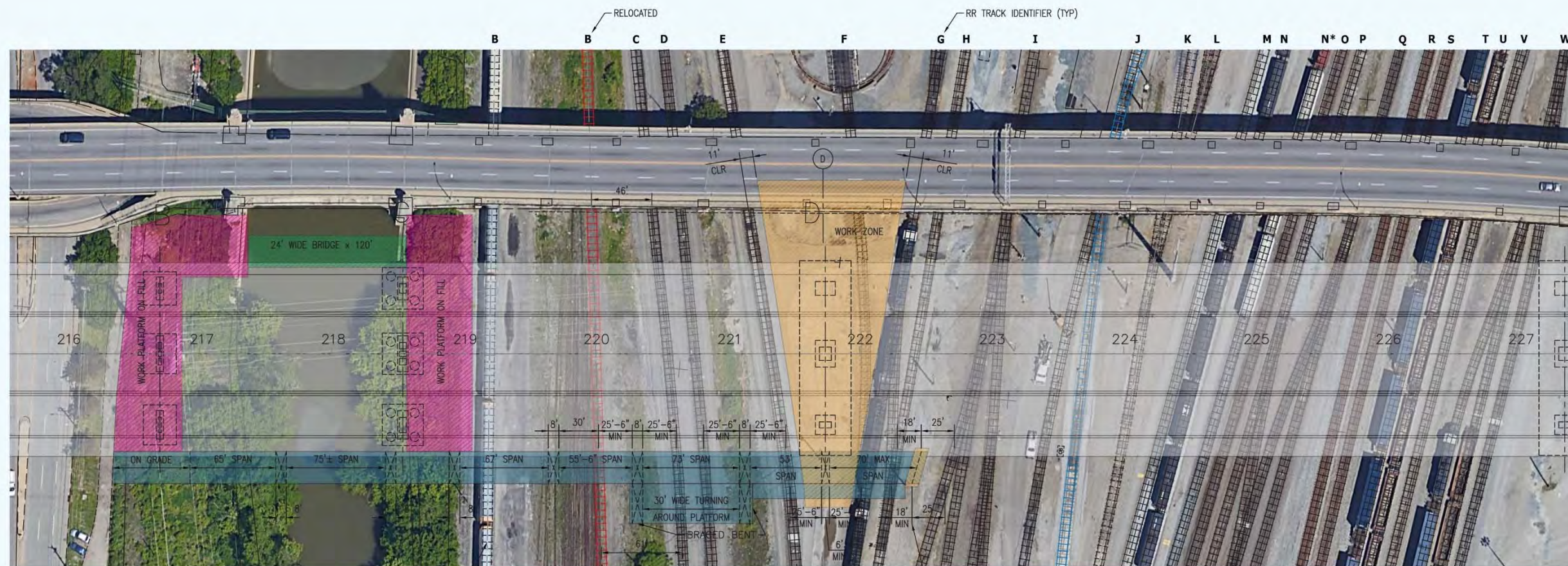
**CIP Segmental
Typical Sections 1 of 2**



SECTION AT PIER H

SECTION AT PIER I

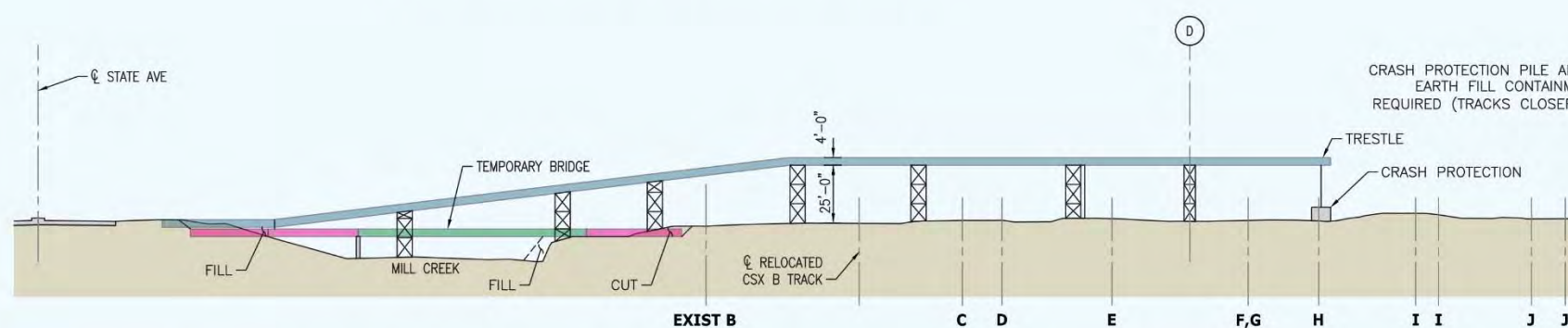
CIP Segmental
Typical Sections 2 of 2



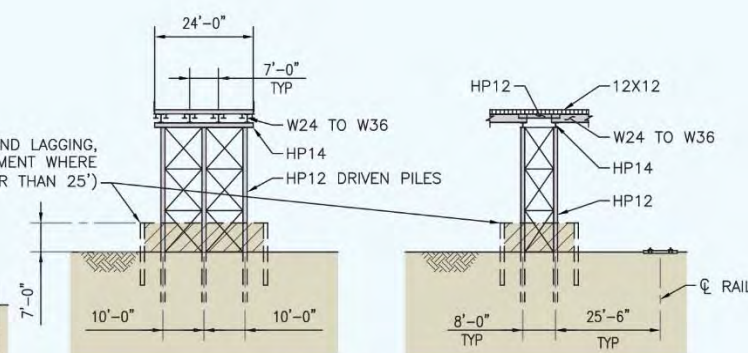
TO BE TAKEN OUT OF SERVICE BEFORE CONSTRUCTION BEGINS
RELOCATED CSX TRACK
CRASH PROTECTION REQUIRED AT THIS BENT ONLY

TRESTLE PLAN

RAILROAD HORIZONTAL CLEARANCE REQUIREMENT:
DURING CONSTRUCTION = 10'-0" MIN. MEASURED FROM C TRACK



TRESTLE ELEVATION



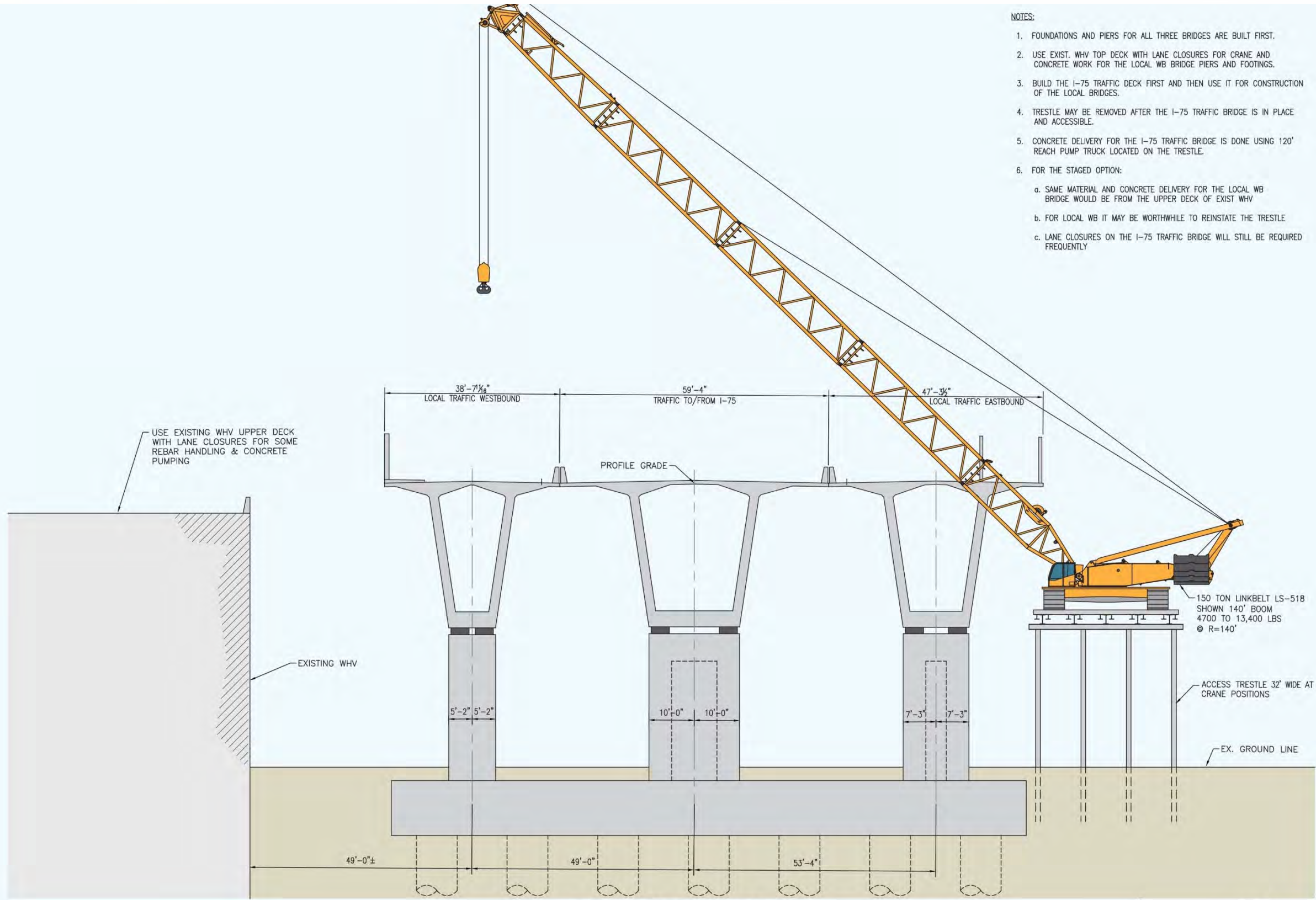
TRESTLE SUPPORT DETAILS

LEGEND - RR TRACK IDENTIFIER

- | | | |
|--------------------------|------------------------------------|------------------------|
| A - CSX (OUT OF SERVICE) | I - HUMP TRACK | Q - NS TRACK |
| B - CSX MAIN LINE | J - CSX EAST OPEN TRACK | R - CSX MAIN LINE |
| C - CSX RECEIVING TRACK | K - CSX BYPASS TRACK | S - CSX MAIN LINE |
| D - CSX RECEIVING TRACK | L - CSX SHORT DEPARTURE TRACKS (3) | T - CSX RAMP TRACK |
| E - CSX RECEIVING TRACK | M - CSX LONG DEPARTURE TRACK | U - CSX RAMP TRACK |
| F - CSX LOCOMOTIVE TRACK | N, N* - CSX LONG DEPARTURE TRACK | V - CSX RAMP TRACK |
| G - CSX LOCOMOTIVE TRACK | O - NS TRACK | W - INTERMODAL TRACK |
| H - CSX WEST OPEN TRACK | P - NS TRACK | X - GANTRY CRANE TRACK |

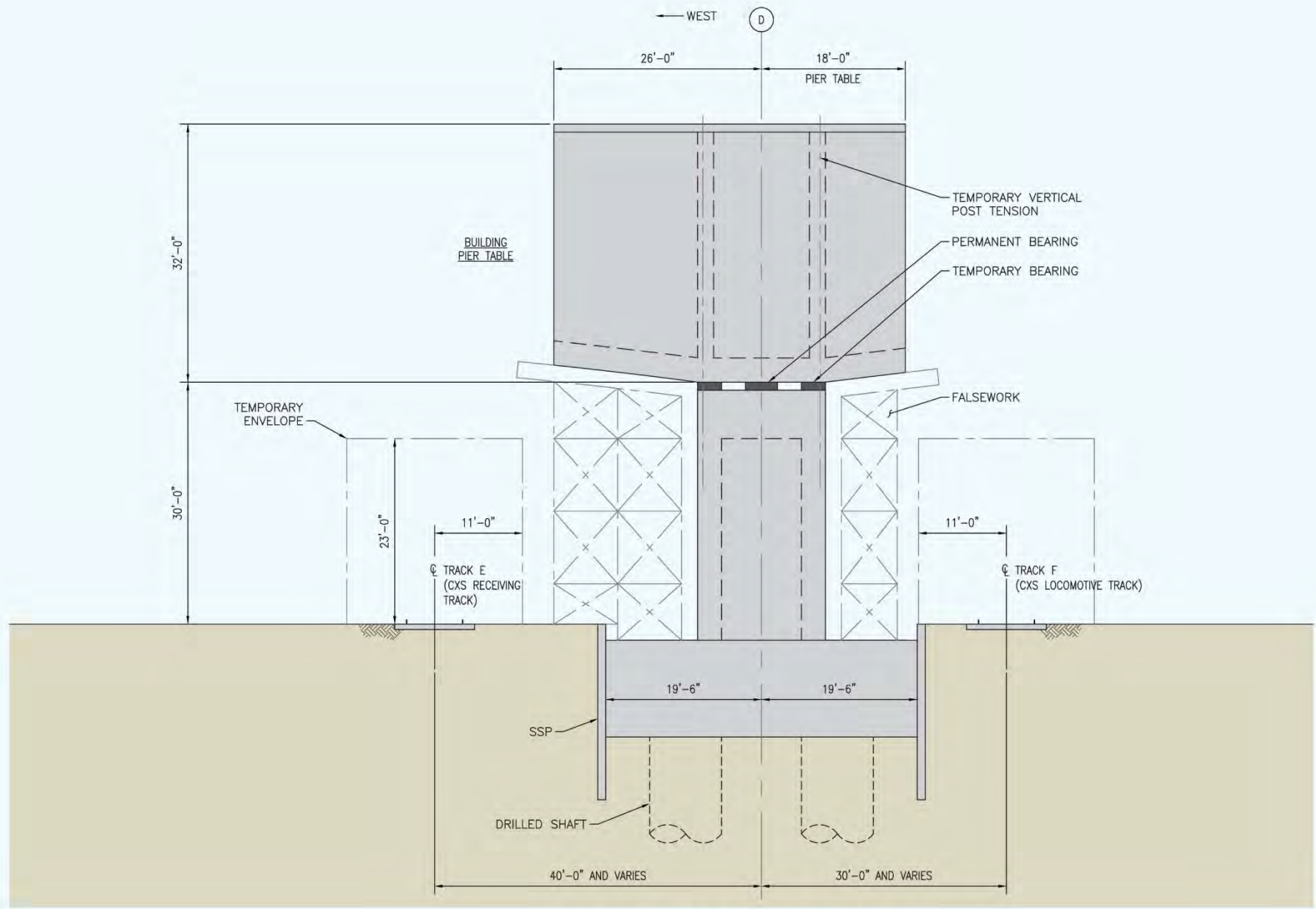
CIP Segmental
Construction 1 of 4

- NOTES:
1. FOUNDATIONS AND PIERS FOR ALL THREE BRIDGES ARE BUILT FIRST.
 2. USE EXIST. WHV TOP DECK WITH LANE CLOSURES FOR CRANE AND CONCRETE WORK FOR THE LOCAL WB BRIDGE PIERS AND FOOTINGS.
 3. BUILD THE I-75 TRAFFIC DECK FIRST AND THEN USE IT FOR CONSTRUCTION OF THE LOCAL BRIDGES.
 4. TRESTLE MAY BE REMOVED AFTER THE I-75 TRAFFIC BRIDGE IS IN PLACE AND ACCESSIBLE.
 5. CONCRETE DELIVERY FOR THE I-75 TRAFFIC BRIDGE IS DONE USING 120' REACH PUMP TRUCK LOCATED ON THE TRESTLE.
 6. FOR THE STAGED OPTION:
 - a. SAME MATERIAL AND CONCRETE DELIVERY FOR THE LOCAL WB BRIDGE WOULD BE FROM THE UPPER DECK OF EXIST WHV
 - b. FOR LOCAL WB IT MAY BE WORTHWHILE TO REINSTATE THE TRESTLE
 - c. LANE CLOSURES ON THE I-75 TRAFFIC BRIDGE WILL STILL BE REQUIRED FREQUENTLY



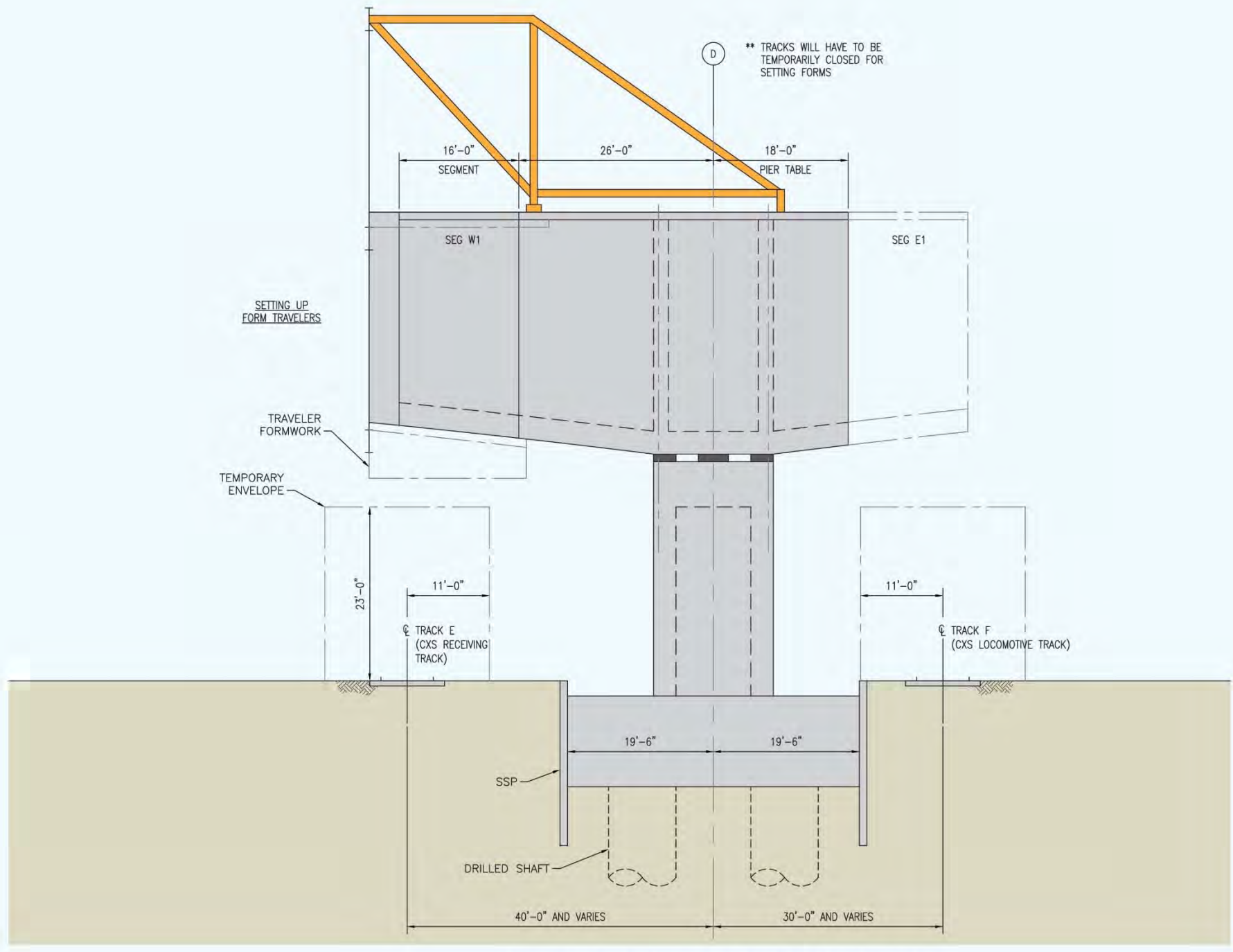
TYPICAL SECTION AT PIER - (PIERS D AND E)

CIP Segmental
Construction 2 of 4



(BUILDING PIER TABLE)
SECTION AT PIER D

CIP Segmental
Construction 3 of 4



ERECTION OF FIRST TRAVELER & FIRST SEGMENT
SECTION AT PIER D

CIP Segmental
Construction 4 of 4

2.3 Parallel Twin Arches

2.3.1 Introduction

For this alternative, the main portion of the bridge comprises two parallel 770-ft long tied arches that span the most active part of the railyard. The superstructure in the main spans and the approaches consists of steel framing with a composite concrete deck which is cast-in-place. The bridge substructure is concrete.

For the main arch spans, the steel structure is built off the alignment away from the rail yard. It is relatively light and can be easily transported across the rail yard and lifted and positioned in place on its piers in a single shift for each arch. Once both arch spans are set on the piers there will be no further interference with rail yard operations during forming, pouring and stripping the concrete deck. Stay in place metal formwork would eliminate the need to strip the formwork after the bridge is completed. The "Railway Premium" that must be added to the basic construction cost to account for construction delays due to railway operations is condensed to a short duration and is therefore minimized.

The ends of each arch are tied together to cancel horizontal thrust. The proposed arch ties rely on prestressing, so the ties always remain in compression, and fracture critical issues are thereby avoided. Prestressing of steel arch ties is not typically done in the USA so the concept may encounter some extra scrutiny from reviewing and funding agencies. However, the concept has been used successfully elsewhere and the principles and construction techniques are sound. We find there to be no negative issues with this concept.

An arch with an all concrete deck structure, which is prestressed longitudinally to resist the arch tie force, was also considered but was rejected. Construction would be slower and the weight that would have to be carried across the railyard would be over double the carry-in weight of the structure selected. Even at this much higher weight, the carry-in concept would still be feasible. Therefore, the concept of a concrete deck and tie-beam could be revisited if desired.

The arch alternative is not well suited to a staged approach, in which the I-75 connection is built first under one contract and the local traffic connections are built later, under another contract. It could be done, but at a significant cost premium. The staged approach would only be considered if it were important to start work before full funding for the project becomes available. The reasons why the arches are not suited to a staged approach are:

- The arch construction and transportation require considerable special engineering, equipment and purpose-built material. Staging the project would essentially amount to buying those items twice.
- Staging must have a temporary traffic weave at the east end of the arches which requires that some additional structure, not required in the final configuration, be built.

Accordingly, a staged option for the parallel twin arches alternatives has not been developed at this time.

2.3.2 Traffic and Alignment Considerations

It has been established that traffic management works better at the west end of the project if all four westbound lanes arrive beside each other, i.e., on the same bridge, and the four eastbound lanes are similarly grouped. In order to achieve this configuration, it is necessary to start to separate the I-75 traffic from the local traffic immediately to the east of the two arches, a location where space is somewhat limited.

The parallel twin arch bridges are wider than most of the other alternatives considered because the arch ribs require additional space on the edges of each bridge. However, this condition has the advantage of creating more lateral room to achieve the vertical separation necessary to allow the traffic crossover and makes it possible to do this within the limited space available.

Plan, profile, and elevation drawings are shown on pages 48 through 50. Cross sections for the arch spans and the approach spans are shown on pages 51 through 55. (See Appendix C3: Parallel Twin Arches – Alignment Plans)

The alignment considered has two parallel arches of 770 feet span, both at the same elevation, over the rail yard. One arch carries all eastbound traffic while the other carries all westbound traffic. A structure cross-over at the east end of the arches allows the upper and lower level traffic to be merged (westbound) or separated (eastbound), all to the east of the arches. Once on the arches, the traffic has a very long distance to weave as necessary to organize itself into the correct lanes for the different destinations at the west end.

In order to achieve the vertical separation required for the east-end structure cross-over it is necessary to use shallow depth, and therefore short span, structures everywhere to the east of the arch span. The use of steel plate girders is recommended.

We had previously found that the Duke Energy substation could be left where it is, undisturbed, and the new WHV threaded to the north of the Duke property as a double deck structure. However, it now appears that Duke Energy will be relocating and so more room is available for the new viaduct at this location. Separating the local traffic bridge from the I-75 traffic bridge is desirable from the traffic point of view, and from the I-75 profile point of view. Accordingly, we have revised the location of the I-75 traffic bridge over I-75 to take advantage of this opportunity.

The high-tension line crossing the rail yard will have to be relocated (as with all options).

The Shared Use Path is located on the south side of the new bridges.

2.3.3 Commentary Regarding the Structure

This study is based on using long span arches (770 feet) that span completely over the busy part of the rail yard and that do not require any permanent work on the ground in this portion of the yard except for the two, short, full-yard closures described below. These two closures are necessary to allow the steel skeletons of the arch spans to be carried out and installed on their piers.

The arch hanger pattern selected is a network arch pattern. In this pattern the hangers are not vertical, but rather cross each other in a "network" pattern. Network arches provide considerable

additional stiffening to the arch rib compared to traditional arches with only vertical hangers. As well, the network pattern significantly reduces the bending moments in the arch tie beams. Both of these effects result in savings in material and improvements in performance.

An arch is not the natural choice for a location like this because many of the possible arch construction techniques would be very disruptive to operations in the rail yard. However, we have determined that it is possible to assemble the steel skeletons of the two arch spans off the final alignment, and then to transport them to their final locations using SPMTs (Self Propelled Motorized Transporters). Once the steel structures are set in place, construction of the concrete deck can be completed using conventional forming techniques working exclusively from above.

The actual transportation into place of the steel skeleton of the arch spans requires a complete shut-down of yard operations for no more than 12 hours for each arch (24 hours total), but with careful planning and controls set in place, the duration of the shutdowns would be of the order of only 4 hours. The use of the maintenance traveler rails to carry a forming/stripping traveler during deck construction makes all subsequent activities independent of rail operations.

The transportable structure considered comprises steel arch ribs, a steel tie beams, steel floor beams and stringers. A conventional 8½" thick concrete deck is then poured on the steel framing once the arch steel skeleton is put into place. The arch ties are longitudinally post-tensioned sufficiently that the structural steel part of the tie is never in significant tension. This removes fracture-critical issues from consideration and also allows for simpler detailing because fatigue detailing considerations become of little consequence.

The post-tensioning is "external", i.e., not bonded to the steel rib section. Strands are carried in smooth plastic ducts for the length of the tie-beam and anchored at each arch springing. The plastic ducts are grouted after stressing to prevent corrosion. Each post-tensioning cable can therefore be easily removed and replaced should the need arise in the future.

The arch ribs are leaned toward each other for aesthetic reasons and to reduce bracing weight. It is not practical to use unbraced arch ribs for this project given the arch span length.

Should this alternative, or any steel option, advance further in the design development process it is recommended that a cost-benefit study be done relating to the use of metalizing, rather than painting, the exterior surfaces to reduce life-cycle costs from repainting. There is some credible evidence that metalizing of weathering steel, though initially costlier, is in fact more economical in the long run for structures that are intended to have a long service life.

Because this is a steel bridge it will be necessary to provide a maintenance traveler to allow for inspection and painting without disrupting rail yard operations.

A preliminary estimate of the weight of structural steel in each arch is as follows:

- Arch ribs and arch ties 3650 tons per bridge
- Deck and Floor beam structure 1250 tons per bridge
- Miscellaneous steel 300 tons per bridge

- Total 5200 tons per bridge

There are 2 bridges.

The concrete deck would be placed in several individual pours. Deck forming would be conventional and would use small formwork elements; it will not inhibit rail yard operations. The maintenance traveler, or a construction traveler, would be used for stripping the formwork and would also serve to protect the rail yard from falling debris.

For the east approaches in this option it is necessary to use shallow depth structures and consequently, short spans. Steel plate girders are the natural choice. Trapezoidal steel boxes (tubs) could also be used, though these would be more costly.

2.3.4 Construction Considerations

With regard to the SPMT (Self Propelled Motorized Transporters) transport equipment, the weight to be carried for the steel structure is not large - about 3,000 US tons. The maximum weight that has been transported as one load on SPMTs is of the order of 13,000 US tons. What is somewhat unusual for this project are the geometric constraints from two parallel bridges being closely spaced and also the presence of the existing viaduct nearby. These constraints will dictate a compact arrangement of the transporters. The arch span steel structure can be made to be carried at points about 50 feet inboard of each springing, so the SPMTs can be connected together at each end and precise coordination and control of individual SPMTs during transportation is not required. Figure 5 shows an arch of similar weight being transported as a complete finished unit. Figure 6 shows an arch bridge being carried into place over rail lines. Figure 7 shows a typical, 6 axle configuration, SPMT. The proposed carrying arrangement, and the arch reinforcement required to permit this, are shown schematically on page 57.



Figure 5: A Completed Arch Bridge being transported on SPMT's



Figure 6: An Arch Bridge being transported over rail lines on SPMT's



Figure 7: Six (6) Line SPMT

The possibility of building the complete arch span, including the concrete deck, off the alignment and then transporting the completed structure to its final location has also been considered. At an estimated weight of 7,000 US tons this is also a plausible approach.

The actual transport movement proceeds at a slow walking pace (0.3 miles per hour), hence, theoretically only an hour would be required to make the move for each arch span. However, there are many potential complications requiring extra care, and other potential problems that could slow progress, so planning for a shut-down of yard operations for a longer period for each arch delivery should be considered when planning the work.

Pages 58 and 59 show the two possibilities considered for the arch assembly area and the transport path for the move. One path swings the south end of the arch across the rail yard while the second option foresees an orthogonal delivery path – eastwards and then directly north. The orthogonal approach shown on page 65 has the disadvantage that it would require a substantial temporary bridge over Mill Creek to carry the full weight of one end of each arch and would also require a road closure in the assembly area. For the option which involves swinging the south end on the arch. Extensive retained earthwork adjacent to Mill Creek is required as well as the construction of a temporary access bridge over Mill Creek as indicated on page 59.

In the transport path it will be necessary to more or less level out the ground so that the SPMTs do not have to climb abruptly over rails. This can be done with compacted granular fill between rail lines and laying 8” timber on the ties between rails. Detailed consultation with heavy transport contractors who are familiar with SPMT use may determine that there are easier ways to achieve a delivery runway – wedges that allow the SPMTs to climb over the rails for instance.

An issue with transportation via SPMTs is that there are a number of switches that lie within the transport path. We have determined that it is possible to steer the transportation around most of the switches so that it is not necessary to remove any switchgear for the transportation of the arches. One possible exception is a switch on Track W close to the existing WHV. Switch gear may have to be removed at this one location, but only for the delivery of the northern arch.

2.3.5 Work Within the Rail Yard

The pier construction would require a trestle similar to other alternatives and construction of the trestle itself will be subject to considerable disruption from rail operations. The parallel twin arches alternative has only one significant impact on the rail yard operation. All operations in the rail yard, including at the northern end of the intermodal yard, would need to be suspended and all trains cleared out while each of the arch spans are transported into place. It is advisable to allow up to a twelve-hour shutdown for the radial swing delivery (see page 59) and a six-hour shutdown for the orthogonal delivery (see page 58) for each of the two arch spans, although it is probable either could be completed in less time. The cost estimate provided is for the former which is preferred due to a simplified delivery path, minimized interaction with the railroad yard operations during arch erection, and minimized area required for railroad yard clearing prior to delivery.

We have been informed by CSX that any full closure of the yard, even for just a short 12-hour period, would generally be difficult to arrange and would be unwelcome. The exceptions to this would be on Thanksgiving Day and on Christmas Day, when yard activity is already nearly zero and a complete shutdown would not be onerous. Having only two possible days a year to make the move represents a severe restriction on the contractor. Missing a window could delay the project. However, it seems reasonable to assume that there is a price for which the railroads would be willing to arrange a shutdown on some other date. In our opinion, it is feasible to work the project around these two possible holiday dates for the deliveries of the arch spans, but it is advisable to request the railroads plan for a contingency date for a shutdown to avoid a long project delay in the event there is a problem which precludes the originally planned date.

In addition, if the orthogonal delivery method is used for transporting the arch spans into position on the pier, it would be possible to perform the transport in two movements, temporarily stopping the delivery about halfway when the SPMT carrying the east end of the arch span is between tracks J and K. This extra step would allow rail operations in the eastern half of the yard to continue during the initial transport movement, thus reducing the duration of the shutdown.

As noted in a previous section, there are a number of switches on the delivery path which must be avoided by the SPMTs during transport. With one possible exception, the switches can be avoided. Switchgear might have to be temporarily removed at one switch only for the first carryout.

The location of the southern bridge (Eastbound Local) infringes somewhat on the straddle crane turnaround at the north end of the intermodal yard. We have been informed by CSX that the straddle cranes do not use this location to turn around. See Alignment Plans on Pages 48 through 50.

The CSX through track on the west side of the yard is to be relocated to allow free access to the west pier (Pier C) area.

2.3.6 Scheduling

A preliminary construction schedule for this alternative is attached as page 60.

The schedules presented are for "greenfield" working conditions (i.e. without consideration of the impacts from the rail yard). To the durations shown there has to be added an allowance for construction inefficiencies due to the "Railway Effect".

For this alternative, for the "Full Project" option, the greenfield schedule shows a duration on 46 months. It is estimated that the Railway Effect will add another 6 months to this duration provided that the carryout windows can be met.

2.3.7 Interface with I-75

For the sake of completeness, it has been necessary to make some assumptions about the timing of the interface between WHV construction and the planned reconstruction of I-75. It is unclear at this time whether I-75 will go first, WHV will go first, or both will proceed together. This report has been based on the assumption that WHV will proceed to completion before I-75 is reconstructed. In this case it will be necessary to do some work on I-75 near the WHV in order to make the interchange work in the time period before the full reconstruction of I-75 is undertaken. This is discussed more fully in Section 3 of this report.

2.3.8 Items Specific to the Full Project Option

The Full Project option allows for shortened closures of both local and I-75 traffic access to the WHV, provided that existing I-75 can be closed for 30 hours to allow an accelerated regrading in the vicinity of the WHV. This then permits existing I-75 to pass below the new bridges. Local traffic closure is estimated at about 4 months.

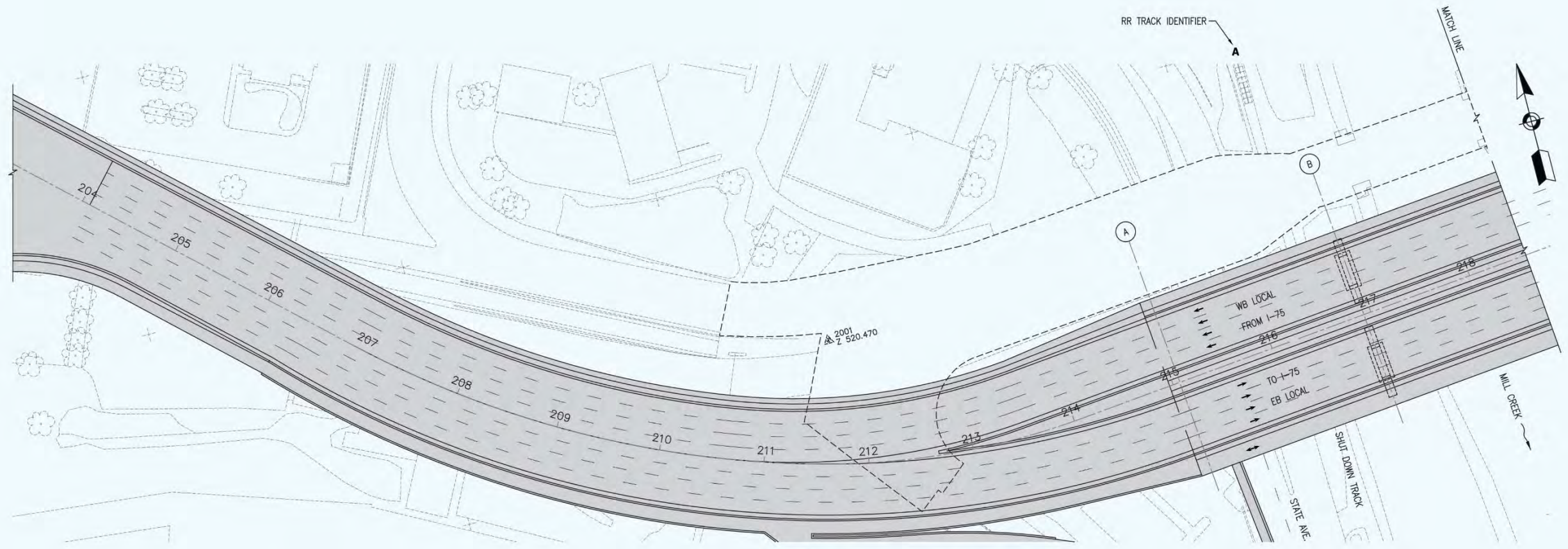
Interruptions to I-75 access are expected to vary from about 4 months (I-75 NB on-ramp) to about 12 months (I-75 NB off-ramp). The I-75 SB on-ramp movement would need to be closed 21 months unless a temporary on ramp is built. This temporary on-ramp would reduce the total closure of this movement from 21 months to 6 months.

The Full Project option will be the most economical option if sufficient funding is available to construct the entire project at once.

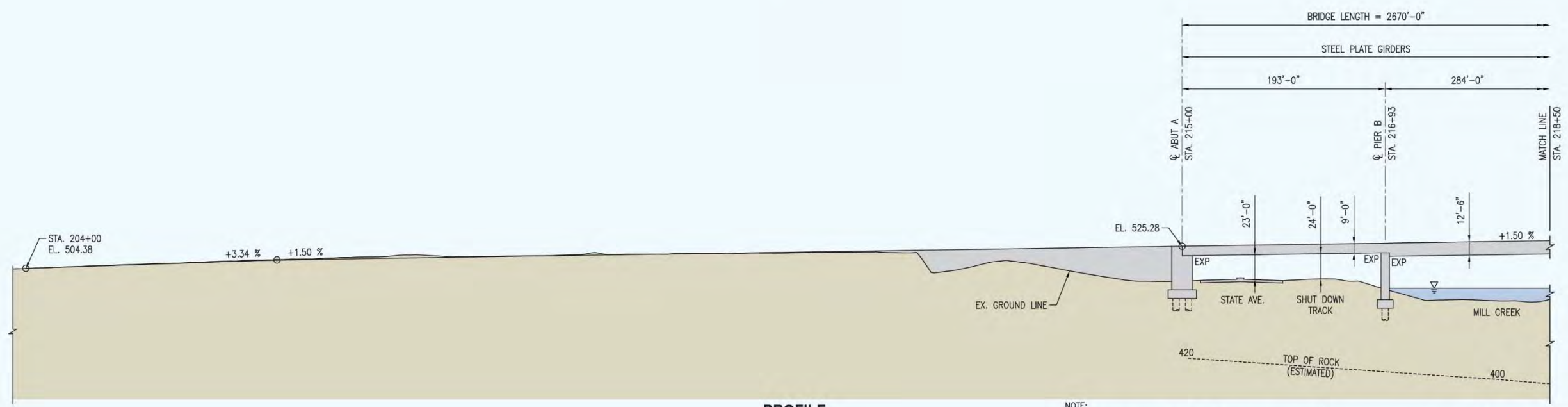
2.3.9 Items Specific to the Staged Option

As explained elsewhere, it appears that attempting to stage this alternative would attract a very large cost penalty associated with the parallel twin arch span construction. We have not, therefore, developed any scheduling for a staged option for the twin arch alternative.

If there is serious interest in a staged option, this could be examined in more detail and a more reasoned estimate of cost and time penalties can be generated.



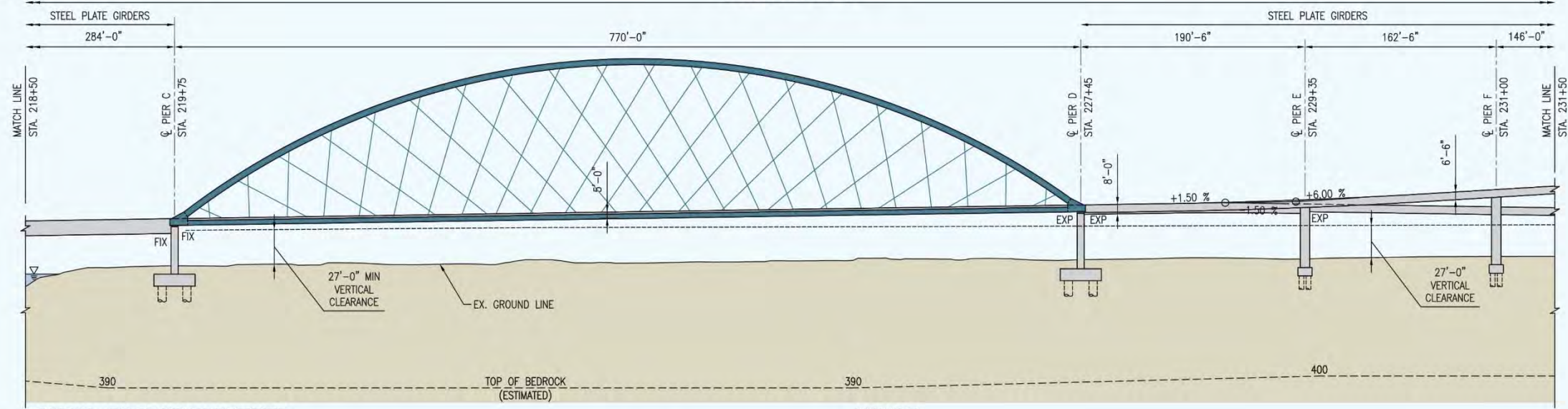
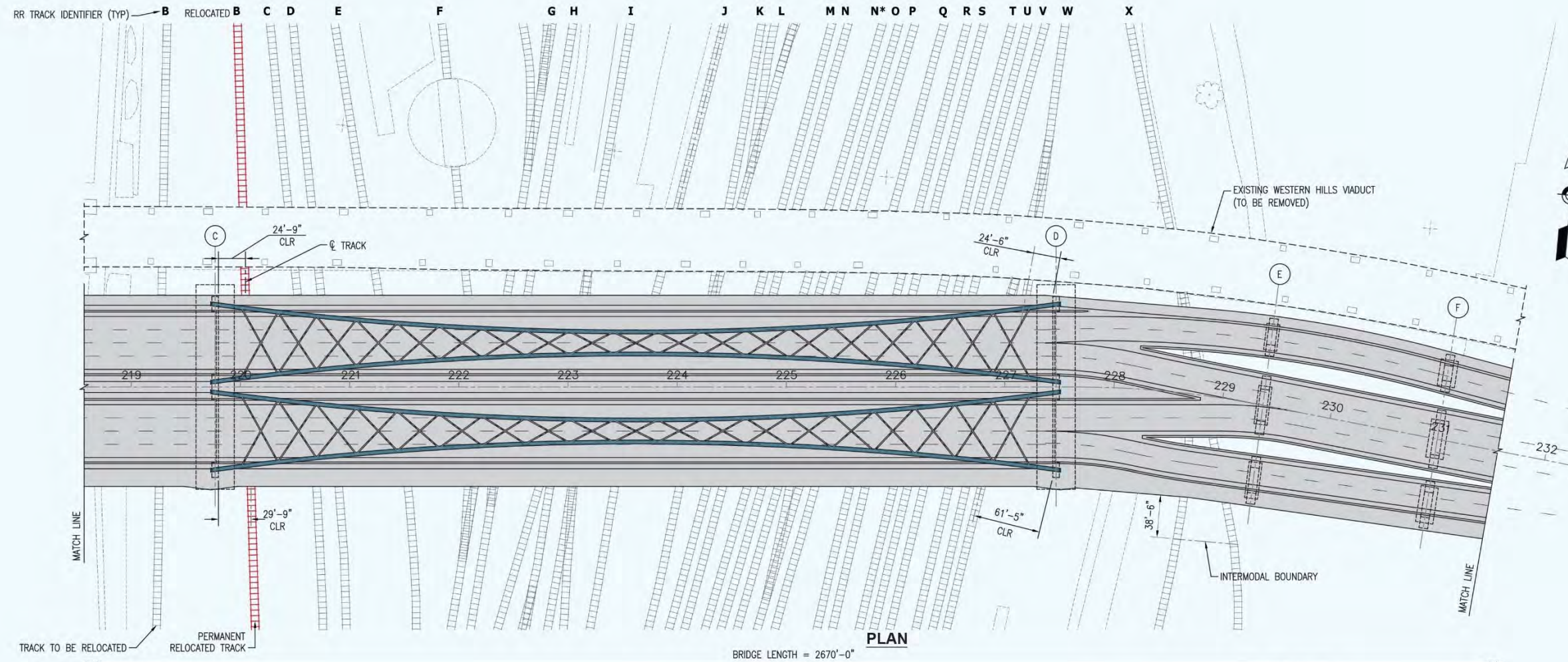
PLAN



PROFILE

NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

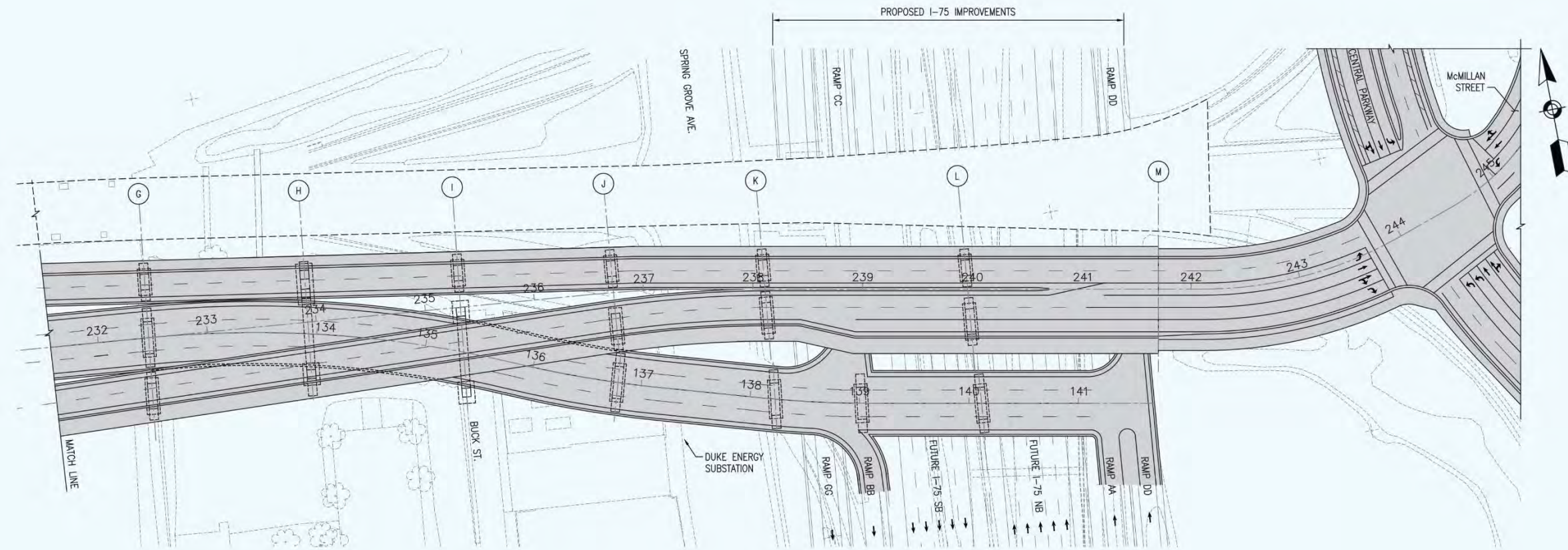
**Parallel Twin Arch
Site Plan 1 of 3**



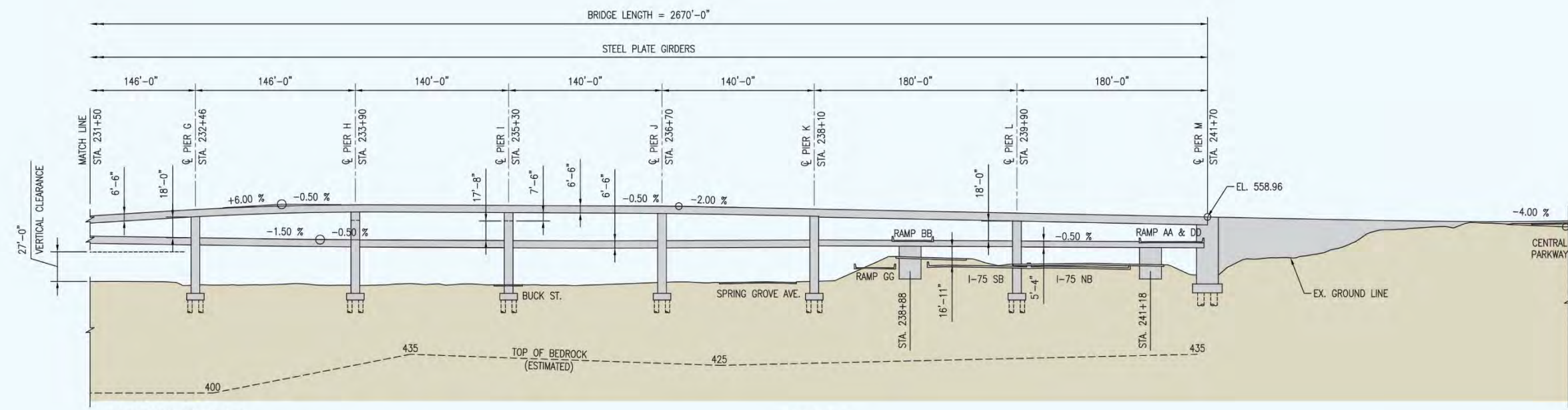
LEGEND - RR TRACK IDENTIFIER

A - CSX (OUT OF SERVICE)	G - CSX LOCOMOTIVE TRACK	M - CSX LONG DEPARTURE TRACK	S - CSX MAIN LINE
B - CSX MAIN LINE	H - CSX WEST OPEN TRACK	N, N* - CSX LONG DEPARTURE TRACK	T - CSX RAMP TRACK
C - CSX RECEIVING TRACK	I - HUMP TRACK	O - NS TRACK	U - CSX RAMP TRACK
D - CSX RECEIVING TRACK	J - CSX EAST OPEN TRACK	P - NS TRACK	V - CSX RAMP TRACK
E - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	Q - NS TRACK	W - INTERMODAL TRACK
F - CSX LOCOMOTIVE TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	R - CSX MAIN LINE	X - GANTRY CRANE TRACK

Parallel Twin Arch
Site Plan 2 of 3



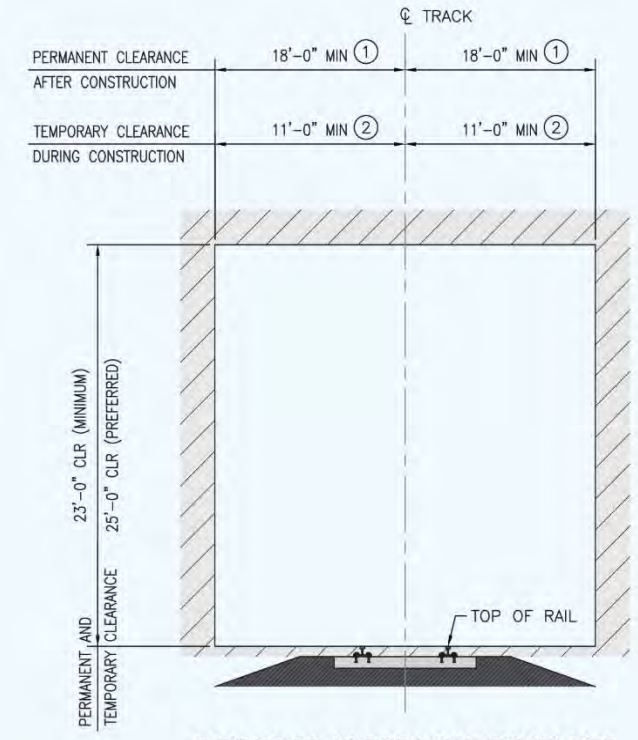
PLAN



PROFILE

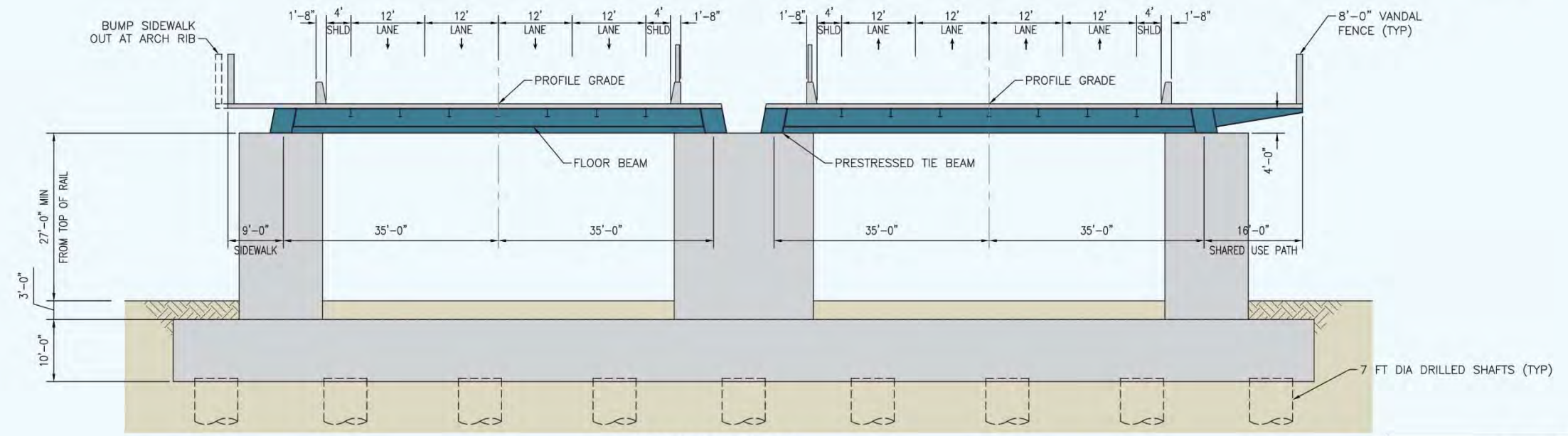
- LEGEND - RAMPS**
- RAMP AA - FUTURE RAMP FROM I-75 NB/WHV
 - RAMP DD - FUTURE RAMP FROM BANK STREET TO I-75 NB
 - RAMP CC - FUTURE RAMP FROM I-75 SB/WHV
 - RAMP GG - FUTURE RAMP TO FINDLAY STREET
 - RAMP BB - FUTURE RAMP TO I-75 SB

Parallel Twin Arch
Site Plan 3 of 3



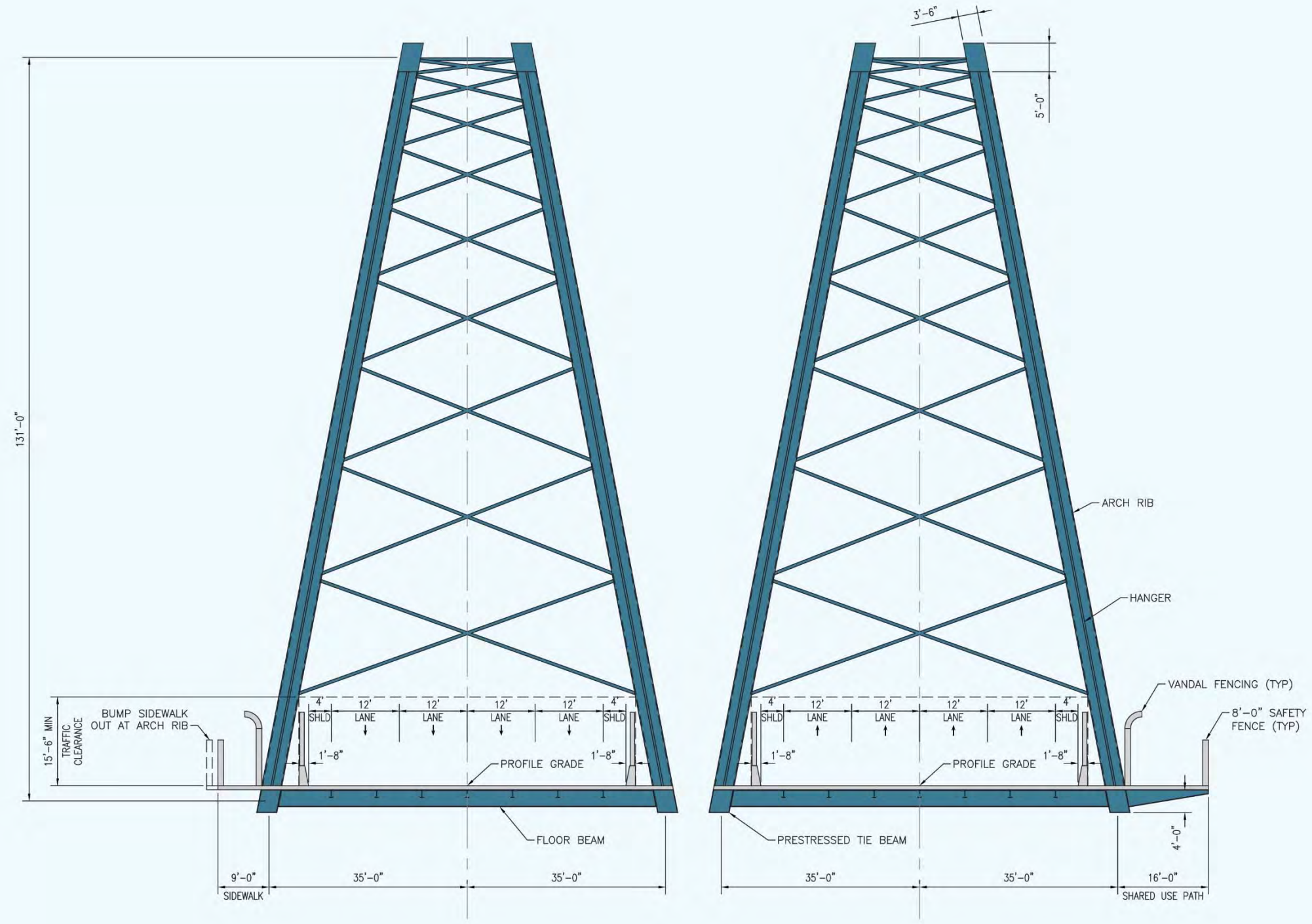
RAILROAD CLEARANCE ENVELOPE
(NOT TO SCALE)

- ① 25'-0" PREFERRED. HORIZONTAL CLEARANCE LESS THAN THE 25'-0", CRASH WALL PROTECTION MAY BE REQUIRED UNLESS ADJACENT PIER CROSS-SECTION DIMENSIONS ARE NO LESS THAN 2'-6" THICK x 20'-0" LONG (MEASURED ALONG DIRECTION OF TRACK) OR MIN 50 FT².
- ② FOR A TEMPORARY WALKWAY AND HANDRAIL SYSTEM A MINIMUM CLEARANCE OF 12' SHALL BE PROVIDED.



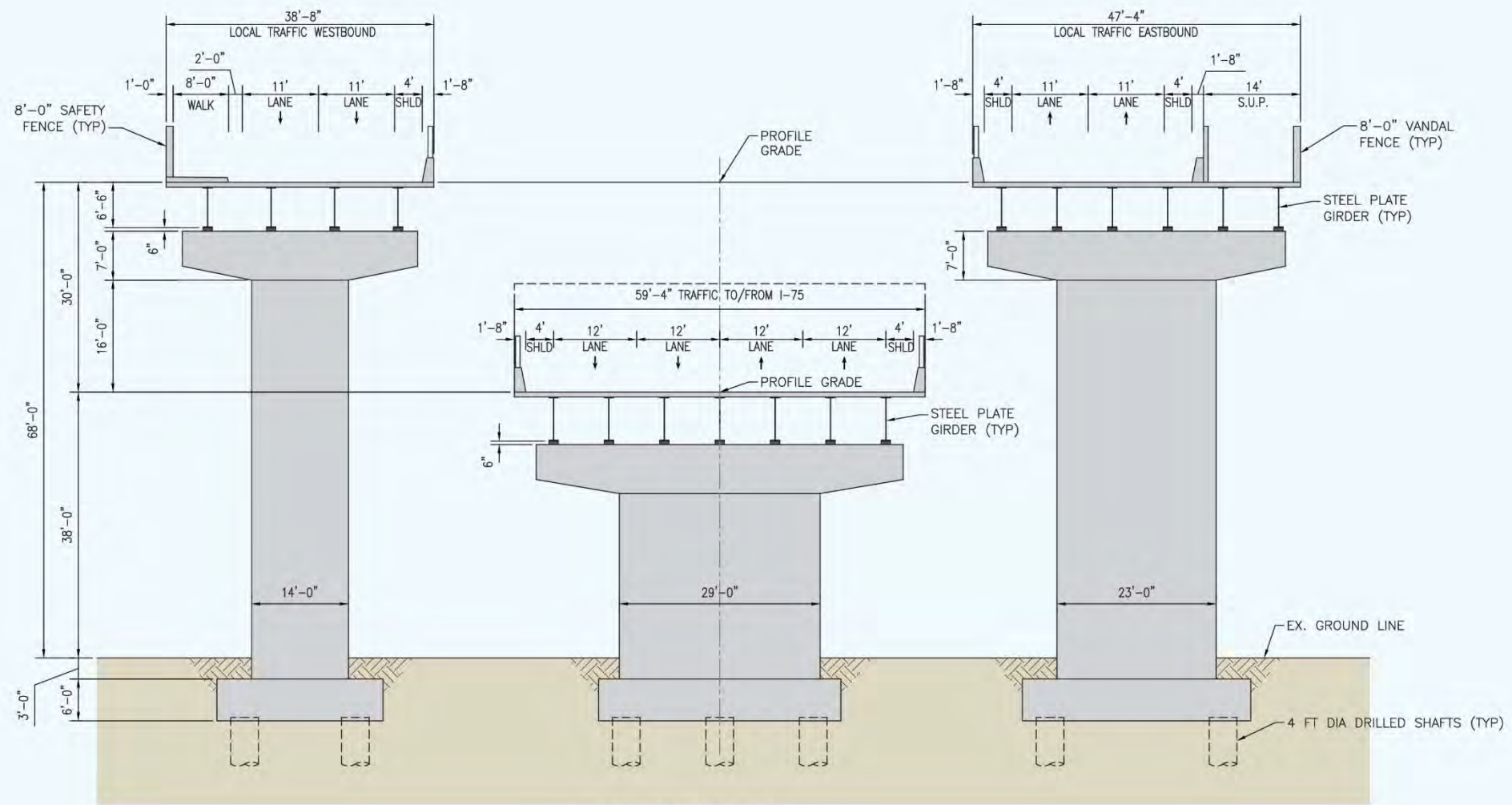
**SECTION AT PIER C
(PIER D SIMILAR)**

**Parallel Twin Arch
Typical Sections 1 of 5**



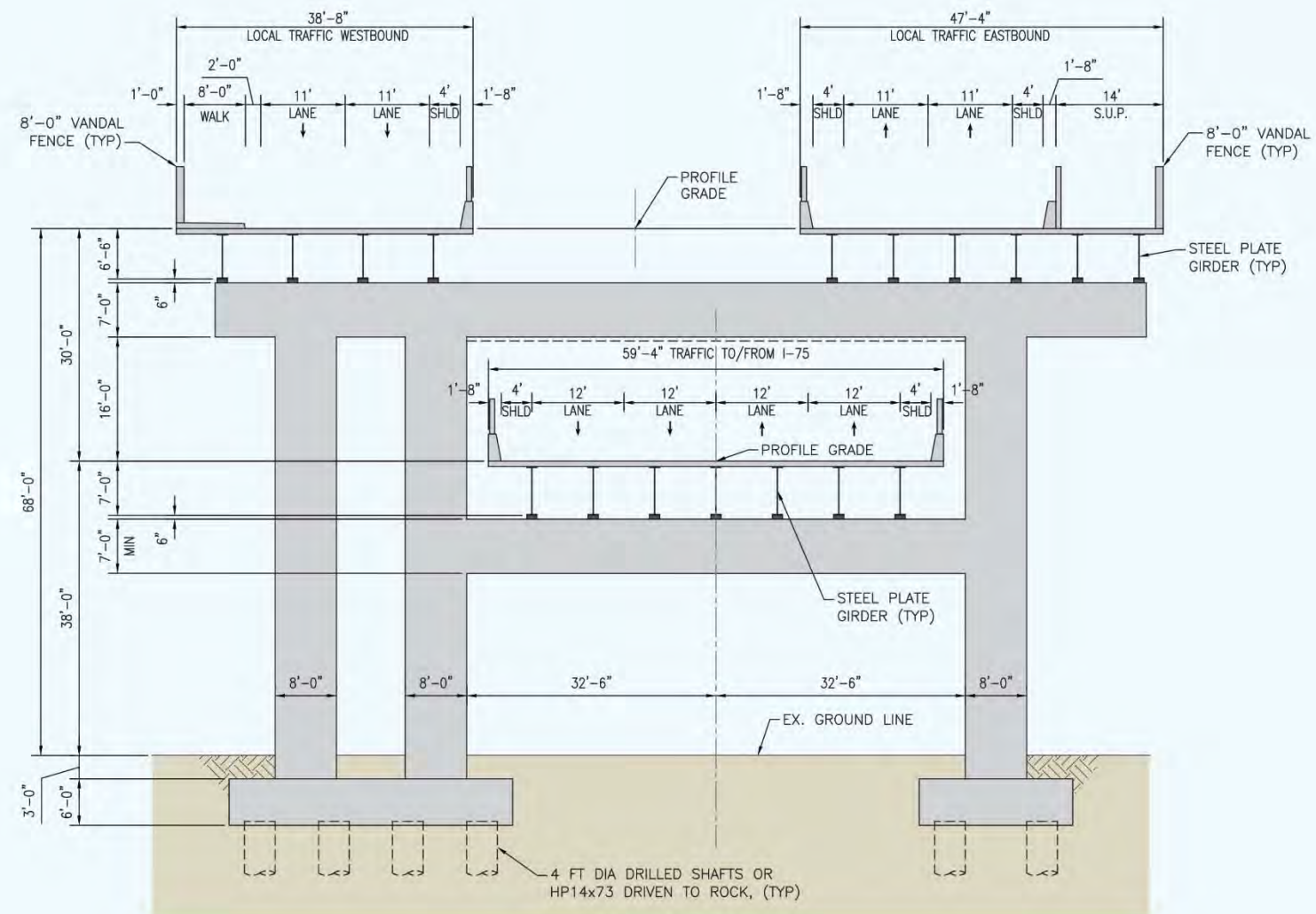
SECTION AT MIDSPAN

Parallel Twin Arch
Typical Sections 2 of 5



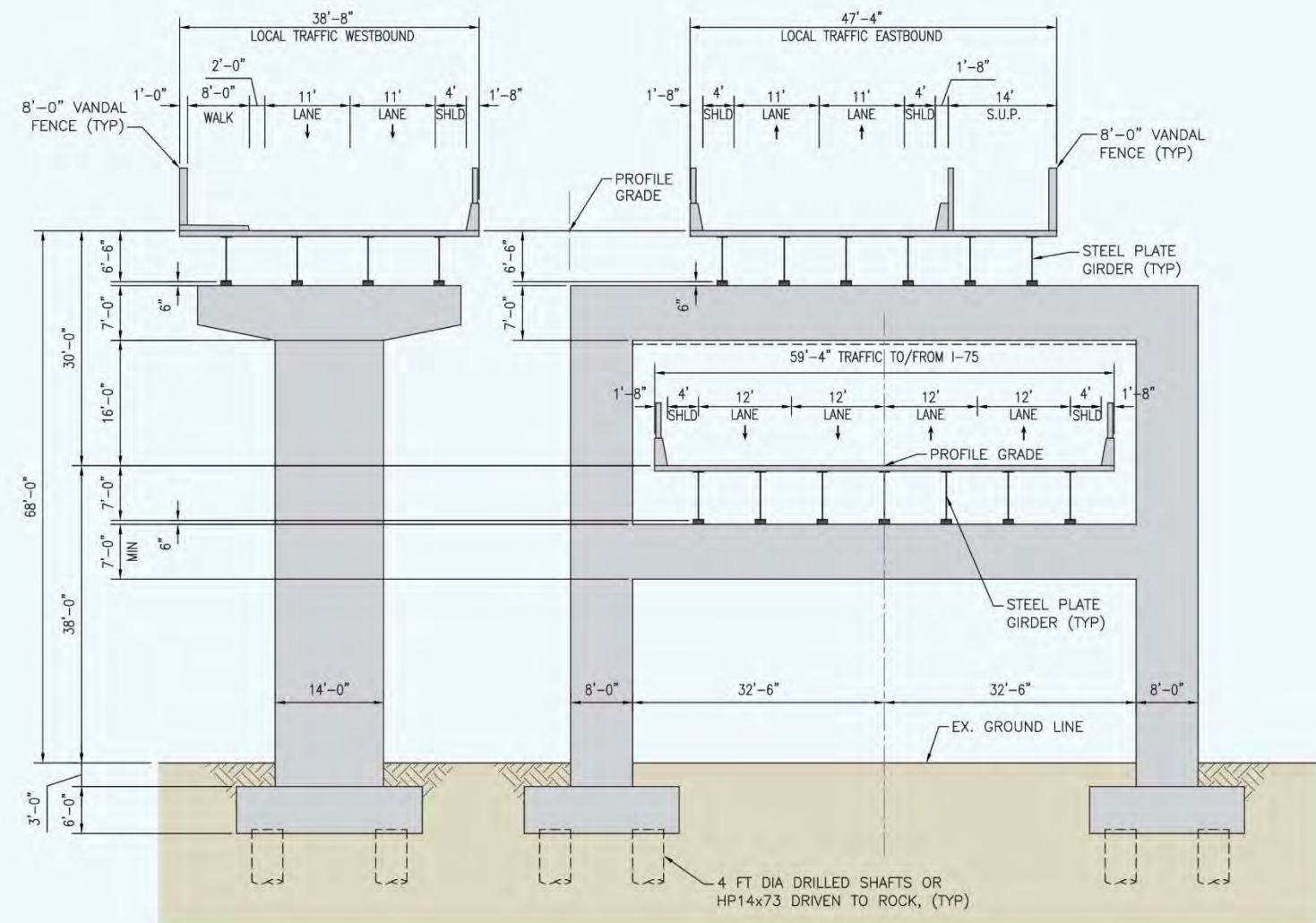
SECTION AT PIER F

Parallel Twin Arch
Typical Sections 3 of 5



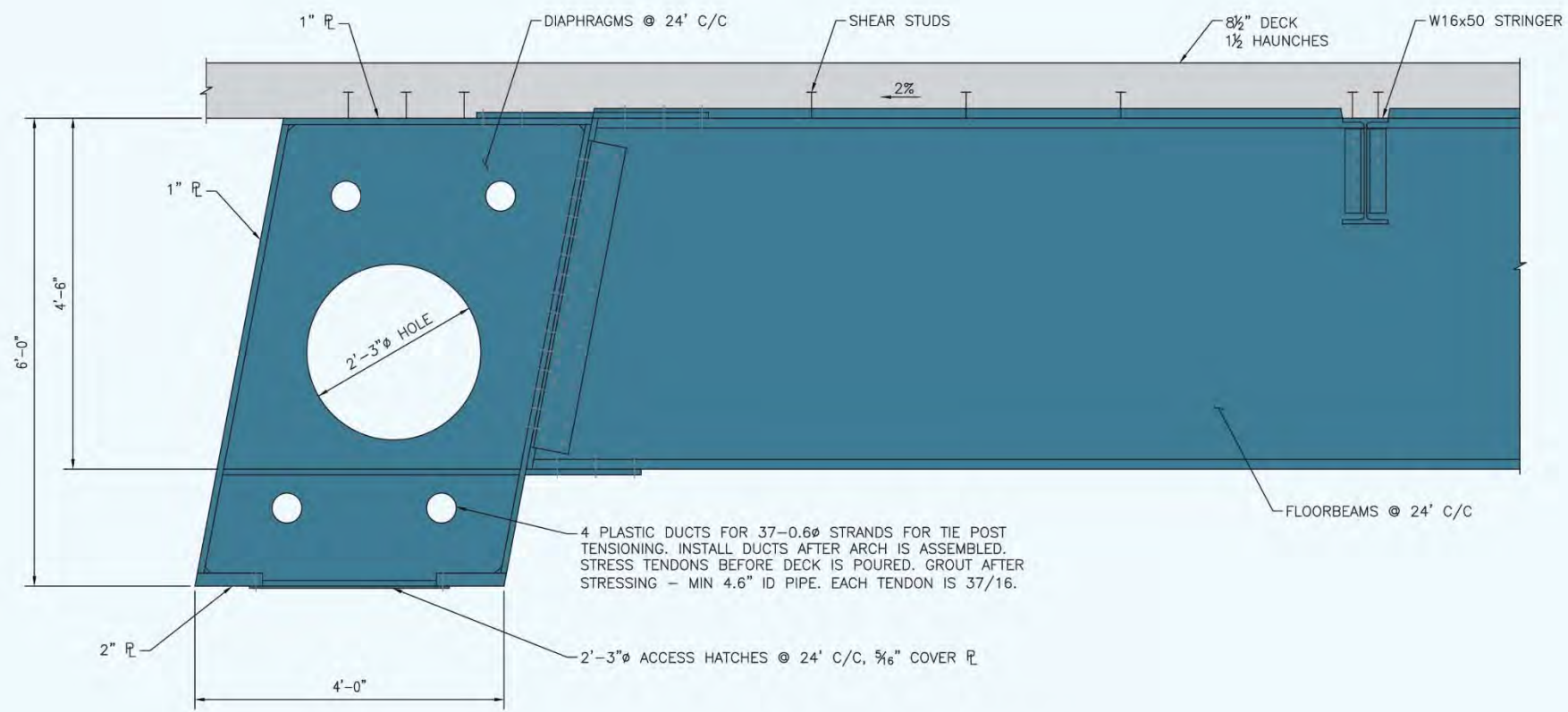
SECTION AT PIER H

Parallel Twin Arch
Typical Sections 4 of 5

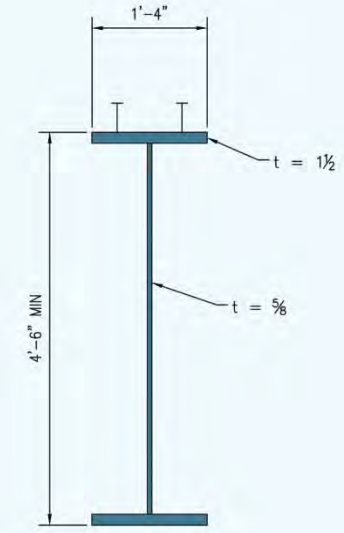


SECTION AT PIER I

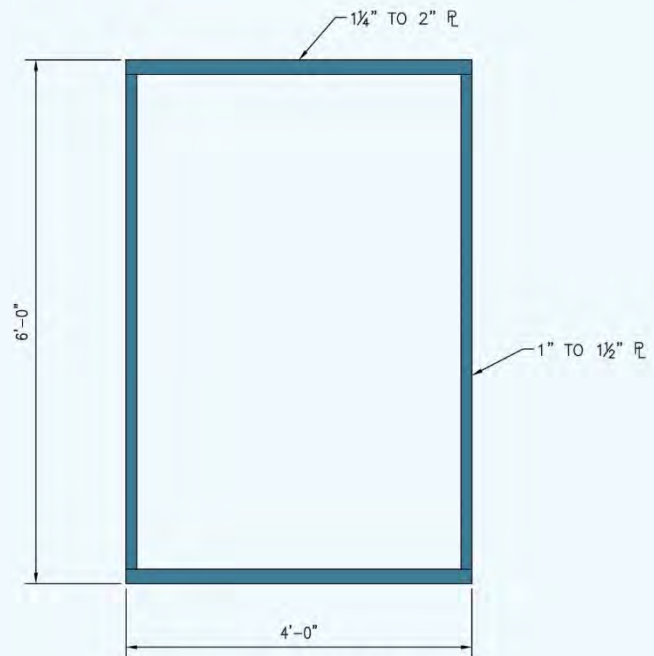
Parallel Twin Arch
Typical Sections 5 of 5



TYPICAL ARCH RIB & FLOOR ASSEMBLY

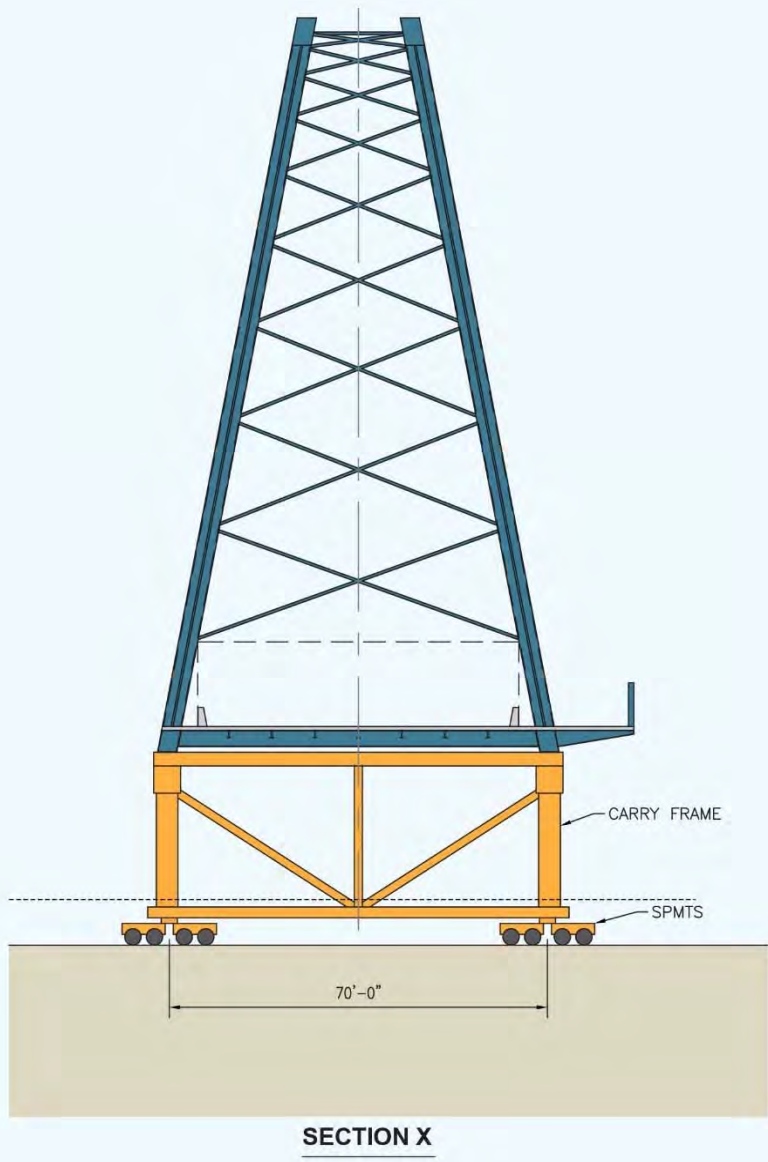
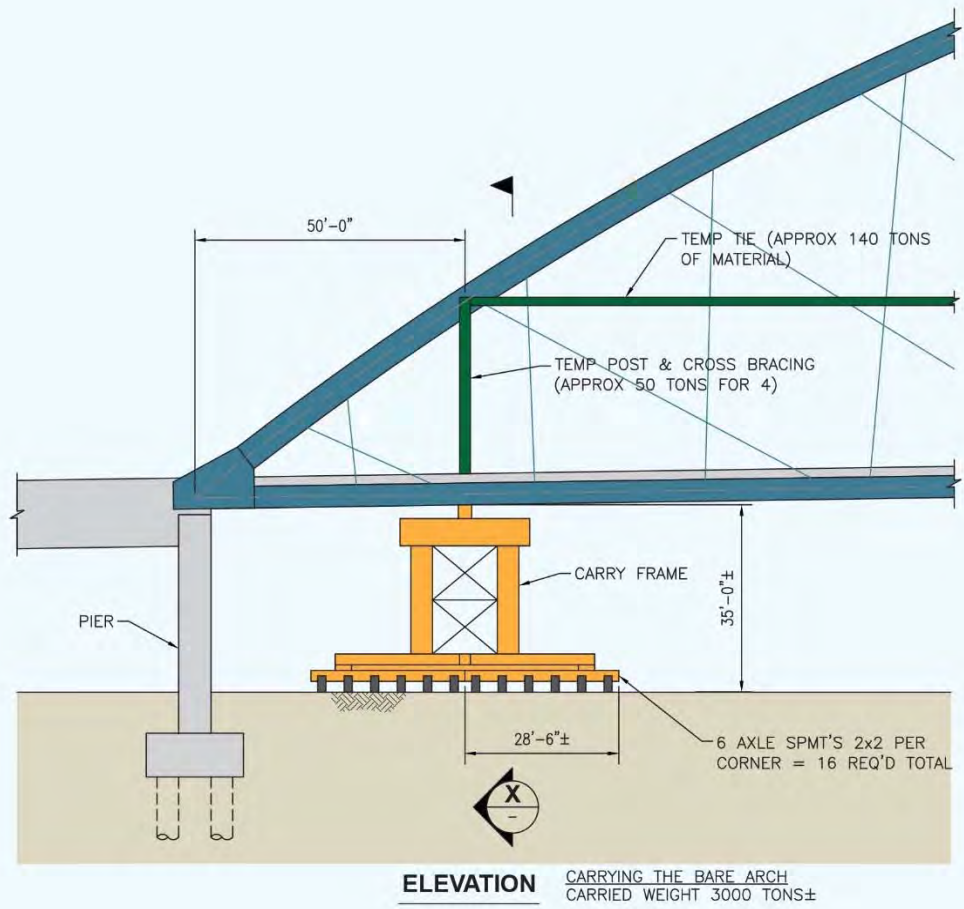


FLOOR BEAM

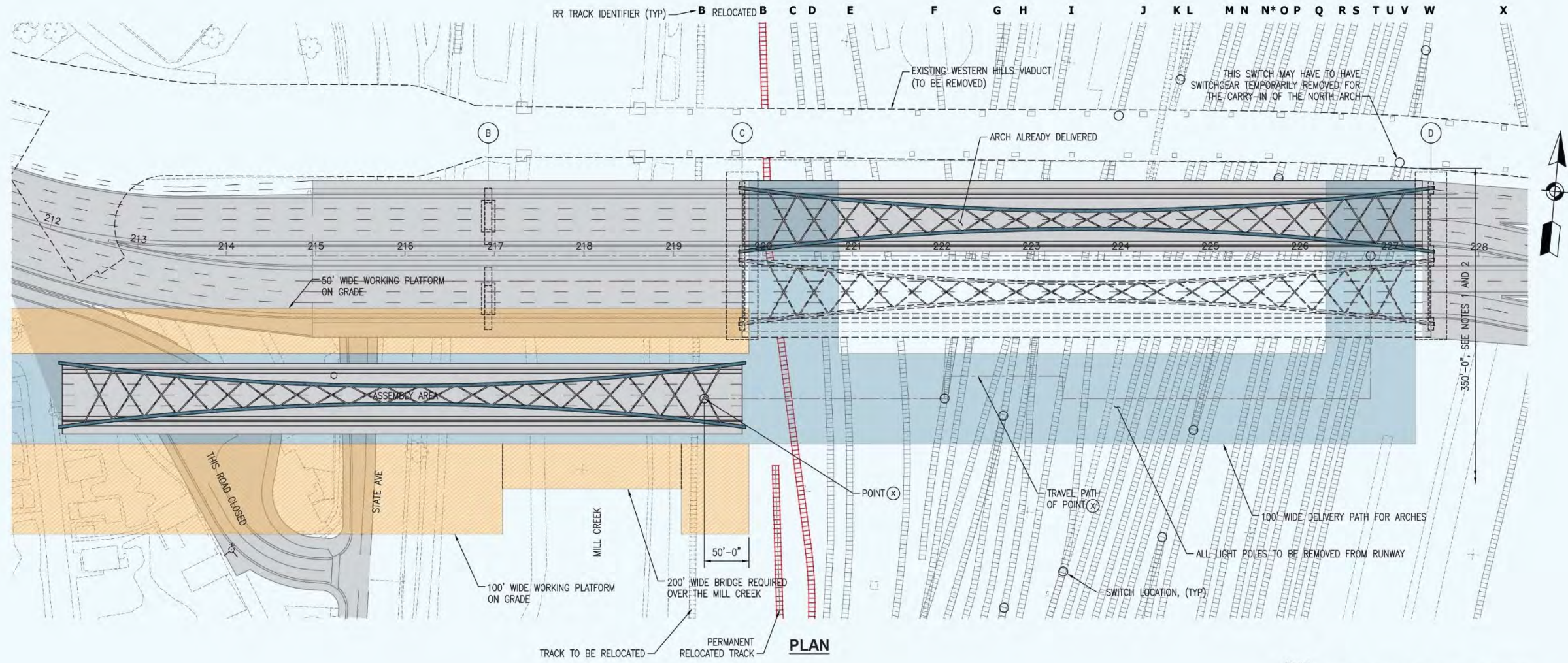


ARCH RIB SECTION

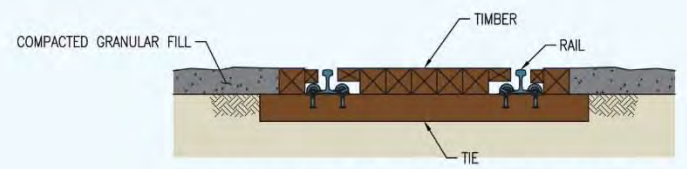
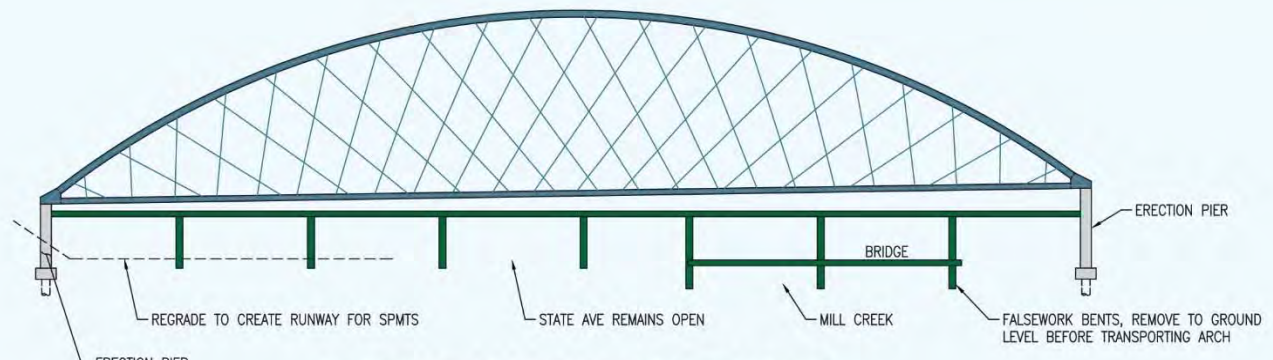
Parallel Twin Arch
Structural Details



Parallel Twin Arch
Construction Methods



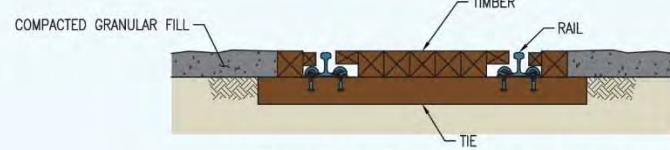
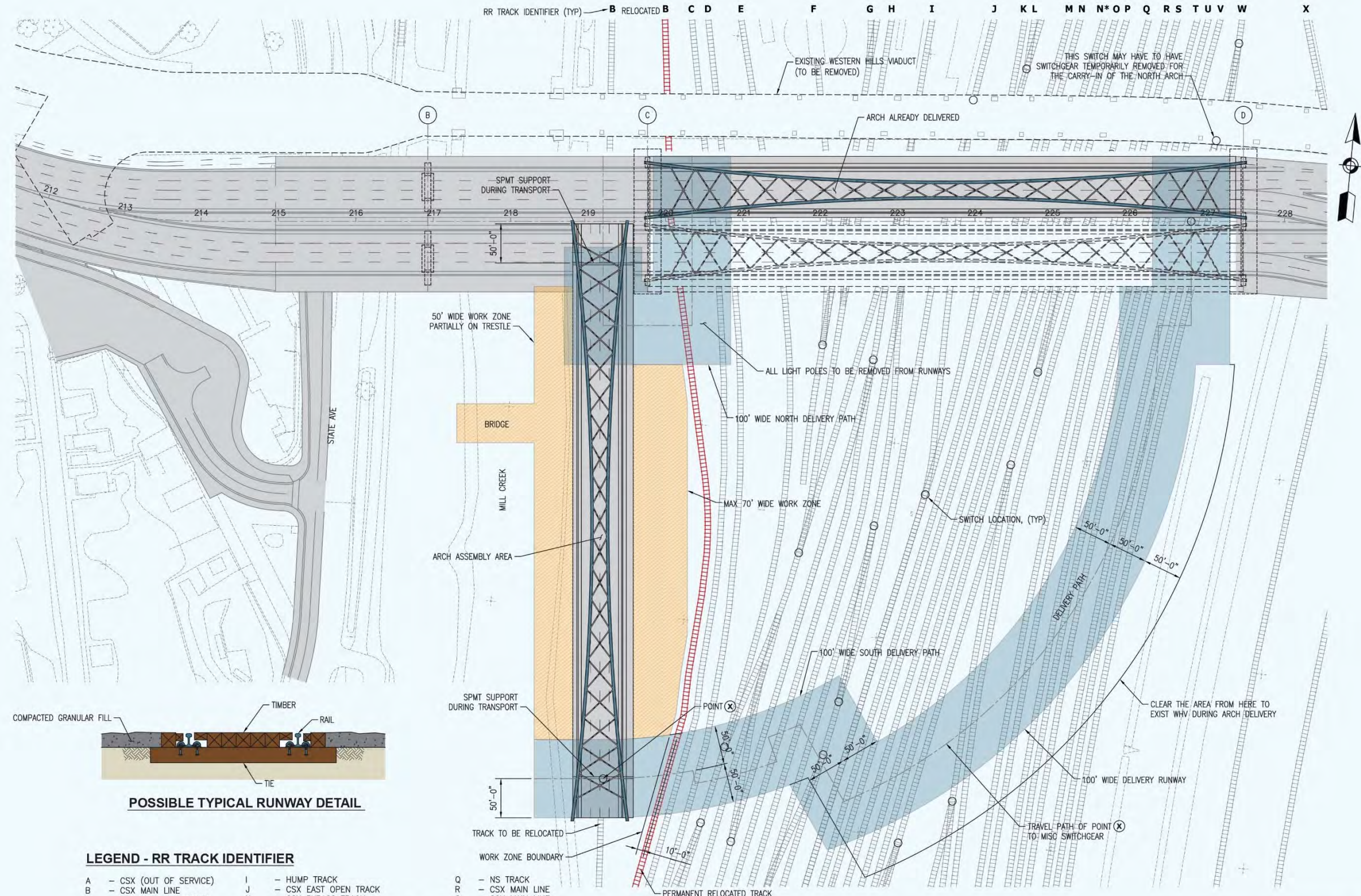
- NOTES:
1. TRAINS TO BE STOPPED FOR A MAX ONE 12 HOUR PERIOD PER ARCH TO ALLOW FOR DELIVERY FROM ASSEMBLY AREA TO FINAL POSITION.
 2. NO TRAINS PERMITTED IN THIS ZONE DURING EACH ARCH DELIVERY.



LEGEND - RR TRACK IDENTIFIER

A - CSX (OUT OF SERVICE)	I - HUMP TRACK	Q - NS TRACK
B - CSX MAIN LINE	J - CSX EAST OPEN TRACK	R - CSX MAIN LINE
C - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	S - CSX MAIN LINE
D - CSX RECEIVING TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	T - CSX RAMP TRACK
E - CSX RECEIVING TRACK	M - CSX LONG DEPARTURE TRACK	U - CSX RAMP TRACK
F - CSX LOCOMOTIVE TRACK	N, N* - CSX LONG DEPARTURE TRACK	V - CSX RAMP TRACK
G - CSX LOCOMOTIVE TRACK	O - NS TRACK	W - INTERMODAL TRACK
H - CSX WEST OPEN TRACK	P - NS TRACK	X - GANTRY CRANE TRACK

**Parallel Twin Arch
Erection Methods 1 of 2**



POSSIBLE TYPICAL RUNWAY DETAIL

LEGEND - RR TRACK IDENTIFIER

- | | | |
|--------------------------|------------------------------------|------------------------|
| A - CSX (OUT OF SERVICE) | I - HUMP TRACK | Q - NS TRACK |
| B - CSX MAIN LINE | J - CSX EAST OPEN TRACK | R - CSX MAIN LINE |
| C - CSX RECEIVING TRACK | K - CSX BYPASS TRACK | S - CSX MAIN LINE |
| D - CSX RECEIVING TRACK | L - CSX SHORT DEPARTURE TRACKS (3) | T - CSX RAMP TRACK |
| E - CSX RECEIVING TRACK | M - CSX LONG DEPARTURE TRACK | U - CSX RAMP TRACK |
| F - CSX LOCOMOTIVE TRACK | N, N* - CSX LONG DEPARTURE TRACK | V - CSX RAMP TRACK |
| G - CSX LOCOMOTIVE TRACK | O - NS TRACK | W - INTERMODAL TRACK |
| H - CSX WEST OPEN TRACK | P - NS TRACK | X - GANTRY CRANE TRACK |

PLAN

NOTE:
1. TRAINS TO BE STOPPED FOR A MAX ONE 12 HOUR PERIOD PER ARCH TO ALLOW FOR DELIVERY FROM ASSEMBLY AREA TO FINAL POSITION.

**Parallel Twin Arch
Erection Methods 2 of 2**

2.4 Extradosed

2.4.1 Introduction

An extradosed bridge alternative was developed for spanning the tracks of the CSX Queensgate Yard at the site of the Western Hills Viaduct replacement. An extradosed bridge can be considered a hybrid of a cable-stayed and a girder bridge. By employing cable-stays the girder depth can be reduced as compared to a conventional girder bridge. The towers, or pylons, of an extradosed bridge are not as tall as typical cable-stayed bridges and the stay cables are at a flatter angle to the deck resulting in material inefficiency and higher cost than a girder bridge, but still lower cost than a typical cable-stayed bridge solution. This alternative is a competitive choice, since the difference in efficiency and cost is small, and the extradosed is an elegant bridge type.

Three extradosed bridge concepts were developed in the Alternative Evaluation Phase.

Initial studies led to the development of two concrete box girder structures. One of them comprises a single multi-cell box carrying all traffic across the railyard. The other comprises two box girders, one to the north carrying westbound traffic and one to the south carrying eastbound traffic. Drawings for the box girder alternatives are provided in the appendix F. The extradosed main and back span box girders are built segmentally in balanced cantilever out from the two piers in the railyard, in order to minimize interruption to rail operations.

The third concept developed has a superstructure which comprises longitudinal steel edge girders and steel floor beams that are composite with the concrete deck. Drawings for this alternative are included in this section. This structure would be easier to construct and presents less risk of complications with railyard activities than the concrete box girder concepts and is thus the preferred extradosed option.

2.4.2 Alignment Description

Drawings for the bridge are provided in this section. The extradosed structure spans all the tracks in the railyard, with a main span of 560 feet and side spans of 280 feet. The approach structures to the west and east of the railyard comprises steel girders with a cast in place concrete deck.

The structure carries eight lanes of traffic with an 8-foot wide sidewalk along the north side and a 14-foot wide shared use path (SUP) along the south side of the structure. At the east end of the bridge the traffic is separated onto two levels. The four center lanes of traffic connect at a lower level to the I-75 freeway interchange. The outer lanes, the two along the north side carrying westbound traffic and the two along the south side carrying eastbound traffic, connect at an upper level to the West McMillan Street/ Central Parkway intersection. Whether there will be a direct connection to Spring Grove is yet to be determined.

The alignment at the east end for the extradosed structure is the latest development in an effort to simplify the traffic transitions on and off the new Western Hills Viaduct. It involves a minor shift in the location of the I-75 Interchange to the north from an earlier iteration and those presented in the other alternatives in this report which braided the local traffic structures up over and to the north of the interstate traffic structure.

In the railyard, the profile of the bridge accommodates a clearance of 27 feet above the railyard, allowing for the normal rail clearance of 23 feet plus 4 feet clearance for a maintenance traveler or snooper truck arm. The high point of the bridge profile over the railyard is at the midpoint of the main extradosed span, with a 2% slope in either direction to facilitate drainage.

The bridge is straight in plan in the extradosed portion, from piers C to F, in order to keep the cables straight. The new structure is situated just under 20 feet from the intermodal boundary and limits of the gantry crane operations.

2.4.3 Structural Considerations

In the extradosed spans, the pylons and planes of cables are located between the traffic and the sidewalk and SUP, serving as a barrier between pedestrians and vehicular traffic. The overall deck width is 166 feet, widening to 170 feet at the pylons. The steel edge girder is a built-up box section with an 8-foot depth for the majority of the span tapering to 14 feet deep at the pylons. The steel floor beams are plate girder sections with a maximum depth of 8 feet at midspan. The edge girders and floor beams are designed to be composite with the concrete deck.

It is recommended that a cost-benefit study be done relating to the use of metalizing or the use of weathering steel, rather than painting, the exterior surfaces to reduce life-cycle costs from repainting. There is some credible evidence that metalizing or weathering steel, though initially costlier, is in fact more economical in the long run for structures that are intended to have a long service life.

The deck is 10 inches thick and can be cast-in-place or constructed using pre-cast panels. Since deck replacement is not possible for this alternative, a CIP concrete overlay would be provided and is included in the cost estimate. It is anticipated that the overlay would need to be replaced about every 15 years throughout the service life of the bridge to protect the deck from deterioration. In the case of deck deterioration, a partial replacement of the deck may be possible. The upper 2" of the deck would be hydro-demolished and replaced with UHPC.

The extradosed pylons and substructure are concrete. The height of the pylons is 100 ft above the bridge deck. The cables are anchored and stressed within the tower. Steel anchor boxes are used to anchor the cables. At the deck level, the cables are anchored within the edge girder. The towers and the edge girders will be internally accessible for inspection, maintenance, and in the case of the anchor boxes within the towers, for stressing of the cables.

The foundation comprises conventional footings below grade supported on two rows of six-foot diameter drilled shafts, with a total of twenty shafts used at each of the main piers.

2.4.4 Construction and Working Area Within the Rail Yard

1. Work Zone around Pier D and Access Trestle

- For construction of the westernmost main pier (Pier D) close to the locomotive turnaround track (that passes over the turntable), it will be necessary to discontinue use of the locomotive track south of the existing viaduct structure for certain time periods when the extra space is needed for construction.

- The easternmost main pier (Pier E) is easily accessible via the intermodal yard and will not impact rail traffic.
- The work zone for Pier D construction is conceived to be a trapezoidal plot of land about 300 feet long and 45 to 110 feet wide. The work zone should also continue under the existing structure to allow for material storage etc.
- The work zone has been defined herein as approaching no closer than 10 feet to centerline of the nearest track, which is understood to be the normal CSX minimum horizontal clearance requirement. It is presumed that a flag person will have to be present during all construction activities, but work done within this zone will not be slowed down by rail activity if the 10 feet setback is respected.
- In order to permit the contractor to work efficiently within the rail yard, it is proposed to construct an access trestle 25' above track level to provide access for workers and materials to the work zone. This trestle would be able to support cranes and other erection equipment as required. Equipment operating at grade level (e.g., pile drivers and cranes) would be driven in over the rails. Once within the work zones, they could operate uninhibited by rail operations. It is estimated that the cost of this trestle would be on the order of \$5.5 million. It is possible this work trestle is not needed since the back span is being built on falsework. The back-span falsework structure could serve the purpose of getting workers and equipment over to the Pier D Work Zone.

2. Construction

- Construction of the extradosed structure will essentially be as follows:
 - a. Construct foundation and piers.
 - b. Erect the back spans including the deck without overlay, from Pier C to D and from Pier E to F, on falsework. Falsework supports would be located approximately at the quarter points of the span where there is sufficient spacing between the tracks.
 - c. Erect the pylons. Back span stay cables are installed but not stressed at this point.
 - d. Erect the main span segmentally in cantilever from the main piers, Pier D and E. Use the back spans to transport sections of the steel skeleton (the floor beams and edge girders) for assembly in the main span. These sections comprise one interior floor beam (excluding the floor beams supporting sidewalk and SUP) with a 15-foot section of edge girder on each side. The weight of these sections is approximately 115 tons. The sections are delivered using Self-Propelled Motorized Transport (SPMTs) and then an erection crane supported on the bridge deck is used to lower the sections into place. An example of floor beam installation by this method is shown in the following photo during construction of the New Gerald Desmond Bridge in California. This procedure is done without

use of equipment in the yard below, however, as a safety precaution, while the section is being attached, no rail activity will be allowed within a specified zone directly below. This is discussed in more detail in the following section.

- e. As the cantilever erection progresses in 30-foot long increments, the forestays will be installed, and the concrete deck cast or precast deck panels will be placed and their joints grouted. The fore and back stays are then stressed. In this way the new section of bridge that has been placed is supported back to the pylon and erection of the main span can advance towards midspan.
 - f. Once segmental erection of the main span from either end reaches midspan, the two cantilevers are connected to complete the span. The cable stays are stressed again for geometry control.
 - g. Erect sidewalk and SUP structures. Apply the superimposed dead load. Cable stay forces are adjusted as required.
- The approach structures are erected from ground-based cranes.



Figure 8: Installation of floor beam for the New Gerald Desmond Bridge in California using an erection crane.

2.4.5 Railway Impacts

1. Pier D – Footings, Pier

- Use of the south end of the locomotive track would have to be curtailed for a period of approximately 5 months. The turntable can still be used during the period, but locomotives would have to come and go only from the north. This restriction is seen as workable. The functionality of the locomotive turnaround is not impaired. This permits construction of the Pier D footings and piers.
- It is expected construction of the footings and columns at Pier D, including installation of drilled shafts, would require about 4.5 months of work.

2. Erection of the main span

- The most significant interaction between rail and construction operations occurs when sections of the steel skeleton are being installed in the main span of the extradosed structure. There is a hazard from falling components and it is suggested that a “hazard zone” which is set by the size of the component that could fall with a 1.0V:0.25H amount of additional space around it.
- The sections being installed are approximately 145ft long (interior floor beam plus section of edge girder on either side) by 15ft wide. At midspan where the bridge is approximately 55ft above the yard, this requires a 175ft by 45 ft hazard zone in which no rail operations can take place while the steel section is being attached. The time it takes to position and bolt up each steel section will likely be up to 2 hours in duration.
- Interruptions will progress across the yard as the sections are being installed in cantilever out to the middle of the span. Once each steel section has been bolted into place there is no further hazard from the erection process of that section because the cantilevering structure can be made as safe as any completed structure would be. Stay cable installation and concrete deck placement will not cause interruption to rail operations below.
- There is also a small-debris hazard extending over a longer period when small objects may possibly fall. This can be dealt with by using debris nets so that there will be no impact on or from rail operations.

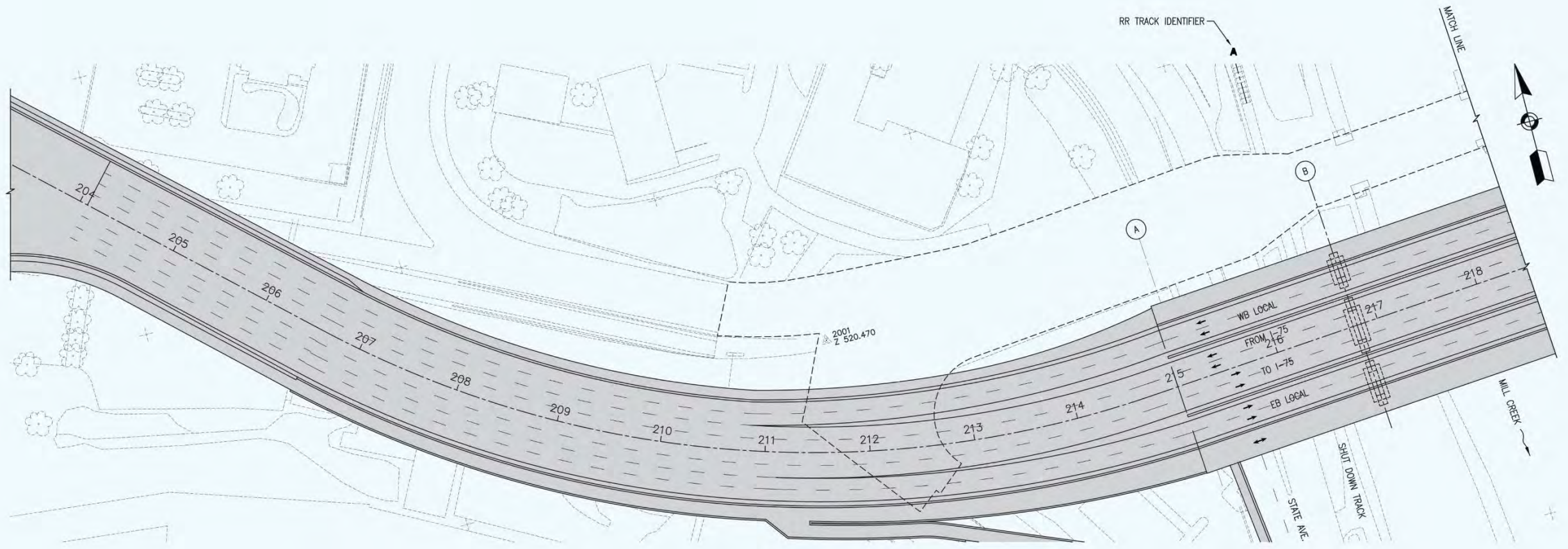
2.4.6 Schedule and Staging Considerations

The extradosed alternative with composite deck system that has been described in the above sections is a recent development. The schedule for its construction has not yet been developed. The project schedule is anticipated to be similar in duration to the other alternatives, taking close to four years to complete.

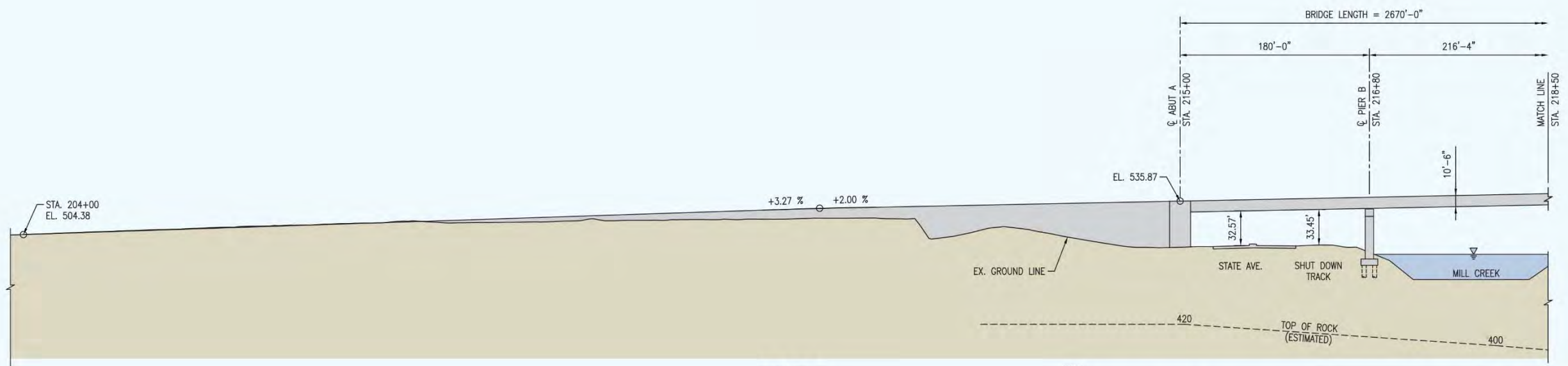
The schedule for the single cell concrete box girder alternative is shown on page 69. The schedule for twin box girders will be similar.

The schedule does not incorporate any "Railway Premium" delay time. That is the subject of a separate area of study.

It is presumed that the interface with I-75 will be executed by early re-grading of the existing alignment using a 30-hour long full closure of I-75. For more information regarding this, and a detailed discussion of the interface between the Western Hills Viaduct and the I-75 reconstruction, this is discussed more fully in Section 3 of this report.



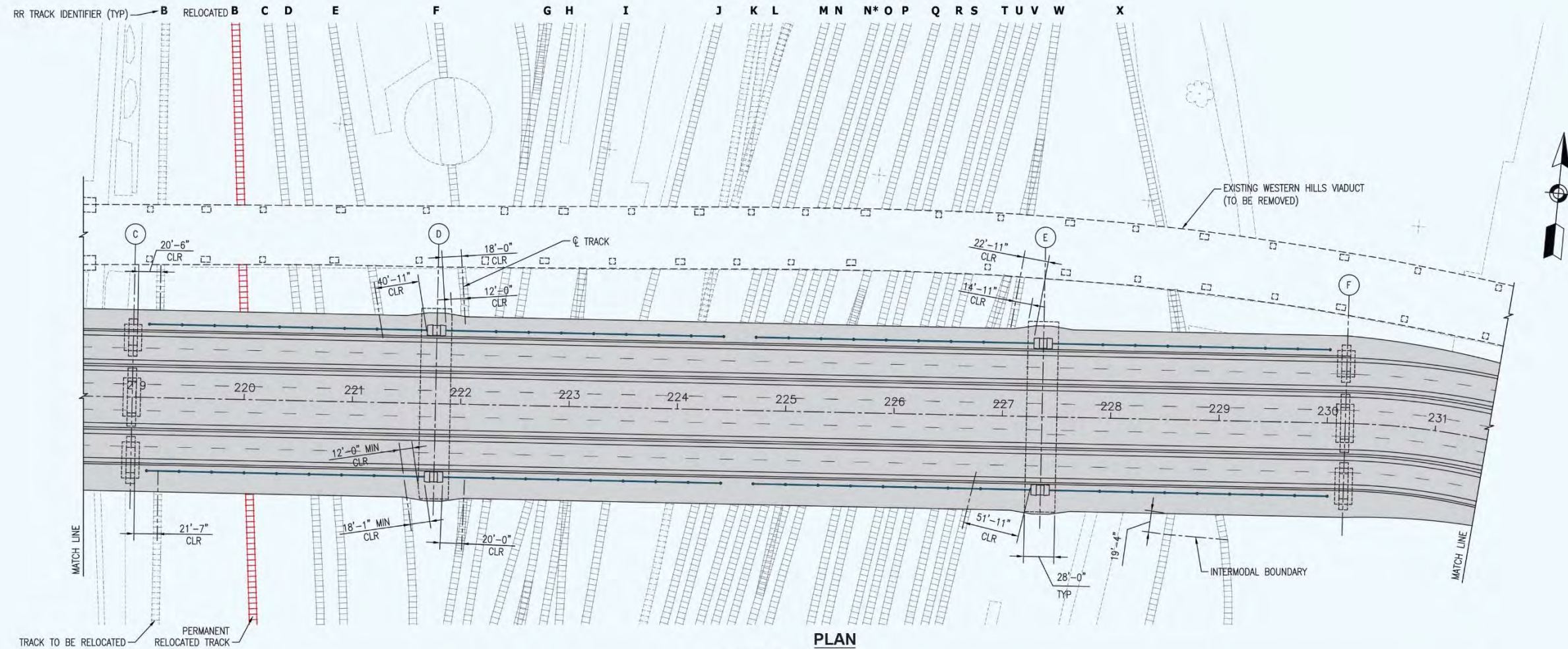
PLAN



PROFILE

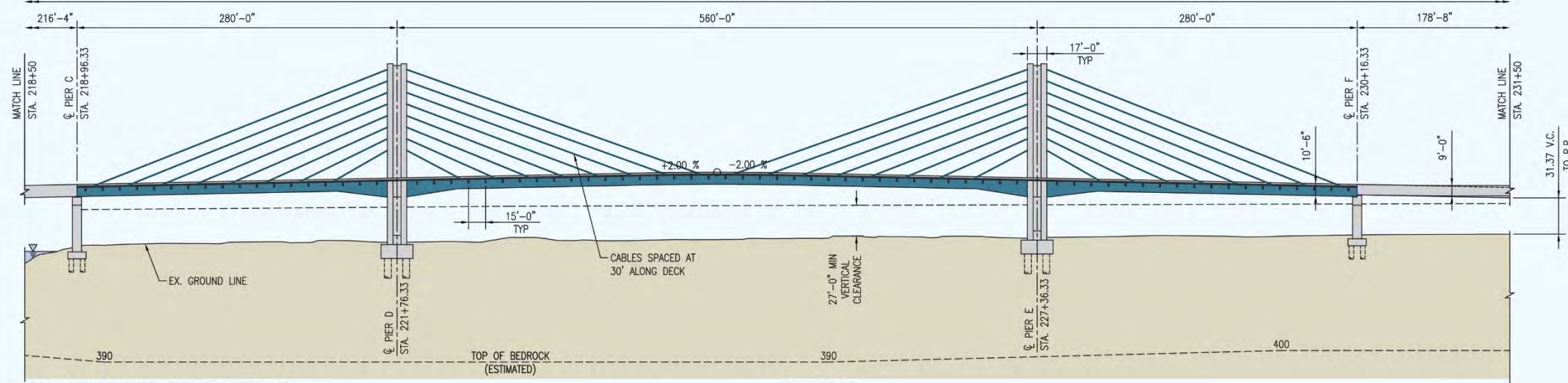
NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

Extradosed Bridge
Site Plan 1 of 3



PLAN

BRIDGE LENGTH = 2670'-0"

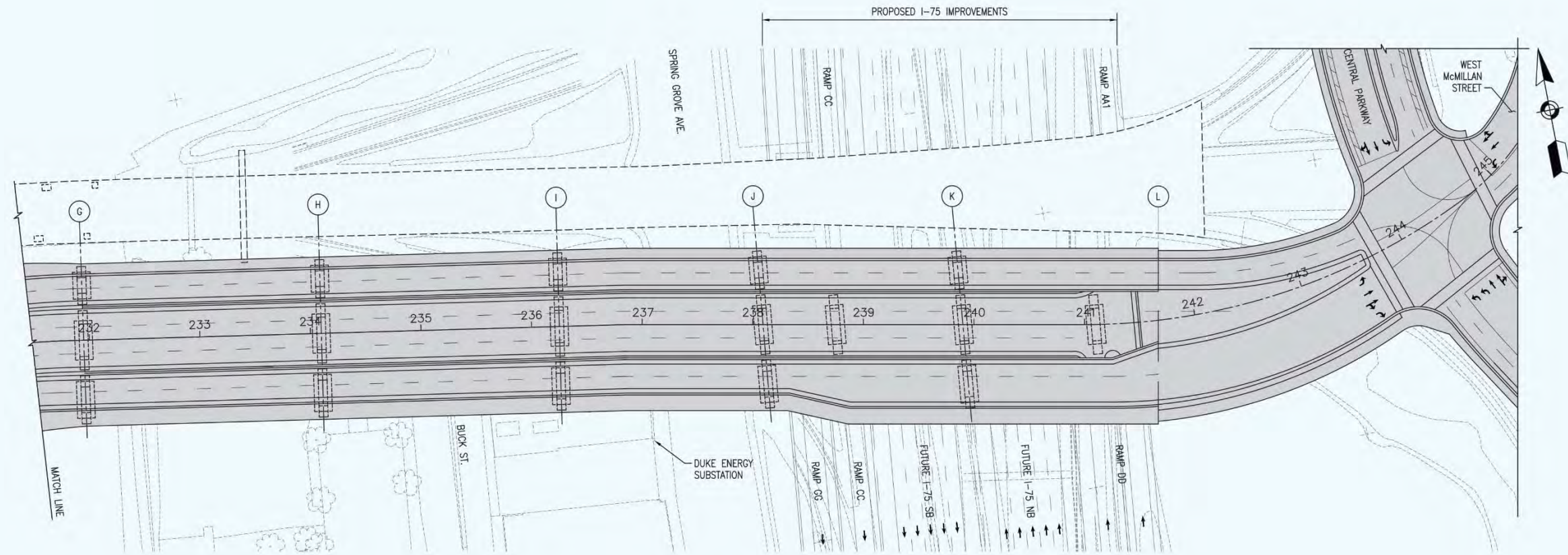


PROFILE

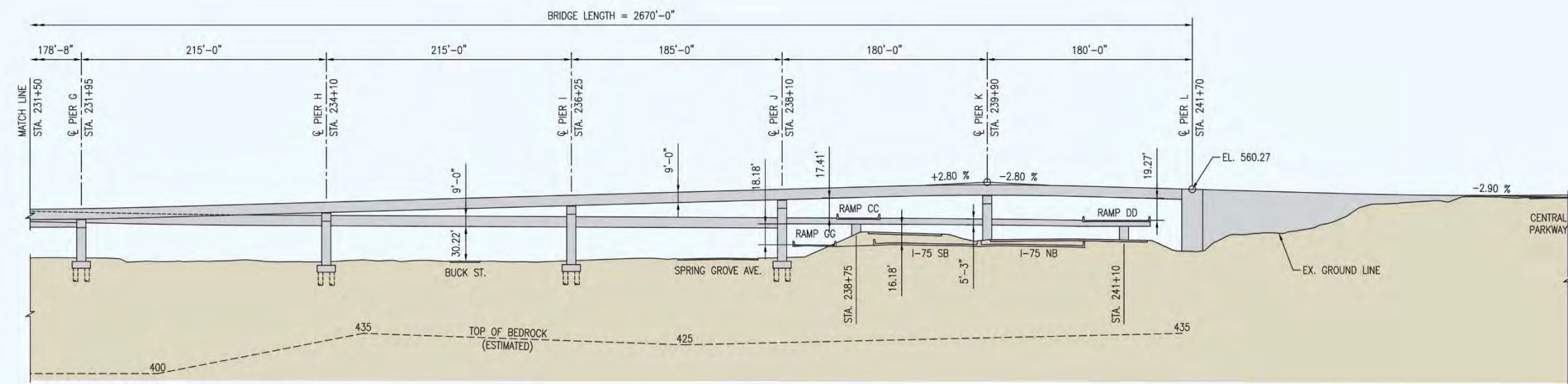
LEGEND - RR TRACK IDENTIFIER

- | | | | |
|--------------------------|------------------------------------|----------------------------------|------------------------|
| A - CSX (OUT OF SERVICE) | G - CSX LOCOMOTIVE TRACK | M - CSX LONG DEPARTURE TRACK | S - CSX MAIN LINE |
| B - CSX MAIN LINE | H - CSX WEST OPEN TRACK | N, N* - CSX LONG DEPARTURE TRACK | T - CSX RAMP TRACK |
| C - CSX RECEIVING TRACK | I - HUMP TRACK | O - NS TRACK | U - CSX RAMP TRACK |
| D - CSX RECEIVING TRACK | J - CSX EAST OPEN TRACK | P - NS TRACK | V - CSX RAMP TRACK |
| E - CSX RECEIVING TRACK | K - CSX BYPASS TRACK | Q - NS TRACK | W - INTERMODAL TRACK |
| F - CSX LOCOMOTIVE TRACK | L - CSX SHORT DEPARTURE TRACKS (3) | R - CSX MAIN LINE | X - GANTRY CRANE TRACK |

Extradosed Bridge
Site Plan 2 of 3



PLAN

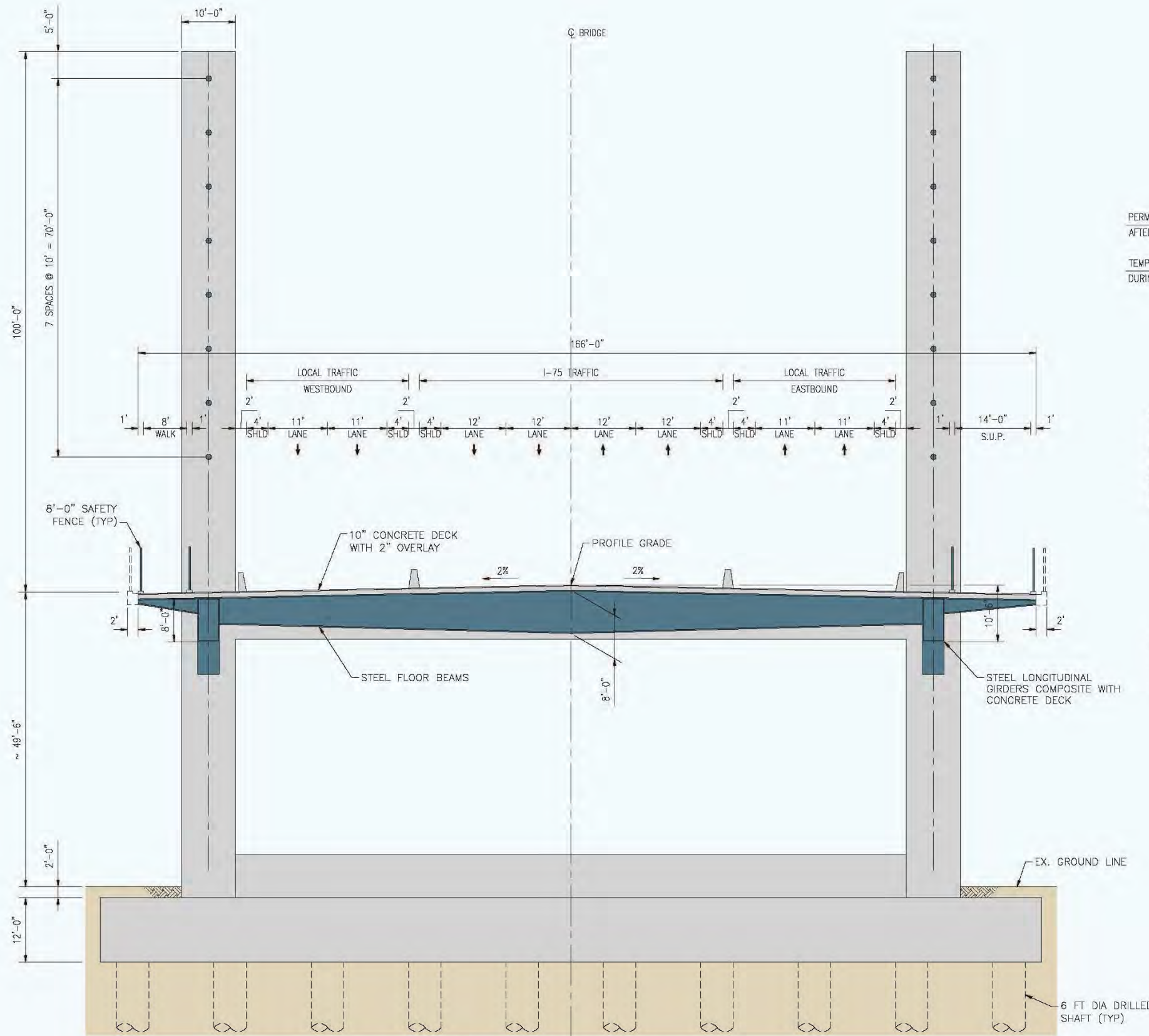


PROFILE

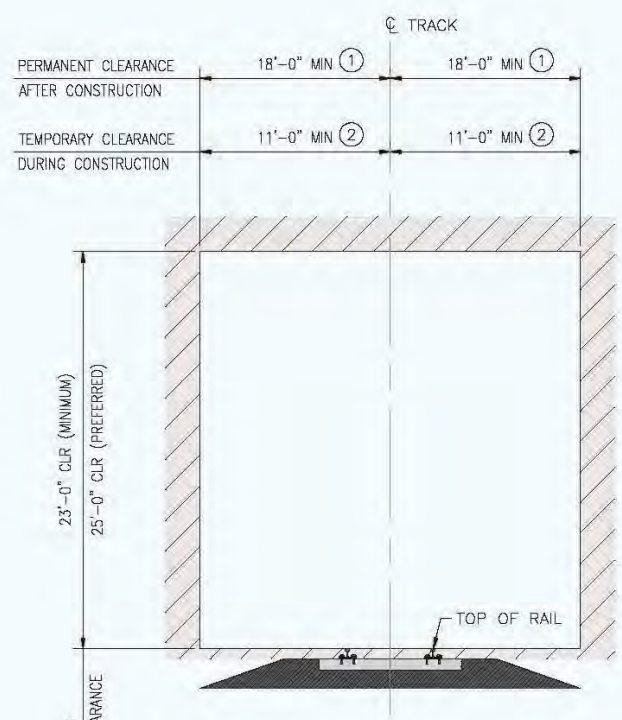
LEGEND - RAMPS

- RAMP AA - FUTURE RAMP FROM I-75 NB/WHV
- RAMP DD - FUTURE RAMP FROM BANK STREET TO I-75 NB
- RAMP CC - FUTURE RAMP FROM I-75 SB/WHV
- RAMP GG - FUTURE RAMP TO FINDLAY STREET
- RAMP BB - FUTURE RAMP TO I-75 SB

**Extradosed Bridge
Site Plan 3 of 3**



TYPICAL SECTION AT PIER D AND PIER E

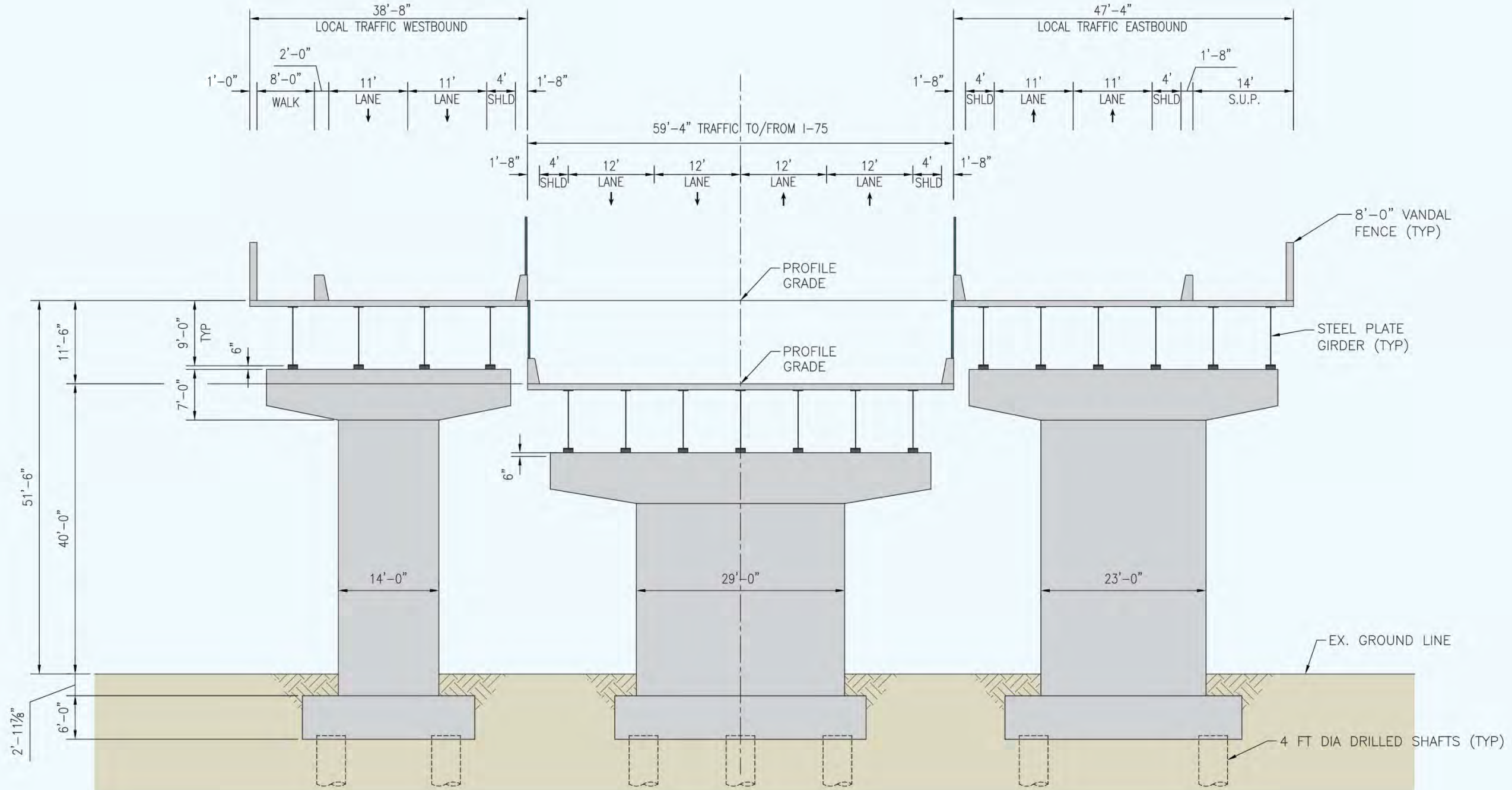


RAILROAD CLEARANCE ENVELOPE

(NOT TO SCALE)

- ① 25'-0" PREFERRED. HORIZONTAL CLEARANCE LESS THAN THE 25'-0", CRASH WALL PROTECTION MAY BE REQUIRED UNLESS ADJACENT PIER CROSS-SECTION DIMENSIONS ARE NO LESS THAN 2'-6" THICK x 20'-0" LONG (MEASURED ALONG DIRECTION OF TRACK).
- ② FOR A TEMPORARY WALKWAY AND HANDRAIL SYSTEM A MINIMUM CLEARANCE OF 12' SHALL BE PROVIDED.

**Extradosed Bridge
Typical Sections 1 of 2**



TYPICAL SECTIONS AT PIER G TO L
(PIER H SHOWN)

Extradosed Bridge
Typical Sections 2 of 2

2.5 Push Launched Long Span Double Decker Truss (Steel Truss)

2.5.1 Introduction

In this alternative, the bridge is push-launched over the busy portion of the rail yard. The main span is 560 feet. The launched structure is a double deck steel truss with cast-in-place concrete decks. The bridge is launched as only the steel skeleton, without the concrete decks, which will be cast in place once the steel trusses are fully built and in final position. At a 31 feet structural depth (36 feet overall), the truss is deep enough that it will span the required 560 feet without need for stay cables or extradosed structure.

The approach structures to the east and west of the truss will be conventional steel girder bridges. As with any double decker structure, this alternative is not suitable for being constructed in stages. The whole project should be built at once with this alternative.

2.5.2 Traffic and Alignment Considerations

The proposed alignment carries all traffic to/from I-75. I-75 on the lower deck while all local traffic is carried on the upper deck.

We had found that the Duke Energy substation could be left where it is, undisturbed, and the new WHV could be threaded to the north of the Duke property as a double deck structure. However, it now appears that Duke Energy will be relocating and so more room is available for the new viaduct at this location. Separating the local traffic bridge from the I-75 traffic bridge is desirable from the traffic point of view and it will be easier to contractually separate the I-75 traffic bridge from the rest of the work. Accordingly, we have revised the alignment near I-75 to take advantage of this opportunity.

As with any double deck solution, the transition from the single traffic level (at grade) to the two levels has to happen at the west end of the project. West of State Avenue, elevated ramps are required to allow the upper deck traffic to merge with the traffic from the lower deck. Because the transition cannot be completed on the double deck truss structure (it is not practical to widen the structure itself or to start profile separation within the structure length), it has proven necessary to add one more ramp at the west end to give the lower deck traffic that will eventually be turning right, sufficient time to achieve this movement, see page 73.

The ramp would be constructed after traffic is transitioned to the replacement viaduct and the existing viaduct is demolished. The beginning of the upper deck flare at the west end does occur on the last span of the truss structure. It has been accommodated through simple flaring of the top deck without changing the width of the structural steel truss, see typical sections shown on page 76 through 79.

The location of the bridge infringes somewhat on the straddle crane turnaround at the north end of the intermodal yard, if in fact, the space in question is actually used to turn the straddle cranes. We have been informed by CSX that the straddle cranes do not use this location to turn around but have not had this confirmed. If it were necessary to turn the straddle cranes here, approximately 55 feet of container storage and train-building space would be lost assuming that 125 feet is required to turn the cranes. (See Appendix C5: Long Span Push Launch – Alignment Plans)

The launch of the bridge structure requires that the alignment be straight from Pier E to Pier J and that there be 100 feet of working room available both west of Pier E and east of Pier J.

2.5.3 Structural Considerations

The double decked truss structure itself is 1,314 feet long.

Steel quantities for this alternative are estimated as follows:

- Truss main structure 6950 tons
- Truss roadway structural steel 850 tons
- Truss miscellaneous steel 500 tons
- Total Double Deck Truss 9300 tons

- Approach structures 4140 tons

An important design issue with this type of structure is that many members would be considered fracture critical, and therefore would require special design and fabrication measures to deal with this fact. At this early stage of design development, it is not evident which approach(es) to resolving the issue will be optimal. For the purposes of preliminary design, we have assumed that the tension zones of the top and bottom chords will be prestressed after erection to eliminate any significant net tensile stress in these chords in service. This requires about 200 tons of post-tensioning strand. For the tension diagonals it has been assumed that a form of bolted built-up (laminated) member will be used, where the fracture of one element would not lead to the failure of the whole member.

It is probable that further study will show that it is lower cost, lighter and easier to laminate all chord tension members out of multiple plates that are bolted together so that a failure in one element will not propagate to adjacent elements. For instance, a 3-inch thick flange could be assembled out of 3 elements each being 1" thick. If this truss option is to go forward, the first design work would be to establish the most efficient and analytically justifiable concept for eliminating or dealing with fracture critical issues. The post-tensioning of the chords described herein should be considered a placeholder to identify and quantify the issue.

The truss elevation shown is not structurally optimal because aesthetic considerations were favored in selecting a Vee diagonal pattern. There is additional cost associated with this architectural choice. Also, the chord members are necessarily deeper than usual in order to accommodate the demands of flexure during launching operations.

Should this alternative, or any steel option, advance further in the design development process it is recommended that a cost-benefit study be done relating to the use of metalizing, rather than painting, the exterior surfaces to reduce life-cycle costs from repainting. There is some credible evidence that metalizing of weathering steel, though initially costlier, is in fact more economical in the long run for structures that are intended to have a long service life.

2.5.4 Work within the Rail Yard

The location of Pier G places the pier in a location that temporarily blocks the locomotive track south of the existing WHV during pier construction. It appears that this particular track is not functionally necessary for the operation of the locomotive turntable, since the locomotives can arrive and depart from the north. At the time of the site inspection, this particular track dead-ended a short distance south of the new viaduct location. After pier construction is completed, the locomotive track could be reinstated to its present location and function. Accordingly, we do not see any impediment to using this space for a permanent pier.

An access trestle is proposed to provide unfettered access for labor and materials during pier construction, during launching operations and during concreting of the decks. Impact on construction from rail operations is expected to be minimal once the trestle is constructed. The construction of the trestle itself will be subject to considerable disruption from rail operations. The construction of the trestle itself will be subject to considerable disruption from rail operations.

The cost estimates allow \$2.6M for construction and removal of the trestle to Pier G.

It is understood that work within the work zone can proceed independently of rail operations provided all construction work is kept a minimum of 10 feet from centerline of any active rail and provided railway flag persons are always present during working hours. See page 85 for the proposed work zone boundaries at Pier G.

It should be noted that all piers close to rail lines are massive and therefore require only 18 feet horizontal clearance from centerline rail to face of concrete.

2.5.5 Construction Methods

Launching a double deck truss structure such as this one is outside of the normal range of push-launched bridges because of the heavy weight involved and because of the concentration of loading. Specialized expertise will be necessary and it is probable that the actual launching equipment will need to be custom-fabricated for this project. The concepts are not unusual, but the scale is larger than usual. A concept for the custom launch gear is shown on page 81. This configuration launches in 5 foot strokes and allows rapid repetition of the launch strokes.

The launch will take place in two operations - pushing east over Pier G and pushing west over Pier H. The two sections will meet at midspan between Piers G and H. A temporary tower is not required between G and H. Details of the construction sequence are shown on pages 83 and 84.

Following launching of the two sides, the midspan would be connected (see page 80). Then the top chords would be post-tensioned. Finally, the bottom chords would be post-tensioned.

Once the steel skeleton has been completed from end to end, the forming, rebar installation and concreting of the decks would commence. The use of the maintenance traveler during forming and stripping would provide a work deck and also protection from debris dropping onto active rail lines. Stay in place metal formwork would eliminate the need to strip the formwork after the bridge is completed. Thus, the forming and stripping could proceed independently of all rail operations. Each

deck would be poured in a minimum of 7 discrete pours. All access to the forming and pouring would be from above - not requiring equipment or personnel on the ground in the rail yard.

A substantial work bridge over Mill Creek will be required during construction. It has to carry heavy cranes to erect the steel truss sections. Falsework in Mill creek for initial erection of truss sections will also be required.

It will be important to establish what operations, if any, during the launching and the deck construction could be considered as hazards to rail operations that would require coordination with the railroad and interruption of rail traffic below. It is clear that forming, concreting, and stripping need not be hazardous to operations in the yard. It is less clear at this point whether there actually is any time during launching that needs to be considered hazardous.

The truss will be launched in increments of about 90 feet long at a time. There will be about a two-week period between each launch as another 90 feet of truss is assembled in cantilever. Each launch increment of 90 feet would involve 18 to 20 individual pushes of some 5 feet at a time, each taking about 20 minutes. There would be about 40 minutes between pushes to allow the launch equipment to be re-set for the next push. This amounts to about 20 hours of launch activity every two weeks per cantilever.

The truss itself has no possibility of failure during launch since the stresses during launch are generally well below the in-service stresses. The hazard, if any, is that the launch gear could suffer a failure. To have some 20 individual operations per launch, any of which could be considered hazardous, is not very viable. If each launch had to wait for all train traffic immediately below to cease for 20 minutes, a nominally 20-hour operation could extend over several days, which is undesirable. This is better handled by requiring redundancy in the launch gear so that the failure of any component would not impair the structural integrity of the whole operation. Preliminarily, such redundancy is possible.

Ensuring that redundant critical components are actually present would require involvement in the review of the launching details by the design team. It is unlikely to be sufficient to rely on the contractor's system without thorough review by the design team. A proof of concept check from the design team would be necessary.

An alternative erection method for a double deck truss is to assemble the mid-section of the truss (Piers G to H) outside the yard and then to carry it in on SPMTs in a manner similar to what is proposed for the twin arches. The remaining portions could then be crane-erected in cantilever towards piers E and J using the temporary piers to keep the cantilever spans within reason. In this method there would need to be one shutdown of the entire yard for an 8 to 10-hour period. We understand that such a shutdown could only take place on Christmas Day or Thanksgiving Day. Once the steel skeleton is in place, the decks etc. would be cast conventionally.

2.5.6 Scheduling

A preliminary construction schedule is shown on page 86. The schedules presented are for "greenfield" working conditions (i.e. without consideration of the impacts from the rail yard). To the durations shown there has to be added an allowance for construction inefficiencies due to the "Railway Effect".

For this alternative, for the "Full Project" option, the greenfield schedule shows a duration of 45 months. It is estimated that the Railway Effect will add another 6 months to this duration.

In this schedule it has been assumed that the east and west portions of the truss structure will be under construction simultaneously. This is inefficient from the point of view of the launch gear cost since two sets of gear would be necessary, but it minimizes the length of time during which long cantilevers exist. It is efficient from the point of view of personnel and equipment utilization. Simultaneous construction may not be the approach of choice for a contractor.

In the schedule, allowance has been made for one push-launch of 90 feet to be done every 2.9 weeks. This is the two-week cycle described above plus an allowance for unforeseen delays due to resource balancing etc.

2.5.7 Interface with I-75

For the sake of completeness, it has been necessary to make some assumptions about the timing of the interface between WHV construction and the planned reconstruction of I-75. It is unclear at this time whether I-75 will go first, WHV will go first or both will proceed together. This report has been based on the assumption that WHV will proceed to completion before I-75 is reconstructed. In this case it will be necessary to do some considerable work on I-75 near the WHV in order to make the interchange work in the time period before the full reconstruction of I-75 is undertaken. This is discussed more fully in Section 3 of this report.

The closure times for the I-75 connections and for the local traffic connections at the east end can be kept to a minimum through the expedient of an early regrading of the existing I-75 mainline near the new WHV. This requires a 30-hour closure of I-75.

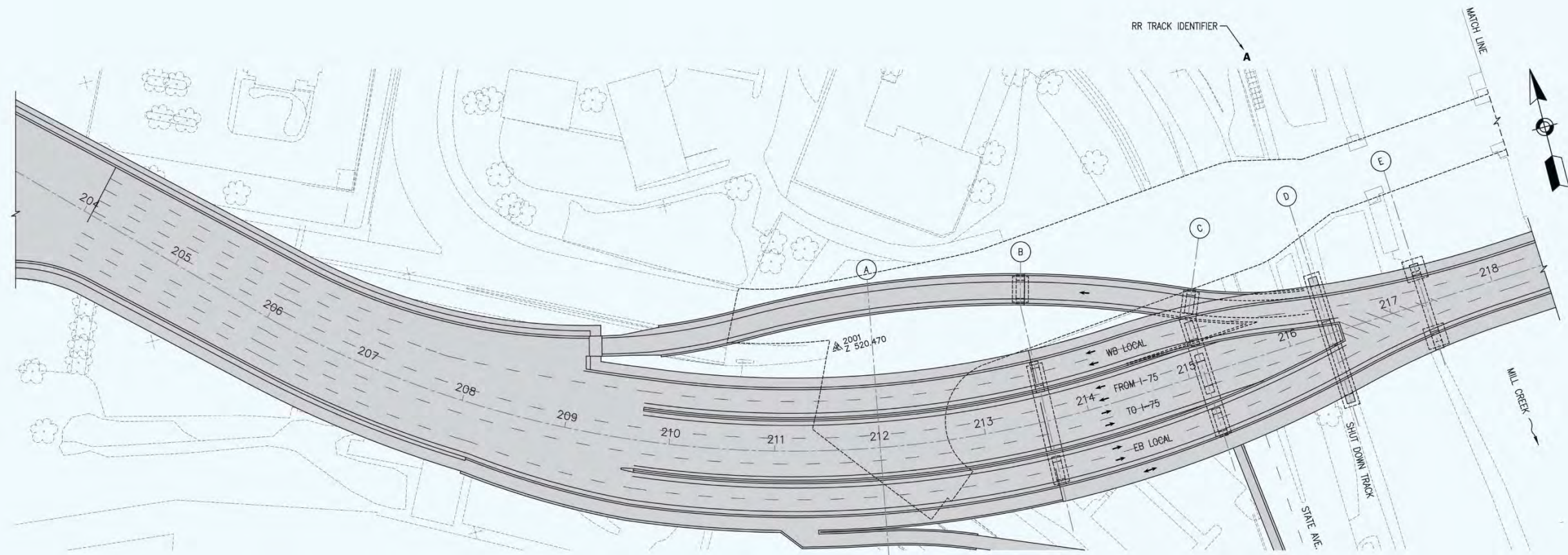
The schedule assumes a (suboptimal) temporary detour for the I-75 SB on-ramp will be implemented so as to minimize the closure time of this ramp.

2.5.8 Other Items

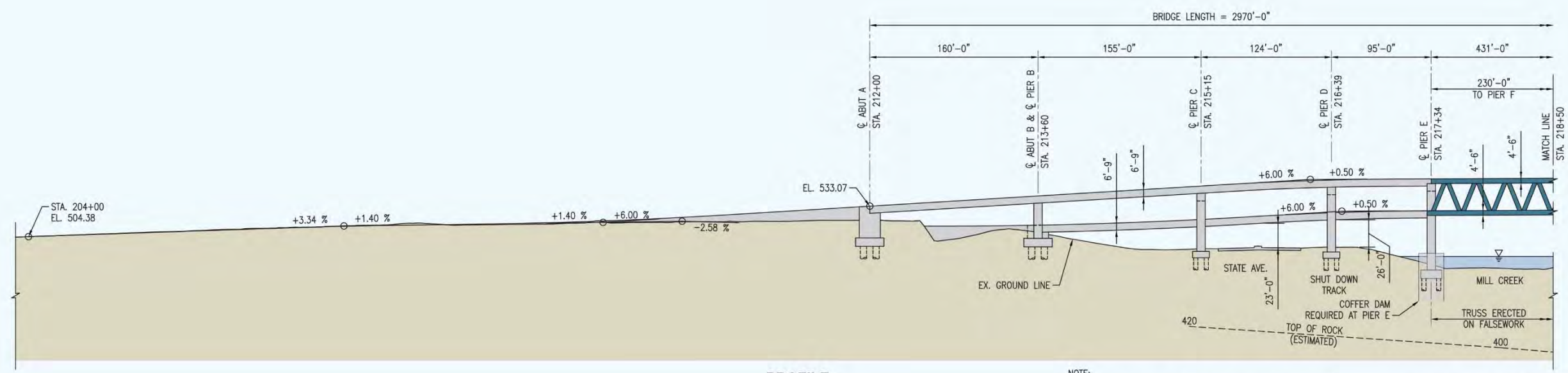
A maintenance and inspection traveler will be required below the lower deck. Its use should not impose restrictions on rail operations and whether the use of the traveler should be independent of rail operations. A minimum of four feet of vertical clearance would be necessary over the operating railyard. The profile as now set allows greater than 27 feet of clearance from rail top. This is 4 feet greater than the 23 feet clearance which is the CSX minimum standard, but only 2 feet greater than the 25 feet clearance requested by CSX. It has been presumed that railyard operations would not be affected with a 23 feet clearance below the traveler.

The CSX through line at the western edge of the yard (Line B) is proposed to be relocated so the contractor can have direct and uninterrupted access to temporary Pier F and for uninterrupted access to build the truss structure for launching

The high-tension line crossing the railyard will have to be relocated, as is the case with all alternatives.



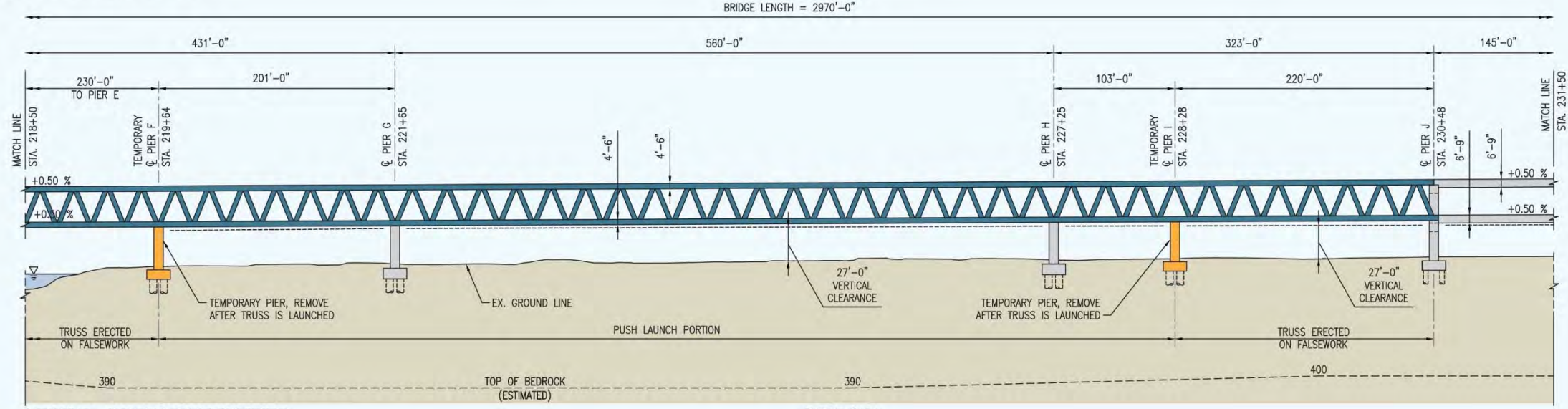
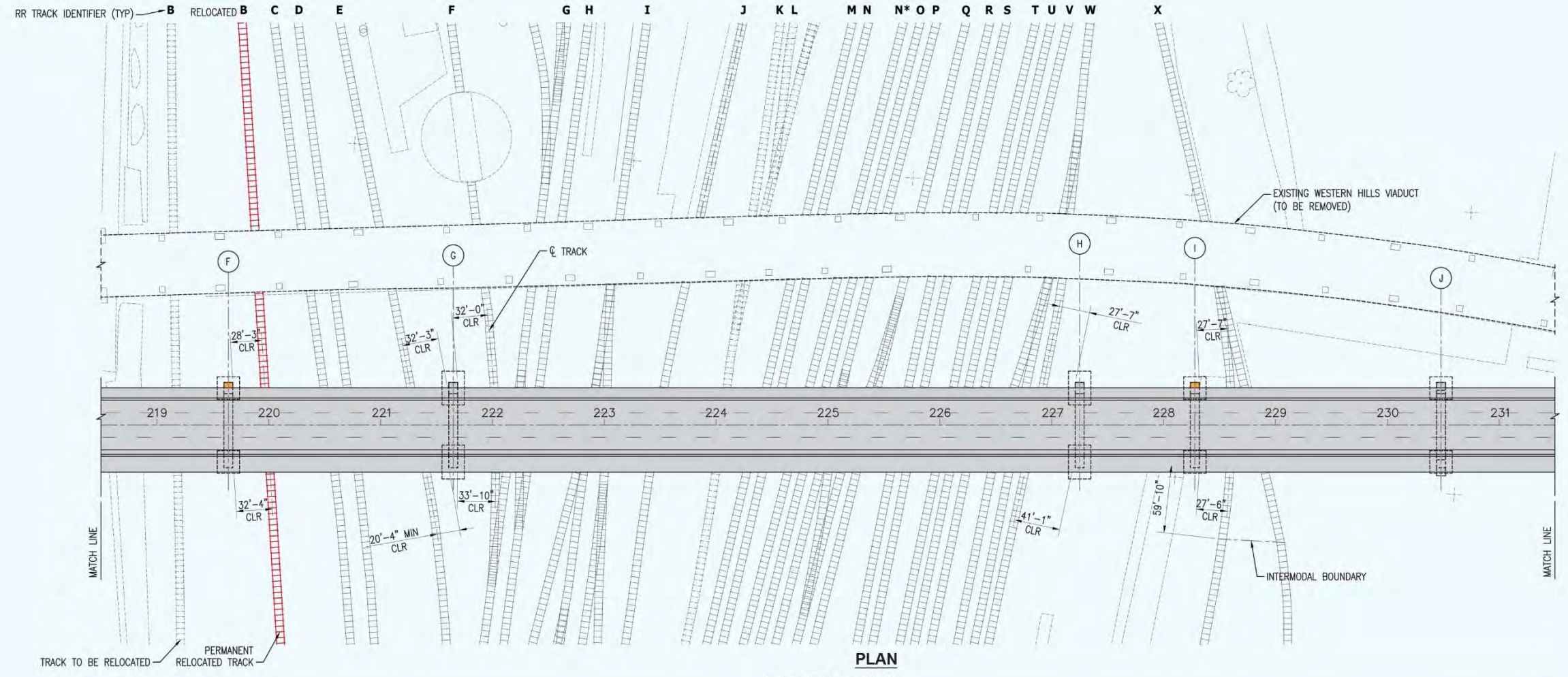
PLAN



PROFILE

NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

Long Span Push Launch
Site Plan 1 of 3

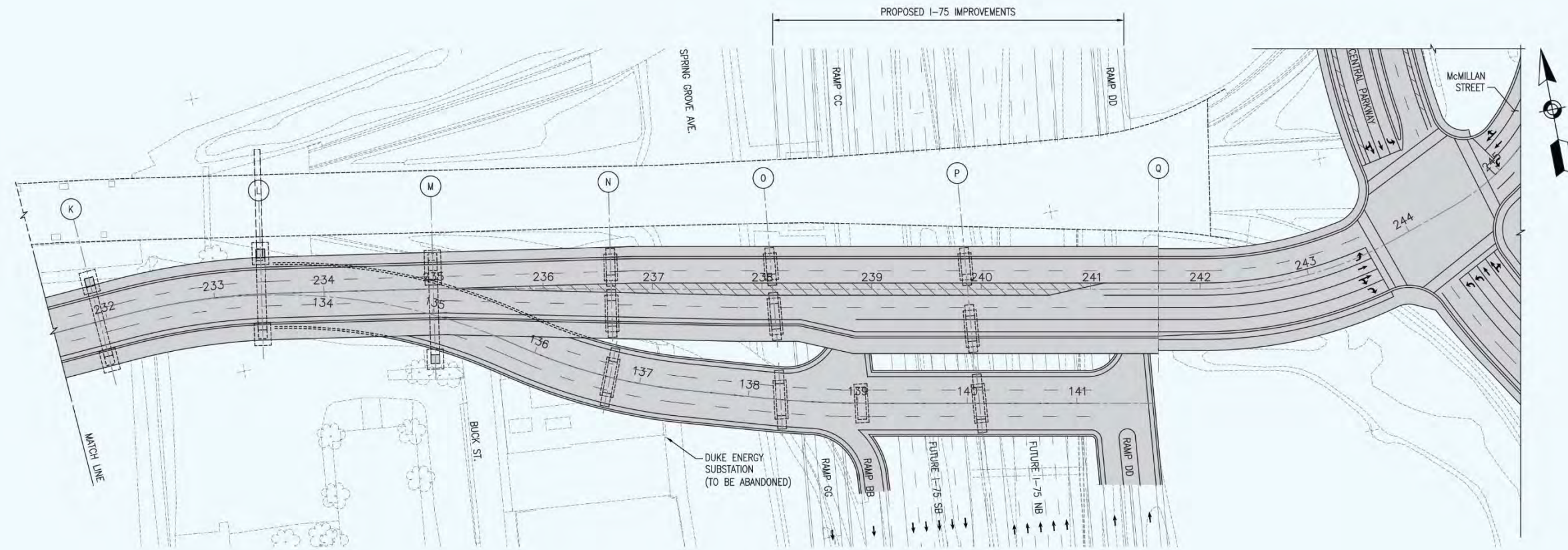


LEGEND - RR TRACK IDENTIFIER

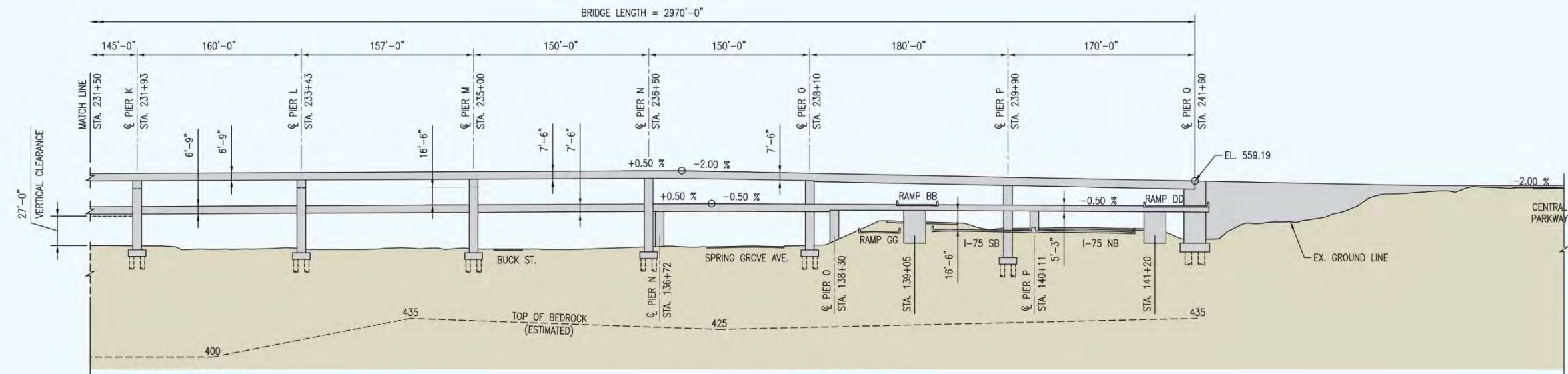
A - CSX (OUT OF SERVICE)	G - CSX LOCOMOTIVE TRACK	M - CSX LONG DEPARTURE TRACK	S - CSX MAIN LINE
B - CSX MAIN LINE	H - CSX WEST OPEN TRACK	N, N* - CSX LONG DEPARTURE TRACK	T - CSX RAMP TRACK
C - CSX RECEIVING TRACK	I - HUMP TRACK	O - NS TRACK	U - CSX RAMP TRACK
D - CSX RECEIVING TRACK	J - CSX EAST OPEN TRACK	P - NS TRACK	V - CSX RAMP TRACK
E - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	Q - NS TRACK	W - INTERMODAL TRACK
F - CSX LOCOMOTIVE TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	R - CSX MAIN LINE	X - GANTRY CRANE TRACK

PROFILE

Long Span Push Launch
Site Plan 2 of 3



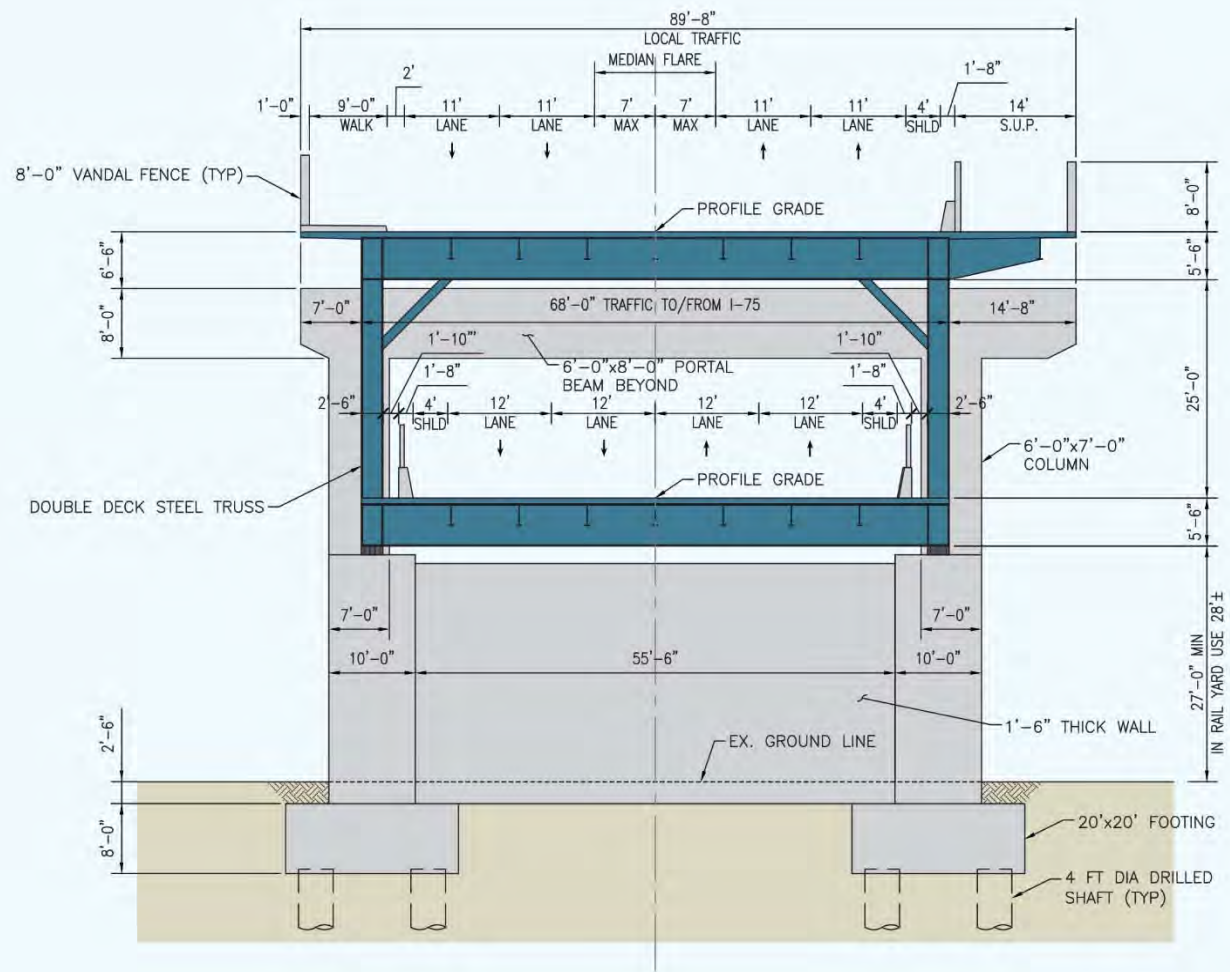
PLAN



PROFILE

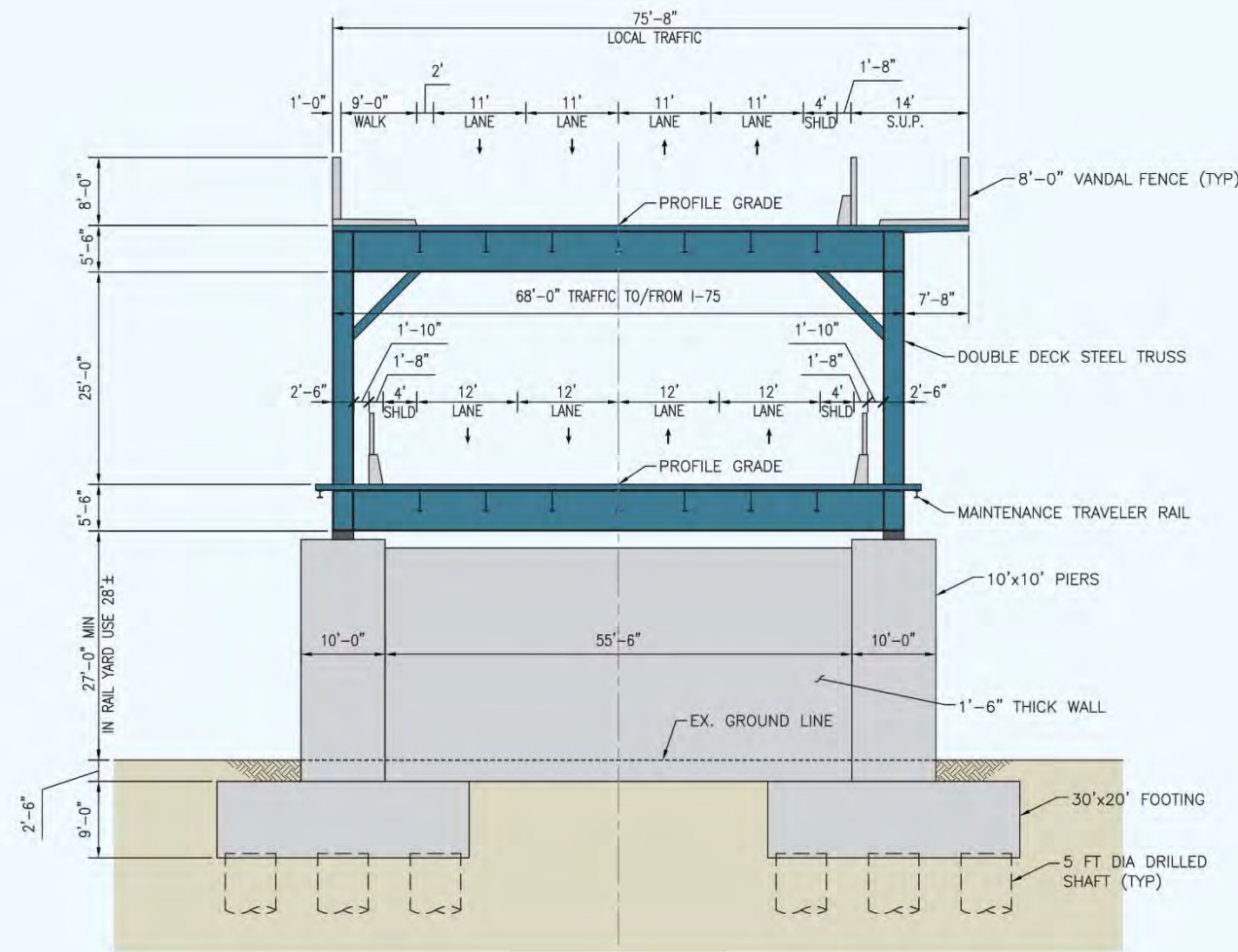
- LEGEND - RAMPS**
- RAMP AA - FUTURE RAMP FROM I-75 NB/WHV
 - RAMP DD - FUTURE RAMP FROM BANK STREET TO I-75 NB
 - RAMP CC - FUTURE RAMP FROM I-75 SB/WHV
 - RAMP GG - FUTURE RAMP TO FINDLAY STREET
 - RAMP BB - FUTURE RAMP TO I-75 SB

Long Span Push Launch
Site Plan 3 of 3

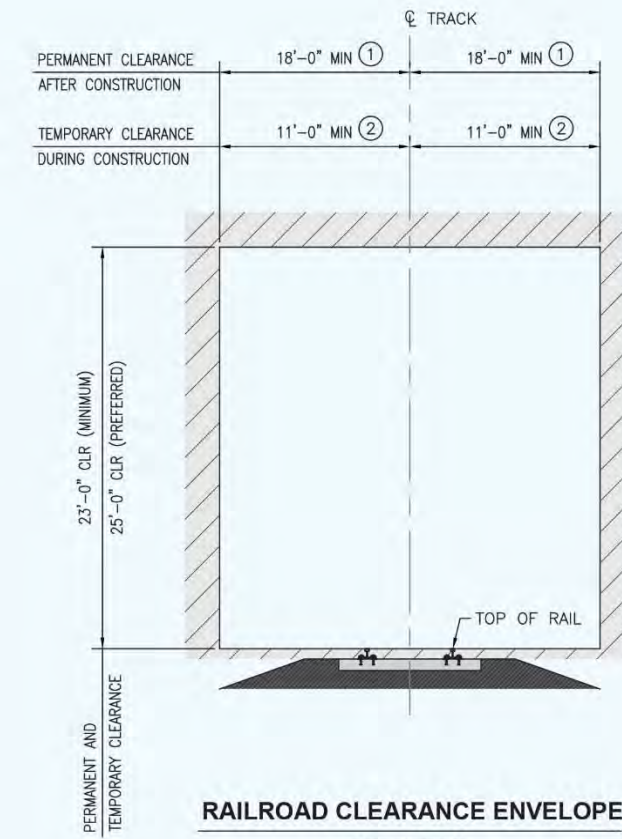


**SECTION NEAR FLARED UPPER DECK AT WEST END
(SHOWN AT PIER E)**

Long Span Push Launch
Typical Sections 1 of 4



SECTION AT PIERS G AND H
PIERS F & I ARE TEMPORARY PIERS AND ARE SMALLER

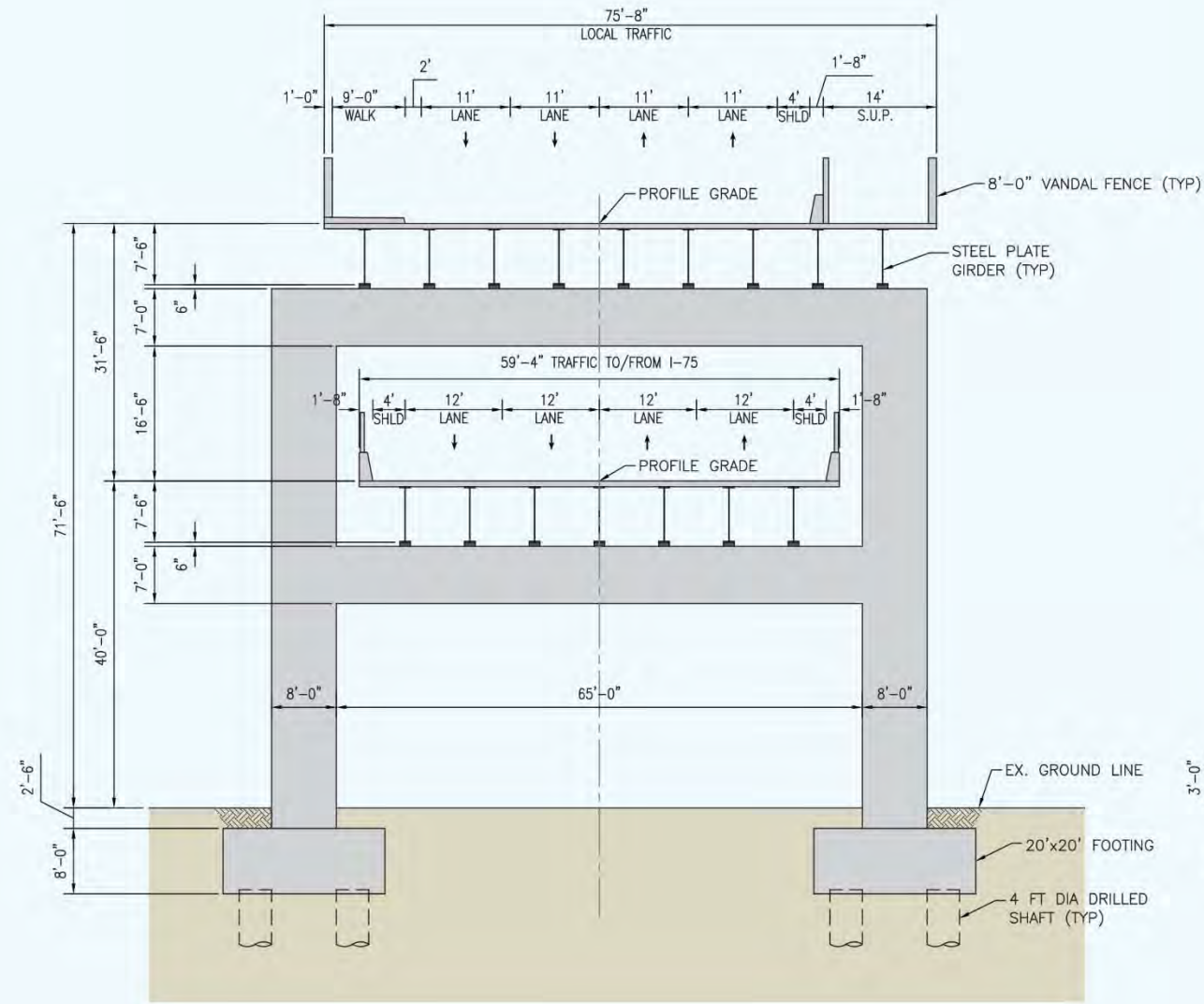


RAILROAD CLEARANCE ENVELOPE

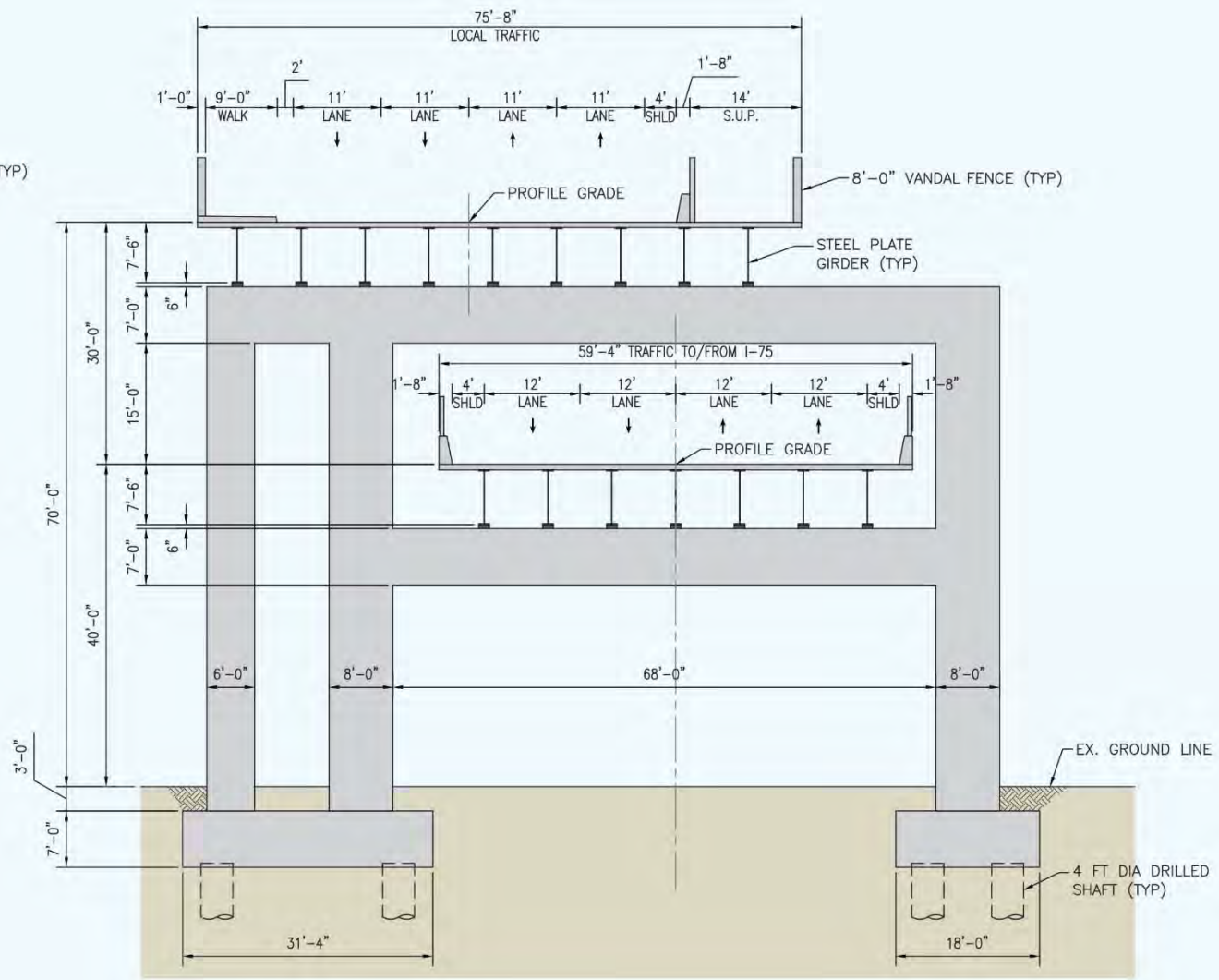
(NOT TO SCALE)

- ① 25'-0" PREFERRED. HORIZONTAL CLEARANCE LESS THAN THE 25'-0", CRASH WALL PROTECTION MAY BE REQUIRED UNLESS ADJACENT PIER CROSS-SECTION DIMENSIONS ARE NO LESS THAN 2'-6" THICK x 20'-0" LONG (MEASURED ALONG DIRECTION OF TRACK).
- ② FOR A TEMPORARY WALKWAY AND HANDRAIL SYSTEM A MINIMUM CLEARANCE OF 12' SHALL BE PROVIDED.

**Long Span Push Launch
Typical Sections 2 of 4**

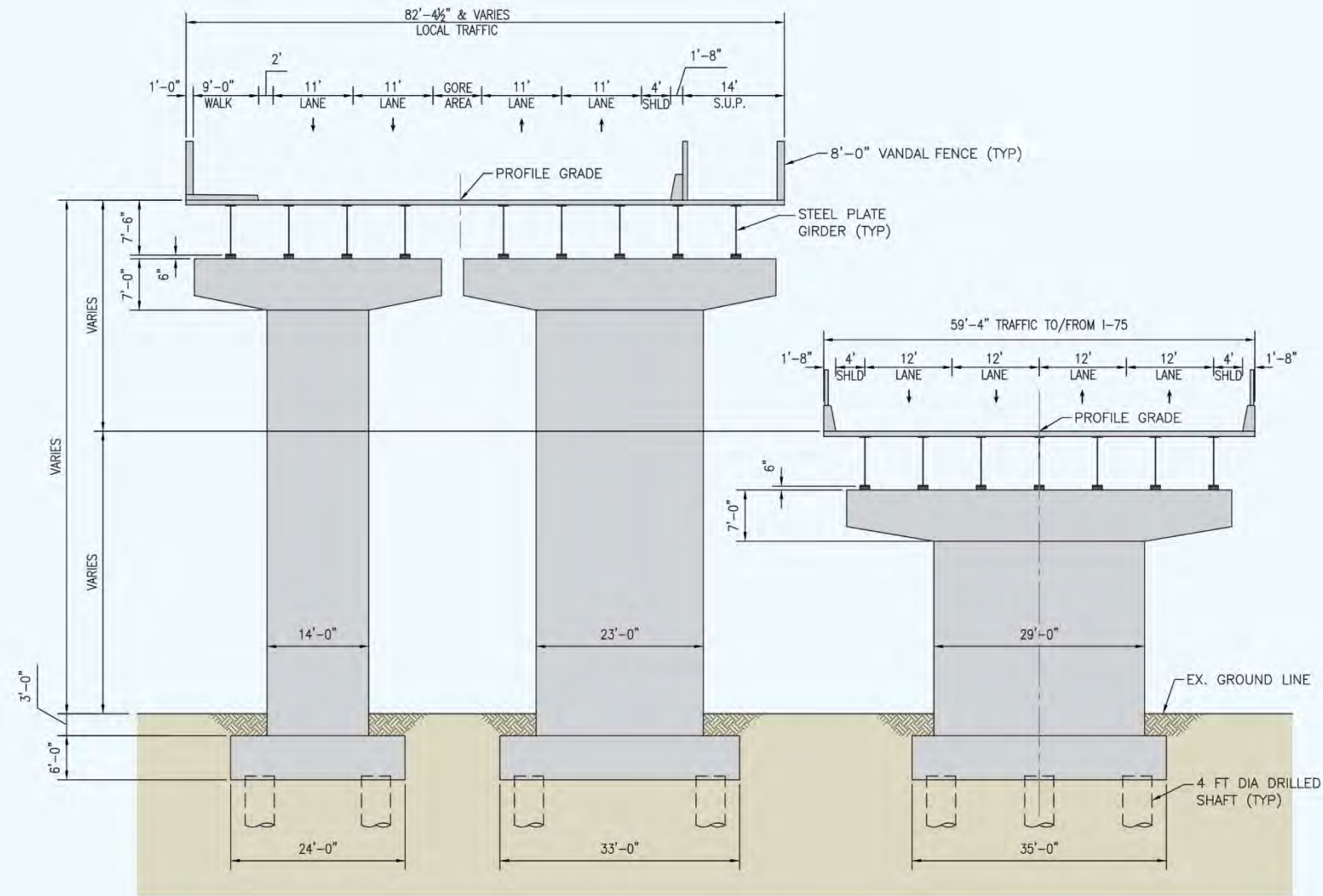


**SECTION AT PIERS K AND L
(PIER L SHOWN)**



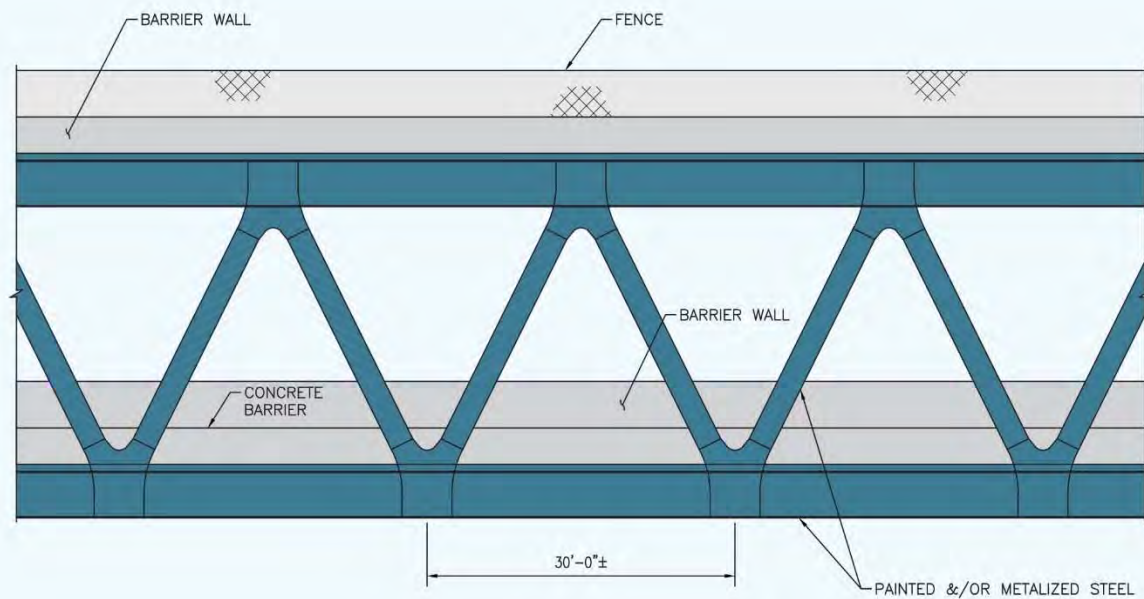
SECTION AT PIER M

Long Span Push Launch
Typical Sections 3 of 4

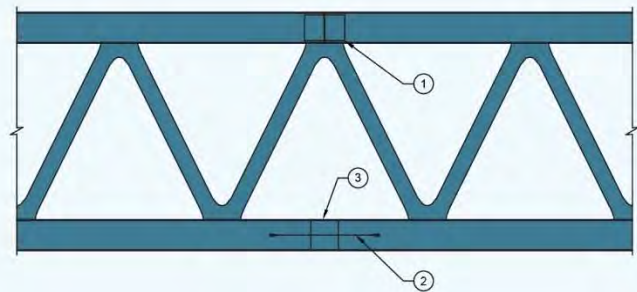


SECTION AT PIERS N THRU P
(PIER N SHOWN)

Long Span Push Launch
Typical Sections 4 of 4

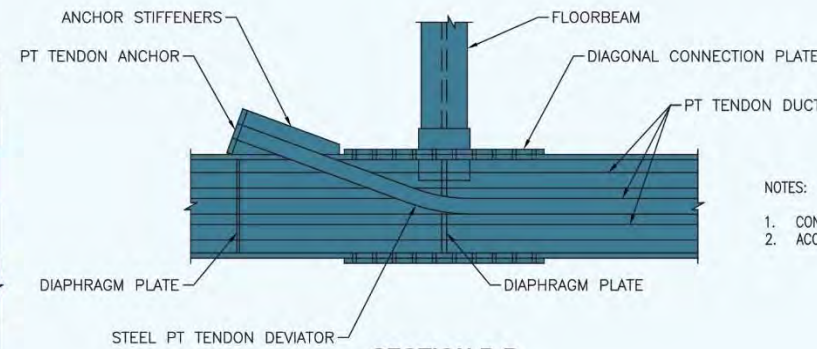


TRUSS ELEVATION



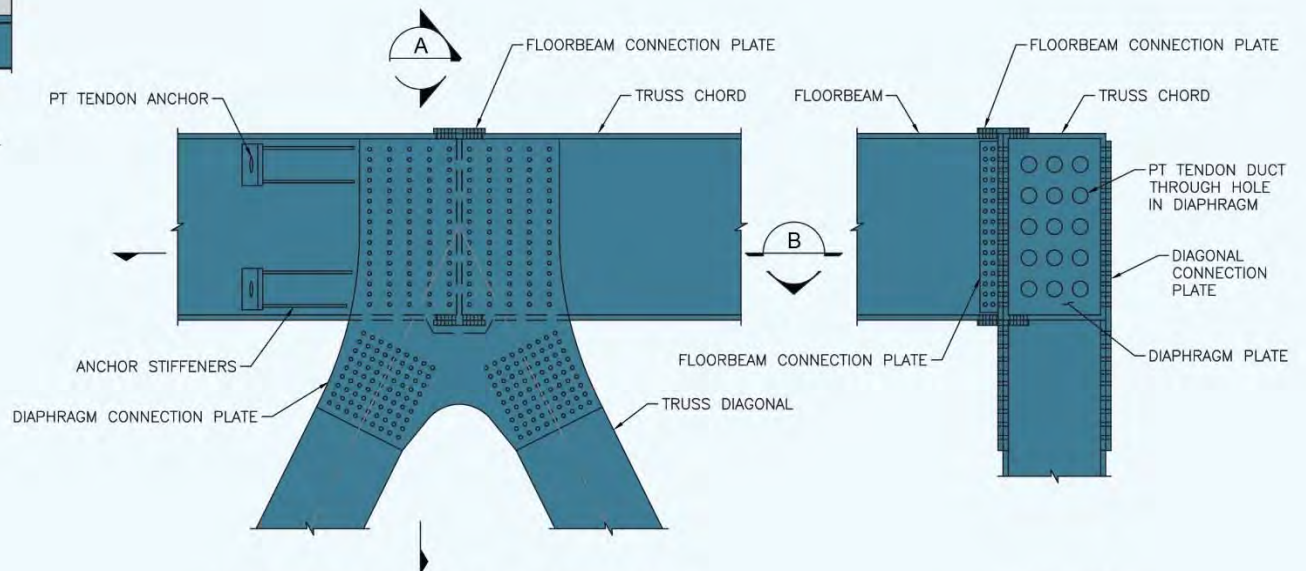
MID-SPAN CONNECTION SEQUENCE CONCEPT

1. CONNECT UPPER CHORD
2. STRESS LOWER CHORD TO CLOSE GAP
3. CONNECT LOWER CHORD



SECTION B-B

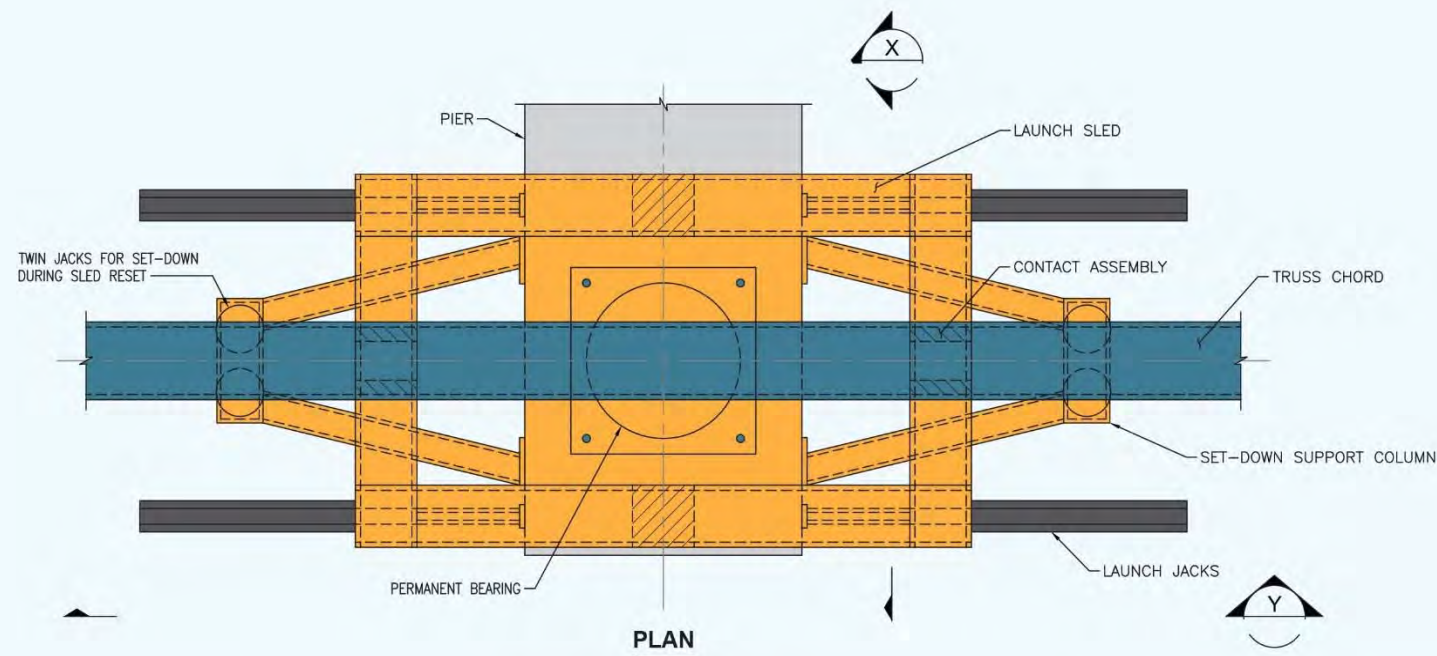
- NOTES:
1. CONCEPTUAL CONNECTION SHOWN
 2. ACCESS HOLES IN CHORD REQUIRED ON INSIDE OR BOTTOM FACES



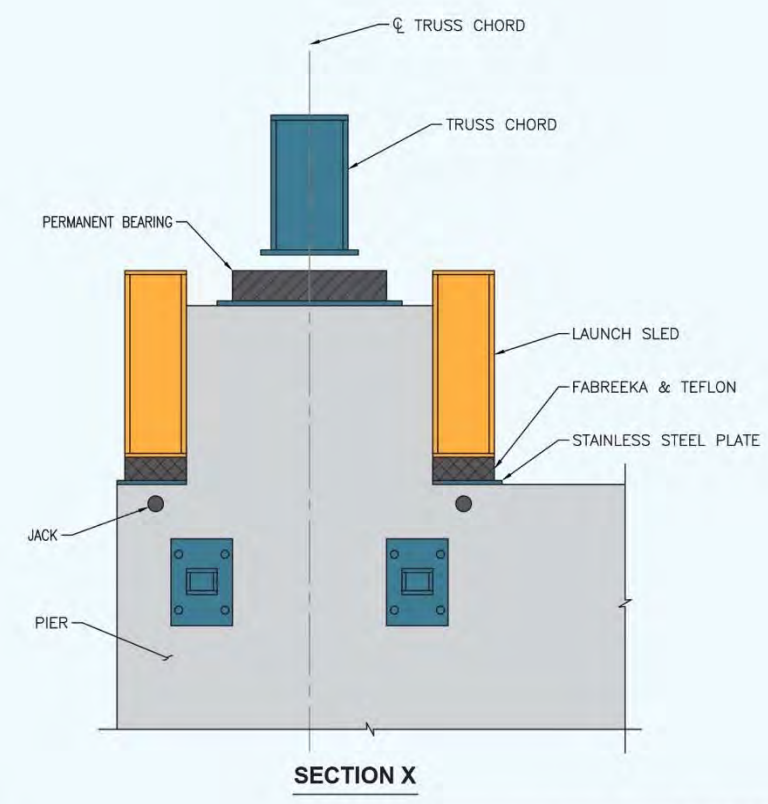
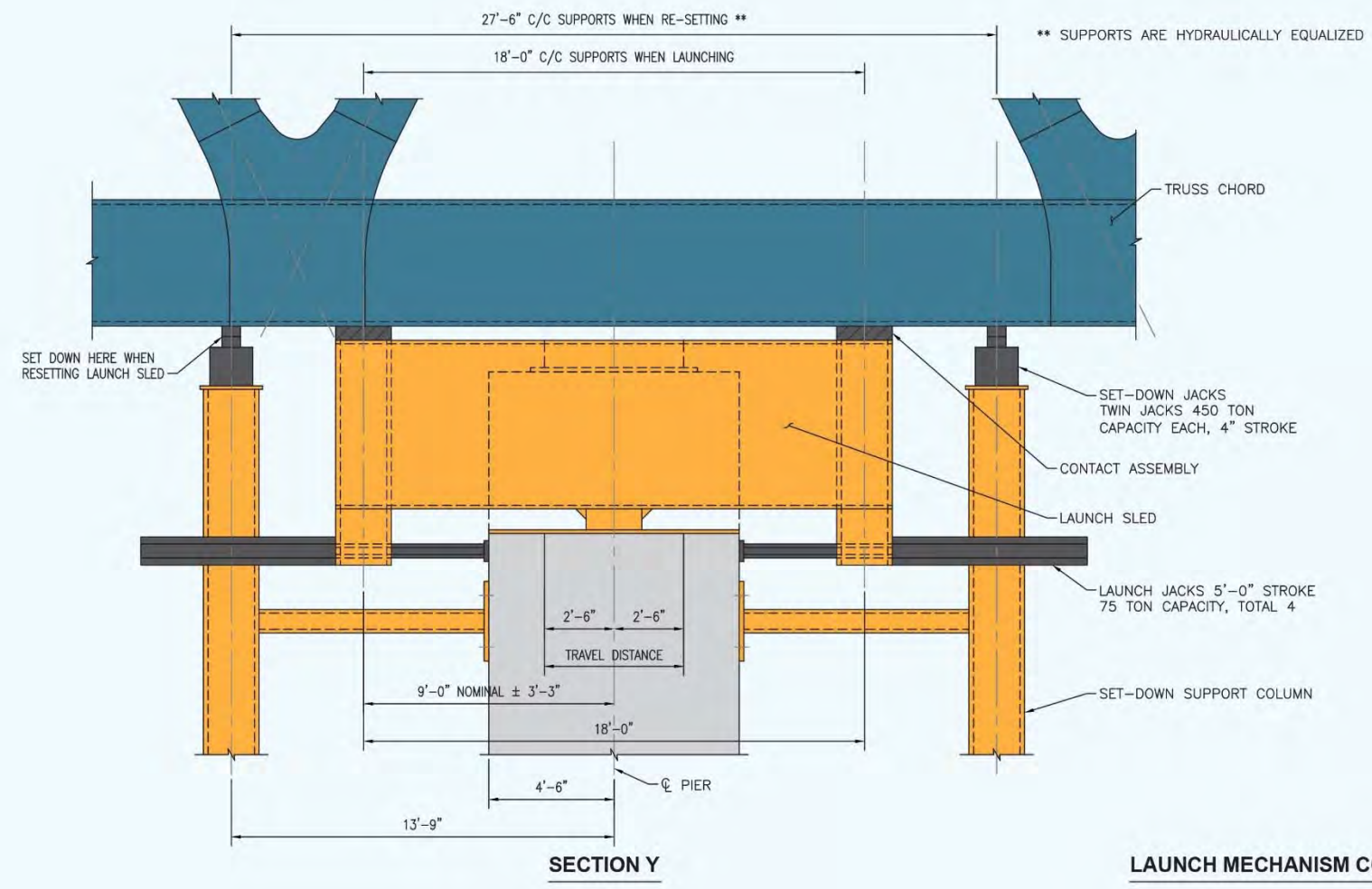
TOP CHORD INTERIOR CONNECTION DETAIL

SECTION A-A

Long Span Push Launch
Construction Method 1 of 5

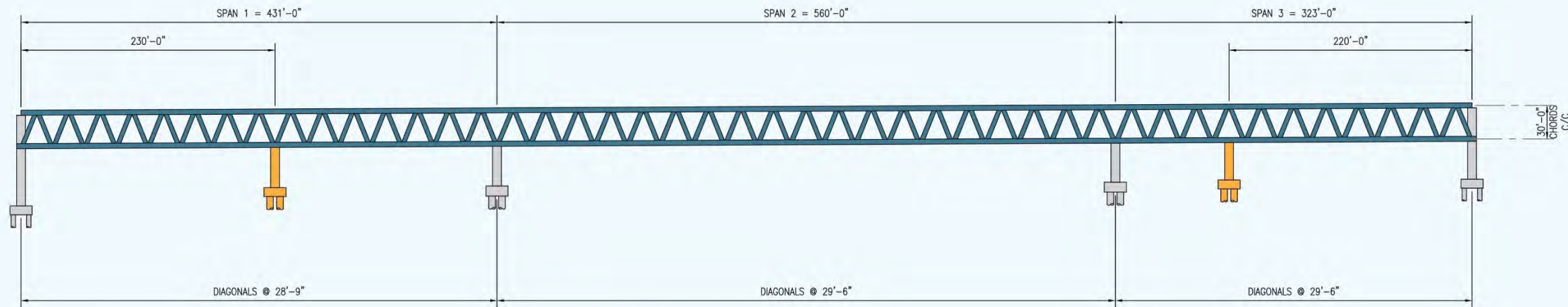


- CYCLE DESCRIPTION:
1. TRUSS IS SUPPORTED ON SET-DOWN JACKS.
 2. BACK-UP LAUNCH SLED TO 2'-6" OFF CENTER.
 3. LOWER TRUSS ONTO LAUNCH SLED AND RETRACT SET-DOWN JACKS.
 4. ADVANCE TRUSS 5'-0" BY MOVING LAUNCH SLED.
 5. PICK TRUSS UP ON SET-DOWN JACKS. REPEAT THE CYCLE.
- NOTE: SET-DOWN JACKS ARE HYDRAULICALLY EQUALIZED.



LAUNCH MECHANISM CONCEPT

**Long Span Push Launch
Construction Method 2 of 5**



PRELIMINARY WEIGHT OF STRUCTURAL STEEL:

TRUSS STRUCTURE	6950 TONS
DECK STRUCTURE	1850 TONS
MISC STEEL	500 TONS
TOTAL	9300 TONS

DOUBLE DECKER TRUSS ALTERNATIVE

TOP CHORD:	4.50' H x 2.50' W FLANGES: 1.50" TO 2.00" WEBS: 1.75" TO 2.00"	
BOTTOM CHORD:	4.50' H x 2.50' W FLANGES: 1.50" TO 3.00" WEBS: 1.75" TO 3.00"	
DIAGONALS - APPROX. EQUAL NUMBER OF COMPRESSION ONLY AND TENSION ONLY DIAGONAL MEMBERS AT EOC		↑ ↑
DIAGONAL (COMPRESSION):	2.50' H x 2.50' W FLANGES: 1.00" TO 2.00" WEBS: 1.00" TO 2.00"	
LAMINATE TENSION DIAGONAL MEMBERS 2 PER LOCATION WITH APPEARANCE OF SINGLE MEMBER DESIGNED FOR REDUNDANCY TO ELIMINATE FCM		
DIAGONAL (TENSION):	2.50' H x 1.17' W CHANNEL FLANGES: 1.00" TO 3.00" WEBS: 1.00" TO 3.00"	

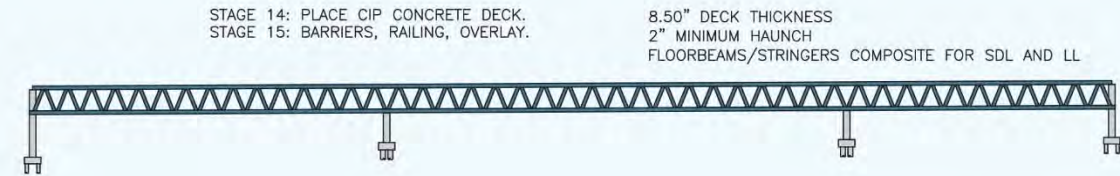
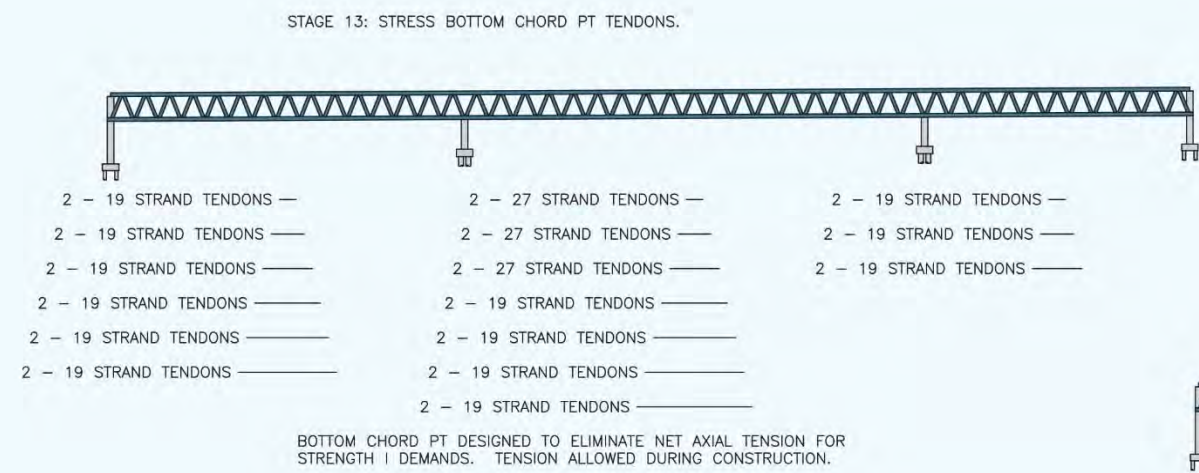
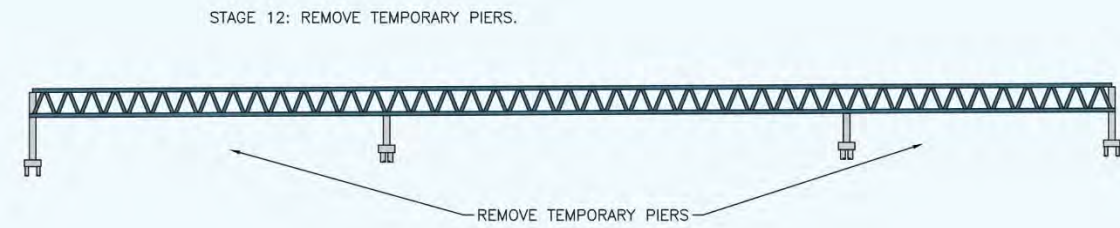
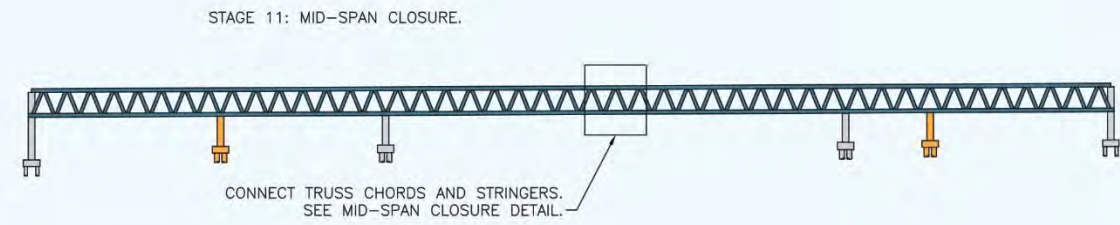
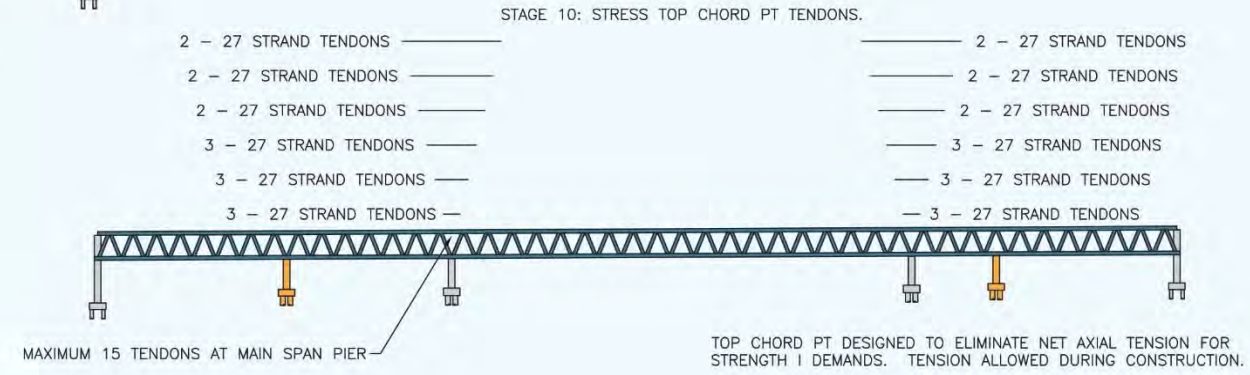
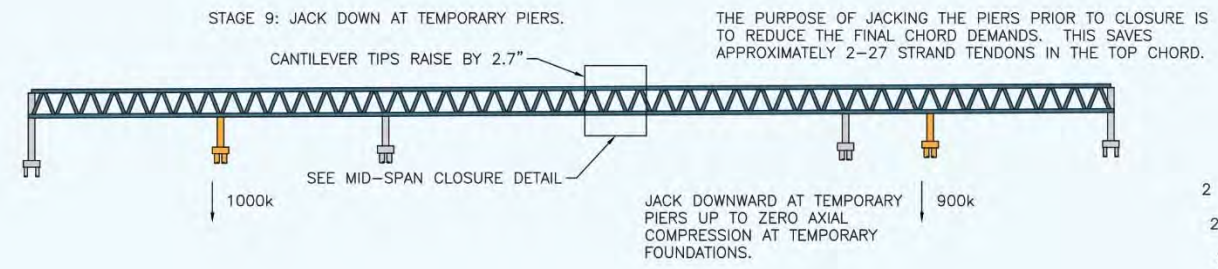
NOTE:
TOP AND BOTTOM CHORDS HAVE INTERNAL POST-TENSIONING TO OFFSET TENSIONS AND AVOID FRACTURE CRITICAL DESIGN ISSUES.

APPROX. 200 TONS OF 0.6" DIA STRANDS FOR THE WHOLE BRIDGE.

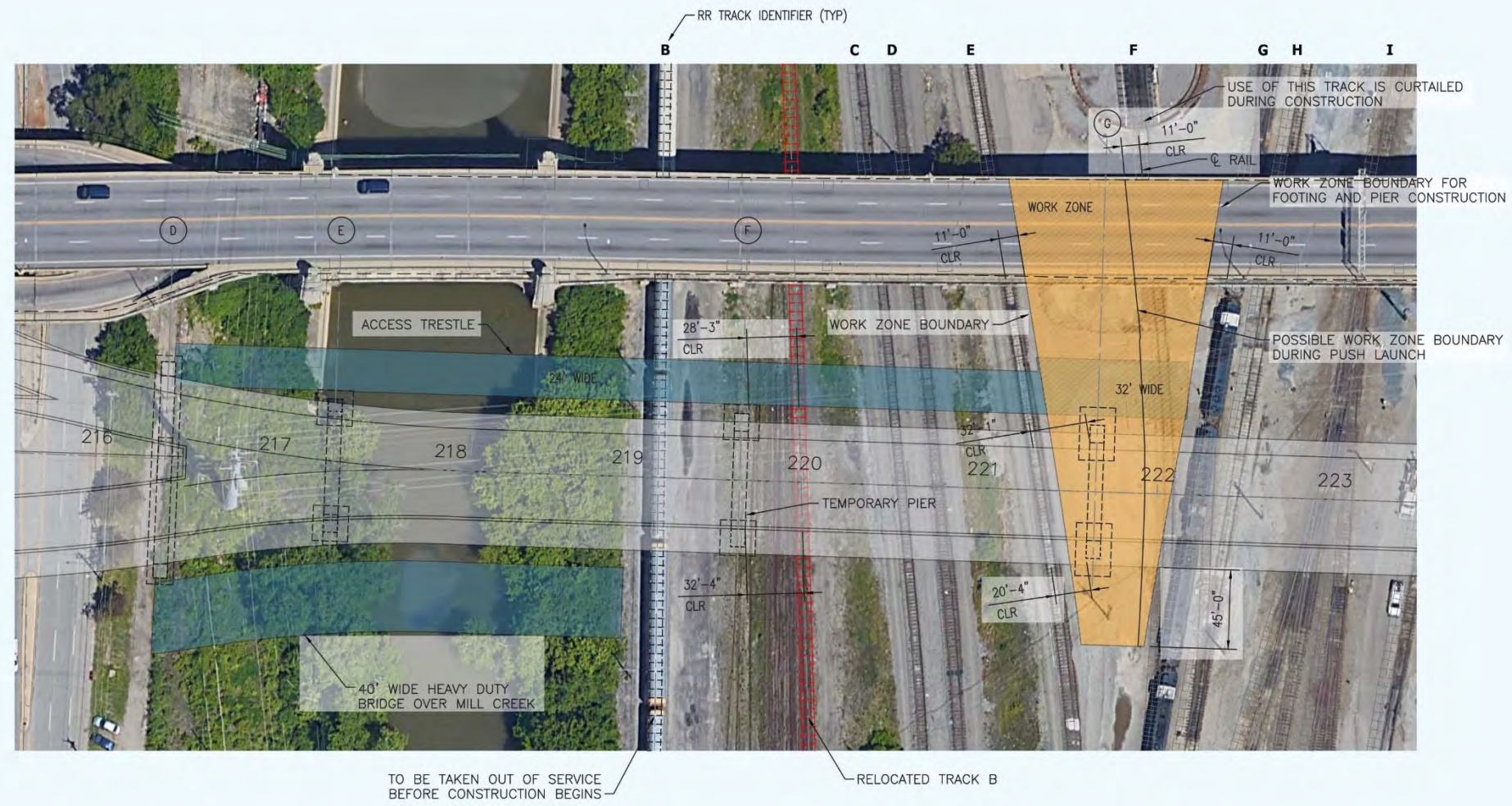
Long Span Push Launch
Construction Method 3 of 5



Long Span Push Launch
Construction Method 4 of 5



Long Span Push Launch
Construction Method 5 of 5



PLAN

LEGEND - RR TRACK IDENTIFIER

A - CSX (OUT OF SERVICE)	I - HUMP TRACK	Q - NS TRACK
B - CSX MAIN LINE	J - CSX EAST OPEN TRACK	R - CSX MAIN LINE
C - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	S - CSX MAIN LINE
D - CSX RECEIVING TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	T - CSX RAMP TRACK
E - CSX RECEIVING TRACK	M - CSX LONG DEPARTURE TRACK	U - CSX RAMP TRACK
F - CSX LOCOMOTIVE TRACK	N, N* - CSX LONG DEPARTURE TRACK	V - CSX RAMP TRACK
G - CSX LOCOMOTIVE TRACK	O - NS TRACK	W - INTERMODAL TRACK
H - CSX WEST OPEN TRACK	P - NS TRACK	X - GANTRY CRANE TRACK

**Long Span Push Launch
Work Zone and Access Trestle at Pier G**

2.6 Cable-stayed Bridge (Twin Tower Option)

2.6.1 Introduction

A large number of possible cable-stay and tower configurations have been suggested for this alternative. The costs for a cable stayed bridge can vary greatly depending on whether the geometry and the details are simple or complex. For the purpose of this study, a structurally straightforward stay cable configuration and a simple tower geometry have been used. Sufficient details have been developed to allow a consistent construction process to be described and scheduled.

Two possible basic configurations have been considered for the cable stayed alternative. One uses two towers and spans clear across the busy portion of the yard (Twin Tower Option). The other uses a single tower located near locomotive Track F which is within the rail yard (Single Tower Option).

The Twin Tower option is favored and that is what is described herein. A single tower cable-stayed solution is briefly described in the next section.

For this alternative, the geometry of the site limits the back-span length and results in a suboptimal structure that requires extensive ballasting in its back-spans. Part of the required ballast effect would be achieved by having the adjacent approach spans rest upon the main structure back-spans thereby providing hold-down reaction. This will not provide all the reaction that is required and so substantial purpose-built ballast will also be necessary.

The bridge is a double decked structure with the upper deck carrying local traffic (eastbound and westbound) and the lower deck carrying traffic to and from I-75.

Plan and profile drawings for the structure are shown on pages 91 to 93. The span lengths are 320 feet, 770 feet and 320 feet. The structure's main span extends completely across the rail yard. The towers are located outside the rail yard where the tower construction will not be affected by, or have an effect on, major rail yard operations. Construction of the east tower (Pier E) will result in some small restrictions to the intermodal operations during construction.

Even though the structure spans across the busy portion of the rail yard, its construction will require the temporary, short-term interruption of each of the rail lines in the yard so as to avoid hazards to rail traffic from work overhead. These required interruptions are described in more detail in the Section 4 in this report.

2.6.2 Alignment Description

Previously it was found that the Duke Energy substation could be left where it is, undisturbed, and the new WHV threaded to the north of the Duke property as a double deck structure. However, it now appears that Duke Energy will be relocating and so more room is available for the new viaduct at this location.

Separating the local traffic bridge from the I-75 traffic bridge is desirable from the traffic point of view, it provides an opportunity to more easily stage the project and it will be easier to contractually

separate the I-75 traffic bridge from the rest of the work. Accordingly, we have revised the alignment near I-75 to take advantage of this opportunity.

The alignment is a double deck alignment over most of the structure length, from State Avenue towards Central Parkway. Close to I-75 the I-75 traffic structures and the local traffic structures separate in plan.

A vertical transition to two traffic levels has to happen at the west end of the project. West of State Avenue, elevated ramps are required to allow the upper deck traffic to merge with the traffic from the lower deck. Because the transition cannot be started on the double deck cable-stayed structure (it is not practical to widen the structure itself or to start profile separation within the structure length), it has proven necessary to add one more ramp at the west end to give the lower deck traffic that will eventually be turning right, sufficient time to achieve this movement, see page 91. The ramp would be constructed after traffic is transitioned to the replacement viaduct and the existing viaduct is demolished.

The upper deck flare at the west end starts in Span B-C, once it is clear of the main structure and its stay cables.

The use of a cable-stayed bridge structure requires that the alignment be straight from Pier C to Pier F. As it is laid out in this study, in order to minimize infringement on the north end of the intermodal operations, a relatively sharp curve in Span F-G results, see pages 91 and 92. If desired, this curve can be eased by moving the east end of the main structure to the south at Pier F. This will cause more infringement on intermodal operations but will result in improved roadway geometry.

There is no reasonable way that this alternative can have its construction staged since very little of the total project can realistically be delayed.

2.6.3 Structural Considerations

The main structure consists of a double-deck steel truss carrying the upper and lower roadways. Stay cables could be quite widely spaced, at approximately 60 feet centers along the deck, because the truss is so stiff. However, redundancy considerations (in the event of failure of a stay cable) suggest that a closer spacing would be preferable. There are also aesthetic benefits to using a closer spacing. Accordingly, a spacing of approximately 30 feet horizontally has been used.

This structure is unusual and suboptimal in that the back-spans are shorter than they should be to balance the long main-span. The road geometry does not permit lengthening of the back-spans at the west end because the cable-stayed structure has to end before the gore where eastbound and westbound traffic start to separate. At the east end the backspan is too short because the requirement to minimize impact on the intermodal operations does not permit Pier F to be moved any further to the east. As a result, the back-spans will have to be ballasted to hold the structure down at Piers C and F. It is currently estimated that the ballasting requirement will be of the order of 1200 tons each at Piers C and E. About half the requirement can be mobilized by having the approach spans rest upon the backspans of the cable stayed structure but the remainder must be provided as ballast. This ballast weight is about 300 cubic yards of concrete at each location (66 feet x 25 feet long x 2.5 feet thick x 2 decks).

The cross section selected is shown on page 95. Some preliminary structural details are shown on page 95. Tower shapes considered are shown on page 98.

The truss chords are, for the most part, strongly in compression due to the force from the stay cables. Also, the chords will develop little flexure in service. Therefore, there are very few significant fracture-critical considerations that affect the truss chord design. As well, for the chords themselves, there are very few onerous fatigue design limitations that need to be considered. Therefore, compact and economical welded connections can be used. Page 101 shows a sample detail of the typical node and stay cable anchorage connection in the truss.

The tension diagonals, however, do require fracture-critical detailing and design. Since these members are not heavily loaded in service conditions, it is expected to be feasible to design for fracture criticality in these members through load path redundancy considerations and/or through the addition of material in order to lower stress levels. The economic cost of these measures will not be large.

For economy, it is desirable to have the stay cables in nearly the same plane as the trusses so as to avoid the complications and expense of outriggers and/or stay cable deviators. The geometry selected keeps the deviation from the plane of the trusses to less than approximately 1 in 8.

It is necessary to break the trusses down into shippable components. To preserve the integrity of the welded node connections it is suggested that the trusses be divided using mid-height bolted splices in all the diagonal members. As well, it is necessary to splice the chords at frequent intervals to allow erection of the trusses to be done in modular units of manageable size. The truss elevation detail shown on page 95 shows a concept that divides the trusses into segments 45 feet long with the diagonals spliced at mid height to keep the fabricated sections within shippable limits. This creates a unit height of 17.8 feet, which can be shipped by rail, or which can be shipped by truck on the flat as an over-sized load. Alternatively, two bolted splices could be used in each diagonal and the shipping height reduced to less than 11 feet.

The concept for the tower that is considered is shown on page 95. The essential feature is that the upper tower legs, where the stay cables attach, are directly in line with the plane of the stay cables. It is also necessary to create an opening at least 50 feet high above the upper deck to allow space for truss segment delivery and thereby to permit erection in cantilever over the rail yard.

Two alternate tower concepts are shown on page 98. The cost of any of these tower shapes will not be greatly different.

The approach structures, east and west, are seen as being conventional concrete deck on steel plate girder structures.

For the purposes of this report, cast-in-drilled-hole concrete piles (caissons) have been shown as the deep foundations for all the footings. Driven steel H-piles are also possible and would likely be faster and less expensive.

Should this alternative, or any steel option, advance further in the design development process it is recommended that a cost-benefit study be done relating to the use of metalizing, rather than painting, the exterior surfaces to reduce life-cycle costs from repainting. There is some credible evidence that metalizing of weathering steel, though initially costlier, is in fact more economical in the long run for structures that are intended to have a long service life.

A preliminary estimate of structural steel quantities for this alternative is:

- Structural steel in the cable-stayed structure
 - Truss steel incl. 15% detail 3100 US tons
 - Deck structural steel incl. 15% detail 2100 US tons
 - Misc. structural steel 400 US tons
 - Stay cables incl anchors 350 US tons

2.6.4 Work Affecting the Rail Yard

Even though the cable-stayed structure does not need any support within the busy portion of the rail yard, there are still significant interactive restrictions on both rail and construction operations that are inevitable with this type of structure. The most significant type of interaction occurs when structural steel truss sections are being installed and there is a hazard from falling components. It is suggested that a "hazard zone" comprising the length of the component that could fail, plus a 1.0V:0.25H addition all around would, be an appropriate definition. This is illustrated on page 99.

The erection of the large truss sections anticipated cannot be accomplished in short durations of 1 to 3 hours and also cannot be stopped and re-started at will. Therefore, it will be necessary to interrupt all affected tracks in any particular Hazard Zone for periods of up to 8 hours at a time while a segment of truss is being delivered and installed. This can be shortened to a duration of 4 hours per segment if it is contractually stipulated that all segment erection must allow for a safe secondary means of support to be activated immediately that the segment is correctly oriented and before bolting up can start. A further interruption of about 4 hours will also be required for the advancement of the erection gantry/traveler. Interruptions will progress across the rail yard as the truss sections are being installed in cantilever. Once cantilever erection has passed any particular point, there is no further hazard from the erection process because the cantilevering structure can be made as safe as any completed structure would be.

The anticipated erection cycle is shown schematically on page 99. The estimated durations for each sub-operation are shown and the time in which the existence of a hazard would require track interruption is also indicated. It is presumed that erection operations over the rail yard will take place on a single shift per day, 5 working days per week basis. The cycle erects 90 feet of bridge structure and 3 pairs of stay cables. It is anticipated that a full cycle (two truss segments plus three pairs of cables) would require 20 working days (4 weeks) to complete, provided that rail operations do not slow things down. 8 ½ cycles will be required to fully cross the rail yard. This would take about 8 months if operations were not impacted by rail operations.

In that 8-month period, there would be approximately 200 hours during which some tracks would need to be interrupted because they are in a Hazard Zone. Productivity will also be affected through having to sometimes wait for windows of time to become available.

There is also a small-debris hazard extending over a longer period when small objects may possibly fall. This can be dealt with by using debris nets so that there will be no impact on or from rail operations.

The erection of deck stringers can be timed to take place in 1 to 2-hour windows whenever rail operations permit and need not require pre-planned track closures. Waiting for work windows will, however, impact productivity.

In our assessment, there is no hazard to rail operations from placing reinforcing steel or from placing concrete. The re-stressing of the guy cables takes place working from the lower deck and also presents no hazard. These operations should proceed without interruption.

In summary, there are some real and unavoidable requirements to interrupt rail operations, locally and relatively infrequently, during the work over the rail yard. It is not possible to carry out the construction of this type of bridge in less than 4-hour time windows.

Construction of the bridge tower could be facilitated by the use of a tower crane. Although tower cranes are widely considered to be safe machines, there have been instances where failures have occurred. All the failures that we are aware of would have been preventable. We anticipate that detailed discussions with the affected railroads may result in some restrictions on tower crane use which are more stringent than usual so as to demonstrate a level of security with which the railroads can be comfortable.

2.6.5 Construction Methods

The use of the maintenance traveler for forming and stripping would provide a work deck and also protection from debris dropping onto active rail lines, and so would allow the forming and stripping to proceed independently of all rail operations. Each deck would be placed in 90 foot lengths. All access to the forming and pouring would be from above – not requiring equipment or personnel on the ground in the rail yard.

A substantial work bridges over Mill Creek will be required during construction.

The steel trusses of the back-spans will be built in situ on falsework. Deck stringers will then be installed on both levels. The upper and lower decks will then be formed, rebar installed, and concrete poured, creating the space where subsequent truss segments for the main-span will be assembled. The stay cables in the backspans will be installed but not stressed at this point.

An erection traveler as depicted on page 100 will then be installed on the upper deck. It will be used to erect all subsequent truss segments in cantilever. The truss segments are quite heavy; it is anticipated that the heaviest 45 feet long segment will weigh about 200 tons. The erection traveler is estimated to cost approximately \$1.0 million.

The construction methodology over the rail yard is depicted in the Cycle Description shown on page 99.

As the cantilever erection progresses in 45 feet long increments, forestays will be installed and fore and back stays will be stressed.

Segment delivery from the assembly area on the deck to the erection traveler is anticipated to be by SPMT (Self-Propelled Motorized Transport) vehicles travelling on the upper deck, which will have been concreted.

Because of the high cost of the erection equipment, and because of the specialized erection expertise required, it will be most practical to build the cable-stayed structure half at a time - west tower and then east tower. The project has been scheduled on this basis.

2.6.6 Schedule

A preliminary schedule for this alternate is shown on page 103.

The estimated duration of tower construction is shown on page 102.

The schedules presented are for "greenfield" working conditions (i.e. without consideration of the impacts from the rail yard). To the durations shown there has to be added an allowance for construction inefficiencies due to the "Railway Effect".

For this alternative, for the "Full Project" option, the greenfield schedule shows a duration of 43 months. It is estimated that the Railway Effect will add another 4 months to this duration. As noted elsewhere, the Full Project Option is the only viable option for this type of structure.

In this schedule it has been assumed that the east and west portions of the cable stayed structure will not be under construction simultaneously.

The schedule presumes that a suboptimal temporary detour for the I-75 southbound on-ramp will be implemented to minimize the closure time of this ramp. See Section 3 of this report for conceptual details of this temporary ramp.

2.6.7 Interface with I-75

For the sake of completeness, it has been necessary to make some assumptions about the timing of the interface between WHV construction and the planned reconstruction of I-75. It is unclear at this time whether I-75 will go first, WHV will go first or both will proceed together. This report has been based on the assumption that WHV will proceed to completion before I-75 is reconstructed. In this case it will be necessary to do some work on I-75 near the WHV in order to make the interchange work in the time period before the full reconstruction of I-75 is undertaken. This is discussed more fully in Section 3 of this report.

2.6.8 Other items

One thing that must be considered when setting the vertical geometry over the rail yard is whether a maintenance and inspection traveler will be required below the lower deck and whether or not the use of the traveler should be independent of rail operations. If an independently operable traveler is required, a minimum of four feet of vertical clearance would be necessary over the operating rail yard clearance envelope. The profile as now set allows greater than 27 feet of vertical clearance from top

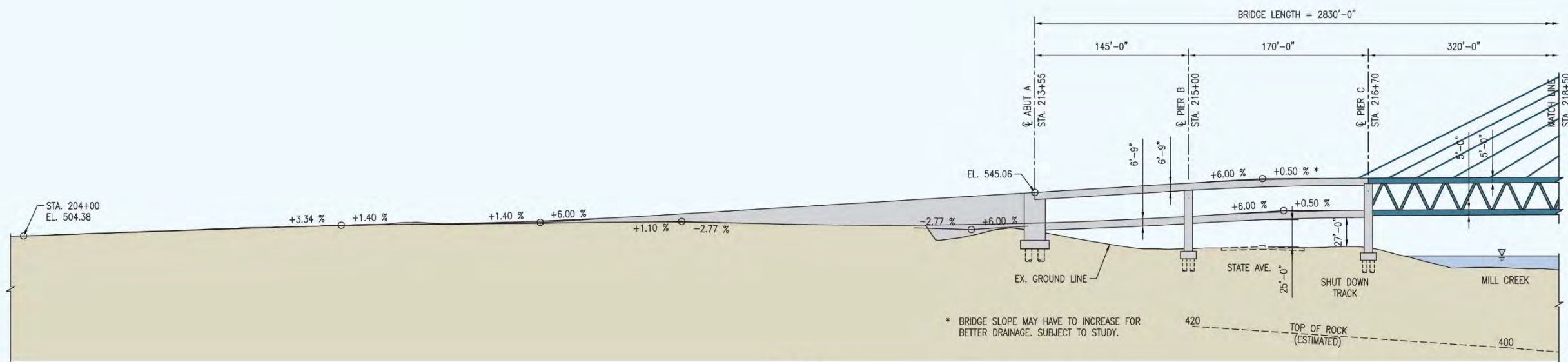
of rail. This is 4 feet more than the 23 feet clearance which is the CSX minimum, but only 2 feet greater than the 25 feet vertical clearance which CSX has requested.

The high-tension line crossing the rail yard will have to be relocated (as with all options).

The location of the bridge infringes somewhat on the straddle crane turnaround at the north end of the intermodal yard, if in fact, the space in question is actually used to turn the straddle cranes. We have been informed by CSX that the straddle cranes do not use this location to turn around but have not had this confirmed. If it were necessary to turn the straddle cranes here, approximately 40 feet of container storage and train-building space would be lost, assuming that 125 feet is required to turn the carriers. (See Appendix C6: Cable Stayed Bridge – Alignment Plans)



PLAN

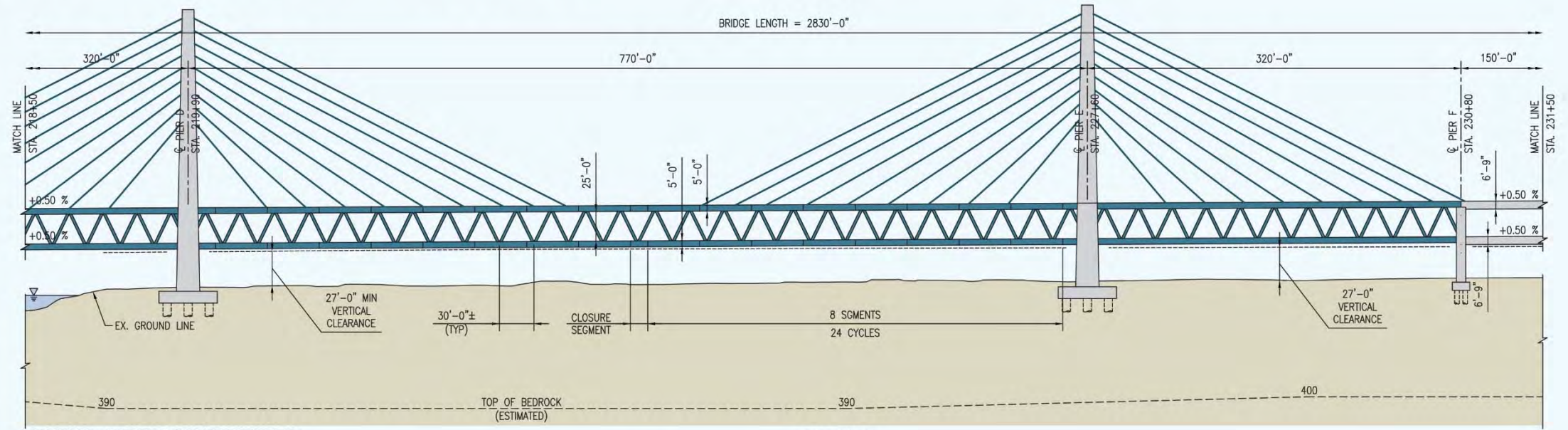
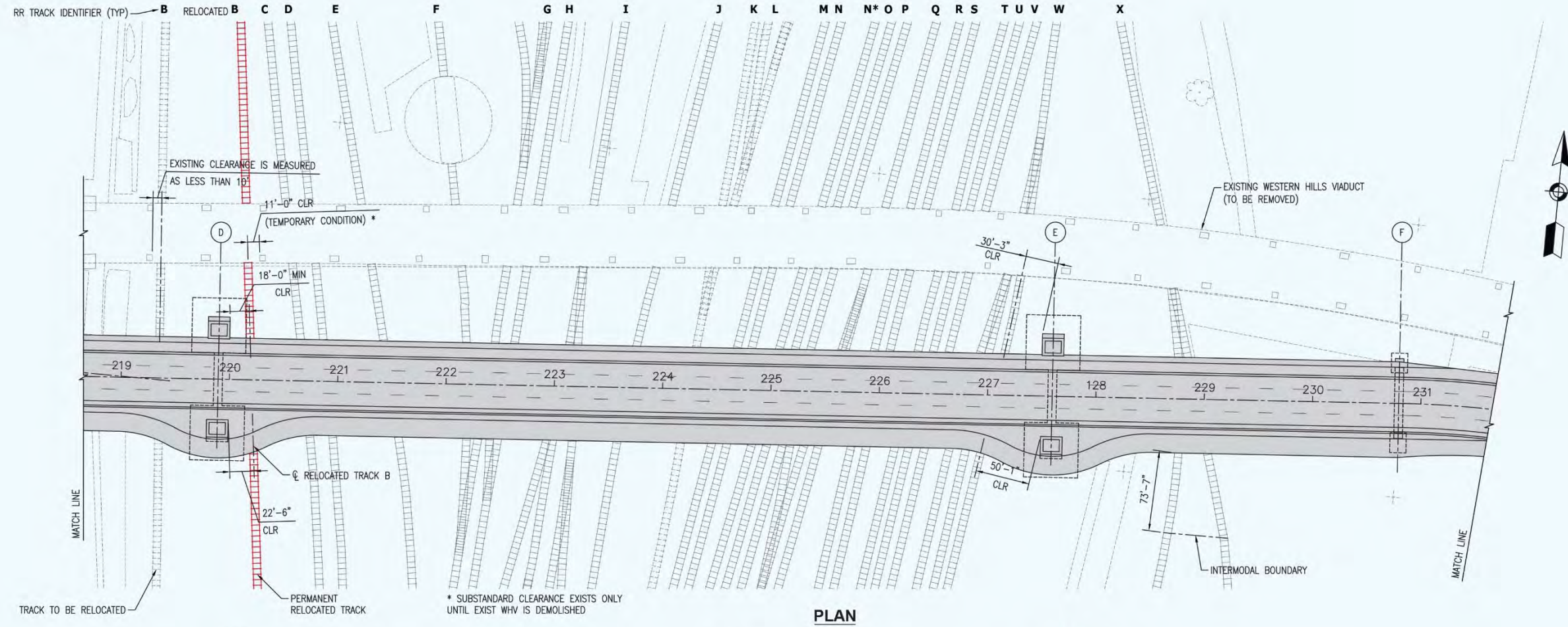


PROFILE

* BRIDGE SLOPE MAY HAVE TO INCREASE FOR BETTER DRAINAGE. SUBJECT TO STUDY.

NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

Cable Stayed Bridge (Twin Tower)
Site Plan 1 of 3

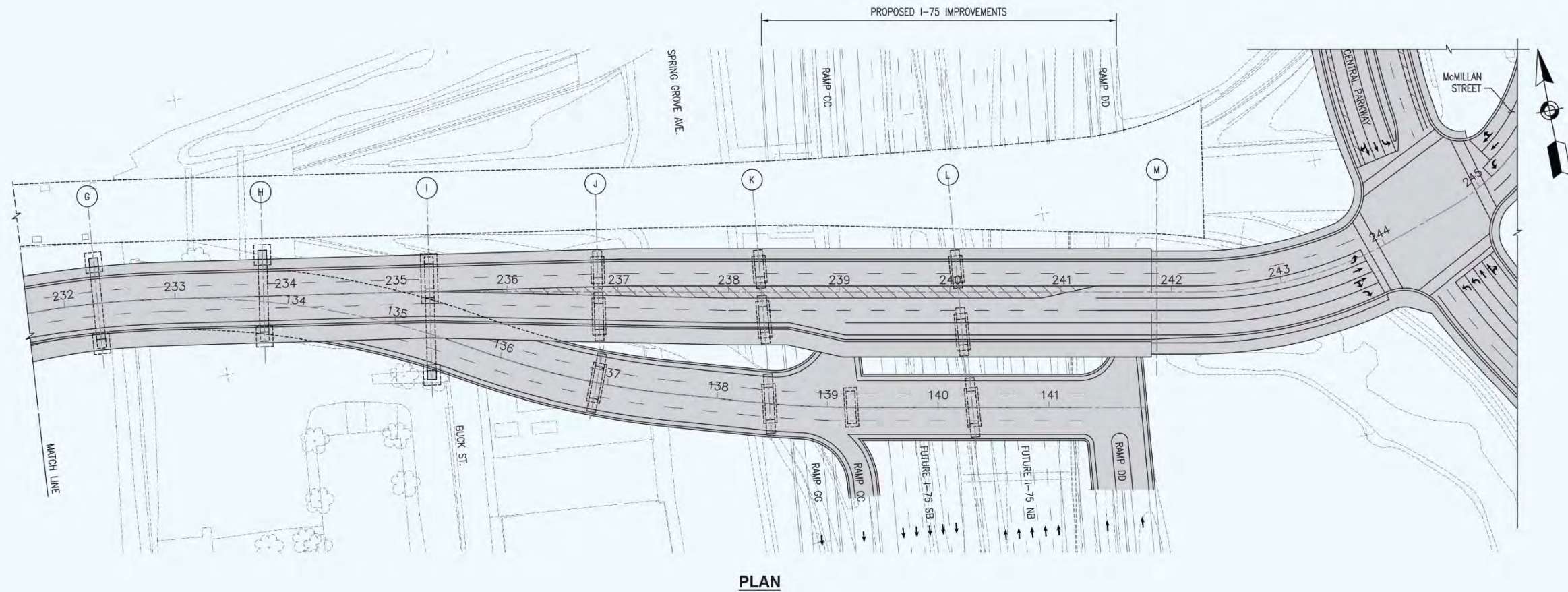


LEGEND - RR TRACK IDENTIFIER

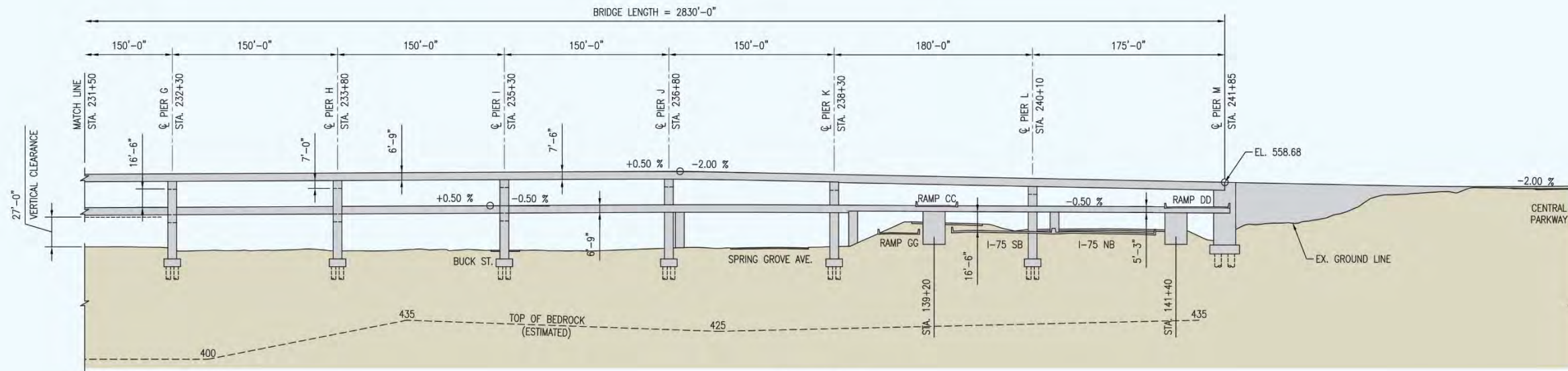
A - CSX (OUT OF SERVICE)	G - CSX LOCOMOTIVE TRACK	M - CSX LONG DEPARTURE TRACK	S - CSX MAIN LINE
B - CSX MAIN LINE	H - CSX WEST OPEN TRACK	N, N* - CSX LONG DEPARTURE TRACK	T - CSX RAMP TRACK
C - CSX RECEIVING TRACK	I - HUMP TRACK	O - NS TRACK	U - CSX RAMP TRACK
D - CSX RECEIVING TRACK	J - CSX EAST OPEN TRACK	P - NS TRACK	V - CSX RAMP TRACK
E - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	Q - NS TRACK	W - INTERMODAL TRACK
F - CSX LOCOMOTIVE TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	R - CSX MAIN LINE	X - GANTRY CRANE TRACK

PROFILE

Cable Stayed Bridge (Twin Tower)
Site Plan 2 of 3



PLAN

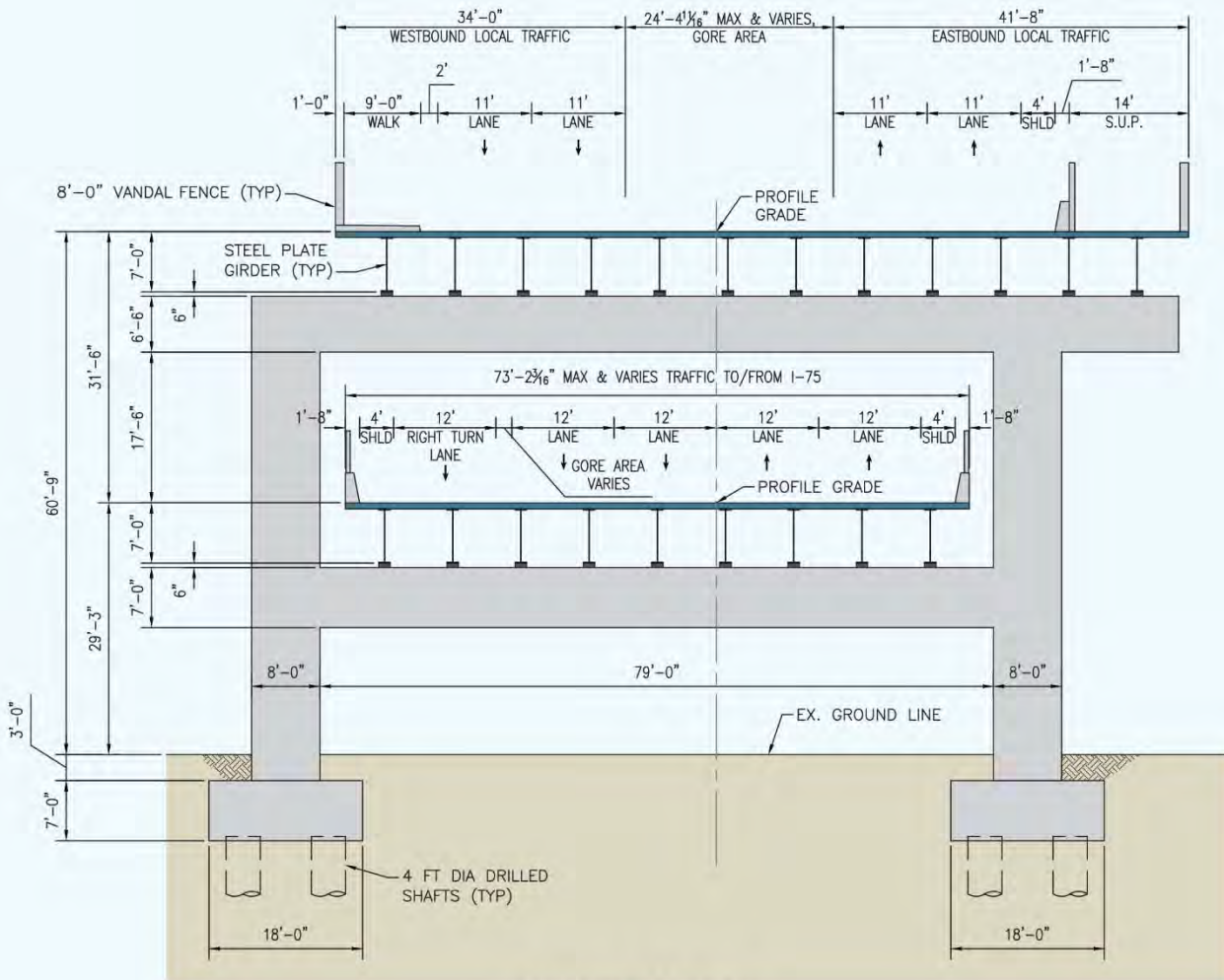


PROFILE

LEGEND - RAMPS

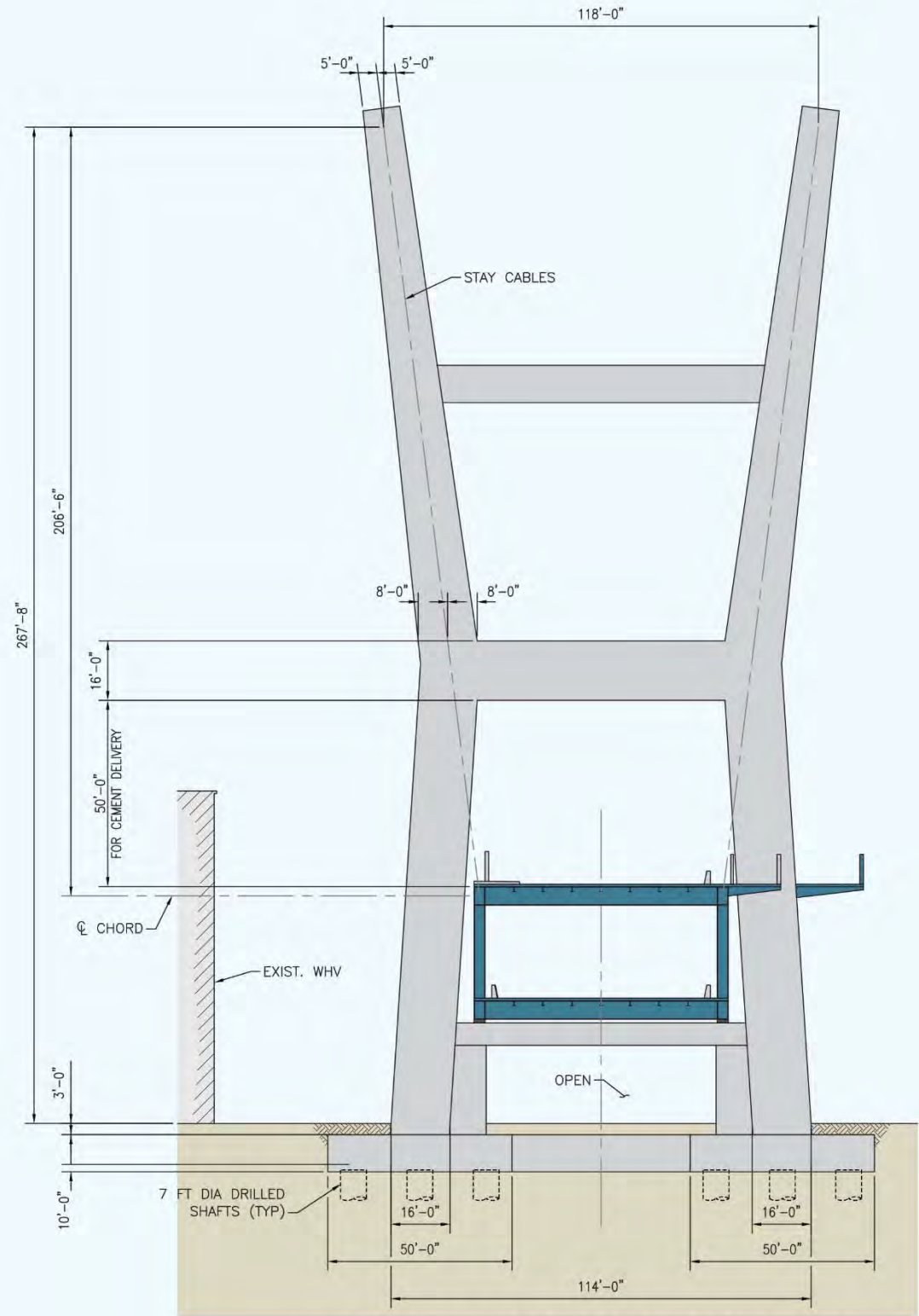
- RAMP AA1 - FUTURE RAMP TO/FROM I-75 NB/WHV
- RAMP AA2 - FUTURE RAMP FROM BANK STREET
- RAMP CC - FUTURE RAMP TO/FROM I-75 SB/WHV
- RAMP GG - FUTURE RAMP TO FINDLAY STREET

Cable Stayed Bridge (Twin Tower)
Site Plan 3 of 3

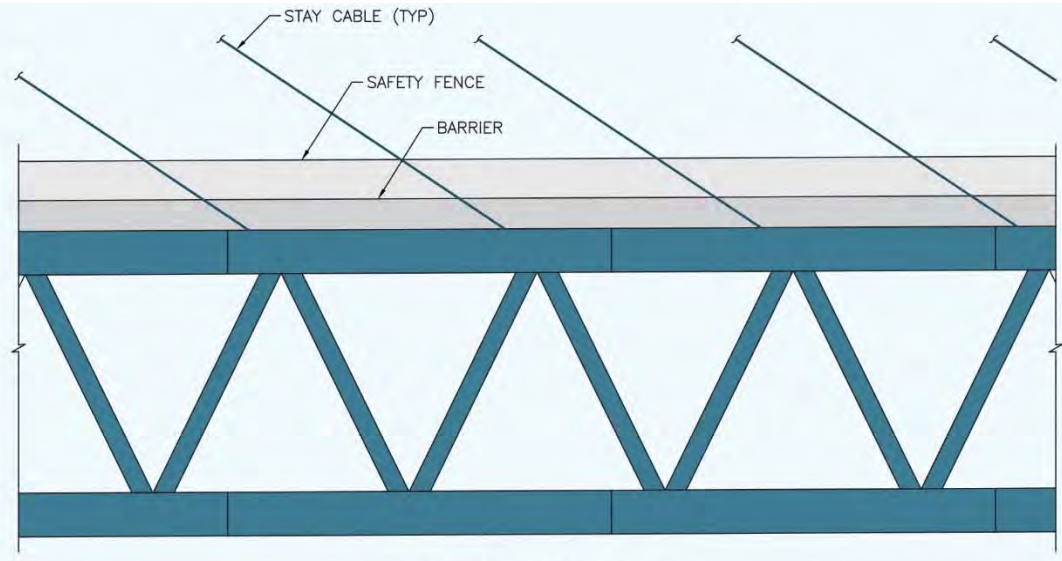


SECTION AT PIER B

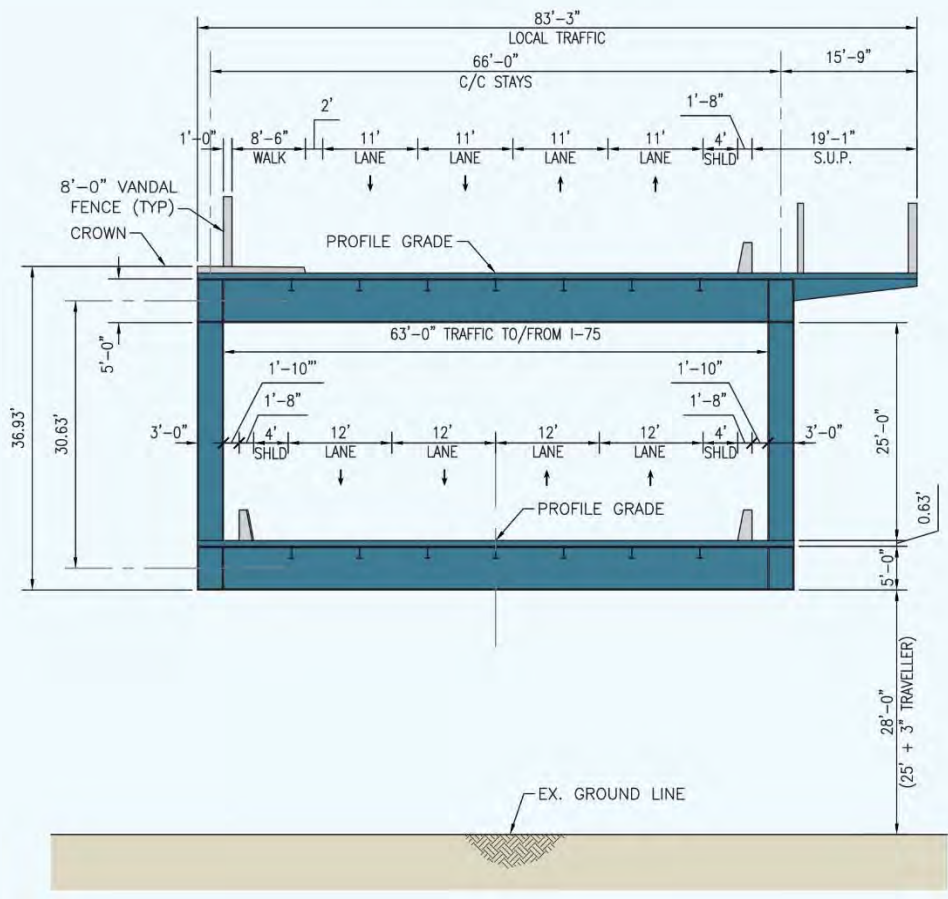
Cable Stayed Bridge (Twin Tower)
Typical Sections 1 of 5



TOWER ELEVATION CONFIGURATION CONSIDERED

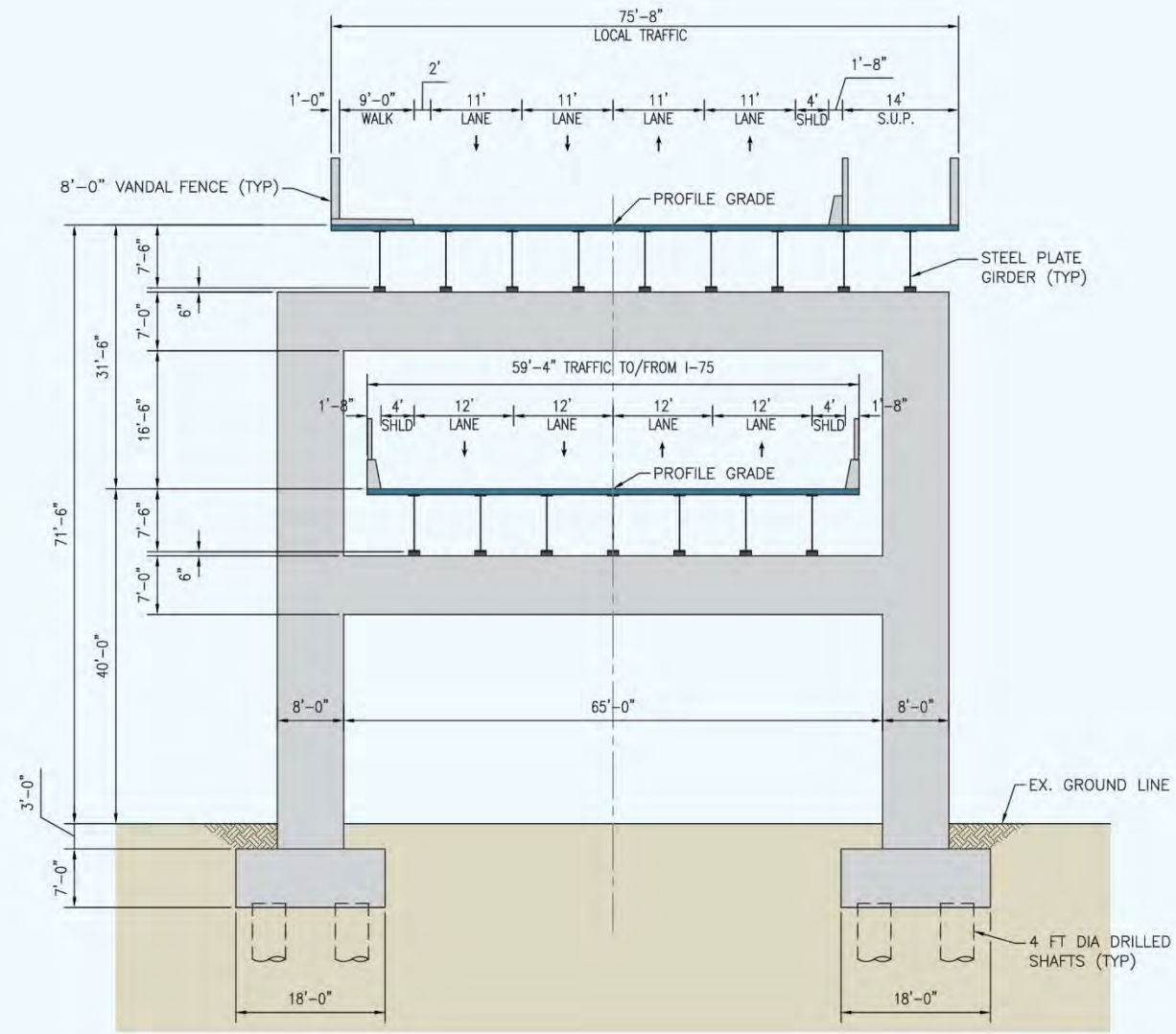


ELEVATION - PARTIAL

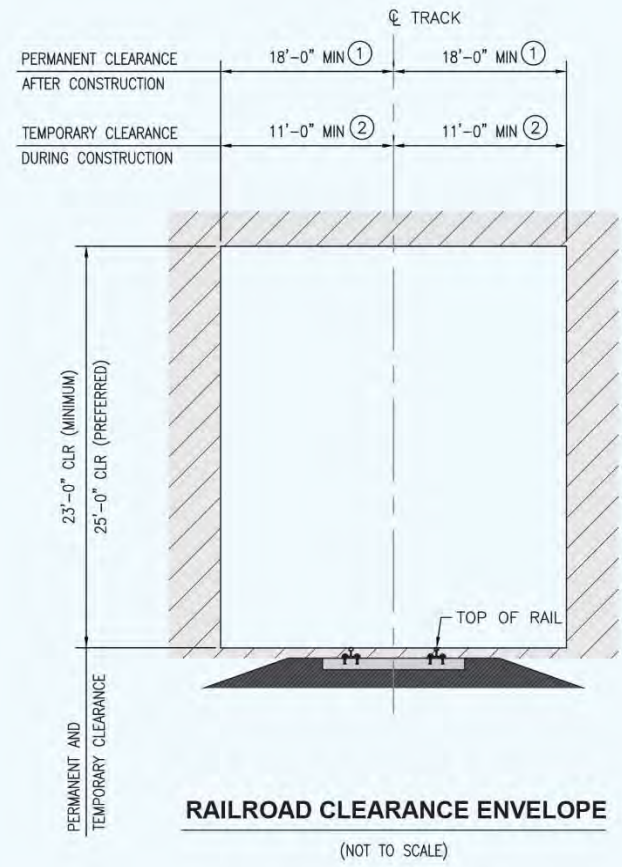


TYPICAL SECTION - CABLE STAYED BRIDGE

Cable Stayed Bridge (Twin Tower)
Typical Sections 2 of 5

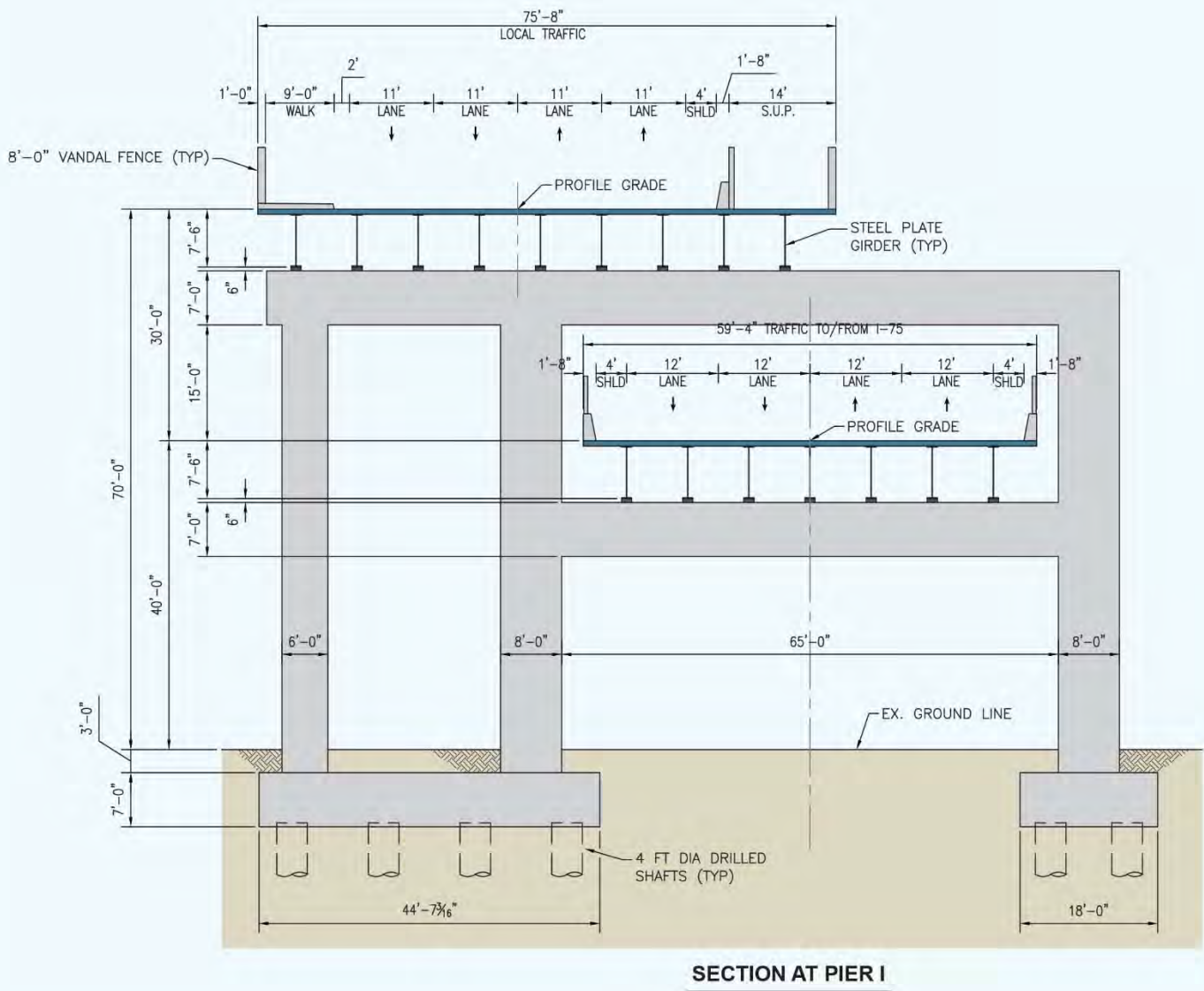


SECTION AT PIERS G & H



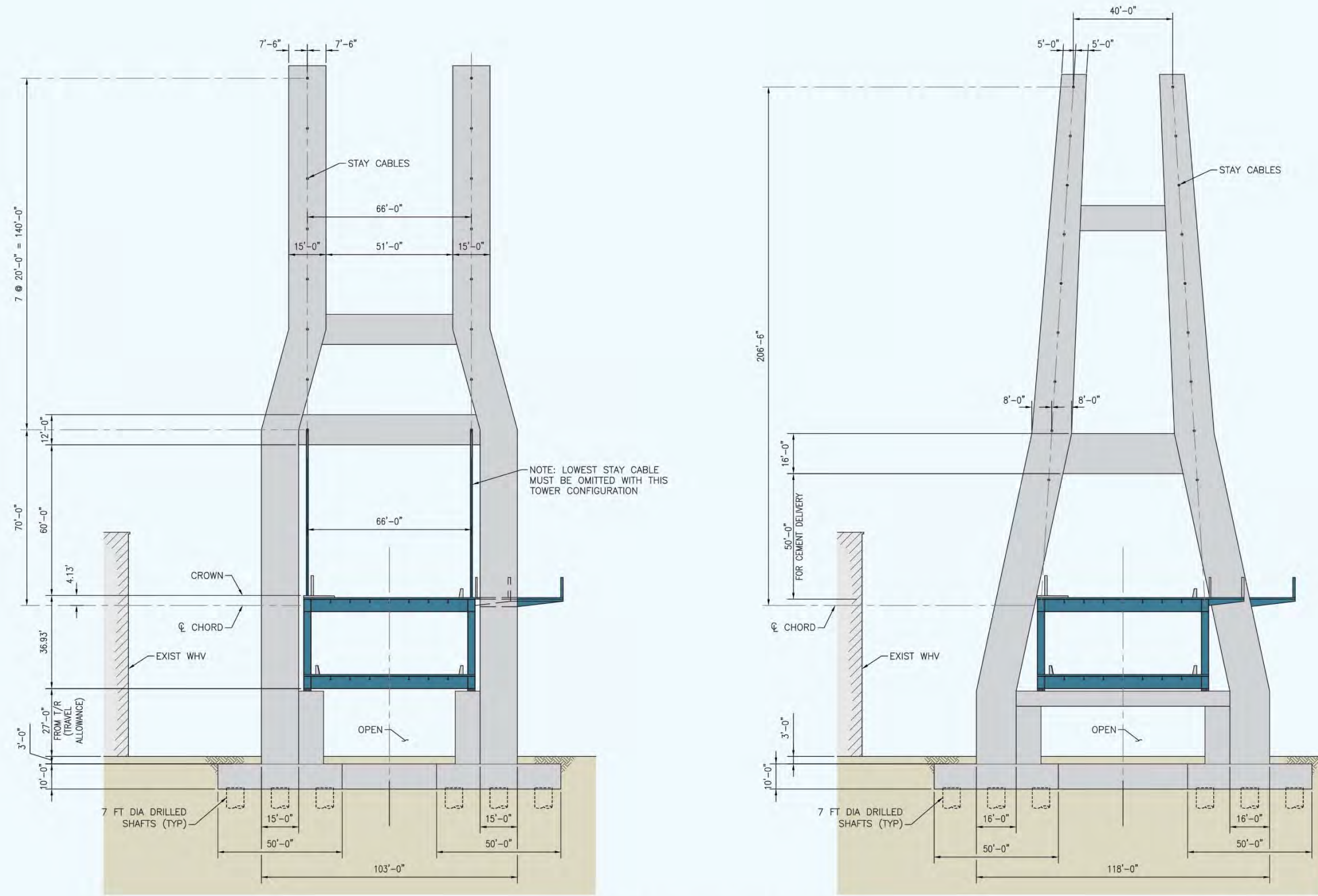
- RAILROAD CLEARANCE ENVELOPE**
(NOT TO SCALE)
- ① 25'-0" PREFERRED FOR HORIZONTAL CLEARANCE LESS THAN THE 25'-0", CRASH WALL PROTECTION MAY BE REQUIRED UNLESS ADJACENT PIER CROSS-SECTION DIMENSIONS ARE NO LESS THAN 2'-6" THICK x 20'-0" LONG (MEASURED ALONG DIRECTION OF TRACK) OR 50 FT² MIN AREA.
 - ② FOR A TEMPORARY WALKWAY AND HANDRAIL SYSTEM A MINIMUM CLEARANCE OF 12'-0" SHALL BE PROVIDED.

**Cable Stayed Bridge (Twin Tower)
Typical Sections 3 of 5**



SECTION AT PIER I

Cable Stayed Bridge (Twin Tower)
Typical Sections 4 of 5



ALTERNATE TOWER CONFIGURATIONS

Cable Stayed Bridge (Twin Tower)
Typical Sections 5 of 5

**TWIN TOWER CABLE STAYED
PRELIMINARY CYCLE FOR SEGMENT ERECTION IN CANTILEVER**

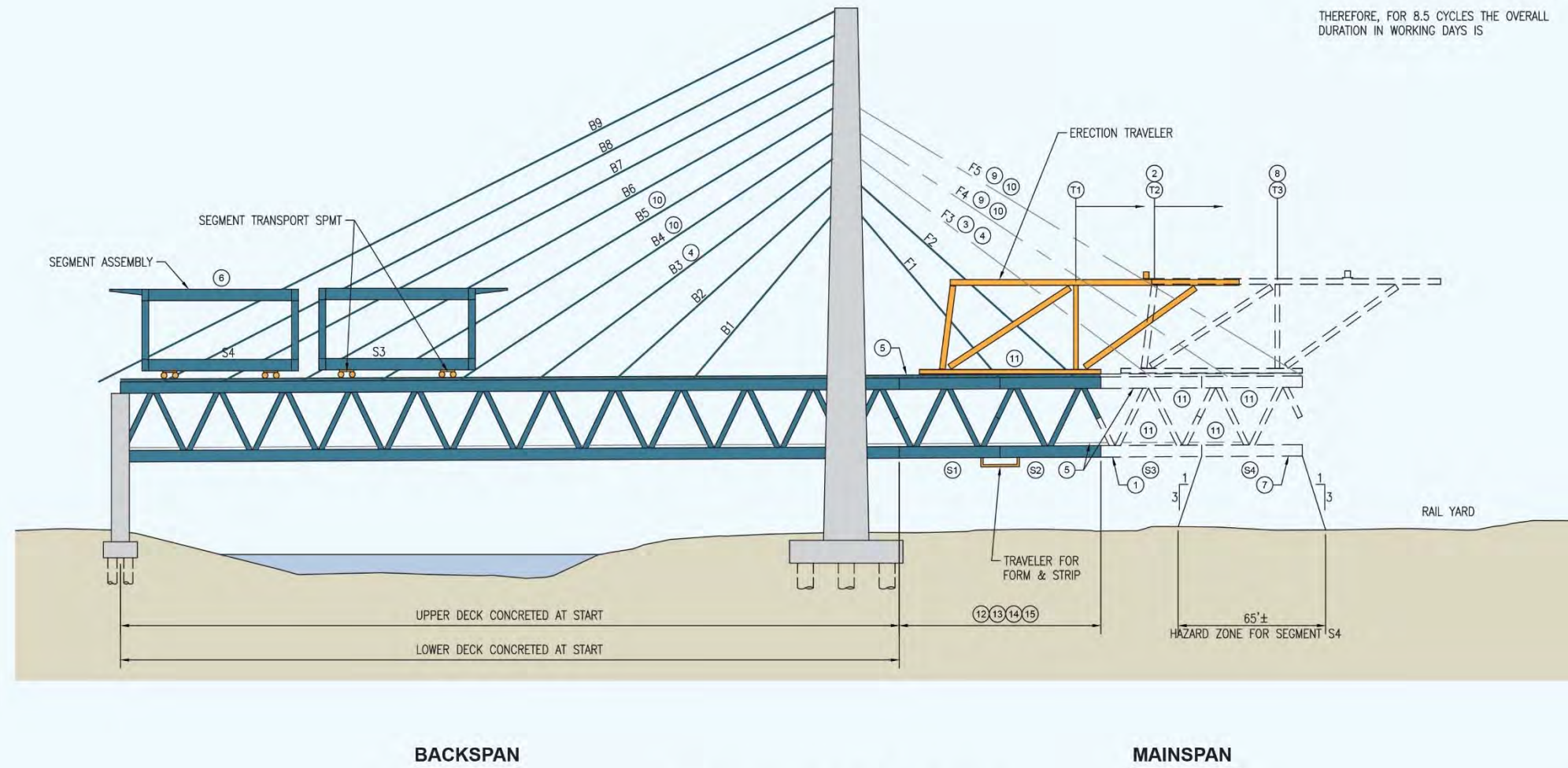
- AT START OF CYCLE SHOWN
- BACKSPAN HAS BEEN ERECTED ON FALSEWORK
 - MAINSPAN SEGMENTS S1 & S2 HAVE BEEN ERECTED
 - UPPER AND LOWER DECKS HAVE BEEN CONCRETED AS SHOWN
 - FORESTAYS F1 & F2 ARE INSTALLED AND ACTIVE
 - BACKSTAYS B1 & B2 ARE INSTALLED AND ACTIVE
 - BACKSTAYS B3 THRU B9 ARE INSTALLED BUT NOT YET ACTIVE
 - ERECTION TRAVELER IS AT POSITION T1
 - SEGMENT S3 IS ASSEMBLED ON THE BACKSPAN
 - SEGMENT S4 IS BEING ASSEMBLED ON THE BACKSPAN

CYCLE FOR TWO SEGMENTS (90' OF BRIDGE)

NO.	ACTIVITY	CRITICAL PATH WORK		NON-CRITICAL DURATION HOURS
		DURATION (HOURS)	RAIL HAZARD (HOURS)	
1.	DELIVER AND ERECT SEGMENT S3	8	4	
2.	ADVANCE TRAVELER TO POSITION T2	6	4	
3.	INSTALL FORESTAY F3	10	0	
4.	STRESS FORESTAY F3 AND BACKSTAY B3	4	0	
5.	INSTALL 30' LENGTH (1 BAY) OF DECK STRINGERS - UPPER AND LOWER DECKS	6	2.5	
6.	ASSEMBLE SEGMENT S4 - NOT ON CRITICAL PATH	0	0	40
7.	DELIVER AND ERECT SEGMENT S4	8	4	
8.	ADVANCE TRAVELER TO POSITION T3	6	4	
9.	INSTALL FORESTAYS F4 & F5	20	0	
10.	STRESS FORESTAYS F4 & F5 AND BACKSTAYS B4 & B5	12	0	
11.	INSTALL 60' LENGTH (2 BAYS) OF DECK STRINGERS - UPPER AND LOWER DECKS	12	5	
12.	FORM AND REINFORCE 90' OF DECK - UPPER AND LOWER DECKS	24	0	
13.	POUR 90' OF DECK ON TWO LEVELS	4	0	
14.	CURE DECK CONCRETE	40	0	
15.	STRIP DECK FORMWORK - NOT CRITICAL PATH	0	0	10
TOTALS PER CYCLE - HOURS		160	23.5	
TOTALS PER CYCLE - WORKING DAYS OF 8 HOURS		20	2.9	

THERE ARE 4 CYCLES PER CANTILEVER (8 TOTAL) PLUS THE CLOSURE (1/2 CYCLE)

THEREFORE, FOR 8.5 CYCLES THE OVERALL DURATION IN WORKING DAYS IS 170 24.7 DAYS
7.8 MONTHS

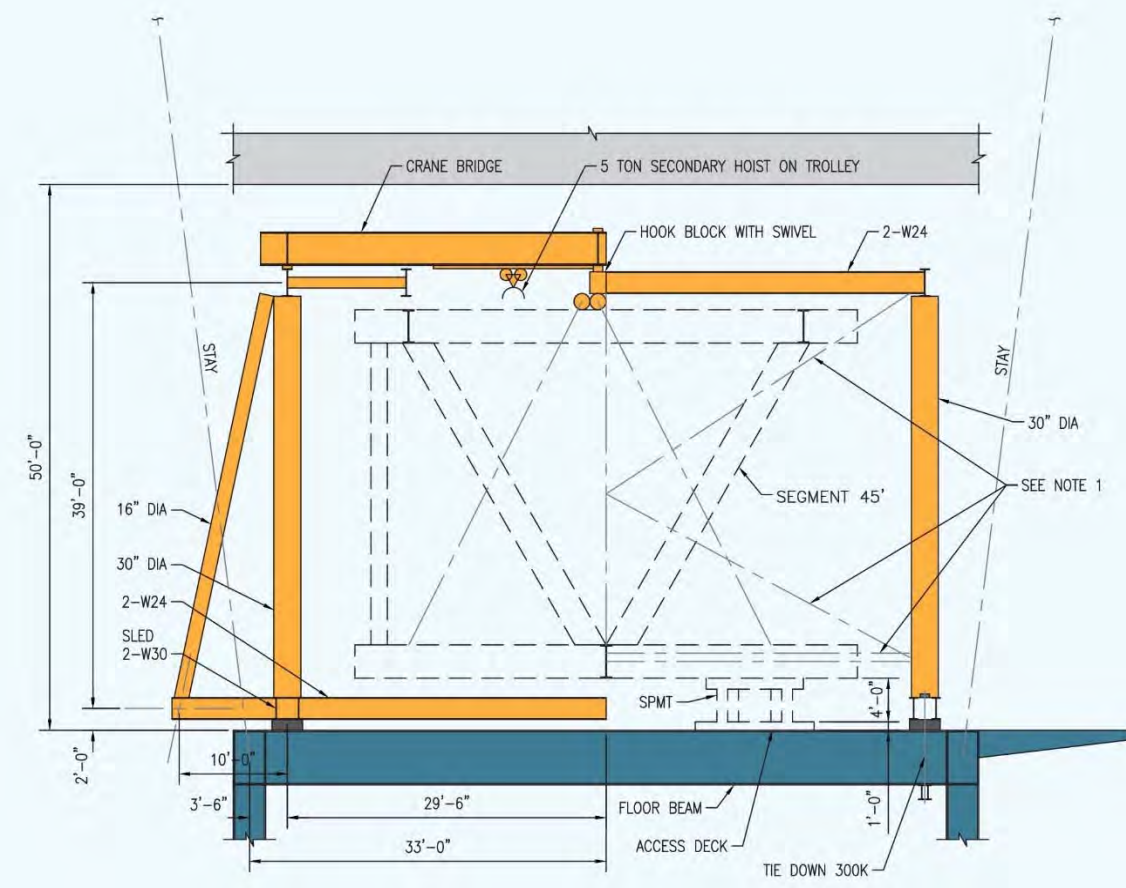
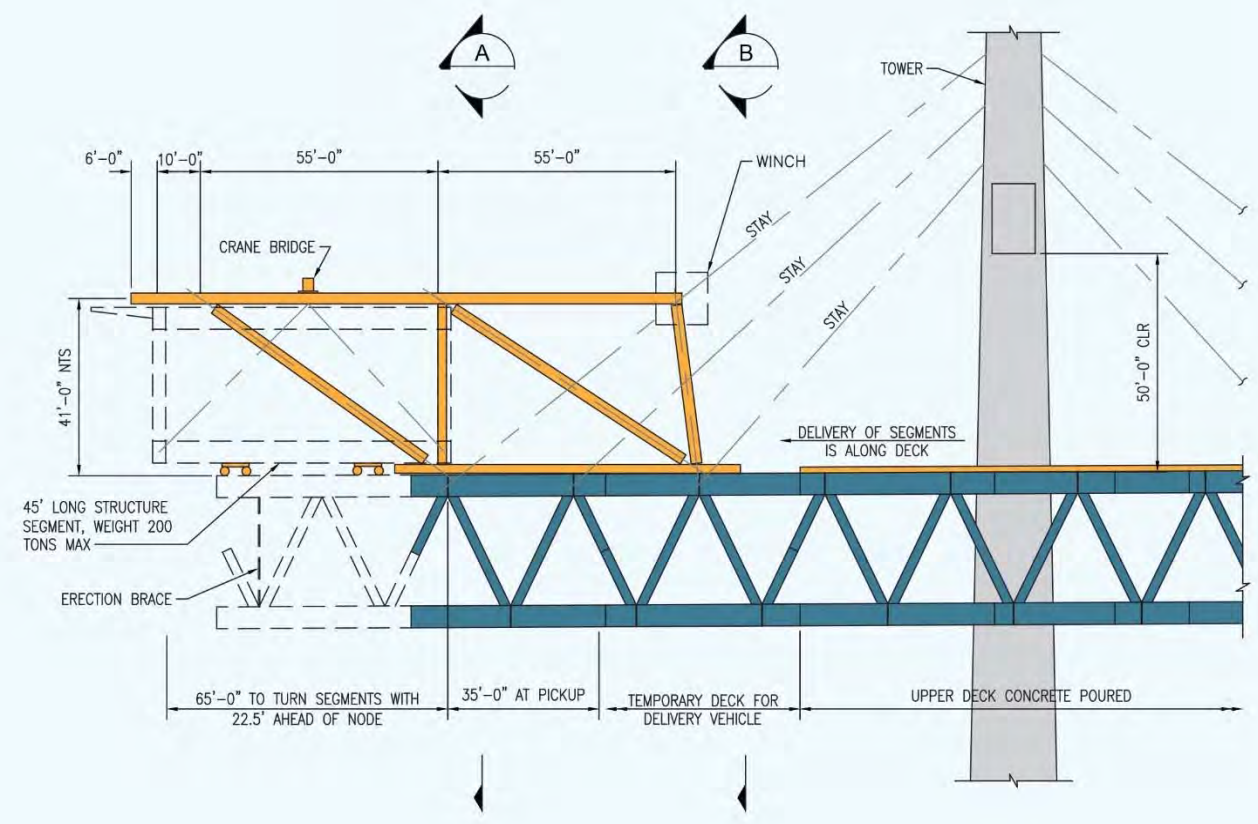


BACKSPAN

MAINSPAN

ERECTION CYCLE OVER RAIL YARD

Cable Stayed Bridge (Twin Tower)
Construction Method 1 of 4



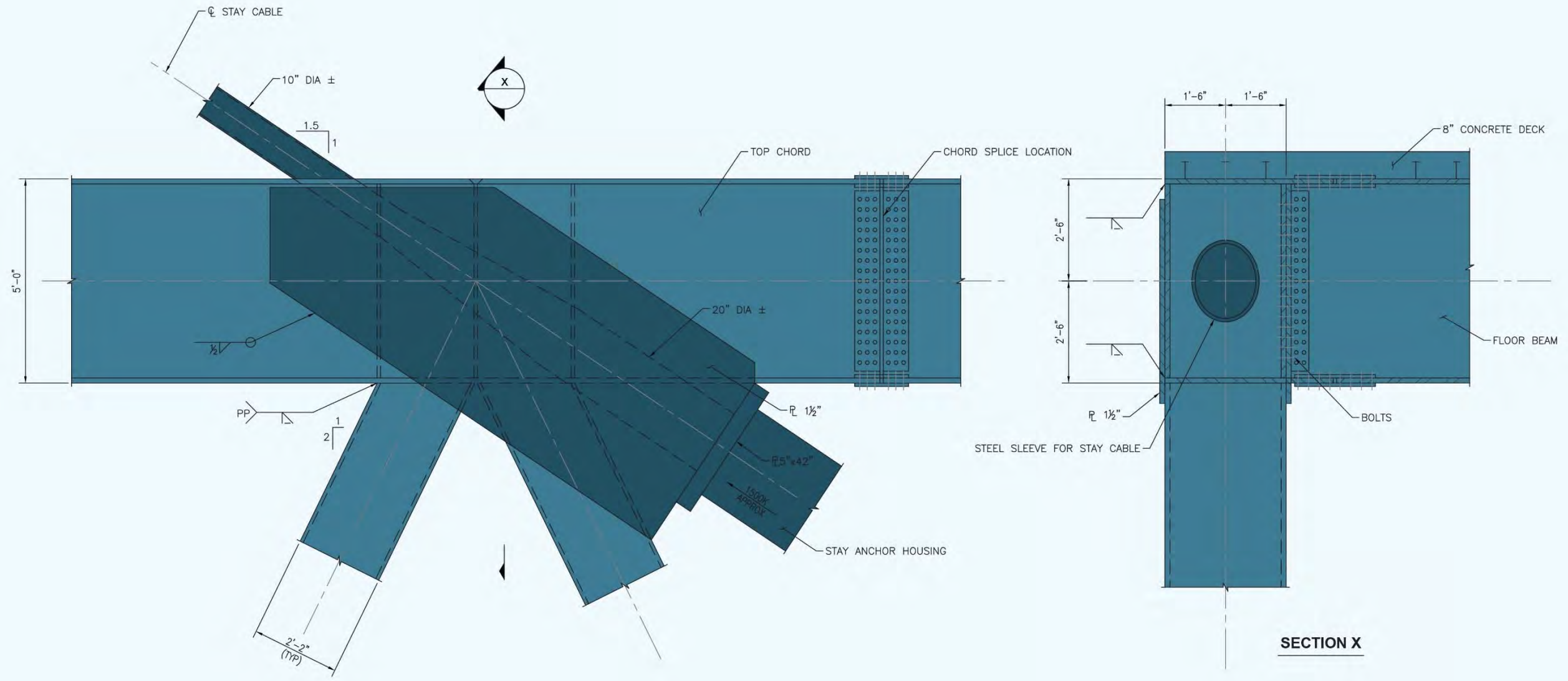
ERECTION GANTRY CONCEPT

SECTION A

SECTION B

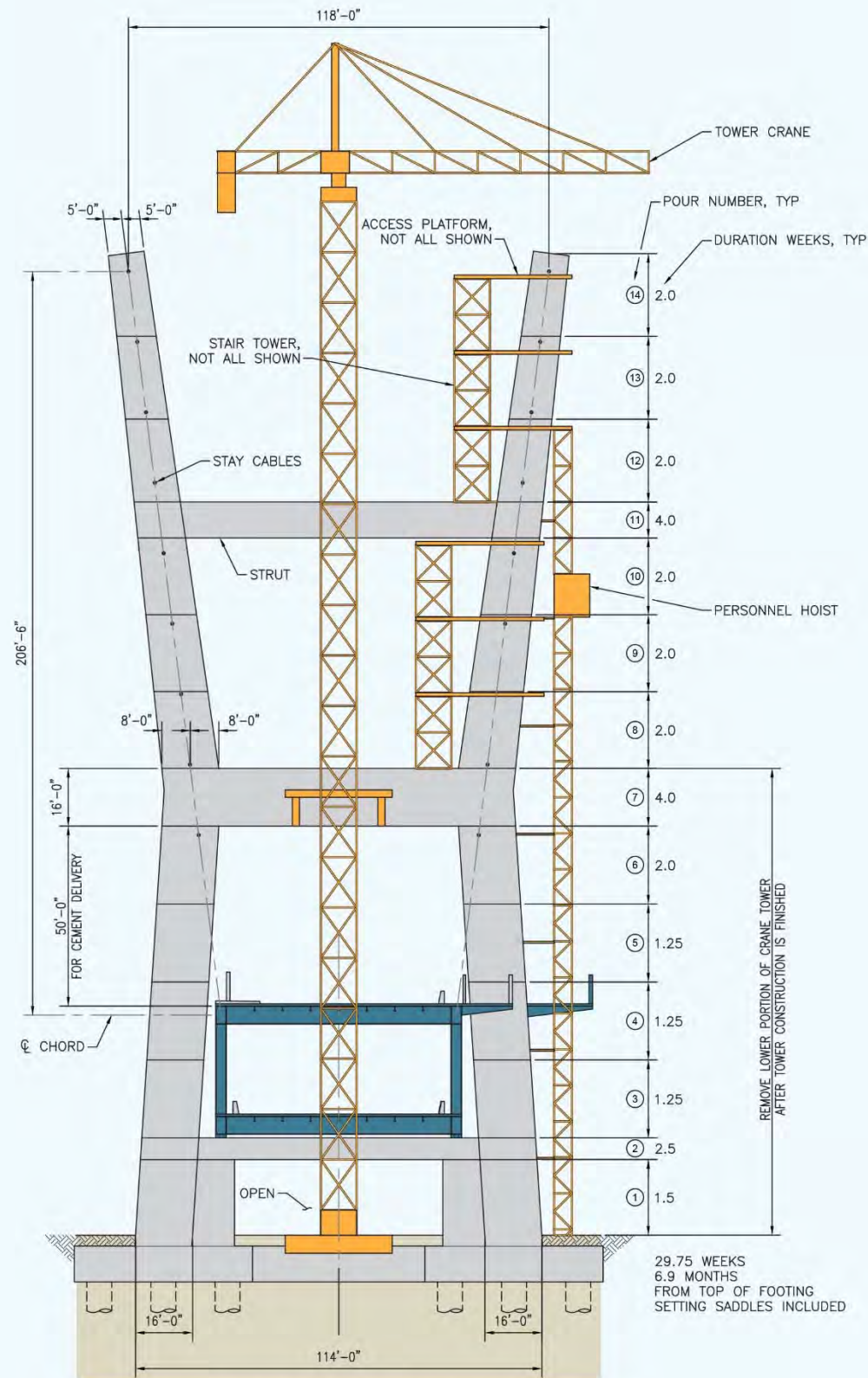
NOTE 1:
CABLE GUYS AND SWING-AWAY STRUT.
ATTACH BEFORE LIFTING SEGMENT.

**Cable Stayed Bridge (Twin Tower)
Construction Method 2 of 4**



TRUSS NODE PRELIMINARY DETAILS

Cable Stayed Bridge (Twin Tower)
Construction Method 3 of 4



TOWER CONSTRUCTION DURATIONS & ACCESS

Cable Stayed Bridge (Twin Tower)
Construction Method 4 of 4

2.7 Cable-stayed Bridge (Single Tower Option)

A single tower option was also considered as described below. It is considered that this option offers no material advantages over the twin tower option and so this concept has not been carried forward.

2.7.1 Bridge Structure Description

The structure considered consists of a double deck steel truss carrying the upper and lower roadways. Stay cables are shown quite widely spaced at 60 feet centers along the deck. The cross section selected is shown on page 109.

The general layout of the structure is shown in plan and elevation on pages 105 through 107. The spans are 495 feet and 555 feet long. The structure runs from State Avenue eastward across the rail yard. The tower is located within the rail yard close to the locomotive track (Track F), where space is available and where no tracks will be disrupted in the long run.

The concept for the tower that is considered is shown on page 109.

2.7.2 Work Area Within the Rail Yard

The proposed structure requires one work area within the busy portion of the rail yard for construction of the main tower. It is located close to the locomotive track (Track F) where space is available.

Track F needs to be taken out of service for the duration of tower construction of about one year.

Unlike some other alternatives and options, the single tower cable stay requires extensive work within the rail yard. To obtain the ability to do this work without disrupting rail operations, and without being disrupted by the rail operations, it is proposed to construct an access trestle from State Avenue, over the active rail lines, to reach the work zone. Construction of the trestle will be strongly affected by railroad operational considerations but, once it is built, access for labor and materials will be unaffected by rail operations. The cost of this trestle is estimated to be about \$5.5 million.

2.7.3 Construction Method and Timing

The construction methodology is shown on page 113 (End-span Erection) and page 114 (Cycle Description). Page 114 is a study of the details of the initial erection of the west end on falsework.

The steel trusses of the back-span would be built on falsework starting from State Avenue and proceeding to a temporary pier on the east side of Mill Creek. The existing CSX through-track will have been relocated eastwards to allow free access up to this temporary pier location.

Deck stringers will then be installed on both levels. The upper deck will then be formed and the concrete poured, creating the space where all subsequent truss segments will be assembled.

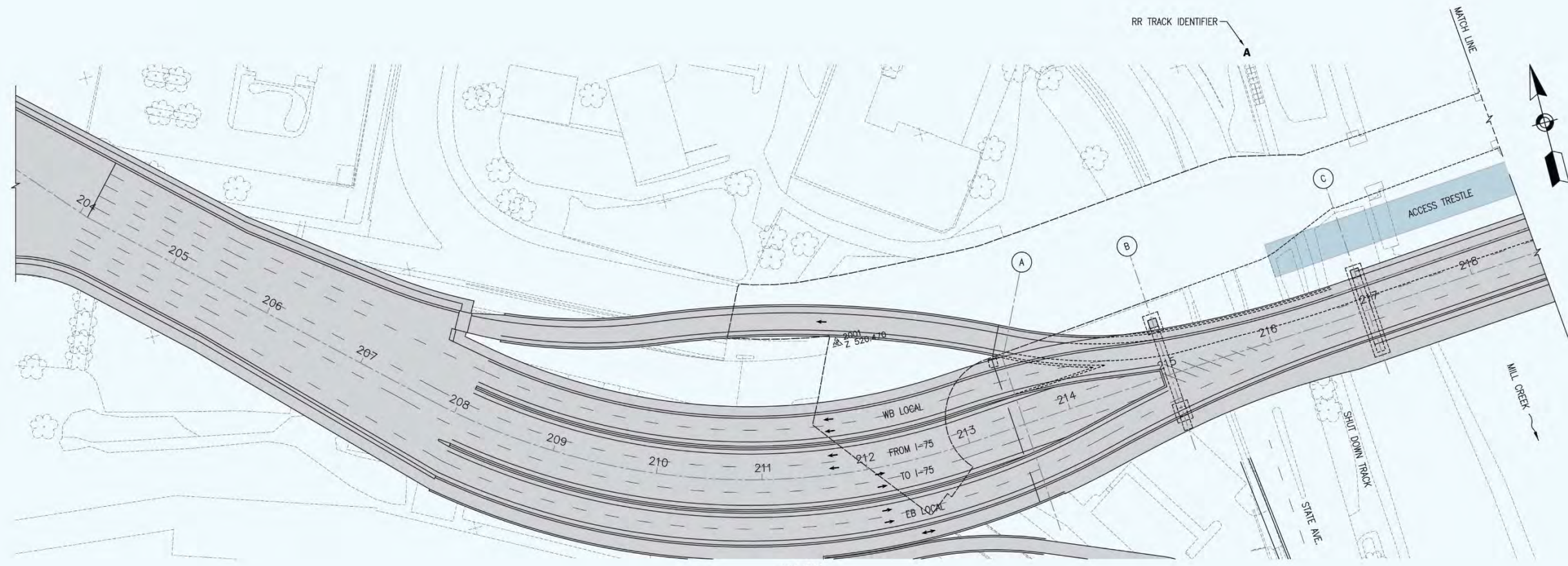
An erection traveler as shown for the Twin Tower Option will then be installed on the upper deck. It will be used to erect all subsequent truss segments. Segment delivery from the assembly area on the

deck to the erection traveler is anticipated to be by SPMT (Self-Propelled Motorized Transport) vehicles travelling on the upper deck which will have been concreted.

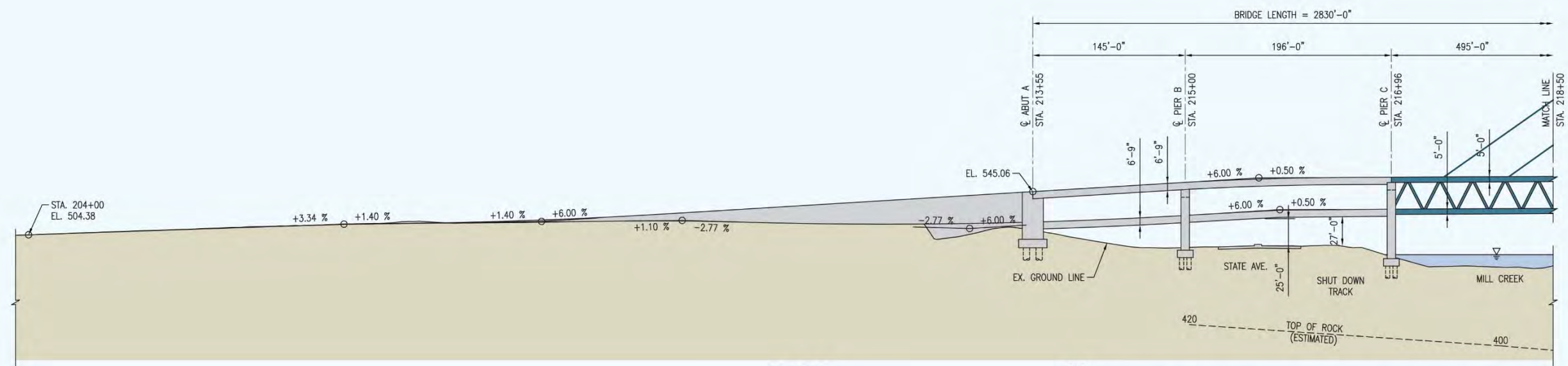
From the temporary pier eastward to the tower, 45 feet long truss sections would be erected in cantilever. This operation crosses over the CSX through-track and will require interruption of rail operations at critical points in the erection process.

Once the steel truss erection reaches the tower, deck stringers will be installed and both levels of deck will be formed and poured. The temporary pier will be retained until the cable stays are installed and stressed.

The next 555 feet will be built in cantilever over the active rail yard following the erection cycle shown on page 114.



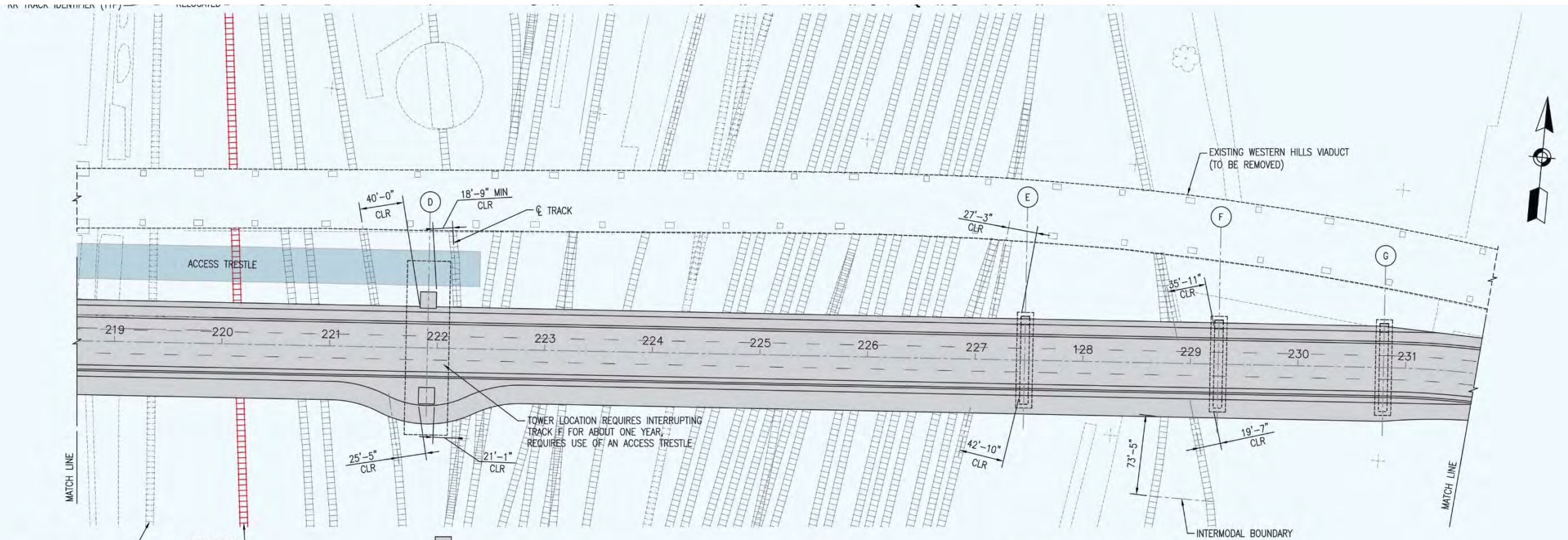
PLAN



PROFILE

NOTE:
TOP OF ROCK ELEVATIONS ARE VERY APPROXIMATE BETWEEN PIERS D AND I. THERE IS NO RELIABLE INFORMATION. TOP OF ROCK MAY BE AS MUCH AS 50' LOWER IN THAT ZONE.

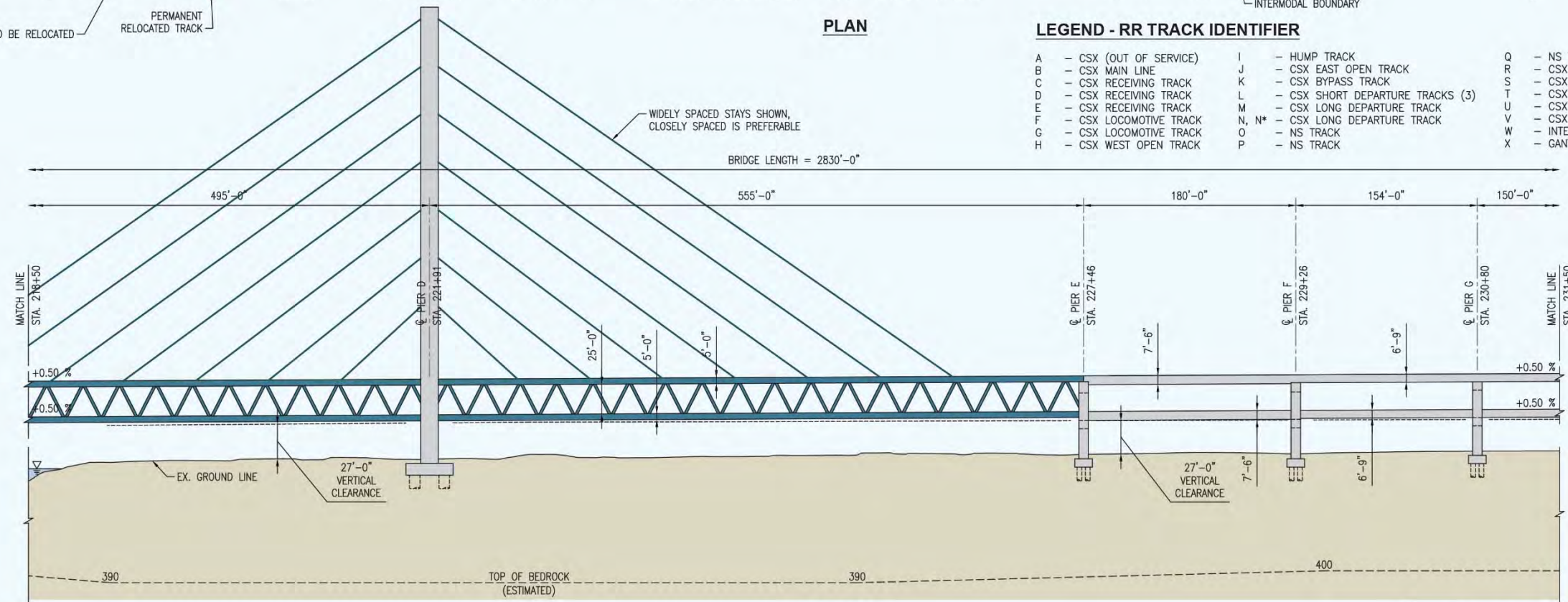
Cable Stayed Bridge (Single Tower)
Site Plan 1 of 3



PLAN

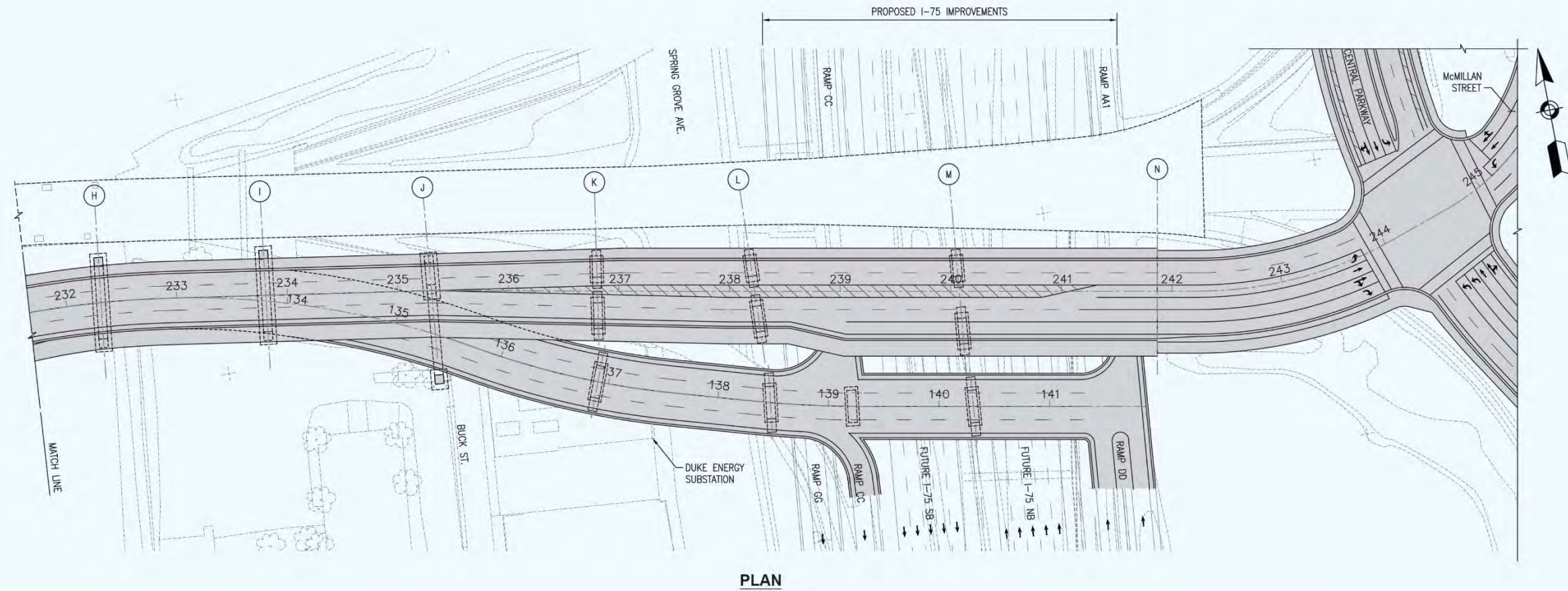
LEGEND - RR TRACK IDENTIFIER

A - CSX (OUT OF SERVICE)	I - HUMP TRACK	Q - NS TRACK
B - CSX MAIN LINE	J - CSX EAST OPEN TRACK	R - CSX MAIN LINE
C - CSX RECEIVING TRACK	K - CSX BYPASS TRACK	S - CSX MAIN LINE
D - CSX RECEIVING TRACK	L - CSX SHORT DEPARTURE TRACKS (3)	T - CSX RAMP TRACK
E - CSX RECEIVING TRACK	M - CSX LONG DEPARTURE TRACK	U - CSX RAMP TRACK
F - CSX LOCOMOTIVE TRACK	N, N* - CSX LONG DEPARTURE TRACK	V - CSX RAMP TRACK
G - CSX LOCOMOTIVE TRACK	O - NS TRACK	W - INTERMODAL TRACK
H - CSX WEST OPEN TRACK	P - NS TRACK	X - GANTRY CRANE TRACK

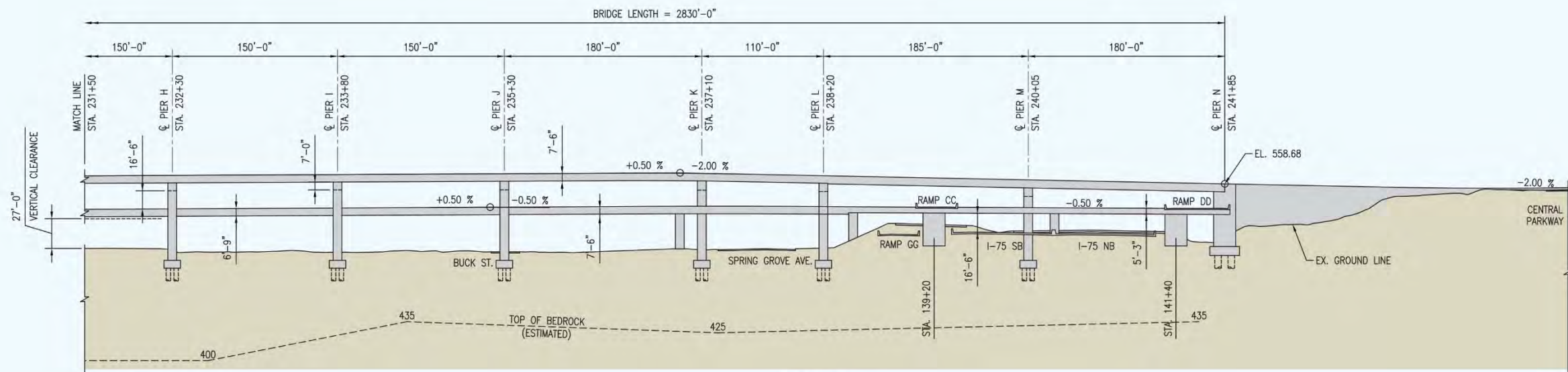


PROFILE

Cable Stayed Bridge (Single Tower)
Site Plan 2 of 3



PLAN

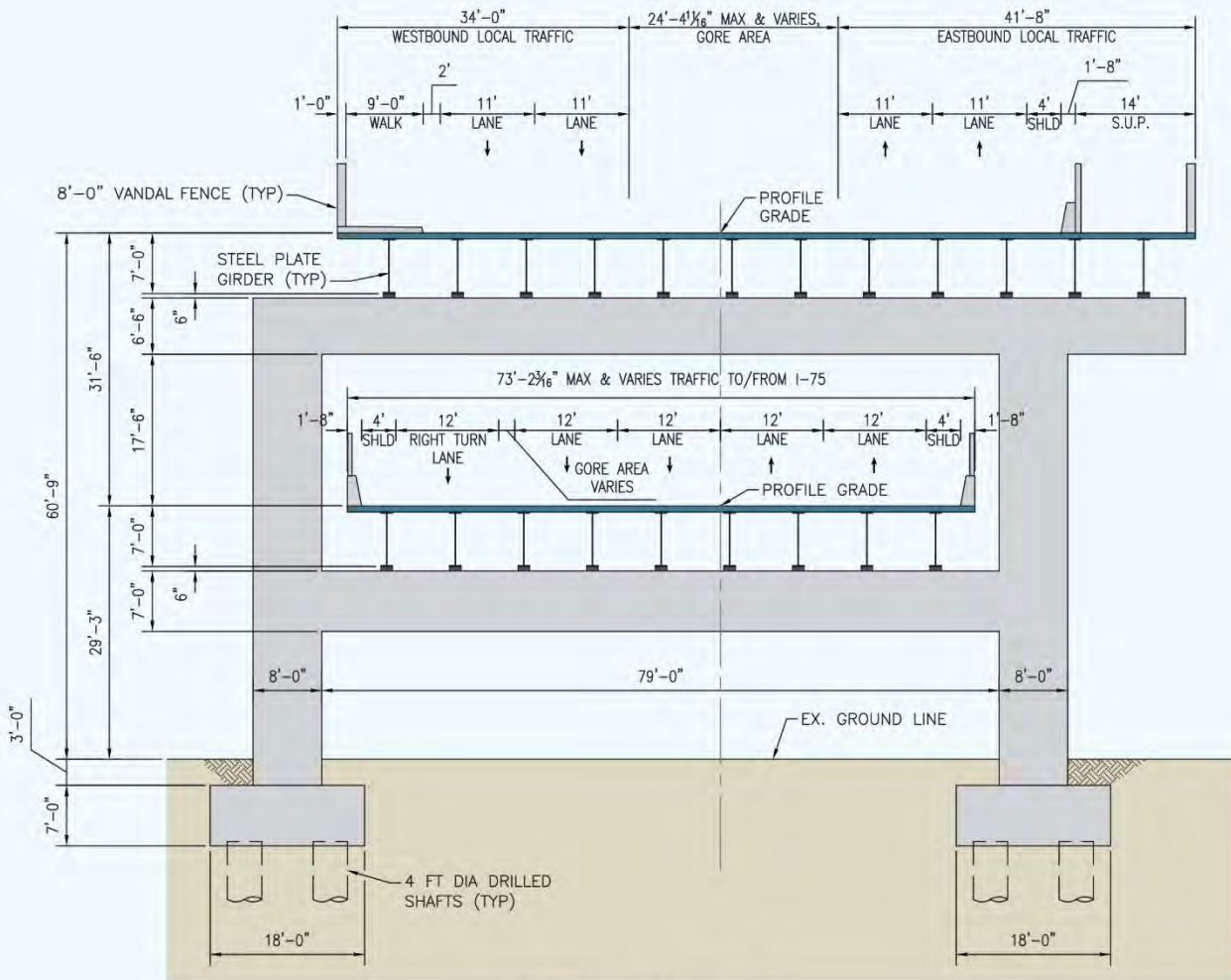


PROFILE

LEGEND - RAMPS

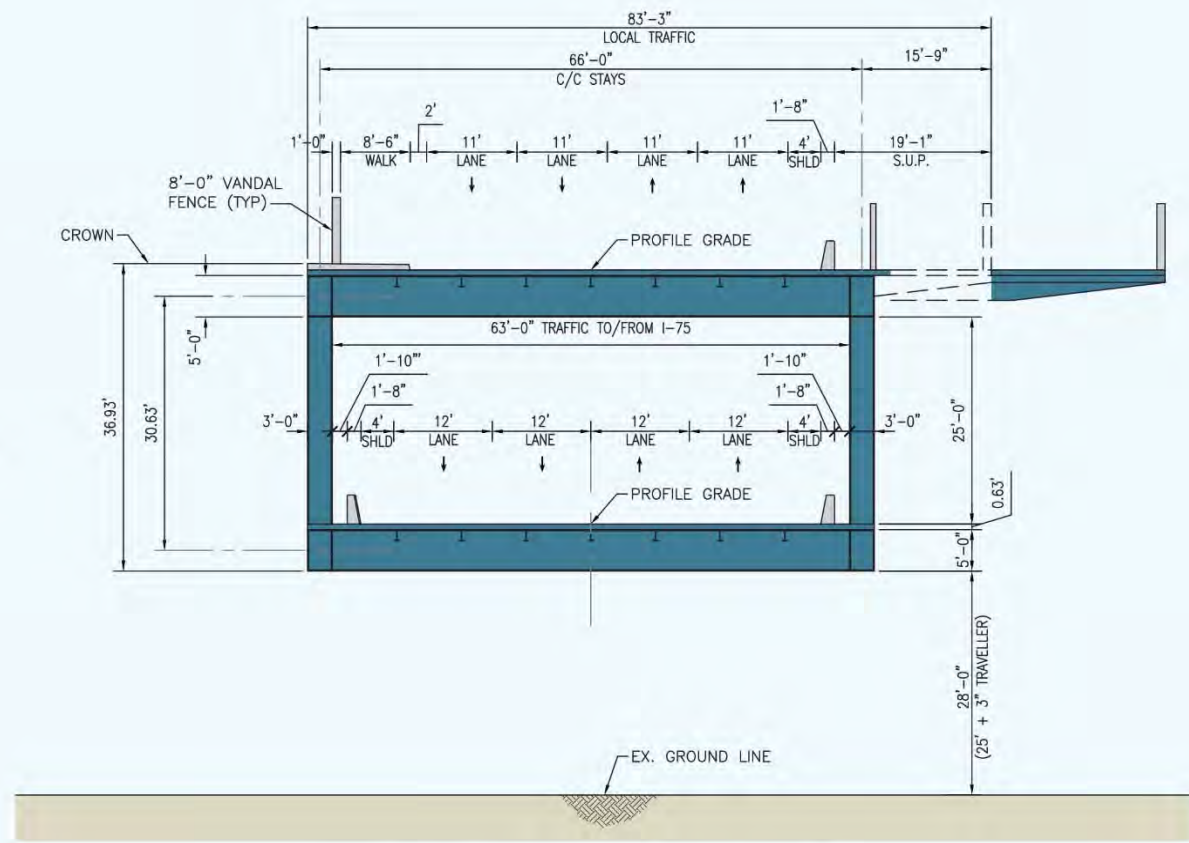
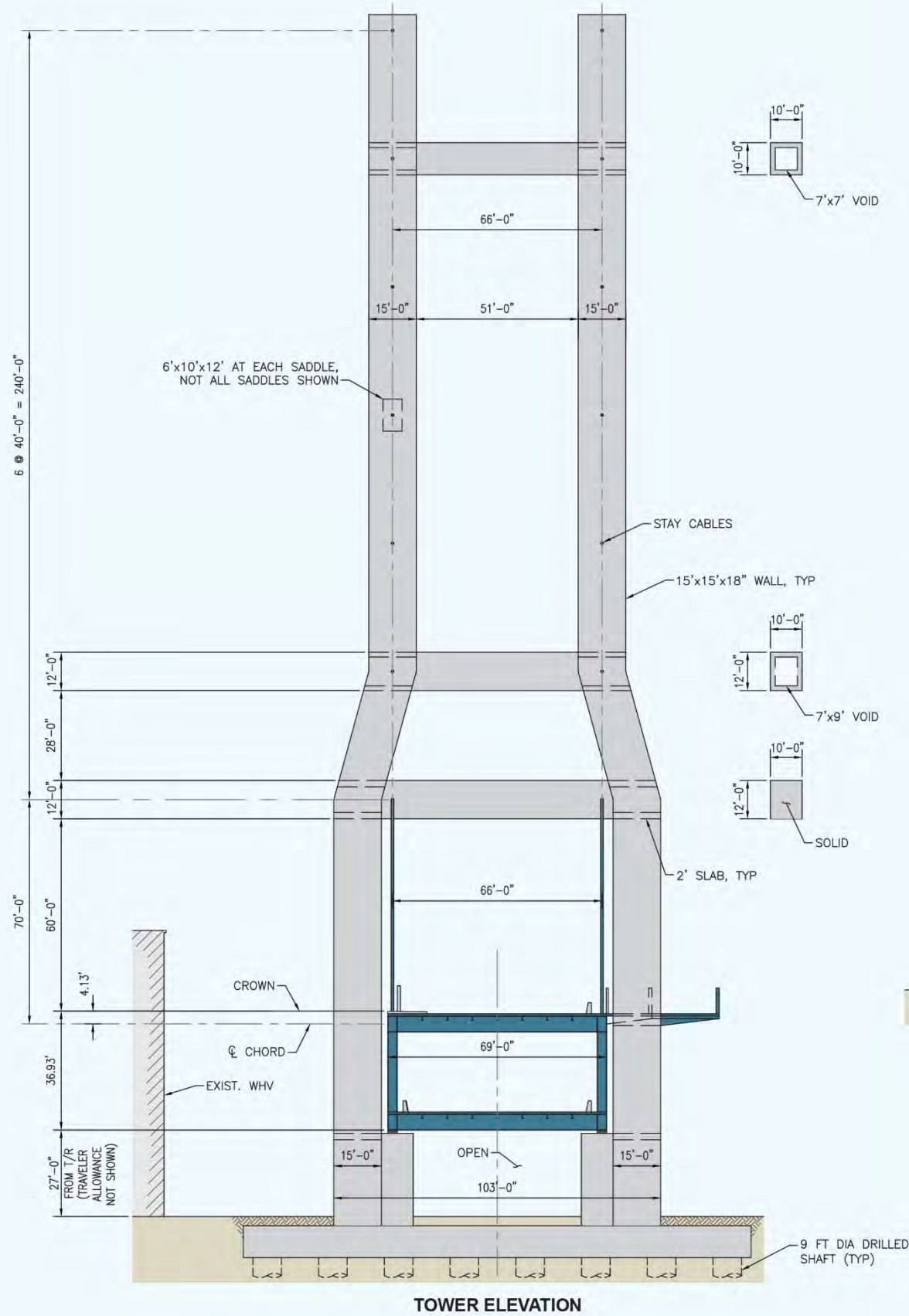
- RAMP AA1 - FUTURE RAMP TO/FROM I-75 NB/WHV
- RAMP AA2 - FUTURE RAMP FROM BANK STREET
- RAMP CC - FUTURE RAMP TO/FROM I-75 SB/WHV
- RAMP GG - FUTURE RAMP TO FINDLAY STREET

Cable Stayed Bridge (Single Tower)
Site Plan 3 of 3



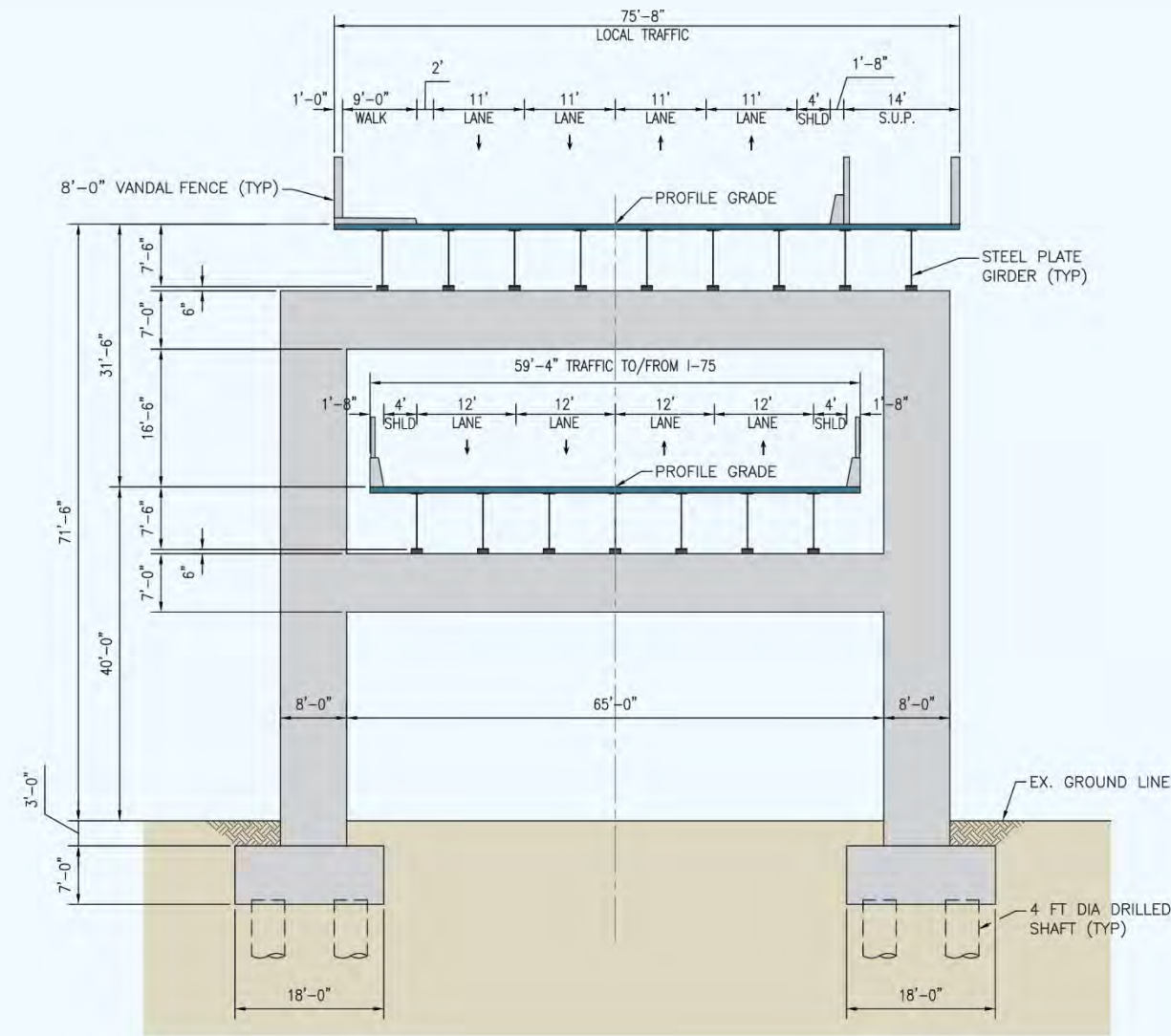
SECTION AT PIER B

Cable Stayed Bridge (Single Tower)
Typical Sections 1 of 4

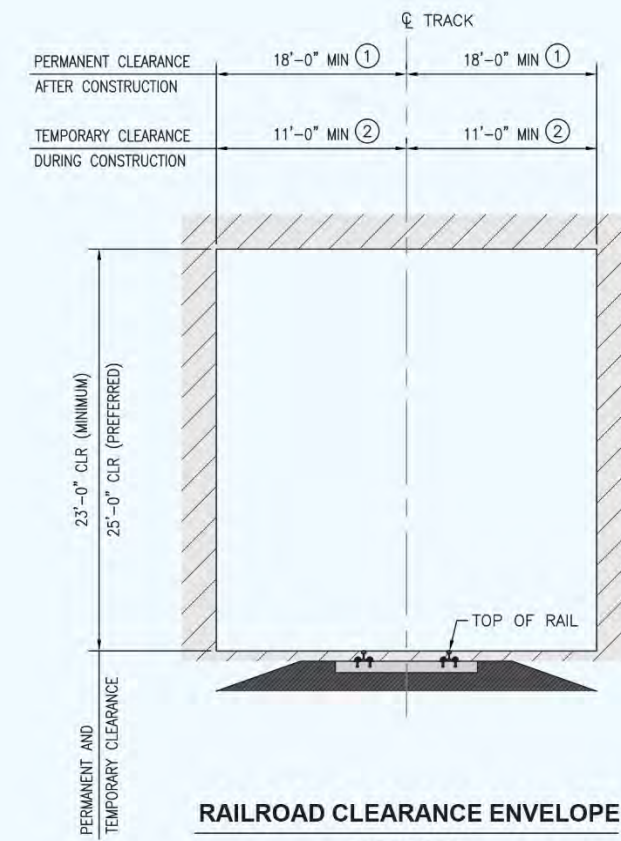


TYPICAL SECTION - CABLE STAYED BRIDGE

Cable Stayed Bridge (Single Tower)
Typical Sections 2 of 4



**SECTION AT PIERS E THRU I
(PIER E SHOWN)**

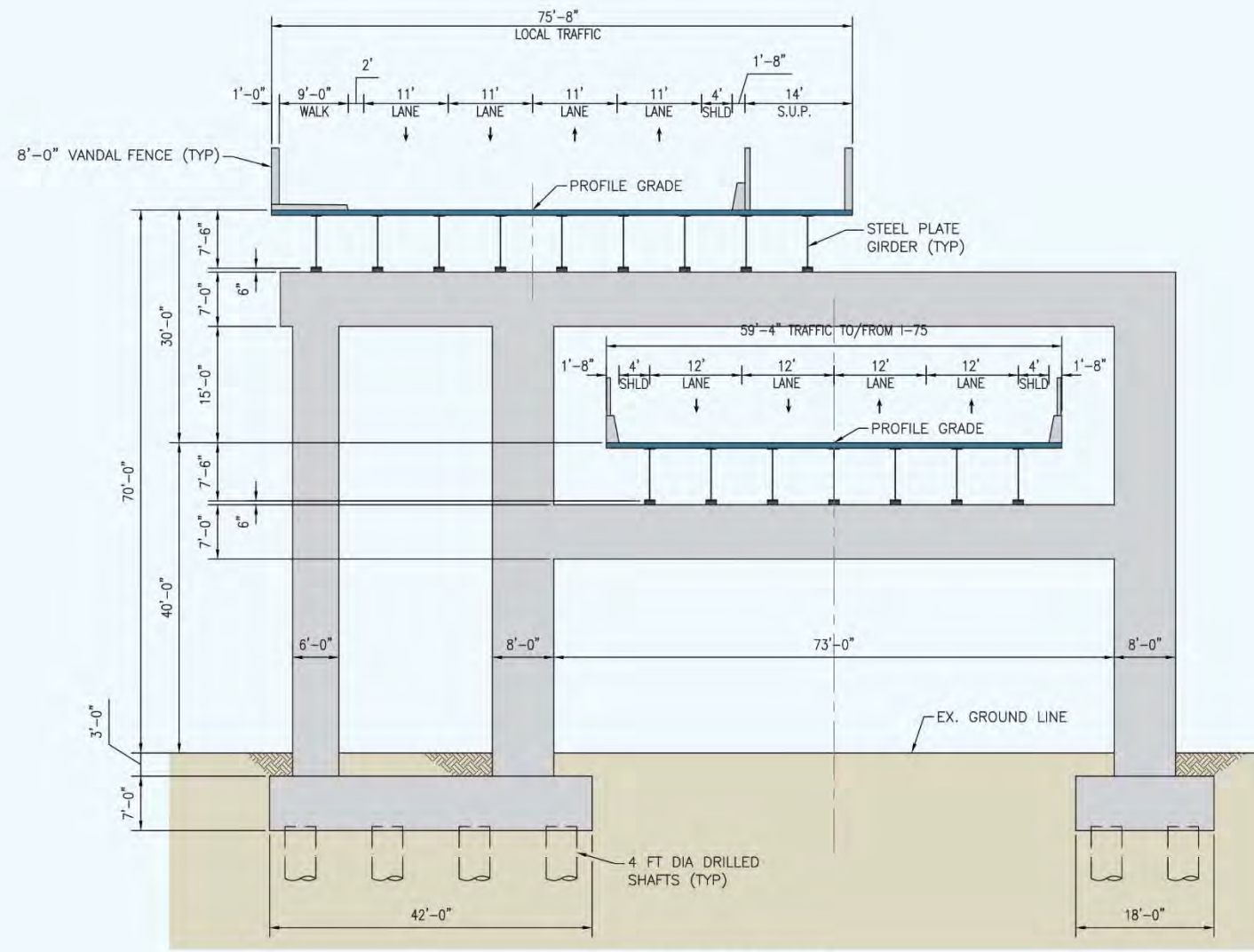


RAILROAD CLEARANCE ENVELOPE

(NOT TO SCALE)

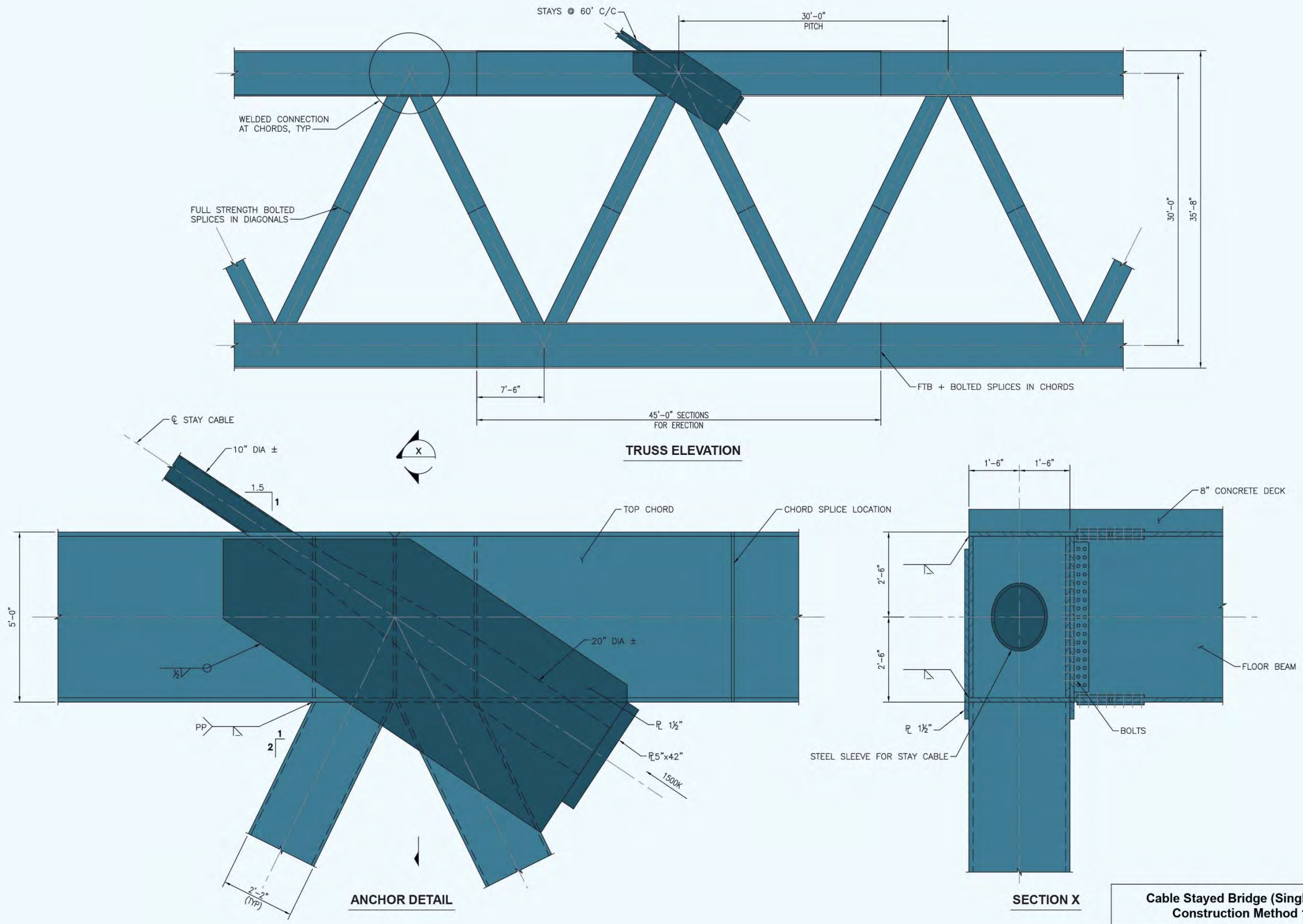
- ① 25'-0" PREFERRED. HORIZONTAL CLEARANCE LESS THAN THE 25'-0", CRASH WALL PROTECTION MAY BE REQUIRED UNLESS ADJACENT PIER CROSS-SECTION DIMENSIONS ARE NO LESS THAN 2'-6" THICK x 20'-0" LONG (MEASURED ALONG DIRECTION OF TRACK).
- ② FOR A TEMPORARY WALKWAY AND HANDRAIL SYSTEM A MINIMUM CLEARANCE OF 12'-0" SHALL BE PROVIDED.

**Cable Stayed Bridge (Single Tower)
Typical Sections 3 of 4**

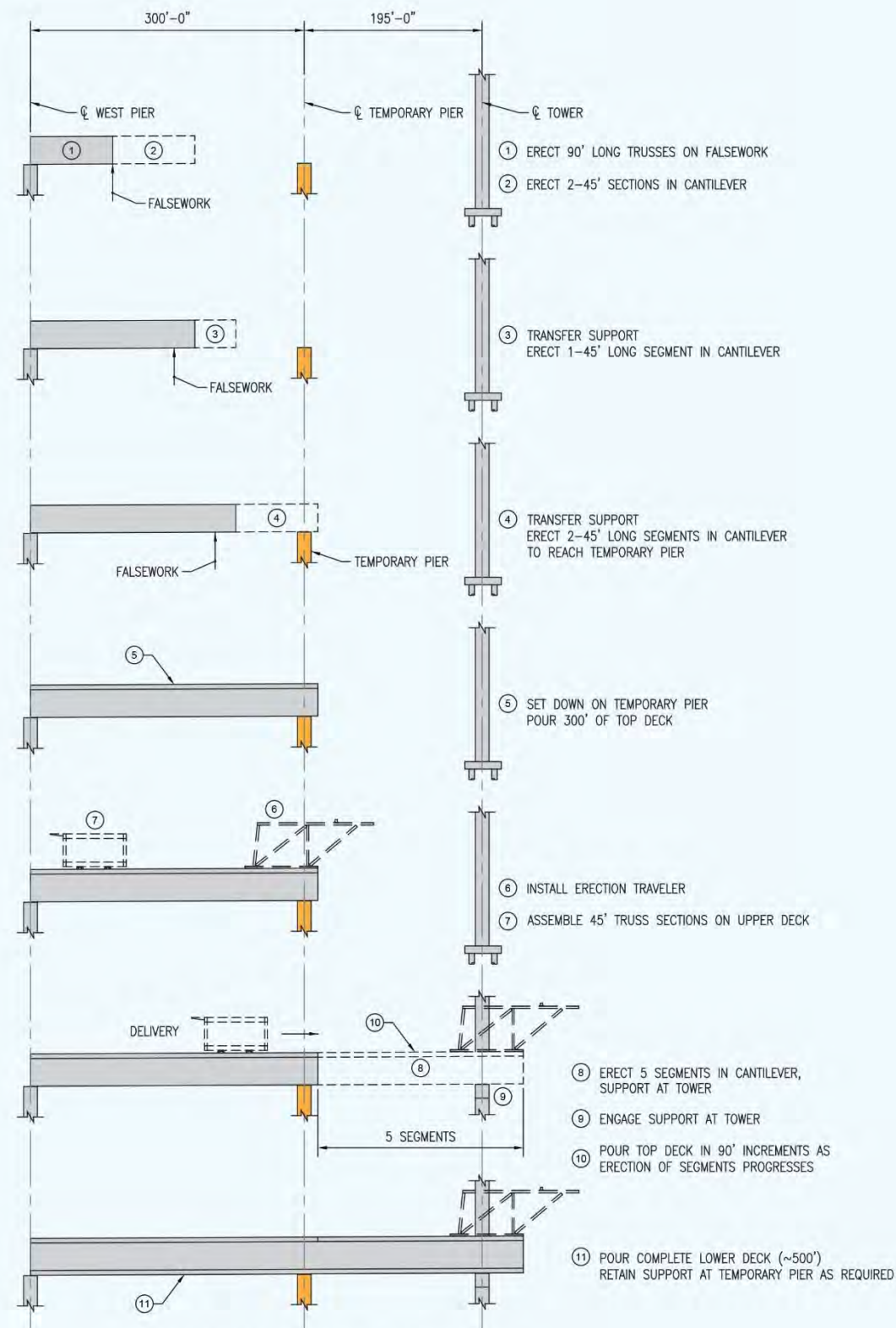


SECTION AT PIER J

Cable Stayed Bridge (Single Tower)
Typical Sections 4 of 4



Cable Stayed Bridge (Single Tower)
Construction Method 1 of 3



**BACK SPAN ERECTION SEQUENCE
SINGLE TOWER CABLE STAYED**

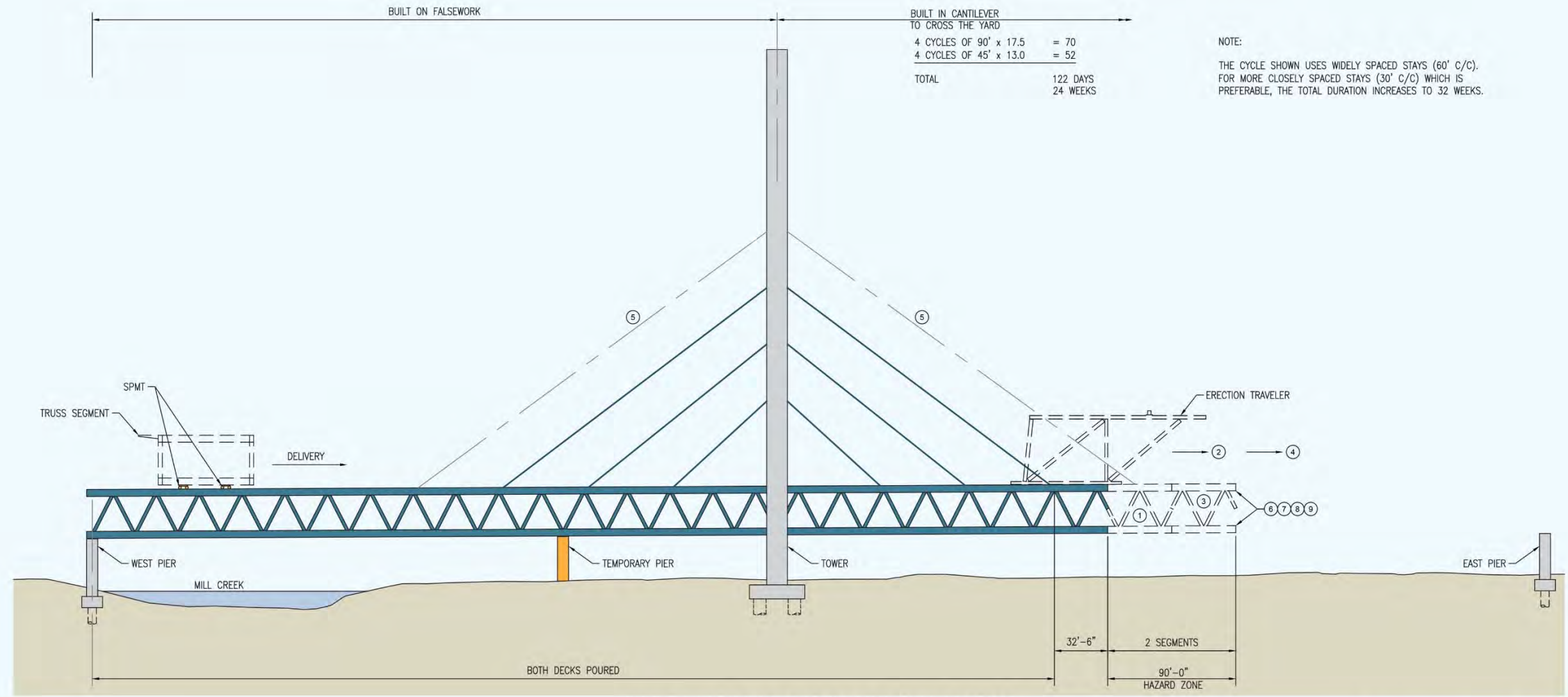
**Cable Stayed Bridge (Single Tower)
Construction Method 2 of 3**

CYCLE DESCRIPTION (ONE CYCLE BUILDS 90' OF CANTILEVER)

NO.	ACTIVITY	DURATION (DAYS)
1.	DELIVER AND ERECT ONE 45' SEGMENT OF STEEL FRAMEWORK	1.0
2.	ADVANCE ERECTION TRAVELER 45'	0.75
3.	DELIVER AND ERECT ONE 45' SEGMENT OF STEEL FRAMEWORK	1.0
4.	ADVANCE ERECTION TRAVELER 45'	0.75
5.	INSTALL AND TENSION ONE SET OF CABLE STAYS EAST AND WEST OF TOWER	2.5
6.	INSTALL 90' OF DECK STRINGERS - UPPER AND LOWER DECK	2.5
7.	FORM 90' OF UPPER AND LOWER DECKS	2.0
8.	PLACE REINFORCEMENT FOR 90' OF BOTH DECKS	1.5
9.	POUR 90' OF DECK ON BOTH LEVELS	0.5
10.	CURE UPPER DECK FOR 5 DAYS	5.0
TOTAL		17.5 (3.5 WEEKS)

3.5 DAYS TRACK CLOSURES 2x 4 HOUR PERIODS PER ADVANCE

PER DECK, OPERATIONS ARE STAGGERED



BUILT IN CANTILEVER TO CROSS THE YARD	
4 CYCLES OF 90' x 17.5	= 70
4 CYCLES OF 45' x 13.0	= 52
TOTAL	122 DAYS 24 WEEKS

NOTE:
THE CYCLE SHOWN USES WIDELY SPACED STAYS (60' C/C). FOR MORE CLOSELY SPACED STAYS (30' C/C) WHICH IS PREFERABLE, THE TOTAL DURATION INCREASES TO 32 WEEKS.

SINGLE TOWER CABLE STAY CANTILEVER PORTION

**Cable Stayed Bridge (Single Tower)
Construction Method 3 of 3**

3 INTERFACE OF THE NEW WHV WITH I-75 RECONSTRUCTION

3.1 General Remarks

This section looks at the requirements for the interface between WHV new construction and the general reconstruction of I-75 in an effort to outline generally what is, or is not, possible.

A *hypothetical scenario* is developed where WHV construction is completed first before the I-75 work is started.

This discussion of the I-75 interface is based on the specific case of the cast-in-place segmental alternative. The issues with this particular alternative are characteristic of those with the other alternatives that can be staged.

Two construction sequences are presented.

1. Full Project Option: All three bridges are constructed under one contract.
2. Staged Option: The central bridge that provides access to I-75 traffic is constructed first. The north and south bridges that provide local access are built later.

Some of the key observations from this study are as follows:

- a. Some considerable local work will have to be done to existing I-75 in order to make the new WHV connections to I-75 work. This includes locally regrading the existing I-75. It includes also the replacement of at least two bridges over Harrison Ave. – the bridges for Ramps BB and AA.
- b. It is possible to essentially preserve the existing I-75 mainline plan alignment as-is until reconstruction of I-75 starts.
- c. There is no need for a local traffic temporary bridge over I-75.
- d. The existing local traffic bridge over I-75 does have to be removed before the new ramp connections to the new WHV I-75 traffic bridge can be completed.

Among the many sub-options that have been considered is one in which the WHV construction is staged due to budgetary constraints (Staged Option). In this approach, the new connection to I-75 would be built and opened in the first stage (Stage 1) while local traffic continues to be carried on the existing WHV. At some later date, as funding permits, the local traffic portion of the new WHV would be constructed. In Stage 1, it would be necessary to build a temporary, upper level bridge over I-75 to carry local traffic, as the existing bridge has foundation locations that make it virtually impossible to construct the ramps to/from WHV to I-75.

3.1.1 Sequence for the Full Project Option

The basic assumption here is that WHV will be complete and operational before the extensive I-75 upgrades start. However, local work on I-75 (quite extensive) in the vicinity of WHV must be carried out in coordination with WHV construction in order to make the I-75/WHV connections functional.

- At least two bridges associated with the future I-75 work will have to be constructed early to carry Ramps AA and BB.
- Ramps DD and GG would not be constructed at this time.

- The I-75 SB on-ramp will have to be closed for an extended period. This can be avoided through the construction of a temporary on-ramp. Unfortunately, this temporary ramp is sub-standard in some aspects.
- The I-75 NB off-ramp will have to be closed at the start of construction of the structures over I-75.
- The I-75 NB on-ramp can be kept operational for a longer period of time
- Existing WHV over I-75 is to remain in place for as long as possible to preserve the local traffic

The following is described for the CIP segmental alternative – Full Project Option. It is one plausible sequence for carrying out the work. Other approaches may be possible.

A schedule for the full project (not staged) is shown on page 125. It shows a total construction period for the complete WHV of 47 months. A duration of 6 months should be added to the schedule to take into account the “Railroad Effect”.

In this scenario, access to/from I-75 is closed as follows:

- I-75 SB on ramp – 3.4 months (1st at 1 month, 2nd at 2.4 months) with temporary on ramp; 26 months without temporary on ramp
- I-75 SB off ramp – 2.4 months
- I-75 NB on ramp – 4.6 months
- I-75 NB off ramp – 11.5 months

The WHV is closed to local traffic for 4.4 months

Detailed Sequence Steps

For existing conditions see page 119.

Stage 1

- Construct new WHV from west end to Pier H
Some minor geometric adjustments may be necessary to avoid conflict with the existing WHV straddle bents near new pier H

Stage 2

- Build temporary optional on-ramp to I-75 SB. See page 120 for the ramp concept. This ramp is about 8% slope and also offers Spring Grove traffic an option to access I-75 SB. It is substandard for these reasons. It does save many months during which this movement would otherwise have to be closed.
- Close exist on-ramp to I-75 SB and open temporary on-ramp. Bridge construction H to K forces the ramp closure

Stage 3

- Construct new WHV from Pier H to Pier K. See page 120.

Stage 4

- Close left exit off-ramp from I-75NB. Pier M is right in the middle of this ramp. The I-75 NB on-ramp can be kept operational for a while
Ramps to/from I-75 SB remain operational
Upper deck becomes local traffic only once the I-75 NB on-ramp is closed.
- Build local traffic upper level new bridge over I-75. Pier K to Pier M. There will be some closures of the SB on-ramp during the construction. This must be built before the I-75 traffic bridge for reasons of construction access.

Stage 5

- Regrade I-75 locally to allow construction of the I-75 bridge to be carried out – rapid regrade with a 30-hour closure. See page 121.
In order to fit existing I-75 below the new I-75 traffic structure with minimal disturbance while maintaining a design speed of 55 mph, it is necessary to use a slender structure for the I-75 traffic bridge. The geometry is tight but appears workable. See page 123 for the vertical road geometry.
Included in this regrading is a widening of I-75 SB into the median so as to create space on the west for construction of the retaining walls that will support new Ramp CC.

Stage 6

- Close I-75 SB temporary on-ramp and I-75 NB on-ramp
- Build WHV I-75 bridge with traffic below it – Pier K to Pier M. See page 122
For construction clearance reasons this must be a girder bridge (not CIP). It appears as if a slender span to depth ratio of at least 25 is required.
- Partially build new ramps to the new I-75 bridge. The piers of the existing WHV across I-75 prevent completion of Ramp DD North and Ramp CC. Ramps AA and BB can be completed. See page 122. Moveable barrier wall and a “Road Zipper” machine can create one lane of working space during off-peak hours for the construction of the MSE walls for the new ramps.

Stage 7

- Close exist WHV across I-75. *There is now no local traffic*
- Demolish exist WHV over I-75.
- Complete Ramps DD North and CC. Note the southern ramps (AA, DD South and BB could be opened earlier
- Open I-75 bridge to traffic to/from I-75. All moves to/from I-75 are activated.
- Rework the interchange at Central Parkway
- Open upper level local traffic bridge. Full local traffic is restored.
- Close the existing WHV completely. Access to/from Spring Grove Ave is also closed. The interchange then remains in this condition (Interim Condition A – see page 125) until I-75 reconstruction starts.

- At some future time reconstruct I-75 to final conditions (see page 125)

3.1.2 Sequence for the Staged Option

In this scenario, a temporary, high level, bridge over I-75 must be constructed for the local traffic.

A schedule for this option is shown on page 133. The schedule is a “greenfield” schedule that does not allow for delays due to the “Railway Effect”. It shows a total construction period for the I-75 connection structures of 33 months and a total duration to the completion of all WHV work of 75 months. Six months should be added to the schedule to take into account the “Railroad Effect.”

This sequence requires the construction of a temporary bridge over I-75 for the local traffic.

In this scenario, access to/from I-75 is closed as follows:

- I-75 SB on ramp – 9 months (1st at 1 month, 2nd at 8 months) with temporary on ramp; 26 months without temporary on ramp
- I-75 SB off ramp – 8 months
- I-75 NB on ramp – 8 months
- I-75 NB off ramp – 8 months

The WHV is closed to local traffic for a total of 9 months – one period of 5 months plus one period of 4 months

Detailed Sequence Steps

For initial conditions see page 126.

Phase 1 (I-75 Bridges)

Stage 1

- Construct new WHV central bridge (I-75 traffic) from west end to Pier H. Local traffic bridges will be built later. Some minor geometric adjustments may be necessary to avoid conflict with the existing WHV straddle bents near new pier H.

Stage 2

- Build temporary optional on-ramp to I-75 SB. See page 127 for the ramp concept. This ramp is about 8% slope and also offers Spring Grove traffic an option to access I-75 SB. It is substandard for these reasons. It does save many months during which this movement would otherwise have to be closed.
- Close exist on-ramp to I-75 SB and open temporary on-ramp. Bridge construction H to K forces this closure.

Stage 3

- Construct the lower level (I-75 traffic) of the new WHV from Pier H to Pier K. See page 127.

Stage 4

- Close left exit off ramp from I-75NB. Pier M is right in the middle of this ramp. The I-75 NB on-ramp can be kept operational for a while with some periodic closures.
 - Ramps to/from I-75 SB remain operational
 - Upper deck becomes local traffic only once the I-75 NB on-ramp is closed.
- Regrade I-75 locally (rapid regrade, 30-hour closure) to create clearance under the new I 75 traffic bridge. See page 128.
 - In order to fit existing I-75 below the new I-75 traffic structure with minimal disturbance while maintaining a design speed of 55 mph, it is necessary to use a slender structure for the I-75 traffic bridge. The geometry is tight but appears workable. See page 129 for the vertical road geometry.
 - Included in this regrading is a widening of I-75 SB into the median so as to create space on the west for construction of the retaining walls that will support new Ramp CC.

Stage 5

- Demolish the existing WHV upper level bridge over I-75.
- Build a new, temporary, bridge for local traffic over I-75. It occupies the same footprint as the bridge that was just demolished but has its piers placed in new locations

Stage 6

- Build the new I-75 traffic bridge over I-75 Pier K to Pier M'. See page 129.
- Build new ramps to the I-75 traffic bridge. Moveable barrier wall and a “Road Zipper” machine can create one lane of working space during off-peak hours for the construction of the MSE walls for the new ramps.
- Open the new WHV for traffic to/from I-75.
 - Local traffic remains on existing WHV using the temporary bridge over I-75.
 - Traffic to/from I-75 is on the new structure.
 - Spring Grove access can be maintained via existing WHV.

INTERIM CONDITION B. This is a pause between construction stages until funds become available to complete the project. See page 130.

Phase 2 (Local Traffic Bridges)

Stage 7

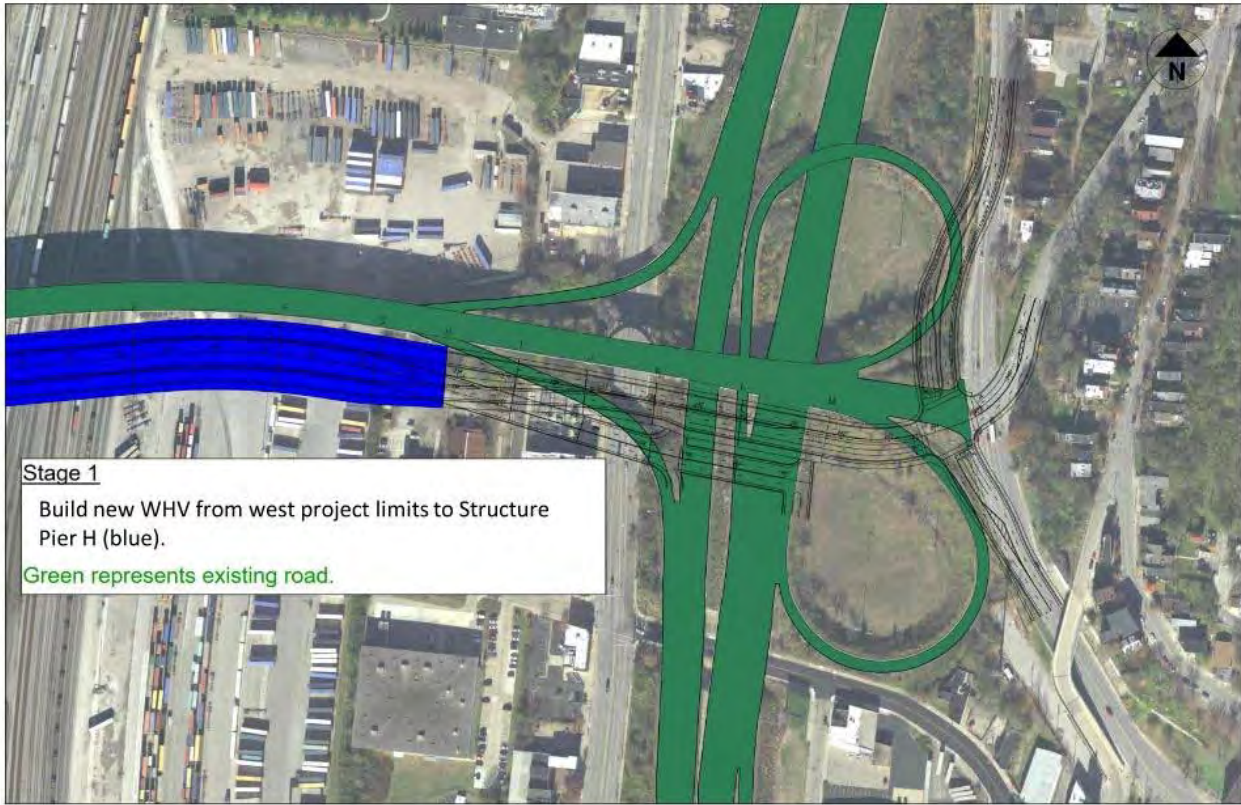
- Build the local traffic bridges from the west end to Pier H. Use 1 to 2 lanes of the upper deck and 2 lanes of the lower deck of existing WHV for access and material handling. There will also be frequent lane restrictions on the I-75 traffic portion of the new WHV during this stage of construction.
- Build local traffic WB bridge from Pier H to Pier K. Use 2 lanes of upper and lower deck of existing WHV for access and material handling. There will also be frequent lane restrictions on the I-75 traffic portion of the new WHV during this construction.

- Build local traffic EB bridge from Pier H to Pier K. There will be work overhead of the I-75 traffic.

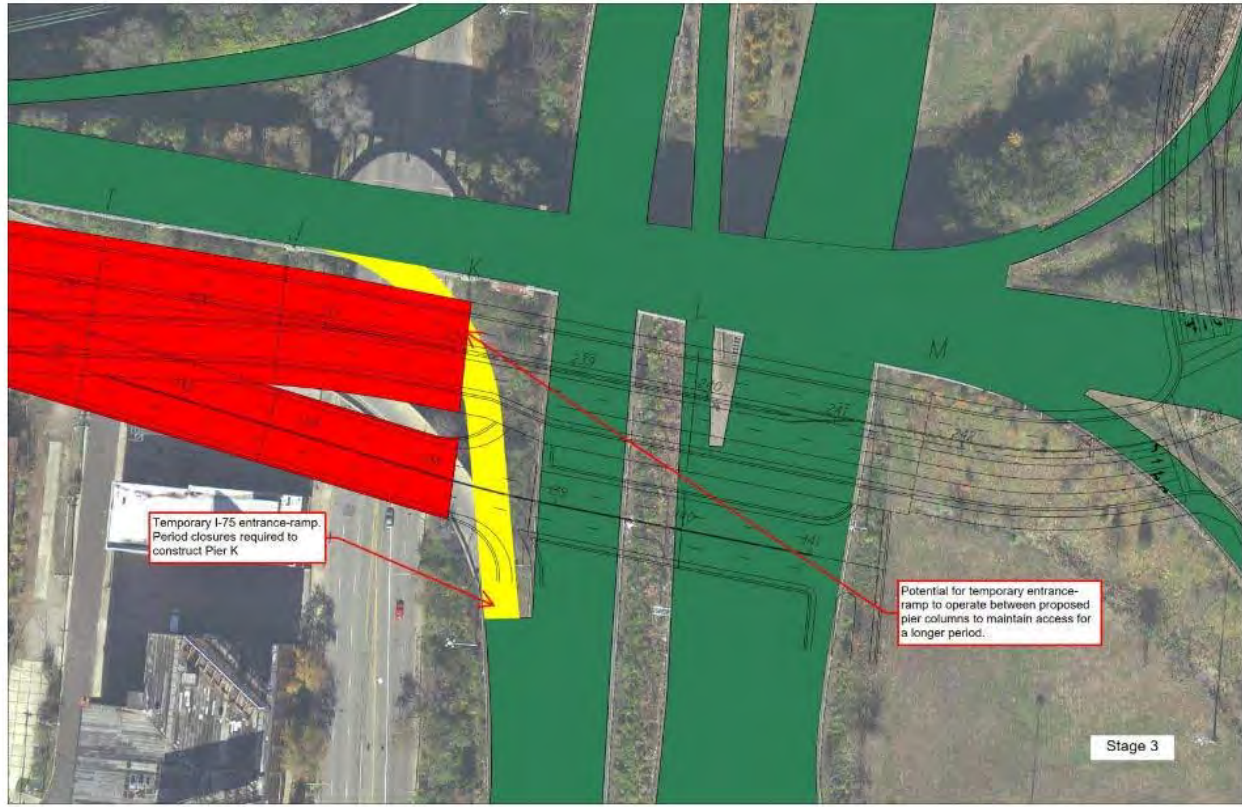
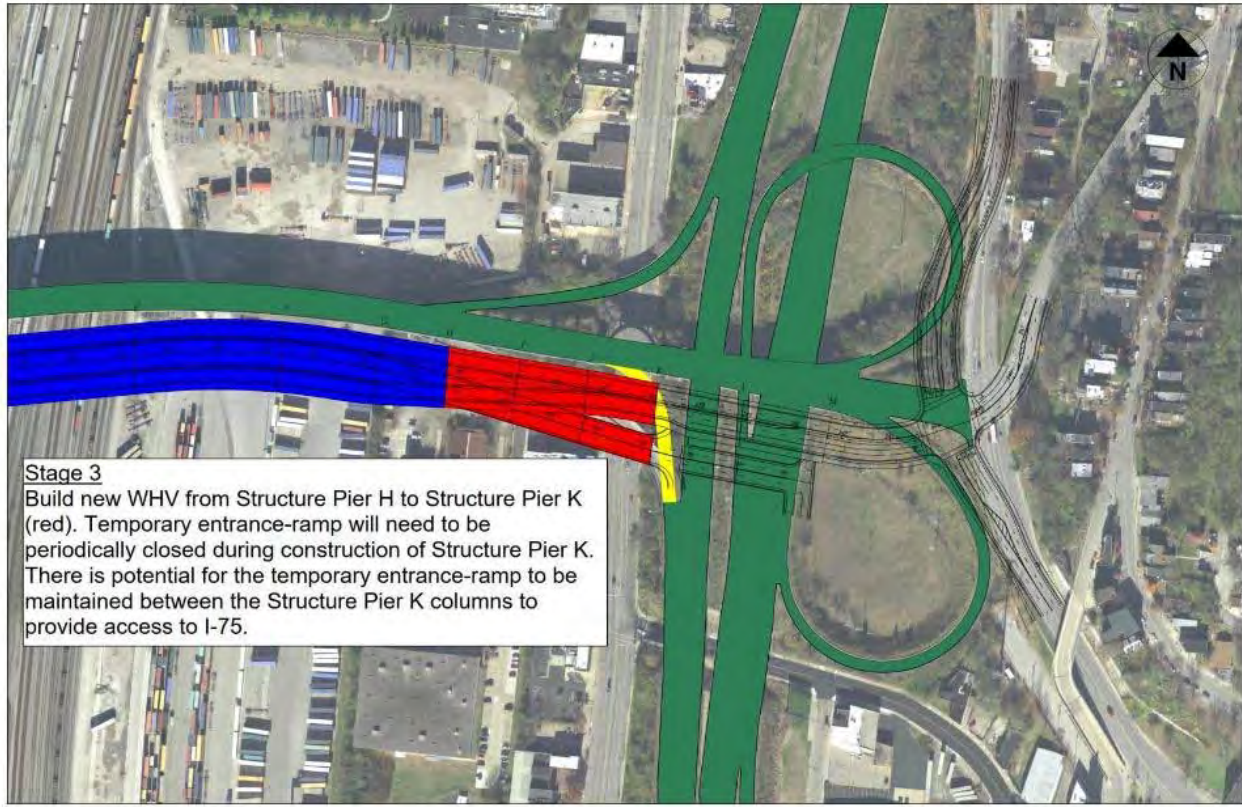
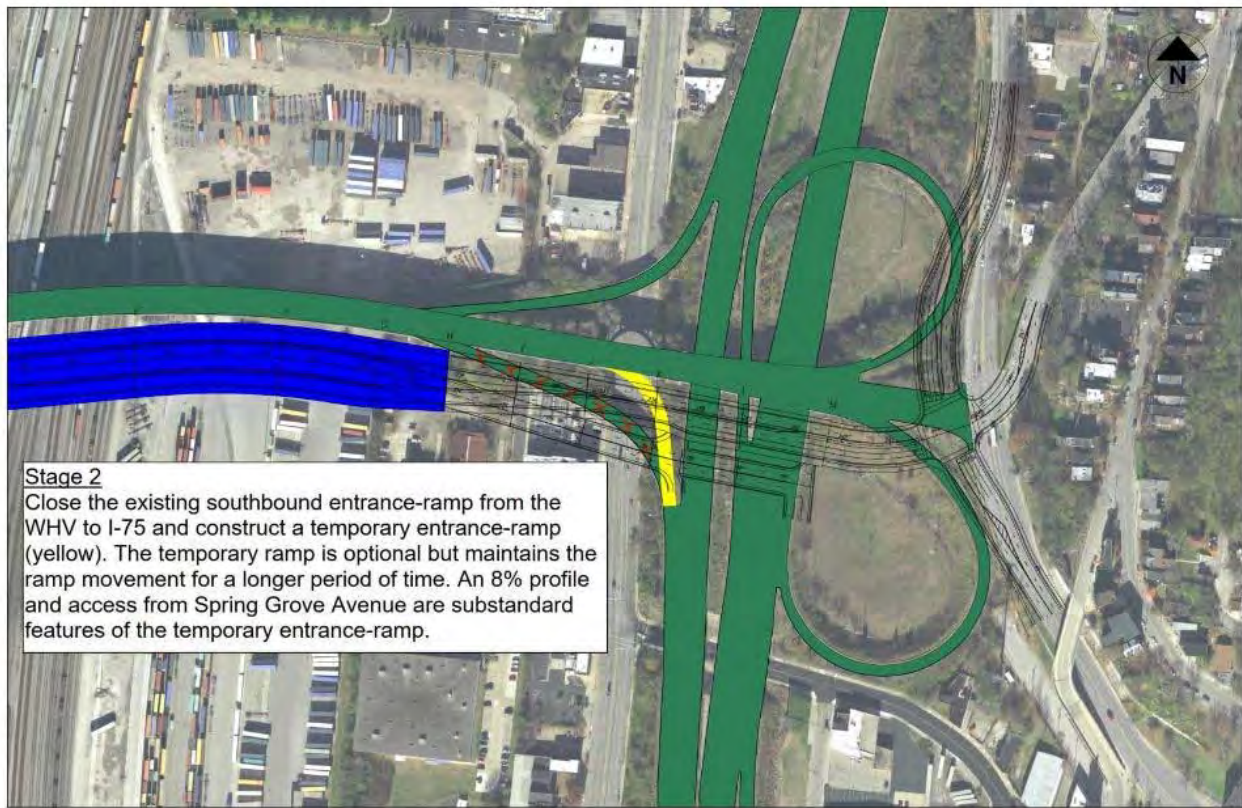
Stage 8

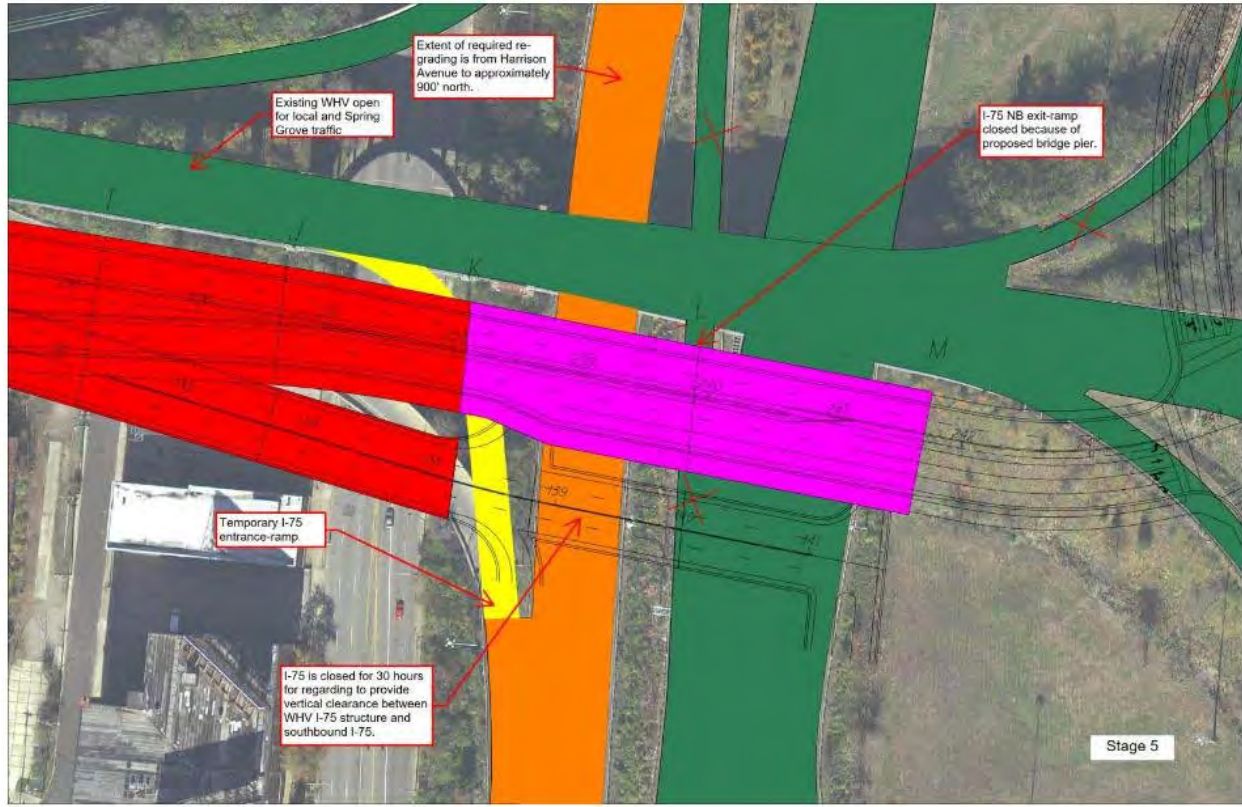
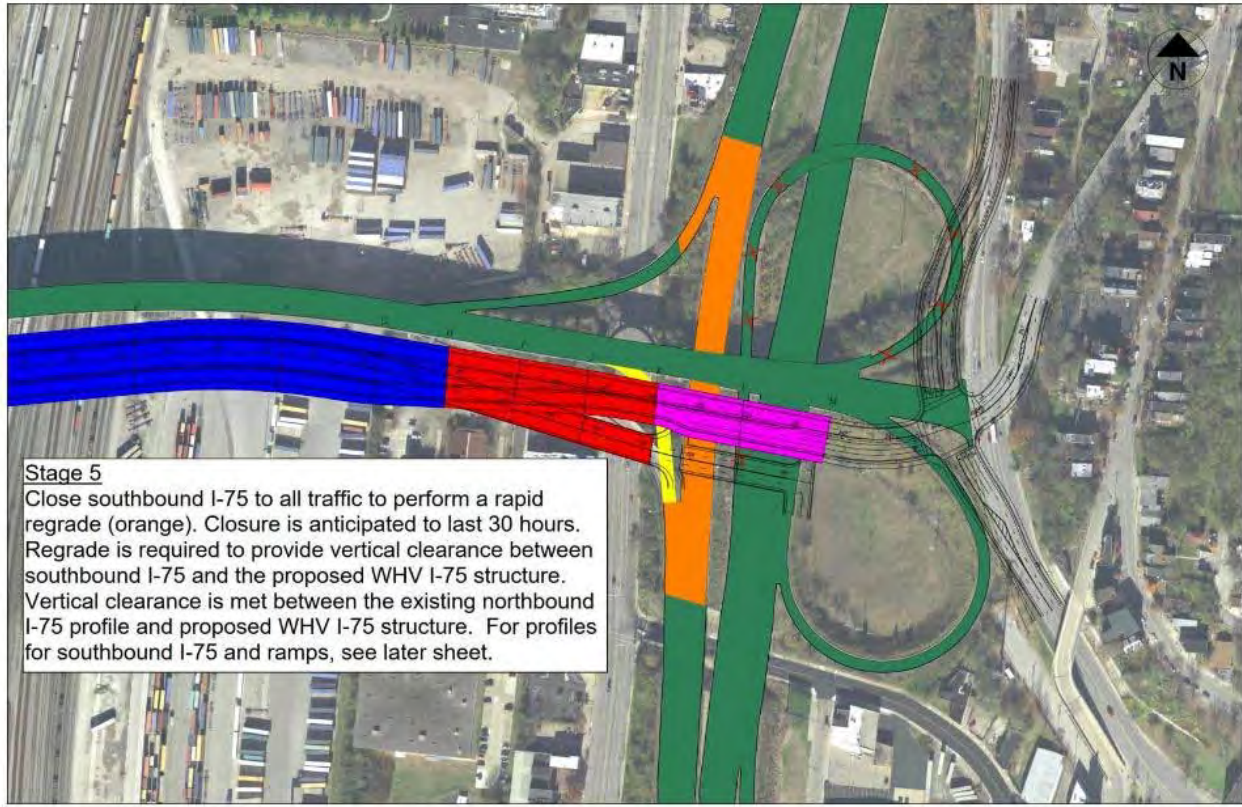
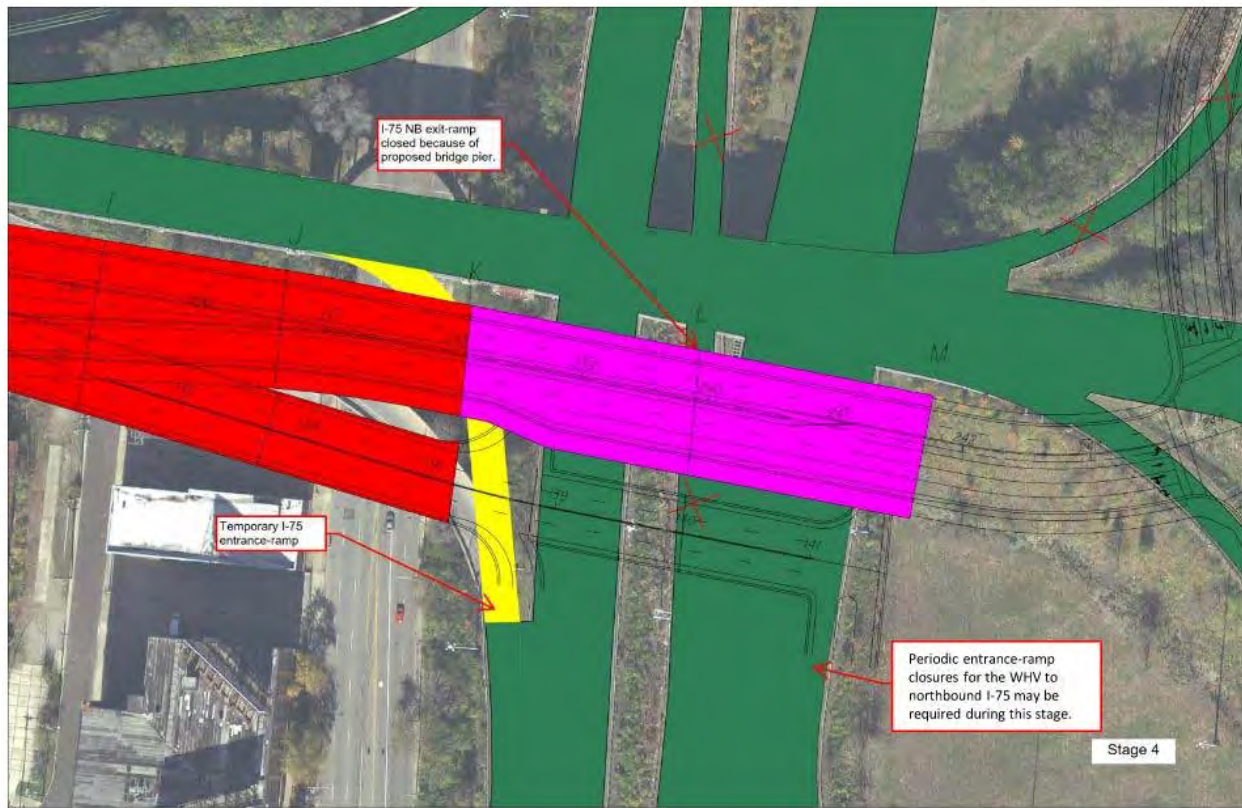
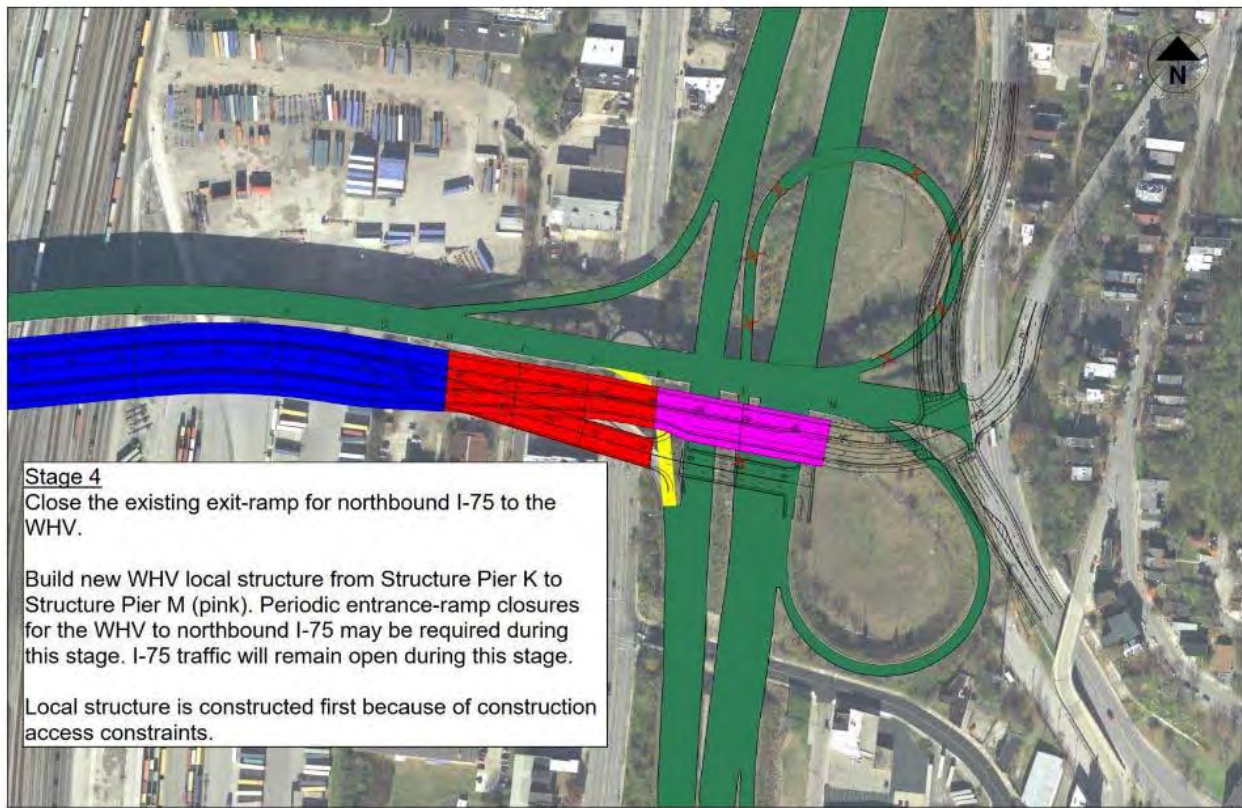
- Close local traffic and Spring Grove traffic on the existing WHV temporary bridge over I-75.
- Demolish existing temporary WHV bridge over I-75 from east end to Spring Grove Ave. This is required for construction access in the next step.
- Build new local traffic (upper level) bridge over I-75. See page 130.
- Rework the interchange at Central Parkway.
- Open the new WHV to local traffic.
- Close the existing WHV completely. Access to/from Spring Grove Ave is also closed. The interchange then remains in this condition (Interim Condition A – see page 124) until I-75 reconstruction starts

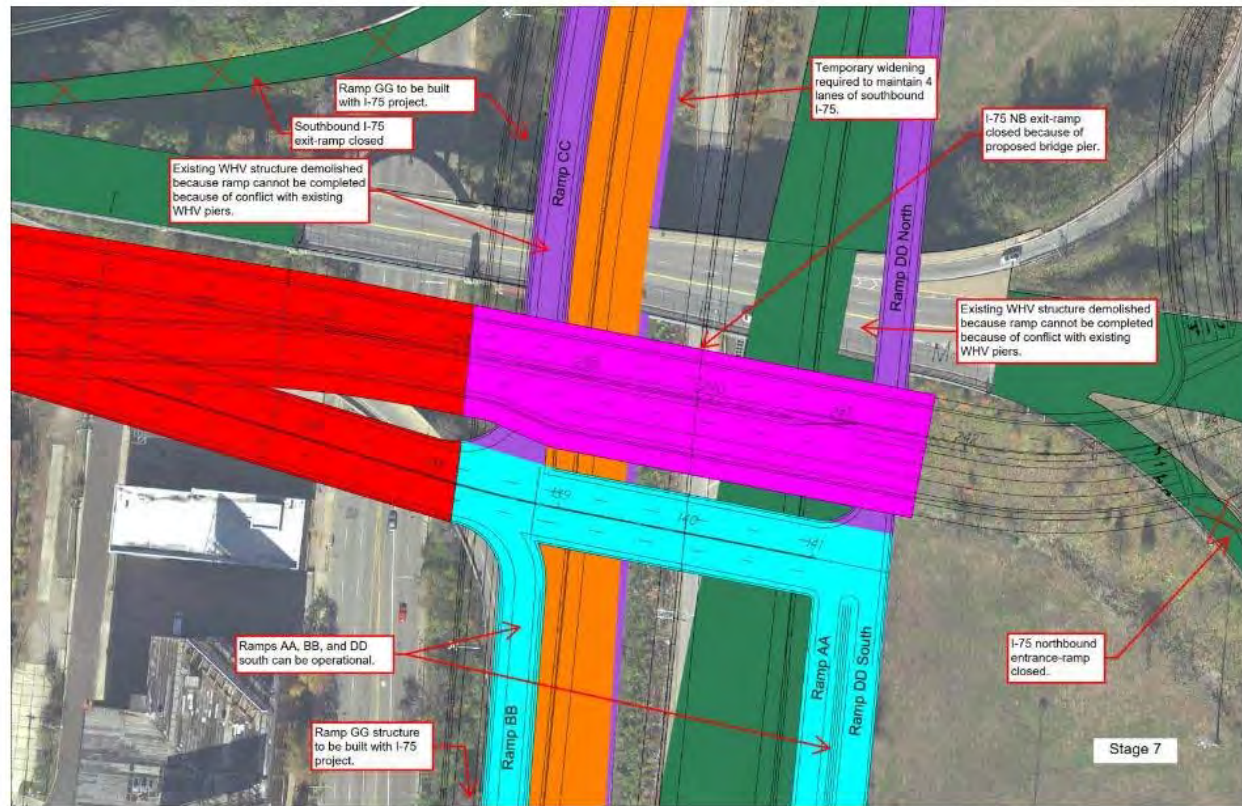
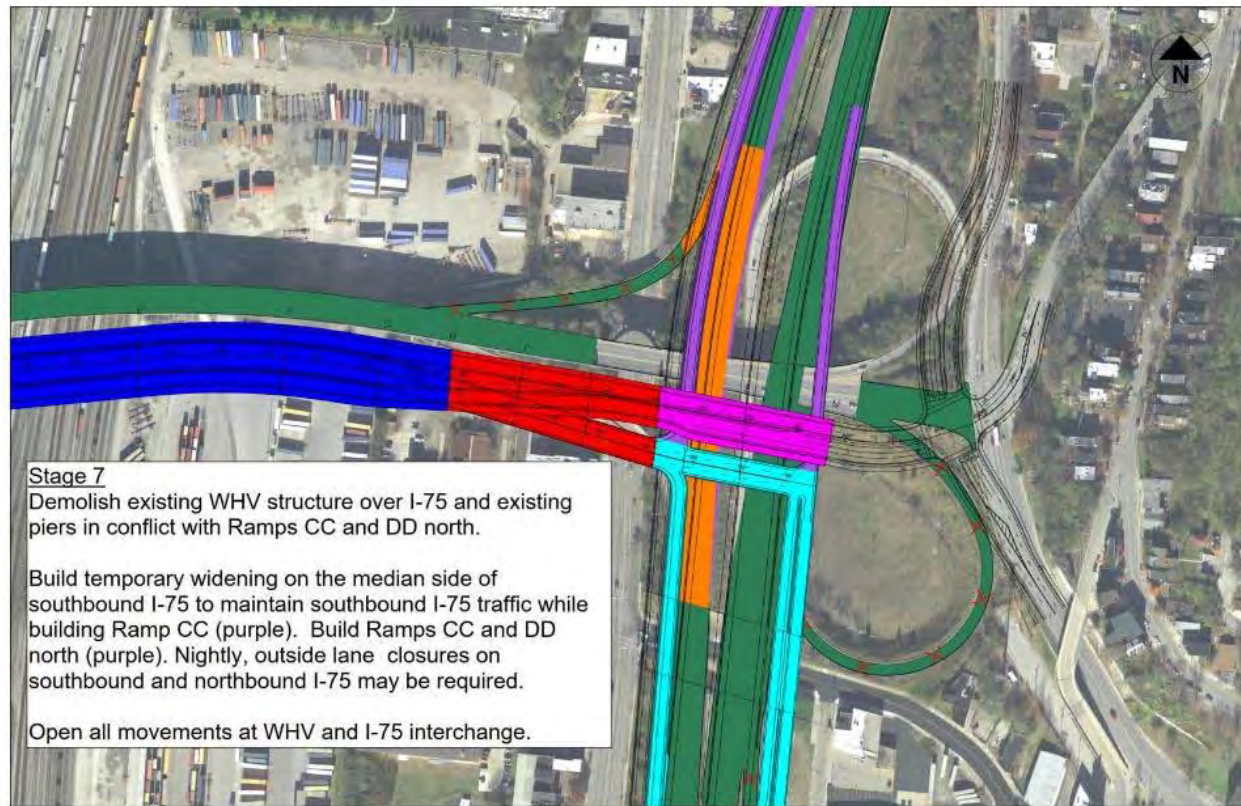
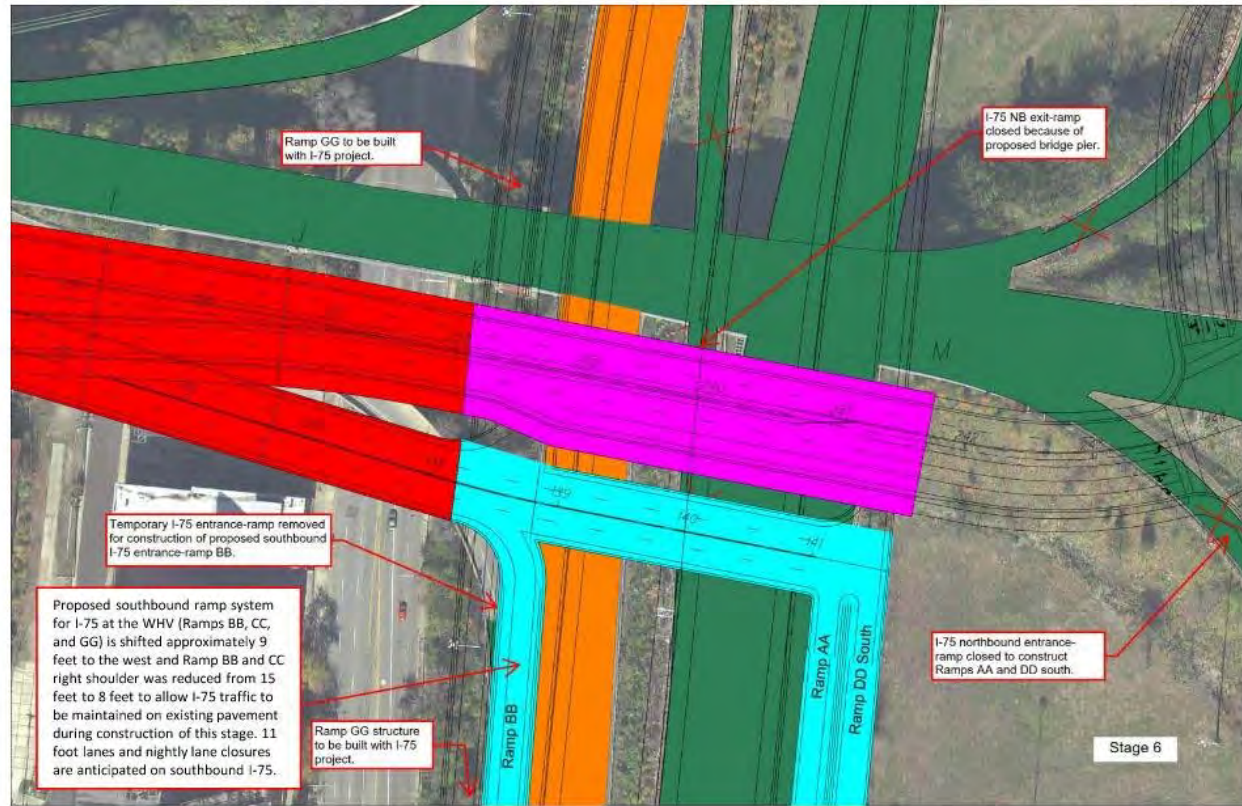
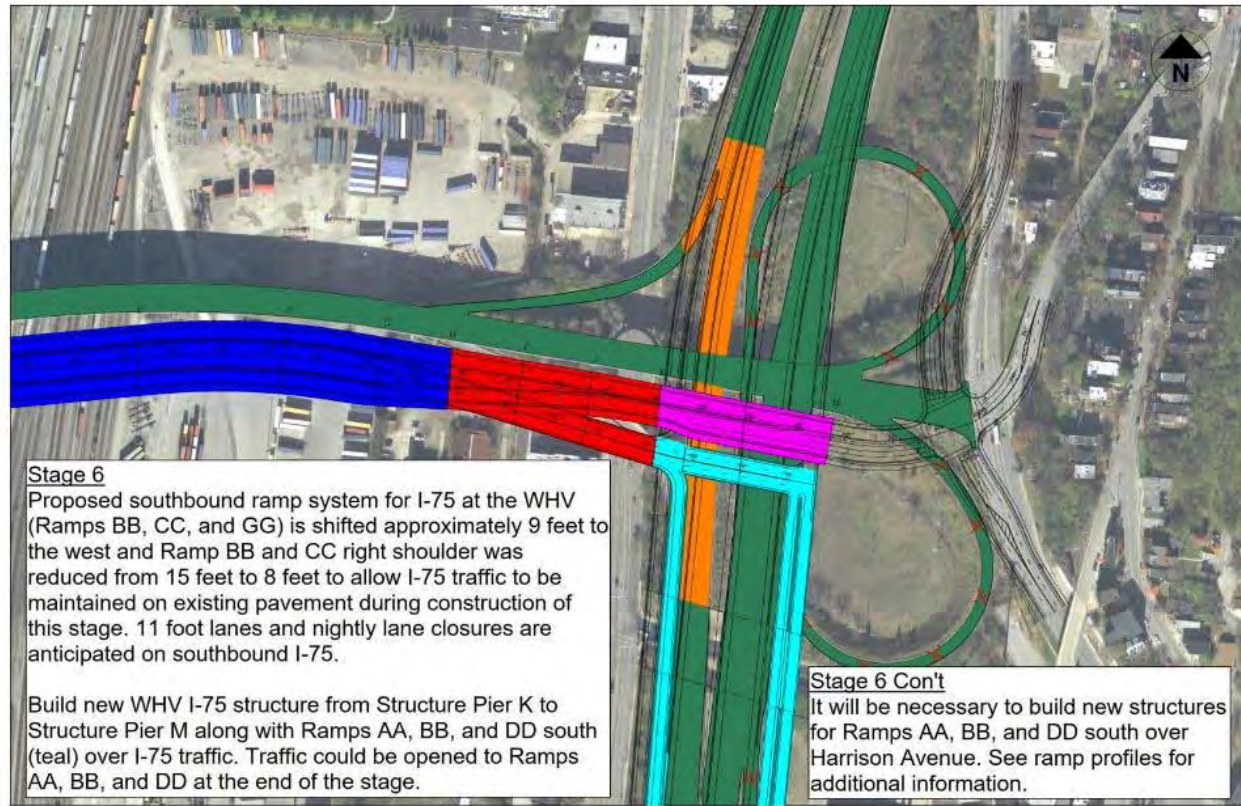
At some future time reconstruct I-75 to final conditions (see page 131)

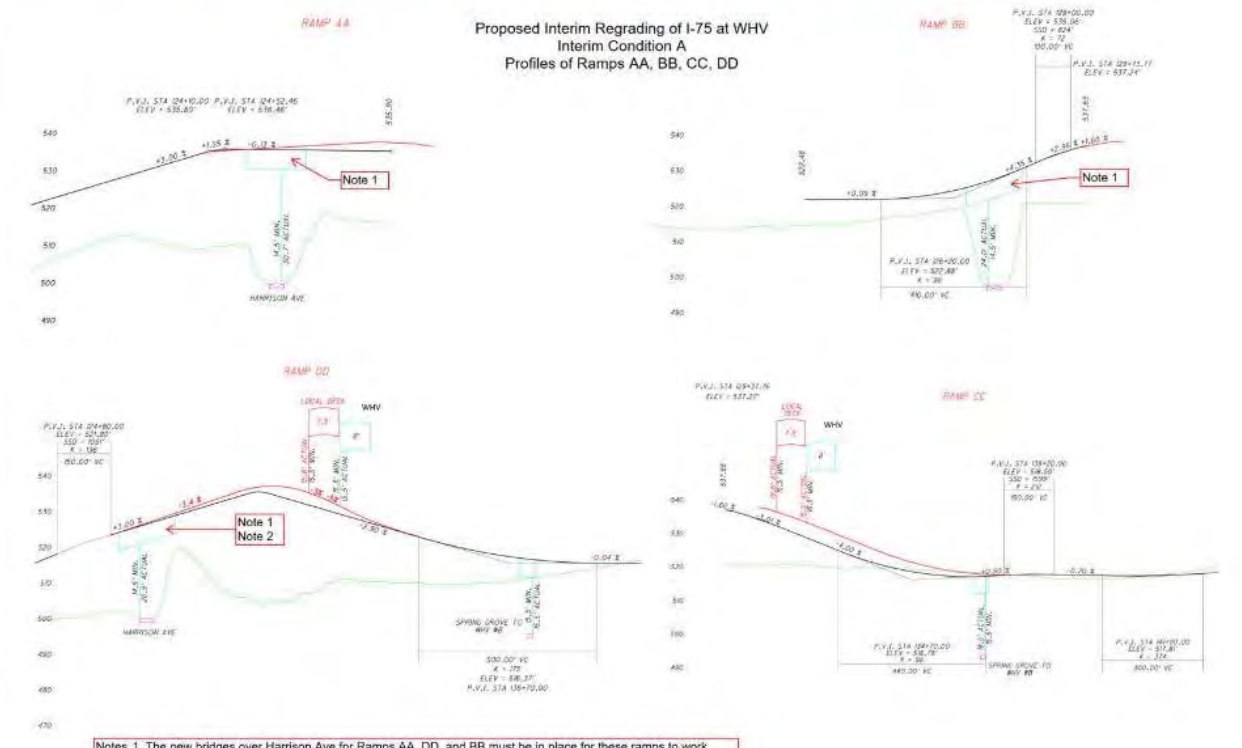
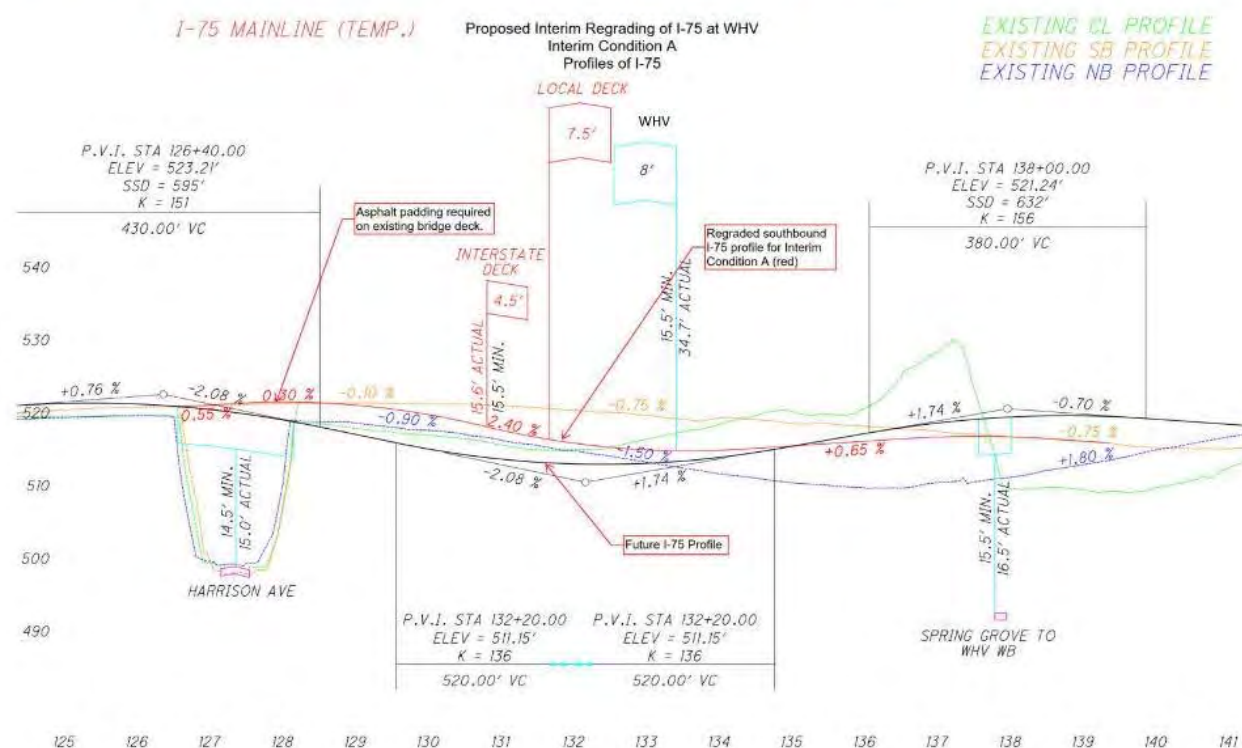
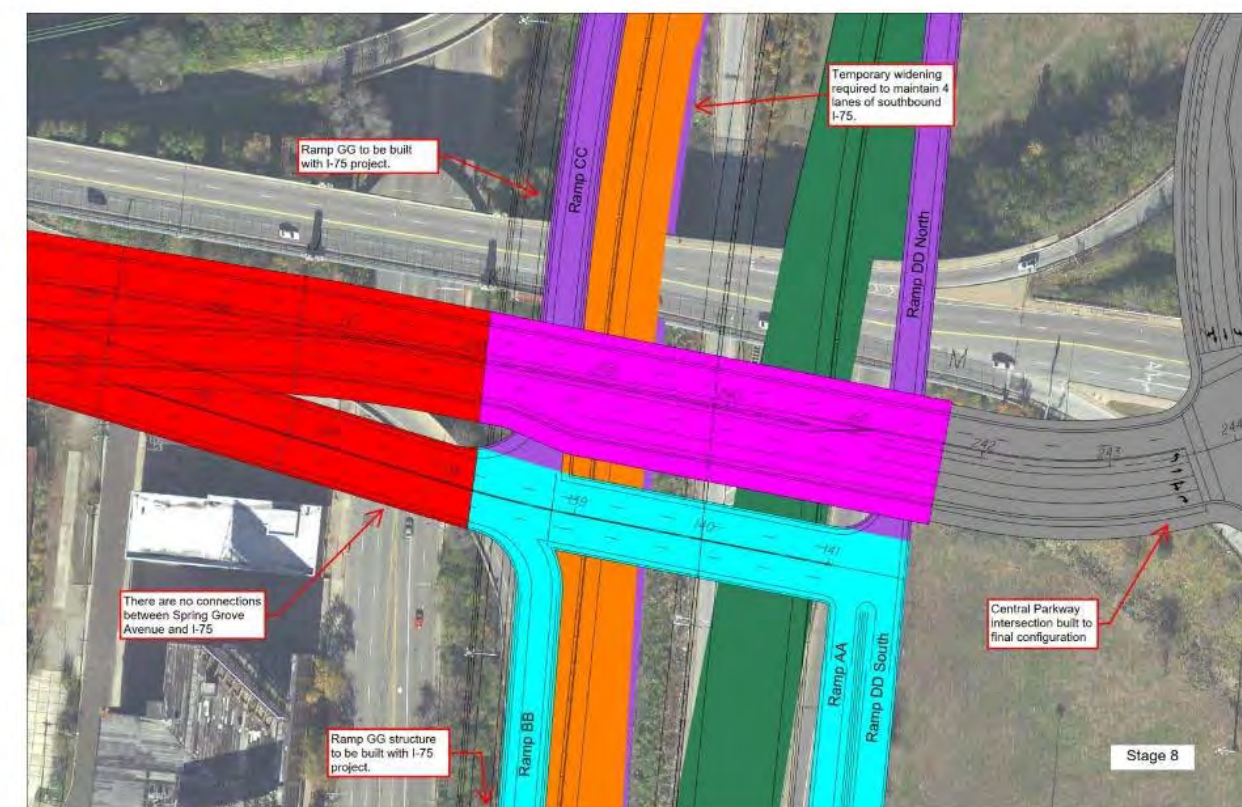
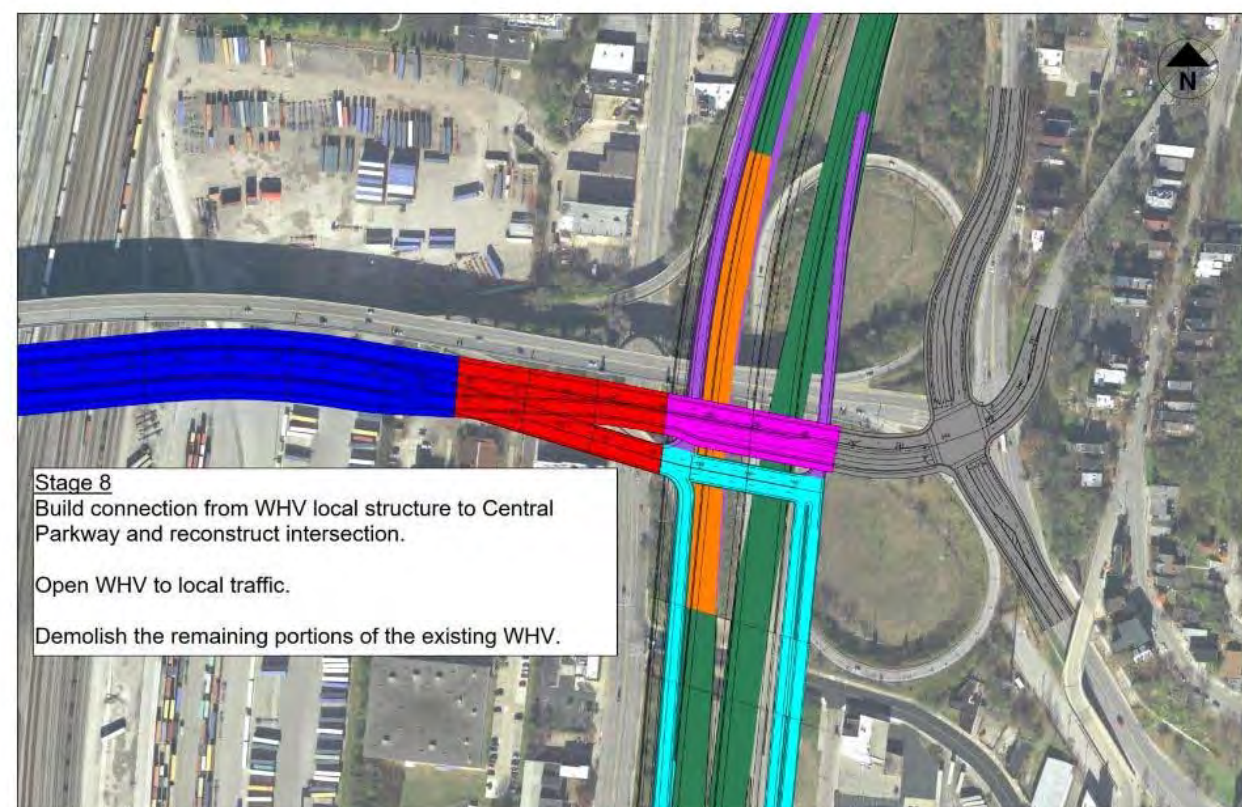


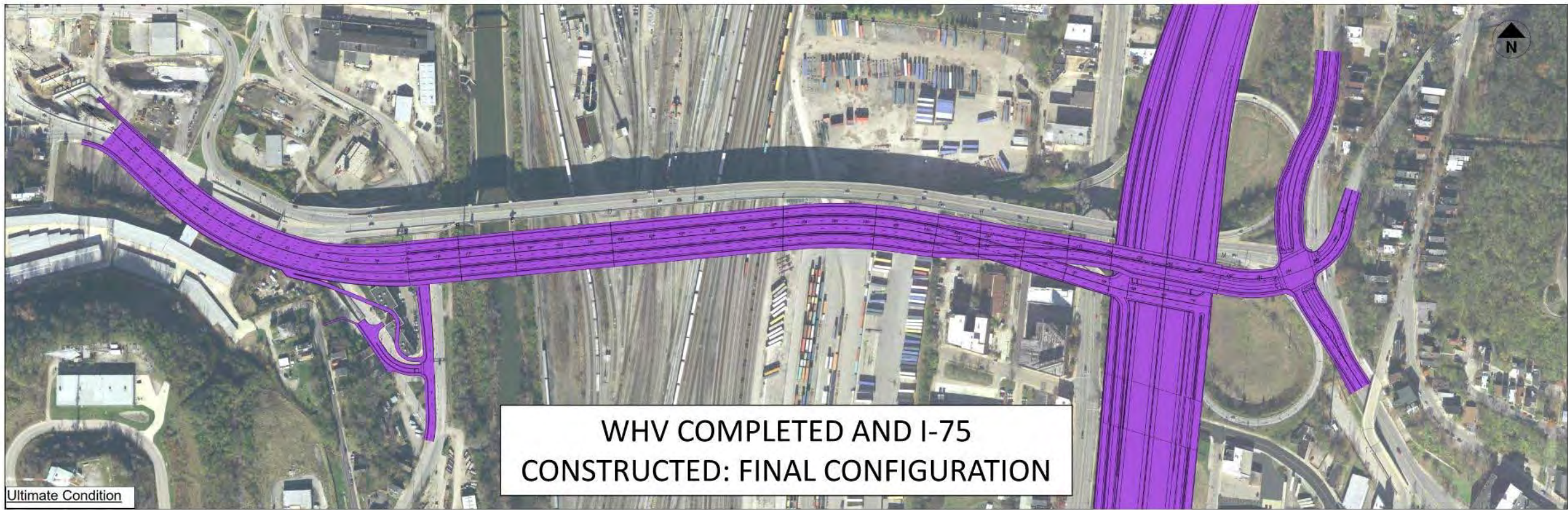
INTERFACE WHV & I-75
CONSTRUCTION STAGES
FULL PROJECT OPTION
CIP SEGMENTAL ALTERNATIVE IS SHOWN

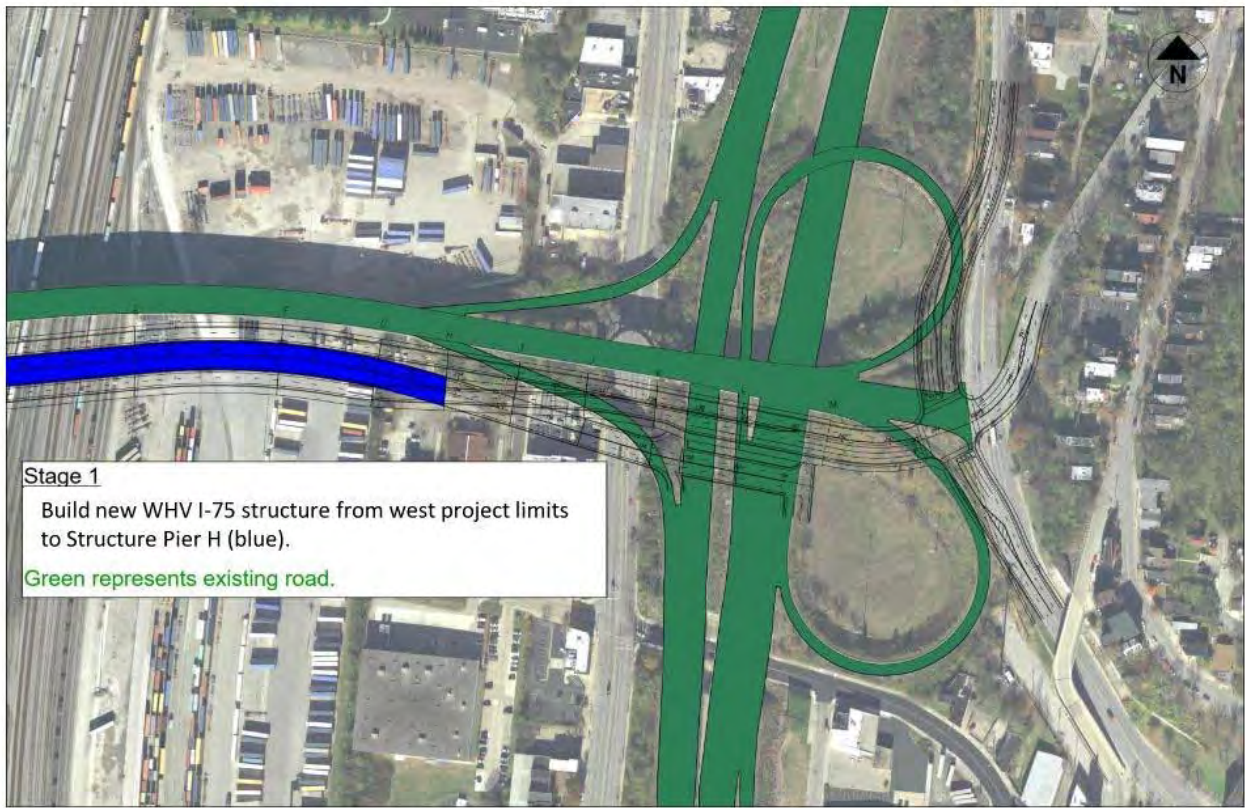




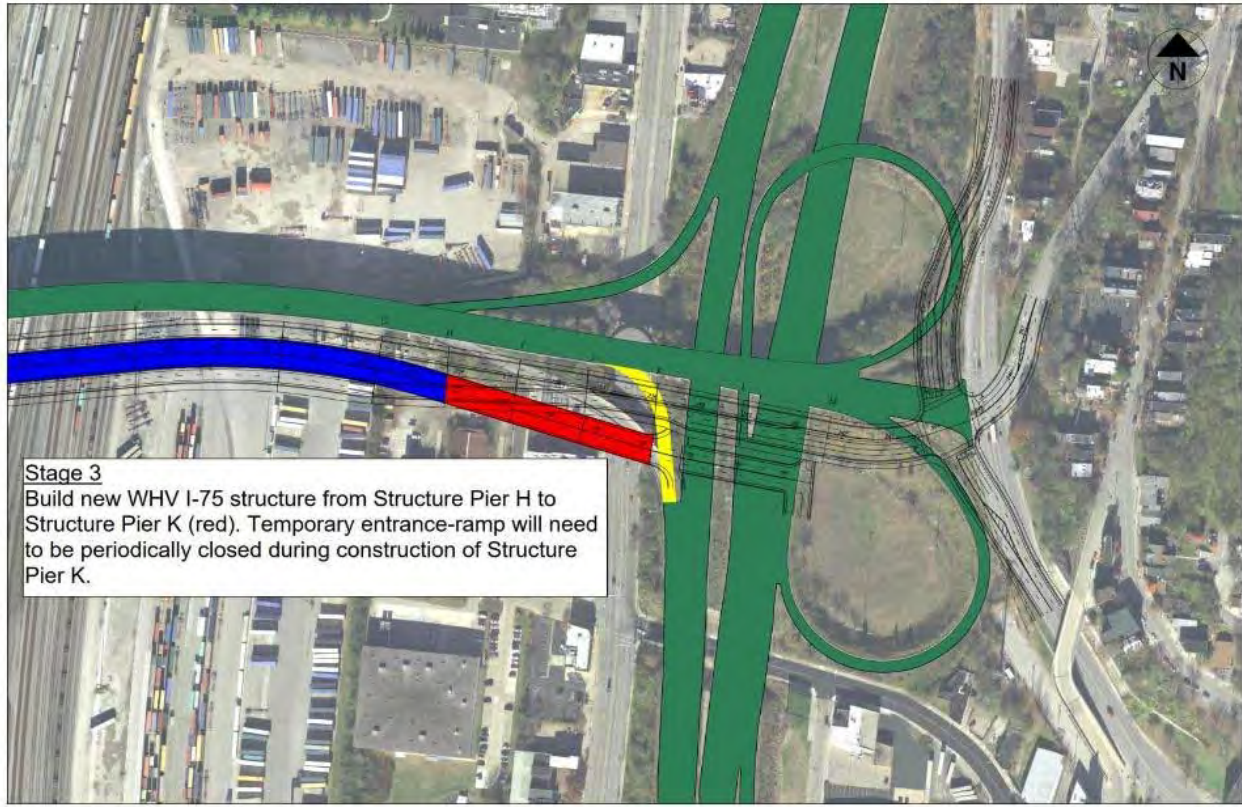
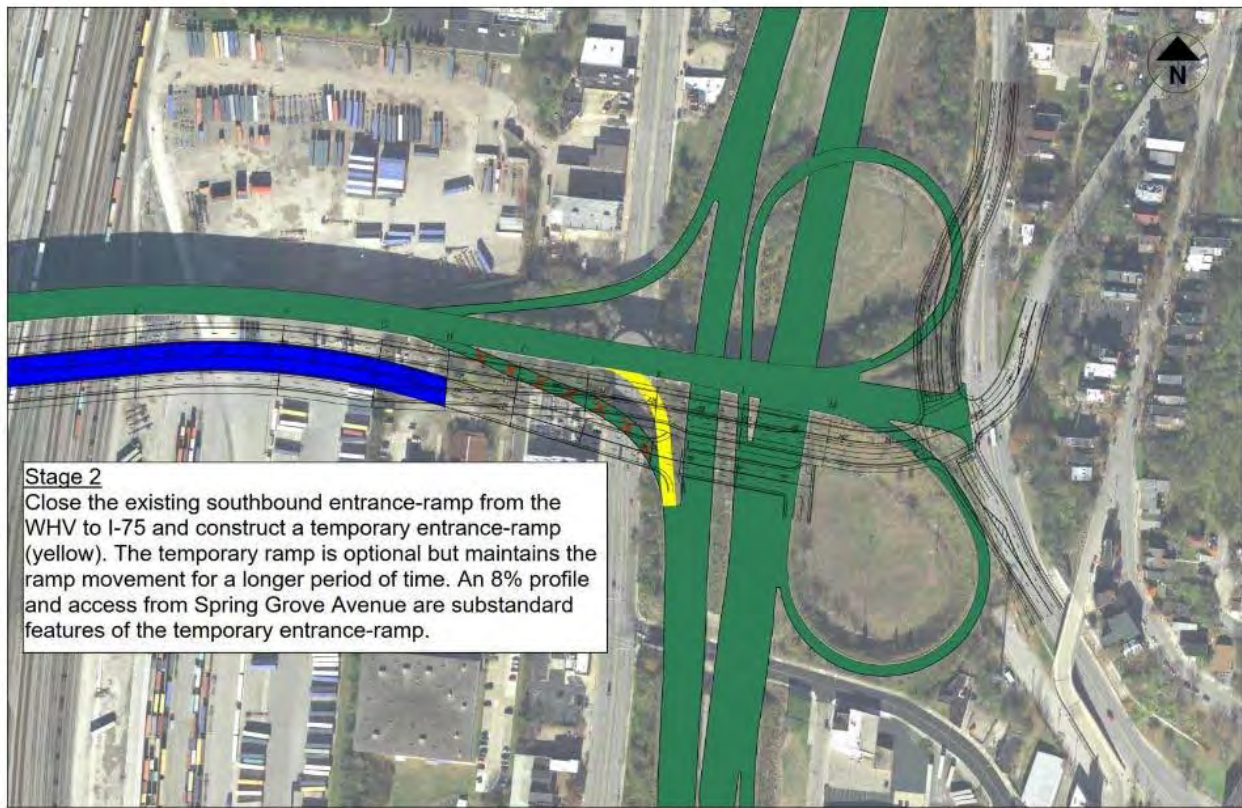


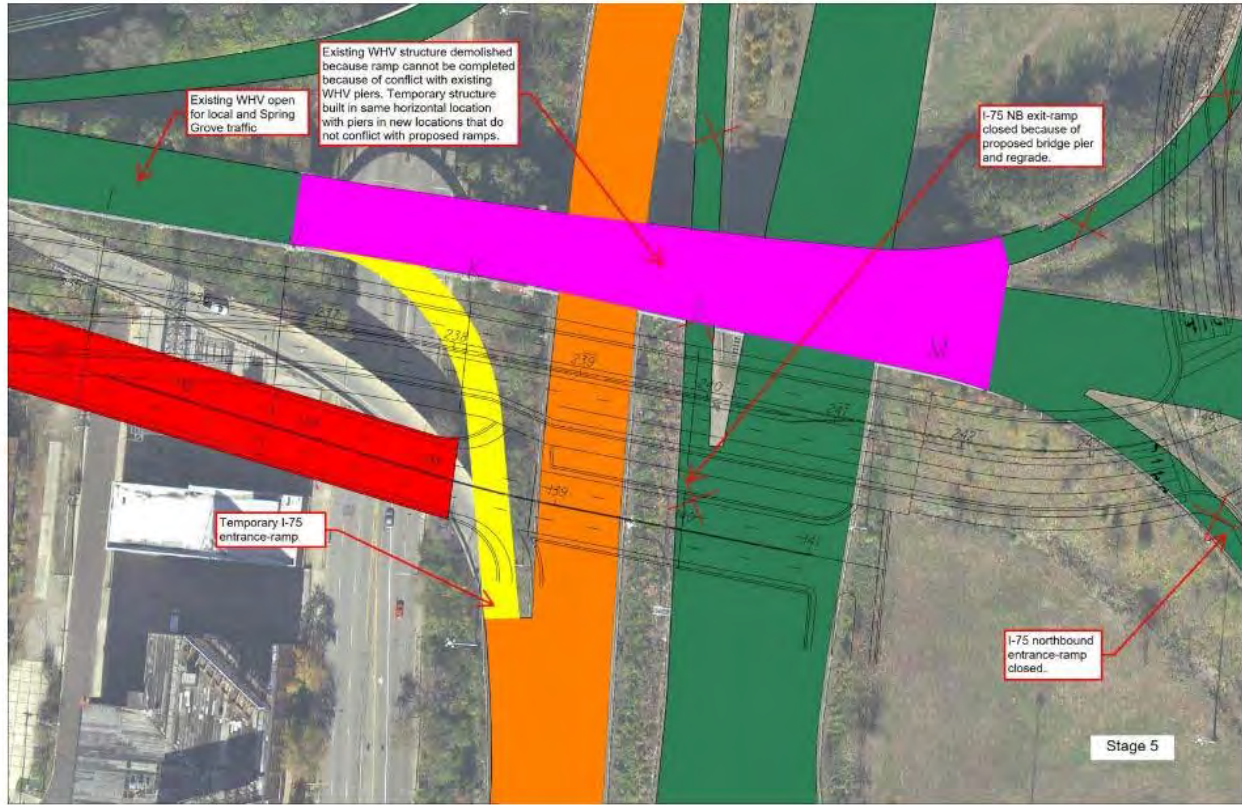
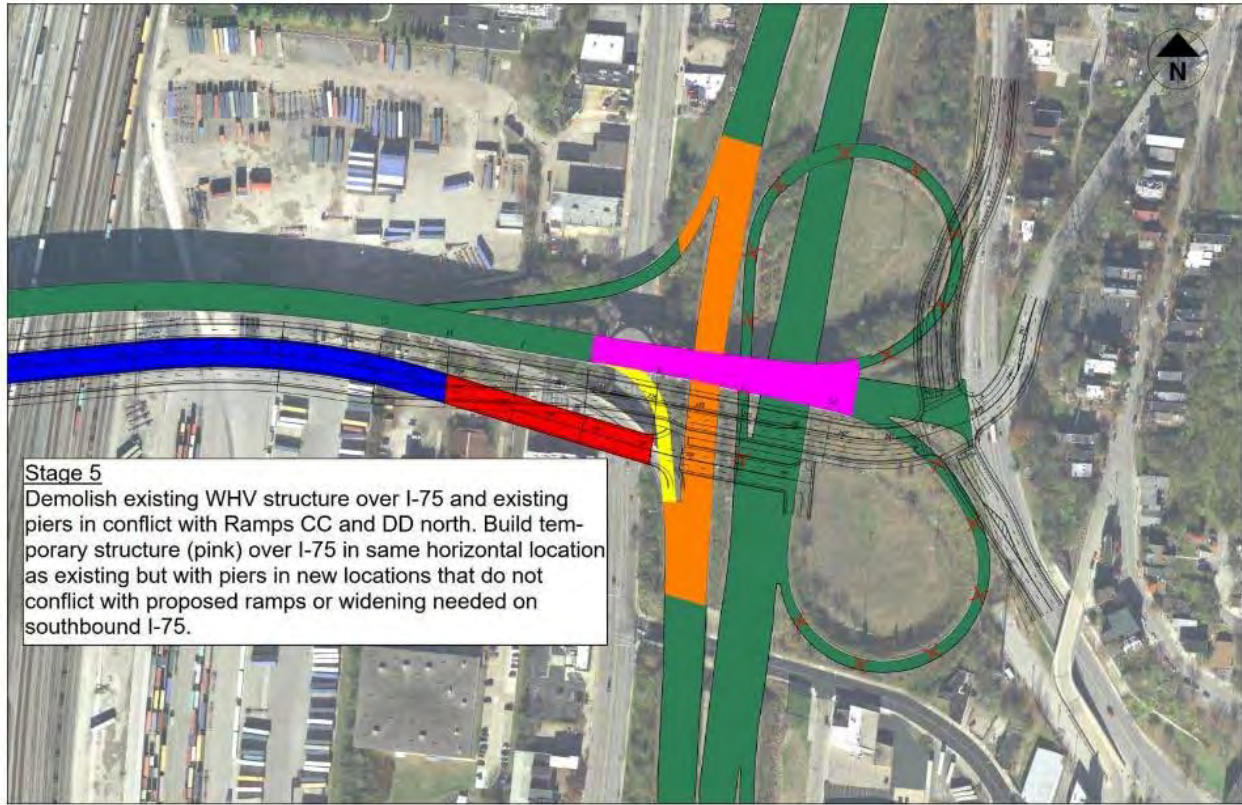
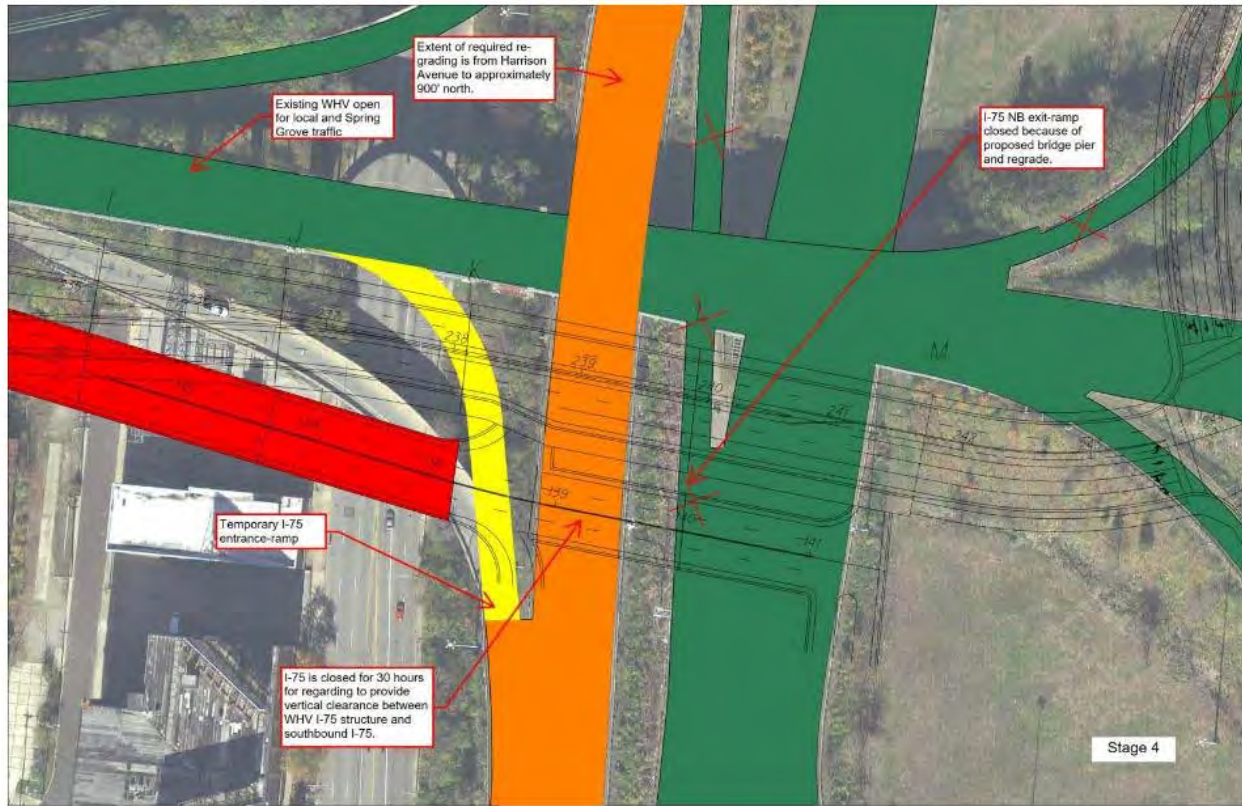
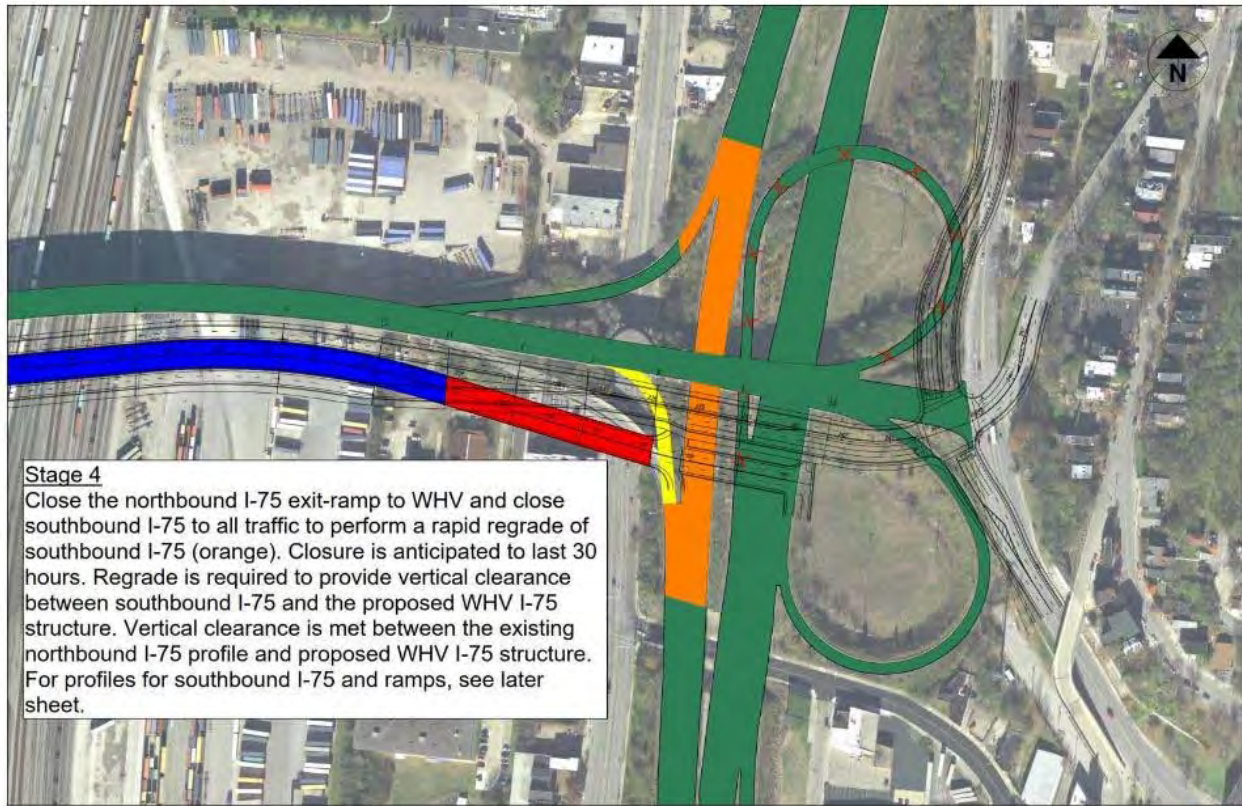


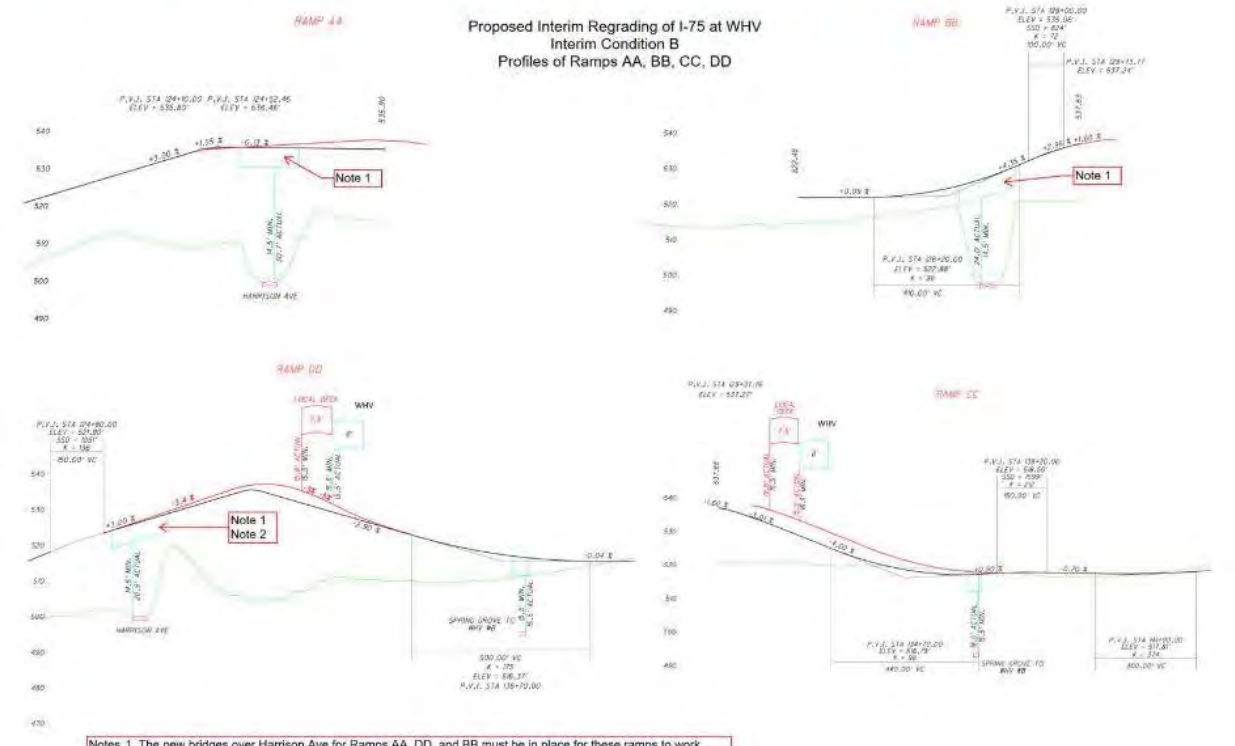
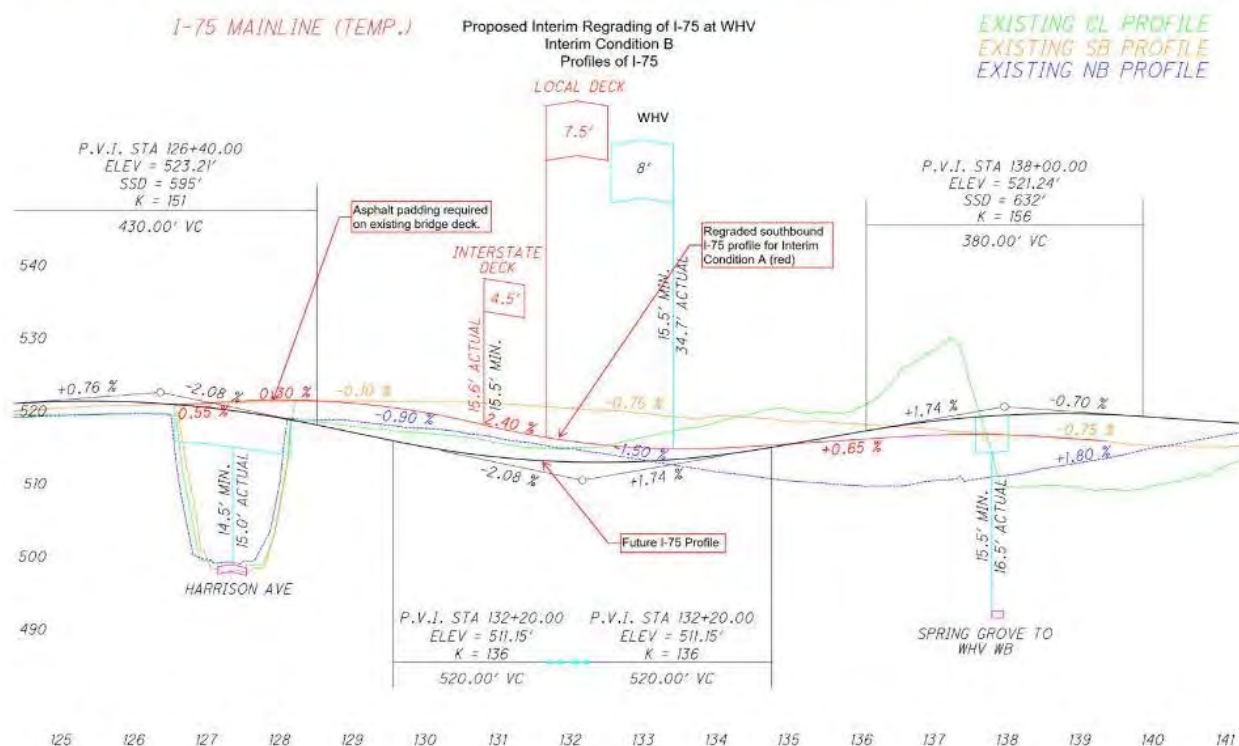
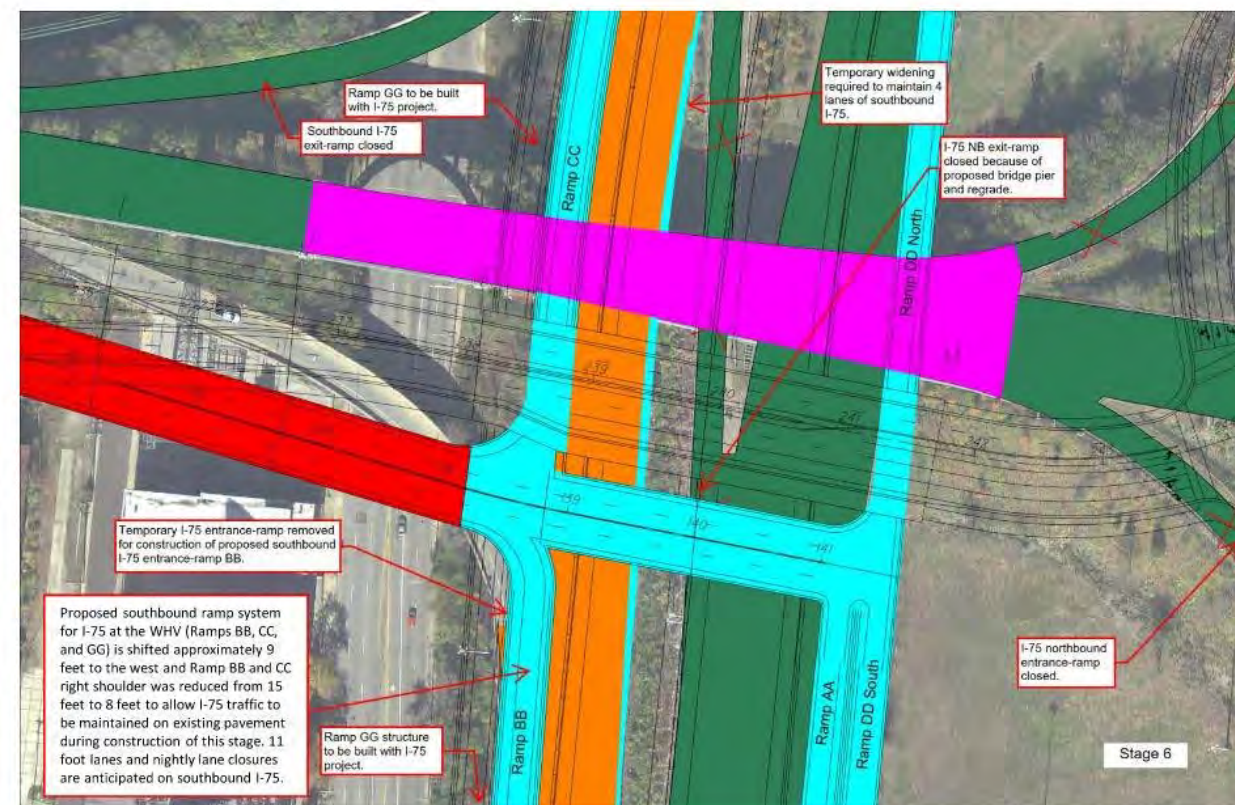
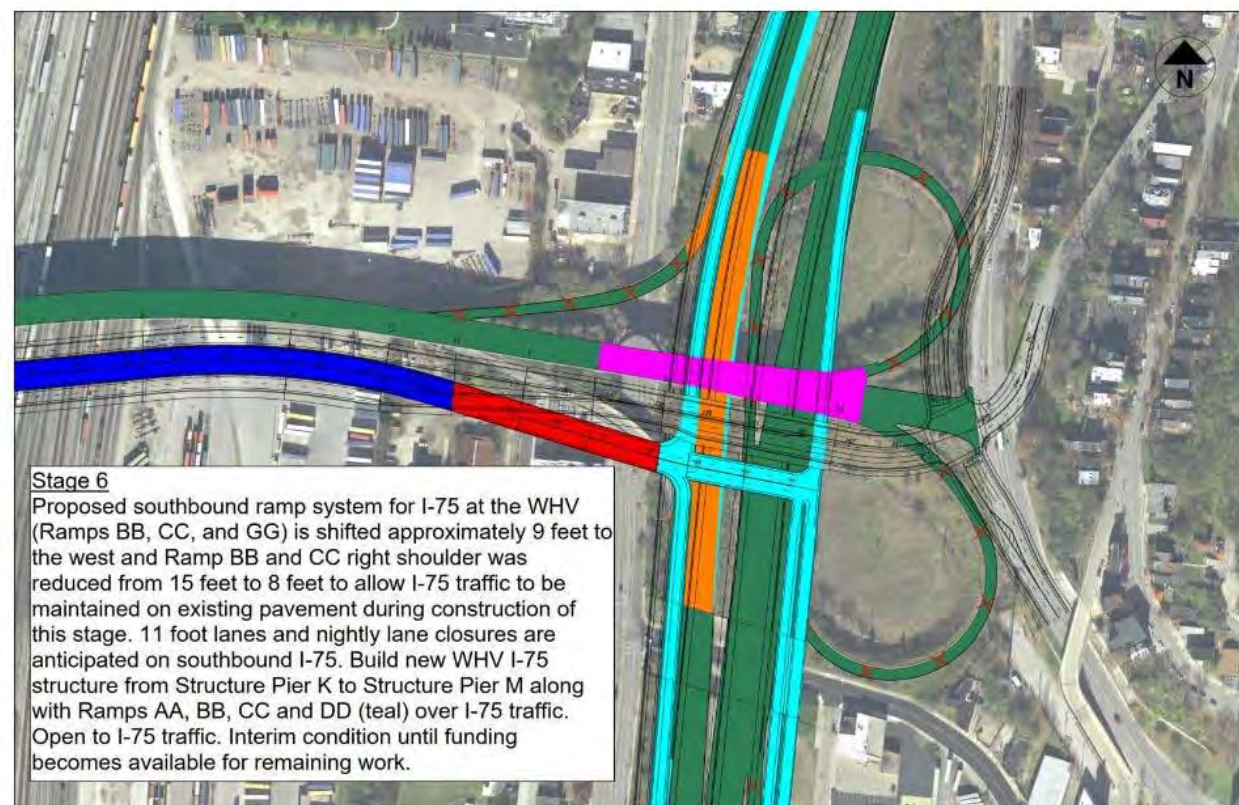




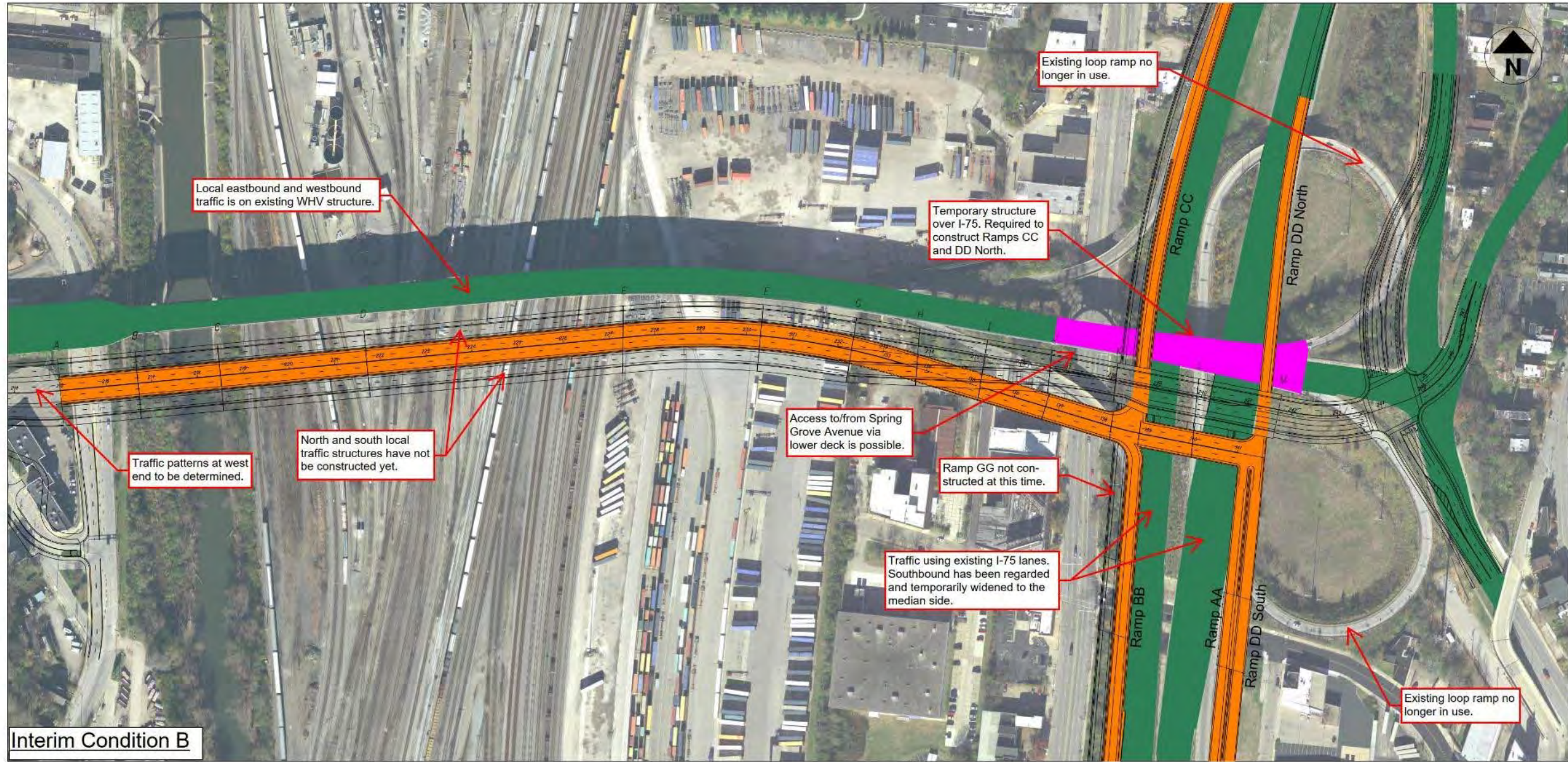
INTERFACE WHV & I-75
CONSTRUCTION STAGES
STAGED OPTION
CIP SEGMENTAL ALTERNATIVE IS
SHOWN



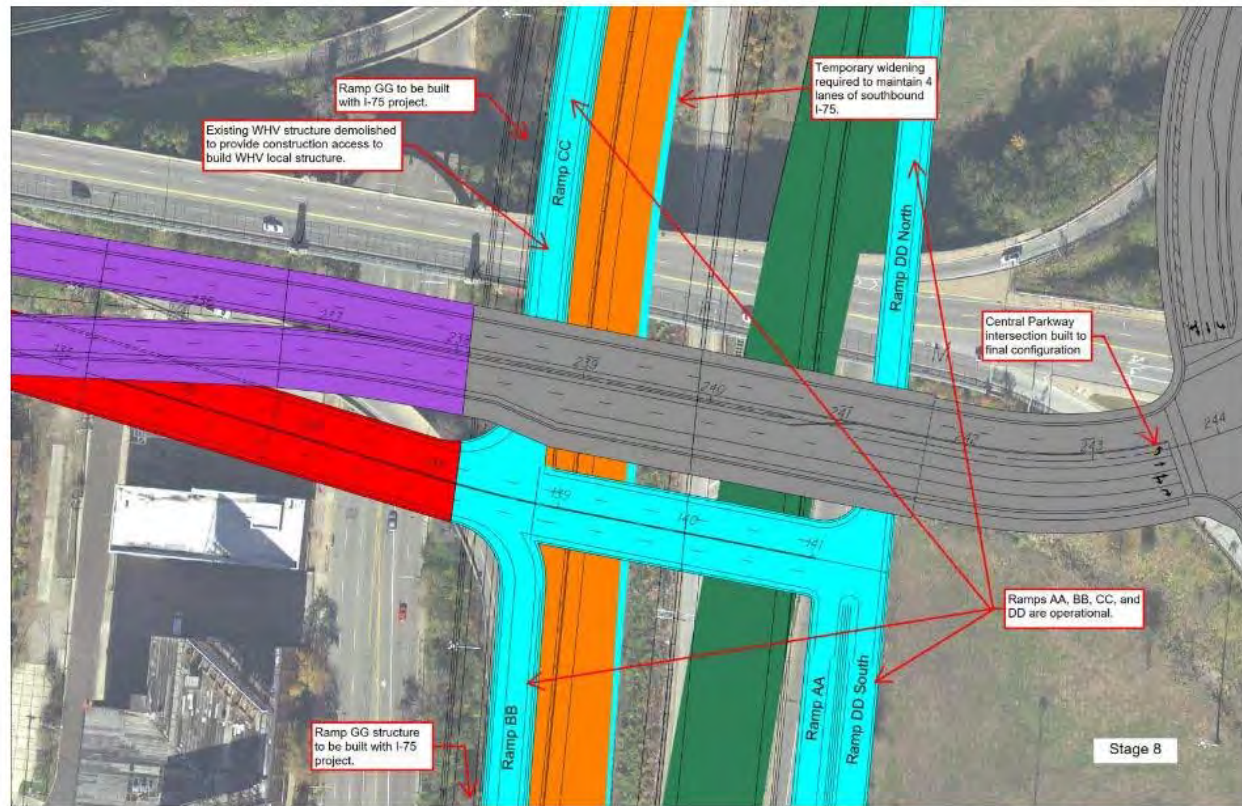
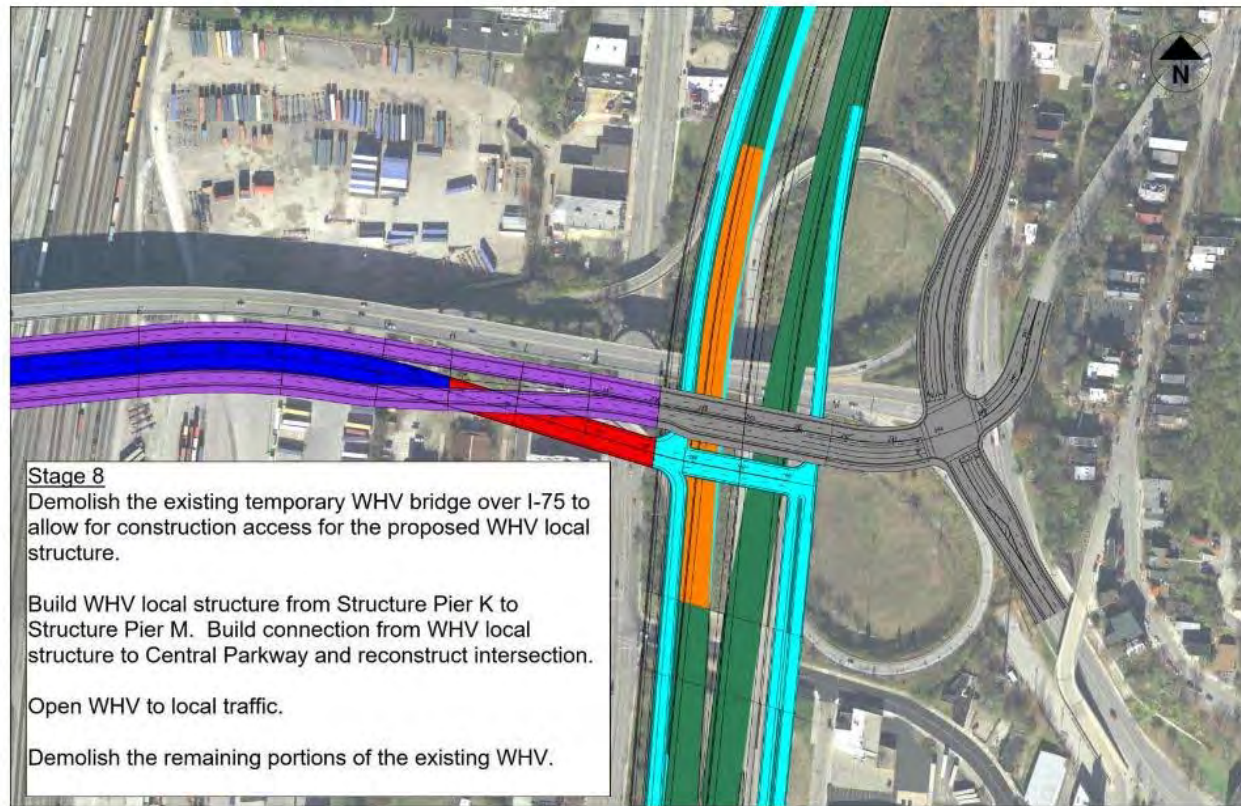
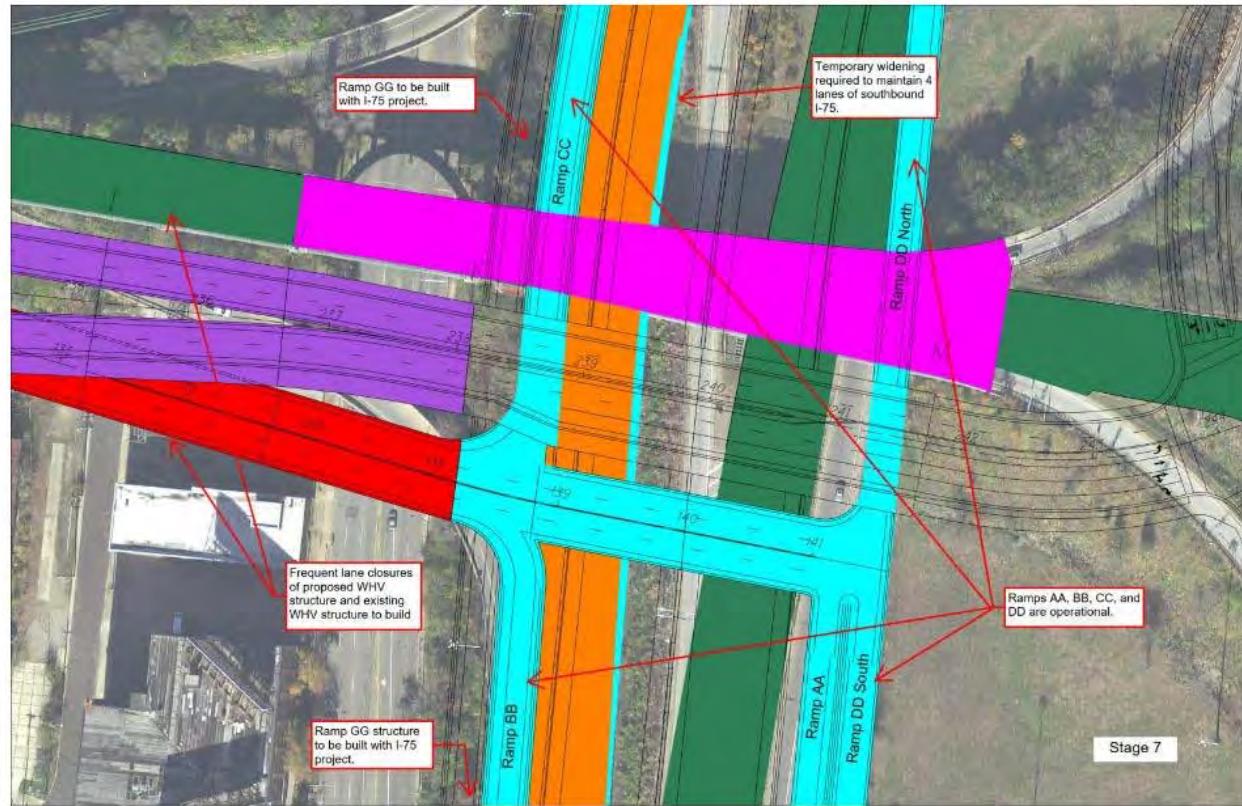
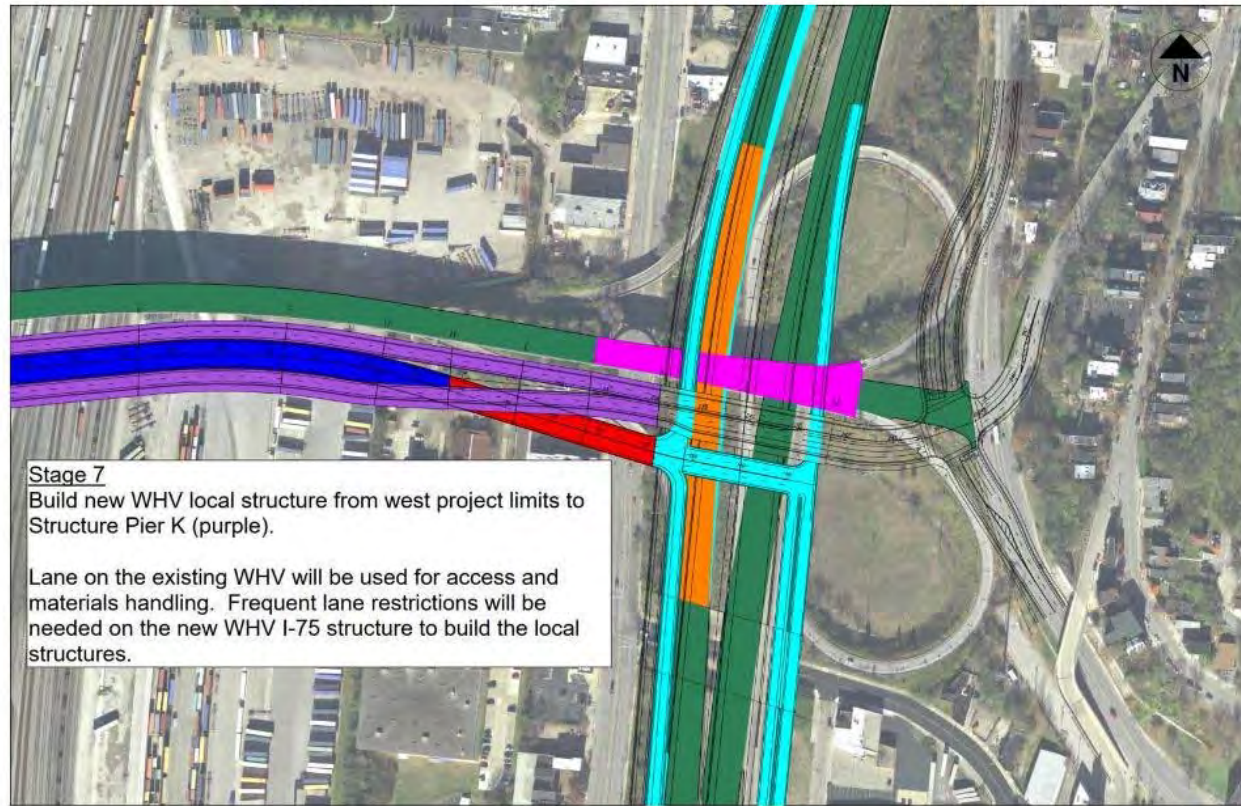


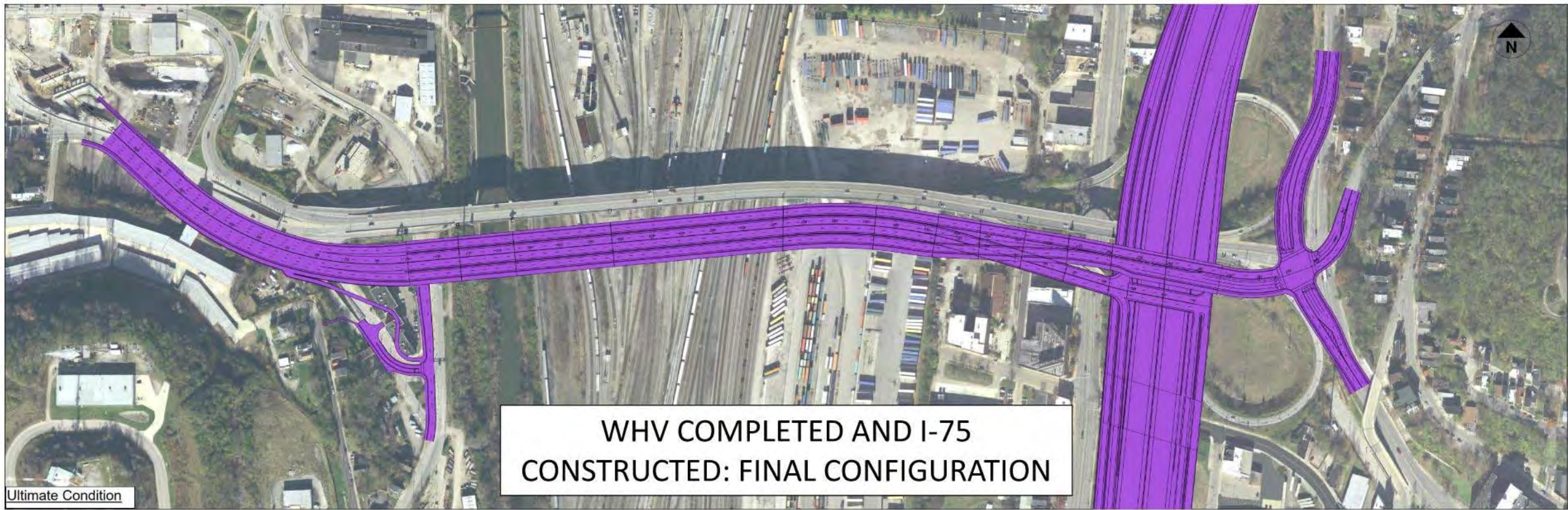


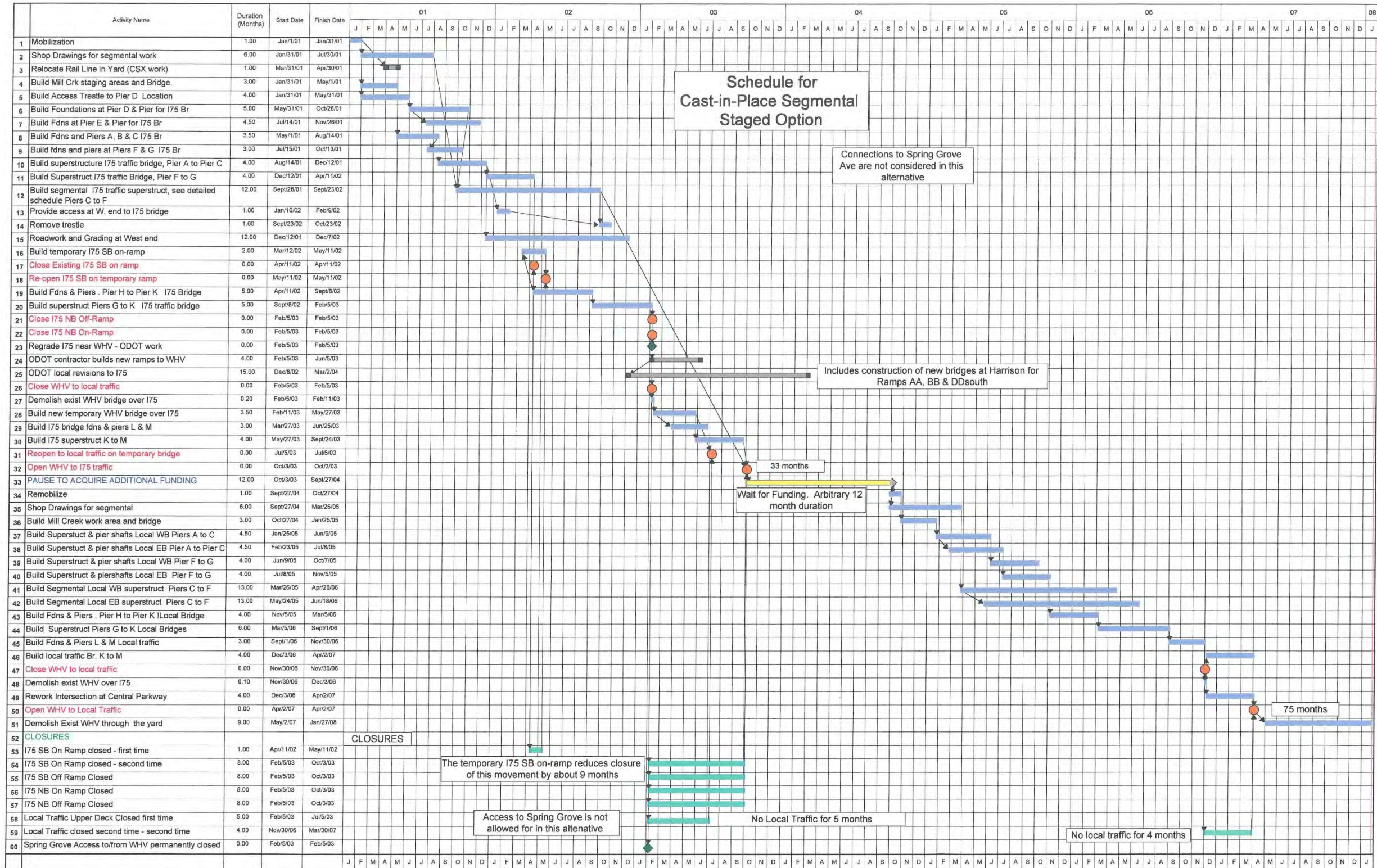
Notes 1. The new bridges over Harrison Ave for Ramps AA, DD, and BB must be in place for these ramps to work.
2. It would be preferable to delay construction of Ramp DD south until the future (final) I-75 work is being done.



**INTERIM CONFIGURATION:
WHV I-75 STRUCTURE AND INTERCHANGE COMPLETED**
I-75 CONSTRUCTION COULD TAKE PLACE WITHOUT AFFECTING THE WHV







4 RAILWAY DISCUSSION & COMMENTS

As discussed earlier, the primary challenge in this project is to design a bridge that would span the CSX Queensgate Railyard while limiting interruptions to normal yard operations.



Located along the Mill Creek west of downtown Cincinnati, Queensgate Yard is one of the largest rail classification facilities in North America. With a length of approximately five miles and over 70 miles of track, Queensgate is one of the most important hump yards on the CSX system. Thus, making CSX Transportation the most important stakeholder for this project [Ref. 1].



Classification is handled by a gravity fed hump under the control of a fully automated Process Control computer system. The system uses an arrangement of field sensing devices to measure car speed and calculate their roll-ability. Based on these calculations, the system automatically controls retarder pressures to enable cars to roll at a safe couple speed. It also operates automatic hump switches to properly classify cars and contains the logic for the proper operation of other non-interlocking power-operated hump switches. The image below shows an engine climbing the hump crest and passing the Hump tower.

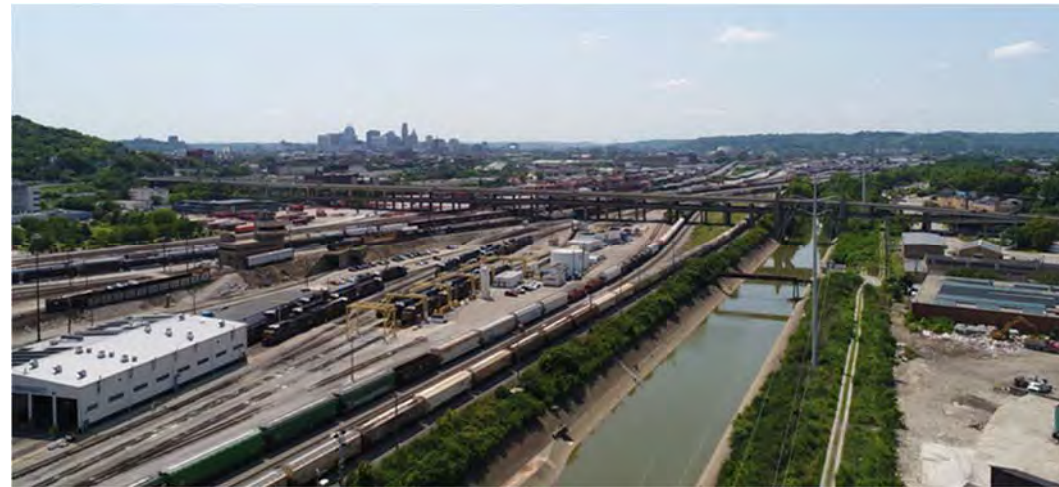


A second system at Queensgate, the Management Information System (MIS), is located in the Terminal Services Center. Major functions of this system include preparation of hump lists from consists, maintenance of car inventories for the terminal, generation of car records, classification of cars, preparation and transmission of outbound consists, creation of yard and industrial work orders, and distribution of messages. This system communicates with the Process Control system described above to maximize productivity in the terminal.

The general sequence of events for processing cars through Queensgate Yard is as follows: Inbound trains will arrive on one or more receiving tracks as assigned by the hump yardmaster. Customer Service will receive a closeout report as to where the train was yarded. The MIS system will verify the standing order of the yarded train using car identification scanners and video cameras. These sites are located throughout Cincinnati Terminal.

- Inbound trains are inspected by the car department who perform light repairs and ensure that the cars are safe for movement and their shipments are secure.
- When mechanical inspection and clerical work is complete, a hump list is prepared by either the yardmaster or Customer Service and passed from MIS to the Process Control system. Trains will be humped according to the priority established by the hump yardmaster.

- Outbound trains are assembled by moving classified blocks of cars from the classification tracks (Bowl Yard) and placed in one of thirteen departure tracks in standing order.
- Assembled trains receive an outbound inspection by the car department and brake test prior to departure. Meanwhile, the yardmaster will send an outbound closeout to Customer Service and the proper paperwork needed to move the train issued to the train crew.
- The train then departs the yard with joint approval of the yardmaster and train dispatcher.



Other facilities at Queensgate include a locomotive shop, car shop, CSX Intermodal Yard and CSX TranFlo terminal. Regional engineering departments are also headquartered at the terminal. A view of the intermodal yard is shown in the image below.



The City and the County Engineers supported by the TYLI Design Team have held several meetings with CSX Transportation. The various designs developed by the team were discussed with the Railways and their input solicited. All activities that may be impacted by railway operations were marked up with a railway premium and included in the cost estimates.

In addition, the City/County has also reached out to Norfolk Southern (NS) that owns three tracks going through the railyard. Design documents have been submitted to them for their input.

The City and County Engineers have asked the Railroads to look at the various alternates and provide qualitative feedback as to the cost impact of a given alternative, either direct or through loss of efficiency of construction operations; both costs are flagged for various alternatives in the two tables below.

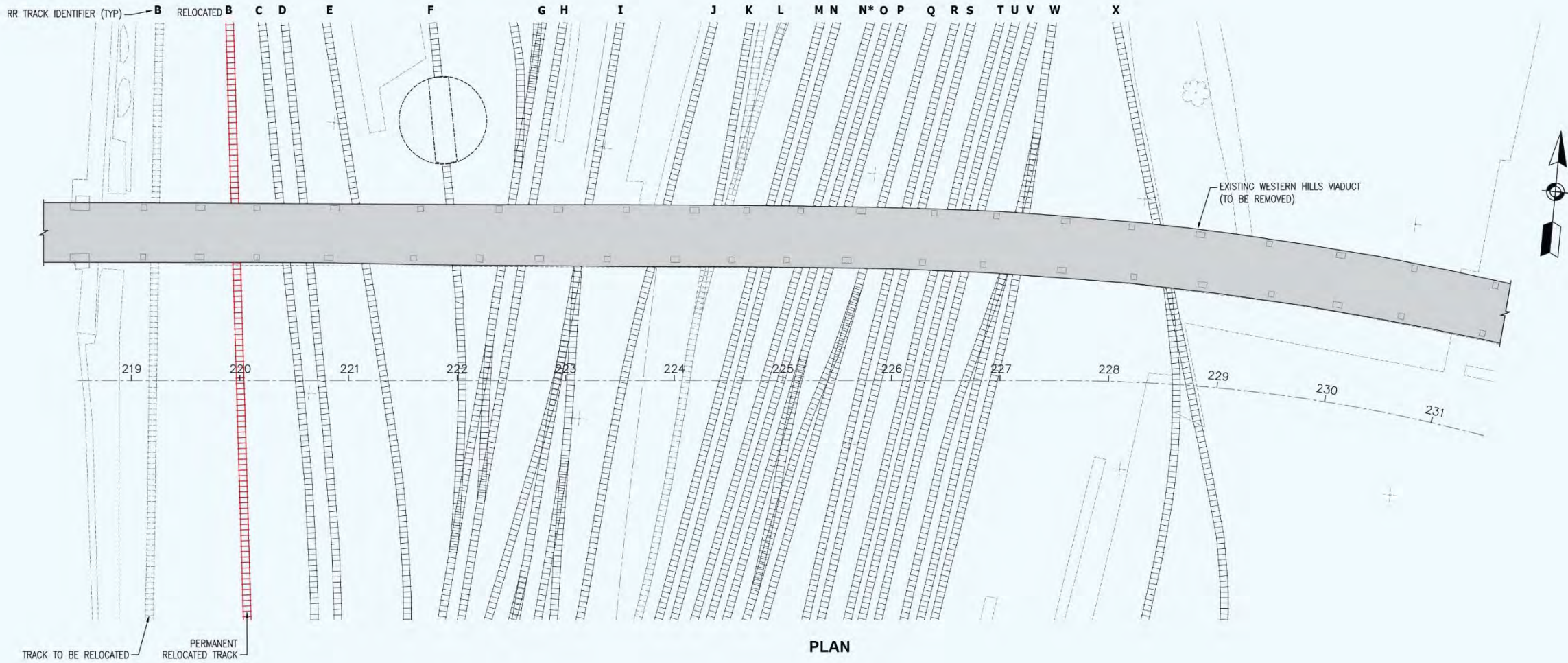
One of the most significant impacts is the placement of a pier in the middle of the railyard as required for the short-span push-launch alternative. The least interruption is caused by the long-span push-launch alternative. The twin arches were well received by CSX Transportation, except for some concern over the closure of the whole railyard for one day over Thanksgiving or Christmas as well as how the SPMT loading will impact the rail tracks.

IMPACTS TO RAILROAD OPERATIONS - DIRECT COSTS						
Bridge Type	Trestle to Pier D (near turntable)	Trestle to Pier E (near short D tracks)	Bridge on Mill Creek	Launching Runway	Temporary Relocation of Track	Permanent Relocation of Track
SSPL	X	X			X	X
CIP	X					X
TA			X	X		X
EX	X					X
LSPL	X					X
CSB						X

IMPACTS FROM RAILROAD OPERATIONS - LOSS OF EFFICIENCY OF CONSTRUCTION OPERATIONS							
Bridge Type	Pier D Substructure	Pier E Substructure	Pier D Formwork for Pier Segment	Pier D Erect Travelers	Interference Incremental Launch	Interference Launch Form Traveler	Interference Intermodal Operations
SSPL	X	X			X		X
CIP	X		X	X		X	
TA					X		X
EX	X		X	X		X	
LSPL	X				X		X
CSB						X	X

References:

1. <http://cincyrails.com/queensgate.htm>



LEGEND - RR TRACK IDENTIFIER

- | | | |
|--------------------------|------------------------------------|----------------------------------|
| A - CSX (OUT OF SERVICE) | G - CSX LOCOMOTIVE TRACK | M - CSX LONG DEPARTURE TRACK |
| B - CSX MAIN LINE | H - CSX WEST OPEN TRACK | N, N* - CSX LONG DEPARTURE TRACK |
| C - CSX RECEIVING TRACK | I - HUMP TRACK | O - NS TRACK |
| D - CSX RECEIVING TRACK | J - CSX EAST OPEN TRACK | P - NS TRACK |
| E - CSX RECEIVING TRACK | K - CSX BYPASS TRACK | Q - NS TRACK |
| F - CSX LOCOMOTIVE TRACK | L - CSX SHORT DEPARTURE TRACKS (3) | R - CSX MAIN LINE |

**Existing Western Hills Viaduct
(To Be Removed)**

4.1 Preamble

Approximate Scoring System used by CSX
Low scores are good – High scores are bad

1. Minimum interference with railway operations
No relocation required
Coordinate around train traffic and flagging schedule
Will need to accommodate loss of storage
2. Coordinate around train traffic and flagging schedule.
One week notice for 20-minute window.
Will need to accommodate loss of storage
3. Coordinate around train traffic and flagging schedule
One to two-week notice for 4-hour window. Tolerance +2 days.
Will need to accommodate loss of storage
CSX could work around track being out. Need track modifications.
4. Need to coordinate around train traffic.
One to two-week notice for 6-hour window. Tolerance +2 days.
CSX could work around track being out. Need track modifications.
5. Need to coordinate around train traffic.
One to two-week notice for 8-hour window. Tolerance +2 days.
Restricts ability to turn vehicles around at grade crossings. Temporary runaround needed.
6. Need to coordinate around train traffic.
One to two-week notice for 10-hour window. Tolerance +2 days.
Heavy coordination needed to build driving surface for SPMTs.
7. Need to coordinate train and roadway traffic and flagging schedule.
8. Need design work and planning to satisfy operations.
9. Need design work and planning to satisfy operations.
Tracks have to remain in operation except when in construction.
10. Challenging to accommodate.

4.2 CSX Comments

WESTERN HILLS VIADUCT REPLACEMENT OPTIONS			INTERACTIONS WITH RAIL YARD OPERATIONS				Rev 0
			With Comments made by	W Bolen (Benesch)			September 16, 2019
DESIGN ALTERNATIVE See Sheets ITEM	SHORT SPAN PUSH LAUNCHED SSPL - 01 to 03	CAST IN PLACE SEGMENTAL CIP - 01 to 07	EXTRADOSED EX - 01 to 06	LONG SPAN PUSH LAUNCHED LSPL - 01	TWIN ARCHES TA - 01 to 02	TWIN TOWER CABLE STAYED TTCS - 01	
BASIC FACTS							
MAINSpan LENGTH (feet)	253/301	560	560	555	760	770'	
NUMBER OF PARALLEL STRUCTURES	3	3	1	1	2	1	
WEST PIER LOCATION	Close to turntable track	Close to turntable track	Close to turntable track	Close to turntable track	Outside of active rail yard	Outside of active rail yard	
CENTER PIER LOCATION	At Short D track - (Track L)	N/A	N/A	N/A	N/A	N/A	
EAST PIER LOCATION	East of track W	East of track W	East of track W	East of track W	East of Track W	East of Track W	
ACCESS / RESTRICTION REQUIRED?	Yes. To 2 pier locations (see Sheet I-02)	Yes. To one location. See Sheet I-01	Yes. To one location. See Sheet I-01	Yes. To one location. See Sheet I-01	Not Required	Not Required	
INTERMODAL DIMENSION (feet)	60'	65'	25'	65'	44'	65'	
Comment	Score 4 - Blocking crossing for traffic between loading tracks. Will need to relocate crossing and accommodate logistics/storage.	Score 4 - Blocking crossing for traffic between loading tracks. Will need to relocate crossing and accommodate logistics/storage.	Score 6 - Blocking crossing for traffic between loading tracks. Will need to relocate crossing and accommodate logistics/storage...final product could create a new permanent route over the loading tracks.	Score 4 - Blocking crossing for traffic between loading tracks. Will need to relocate crossing and accommodate logistics/storage.	Score 7 - Blocking crossing for traffic between loading tracks. Will need to relocate crossing and accommodate logistics/storage...final product could create a permanent route over the loading tracks.	Score 4 - Blocking crossing for traffic between loading tracks. Will need to relocate crossing and accommodate logistics/storage...reduce zone area to keep existing crossing open, Score 2.	
PERMANENT RAIL RELOCATIONS REQUIRED							
WESTERN CSX THRU TRACK	Yes. Move east	Yes. Move east	Yes. Move east	Yes. Move east	Yes. Move east	Yes. Move East	
Comment	Score 1 - Track shift appears to be fairly easy.	Score 1 - Track shift appears to be fairly easy.	Score 1 - Track shift appears to be fairly easy.	Score 1 - Track shift appears to be fairly easy.	Score 1 - Track shift appears to be fairly easy.	Score 1 - Track shift appears to be fairly easy.	
SHORT DEPARTURE TRACK L	Yes. To bypass new pier E. Relocation requires 3 new switches	Relocation not req'd	Relocation not req'd	Relocation not req'd	Relocation not req'd	Relocation not req'd	
Comment	Score 9 - Need more design work and planning to satisfy operations. Tracks have to remain in operation except when in construction. Track construction period has to be small.	Score 1 - No relocation required.	Score 1 - No relocation required.	Score 1 - No relocation required.	Score 1 - No relocation required.	Score 1 - No relocation required.	

WESTERN HILLS VIADUCT REPLACEMENT OPTIONS			INTERACTIONS WITH RAIL YARD OPERATIONS			Rev 0
			With Comments made by	W Bolen (Benesch)		September 16, 2019
DESIGN ALTERNATIVE	SHORT SPAN PUSH LAUNCHED	CAST IN PLACE SEGMENTAL	EXTRADOSED	LONG SPAN PUSH LAUNCHED	TWIN ARCHES	TWIN TOWER CABLE STAYED
See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01
ITEM						
TEMPORARY RAIL RELOCATIONS REQUIRED AT THE EXISTING SHORT D TRACK, TRACKS K & L	The Short D tracks have to be temporarily detoured around the construction of the center pier. Detour required to be complete before pier construction starts. Duration of detour approx. 6 months. Detour requires 5 relocated switches	None Required	None Required	None Required	None Required	None Required
Comment	Score 9 - Need more design work and planning to satisfy operations. Tracks have to remain in operation except when in Construction. Track construction period has to be small.					
TEMPORARY TRACK INTERRUPTIONS REQUIRED FOR PIER CONSTRUCTION AND INITIAL SETUP AT PIERS						
FOR CONSTRUCTION OF WEST PIER	Track F south of exist WHV to be closed for about 5 months with driven pile foundations. Closure is dsireable but not necessary required if drilled shafts are used. Duration of closure using drilled shafts is about one month less	Track F south of exist WHV to be closed for two periods irrespective of foundation type. First closure is about 9 months for construction of foundations and pier and pier table and travelers for the center (I75) bridge. The second period is for about 6 months while the piers, pier tables and form travelers are being built for the local traffic bridges. Between closures Track F may be used passing through the work zone.	Track F south of exist WHV is to be closed for about 15 months irrespective of foundation type. The time period involved is from the start of foundation construction, through construction of the pier table and masts, the erection of the form travelers and the casting of about 15 segment pairs until balancing of the cantilever is taken over by the temporary piers	Track F south of exist WHV to be closed for 6 months irrespective of foundation type	None Required	None Required
Comment	Score 4 - CSX could work around this track being out. Need track mod to accommodate movement around the locomotive shop moves.					
FOR CONST. OF WEST PIER PIER TABLE	N/A	Lines E & G will require short duration interruptions for erecting formwork and then two 4 hour interruptions per line for stripping. This is repeated for each of the 3 bridges. See above for Line F interruptions	Line E will have to be interrupted for one full shift per day for about 20 non-consecutive days over a three month period for erection and stripping of the pier table and mast. Train traffic may resume during the time when construction work does not require interruptions	N/A	N/A	N/A

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See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01	
ITEM							
Comment	N/A	Score 3 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow formwork construction.	Score 5 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow construction.	N/A	N/A	N/A	
FOR ERECTION OF FORM TRAVELERS AT WEST PIER		N/A Erection of the west traveler will require 36 hours of interruption of Line E, minimum duration of 4 hours each. Erection of the east traveler will require 36 hours of interruption of Line G, minimum duration of 4 hours each. This is repeated for each of the 3 bridges. See above for Line F interruptions.	Line E will be interrupted for continuous 8 hour periods for 8 non-consecutive days to set up the west traveler. Then Lines G & H will be interrupted for 8 hour periods over 8 non-consecutive days to set up the east traveler. Train traffic may resume during the time when construction work does not require interruptions. Elapsed time for this operation is about 2 months	N/A	N/A	N/A	N/A
Comment	N/A	Score 3 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow formwork construction.	Score 8 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow construction....drawings show track F out of service??	N/A	N/A	N/A	
FOR CONSTRUCTION OF CENTER PIER	Instead of closures, a detour is proposed. See above. Interruptions are only required when detoured lines are being cut in and/or removed. Duration of the detour being in service is about 6 months.	N/A	N/A	N/A	N/A	N/A	N/A
Comment	Score 9 - Need more design work and planning to satisfy operations. Tracks have to remain in operation except when in Construction. Track construction period has to be small.	N/A	N/A	N/A	N/A	N/A	
FOR CONSTRUCTION OF EAST PIER	No interruptions are required	No interruptions are required	No interruptions are required	N/A	None Required	None Required	
Comment	Score 1 - minimum interference.	N/A	N/A	N/A	Score 1 - minimum interference.	Score 1 - minimum interference.	
FOR CONST. OF EAST PIER PIER TABLE		N/A Line W1 will be interrupted for 2 hours x 3 times for falsework installation and 4 hours x 2 times for removal. This is repeated for each of the 3 bridges.	No interruptions	N/A	N/A	N/A	N/A

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			With Comments made by	W Bolen (Benesch)			September 16, 2019
DESIGN ALTERNATIVE	SHORT SPAN PUSH LAUNCHED	CAST IN PLACE SEGMENTAL	EXTRADOSED	LONG SPAN PUSH LAUNCHED	TWIN ARCHES	TWIN TOWER CABLE STAYED	
See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01	
ITEM							
Comment	N/A	Score 2 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow falsework construction.	N/A	N/A	N/A	N/A	
FOR ERECTION OF FORM TRAVELERS AT EAST PIER		N/A Lines W1 & W2 will be interrupted for 36 hours, minimum of 4 hours per interruption. This will be repeated 3 times for the 3 separate bridges	Short term interruptions to Line W1 will be required during hoisting of components for the west travelers.		N/A	N/A	N/A
Comment	N/A	Score 3 - will need to coordinate work around train traffic. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch.	Score 2 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to hoist items.	N/A	N/A	N/A	

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See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01
ITEM						
FOR REMOVAL OF FORM TRAVELERS	N/A	Traffic is to be halted on Lines M & N for 4 hours for soffit lowering and removal. This is repeated for each of the three bridges	Traffic is to be halted on Lines M & N for 6 hours for soffit lowering and removal.	N/A	N/A	N/A
Comment	N/A	Score 4 - will need to coordinate work around train traffic. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to remove soffit...How do you get the soffit out?	Score 4 - will need to coordinate work around train traffic. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to remove soffit...How do you get the soffit out?	N/A	N/A	N/A
TEMPORARY TRACK INTERRUPTIONS REQUIRED DURING LAUNCHING AND/OR SEGMENT ERECTION						
PUSH LAUNCHING	There is a potential hazard while the steel tubs are actually being pushed ahead and no hazard once movement is stopped. If a hazard is deemed to exist, then all train traffic in the span being crossed by the launching nose must be stopped, and parked trains moved out of the Hazard Zone but only while the structure is being pushed. A 10' push will take about 10 minutes and can be repeated about every half hour. Supplementary safety supports and/or increased factors of safety during launch could eliminate perceived hazard during push launch. Launch would be in 60' sections at about 4 day intervals. The 3 bridges will be launched at separate times	N/A	N/A	There is a potential hazard while the steel truss is actually being pushed ahead, and no hazard once movement is stopped. If a hazard is deemed to exist, then all train traffic immediately below the moving bridge must be stopped and all parked trains removed from the hazard zone, but only while the structure is actually being pushed. A 5' push will take about 20 minutes and can be repeated about once every hour. 18 such pushes will advance a single 90' long segment. There will be 2 to 3 weeks between the launching of each 90' segment. Rail operations would be affected by the launching of 8 segments. There are therefore 144 pushes of 5' each pushes for the complete bridge. Supplementary safety supports and/or increased factors of safety during launch could eliminate the perceived hazard during push launch.	N/A	N/A
Comment	Score 3 - will need to coordinate work around train traffic. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch.	N/A	N/A	Score 3 - will need to coordinate work around train traffic. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch.	N/A	N/A

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ITEM						
FORM TRAVELER ADVANCEMENT	N/A	For each of the 3 bridges a Hazard Zone will exist for a 4 hour period during each traveler launch. Hazard zone is 66' long and progresses forward 16' at a time. As many as 6 lines may be affected each time. There are about 140 individual launches for all the 3 bridges that will affect train traffic traveler launches in total	A hazard zone will exist for a 6 hour period during each traveler launch. The Hazard Zone is 50' long and progresses forward in 10' increments. As many as 5 lines may be affected by any one hazard zone. There are about 75 individual launches that may affect rail traffic and train parking.	N/A	N/A	N/A
Comment	N/A	Score 4 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch...Reduce the Hazard zone, estimate 15' beyond the out edge at a vertical drop.	Score 4 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch...Reduce the Hazard zone, estimate 15' beyond the out edge at a vertical drop.	N/A	N/A	N/A
STEEL SEGMENT ERECTION	No interruption required for the push launch portion of the bridge since steel segments are assembled outside the active yard. Intermodal lines X will require 3 stoppages of 8 hours each for crane erection of steelwork.	N/A	N/A	No interruption is required for the push-launch portion of the work. About 5 interruptions of 6 hours each will be required to Lines X (Gantry crane track) to allow erection of truss sections on falsework.. Steel segments are assembled outside the active yard	N/A	Up to 5 tracks at a time will have to be interrupted for 8 hours whenever a segment is being erected ,and then for a further 4 hours while the erection gantry is being launched. The large footprint (60' long) of the hazard zone means that every track will be affected at least two separate times . There are 16 segments whose erection will affect the rail operations.
Comment	Score 6 - will need to coordinate work around train traffic/Intermodal. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch. 8 hours request is fairly high. Reduce to 4 hours, score to drop to a 3. Reduce time to 20 mins for erecting events,	N/A	N/A	Score 4 - will need to coordinate work around train traffic/Intermodal. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch. 6 hours request may be adequate. Reduce to 4 hours, score to drop to a 3.	N/A	Score 4 - will need to coordinate work around train traffic/Intermodal. May need 1-2 weeks notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow time to push launch. 6 hours request may be adequate. Reduce to 4 hours, score to drop to a 3.

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See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01	
ITEM							
CARRYING ARCHES INTO POSITION	N/A	N/A	N/A	N/A	N/A	Preparation work to build the transport runways (asphalt or unreinforced concrete or granular fill) can take place working within reatively short windows of train inactivity. For the actual moving into place of each arch it will be necessary to clear the yard of parked trains in the vicinity of the new bridge and to stop all train traffic in this zone for a period of up to 8 hours per arch (2 arches total). This applies from the existing Westrrn Hills viaduct to 100' south of the transport path	N/A
Comment	N/A	N/A	N/A	N/A	N/A	Score 6 - level of effort for CSX to build driving surface and coordinate an open yard would require heavy coordination. However, CSX is open to the idea of only having 1 day of disturbance on each event. Most likely would need to do the actual roll in on a holiday (Thanksgiving/Christmas). Also need NS to keep their tracks open...Driving surface needs to avoid switches.	N/A
OPERATIONS THAT ARE UNDERSTOOD TO REQUIRE ABSENCE OF TRAIN TRAFFIC AND/OR PARKED TRAINS BELOW							
ADVANCEMENT OF FORM TRAVELERS	N/A	Applicable	Applicable	N/A	N/A	N/A	N/A
Comment	N/A	Score 2 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow construction.	Score 2 - will need to coordinate work around train traffic. May need 1 week notice to plan for the event and could lose a day or two in the field if train traffic doesn't allow construction.	N/A	N/A	N/A	N/A
ERECTION OF STEEL SEGMENTS OVER ACTIVE LINES	N/A	N/A	N/A	N/A	N/A	N/A	See above. With redundant suspension and extra load factors it would be possible to reduce the 8 hour closure for segment erection to 4 hours

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See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01
ITEM						
OPERATIONS THAT ARE UNDERSTOOD TO NOT REQUIRE ABSENCE OF TRAIN TRAFFIC AND/OR PARKED TRAINS BELOW						
FORMING OF DECKS	Forming takes place before push launch	Forming is secure once the form travelers have been launched and tied down	Forming is secure once the form travelers have been launched and tied down	The maintenance traveler can be used as a work platform and debris catcher so that forming and stripping may proceed without affecting rail traffic	The maintenance traveler can be used as a work platform and debris catcher so that forming and stripping may proceed without affecting rail traffic	The maintenance traveler can be used as a work platform and debris catcher so that forming and stripping may proceed without affecting rail traffic
Comment	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.
PLACING OF REBAR	Not a hazard	Not a hazard	Not a hazard	Not a hazard	Not a hazard	Not a hazard
Comment	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.
POURING OF CONCRETE	Analogous to pouring a deck on a conventional steel tub structure	Analogous to pouring a deck on a conventional structure	Analogous to pouring a deck on a conventional structure	Analogous to pouring a deck on a conventional structure	Analogous to pouring a deck on a conventional structure	Analogous to pouring a deck on a conventional structure
Comment	Score 2 - Coordinate around train traffic and flagging schedule.	Score 2 - Coordinate around train traffic and flagging schedule.	Score 2 - Coordinate around train traffic and flagging schedule.	Score 2 - Coordinate around train traffic and flagging schedule.	Score 2 - Coordinate around train traffic and flagging schedule.	Score 2 - Coordinate around train traffic and flagging schedule.
STRIPPING OF FORMS	Forms are stripped using stripping platforms for deck overhangs and a working deck for forms between tubs	Loosening of forms prior to traveler movement is a safe operation	Loosening of forms prior to traveler movement is a safe operation	See above	See above	See above
Comment	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.	Score 1 - Coordinate around train traffic and flagging schedule.
WORK IN THE INTERMODAL YARD - These are restrictions on Intermodal operations but do not interrupt any rail lines.						
Zone 1	At Pier F	At Pier F	At Pier F	At Piers H&I and for initial erection on falsework	At Pier D for pier construction	At Piers F & G and for plate girder erection
Comment	Score 3 - Coordinate around train traffic and flagging schedule.	Score 3 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 3 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 5 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 2 - Coordinate around train traffic and flagging schedule.	Score 2 - Coordinate around roadway traffic. Will need to accommodate loss of storage.
Zone 2	At Pier G	At Pier G	At Pier G	At Pier J	At Piers E & F for pier construction	For erection of back span on falsework
Comment	Score 5 - restricts ability to move vehicles around at-grade crossing. Temporary run-a-round needed.	Score 1 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 1 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 1 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 6 - Coordinate around roadway traffic. Will need to accommodate loss of storage. May need to create new turning area over tracks.	Score 7 - Coordinate around train traffic and flagging schedule. In addition, coordinate around roadway traffic.
Zone 3	At Pier H	Building Span F-G	Building Span F-G	For Assembly of sections to be launched	At Piers G & H for pier construction	For assembly of segments etc.
Comment	Score 1 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 4 - Coordinate around roadway traffic.	Score 4 - Coordinate around roadway traffic.	Score 3 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 1 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 7 - Coordinate around train traffic and flagging schedule. In addition, coordinate around roadway traffic.
Zone 4	Pier G to Pier H	N/A	N/A	For operation of push launch gear	At Pier D for erection of Span D-E	For Tower and foundation at Line E
Comment	Score 2 - Coordinate around roadway traffic.	N/A	N/A	Score 3 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	Score 6 - Coordinate around train traffic and flagging schedule. In addition, coordinate around roadway traffic.	Score 7 - Coordinate around train traffic and flagging schedule. In addition, coordinate around roadway traffic.
Zone 5	N/A	N/A	N/A	N/A	At Piers E & F for erection of spans D-E, E-F, & F-G	N/A

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See Sheets	SSPL - 01 to 03	CIP - 01 to 07	EX - 01 to 06	LSPL - 01	TA - 01 to 02	TTCS - 01
ITEM						
Comment	N/A	N/A	N/A	N/A	Score 6 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	N/A
Zone 6	N/A	N/A	N/A	N/A	At Piers F & G for erection of spans F-G, G-H & H-I	N/A
Comment	N/A	N/A	N/A	N/A	Score 2 - Coordinate around roadway traffic. Will need to accommodate loss of storage.	N/A

4.3 NS Comments

Western Hills Viaduct Replacement over NS MP 0.5 CNO&T NS File BR0120562

Comments on Western Hills Viaduct Replacement Options from meeting with the City/County and Designer in Cincinnati November 20, and meeting with CPB/EWC November 26, 2019:

General comments: NS prefers to not provide a ranking but will provide comments so that the design team can apply the cost increase value they feel appropriate for working on the structure(s) over the NS tracks.

4.3.1 Short Span Push Launched:

1. Need to know locations of any temporary supports in relation to NS.
2. Start-Stop potential would be helpful to have to evaluate the effect of any track time required while pushing ahead over tracks.
3. Standard protection per the NS Public Projects Manual would be required.

4.3.2 Cast-in-place Segmental:

4. In future evaluations there would need to be details for how the lower formwork would be supported during the move ahead operation.
5. A timeline for the moving of the formwork would be required showing how long the operations would take place over NS tracks.
6. It appears there could be a need for an extended track outage as passes over NS tracks, more than a typical flagged track closure, which would be difficult to obtain or manage. NS was not in favor of this option due to track outage concerns.
7. Lower form removal, after the span over NS is completed, would need to have additional details provided so it can be determined if lowering to ground for removal would require an excessive track outage.
8. Would a temporary track crossing be required to allow lower form to be removed from the site?
9. Standard protection per the NS Public Projects Manual would be required.

4.3.3 Extradosed:

10. Crane placement potentially could affect NS operations and require excessive track outages that would not be acceptable.
11. Formwork over tracks could lead to potentially longer track windows required to place and remove.
12. A timeline for the moving of the formwork would be required showing how long the operations would take place over NS tracks.

13. It appears there could be a need for an extended track outage as passes over NS tracks, more than a typical flagged track closure, which would be difficult to obtain or manage. NS is not in favor of this option due to track outage concerns.
14. Lower formwork removal, after the span over NS is completed, would need to have additional details provided, so it can be determined if lowering to ground for removal would potentially require an excessive track outages.
15. Would a temporary track crossing be required to allow lower form to be removed from the site?
16. On a positive note, there would only be one forming/casting pass over the NS tracks rather than multiple separate bridges as in the other options.
17. Standard protection per the NS Public Projects Manual would be required.

4.3.4 Long Span Push Launched:

18. Need to know locations of any temporary supports in relation to NS.
19. Start-Stop potential would be helpful to have to evaluate the effect of any track time required while pushing ahead over tracks.
20. Over NS Right-of-Way any push would have to be coordinated with NS and would be considered only at NS discretion, and dependent on train traffic and movement.
21. Deck formwork over the tracks could potentially require daily flagging-controlled track outages.
22. Standard protection per the NS Public Projects Manual would be required.

4.3.5 Parallel Twin Arches:

23. Two major track outages that would have to take place to roll the arches into place.
24. The amount of roadway preparation for the move over NS would require numerous track outages to install a temporary timber and asphalt crossing 100+/- feet long.
25. The temporary crossing would potentially be over a track turnout that would require special crossing installations or relocation of the turnout.
26. There is no profile of the ground/track at the proposed location and the potential for track profile changes is high.
27. Any scheduled outage to roll the arches into place would require major coordination of NS traffic, both thru and local switching operations. It is unknown if these outages would be considered.
28. Deck placement would require typical track outages but access to place concrete and forms for the first arch placed would potentially require temporary crossings or crane placements near NS.
29. Standard protection per the NS Public Projects Manual would be required.
30. NS was not in favor of progressing this option.

4.3.6 Cable-stayed Bridge Twin Tower:

31. Extreme concerns were raised due to the large/tall tower cranes required to build the towers. These would require constant requests for track time, whether moving materials over NS or not, due to the potential for fouling a NS track with the tower falling or suspended load and boom moving over tracks. The frequency of potential train movements combined with the potential to foul a track deems this option unacceptable to NS.
32. Location(s) for material delivery to be picked up by the crane for construction could greatly affect the contractor's ability to make lifts due to the boom or counterweight section overhanging the NS tracks.
33. Standard protection per the NS Public Projects Manual would be required.
34. NS was not in favor of progressing this option.

5 COST ANALYSIS

5.1 Cost Analysis Approach

Cost estimates were developed for each individual alternate using the “green sheet” format of estimating. This style of estimating is very common for contractors to use at early stages of design in order to develop rough order of magnitude estimates on projects. What makes this style unique from a traditional “bid-tab” style estimate is that it utilizes true contractor direct costs. Traditional state bid-tabulations from past projects contain unit prices that contractors will manipulate to shift money from late items to early items on a project to get more upfront money, thus skewing what the costs really are. Most states also have a mobilization bid item ranging anywhere from 5% to 10% of the total bid that is pulled and excluded from bid tab unit costs.

The first step in setting up a green sheet estimate for each alternate was to develop a comprehensive list of bid items. This list was generated by looking at bid item lists for past projects for each of the structure types to ensure that all the major components to each alternate is covered. Next, quantities were developed for each of the bid items. Some quantities were developed based on plan takeoffs, specifically for items such as drilled shafts and concrete items. Other quantities were developed based on assumed design ratios from past fully designed projects, such as LBS/CY for reinforcing steel LBS/SF for post-tensioning, etc. The next step was to research unit costs for each of the bid items utilizing similar projects in the region. Once all of this was complete, we had a total direct cost for each alternate. Allowances were then added below the bottom line for a contractor’s overhead costs, profit/margin and bond based on percentages and ratios typically seen on a project of this size and type. Design contingency was also added to each alternate based on the current level of design to account for any unknowns or missing details during this early stage.

The main goal for the cost analysis at this stage is to develop relative costs for each alternate. In order to achieve this, special care was taken to ensure each alternate utilized either the same or relatively similar unit costs for each item. It is to be noted that due to this, the total price for each alternative is subject to change when the design is further developed for the selected alternative(s). To account for possible change, a design contingency of 25% is added to the estimated cost for each alternative. Full understanding of the preliminary and variable nature of the total prices indicated for the alternatives is necessary if the values are used for budgetary purposes.

The limits of the structure included in the cost estimates for each alternative start at West Abutment A and extend to the East Abutment L for the local traffic lanes, and to the pier east of Spring Grove Ave. for the I-75 traffic lanes. Note that the construction of the pier east of Spring Grove is included within the estimate.

The estimates assume that the start of the project would be in 2020 and would end in 2024/2025 (41 to 47 months depending on the alternate). The estimates include escalations and inflation during the project duration only. A 3% per year escalation should be applied for every year beyond a 2020 start date.

5.2 Cost Analysis Assumptions

At the current level of design, various design and cost assumptions were needed in order to have a complete estimate for each alternate. Design assumptions were developed for various items such as

rebar densities, post-tensioning weights, stay cable weights, etc. and are based on past designs of projects of similar structure type. For foundations it was also assumed that each alternate would require at least one non-production demonstration shaft with a bi-axial load test, along with CSL testing of each shaft. Assumptions were made on the type of bearing needed for each structure type between neoprene bearing pads, structural pot bearings or disc bearings. Lastly, miscellaneous items were added to each alternate that may or may not be required such as allowances for aesthetic lighting, aviation lighting, lighting protection, permanent access stairs and platforms, permanent access elevators, etc. Again, care was taken when making these assumptions that each alternate was treated fairly relative to the others. The cost estimates do not include consideration of winter shutdowns since all alternatives would be similarly affected.

5.3 Railroad Premium Calculation

Another step that was taken was to develop a railroad premium cost for each of the alternatives. In order to develop these costs, the unit costs used within the “base bid” were based on projects where there was no railroad interference, effectively imagining there are no rail lines on this project. To calculate the RR premium costs, we again looked at the unit costs for every individual bid item and developed an uplifted rate based on a percentage increase of each item. This percentage varies and is based on a combination of factors including upsizing of equipment working within or adjacent to rail tracks, slower production, a change in the method of construction and additional access costs, all of which are based on a “feel” from past experience. In summary, the alternatives with the highest base cost of work within or near the railroad typically have the highest RR premium costs.

All costs associated with lost productivity and other related costs due to proximity to the RR are considered within the “RR Premium” costs. Various percentages, from 5% to 25%, were used to increase the overall unit costs for items impacted by railroad operations. Since the unit cost includes permanent & construction materials, labor, equipment, etc. all blended together, doubling the labor cost may only result in a 20% overall increase in unit cost for an item (depending on the item). As the designs are developed further, cost estimates will be refined; this will include an analysis of unit-costs based on the anticipated use of equipment and labor. This analysis will allow for an improved evaluation of railway premiums using a more rational estimate for time delays.

The railway premium can be divided into two broad categories, construction costs and railroad incurred costs. Brief details are as follows:

1. Construction Costs
 - a. Construction of Trestle to Pier D near the turntable
This is needed for all bridge alternatives with a main span of 560 feet
 - b. Extension of Trestle to Pier E in the middle of the yard
This is needed for the short-span push-launch alternative
 - c. Heavy Bridge over Mill Creek
The preferred method of Arch positioning is the Orthogonal Delivery. This option minimizes disruption to the yard and requires a heavy bridge over Mill Creek.
 - d. Launching Runway across the yard
This is needed for the Twin Arches
 - e. Superstructure
This includes the impact of railyard interruptions due to superstructure construction

operations. For CIP segmental bridge this includes the setting up, launching for casting each segment and removal of form travelers. For twin arch bridges, this includes impact of launching the structure over SPMTs through the railyard. For the extradosed bridge this includes the impact of erection of steel girder and floor beam segments over the railyard. For the push-launch options, this includes the impact of closures during the various launch windows. For the double-deck cable-stayed bridge this includes the impact of erection of steel truss segments over the railyard.

f. Substructure at Pier D

This includes the impact of railway interruptions on the construction of foundations, piers and pier-tables at Pier D

g. Substructure at Pier E

This includes the impact of railway interruptions on the construction of foundations, piers and pier-tables at Pier E. This is primarily applicable to the short-span push-launch alternative.

2. Railroad Incurred Costs

a. Temporary relocation of Track

This includes temporary relocation of tracks near Pier E for the short-span push-launch alternative.

b. Permanent relocation of Track

This includes relocation of track B from the east bank of Mill Creek closer to track C in the railyard; this is applicable to all bridge design alternatives. This also includes some permanent relocation of tracks near Pier E for the short-span push-launch alternative.

c. Interference with intermodal yard

This reflects the impact of the construction of the approach spans on the storage areas in the inter-modal yard and interruption of traffic running in the N-S direction beneath the existing viaduct

5.4 Escalation

The estimates assume that the start of the project would be in 2020 and would end in 2024/2025 (41 to 47 months depending on the alternative). The estimates include escalations and inflation during the project duration only. A 3% per year escalation should be applied for every year beyond a 2020 start date.

Cost summaries are provided in the table below:

	Trestle to Pier D	Trestle to Pier E	Bridge on Mill Creek	Launching Runway	Superstructure	Substructure at Pier D	Substructure at Pier E	Temporary Relocation of Track	Permanent Relocation of Track	Interference with Intermodal Yard
SSPL	X	X			X	X	X	XX	XX	X
CIP	X				X	X			X	X
TA			X	X	X				X	X
EX	X				X	X			X	X
LSPL	X				X	X			X	X
CSB					X				X	X

RAILROAD COST										
	Construction Incurred Cost (25% Contingency Included)							Railroad Incurred Cost		
	Trestle to Pier D	Trestle to Pier E	Bridge on Mill Creek	Launching Runway	Superstructure	Substructure at Pier D	Substructure at Pier E	Temporary Relocation of Track	Permanent Relocation of Track	Interference with Intermodal Yard
SSPL	\$ 3,131,467	\$ 1,693,691			\$ 8,852,189	\$ 1,243,763	\$ 1,259,655	\$ 500,843	\$ 3,077,763	\$ 1,500,000
CIP	\$ 3,224,526				\$ 13,891,539	\$ 1,542,770			\$ 1,526,764	\$ 1,000,000
TA			\$ 4,933,485	\$ 5,915,821	\$ 9,984,582				\$ 1,526,764	\$ 2,000,000
EX	\$ 3,280,362				\$ 14,334,438	\$ 1,658,846			\$ 1,526,764	\$ 1,000,000
LSPL	\$ 2,601,025				\$ 13,530,917	\$ 625,675			\$ 1,526,764	\$ 1,500,000
CSB					\$ 18,267,817				\$ 1,526,764	\$ 2,000,000



Western Hills Viaduct
Bridge Type Selection Greensheet

Item Description	ALTERNATE 1A SHORT SPAN PUSH LAUNCHED (TRAPEZOIDAL STEEL BOX)		ALTERNATE 1B SHORT SPAN PUSH LAUNCHED (STEEL PLATE GIRDER)		ALTERNATE 2 CIP SEGMENTAL		ALTERNATE 3 PARALLEL TWIN ARCHES		ALTERNATE 4 EXTRADOSED (COMPOSITE GIRDER)		ALTERNATE 5 LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)		ALTERNATE 6 DUAL PYLON CABLE-STAYED	
	Base Bid	w/ RR Premium	Base Bid	w/ RR Premium	Base Bid	w/ RR Premium	Base Bid	w/ RR Premium	Base Bid	w/ RR Premium	Base Bid	w/ RR Premium	Base Bid	w/ RR Premium
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE	\$ 21,668,373	\$ 30,682,434	\$ 21,668,373	\$ 30,682,434	\$ 22,779,922	\$ 33,372,722	\$ 14,511,199	\$ 24,671,995	\$ 26,221,145	\$ 37,121,350	\$ 16,193,133	\$ 24,469,700	\$ 29,945,098	\$ 40,842,389
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE	\$ 24,890,097	\$ 24,890,097	\$ 24,890,097	\$ 24,890,097	\$ 22,049,813	\$ 22,049,813	\$ 21,132,846	\$ 21,132,846	\$ 14,121,485	\$ 14,121,485	\$ 20,050,927	\$ 20,050,927	\$ 15,754,261	\$ 15,754,261
MAIN SPAN SUPERSTRUCTURE	\$ 30,866,644	\$ 39,880,705	\$ 23,969,044	\$ 32,983,105	\$ 50,614,534	\$ 61,207,334	\$ 44,795,489	\$ 54,956,285	\$ 57,762,274	\$ 68,662,480	\$ 53,625,269	\$ 61,901,836	\$ 90,302,192	\$ 101,199,483
APPROACH SPAN SUPERSTRUCTURE	\$ 36,859,189	\$ 36,859,189	\$ 33,279,689	\$ 33,279,689	\$ 29,106,790	\$ 29,106,790	\$ 35,581,643	\$ 35,581,643	\$ 36,838,558	\$ 36,838,558	\$ 28,230,950	\$ 28,230,950	\$ 24,300,651	\$ 24,300,651
TOTAL DIRECT COST	\$ 114,284,302	\$ 134,371,405	\$ 103,807,202	\$ 124,551,059	\$ 124,551,059	\$ 154,727,458	\$ 116,021,176	\$ 134,943,462	\$ 134,943,462	\$ 134,943,462	\$ 118,100,278	\$ 134,371,405	\$ 160,302,201	\$ 182,491,966
INDIRECT COST	\$ 20,571,174	\$ 20,571,174	\$ 18,685,296	\$ 18,685,296	\$ 22,419,191	\$ 22,419,191	\$ 20,883,812	\$ 20,883,812	\$ 24,289,823	\$ 24,289,823	\$ 21,258,050	\$ 21,258,050	\$ 28,854,396	\$ 28,854,396
PROFIT/MARGIN	\$ 20,228,322	\$ 20,228,322	\$ 18,373,875	\$ 18,373,875	\$ 22,045,537	\$ 22,045,537	\$ 20,535,748	\$ 20,535,748	\$ 23,884,993	\$ 23,884,993	\$ 20,903,749	\$ 20,903,749	\$ 28,373,490	\$ 28,373,490
BOND	\$ 985,558	\$ 985,558	\$ 895,206	\$ 895,206	\$ 1,074,095	\$ 1,074,095	\$ 1,000,536	\$ 1,000,536	\$ 1,163,717	\$ 1,163,717	\$ 1,018,466	\$ 1,018,466	\$ 1,382,404	\$ 1,382,404
DESIGN CONTINGENCY	\$ 28,571,076	\$ 28,571,076	\$ 25,951,801	\$ 25,951,801	\$ 31,137,765	\$ 31,137,765	\$ 29,005,294	\$ 29,005,294	\$ 33,735,866	\$ 33,735,866	\$ 29,525,070	\$ 29,525,070	\$ 40,075,550	\$ 40,075,550
TOTAL STRUCTURE PRICE	\$ 184,640,432	\$ 202,668,554	\$ 167,713,380	\$ 185,741,503	\$ 201,227,647	\$ 222,413,248	\$ 187,446,566	\$ 207,768,159	\$ 218,017,860	\$ 239,818,271	\$ 190,805,612	\$ 207,358,746	\$ 258,988,041	\$ 280,781,411
RAILROAD PREMIUM		\$ 18,028,123		\$ 18,028,123		\$ 21,185,600		\$ 20,321,593		\$ 21,800,411		\$ 16,553,134		\$ 21,794,582
TOTAL Unit Price (\$/SF)	\$ 503.57 / SF	\$ 552.74 / SF	\$ 457.41 / SF	\$ 506.58 / SF	\$ 540.86 / SF	\$ 597.8 / SF	\$ 473.67 / SF	\$ 525.02 / SF	\$ 553.95 / SF	\$ 609.35 / SF	\$ 443.97 / SF	\$ 482.48 / SF	\$ 642.7 / SF	\$ 696.79 / SF
Main Span Unit Price (\$/SF)	\$ 567.01 / SF	\$ 687.44 / SF	\$ 492.56 / SF	\$ 612.99 / SF	\$ 674.25 / SF	\$ 794.72 / SF	\$ 764.09 / SF	\$ 926.15 / SF	\$ 729.81 / SF	\$ 847.06 / SF	\$ 597.53 / SF	\$ 685.21 / SF	\$ 906.89 / SF	\$ 1008.63 / SF
Approach Span Unit Price (\$/SF)	\$ 459.81 / SF	\$ 459.81 / SF	\$ 433.15 / SF	\$ 433.15 / SF	\$ 421.28 / SF	\$ 421.28 / SF	\$ 338.95 / SF	\$ 338.95 / SF	\$ 396.5 / SF	\$ 396.5 / SF	\$ 323.68 / SF	\$ 323.68 / SF	\$ 342.86 / SF	\$ 342.86 / SF
Complete Bridge Area (SF)	366,661	366,661	366,661	366,661	372,054	372,054	395,731	395,731	393,567	393,567	429,776	429,776	402,967	402,967
Main Span Bridge Area (SF)	149,693	149,693	149,693	149,693	175,865	175,865	125,400	125,400	185,920	185,920	188,778	188,778	214,221	214,221
Approach Span Bridge Area (SF)	216,968	216,968	216,968	216,968	196,189	196,189	270,331	270,331	207,647	207,647	240,998	240,998	188,746	188,746

LEGEND:

Lowest Cost
Low Cost
Medium Cost
High Cost

Western Hills Viaduct Bridge Type Selection Greensheet		Alternate 1A: SHORT SPAN PUSH LAUNCHED (TRAPEZOIDAL STEEL BOX)		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	8,000	\$ 1,000.00	\$ 8,000,000
60" Dia Drilled Shaft (Rock)	LF	1,600	\$ 1,500.00	\$ 2,400,000
Drilled Shaft Reinforcement (Black)	LB	2,010,619	\$ 1.05	\$ 2,111,150
Bi-Axial Load Test (Osterberg)	EA	1	\$ 175,000.00	\$ 175,000
Demonstration Shaft	EA	1	\$ 140,000.00	\$ 140,000
Crosshole Sonic Logging (Testing)	EA	80	\$ 5,500.00	\$ 440,000
Pile Cap Concrete	CY	4,817	\$ 375.00	\$ 1,806,375
Column Concrete	CY	3,920	\$ 500.00	\$ 1,960,000
Pier Cap Concrete	CY	880	\$ 900.00	\$ 792,000
Crashwall Concrete	CY	667	\$ 500.00	\$ 333,333
Substructure Reinforcement (Black)	LB	2,374,067	\$ 1.05	\$ 2,492,770
Structure Excavation	CY	6,395	\$ 12.00	\$ 76,740
Structure Backfill	CY	1,578	\$ 18.00	\$ 28,404
Support of Excavation	SF	22,680	\$ 25.00	\$ 567,000
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 21,668,373
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	10,000	\$ 1,000.00	\$ 10,000,000
60" Dia Drilled Shaft (Rock)	LF	2,000	\$ 1,500.00	\$ 3,000,000
Drilled Shaft Reinforcement (Black)	LB	1,745,329	\$ 1.05	\$ 1,832,596
Crosshole Sonic Logging (Testing)	EA	100	\$ 5,500.00	\$ 550,000
Pile Cap Concrete	CY	5,473	\$ 375.00	\$ 2,052,375
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	2,838	\$ 500.00	\$ 1,419,000
Pier Cap Concrete	CY	1,934	\$ 900.00	\$ 1,740,600
Substructure Reinforcement (Black)	LB	2,463,400	\$ 1.05	\$ 2,586,570
Substructure Post-Tensioning	LB	116,040	\$ 4.50	\$ 522,180
Structure Excavation	CY	7,768	\$ 12.00	\$ 93,216
Structure Backfill	CY	2,295	\$ 18.00	\$ 41,310
Support of Excavation	SF	26,722	\$ 25.00	\$ 668,050
				\$ 24,890,097
MAIN SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	30	\$ 3,500.00	\$ 105,000
Trapezoidal Structural Steel - Launched	LB	10,056,000	\$ 2.10	\$ 21,117,600
Launching Equipment	LS	1	\$ 2,000,000.00	\$ 2,000,000
Paint Structural Steel	TN	5,028	\$ 200.00	\$ 1,005,600
CIP Deck Concrete	CY	3,937	\$ 750.00	\$ 2,952,750
Superstructure Reinforcement (Black)	LB	885,825	\$ 1.05	\$ 930,116
Post-Tensioning Tendons - Transverse	LB	149,693	\$ 4.25	\$ 636,195
Sidewalk Concrete (incl rebar)	SF	9,270	\$ 8.00	\$ 74,160
Deck Grinding & Grooving	SY	14,000	\$ 7.00	\$ 98,000
Strip Seal Expansion Joints	LF	291	\$ 135.00	\$ 39,285
Bridge Concrete Railing (incl rebar)	LF	6,180	\$ 105.00	\$ 648,900
Safety Fence	LF	3,090	\$ 350.00	\$ 1,081,500
Bridge Drainage	LS	1	\$ 164,662.30	\$ 164,662
Bridge Striping	LF	11,330	\$ 1.14	\$ 12,875
				\$ 30,866,644

APPROACH SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	68	\$ 3,500.00	\$ 238,000
Trapezoidal Structural Steel - Crane Erected	LB	12,212,000	\$ 2.10	\$ 25,645,200
Paint Structural Steel	TN	6,106	\$ 200.00	\$ 1,221,200
CIP Deck Concrete	CY	5,692	\$ 750.00	\$ 4,269,000
Superstructure Reinforcement (Black)	LB	1,280,700	\$ 1.05	\$ 1,344,735
Sidewalk Concrete (incl rebar)	SF	14,715	\$ 8.00	\$ 117,720
Post-Tensioning Tendons - Transverse	LB	216,968	\$ 4.25	\$ 922,114
Deck Grinding & Grooving	SY	19,929	\$ 7.00	\$ 139,503
Strip Seal Expansion Joints	LF	559	\$ 135.00	\$ 75,465
Bridge Concrete Railing (incl rebar)	LF	8,480	\$ 105.00	\$ 890,400
Safety Fence	LF	4,905	\$ 350.00	\$ 1,716,750
Bridge Drainage	LS	1	\$ 238,664.80	\$ 238,665
Bridge Striping	LF	17,985	\$ 1.14	\$ 20,438
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
				\$ 36,859,189
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 114,284,302
INDIRECT COST				18% \$ 20,571,174
PROFIT/MARGIN				15% \$ 20,228,322
BOND				0.6355% \$ 985,558
DESIGN CONTIGENCY				25% \$ 28,571,076
TOTAL PRICE				\$ 503.57 / SF \$ 184,640,432
Main Span Sub-Total				
				\$ 567.01 / SF \$ 84,876,819
Approach Span Sub-Total				
				\$ 459.81 / SF \$ 99,763,612
Complete Bridge Length	FT	2,665		
Bridge Approach Span Length	FT	1,635		
Bridge Main Span Length	FT	1,030		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	145.33		
Complete Bridge Area	SF	366,661		
Main Span Bridge Area	SF	149,693		
Approach Span Bridge Area	SF	216,968		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Column Conc Rebar Density	LB/CY	250		
Crashwall Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Abutment Conc Rebar Density	LB/CY	175		
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-Deck	LB/CY	225		
Transverse Post-Tensioning Weight	LB/SF	1		
Structural Steel Weight - Steel Box (Ratio Check)	LB/SF	61		
ACS Assumed				

Western Hills Viaduct Bridge Type Selection Greensheet		Alternate 1B: SHORT SPAN PUSH LAUNCHED (STEEL PLATE GIRDER)		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	8,000	\$ 1,000.00	\$ 8,000,000
60" Dia Drilled Shaft (Rock)	LF	1,600	\$ 1,500.00	\$ 2,400,000
Drilled Shaft Reinforcement (Black)	LB	2,010,619	\$ 1.05	\$ 2,111,150
Bi-Axial Load Test (Osterberg)	EA	1	\$ 175,000.00	\$ 175,000
Demonstration Shaft	EA	1	\$ 140,000.00	\$ 140,000
Crosshole Sonic Logging (Testing)	EA	80	\$ 5,500.00	\$ 440,000
Pile Cap Concrete	CY	4,817	\$ 375.00	\$ 1,806,375
Column Concrete	CY	3,920	\$ 500.00	\$ 1,960,000
Pier Cap Concrete	CY	880	\$ 900.00	\$ 792,000
Crashwall Concrete	CY	667	\$ 500.00	\$ 333,333
Substructure Reinforcement (Black)	LB	2,374,067	\$ 1.05	\$ 2,492,770
Structure Excavation	CY	6,395	\$ 12.00	\$ 76,740
Structure Backfill	CY	1,578	\$ 18.00	\$ 28,404
Support of Excavation	SF	22,680	\$ 25.00	\$ 567,000
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 21,668,373
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	10,000	\$ 1,000.00	\$ 10,000,000
60" Dia Drilled Shaft (Rock)	LF	2,000	\$ 1,500.00	\$ 3,000,000
Drilled Shaft Reinforcement (Black)	LB	1,745,329	\$ 1.05	\$ 1,832,596
Crosshole Sonic Logging (Testing)	EA	100	\$ 5,500.00	\$ 550,000
Pile Cap Concrete	CY	5,473	\$ 375.00	\$ 2,052,375
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	2,838	\$ 500.00	\$ 1,419,000
Pier Cap Concrete	CY	1,934	\$ 900.00	\$ 1,740,600
Substructure Reinforcement (Black)	LB	2,463,400	\$ 1.05	\$ 2,586,570
Substructure Post-Tensioning	LB	116,040	\$ 4.50	\$ 522,180
Structure Excavation	CY	7,768	\$ 12.00	\$ 93,216
Structure Backfill	CY	2,295	\$ 18.00	\$ 41,310
Support of Excavation	SF	26,722	\$ 25.00	\$ 668,050
				\$ 24,890,097
MAIN SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	30	\$ 3,500.00	\$ 105,000
Structural Steel Plate Girder - Launched	LB	7,808,000	\$ 1.85	\$ 14,444,800
Launching Equipment	LS	1	\$ 2,000,000.00	\$ 2,000,000
Paint Structural Steel	TN	3,904	\$ 200.00	\$ 780,800
CIP Deck Concrete	CY	3,937	\$ 750.00	\$ 2,952,750
Superstructure Reinforcement (Black)	LB	885,825	\$ 1.05	\$ 930,116
Post-Tensioning Tendons - Transverse	LB	149,693	\$ 4.25	\$ 636,195
Sidewalk Concrete (incl rebar)	SF	9,270	\$ 8.00	\$ 74,160
Deck Grinding & Grooving	SY	14,000	\$ 7.00	\$ 98,000
Strip Seal Expansion Joints	LF	291	\$ 135.00	\$ 39,285
Bridge Concrete Railing (incl rebar)	LF	6,180	\$ 105.00	\$ 648,900
Safety Fence	LF	3,090	\$ 350.00	\$ 1,081,500
Bridge Drainage	LS	1	\$ 164,662.30	\$ 164,662
Bridge Striping	LF	11,330	\$ 1.14	\$ 12,875
				\$ 23,969,044

APPROACH SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	68	\$ 3,500.00	\$ 238,000
Structural Steel Plate Girder - Launched	LB	11,942,000	\$ 1.85	\$ 22,092,700
Paint Structural Steel	TN	5,971	\$ 200.00	\$ 1,194,200
CIP Deck Concrete	CY	5,692	\$ 750.00	\$ 4,269,000
Superstructure Reinforcement (Black)	LB	1,280,700	\$ 1.05	\$ 1,344,735
Sidewalk Concrete (incl rebar)	SF	14,715	\$ 8.00	\$ 117,720
Post-Tensioning Tendons - Transverse	LB	216,968	\$ 4.25	\$ 922,114
Deck Grinding & Grooving	SY	19,929	\$ 7.00	\$ 139,503
Strip Seal Expansion Joints	LF	559	\$ 135.00	\$ 75,465
Bridge Concrete Railing (incl rebar)	LF	8,480	\$ 105.00	\$ 890,400
Safety Fence	LF	4,905	\$ 350.00	\$ 1,716,750
Bridge Drainage	LS	1	\$ 238,664.80	\$ 238,665
Bridge Striping	LF	17,985	\$ 1.14	\$ 20,438
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
				\$ 33,279,689
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 103,807,202
INDIRECT COST			18%	\$ 18,685,296
PROFIT/MARGIN			15%	\$ 18,373,875
BOND			0.6355%	\$ 895,206
DESIGN CONTIGENCY			25%	\$ 25,951,801
TOTAL PRICE			\$ 457.41 / SF	\$ 167,713,380
Main Span Sub-Total				
			\$ 492.56 / SF	\$ 73,732,893
Approach Span Sub-Total				
			\$ 433.15 / SF	\$ 93,980,487
Complete Bridge Length	FT	2,665		
Bridge Approach Span Length	FT	1,635		
Bridge Main Span Length	FT	1,030		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	145.33		
Complete Bridge Area	SF	366,661		
Main Span Bridge Area	SF	149,693		
Approach Span Bridge Area	SF	216,968		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Column Conc Rebar Density	LB/CY	250		
Crashwall Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Abutment Conc Rebar Density	LB/CY	175		
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-Deck	LB/CY	225		
Transverse Post-Tensioning Weight	LB/SF	1		
Structural Steel Weight - Steel Box (Ratio Check)	LB/SF	54		

ACS Assumed

Western Hills Viaduct Bridge Type Selection Greensheet		Alternate 2: CIP SEGMENTAL		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
84" Dia Drilled Shaft (Common)	LF	2,400	\$ 1,600.00	\$ 3,840,000
84" Dia Drilled Shaft (Rock)	LF	400	\$ 2,000.00	\$ 800,000
108" Dia Drilled Shaft (Common)	LF	2,800	\$ 2,200.00	\$ 6,160,000
108" Dia Drilled Shaft (Rock)	LF	500	\$ 2,750.00	\$ 1,375,000
Drilled Shaft Reinforcement (Black)	LB	2,353,286	\$ 1.05	\$ 2,470,950
Bi-Axial Load Test (Osterberg)	EA	1	\$ 135,000.00	\$ 135,000
Demonstration Shaft	EA	1	\$ 198,000.00	\$ 198,000
Crosshole Sonic Logging (Testing)	EA	52	\$ 5,250.00	\$ 273,000
Pile Cap Concrete	CY	6,250	\$ 375.00	\$ 2,343,750
Column Concrete	CY	3,529	\$ 500.00	\$ 1,764,500
Substructure Reinforcement (Black)	LB	2,132,250	\$ 1.05	\$ 2,238,863
Structure Excavation	CY	10,542	\$ 12.00	\$ 126,504
Structure Backfill	CY	4,292	\$ 18.00	\$ 77,256
Support of Excavation	SF	25,260	\$ 25.00	\$ 631,500
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 22,779,922
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	9,200	\$ 1,000.00	\$ 9,200,000
60" Dia Drilled Shaft (Rock)	LF	2,300	\$ 1,500.00	\$ 3,450,000
Drilled Shaft Reinforcement (Black)	LB	1,672,607	\$ 1.05	\$ 1,756,238
Crosshole Sonic Logging (Testing)	EA	92	\$ 5,250.00	\$ 483,000
Pile Cap Concrete	CY	3,704	\$ 375.00	\$ 1,389,000
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	3,685	\$ 500.00	\$ 1,842,500
Pier Cap Concrete	CY	553	\$ 900.00	\$ 497,700
Substructure Reinforcement (Black)	LB	1,907,050	\$ 1.05	\$ 2,002,403
Substructure Post-Tensioning	LB	33,180	\$ 4.50	\$ 149,310
Structure Excavation	CY	8,217	\$ 12.00	\$ 98,604
Structure Backfill	CY	4,513	\$ 18.00	\$ 81,234
Support of Excavation	SF	28,625	\$ 25.00	\$ 715,625
				\$ 22,049,813
MAIN SPAN SUPERSTRUCTURE				
Disc Bearings	EA	12	\$ 22,500.00	\$ 270,000
C.I.P Balanced Cantilever Box Girder Concrete	CY	21,579	\$ 1,550.00	\$ 33,447,450
C.I.P Box Girder Concrete on Falsework	CY	1,482	\$ 1,100.00	\$ 1,630,200
C.I.P Closure Concrete - Transverse	CY	389	\$ 2,800.00	\$ 1,089,200
C.I.P Closure Concrete - Longitudinal	CY	291	\$ 900.00	\$ 261,900
Superstructure Reinforcement (Black)	LB	4,154,675	\$ 1.05	\$ 4,362,409
Post-Tensioning Tendons - Logitudinal	LB	1,231,055	\$ 3.00	\$ 3,693,165
Post-Tensioning Tendons - Transverse	LB	175,865	\$ 4.25	\$ 747,426
Sidewalk Concrete (incl rebar)	SF	10,080	\$ 8.00	\$ 80,640
Deck Overlay	SF	149,301	\$ 9.00	\$ 1,343,709
Deck Grinding & Grooving	SY	16,589	\$ 7.00	\$ 116,123
Modular Expansion Joints	LF	291	\$ 1,500.00	\$ 435,990
Bridge Concrete Railing (incl rebar)	LF	10,474	\$ 105.00	\$ 1,099,770
Safety Fence	LF	5,226	\$ 350.00	\$ 1,829,100
Bridge Drainage	LS	1	\$ 193,451.50	\$ 193,452
Bridge Striping	LF	12,320	\$ 1.14	\$ 14,000
				\$ 50,614,534

APPROACH SPAN SUPERSTRUCTURE				
Disc Bearings	EA	30	\$ 22,500.00	\$ 675,000
C.I.P Box Girder Concrete on Falsework	CY	17,567	\$ 1,100.00	\$ 19,323,333
Superstructure Reinforcement (Black)	LB	3,513,333	\$ 1.05	\$ 3,689,000
Post-Tensioning Tendons - Logitudinal	LB	1,079,040	\$ 3.00	\$ 3,237,119
Sidewalk Concrete (incl rebar)	SF	13,950	\$ 8.00	\$ 111,600
Deck Grinding & Grooving	SY	18,194	\$ 7.00	\$ 127,358
Strip Seal Expansion Joints	LF	436	\$ 250.00	\$ 108,998
Bridge Concrete Railing (incl rebar)	LF	5,640	\$ 105.00	\$ 592,200
Safety Fence	LF	2,820	\$ 350.00	\$ 987,000
Bridge Drainage	LS	1	\$ 215,807.90	\$ 215,808
Bridge Striping	LF	17,050	\$ 1.14	\$ 19,375
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
				\$ 29,106,790
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 124,551,059.18
INDIRECT COST		18%		\$ 22,419,191
PROFIT/MARGIN		15%		\$ 22,045,537
BOND		0.6355%		\$ 1,074,095
DESIGN CONTIGENCY		25%		\$ 31,137,765
TOTAL PRICE			\$ 540.86 / SF	\$ 201,227,647
Main Span Sub-Total			\$ 674.25 / SF	\$ 118,577,825
Approach Span Sub-Total			\$ 421.28 / SF	\$ 82,649,822
Complete Bridge Length	FT	2,670		
Bridge Approach Span Length	FT	1,550		
Bridge Main Span Length	FT	1,120		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	145.33		
Complete Bridge Area	SF	372,054		
Main Span Bridge Area	SF	175,865		
Approach Span Bridge Area	SF	196,189		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Abutment Conc Rebar Density	LB/CY	175		
Column Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-C.I.P Balanced Cantilever (Main Span)	LB/CY	175		
Superstructure Concrete Rebar Density-C.I.P Box Girder (Approaches)	LB/CY	200		
Longitudinal Post-Tensioning Weight-Balanced Cantilever (Main Span)	LB/SF	7		
Longitudinal Post-Tensioning Weight-CIP Box Girder (Approaches)	LB/SF	5.5		
Transverse Post-Tensioning Weight	LB/SF	1		
ACS Assumed				

Western Hills Viaduct Bridge Type Selection Greensheet		ALTERNATE 3: PARALLEL TWIN ARCHES		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
84" Dia Drilled Shaft (Common)	LF	4,200	\$ 1,600.00	\$ 6,720,000
84" Dia Drilled Shaft (Rock)	LF	630	\$ 2,000.00	\$ 1,260,000
Drilled Shaft Reinforcement (Black)	LB	1,376,890	\$ 1.05	\$ 1,445,735
Bi-Axial Load Test (Osterberg)	EA	1	\$ 175,000.00	\$ 175,000
Demonstration Shaft	EA	1	\$ 198,000.00	\$ 198,000
Crosshole Sonic Logging (Testing)	EA	42	\$ 5,500.00	\$ 231,000
Pile Cap Concrete	CY	5,227	\$ 325.00	\$ 1,698,775
Column Concrete	CY	954	\$ 600.00	\$ 572,400
Substructure Reinforcement (Black)	LB	1,283,900	\$ 1.05	\$ 1,348,095
Structure Excavation	CY	7,226	\$ 12.00	\$ 86,712
Structure Backfill	CY	1,999	\$ 18.00	\$ 35,982
Support of Excavation	SF	15,756	\$ 25.00	\$ 393,900
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 14,511,199
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
48" Dia Drilled Shaft (Common)	LF	8,569	\$ 700.00	\$ 5,998,300
48" Dia Drilled Shaft (Rock)	LF	2,640	\$ 900.00	\$ 2,376,000
Drilled Shaft Reinforcement (Black)	LB	1,043,381	\$ 1.05	\$ 1,095,550
Crosshole Sonic Logging (Testing)	EA	132	\$ 5,500.00	\$ 726,000
Pile Cap Concrete	CY	2,199	\$ 375.00	\$ 824,625
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	6,075	\$ 500.00	\$ 3,037,500
Pier Cap Concrete	CY	2,500	\$ 900.00	\$ 2,250,000
Substructure Reinforcement (Black)	LB	2,787,650	\$ 1.05	\$ 2,927,033
Substructure Post-Tensioning	LB	150,000	\$ 4.50	\$ 675,000
Structure Excavation	CY	5,714	\$ 12.00	\$ 68,568
Structure Backfill	CY	3,515	\$ 18.00	\$ 63,270
Support of Excavation	SF	28,272	\$ 25.00	\$ 706,800
				\$ 21,132,846
MAIN SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	8	\$ 35,000.00	\$ 280,000
Structural Steel (Arch)	LB	10,400,000	\$ 2.95	\$ 30,680,000
Launching Equipment	LS	1	\$ 2,500,000.00	\$ 2,500,000
Paint Structural Steel	TN	5,200	\$ 200.00	\$ 1,040,000
Cable Hanger System	LB	131,670	\$ 34.00	\$ 4,476,780
CIP Deck Concrete	CY	3,290	\$ 775.00	\$ 2,549,750
Superstructure Reinforcement (Black)	LB	740,250	\$ 1.05	\$ 777,263
Sidewalk Concrete (incl rebar)	SF	6,840	\$ 8.00	\$ 54,720
Deck Overlay	SF	106,398	\$ 9.00	\$ 957,582
Deck Grinding & Grooving	SY	11,822	\$ 7.00	\$ 82,754
Modular Expansion Joints	LF	330	\$ 1,100.00	\$ 363,000
Bridge Concrete Railing (incl rebar)	LF	3,040	\$ 105.00	\$ 319,200
Safety Fence	LF	1,520	\$ 350.00	\$ 532,000
Bridge Drainage	LS	1	\$ 137,940.00	\$ 137,940
Bridge Striping	LF	8,360	\$ 1.14	\$ 9,500
Aviation Lighting	LS	1	\$ 35,000.00	\$ 35,000
				\$ 44,795,489

APPROACH SPAN SUPERSTRUCTURE				
Elastomeric Bearings	EA	214	\$ 1,850.00	\$ 395,900
Structural Steel (Plate Girders)	LB	13,262,000	\$ 1.75	\$ 23,208,500
Paint Structural Steel	TN	6,631	\$ 200.00	\$ 1,326,200
CIP Deck Concrete	CY	7,092	\$ 750.00	\$ 5,319,000
Superstructure Reinforcement (Black)	LB	1,595,700	\$ 1.05	\$ 1,675,485
Sidewalk Concrete (incl rebar)	SF	17,190	\$ 8.00	\$ 137,520
Deck Grinding & Grooving	SY	24,937	\$ 7.00	\$ 174,559
Strip Seal Expansion Joints	LF	456	\$ 135.00	\$ 61,560
Bridge Concrete Railing (incl rebar)	LF	10,506	\$ 105.00	\$ 1,103,130
Safety Fence	LF	5,253	\$ 350.00	\$ 1,838,550
Bridge Drainage	LS	1	\$ 297,364.10	\$ 297,364
Bridge Striping	LF	21,010	\$ 1.14	\$ 23,875
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
				\$ 35,581,643
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 116,021,176.01
INDIRECT COST			18%	\$ 20,883,812
PROFIT/MARGIN			15%	\$ 20,535,748
BOND			0.6355%	\$ 1,000,536
DESIGN CONTIGENCY			25%	\$ 29,005,294
TOTAL PRICE			\$ 473.67 / SF	\$ 187,446,566
Main Span Sub-Total				
			\$ 764.09 / SF	\$ 95,817,292
Approach Span Sub-Total				
			\$ 338.95 / SF	\$ 91,629,274
Complete Bridge Length	FT	2,670		
Bridge Approach Span Length	FT	1,910		
Bridge Main Span Length	FT	760		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	165.00		
Complete Bridge Area	SF	395,731		
Main Span Bridge Area	SF	125,400		
Approach Span Bridge Area	SF	270,331		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Column Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Abutment Conc Rebar Density	LB/CY	175		
Substructure Post-Tensioning Weight - Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-Deck	LB/CY	225		
Approach Structural Steel Weight - Plate Girders (CHECK)	LB/SF	49		
Main Bridge Structural Steel Weight - Steel Arch (CHECK)	LB/SF	83		
Main Bridge Cable Hanging System Weight	LB/SF	1.05		
ACS Assumed				

Western Hills Viaduct Bridge Type Selection Greensheet		ALTERNATE 4: EXTRADOSED (COMPOSITE GIRDER)		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
72" Dia Drilled Shaft (Common)	LF	5,600	\$ 1,300.00	\$ 7,280,000
72" Dia Drilled Shaft (Rock)	LF	1,680	\$ 1,750.00	\$ 2,940,000
Drilled Shaft Reinforcement (Black)	LB	1,524,720	\$ 1.05	\$ 1,600,956
Bi-Axial Load Test (Osterberg)	EA	1	\$ 175,000.00	\$ 175,000
Demonstration Shaft	EA	1	\$ 195,000.00	\$ 195,000
Crosshole Sonic Logging (Testing)	EA	56	\$ 5,500.00	\$ 308,000
Pile Cap Concrete	CY	6,748	\$ 325.00	\$ 2,193,100
Column Concrete	CY	1,565	\$ 500.00	\$ 782,500
Substructure Reinforcement (Black)	LB	1,740,850	\$ 1.05	\$ 1,827,893
Pylon Concrete (incl. Cross Beam)	CY	3,284	\$ 650.00	\$ 2,134,600
Steel Anchor Box	LB	1,390,130	\$ 3.00	\$ 4,170,390
Pylon Reinforcing Steel	LB	1,149,400	\$ 1.05	\$ 1,206,870
Pylon Post-Tensioning	LB	102,919	\$ 4.50	\$ 463,136
Structure Excavation	CY	9,249	\$ 12.00	\$ 110,988
Structure Backfill	CY	3,959	\$ 18.00	\$ 71,262
Support of Excavation	SF	16,634	\$ 25.00	\$ 415,850
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 26,221,145
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
48" Dia Drilled Shaft (Common)	LF	4,680	\$ 700.00	\$ 3,276,000
48" Dia Drilled Shaft (Rock)	LF	1,560	\$ 900.00	\$ 1,404,000
Drilled Shaft Reinforcement (Black)	LB	580,846	\$ 1.05	\$ 609,888
Crosshole Sonic Logging (Testing)	EA	90	\$ 5,500.00	\$ 495,000
Pile Cap Concrete	CY	2,655	\$ 375.00	\$ 995,625
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	3,714	\$ 500.00	\$ 1,857,000
Pier Cap Concrete	CY	2,005	\$ 900.00	\$ 1,804,500
Substructure Reinforcement (Black)	LB	2,140,100	\$ 1.05	\$ 2,247,105
Substructure Post-Tensioning	LB	120,300	\$ 4.50	\$ 541,350
Structure Excavation	CY	4,707	\$ 12.00	\$ 56,484
Structure Backfill	CY	3,031	\$ 18.00	\$ 54,558
Support of Excavation	SF	15,831	\$ 25.00	\$ 395,775
				\$ 14,121,485
MAIN SPAN SUPERSTRUCTURE				
Disc Bearings	EA	4	\$ 12,000.00	\$ 48,000
Structural Steel (Floorbeams & Edge Girders)	LB	16,352,000	\$ 2.00	\$ 32,704,000
Paint Structural Steel	TN	8,176	\$ 200.00	\$ 1,635,200
CIP Deck Concrete	CY	5,738	\$ 750.00	\$ 4,303,704
Superstructure Reinforcement (Black)	LB	1,291,111	\$ 1.05	\$ 1,355,667
Stay Cable Testing	LS	1	\$ 350,000.00	\$ 350,000
Stay Cable System	LB	929,600	\$ 14.00	\$ 13,014,400
Sidewalk Concrete (incl rebar)	SF	10,080	\$ 8.00	\$ 80,640
Deck Overlay	SF	142,236	\$ 9.00	\$ 1,280,124
Deck Grinding & Grooving	SY	15,804	\$ 7.00	\$ 110,628
Modular Expansion Joints	LF	332	\$ 1,500.00	\$ 498,000
Bridge Concrete Railing (incl rebar)	LF	4,480	\$ 105.00	\$ 470,400
Safety Fence	LF	4,480	\$ 350.00	\$ 1,568,000
Bridge Drainage	LS	1	\$ 204,512.00	\$ 204,512
Bridge Striping	LF	12,320	\$ 1.14	\$ 14,000
Aviation Lighting	LS	1	\$ 50,000.00	\$ 50,000
Lighting Protection	LS	1	\$ 75,000.00	\$ 75,000
				\$ 57,762,274

APPROACH SPAN SUPERSTRUCTURE				
Elastometric Bearings Bearings	EA	166	\$ 1,850.00	\$ 307,100
Structural Steel (Plate Girders)	LB	13,700,000	\$ 1.75	\$ 23,975,000
Paint Structural Steel	TN	6,850	\$ 200.00	\$ 1,370,000
CIP Deck Concrete	CY	6,409	\$ 750.00	\$ 4,806,636
Superstructure Reinforcement (Black)	LB	1,441,991	\$ 1.05	\$ 1,514,090
Sidewalk Concrete (incl rebar)	SF	13,950	\$ 8.00	\$ 111,600
Deck Grinding & Grooving	SY	19,978	\$ 7.00	\$ 139,846
Strip Seal Expansion Joints	LF	460	\$ 250.00	\$ 115,000
Bridge Concrete Railing (incl rebar)	LF	9,300	\$ 105.00	\$ 976,500
Safety Fence	LF	9,300	\$ 350.00	\$ 3,255,000
Bridge Drainage	LS	1	\$ 228,411.33	\$ 228,411
Bridge Striping	LF	17,050	\$ 1.14	\$ 19,375
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
				\$ 36,838,558
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 134,943,462.15
INDIRECT COST		18%		\$ 24,289,823
PROFIT/MARGIN		15%		\$ 23,884,993
BOND		0.6355%		\$ 1,163,717
DESIGN CONTINGENCY		25%		\$ 33,735,866
TOTAL PRICE			\$ 553.95 / SF	\$ 218,017,860
Main Span Sub-Total				
			\$ 729.81 / SF	\$ 135,685,605
Approach Span Sub-Total				
			\$ 396.5 / SF	\$ 82,332,255
Complete Bridge Length	FT	2,670		
Bridge Approach Span Length	FT	1,550		
Bridge Main Span Length	FT	1,120		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	166.00		
Complete Bridge Area	SF	393,567		
Main Span Bridge Area	SF	185,920		
Approach Span Bridge Area	SF	207,647		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Column Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Abutment Conc Rebar Density	LB/CY	175		
Tower Pylon / Main Pier Rebar Density	LB/CY	350		
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-Deck	LB/CY	225		
Anchor Box Steel Density	LB/CF	490		
Stay Cable Density	LB/SF	5		
ACS Assumed				

Western Hills Viaduct Bridge Type Selection Greensheet		ALTERNATE 5: PUSHED LAUNCHED LONG SPAN DOUBLE DECKER TRUSS		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	5,600	\$ 1,000.00	\$ 5,600,000
60" Dia Drilled Shaft (Rock)	LF	1,520	\$ 1,500.00	\$ 2,280,000
Drilled Shaft Reinforcement (Black)	LB	1,035,562	\$ 1.05	\$ 1,087,340
Bi-Axial Load Test (Osterberg)	EA	1	\$ 175,000.00	\$ 175,000
Demonstration Shaft	EA	1	\$ 140,000.00	\$ 140,000
Crosshole Sonic Logging (Testing)	EA	56	\$ 5,500.00	\$ 308,000
Pile Cap Concrete	CY	1,748	\$ 375.00	\$ 655,500
Column Concrete	CY	1,659	\$ 500.00	\$ 829,500
Pier Cap Concrete	CY	2,815	\$ 900.00	\$ 2,533,500
Substructure Reinforcement (Black)	LB	1,608,850	\$ 1.05	\$ 1,689,293
Structure Excavation	CY	5,419	\$ 12.00	\$ 65,028
Structure Backfill	CY	2,604	\$ 18.00	\$ 46,872
Support of Excavation	SF	17,500	\$ 25.00	\$ 437,500
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 16,193,133
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
48" Dia Drilled Shaft (Common)	LF	8,364	\$ 700.00	\$ 5,854,800
48" Dia Drilled Shaft (Rock)	LF	2,614	\$ 900.00	\$ 2,352,600
Drilled Shaft Reinforcement (Black)	LB	1,021,879	\$ 1.05	\$ 1,072,973
Crosshole Sonic Logging (Testing)	EA	130	\$ 5,500.00	\$ 715,000
Pile Cap Concrete	CY	3,482	\$ 375.00	\$ 1,305,750
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	2,876	\$ 500.00	\$ 1,438,000
Pier Cap Concrete	CY	3,054	\$ 900.00	\$ 2,748,600
Substructure Reinforcement (Black)	LB	2,410,700	\$ 1.05	\$ 2,531,235
Substructure Post-Tensioning	LB	183,240	\$ 4.50	\$ 824,580
Structure Excavation	CY	7,434	\$ 12.00	\$ 89,208
Structure Backfill	CY	3,992	\$ 18.00	\$ 71,856
Support of Excavation	SF	26,485	\$ 25.00	\$ 662,125
				\$ 20,050,927
MAIN SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	12	\$ 30,000.00	\$ 360,000
Structural Steel (Truss)	LB	18,600,000	\$ 2.25	\$ 41,850,000
Launching Equipment	LS	1	\$ 2,000,000.00	\$ 2,000,000
Paint Structural Steel	TN	9,300	\$ 180.00	\$ 1,674,000
CIP Deck Concrete	CY	4,953	\$ 775.00	\$ 3,838,575
Superstructure Reinforcement (Black)	LB	1,114,425	\$ 1.05	\$ 1,170,146
Sidewalk Concrete (incl rebar)	SF	11,826	\$ 8.00	\$ 94,608
Deck Grinding & Grooving	SY	7,397	\$ 7.00	\$ 51,779
Modular Expansion Joints	LF	287	\$ 1,500.00	\$ 430,500
Bridge Concrete Railing (incl rebar)	LF	5,256	\$ 105.00	\$ 551,880
Safety Fence	LF	3,942	\$ 350.00	\$ 1,379,700
Bridge Drainage	LS	1	\$ 207,655.80	\$ 207,656
Bridge Striping	LF	14,454	\$ 1.14	\$ 16,425
				\$ 53,625,269

APPROACH SPAN SUPERSTRUCTURE				
Elastomeric Bearings	EA	214	\$ 1,850.00	\$ 395,900
Structural Steel (Plate Girder)	LB	9,543,521	\$ 1.75	\$ 16,701,161
Paint Structural Steel	TN	4,772	\$ 200.00	\$ 954,352
CIP Deck Concrete	CY	6,322	\$ 750.00	\$ 4,741,500
Superstructure Reinforcement (Black)	LB	1,422,450	\$ 1.05	\$ 1,493,573
Sidewalk Concrete (incl rebar)	SF	13,464	\$ 8.00	\$ 107,712
Deck Grinding & Grooving	SY	22,622	\$ 7.00	\$ 158,354
Strip Seal Expansion Joints	LF	448	\$ 135.00	\$ 60,480
Bridge Concrete Railing (incl rebar)	LF	7,100	\$ 105.00	\$ 745,500
Safety Fence	LF	4,488	\$ 350.00	\$ 1,570,800
Bridge Drainage	LS	1	\$ 265,097.80	\$ 265,098
Bridge Striping	LF	16,456	\$ 1.14	\$ 18,700
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
Partial Demolition of Existing Bridge	SF	49,891	\$ 20.00	\$ 997,820
				\$ 28,230,950
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 118,100,278.03
INDIRECT COST		18%		\$ 21,258,050
PROFIT/MARGIN		15%		\$ 20,903,749
BOND		0.6355%		\$ 1,018,466
DESIGN CONTIGENCY		25%		\$ 29,525,070
TOTAL PRICE			\$ 443.97 / SF	\$ 190,805,612
Main Span Sub-Total				\$ 597.53 / SF \$ 112,800,267
Approach Span Sub-Total				\$ 323.68 / SF \$ 78,005,345
Complete Bridge Length	FT	2,810		
Bridge Approach Span Length	FT	1,496		
Bridge Main Span Length	FT	1,314		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	Variable		
Complete Bridge Area	SF	429,776		
Main Span Bridge Area	SF	188,778		
Approach Span Bridge Area	SF	240,998		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Column Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Abutment Conc Rebar Density	LB/CY	175		
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-Deck	LB/CY	225		
Approach Structural Steel Weight - Plate Girders	LB/SF	39.6		
Main Bridge Structural Steel Weight - Steel Truss (considers SF area of both levels)	LB/SF	99		

ACS Assumed

Western Hills Viaduct Bridge Type Selection Greensheet		ALTERNATE 6: DUAL PYLON CABLE-STAYED		
Item Description	Unit	Quantity	Unit Cost	Base Bid
MAIN SPAN FOUNDATIONS / SUBSTRUCTURE				
60" Dia Drilled Shaft (Common)	LF	1,600	\$ 1,000.00	\$ 1,600,000
60" Dia Drilled Shaft (Rock)	LF	400	\$ 1,500.00	\$ 600,000
84" Dia Drilled Shaft (Common)	LF	3,600	\$ 1,600.00	\$ 5,760,000
84" Dia Drilled Shaft (Rock)	LF	720	\$ 2,000.00	\$ 1,440,000
Drilled Shaft Reinforcement (Black)	LB	1,522,393	\$ 1.05	\$ 1,598,512
Bi-Axial Load Test (Osterberg)	EA	1	\$ 175,000.00	\$ 175,000
Demonstration Shaft	EA	1	\$ 140,000.00	\$ 140,000
Crosshole Sonic Logging (Testing)	EA	52	\$ 6,000.00	\$ 312,000
Pile Cap Concrete	CY	4,444	\$ 325.00	\$ 1,444,300
Column Concrete	CY	452	\$ 500.00	\$ 226,000
Pier Cap Concrete	CY	759	\$ 900.00	\$ 683,100
Substructure Reinforcement (Black)	LB	1,229,500	\$ 1.05	\$ 1,290,975
Substructure Post-Tensioning	LB	45,540	\$ 4.50	\$ 204,930
Pylon Concrete	CY	7,901	\$ 1,100.00	\$ 8,691,100
Pylon Reinforcing Steel	LB	3,555,450	\$ 1.05	\$ 3,733,223
Post-Tensioning Crossbeam Pylon	LB	268,531	\$ 4.50	\$ 1,208,390
Structure Excavation	CY	6,252	\$ 12.00	\$ 75,024
Structure Backfill	CY	1,808	\$ 18.00	\$ 32,544
Support of Excavation	SF	15,376	\$ 25.00	\$ 384,400
Temporary Construction Access (Trestle)	SF	3,840	\$ 90.00	\$ 345,600
				\$ 29,945,098
APPROACH SPAN FOUNDATIONS / SUBSTRUCTURE				
48" Dia Drilled Shaft (Common)	LF	6,040	\$ 700.00	\$ 4,228,000
48" Dia Drilled Shaft (Rock)	LF	2,080	\$ 900.00	\$ 1,872,000
Drilled Shaft Reinforcement (Black)	LB	755,844	\$ 1.05	\$ 793,636
Crosshole Sonic Logging (Testing)	EA	104	\$ 5,500.00	\$ 572,000
Pile Cap Concrete	CY	1,601	\$ 375.00	\$ 600,375
Abutment Concrete	CY	452	\$ 850.00	\$ 384,200
Column Concrete	CY	3,703	\$ 500.00	\$ 1,851,500
Pier Cap Concrete	CY	2,293	\$ 900.00	\$ 2,063,700
Substructure Reinforcement (Black)	LB	2,012,950	\$ 1.05	\$ 2,113,598
Substructure Post-Tensioning	LB	137,580	\$ 4.50	\$ 619,110
Structure Excavation	CY	4,307	\$ 12.00	\$ 51,684
Structure Backfill	CY	2,706	\$ 18.00	\$ 48,708
Support of Excavation	SF	22,230	\$ 25.00	\$ 555,750
				\$ 15,754,261
MAIN SPAN SUPERSTRUCTURE				
Structural Pot Bearings	EA	4	\$ 35,000.00	\$ 140,000
Structural Steel (Truss)	LB	20,445,000	\$ 2.25	\$ 46,001,250
Paint Structural Steel	TN	10,223	\$ 200.00	\$ 2,044,500
CIP Deck Concrete	CY	5,620	\$ 775.00	\$ 4,355,500
Superstructure Reinforcement (Black)	LB	1,264,500	\$ 1.05	\$ 1,327,725
Sidewalk Concrete (incl rebar)	SF	12,690	\$ 8.00	\$ 101,520
Deck Overlay	SF	169,920	\$ 9.00	\$ 1,529,280
Deck Grinding & Grooving	SY	18,880	\$ 7.00	\$ 132,160
Counter Weight (Concrete)	CY	800	\$ 300.00	\$ 240,000
Cable Stay Strand System	LB	2,142,210	\$ 12.00	\$ 25,706,520
Stay Cable Testing	LS	1	\$ 350,000.00	\$ 350,000
Steel Anchor Boxes	LB	902,430	\$ 4.00	\$ 3,609,719
Modular Expansion Joints	LF	293	\$ 1,750.00	\$ 512,750
Bridge Concrete Railing (incl rebar)	LF	5,640	\$ 105.00	\$ 592,200
Safety Fence	LF	4,230	\$ 350.00	\$ 1,480,500
Bridge Drainage	LS	1	\$ 235,643.10	\$ 235,643
Bridge Striping	LF	15,510	\$ 1.14	\$ 17,625
Aviation Lighting	LS	1	\$ 50,000.00	\$ 50,000
Lighting Protection	LS	1	\$ 75,000.00	\$ 75,000
Tower Crane Timespan	LS	1	\$ 1,500,000.00	\$ 1,500,000
Permanent Access Stairs & Landing	VF	1,092	\$ 275.00	\$ 300,300
				\$ 90,302,192

APPROACH SPAN SUPERSTRUCTURE				
Elastomeric Bearings	EA	193	\$ 1,850.00	\$ 357,050
Structural Steel (Plate Girder)	LB	8,410,000	\$ 1.75	\$ 14,717,500
Paint Structural Steel	TN	4,205	\$ 200.00	\$ 841,000
CIP Deck Concrete	CY	4,952	\$ 750.00	\$ 3,714,000
Superstructure Reinforcement (Black)	LB	1,114,200	\$ 1.05	\$ 1,169,910
Sidewalk Concrete (incl rebar)	SF	12,780	\$ 8.00	\$ 102,240
Deck Grinding & Grooving	SY	17,185	\$ 7.00	\$ 120,295
Strip Seal Expansion Joints	LF	439	\$ 135.00	\$ 59,265
Bridge Concrete Railing (incl rebar)	LF	6,260	\$ 105.00	\$ 657,300
Safety Fence	LF	4,260	\$ 350.00	\$ 1,491,000
Bridge Drainage	LS	1	\$ 207,620.60	\$ 207,621
Bridge Striping	LF	15,620	\$ 1.14	\$ 17,750
Impact Attenuator	EA	2	\$ 10,000.00	\$ 20,000
Partial Demolition of Existing Bridge	SF	41,286	\$ 20.00	\$ 825,720
				\$ 24,300,651
Assumed Project Duration Excluding Demolition)	MO	-		
TOTAL DIRECT COST				\$ 160,302,201.31
INDIRECT COST			18%	\$ 28,854,396
PROFIT/MARGIN			15%	\$ 28,373,490
BOND			0.6355%	\$ 1,382,404
DESIGN CONTIGENCY			25%	\$ 40,075,550
TOTAL PRICE				\$ 642.7 / SF \$ 258,988,041
Main Span Sub-Total				
			\$ 906.89 / SF	\$ 194,274,376
Approach Span Sub-Total				
			\$ 342.86 / SF	\$ 64,713,665
Complete Bridge Length	FT	2,830		
Bridge Approach Span Length	FT	1,420		
Bridge Main Span Length	FT	1,410		
Bridge Approach Span Width	FT	Variable		
Bridge Main Span Width	FT	Variable		
Complete Bridge Area	SF	402,967		
Main Span Bridge Area	SF	214,221		
Approach Span Bridge Area	SF	188,746		
Drilled Shaft Rebar Density	LB/CY	200		
Pile Cap Conc Rebar Density	LB/CY	200		
Column Conc Rebar Density	LB/CY	250		
Pier Cap Conc Rebar Density	LB/CY	300		
Abutment Conc Rebar Density	LB/CY	175		
Tower Pylon / Main Pier Rebar Density	LB/CY	450		
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60		
Superstructure Concrete Rebar Density-Deck	LB/CY	225		
Approach Structural Steel Weight - Plate Girders (CHECK)	LB/SF	45		
Main Bridge Structural Steel Weight - Truss (considers area of both levels) (CHECK)	LB/SF	95		<- TY Lin provided 14.5 k/ft
Stay Cable Density	LB/SF	10		
ACS Assumed				

Western Hills Viaduct
Bridge Type Selection Greensheet

Alternate 1A: SHORT SPAN PUSH LAUNCHED (TRAPEZOIDAL STEEL BOX)

Item Description	Unit	Quantity	Unit Cost	Direct Cost	Indirect Charge	Profit/Margin	Bond	Design Contingency	Total Price	RR Premium %	RR Premium Bid Cost	Comments
					18%	15%	0.6355%	25%				
TRESTLE TO PIER D												
Temporary Construction Access (Trestle)	SF	21,536	\$ 90.00	\$ 1,938,240	\$ 348,883	\$ 343,068	\$ 16,715	\$ 484,560	\$ 3,131,467	100%	\$ 3,131,467	Base bid only considers trestle over Mill Creek.
											\$ 3,131,467	
TRESTLE TO PIER E												
Temporary Construction Access (Trestle)	SF	11,648	\$ 90.00	\$ 1,048,320	\$ 188,698	\$ 185,553	\$ 9,040	\$ 262,080	\$ 1,693,691	100%	\$ 1,693,691	Base bid only considers trestle over Mill Creek.
											\$ 1,693,691	
SUPERSTRUCTURE												
Structural Pot Bearings	EA	30	\$ 3,500.00	\$ 105,000	\$ 18,900	\$ 18,585	\$ 905	\$ 26,250	\$ 169,640	5%	\$ 8,482	RR Prem: slow production
Trapezoidal Structural Steel - Launched	LB	10,056,000	\$ 2.10	\$ 21,117,600	\$ 3,801,168	\$ 3,737,815	\$ 182,113	\$ 5,279,400	\$ 34,118,096	13%	\$ 4,435,352	RR Prem: Accounts for different means/methods, slower production, larger cranes
Paint Structural Steel	TN	5,028	\$ 200.00	\$ 1,005,600	\$ 181,008	\$ 177,991	\$ 8,672	\$ 251,400	\$ 1,624,671	15%	\$ 243,701	RR Prem: slow production, difficult access, more ground protection costs
CIP Deck Concrete	CY	3,937	\$ 750.00	\$ 2,952,750	\$ 531,495	\$ 522,637	\$ 25,464	\$ 738,188	\$ 4,770,533	15%	\$ 715,580	RR Prem: Upsizing of crane, slow production, access constraints
Superstructure Reinforcement (Black)	LB	885,825	\$ 1.05	\$ 930,116	\$ 167,421	\$ 164,631	\$ 8,021	\$ 232,529	\$ 1,502,718	5%	\$ 75,136	RR Prem: Upsizing of crane, slow production, access constraints
Post-Tensioning Tendons - Transverse	LB	149,693	\$ 4.25	\$ 636,195	\$ 114,515	\$ 112,607	\$ 5,486	\$ 159,049	\$ 1,027,852	10%	\$ 102,785	RR Prem: Upsizing of crane, slow production, access constraints
Sidewalk Concrete (incl rebar)	SF	9,270	\$ 8.00	\$ 74,160	\$ 13,349	\$ 13,126	\$ 640	\$ 18,540	\$ 119,815	0%	\$ -	
Deck Grinding & Grooving	SY	14,000	\$ 7.00	\$ 98,000	\$ 17,640	\$ 17,346	\$ 845	\$ 24,500	\$ 158,331	0%	\$ -	
Strip Seal Expansion Joints	LF	291	\$ 135.00	\$ 39,285	\$ 7,071	\$ 6,953	\$ 339	\$ 9,821	\$ 63,470	0%	\$ -	
Bridge Concrete Railing (incl rebar)	LF	6,180	\$ 105.00	\$ 648,900	\$ 116,802	\$ 114,855	\$ 5,596	\$ 162,225	\$ 1,048,378	0%	\$ -	
Safety Fence	LF	3,090	\$ 350.00	\$ 1,081,500	\$ 194,670	\$ 191,426	\$ 9,327	\$ 270,375	\$ 1,747,297	0%	\$ -	
Bridge Drainage	LS	1	\$ 164,662.30	\$ 164,662	\$ 29,639	\$ 29,145	\$ 1,420	\$ 41,166	\$ 266,032	15%	\$ 39,905	RR Prem: slow production
Bridge Striping	LF	11,330	\$ 1.14	\$ 12,875	\$ 2,318	\$ 2,279	\$ 111	\$ 3,219	\$ 20,801	0%	\$ -	
											\$ 5,620,941	
SUBSTRUCTURE AT PIER D												
60" Dia Drilled Shaft (Common)	LF	1,600	\$ 1,000.00	\$ 1,600,000	\$ 288,000	\$ 283,200	\$ 13,798	\$ 400,000	\$ 2,584,998	20%	\$ 517,000	RR Prem: Upsizing of crane, slow production, access constraints
60" Dia Drilled Shaft (Rock)	LF	320	\$ 1,500.00	\$ 480,000	\$ 86,400	\$ 84,960	\$ 4,139	\$ 120,000	\$ 775,499	20%	\$ 155,100	RR Prem: Upsizing of crane, slow production, access constraints
Drilled Shaft Reinforcement (Black)	LB	402,124	\$ 1.05	\$ 422,230	\$ 76,001	\$ 74,735	\$ 3,641	\$ 105,558	\$ 682,165	15%	\$ 102,325	RR Prem: Upsizing of crane, slow production, access constraints
Crosshole Sonic Logging (Testing)	EA	16	\$ 5,500.00	\$ 88,000	\$ 15,840	\$ 15,576	\$ 759	\$ 22,000	\$ 142,175	5%	\$ 7,109	RR Prem: slow production
Pile Cap Concrete	CY	964	\$ 375.00	\$ 361,500	\$ 65,070	\$ 63,986	\$ 3,117	\$ 90,375	\$ 584,048	20%	\$ 116,810	RR Prem: Upsizing of crane, slow production, access constraints
Column Concrete	CY	696	\$ 500.00	\$ 348,000	\$ 62,640	\$ 61,596	\$ 3,001	\$ 87,000	\$ 562,237	15%	\$ 84,336	RR Prem: Upsizing of crane, slow production, access constraints
Pier Cap Concrete	CY	176	\$ 900.00	\$ 158,400	\$ 28,512	\$ 28,037	\$ 1,366	\$ 39,600	\$ 255,915	15%	\$ 38,387	RR Prem: Upsizing of crane, slow production, access constraints
Crashwall Concrete	CY	334	\$ 500.00	\$ 166,750	\$ 30,015	\$ 29,515	\$ 1,438	\$ 41,688	\$ 269,405	15%	\$ 40,411	RR Prem: Upsizing of crane, slow production, access constraints
Substructure Reinforcement (Black)	LB	502,975	\$ 1.05	\$ 528,124	\$ 95,062	\$ 93,478	\$ 4,554	\$ 132,031	\$ 853,249	15%	\$ 127,987	RR Prem: Upsizing of crane, slow production, access constraints
Structure Excavation	CY	1,279	\$ 12.00	\$ 15,348	\$ 2,763	\$ 2,717	\$ 132	\$ 3,837	\$ 24,797	25%	\$ 6,199	RR Prem: slow production
Structure Backfill	CY	316	\$ 18.00	\$ 5,688	\$ 1,024	\$ 1,007	\$ 49	\$ 1,422	\$ 9,190	25%	\$ 2,297	RR Prem: slow production
Support of Excavation	SF	4,536	\$ 25.00	\$ 113,400	\$ 20,412	\$ 20,072	\$ 978	\$ 28,350	\$ 183,212	25%	\$ 45,803	RR Prem: slow production, more expensive design
											\$ 1,243,763	
SUBSTRUCTURE AT PIER E												
60" Dia Drilled Shaft (Common)	LF	1,600	\$ 1,000.00	\$ 1,600,000	\$ 288,000	\$ 283,200	\$ 13,798	\$ 400,000	\$ 2,584,998	20%	\$ 517,000	RR Prem: Upsizing of crane, slow production, access constraints
60" Dia Drilled Shaft (Rock)	LF	320	\$ 1,500.00	\$ 480,000	\$ 86,400	\$ 84,960	\$ 4,139	\$ 120,000	\$ 775,499	20%	\$ 155,100	RR Prem: Upsizing of crane, slow production, access constraints
Drilled Shaft Reinforcement (Black)	LB	402,124	\$ 1.05	\$ 422,230	\$ 76,001	\$ 74,735	\$ 3,641	\$ 105,558	\$ 682,165	15%	\$ 102,325	RR Prem: Upsizing of crane, slow production, access constraints
Crosshole Sonic Logging (Testing)	EA	16	\$ 5,500.00	\$ 88,000	\$ 15,840	\$ 15,576	\$ 759	\$ 22,000	\$ 142,175	5%	\$ 7,109	RR Prem: slow production
Pile Cap Concrete	CY	964	\$ 375.00	\$ 361,500	\$ 65,070	\$ 63,986	\$ 3,117	\$ 90,375	\$ 584,048	20%	\$ 116,810	RR Prem: Upsizing of crane, slow production, access constraints
Column Concrete	CY	696	\$ 500.00	\$ 348,000	\$ 62,640	\$ 61,596	\$ 3,001	\$ 87,000	\$ 562,237	15%	\$ 84,336	RR Prem: Upsizing of crane, slow production, access constraints
Pier Cap Concrete	CY	176	\$ 900.00	\$ 158,400	\$ 28,512	\$ 28,037	\$ 1,366	\$ 39,600	\$ 255,915	15%	\$ 38,387	RR Prem: Upsizing of crane, slow production, access constraints
Crashwall Concrete	CY	334	\$ 500.00	\$ 166,750	\$ 30,015	\$ 29,515	\$ 1,438	\$ 41,688	\$ 269,405	15%	\$ 40,411	RR Prem: Upsizing of crane, slow production, access constraints
Substructure Reinforcement (Black)	LB	524,475	\$ 1.05	\$ 550,699	\$ 99,126	\$ 97,474	\$ 4,749	\$ 137,675	\$ 889,722	15%	\$ 133,458	RR Prem: Upsizing of crane, slow production, access constraints
Structure Excavation	CY	1,279	\$ 12.00	\$ 15,348	\$ 2,763	\$ 2,717	\$ 132	\$ 3,837	\$ 24,797	25%	\$ 6,199	RR Prem: slow production
Structure Backfill	CY	316	\$ 18.00	\$ 5,688	\$ 1,024	\$ 1,007	\$ 49	\$ 1,422	\$ 9,190	25%	\$ 2,297	RR Prem: slow production
Support of Excavation	SF	4,536	\$ 25.00	\$ 113,400	\$ 20,412	\$ 20,072	\$ 978	\$ 28,350	\$ 183,212	25%	\$ 45,803	RR Prem: slow production, more expensive design
											\$ 1,259,655	
TEMPORARY RELOCATION OF TRACK												
Relocate Rail Yard Track	LF	620	\$ 500.00	\$ 310,000	\$ 55,800	\$ 54,870	\$ 2,673	\$ 77,500	\$ 500,843	100%	\$ 500,843	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 500,843	
PERMANENT RELOCATION OF TRACK												
Relocate Rail Yard Track #1	LF	1,890	\$ 500.00	\$ 945,000	\$ 170,100	\$ 167,265	\$ 8,149	\$ 236,250	\$ 1,526,764	100%	\$ 1,526,764	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
Relocate Rail Yard Track #2	LF	1,920	\$ 500.00	\$ 960,000	\$ 172,800	\$ 169,920	\$ 8,279	\$ 240,000	\$ 1,550,999	100%	\$ 1,550,999	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 3,077,763	
INTERFERENCE WITH INTERMODAL YARD												
Inference Cost Approximation	LS	1	\$ 1,500,000.00	\$ 1,500,000	\$ -	\$ -	\$ -	\$ -	\$ 1,500,000	100%	\$ 1,500,000	Cost approximated by TYLIN
											\$ 1,500,000	

TOTAL RR PREMIUM COST: \$ 18,028,122.55

Complete Bridge Length	FT	2,665
Bridge Approach Span Length	FT	1,635
Bridge Main Span Length	FT	1,030
Bridge Approach Span Width	FT	Variable
Bridge Main Span Width	FT	145.33
Complete Bridge Area	SF	366,661
Main Span Bridge Area	SF	149,693
Approach Span Bridge Area	SF	216,968
Drilled Shaft Rebar Density	LB/CY	200
Pile Cap Conc Rebar Density	LB/CY	200
Column Conc Rebar Density	LB/CY	250
Crashwall Conc Rebar Density	LB/CY	250
Pier Cap Conc Rebar Density	LB/CY	300
Abutment Conc Rebar Density	LB/CY	175
Substructure Post-Tensioning Weight - Pier Caps	LB/CY	60
Superstructure Concrete Rebar Density-Deck	LB/CY	225
Transverse Post-Tensioning Weight	LB/SF	1
Structural Steel Weight - Steel Box (Ratio Check)	LB/SF	

Western Hills Viaduct
Bridge Type Selection Greensheet

Alternate 2: CIP SEGMENTAL

Item Description	Unit	Quantity	Unit Cost	Direct Cost	Indirect Charge	Profit/Margin	Bond	Design Contingency	Total Price	RR Premium %	RR Premium Bid Cost	Comments
TRESTLE TO PIER D												
Temporary Construction Access (Trestle)	SF	22,176	\$ 90.00	\$ 1,995,840	\$ 359,251	\$ 353,264	\$ 17,212	\$ 498,960	\$ 3,224,526	100%	\$ 3,224,526	Base bid only considers trestle over Mill Creek.
											\$ 3,224,526	
SUPERSTRUCTURE												
Disc Bearings	EA	12	\$ 22,500.00	\$ 270,000	\$ 48,600	\$ 47,790	\$ 2,328	\$ 67,500	\$ 436,218	5%	\$ 21,811	RR Prem: slow production
C.I.P Balanced Cantilever Box Girder Concrete	CY	21,579	\$ 1,550.00	\$ 33,447,450	\$ 6,020,541	\$ 5,920,199	\$ 288,442	\$ 8,361,863	\$ 54,038,494	20%	\$ 10,807,699	RR Prem: Upsizing of crane, slow production, access constraints
C.I.P Box Girder Concrete on Falsework	CY	1,482	\$ 1,100.00	\$ 1,630,200	\$ 293,436	\$ 288,545	\$ 14,058	\$ 407,550	\$ 2,633,790	20%	\$ 526,758	RR Prem: Upsizing of crane, slow production, access constraints
C.I.P Clousure Concrete - Transverse	CY	389	\$ 2,800.00	\$ 1,089,200	\$ 196,056	\$ 192,788	\$ 9,393	\$ 272,300	\$ 1,759,737	20%	\$ 351,947	RR Prem: Upsizing of crane, slow production, access constraints
C.I.P Clousure Concrete - Longitudinal	CY	291	\$ 900.00	\$ 261,900	\$ 47,142	\$ 46,356	\$ 2,259	\$ 65,475	\$ 423,132	15%	\$ 63,470	RR Prem: Upsizing of crane, slow production, access constraints
Superstructure Reinforcement (Black)	LB	4,154,675	\$ 1.05	\$ 4,362,409	\$ 785,234	\$ 772,146	\$ 37,620	\$ 1,090,602	\$ 7,048,011	15%	\$ 1,057,202	RR Prem: Upsizing of crane, slow production, access constraints
Post-Tensioning Tendons - Logitudinal	LB	1,231,055	\$ 3.00	\$ 3,693,165	\$ 664,770	\$ 653,690	\$ 31,849	\$ 923,291	\$ 5,966,765	15%	\$ 895,015	RR Prem: Upsizing of crane, slow production, access constraints
Post-Tensioning Tendons - Transverse	LB	175,865	\$ 4.25	\$ 747,426	\$ 134,537	\$ 132,294	\$ 6,446	\$ 186,857	\$ 1,207,560	10%	\$ 120,756	RR Prem: Upsizing of crane, slow production, access constraints
Sidewalk Concrete (incl rebar)	SF	10,080	\$ 8.00	\$ 80,640	\$ 14,515	\$ 14,273	\$ 695	\$ 20,160	\$ 130,284	0%	\$ -	
Deck Grinding & Grooving	SY	16,589	\$ 7.00	\$ 116,123	\$ 20,902	\$ 20,554	\$ 1,001	\$ 29,031	\$ 187,611	0%	\$ -	
Modular Expansion Joints	LF	291	\$ 1,500.00	\$ 435,990	\$ 78,478	\$ 77,170	\$ 3,760	\$ 108,998	\$ 704,396	0%	\$ -	
Bridge Concrete Railing (incl rebar)	LF	10,474	\$ 105.00	\$ 1,099,770	\$ 197,959	\$ 194,659	\$ 9,484	\$ 274,943	\$ 1,776,815	0%	\$ -	
Safety Fence	LF	5,226	\$ 350.00	\$ 1,829,100	\$ 329,238	\$ 323,751	\$ 15,774	\$ 457,275	\$ 2,955,137	0%	\$ -	
Bridge Drainage	LS	1	\$ 193,451.50	\$ 193,452	\$ 34,821	\$ 34,241	\$ 1,668	\$ 48,363	\$ 312,545	15%	\$ 46,882	RR Prem: slow production
Bridge Striping	LF	12,320	\$ 1.14	\$ 14,000	\$ 2,520	\$ 2,478	\$ 121	\$ 3,500	\$ 22,619	0%	\$ -	
											\$ 13,891,539	
SUBSTRUCTURE AT PIER D												
108" Dia Drilled Shaft (Common)	LF	1,400	\$ 2,200.00	\$ 3,080,000	\$ 554,400	\$ 545,160	\$ 26,561	\$ 770,000	\$ 4,976,121	15%	\$ 746,418	RR Prem: Upsizing of crane, slow production, access constraints
108" Dia Drilled Shaft (Rock)	LF	250	\$ 2,750.00	\$ 687,500	\$ 123,750	\$ 121,688	\$ 5,929	\$ 171,875	\$ 1,110,741	15%	\$ 166,611	RR Prem: Upsizing of crane, slow production, access constraints
Drilled Shaft Reinforcement (Black)	LB	777,544	\$ 1.05	\$ 816,421	\$ 146,956	\$ 144,507	\$ 7,041	\$ 204,105	\$ 1,319,030	10%	\$ 131,903	RR Prem: Upsizing of crane, slow production, access constraints
Crosshole Sonic Logging (Testing)	EA	14	\$ 5,250.00	\$ 73,500	\$ 13,230	\$ 13,010	\$ 634	\$ 18,375	\$ 118,748	5%	\$ 5,937	RR Prem: slow production
Pile Cap Concrete	CY	2,271	\$ 375.00	\$ 851,625	\$ 153,293	\$ 150,738	\$ 7,344	\$ 212,906	\$ 1,375,906	15%	\$ 206,386	RR Prem: Upsizing of crane, slow production, access constraints
Column Concrete	CY	786	\$ 500.00	\$ 393,000	\$ 70,740	\$ 69,561	\$ 3,389	\$ 98,250	\$ 634,940	10%	\$ 63,494	RR Prem: Upsizing of crane, slow production, access constraints
Substructure Reinforcement (Black)	LB	650,700	\$ 1.05	\$ 683,235	\$ 122,982	\$ 120,933	\$ 5,892	\$ 170,809	\$ 1,103,851	10%	\$ 110,385	RR Prem: Upsizing of crane, slow production, access constraints
Structure Excavation	CY	3,750	\$ 12.00	\$ 45,000	\$ 8,100	\$ 7,965	\$ 388	\$ 11,250	\$ 72,703	25%	\$ 18,176	RR Prem: slow production
Structure Backfill	CY	1,480	\$ 18.00	\$ 26,640	\$ 4,795	\$ 4,715	\$ 230	\$ 6,660	\$ 43,040	25%	\$ 10,760	RR Prem: slow production
Support of Excavation	SF	8,190	\$ 25.00	\$ 204,750	\$ 36,855	\$ 36,241	\$ 1,766	\$ 51,188	\$ 330,799	25%	\$ 82,700	RR Prem: slow production, more expensive design
											\$ 1,542,770	
PERMANENT RELOCATION OF TRACK												
Relocate Rail Yard Track #1	LF	1,890	\$ 500.00	\$ 945,000	\$ 170,100	\$ 167,265	\$ 8,149	\$ 236,250	\$ 1,526,764	100%	\$ 1,526,764	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 1,526,764	
INTERFERENCE WITH INTERMODAL YARD												
Inference Cost Approximation	LS	1	\$ 1,000,000.00	\$ 1,000,000	\$ -	\$ -	\$ -	\$ -	\$ 1,000,000	100%	\$ 1,000,000	Cost approximated by TYLIN
											\$ 1,000,000	

TOTAL RR PREMIUM COST: \$ 21,185,600.20

Complete Bridge Length	FT	2,670
Bridge Approach Span Length	FT	1,550
Bridge Main Span Length	FT	1,120
Bridge Approach Span Width	FT	Variable
Bridge Main Span Width	FT	145.33
Complete Bridge Area	SF	372,054
Main Span Bridge Area	SF	175,865
Approach Span Bridge Area	SF	196,189
Drilled Shaft Rebar Density	LB/CY	200
Pile Cap Conc Rebar Density	LB/CY	200
Abutment Conc Rebar Density	LB/CY	175
Column Conc Rebar Density	LB/CY	250
Pier Cap Conc Rebar Density	LB/CY	300
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60
Superstructure Concrete Rebar Density-C.I.P Balanced Cantilever (Main Span)	LB/CY	175
Superstructure Concrete Rebar Density-C.I.P Box Girder (Approaches)	LB/CY	200
Longitudinal Post-Tensioning Weight-Balanced Cantilever (Main Span)	LB/SF	7
Longitudinal Post-Tensioning Weight-CIP Box Girder (Approaches)	LB/SF	5.5
Transverse Post-Tensioning Weight	LB/SF	1

Western Hills Viaduct
Bridge Type Selection Greensheet

ALTERNATE 3: PARALLEL TWIN ARCHES

Item Description	Unit	Quantity	Unit Cost	Direct Cost	Indirect Charge	Profit/Margin	Bond	Design Contingency	Total Price	RR Premium %	RR Premium Bid Cost	Comments
					18%	15%	0.6355%	25%				
BRIDGE ON MILL CREEK												
Temporary Construction Access (Trestle)	SF	33,929	\$ 90.00	\$ 3,053,610	\$ 549,650	\$ 540,489	\$ 26,334	\$ 763,403	\$ 4,933,485	100%	\$ 4,933,485	
											\$ 4,933,485	
LAUNCHING RUNWAY												
Grading/Fill Between Tracks	SF	194,423	\$ 1.00	\$ 194,423	\$ 34,996	\$ 34,413	\$ 1,677	\$ 48,606	\$ 314,114	100%	\$ 314,114	
Install Temporary RR Crossing Asphalt	TN	32,404	\$ 95.00	\$ 3,078,364	\$ 554,106	\$ 544,870	\$ 26,547	\$ 769,591	\$ 4,973,478	100%	\$ 4,973,478	
Remove Temp Asphalt	SF	194,423	\$ 2.00	\$ 388,846	\$ 69,992	\$ 68,826	\$ 3,353	\$ 97,212	\$ 628,229	100%	\$ 628,229	
											\$ 5,915,821	
SUPERSTRUCTURE												
Structural Pot Bearings	EA	8	\$ 35,000.00	\$ 280,000	\$ 50,400	\$ 49,560	\$ 2,415	\$ 70,000	\$ 452,375	5%	\$ 22,619	RR Prem: slow production
Structural Steel (Arch)	LB	10,400,000	\$ 2.95	\$ 30,680,000	\$ 5,522,400	\$ 5,430,360	\$ 264,576	\$ 7,670,000	\$ 49,567,336	10%	\$ 4,956,734	RR Prem: Accounts for different means/methods, slower production, larger cranes
Paint Structural Steel	TN	5,200	\$ 200.00	\$ 1,040,000	\$ 187,200	\$ 184,080	\$ 8,969	\$ 260,000	\$ 1,680,249	15%	\$ 252,037	RR Prem: slow production, difficult access, more ground protection costs
Cable Hanger System	LB	131,670	\$ 34.00	\$ 4,476,780	\$ 805,820	\$ 792,390	\$ 38,607	\$ 1,119,195	\$ 7,232,792	0%	\$ -	
CIP Deck Concrete	CY	3,290	\$ 775.00	\$ 2,549,750	\$ 458,955	\$ 451,306	\$ 21,988	\$ 637,438	\$ 4,119,437	15%	\$ 617,915	RR Prem: Upsizing of crane, slow production, access constraints
Superstructure Reinforcement (Black)	LB	740,250	\$ 1.05	\$ 777,263	\$ 139,907	\$ 137,575	\$ 6,703	\$ 194,316	\$ 1,255,764	5%	\$ 62,788	RR Prem: Upsizing of crane, slow production, access constraints
Sidewalk Concrete (incl rebar)	SF	6,840	\$ 8.00	\$ 54,720	\$ 9,850	\$ 9,685	\$ 472	\$ 13,680	\$ 88,407	0%	\$ -	
Deck Grinding & Grooving	SY	11,822	\$ 7.00	\$ 82,754	\$ 14,896	\$ 14,647	\$ 714	\$ 20,689	\$ 133,699	0%	\$ -	
Modular Expansion Joints	LF	330	\$ 1,100.00	\$ 363,000	\$ 65,340	\$ 64,251	\$ 3,130	\$ 90,750	\$ 586,471	0%	\$ -	
Bridge Concrete Railing (incl rebar)	LF	3,040	\$ 105.00	\$ 319,200	\$ 57,456	\$ 56,498	\$ 2,753	\$ 79,800	\$ 515,707	0%	\$ -	
Safety Fence	LF	1,520	\$ 350.00	\$ 532,000	\$ 95,760	\$ 94,164	\$ 4,588	\$ 133,000	\$ 859,512	0%	\$ -	
Bridge Drainage	LS	1	\$ 137,940.00	\$ 137,940	\$ 24,829	\$ 24,415	\$ 1,190	\$ 34,485	\$ 222,859	15%	\$ 33,429	RR Prem: slow production
Bridge Striping	LF	8,360	\$ 1.14	\$ 9,500	\$ 1,710	\$ 1,682	\$ 82	\$ 2,375	\$ 15,348	0%	\$ -	
Aviation Lighting	LS	1	\$ 35,000.00	\$ 35,000	\$ 6,300	\$ 6,195	\$ 302	\$ 8,750	\$ 56,547	0%	\$ -	
											\$ 5,945,522	
PERMANENT RELOCATION OF TRACK												
Relocate Rail Yard Track #1	LF	1,890	\$ 500.00	\$ 945,000	\$ 170,100	\$ 167,265	\$ 8,149	\$ 236,250	\$ 1,526,764	100%	\$ 1,526,764	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 1,526,764	
INTERFERENCE WITH INTERMODAL YARD												
Inference Cost Approximation	LS	1	\$ 2,000,000.00	\$ 2,000,000	\$ -	\$ -	\$ -	\$ -	\$ 2,000,000	100%	\$ 2,000,000	Cost approximated by TYLIN
											\$ 2,000,000	

TOTAL RR PREMIUM COST: \$ 20,321,592.88

Complete Bridge Length	FT	2,670
Bridge Approach Span Length	FT	1,910
Bridge Main Span Length	FT	760
Bridge Approach Span Width	FT	Variable
Bridge Main Span Width	FT	165.00
Complete Bridge Area	SF	395,731
Main Span Bridge Area	SF	125,400
Approach Span Bridge Area	SF	270,331
Drilled Shaft Rebar Density	LB/CY	200
Pile Cap Conc Rebar Density	LB/CY	200
Column Conc Rebar Density	LB/CY	250
Crashwall Conc Rebar Density	LB/CY	250
Pier Cap Conc Rebar Density	LB/CY	300
Abutment Conc Rebar Density	LB/CY	175
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60
Superstructure Concrete Rebar Density-Deck	LB/CY	225
Approach Structural Steel Weight - Plate Girders (CHECK)	LB/SF	49
Main Bridge Structural Steel Weight - Steel Arch (CHECK)	LB/SF	83
Main Bridge Cable Hanging System Weight	LB/SF	1.05

Western Hills Viaduct Bridge Type Selection Greensheet		ALTERNATE 4: EXTRADOSED (COMPOSITE GIRDER)										
Item Description	Unit	Quantity	Unit Cost	Direct Cost	Indirect Charge	Profit/Margin	Bond	Design Contingency	Total Price	RR Premium %	RR Premium Bid Cost	Comments
					18%	15%	0.6355%	25%				
TRESTLE TO PIER D												
Temporary Construction Access (Trestle)	SF	22,560	\$ 90.00	\$ 2,030,400	\$ 365,472	\$ 359,381	\$ 17,510	\$ 507,600	\$ 3,280,362	100%	\$ 3,280,362	Base bid only considers trestle over Mill Creek.
											\$ 3,280,362	
SUPERSTRUCTURE												
Disc Bearings	EA	8	\$ 12,000.00	\$ 96,000	\$ 17,280	\$ 16,992	\$ 828	\$ 24,000	\$ 155,100	5%	\$ 7,755	RR Prem: slow production
C.I.P Balanced Cantilever Box Girder	CY	17,875	\$ 1,650.00	\$ 29,493,750	\$ 5,308,875	\$ 5,220,394	\$ 254,346	\$ 7,373,438	\$ 47,650,803	20%	\$ 9,530,161	RR Prem: Upsizing of crane, slow production, access constraints
C.I.P Box Girder on Falsework	CY	1,055	\$ 1,100.00	\$ 1,160,500	\$ 208,890	\$ 205,409	\$ 10,008	\$ 290,125	\$ 1,874,931	20%	\$ 374,986	RR Prem: Upsizing of crane, slow production, access constraints
C.I.P Clousure Concrete - Transverse	CY	187	\$ 2,800.00	\$ 523,600	\$ 94,248	\$ 92,677	\$ 4,515	\$ 130,900	\$ 845,941	20%	\$ 169,188	RR Prem: Upsizing of crane, slow production, access constraints
Superstructure Reinforcement (Black)	LB	3,345,475	\$ 1.05	\$ 3,512,749	\$ 632,295	\$ 621,757	\$ 30,293	\$ 878,187	\$ 5,675,280	15%	\$ 851,292	RR Prem: Upsizing of crane, slow production, access constraints
PT Logitudinal	LB	1,277,920	\$ 3.00	\$ 3,833,760	\$ 690,077	\$ 678,576	\$ 33,061	\$ 958,440	\$ 6,193,914	15%	\$ 929,087	RR Prem: Upsizing of crane, slow production, access constraints
PT Transverse Deck	LB	182,560	\$ 4.25	\$ 775,880	\$ 139,658	\$ 137,331	\$ 6,691	\$ 193,970	\$ 1,253,530	10%	\$ 125,353	RR Prem: Upsizing of crane, slow production, access constraints
PT Transverse Strut	LB	121,024	\$ 4.00	\$ 484,096	\$ 87,137	\$ 85,685	\$ 4,175	\$ 121,024	\$ 782,117	10%	\$ 78,212	Assume 1 EA 31 strand tendon per strut
Stay Cable Testing	LS	1	\$ 350,000.00	\$ 350,000	\$ 63,000	\$ 61,950	\$ 3,018	\$ 87,500	\$ 565,468	0%	\$ -	
Stay Cable System	LB	912,800	\$ 14.00	\$ 12,779,200	\$ 2,300,256	\$ 2,261,918	\$ 110,204	\$ 3,194,800	\$ 20,646,379	10%	\$ 2,064,638	RR Prem: Upsizing of crane, slow production, access constraints
Tower Steel Anchor Boxes	EA	32	\$ 20,000.00	\$ 640,000	\$ 115,200	\$ 113,280	\$ 5,519	\$ 160,000	\$ 1,033,999	15%	\$ 155,100	RR Prem: Upsizing of crane, slow production, access constraints
Sidewalk Concrete (incl rebar)	SF	10,080	\$ 8.00	\$ 80,640	\$ 14,273	\$ 14,273	\$ 695	\$ 20,160	\$ 130,284	0%	\$ -	
Deck Grinding & Grooving	SY	15,804	\$ 7.00	\$ 110,628	\$ 19,913	\$ 19,581	\$ 954	\$ 27,657	\$ 178,733	0%	\$ -	
Modular Expansion Joints	LF	326	\$ 1,500.00	\$ 489,000	\$ 88,020	\$ 86,553	\$ 4,217	\$ 122,250	\$ 790,040	0%	\$ -	
Bridge Concrete Railing (incl rebar)	LF	6,720	\$ 105.00	\$ 705,600	\$ 127,008	\$ 124,891	\$ 6,085	\$ 176,400	\$ 1,139,984	0%	\$ -	
Safety Fence	LF	3,360	\$ 350.00	\$ 1,176,000	\$ 211,680	\$ 208,152	\$ 10,142	\$ 294,000	\$ 1,899,974	0%	\$ -	
Bridge Drainage	LS	1	\$ 200,816.00	\$ 200,816	\$ 36,147	\$ 35,544	\$ 1,732	\$ 50,204	\$ 324,443	15%	\$ 48,666	RR Prem: slow production
Bridge Striping	LF	12,320	\$ 1.14	\$ 14,000	\$ 2,478	\$ 2,478	\$ 121	\$ 3,500	\$ 22,619	0%	\$ -	
Aviation Lighting	LS	1	\$ 50,000.00	\$ 50,000	\$ 9,000	\$ 8,850	\$ 431	\$ 12,500	\$ 80,781	0%	\$ -	
Lighting Protection	LS	1	\$ 75,000.00	\$ 75,000	\$ 13,500	\$ 13,275	\$ 647	\$ 18,750	\$ 121,172	0%	\$ -	
											\$ 14,334,438	
SUBSTRUCTURE AT PIER D												
72" Dia Drilled Shaft (Common)	LF	2,400	\$ 1,300.00	\$ 3,120,000	\$ 561,600	\$ 552,240	\$ 26,906	\$ 780,000	\$ 5,040,746	15%	\$ 756,112	RR Prem: Upsizing of crane, slow production, access constraints
72" Dia Drilled Shaft (Rock)	LF	480	\$ 1,750.00	\$ 840,000	\$ 151,200	\$ 148,680	\$ 7,244	\$ 210,000	\$ 1,357,124	15%	\$ 203,569	RR Prem: Upsizing of crane, slow production, access constraints
Drilled Shaft Reinforcement (Black)	LB	603,186	\$ 1.05	\$ 633,345	\$ 114,002	\$ 112,102	\$ 5,462	\$ 158,336	\$ 1,023,247	10%	\$ 102,325	RR Prem: Upsizing of crane, slow production, access constraints
Crosshole Sonic Logging (Testing)	EA	24	\$ 5,500.00	\$ 132,000	\$ 23,760	\$ 23,364	\$ 1,138	\$ 33,000	\$ 213,262	5%	\$ 10,663	RR Prem: slow production
Pile Cap Concrete	CY	2,181	\$ 325.00	\$ 708,825	\$ 127,589	\$ 125,462	\$ 6,113	\$ 177,206	\$ 1,145,194	15%	\$ 171,779	RR Prem: Upsizing of crane, slow production, access constraints
Substructure Reinforcement (Black)	LB	436,200	\$ 1.05	\$ 458,010	\$ 82,442	\$ 81,068	\$ 3,950	\$ 114,503	\$ 739,972	10%	\$ 73,997	RR Prem: Upsizing of crane, slow production, access constraints
Pylon Concrete	CY	826	\$ 650.00	\$ 536,900	\$ 96,642	\$ 95,031	\$ 4,630	\$ 134,225	\$ 867,428	15%	\$ 130,114	RR Prem: Upsizing of crane, slow production, access constraints
Pylon Reinforcing Steel	LB	289,100	\$ 1.05	\$ 303,555	\$ 54,640	\$ 53,729	\$ 2,618	\$ 75,889	\$ 490,431	15%	\$ 73,565	RR Prem: Upsizing of crane, slow production, access constraints
Pylon Post-Tensioning	LB	51,460	\$ 4.50	\$ 231,568	\$ 41,682	\$ 40,988	\$ 1,997	\$ 57,892	\$ 374,127	15%	\$ 56,119	
Structure Excavation	CY	3,640	\$ 12.00	\$ 43,680	\$ 7,862	\$ 7,731	\$ 377	\$ 10,920	\$ 70,570	25%	\$ 17,643	RR Prem: slow production
Structure Backfill	CY	1,460	\$ 18.00	\$ 26,280	\$ 4,730	\$ 4,652	\$ 227	\$ 6,570	\$ 42,459	25%	\$ 10,615	RR Prem: slow production
Support of Excavation	SF	5,184	\$ 25.00	\$ 129,600	\$ 23,328	\$ 22,939	\$ 1,118	\$ 32,400	\$ 209,385	25%	\$ 52,346	RR Prem: slow production, more expensive design
											\$ 1,658,846	
PERMANENT RELOCATION OF TRACK												
Relocate Rail Yard Track #1	LF	1,890	\$ 500.00	\$ 945,000	\$ 170,100	\$ 167,265	\$ 8,149	\$ 236,250	\$ 1,526,764	100%	\$ 1,526,764	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 1,526,764	
INTERFERENCE WITH INTERMODAL YARD												
Inference Cost Approximation	LS	1	\$ 1,000,000.00	\$ 1,000,000	\$ -	\$ -	\$ -	\$ -	\$ 1,000,000	100%	\$ 1,000,000	Cost approximated by TYLIN
											\$ 1,000,000	

TOTAL RR PREMIUM COST: \$ 21,800,410.87

Complete Bridge Length	FT	2,683
Bridge Approach Span Length	FT	1,563
Bridge Main Span Length	FT	1,120
Bridge Approach Span Width	FT	Variable
Bridge Main Span Width	FT	163.00
Complete Bridge Area	SF	376,965
Main Span Bridge Area	SF	182,560
Approach Span Bridge Area	SF	194,405
Drilled Shaft Rebar Density	LB/CY	200
Pile Cap Conc Rebar Density	LB/CY	200
Column Conc Rebar Density	LB/CY	250
Crashwall Conc Rebar Density	LB/CY	250
Pier Cap Conc Rebar Density	LB/CY	300
Abutment Conc Rebar Density	LB/CY	175
Tower Pylon / Main Pier Rebar Density	LB/CY	350
Substructure Post-Tensioning Weight - Pier Caps	LB/CY	60
Superstructure Concrete Rebar Density-C.I.P. Balanced Cantilever (Main Span)	LB/CY	175
Superstructure Concrete Rebar Density-C.I.P. Box Girder (Approaches)	LB/CY	200
Longitudinal Post-Tensioning Weight-Balanced Cantilever (Main Span)	LB/SF	7
Longitudinal Post-Tensioning Weight-CIP Box Girder (Approaches)	LB/SF	5.5
Box Girder Post-Tensioning Weight - Transverse Deck	LB/SF	1
Stay Cable Density	LB/SF	5

Western Hills Viaduct Bridge Type Selection Greensheet		ALTERNATE 5: PUSHED LAUNCHED LONG SPAN DOUBLE DECKER TRUSS										
Item Description	Unit	Quantity	Unit Cost	Direct Cost	Indirect Charge	Profit/Margin	Bond	Design Contingency	Total Price	RR Premium %	RR Premium Bid Cost	Comments
					18%	15%	0.6355%	25%				
TRESTLE TO PIER G												
Temporary Construction Access (Trestle)	SF	17,888	\$ 90.00	\$ 1,609,920	\$ 289,786	\$ 284,956	\$ 13,884	\$ 402,480	\$ 2,601,025	100%	\$ 2,601,025	Base bid only considers trestle over Mill Creek.
											\$ 2,601,025	
SUPERSTRUCTURE												
Structural Pot Bearings	EA	12	\$ 30,000.00	\$ 360,000	\$ 64,800	\$ 63,720	\$ 3,105	\$ 90,000	\$ 581,625	5%	\$ 29,081	RR Prem: slow production
Structural Steel (Truss)	LB	18,600,000	\$ 2.25	\$ 41,850,000	\$ 7,533,000	\$ 7,407,450	\$ 360,903	\$ 10,462,500	\$ 67,613,853	13%	\$ 8,789,801	RR Prem: Accounts for different means/methods, slower production, larger cranes
Paint Structural Steel	TN	9,300	\$ 180.00	\$ 1,674,000	\$ 301,320	\$ 296,298	\$ 14,436	\$ 418,500	\$ 2,704,554	15%	\$ 405,683	RR Prem: slow production, difficult access, more ground protection costs
CIP Deck Concrete	CY	4,953	\$ 775.00	\$ 3,838,575	\$ 690,944	\$ 679,428	\$ 33,103	\$ 959,644	\$ 6,201,693	15%	\$ 930,254	RR Prem: Upsizing of crane, slow production, access constraints
Superstructure Reinforcement (Black)	LB	1,114,425	\$ 1.05	\$ 1,170,146	\$ 210,626	\$ 207,116	\$ 10,091	\$ 292,537	\$ 1,890,516	5%	\$ 94,526	RR Prem: Upsizing of crane, slow production, access constraints
Sidewalk Concrete (incl rebar)	SF	11,826	\$ 8.00	\$ 94,608	\$ 17,029	\$ 16,746	\$ 816	\$ 23,652	\$ 152,851	0%	\$ -	
Deck Grinding & Grooving	SY	7,397	\$ 7.00	\$ 51,779	\$ 9,320	\$ 9,165	\$ 447	\$ 12,945	\$ 83,655	0%	\$ -	
Modular Expansion Joints	LF	287	\$ 1,500.00	\$ 430,500	\$ 77,490	\$ 76,199	\$ 3,713	\$ 107,625	\$ 695,526	0%	\$ -	
Bridge Concrete Railing (incl rebar)	LF	5,256	\$ 105.00	\$ 551,880	\$ 99,338	\$ 97,683	\$ 4,759	\$ 137,970	\$ 891,630	0%	\$ -	
Safety Fence	LF	3,942	\$ 350.00	\$ 1,379,700	\$ 248,346	\$ 244,207	\$ 11,898	\$ 344,925	\$ 2,229,076	0%	\$ -	
Bridge Drainage	LS	1	\$ 207,655.80	\$ 207,656	\$ 37,378	\$ 36,755	\$ 1,791	\$ 51,914	\$ 335,494	15%	\$ 50,324	RR Prem: slow production
Bridge Striping	LF	14,454	\$ 1.14	\$ 16,425	\$ 2,957	\$ 2,907	\$ 142	\$ 4,106	\$ 26,537	0%	\$ -	
											\$ 10,299,669	
SUBSTRUCTURE AT PIER G												
60" Dia Drilled Shaft (Common)	LF	1,200	\$ 1,000.00	\$ 1,200,000	\$ 216,000	\$ 212,400	\$ 10,348	\$ 300,000	\$ 1,938,748	15%	\$ 290,812	RR Prem: Upsizing of crane, slow production, access constraints
60" Dia Drilled Shaft (Rock)	LF	360	\$ 1,500.00	\$ 540,000	\$ 97,200	\$ 95,580	\$ 4,657	\$ 135,000	\$ 872,437	15%	\$ 130,866	RR Prem: Upsizing of crane, slow production, access constraints
Drilled Shaft Reinforcement (Black)	LB	226,893	\$ 1.05	\$ 238,237	\$ 42,883	\$ 42,168	\$ 2,054	\$ 59,559	\$ 384,902	10%	\$ 38,490	RR Prem: Upsizing of crane, slow production, access constraints
Crosshole Sonic Logging (Testing)	EA	12	\$ 5,500.00	\$ 66,000	\$ 11,880	\$ 11,682	\$ 569	\$ 16,500	\$ 106,631	5%	\$ 5,332	RR Prem: slow production
Pile Cap Concrete	CY	667	\$ 375.00	\$ 250,125	\$ 45,023	\$ 44,272	\$ 2,157	\$ 62,531	\$ 404,108	15%	\$ 60,616	RR Prem: Upsizing of crane, slow production, access constraints
Column Concrete	CY	254	\$ 500.00	\$ 127,000	\$ 22,860	\$ 22,479	\$ 1,095	\$ 31,750	\$ 205,184	10%	\$ 20,518	RR Prem: Upsizing of crane, slow production, access constraints
Substructure Reinforcement (Black)	LB	196,900	\$ 1.05	\$ 206,745	\$ 37,214	\$ 36,594	\$ 1,783	\$ 51,686	\$ 334,022	10%	\$ 33,402	RR Prem: Upsizing of crane, slow production, access constraints
Structure Excavation	CY	1,215	\$ 12.00	\$ 14,580	\$ 2,624	\$ 2,581	\$ 126	\$ 3,645	\$ 23,556	25%	\$ 5,889	RR Prem: slow production
Structure Backfill	CY	548	\$ 18.00	\$ 9,864	\$ 1,776	\$ 1,746	\$ 85	\$ 2,466	\$ 15,937	25%	\$ 3,984	RR Prem: slow production
Support of Excavation	SF	3,542	\$ 25.00	\$ 88,550	\$ 15,939	\$ 15,673	\$ 764	\$ 22,138	\$ 143,063	25%	\$ 35,766	RR Prem: slow production, more expensive design
											\$ 625,675	
PERMANENT RELOCATION OF TRACK												
Relocate Rail Yard Track #1	LF	1,890	\$ 500.00	\$ 945,000	\$ 170,100	\$ 167,265	\$ 8,149	\$ 236,250	\$ 1,526,764	100%	\$ 1,526,764	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 1,526,764	
INTERFERENCE WITH INTERMODAL YARD												
Inference Cost Approximation	LS	1	\$ 1,500,000.00	\$ 1,500,000	\$ -	\$ -	\$ -	\$ -	\$ 1,500,000	100%	\$ 1,500,000	Cost approximated by TYLIN
											\$ 1,500,000	
TOTAL RR PREMIUM COST:											\$ 16,553,133.78	
Complete Bridge Length	FT	2,810										
Bridge Approach Span Length	FT	1,496										
Bridge Main Span Length	FT	1,314										
Bridge Approach Span Width	FT	Variable										
Bridge Main Span Width	FT	Variable										
Complete Bridge Area	SF	429,776										
Main Span Bridge Area	SF	188,778										
Approach Span Bridge Area	SF	240,998										
Drilled Shaft Rebar Density	LB/CY	200										
Pile Cap Conc Rebar Density	LB/CY	200										
Column Conc Rebar Density	LB/CY	250										
Crashwall Conc Rebar Density	LB/CY	250										
Pier Cap Conc Rebar Density	LB/CY	300										
Abutment Conc Rebar Density	LB/CY	175										
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60										
Superstructure Concrete Rebar Density-Deck	LB/CY	225										
Approach Structural Steel Weight - Plate Girders	LB/SF	39.6										
Main Bridge Structural Steel Weight - Steel Truss (considers SF area of both levels)	LB/SF	6										

Western Hills Viaduct
Bridge Type Selection Greensheet

ALTERNATE 6: DUAL PYLON CABLE-STAYED

Item Description	Unit	Quantity	Unit Cost	Direct Cost	Indirect Charge	Profit/Margin	Bond	Design Contingency	Total Price	RR Premium %	RR Premium Bid Cost	Comments
SUPERSTRUCTURE												
Structural Pot Bearings	EA	4	\$ 35,000.00	\$ 140,000	\$ 25,200	\$ 24,780	\$ 1,207	\$ 35,000	\$ 226,187	5%	\$ 11,309	RR Prem: slow production
Structural Steel (Truss)	LB	20,445,000	\$ 2.25	\$ 46,001,250	\$ 8,280,225	\$ 8,142,221	\$ 396,703	\$ 11,500,313	\$ 74,320,711	15%	\$ 11,148,107	RR Prem: slow production, difficult access, more ground protection costs
Paint Structural Steel	TN	10,223	\$ 200.00	\$ 2,044,500	\$ 368,010	\$ 361,877	\$ 17,631	\$ 511,125	\$ 3,303,143	15%	\$ 495,471	RR Prem: slow production, difficult access, more ground protection costs
CIP Deck Concrete	CY	5,620	\$ 775.00	\$ 4,355,500	\$ 783,990	\$ 770,924	\$ 37,561	\$ 1,088,875	\$ 7,036,849	15%	\$ 1,055,527	RR Prem: Upsizing of crane, slow production, access constraints
Superstructure Reinforcement (Black)	LB	1,264,500	\$ 1.05	\$ 1,327,725	\$ 238,991	\$ 235,007	\$ 11,450	\$ 331,931	\$ 2,145,104	5%	\$ 107,255	RR Prem: Upsizing of crane, slow production, access constraints
Sidewalk Concrete (incl rebar)	SF	12,690	\$ 8.00	\$ 101,520	\$ 18,274	\$ 17,969	\$ 875	\$ 25,380	\$ 164,018	0%	\$ -	
Deck Grinding & Grooving	SY	18,880	\$ 7.00	\$ 132,160	\$ 23,789	\$ 23,392	\$ 1,140	\$ 33,040	\$ 213,521	0%	\$ -	
Counter Weight (Concrete)	CY	800	\$ 300.00	\$ 240,000	\$ 43,200	\$ 42,480	\$ 2,070	\$ 60,000	\$ 387,750	10%	\$ 38,775	RR Prem: slow production
Cable Stay Strand System	LB	2,142,210	\$ 12.00	\$ 25,706,520	\$ 4,627,174	\$ 4,550,054	\$ 221,686	\$ 6,426,630	\$ 41,532,064	10%	\$ 4,153,206	RR Prem: Upsizing of crane, slow production, access constraints
Stay Cable Testing	LS	1	\$ 350,000.00	\$ 350,000	\$ 63,000	\$ 61,950	\$ 3,018	\$ 87,500	\$ 565,468	0%	\$ -	
Steel Anchor Boxes	LB	902,430	\$ 4.00	\$ 3,609,719	\$ 649,749	\$ 638,920	\$ 31,129	\$ 902,430	\$ 5,831,948	15%	\$ 874,792	RR Prem: Upsizing of crane, slow production, access constraints
Modular Expansion Joints	LF	293	\$ 1,750.00	\$ 512,750	\$ 92,295	\$ 90,757	\$ 4,422	\$ 128,188	\$ 828,411	0%	\$ -	
Bridge Concrete Railing (incl rebar)	LF	5,640	\$ 105.00	\$ 592,200	\$ 106,596	\$ 104,819	\$ 5,107	\$ 148,050	\$ 956,772	0%	\$ -	
Safety Fence	LF	4,230	\$ 350.00	\$ 1,480,500	\$ 266,490	\$ 262,049	\$ 12,767	\$ 370,125	\$ 2,391,931	0%	\$ -	
Bridge Drainage	LS	1	\$ 235,643.10	\$ 235,643	\$ 42,416	\$ 41,709	\$ 2,032	\$ 58,911	\$ 380,711	15%	\$ 57,107	RR Prem: slow production
Bridge Striping	LF	15,510	\$ 1.14	\$ 17,625	\$ 3,173	\$ 3,120	\$ 152	\$ 4,406	\$ 28,475	0%	\$ -	
Aviation Lighting	LS	1	\$ 50,000.00	\$ 50,000	\$ 9,000	\$ 8,850	\$ 431	\$ 12,500	\$ 80,781	0%	\$ -	
Lighting Protection	LS	1	\$ 75,000.00	\$ 75,000	\$ 13,500	\$ 13,275	\$ 647	\$ 18,750	\$ 121,172	0%	\$ -	
Tower Crane Timespan	LS	1	\$ 1,500,000.00	\$ 1,500,000	\$ 270,000	\$ 265,500	\$ 12,936	\$ 375,000	\$ 2,423,436	5%	\$ 121,172	RR Prem: Upsizing of crane
Permanent Access Elevator	VF	546	\$ 1,000.00	\$ 546,000	\$ 98,280	\$ 96,642	\$ 4,709	\$ 136,500	\$ 882,131	15%	\$ 132,320	RR Prem: Slow production, access constraints
Permanent Access Stairs & Landing	VF	1,092	\$ 275.00	\$ 300,300	\$ 54,054	\$ 53,153	\$ 2,590	\$ 75,075	\$ 485,172	15%	\$ 72,776	RR Prem: Slow production, access constraints
											\$ 18,267,817	
PERMANENT RELOCATION OF TRACK												
Relocate Rail Yard Track #1	LF	1,890	\$ 500.00	\$ 945,000	\$ 170,100	\$ 167,265	\$ 8,149	\$ 236,250	\$ 1,526,764	100%	\$ 1,526,764	Unit cost based on \$1 million per 2,000 LF of track provided by Wayne Bolen
											\$ 1,526,764	
INTERFERENCE WITH INTERMODAL YARD												
Inference Cost Approximation	LS	1	\$ 2,000,000.00	\$ 2,000,000	\$ -	\$ -	\$ -	\$ -	\$ 2,000,000	100%	\$ 2,000,000	Cost approximated by TYLIN
											\$ 2,000,000	

TOTAL RR PREMIUM COST: \$ 21,794,581.70

Complete Bridge Length	FT	2,830										
Bridge Approach Span Length	FT	1,420										
Bridge Main Span Length	FT	1,410										
Bridge Approach Span Width	FT	Variable										
Bridge Main Span Width	FT	Variable										
Complete Bridge Area	SF	402,967										
Main Span Bridge Area	SF	214,221										
Approach Span Bridge Area	SF	188,746										
Drilled Shaft Rebar Density	LB/CY	200										
Pile Cap Conc Rebar Density	LB/CY	200										
Column Conc Rebar Density	LB/CY	250										
Crashwall Conc Rebar Density	LB/CY	250										
Pier Cap Conc Rebar Density	LB/CY	300										
Abutment Conc Rebar Density	LB/CY	175										
Tower Pylon / Main Pier Rebar Density	LB/CY	450										
Substructure Post-Tensioning Weight -Pier Caps	LB/CY	60										
Superstructure Concrete Rebar Density-Deck	LB/CY	225										
Approach Structural Steel Weight - Plate Girders (CHECK)	LB/SF	45										
Main Bridge Structural Steel Weight - Truss (considers SF area of both levels) (CHECK)	LB/SF	95	<-- TY Lin provided 14.5 k/ft									
Stay Cable Density	LB/SF	10										

6 IDENTIFICATION OF PREFERRED ALTERNATIVE

6.1 General Remarks

To select the best bridge for this location, many important variables must be taken into consideration: the suitability and cost of the design, the interface at the east and west ends, minimizing impacts to the railways, the Duke Energy substation and its power lines, the aesthetic priorities of the City and community, as well as their aspirations for the future.

Working with the City/County and other stake holders, several bridge types have been developed to determine which concept will be the best. They have been verified with a preliminary analysis model, and further developed into a concept design. Planning level cost estimates and schedules have been developed in order to compare the costs of the different structure types and to give the client a reasonable idea of how long it will take to complete the project.

Constructability reviews have been performed and the durability of each structure type has been assessed. Each alternative has been reviewed with a focus on the ease and efficiency with which it can be built and maintained. Potential impacts to time, cost or quality has been identified and incorporated into the selection process.

6.2 Summary of Alternatives

A total of six alternatives were presented for the Western Hills Viaduct:

1. Short Span Push-Launched
2. Cast-in-place Balanced Cantilever Segmental Bridge
3. Parallel Twin Arches
4. Extradosed Bridge
5. Long Span Push Launched
6. Cable-Stayed Bridge

6.3 Choosing an Alternative

In order to facilitate the decision-making process, the bridge alternatives are compared in a matrix, where each is ranked on important factors for the project. A ranking of the options is shown in the following pages. The alternatives were compared for the following factors:

1. Cost Estimates
2. Aesthetics
3. Durability/Maintainability
4. Input from Railroad
5. Constructability
6. Claims Potential
7. Traffic Operations
8. Bridge Drainage

Category description and criteria for ranking are described in the following sections.

6.3.1 Cost Estimates

The cost estimates for various bridge types have been drawn up by John Armeni Consultants, a specialty cost estimating firm for bridges. The cost estimates are based on concept design and carry a 25% contingency. Cost for railway impacts has been estimated based on feedback from CSX and included in the estimate.

6.3.2 Aesthetics

Despite the development of structure types for this site being largely determined by cost and minimizing interference with railyard operations, aesthetic considerations have been taken into account throughout the process.

For all but the Cable-Stayed and Long Span Push Launch options, the lower deck has been eliminated, enhancing the experience of crossing by providing open views for all directions of travel. The Arch and Cable-stay options are high-profile structures which would have a dramatic visual impact in the landscape. The haunched girder of the CIP Segmental option with the given span length and vertical profile lends it an arching form that appears to soar across the railyard. The Extradosed option combines elegance and durability, with the pylon and cable configuration providing visual interest and the girder depth being kept to a minimum. There are no extradosed bridges in the region making this a unique structure that could serve as a landmark for the area. Those options which are purely rectilinear in form, the short and long span push launch, are well suited to this industrial context and could be given a playful quality if the main steel members are painted a bright color.

Once a structure type is chosen the aesthetics of the structure will be developed in subsequent phases, including lighting, enhancing the form of the main elements of the bridge, railing and barrier design, and ensuring good circulation for pedestrian and bicycle users.

6.3.3 Durability and Maintainability

The Design Team has been charged by the City/County to design a durable structure that minimizes the maintenance costs of the bridge.

The approach to developing a durable design will be based on the latest 'probabilistic' methods being put into practice today. By these methods the probabilistic nature of the environment and its degradation processes and the material properties involved can be used to provide a more accurate representation of actual conditions than by taking the more traditional deterministic' approach to design.

One of the structure options, the balanced cantilever segmental bridge, is primarily concrete. The other five alternatives are primarily steel. Three of the options, the Arch, the Extradosed, and the Cable Stayed, use cable-support systems. For four of them, the CIP Segmental, Parallel Twin Arch, Cable Stayed and Extradosed, the deck serves as a primary load carrying member and are thus less amenable to deck replacement. The arch bridge is included since if the deck is composite with the arch tie girders then the deck is a primary load carrying member.

For the concrete structure and those with load carrying concrete decks, providing good corrosion resistance to the rebar and post-tensioning where it is used, is a primary consideration. Care will be taken in the selection of materials to provide a dense and durable deck surface while eliminating to

the greatest extent possible any material related weaknesses. Concrete covers to steel reinforcement will be selected based on the probabilistic approach discussed above. A dense concrete mix will be designed to prevent chloride penetration to the steel layer. If a more stringent protection strategy is desired, CPF liners (Controlled Permeability Formwork) can be explored. The addition of a deck overlay will provide additional cover for the rebar top mat. The use of a higher corrosion threshold rebar (i.e. stainless steel, galvanized steel or epoxy-coated bars) can further enhance the durability of the design. Other non-corrosion deterioration mechanisms, such as alkali-aggregate reactions, freeze/thaw, scaling, ice abrasion, salt weathering and sulphate attack, will be addressed using an avoidance design approach. Materials will be chosen, and compositions will be controlled so as to mitigate their potential effects.

For the steel structures, the main concern is corrosion of the primary members of the steel. Steel begins corroding when exposed to moisture and oxygen and a protective coating, such as marine or epoxy paint, should be considered against any surface corrosion. The protective coating system will be selected based on expected performance, life expectancy, surface preparation requirements, initial costs, and ease of removing and reapplying. The toxicity characteristics of the coatings will also be considered, so that those with less environmental impact and requirements for containment and disposal during repainting operations should be prioritized.

As noted previously in this report, if a bridge type that is primarily steel is advanced further in the design development process, it is recommended that a cost-benefit study be done relating to the use of metalizing or weathering steel, rather than painting, the exterior surfaces to reduce life-cycle costs from repainting. There is some credible evidence that metalizing or weathering steel, though initially costlier, is in fact more economical in the long run for structures that are intended to have a long service life.

The stay and hanger cable systems will be designed not only for tension forces, but also for fatigue resistance, and corrosion protection. The anchorage is the most vulnerable part of a modern cable in terms of durability. The length of cable extending into the anchorage zone must be protected from water, particularly at the lower deck anchorage which is vulnerable to inundation during significant rain events. These anchorages should be equipped with a redundant multi-layer sealing system, which has passed the leak-tightness tests as defined by the Post-Tensioning Institute (PTI) and International Federation for Structural Concrete (fib). In addition, the entire length of the strands should be designed with a protection system to match the performance of the anchorages to ensure the longevity of the entire system.

Maintaining a bridge where the deck cannot be replaced is different than a "standard" bridge where the deck can be removed and replaced using conventional practices. The use of a CIP concrete overlay is typical on bridge types where the deck is a permanent component of the bridge. Alternatively, in case of deck deterioration a partial replacement of deck could be planned. The upper 2" of the deck would be hydro demolished and would be replaced with UHPC. Hence a CIP concrete overlay would not be necessary.

6.3.4 Input from CSX

The City and County engineers held several meetings with the City/County with CSX Transportation. These efforts culminated in CSX providing their input for various bridge alternatives.

This input which has been described in the section on Railways provides CSX input as rankings for various alternatives.

Norfolk Southern (NS) Railway was also consulted and provided the same evaluation matrix as CSX. However, their comments were general and they did not rank the alternatives at this stage. For this reason their input is not used in an explicit manner in section 4.2.

6.3.5 Constructability

Constructability addresses the ease of construction or fabrication of a given bridge type. For example, the composite steel tub bridge with a composite deck can be fabricated with relative ease as compared to a steel truss cable-stayed bridge.

6.3.6 Claims Potential

Claims potential is the probability of claims that can originate from interruptions in construction due to railyard operations. The railroad is the most significant risk that will impact the selection process for the alternatives. There are other less significant risks such as undergrounds utilities, contaminated soil, I-75 Construction, etc.

6.3.7 Traffic Operations

Traffic operations criteria accounts for the clean flow of traffic on the bridge and clean merges into the intersections on the east and west sides as well as access to I-75.

The double-deck bridges, Long-Span Push-Launch and the Double-Deck Cable-stayed bridges, require special ramps on the west side to resolve traffic weaving challenges and thus get a lower ranking.

6.3.8 Bridge Drainage

Discharging stormwater onto the railroad property above ground level will not be allowed. Stormwater down pipes will be provided at each pier location. Flat deck options which require more scuppers and double deck options which require an increased drainage system receive a less favorable score. Options with shorter spans which require more underground pipe to convey water from the railroad property also get a less favorable score.

6.4 Cumulative Rankings

In the following section, a separate matrix is presented for each of the factors or categories described above in which each bridge type is evaluated. The evaluation is done in the form of a discussion or list of pros and cons and then each bridge is given a score. The scoring is based on a scale from 1 to 10; a lower score is less favorable; a higher score is more favorable. For the Cost category the scoring is a quantitative measure; for all the other categories and scoring is based on a qualitative measure.

The scores for all the categories are then brought together in one matrix to compare the bridge types with all factors taken into account. The scores for each bridge are combined by first applying a weight factor to each category depending on its relative importance. The weight factors are as follows:

- Cost 20%
- Aesthetics 10%
- Durability and Maintainability 15%

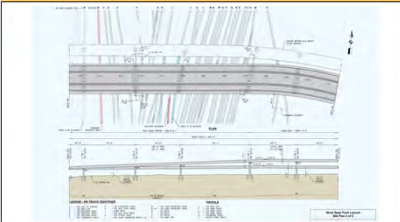
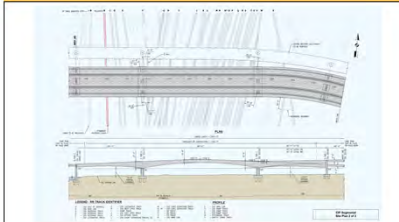
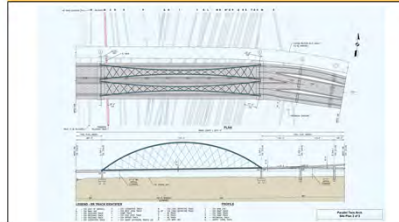
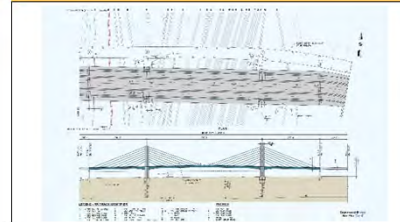
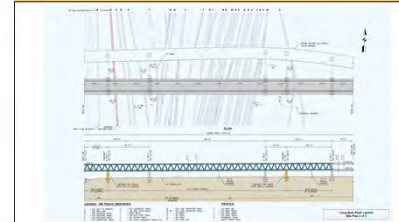
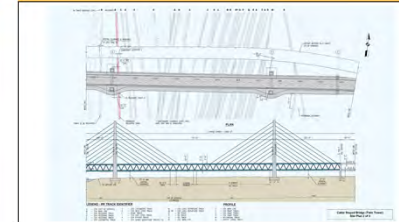
- Railroad Preference 15%
- Constructability 15%
- Claims Potential 15%
- Traffic Operations 5%
- Bridge Drainage 5%

Based on the combined scoring the bridges are then ranked. The final rankings are as follows:

1. EX: Extradosed Bridge
2. CIP: Cast-in-place Segmental
3. TA: Parallel Twin Arches
4. LSPL: Long Span Push Launch
5. SSPL: Short Span Push Launch
6. CSB: Cable Stayed Bridge

Based on the evaluation of six bridge alternatives for the site which is presented in this report, the design team recommends that the City and County conclude the review of alternatives and proceed with development of the top ranked design, the Extradosed Bridge.

6.4.1 Cost

RANK	1	4	1	5	1	6
SCORE	10	8	10	7	10	2
COST	SHORT SPAN PUSH LAUNCH* (TRAPEZOIDAL STEEL BOX) 	CIP SEGMENTAL 	TWIN ARCH** 	EXTRADOSED (COMPOSITE STEEL GIRDER) 	LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS) 	CABLE-STAYED BRIDGE (DUAL PYLON) 
COST APPROXIMATION	Cost = \$203 million	Cost = \$222 million	Cost = \$208 million	Cost = \$240 million	Cost = \$207 million	Cost = \$281 million

SUMMARY The scoring of each alternative was determined on a quantitative basis. The detailed cost estimates are found in Section 5 of the AER. Higher scores were assigned to the lower cost alternatives and lower scores to more expensive alternatives within the ranges shown in the table below. The costs include a 25% cost contingency. The costs take into account contractor inefficiencies while working in the railyard.

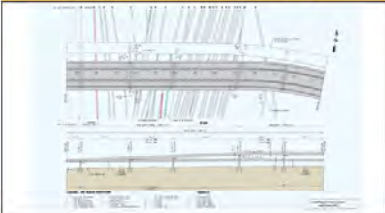
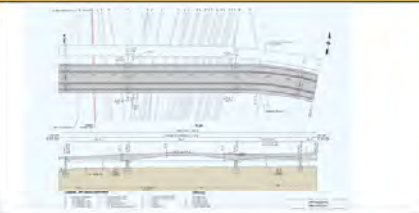
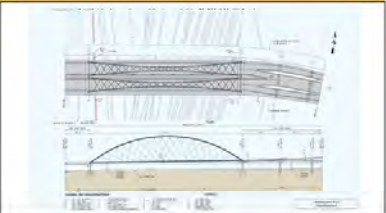
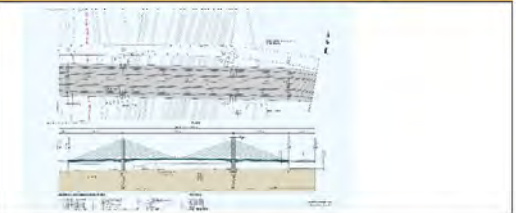
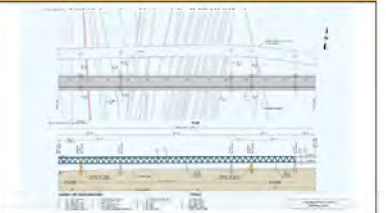
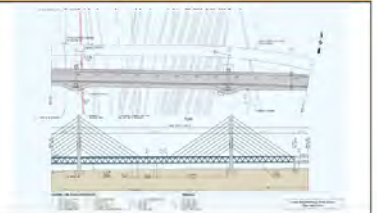
Scoring Criteria

Range	Score
\$200m to \$ 210m	10
\$211m to \$ 220m	9
\$221m to \$ 230m	8
\$231m to \$ 240m	7
\$241m to \$ 250m	6
\$251m to \$ 260m	5
\$261m to \$ 270m	4
\$271m to \$ 280m	3
\$281m to \$ 290m	2
>\$290m	1

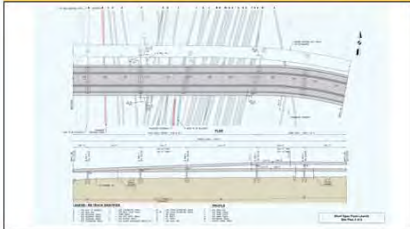
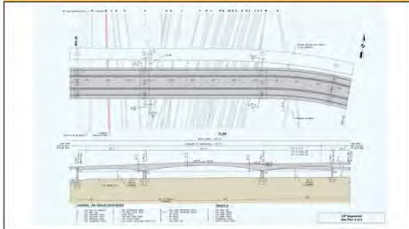
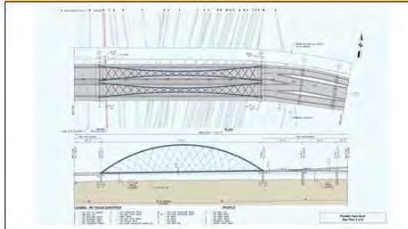
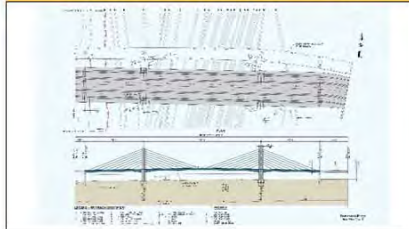
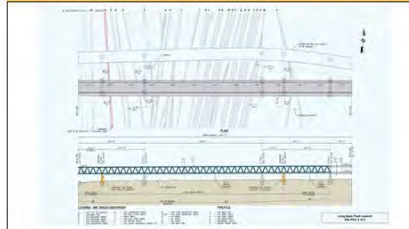
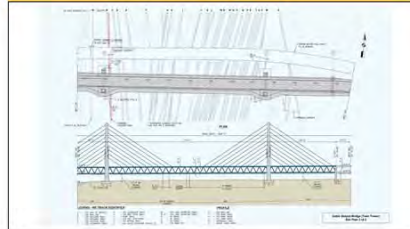
* Short Span Push Launch - This alternative could use either steel trapezoidal box girders or steel plate girders. Since the trapezoidal box girders provide greater torsional rigidity and less exposed steel surface to maintain compared to steel plate girders, only the trapezoidal box girders are presented herein.

** Twin Arch - This cost comparison is based on the orthogonal delivery method which is preferred due to a simplified delivery path, minimized interaction with the railroad yard operations during arch erection, and minimized area required for railroad yard clearing prior to delivery.

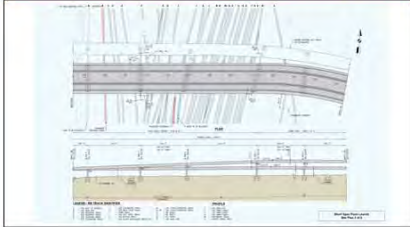
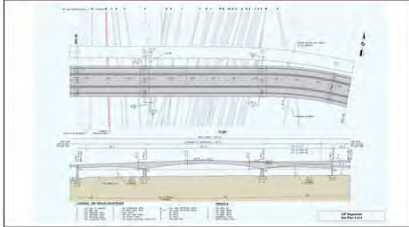
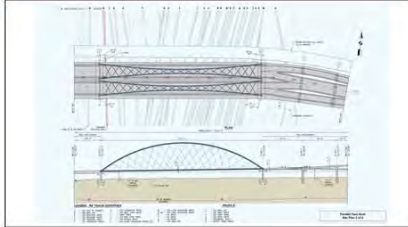
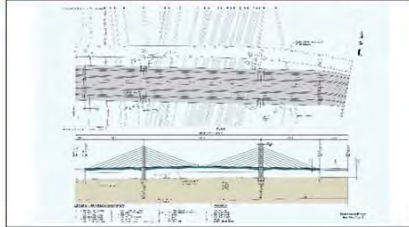
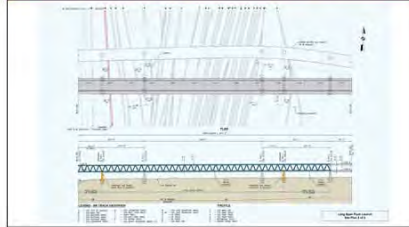
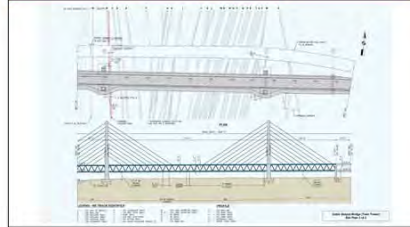
6.4.2 Aesthetics

RANK	6	4	3	1	5	3
SCORE	2	8	6	10	3	6
AESTHETICS	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
DISCUSSION	<p>The SSPL alternative is for the most part a standard looking girder bridge. Because of the single-level open roadway deck it is experientially preferred by the travelling public, however because this bridge type does not have any noteworthy, outstanding features, it is quite ordinary looking. In order to make it stand out in the landscape the steel tubs could be painted a bright color, akin to the colors of the trains travelling below. While important for all of the designs, the total integration of roadway level improvements, including articulated vehicular and pedestrian railings, vertical decorative elements, and coordinated, sympathetic lighting and signing structures, will be important for this type of design to enhance the user experience.</p>	<p>This type of structure can be quite majestic due to the arch effect created by the haunched soffit in the main span. However because the Viaduct crosses the industrial Mill Creek Valley at a relatively low height, the soaring arch quality of the structure is limited and one is rather more aware of how the large depth of the bridge at the piers feels overly massive.</p> <p>With this design, more architectural attention should be applied to the smaller spans to create a more unified design and to compliment and continue the design language of the larger cantilevered spans.</p> <p>The single level open roadway deck is experientially preferred by the traveling public, but in addition, because there are no bridge features above the roadway, this experience would be enhanced by careful attention given to the design of railings, barriers, lighting, and other vertical elements on the structure.</p>	<p>Twin arch structures spanning the railyard would definitely stand out in the landscape and would be thrilling to travel through. By having all levels of traffic on side-by-side structures, the need for a lower deck is eliminated, which is preferable to the traveling public.</p> <p>The light and airy quality of these arch structure types can however be incongruous with this industrial setting; they are better suited for a river crossing. Also, from a vantage point on land, the two arches together can appear cluttered.</p>	<p>By necessity, the material components of this type of design will be larger and carry more visual weight than those of the Twin-Arch proposal and thus provide an opportunity for designing a bridge system that will fit more comfortably within its industrial context while still providing a new, iconic presence. And since this bridge design will employ pylons that are shorter than a typical cable-stayed bridge, the new viaduct will not compete hierarchically with the nearby Ohio River bridges.</p> <p>In general, this option will provide the best opportunity to aesthetically integrate the long-span vertical support structures with those of the structural support system of the approach spans. Additionally, an extradosed bridge design also produces a structure that provides a single-level, open roadway structure which is experientially preferred.</p> <p>The proper execution of this Extradosed Design Option will allow for the construction of a contextually fitting and architecturally significant structure providing a balance of visual weight and a positive daily user experience.</p>	<p>This bridge design with its large pattern of structural trusswork framing is quite possibly the most site contextual of all the design options. The length and scale of the trusswork is at once both monumental and sympathetic to its surrounding industrial environment. Although visually appealing, this concept's grand scale encloses a lower level roadway deck which is not preferred experientially.</p>	<p>Combining the contextual monumentality of the double-decker roadway trusswork with vertical pylons, and harp pattern of cables, makes a strong architectural statement. However, the resulting structure may appear to be too imposing for this site. This scale of structure is more appropriate for a landmark river crossing rather than in an industrial context like the Queen's Gate Railyard.</p> <p>Similar to the Long Span Push Launched Option, enclosing a lower level roadway deck with a web of structural trusswork is not preferred from a user's viewpoint. While potentially quite expressive, the Cable-Stayed Bridge Design Option would also prove incongruent with the historical context of bridge construction within the Mill Creek Valley.</p>
SUMMARY	<p>All options were scored in a qualitative manner with the reasoning described above. In summary, the extradosed bridge offers the best balance of visual weight while still providing an iconic presence. The single deck supported by stay cables will provide an enhanced user experience compared to other alternatives. In addition, the Extradosed Option will provide for an opportunity to aesthetically integrate the long spans with the bridge approach structures, achieving a congruent design throughout the entire length of the structure.</p>					

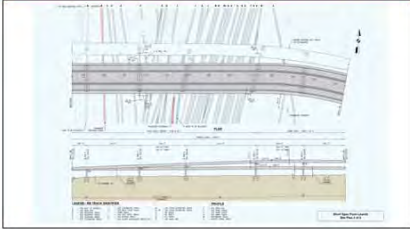
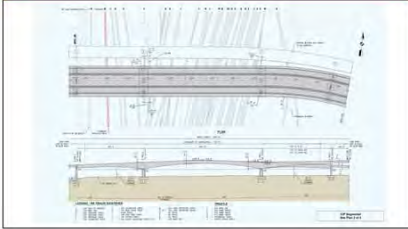
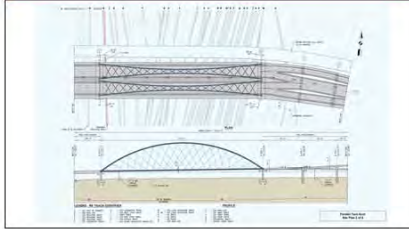
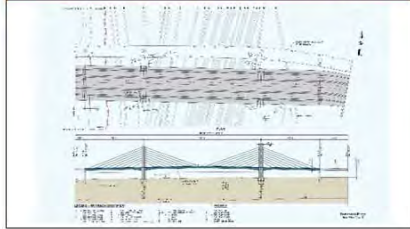
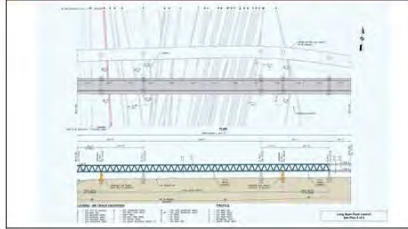
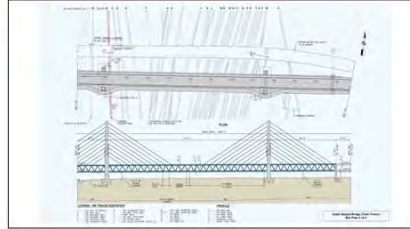
6.4.3 Durability and Maintainability

RANK	3	1	3	2	5	5
SCORE	5	8	5	6	4	4
DURABILITY & MAINTAINABILITY	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
PROS	<p>The enclosed, simple shape of the tub-girders limit exposure to the environment and prevent water accumulation. In addition, the steel tub girders are shielded from the weather by the concrete deck.</p>	<p>Prestressed concrete structures typically limit the frequency of surface cracking and crack widths when compared to conventionally reinforced concrete. This trait makes these structures less susceptible to surface water infiltration and chloride related deterioration.</p>	<p>The closed box used for the arch rib and tension-tie can be sealed against moisture ingress preventing corrosion on the interior surfaces. Alternatively, the boxes can also be dehumidified, thereby prolonging the design life.</p>	<p>This structure type introduces compression into the deck, limiting the frequency and width of surface cracks when compared to the concrete deck of a conventional structure. The edge girders are enclosed steel box sections, reducing the amount of exposed surfaces. The framing connections are simple, making any required maintenance relatively simple. The steel edge girders and floor beams are shielded from the weather by the concrete deck.</p>	<p>Truss members are closed boxes that prevent moisture ingress and limit steel corrosion.</p>	<p>The cable stays introduce compression into the deck, limiting the frequency and width of surface cracks in the deck, thereby limiting chloride ingress.</p>
CONS	<p>Steel construction when compared to concrete typically requires more frequent maintenance. Additionally, the flat profile of this alternative reduces the rate of surface drainage which will increase moisture related deterioration.</p>	<p>Post tensioned structures have the potential for improper duct grouting which can lead to corrosion of the post tensioning tendons. The deck carries most of the post-tensioned cantilever tendons and hence is hard to replace. It is recommended that an integral overlay be used with this bridge type.</p>	<p>The arch tension-tie is a fracture critical element and requires careful design and fabrication and subsequent regular inspections. It may be possible to post-tension the tie and develop a design with increased redundancy. The deck may be post-tensioned and integral with the tension ties and hence not replaceable, thereby requiring an integral concrete overlay.</p>	<p>Steel construction when compared to concrete typically requires more frequent maintenance. The deck carries compression and can not be replaced. It requires an integral overlay.</p>	<p>Steel construction when compared to concrete typically requires more frequent maintenance. The framing of a truss includes multiple connection points and gusset plates that are common areas of debris and moisture accumulation leading to deterioration. Additionally, the flat profile of this alternative reduces the rate of surface drainage which will increase moisture related deterioration.</p>	<p>Steel trusses require a higher level of maintenance. The deck cannot be replaced and would require an integral overlay.</p>
INSPECTION EFFORT	MEDIUM	MEDIUM	HIGH	HIGH	HIGH	HIGH
SUMMARY	<p>The CIP alternative has the highest score as it utilizes a completely prestressed superstructure increasing the entire structure's durability. However, it is scored an 8 due to the difficulty of constructing, inspecting, and repair of grouted structural tendons. The Extradosed alternative is ranked second and scored a 6 due to the compression in the deck increasing durability, its profile promoting positive drainage, and its relatively simple framing.</p>					

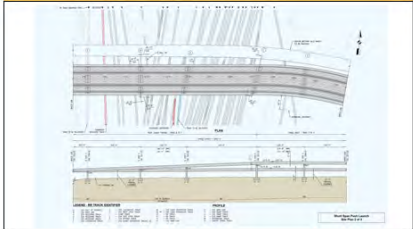
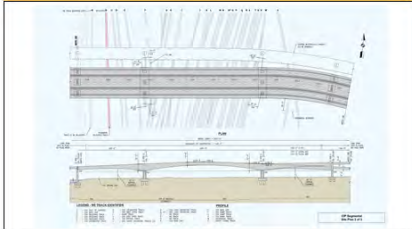
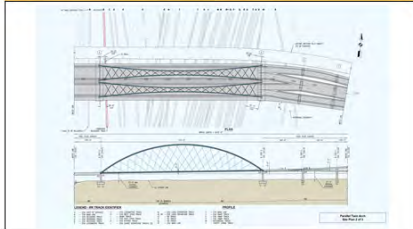
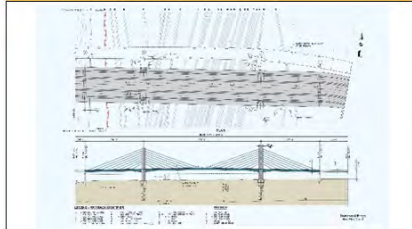
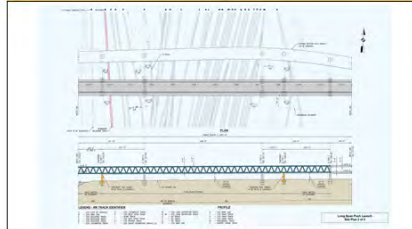
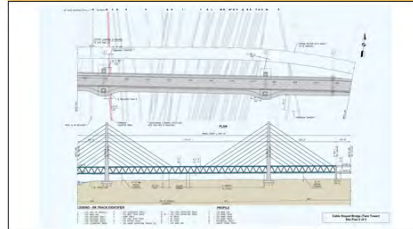
6.4.4 Railroad Preference

RANK	6	5	4	2	1	3
SCORE	3	5	6	8	10	7
RAILROAD PREFERENCE	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
DISCUSSION	<p>This alternative requires a pier (Pier E) to be located within the departure track area of the railroad yard. The location of proposed Pier E is within the most congested area of the railyard, offering limited to no options to work within the space afforded. In order to construct the proposed Pier E, existing tracks would need to be reconfigured. Access to the working area around proposed Pier E is also unfavorable.</p>	<p>This alternate requires the use of form travelers for its construction. The construction of the form travelers and numerous advancements of the form travelers will require multiple track outages in windows of four hours a piece. Depending on the tracks affected, the four-hour required track outages pose significant challenges to the construction. Mainline rail traffic, particularly that of Norfolk Southern, generally cannot afford outages more than two hours. Four-hour outages on high use CSX tracks, though feasible, would need to be planned with significant lead time.</p>	<p>This alternative employs the use of SPMTs. From CSXT's perspective, this is an overall medium impact. There would need to be a high level of coordination with this alternate and most likely an outage would only be allowed on a major holiday. The travel path for the SPMTs would need to avoid track switches. From Norfolk Southern's perspective, this is a high impact. Two major track outages would have to take place in order to allow the transport, which would be problematic given Norfolk Southern's current operational model. As with CSXT, the travel path for the SPMT's would need to avoid track switches. This alternative has the advantage of spanning across the entire railroad yard eliminating the need for a pier near the locomotive tracks.</p>	<p>This alternative, originally posed to be a concrete structure in earlier study versions, had the same issues as the CIP, magnified by the increased width of the superstructure. However, it is feasible to construct the EX alternative in steel thus alleviating the consequences of a concrete structure built with form travelers and significant disruption to rail traffic below. Construction of a steel alternate will reduce the duration of track outages by approximately one-half thereby making it palatable to each of the prospective railroads and easier to obtain needed track time. This alternative also makes possible the use of push launch construction which is also favorable to the railroads. The negative, with respect to the railroads, is that this alternative impinges more on the intermodal operations.</p>	<p>This alternative is the most favored by the railroads given its minimal ground impact and start-stop potential of pushing a bridge over active railroad tracks. It is yet to be determined how many outages will be needed over the various tracks as this long span is being pushed over the railroad yard.</p>	<p>This alternative includes the construction of tall towers and the need for tower or other high mast cranes which are objectionable to the railroads, in particular Norfolk Southern. It does have the advantage of spanning across the entire railroad yard eliminating the need for a pier near the locomotive tracks.</p>
SUMMARY	<p>The LSPL option is most favored by the railroad because it is preassembled outside of the railyard, the only pier that is required in the active part of the yard does not require track relocation, and the railroad considers the interference with railyard activities during launching operations to be the least intrusive. The extradosed alternative also provides an excellent solution with respect to accommodating the railroads, particularly with respect to the extent of track time needed for the overhead operations. The extradosed design affords flexibility in its constructability by allowing either balanced cantilever or push launch methods or combination of the two.</p>					

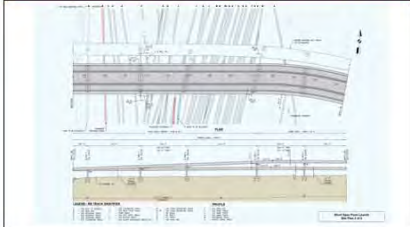
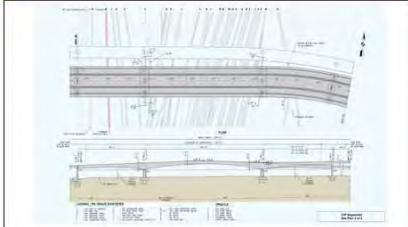
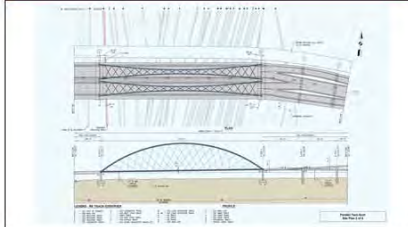
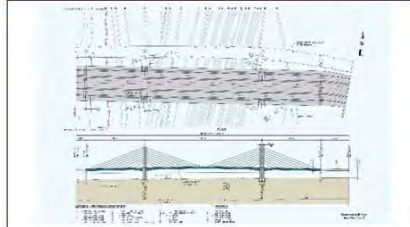
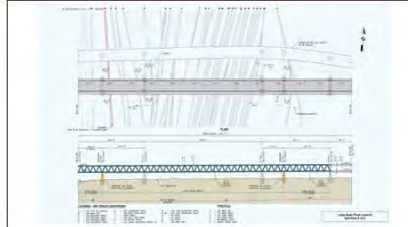
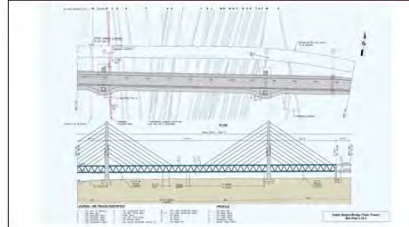
6.4.5 Constructability

RANK	1	4	2	2	5	6
SCORE	10	8	9	9	6	5
CONSTRUCTABILITY	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
CONSTRUCTION COMPLEXITIES	<p>Push launch construction method</p> <p>Details to eliminate or reduce the number of fracture critical members</p>	<p>Balanced cantilever construction</p> <p>Form traveler construction</p> <p>Post-tensioning and grouting</p>	<p>SPMTs</p> <p>Prestressing arch ties</p> <p>Cable Installation</p>	<p>Balanced cantilever construction</p> <p>Cable installation</p> <p>Tower construction</p> <p>Details to build in redundancies or eliminate fracture critical members</p>	<p>Push launch construction method</p> <p>Details to eliminate or reduce the number of fracture critical members</p> <p>Steel truss fabrication and erection</p>	<p>Balanced cantilever construction</p> <p>Cable installation</p> <p>Tower construction</p> <p>Steel truss fabrication and erection</p>
SUMMARY	<p>The alternatives were scored based on rankings starting at 10 signifying the simplest to construct and then incrementally reducing scores for alternatives with increasing complexities. The complexity of the construction was scored irrespective of the environment. Impacts of railroad preference or interference are accounted for in the Railroad Preference category of the matrix.</p>					

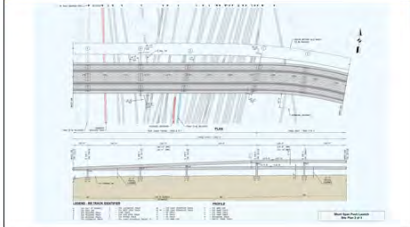
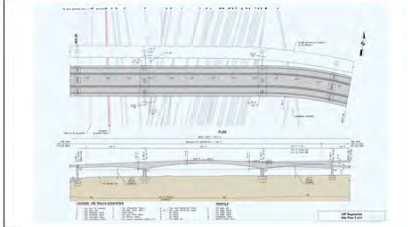
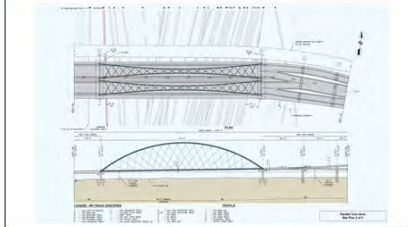
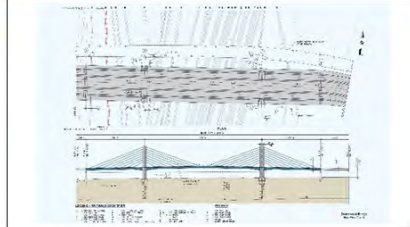
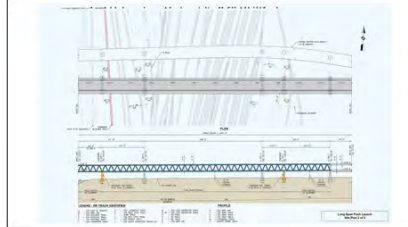
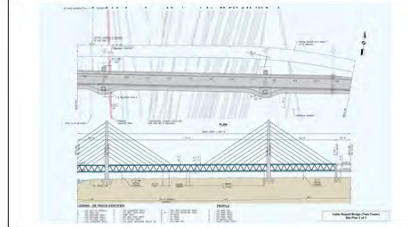
6.4.6 Claims Potential

RANK	6	4	2	1	2	4
SCORE	5	6	7	8	7	6
CLAIM POTENTIAL	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
PROS	<p>By assembling the superstructure segmentally outside the railyard and push launching the bridge into position, there is minimal interference to railyard operations. Flexibility is built in to the push launch process to start and stop at will, so it is easy to work around train movements. For these reasons the potential for claims resulting from railyard activities causing delay to bridge construction is lowered.</p>	<p>This structure is built using overhead construction which causes minimal interference to rail traffic below. The form travelers used in segment erection will enclose the construction activities providing inherent protection for the tracks below and reducing interruptions to trains with the exception of form traveler launching and setup and removal of the form traveler and segment formwork from the structure.</p>	<p>Construction of the arches minimize interference with railyard activities because there are no piers within the active part of the yard and because the arches are completely assembled outside the yard.</p>	<p>The use of balanced cantilever construction or push launched elements where possible, provides inherent protection to the rail activities below. Additionally, superstructure construction will utilize prefabricated components to the extent practical which will limit the time working overhead. The steel superstructure can be erected with cranes at deck level.</p>	<p>Push launch method affords the ability to start and stop operations to allow for the movement of trains below. This method of superstructure construction limits the amount of time working overhead of active tracks. This alternative carries traffic on a single bridge and would require only one push launch operation.</p>	<p>The use of balanced cantilever construction, as well as prefabricated components provides inherent protection to the rail activities below.</p>
CONS	<p>Construction of Pier E in a more congested part of the railyard and relocation of a departure track that sees heavy rail traffic could lead to construction delays and the potential for claims. Even though the time window for stopping rail traffic during launching can be short, since all traffic under the leading cantilever must be stopped this can lead to unanticipated delays in construction. Since there will be three independent superstructures, there will be three separate superstructure push launch operations.</p>	<p>Multiple four-hour windows of track time are needed for the advancement of form travelers. The four-hour windows are at the limit of what CSXT can normally provide and exceed the limit of what Norfolk Southern can provide. Additionally, cold weather can severely limit or stop concrete segmental erection which could lead to prolonged winter shutdowns. These issues are compounded by the fact that three separate superstructures are to be constructed.</p>	<p>Building the runway for SPMT's will affect all tracks within the railroad yard and will require track time for each. Shutdown of the railroad would only be allowed on a weekend or a holiday. The windows made available for a complete shutdown of the railyard needed for this type of operation could result in significant delays.</p>	<p>Multiple two-hour windows of track time will be needed for the erection of the structural steel.</p>	<p>Even though the time window for stopping rail traffic during launching can be short, since all traffic under the leading cantilever must be stopped this can lead to unanticipated delays in construction. Eventually all tracks under the superstructure being launched will need to be clear of rail traffic and obtaining track time to accomplish this will be challenging. Construction of two temporary piers within the railroad yard are needed for the push launch operation.</p>	<p>Erection of large steel segments will require multiple four-hour windows of track time.</p>
SUMMARY	<p>The scoring in the claims potential category focuses on work within the railroad yard only. The pros and cons above list operations which could alleviate claims or which could lead to claims due to some of the following reasons: 1) inability for the contractor to obtain track time; 2) inability for contractor to obtain approval from railroad on its means and methods; 3) difficulty in working around trains and other obstacles within the yard; 4) unforeseen subsurface conditions such as railroad utilities; 5) weather delays having significant schedule impacts. Scores have been assigned qualitatively and comparatively between alternates. The scoring is weighed heavily toward the track time required for each operation.</p>					

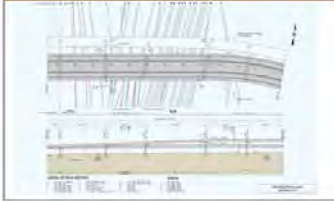
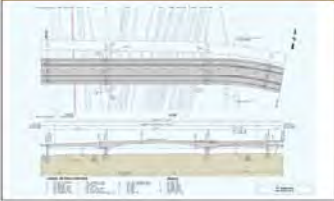
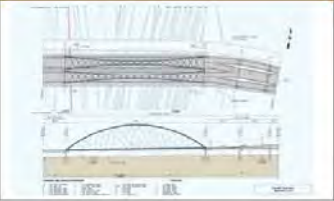
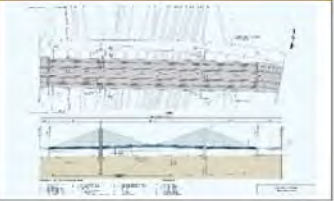
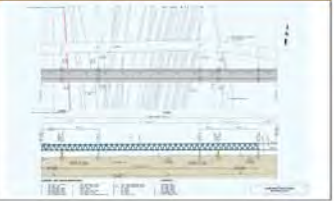

6.4.7 Traffic Operations

RANK	1	1	4	3	5	5
SCORE	10	10	8	9	6	6
TRAFFIC OPERATIONS	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
PROS	<p>Can be built in phases</p> <p>No weaving issues at the west end</p>	<p>Can be built in phases</p> <p>No weaving issues at the west end</p>	<p>No weaving issues at the west end</p>	<p>No weaving issues at the west end</p>		
CONS			<p>East end traffic weave is more complicated due to 2 bridge config</p>	<p>Longer tangent requires tighter curve towards east end of railyard</p>	<p>West end traffic weave due to double deck</p>	<p>West end traffic weave due to double deck</p>
SUMMARY	<p>The SSPL and the CIP Segmental are scored highest because being three independent bridges they are most amenable to phased construction. This will be advantage for maintenance of traffic. The two double deck structures, the LSPL and Cable-stayed alternatives, require an additional ramp structure to accommodate weaving at the west end, hence they receive the lowest score.</p>					

6.4.8 Bridge Drainage

RANK	5	1	4	2	5	2
SCORE	2	6	3	5	2	5
DRAINAGE	<p>SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)</p> 	<p>CIP SEGMENTAL</p> 	<p>TWIN ARCH</p> 	<p>EXTRADOSED (COMPOSITE STEEL GIRDER)</p> 	<p>LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)</p> 	<p>CABLE-STAYED BRIDGE (DUAL PYLON)</p> 
PROS		<p>Steeper slopes along profile, fewer scuppers</p> <p>Profile allows for steeper slope in the "horizontal pipe runs"</p> <p>Limited pipe needed under tracks</p>	<p>Least amount of pipe needed under tracks</p>	<p>Steeper slopes along profile, fewer scuppers</p> <p>Profile allows for steeper slope in the "horizontal pipe runs"</p> <p>Limited pipe needed under tracks</p>	<p>Limited pipe needed under tracks</p>	<p>Least amount of pipe needed under tracks</p>
CONS	<p>Flat profile, more scuppers needed</p> <p>Will need to pipe under tracks to convey water off RR prop</p>	<p>Will need to pipe under tracks to convey water off RR prop</p>	<p>Flat profile, more scuppers needed</p>	<p>Will need to pipe under tracks to convey water off RR prop</p>	<p>Flat profile, more scuppers needed</p> <p>Double deck increases drainage system needed</p>	<p>Double deck increases drainage system needed</p>
SUMMARY	<p>The bridges with flat profile are ranked lowest.</p>					

6.4.9 Cumulative Ranking

	WEIGHT	SHORT SPAN PUSH LAUNCH (TRAPEZOIDAL STEEL BOX)	CIP SEGMENTAL	TWIN ARCH	EXTRADOSED (COMPOSITE STEEL GIRDER)	LONG SPAN PUSH LAUNCHED (DOUBLE DECKER TRUSS)	CABLE-STAYED BRIDGE (DUAL PYLON)
	100						
COST	20	10	8	10	7	10	2
AESTHETICS	10	2	8	6	10	3	6
DURABILITY/MAINTAINABILITY	15	5	8	5	6	4	4
RR PREFERENCE	15	3	5	6	8	10	7
CONSTRUCTABILITY	15	10	8	9	9	6	5
CLAIM POTENTIAL	15	5	6	7	8	7	6
TRAFFIC OPERATIONS	5	10	10	8	9	6	6
BRIDGE DRAINAGE	5	2	6	3	5	2	5
OVERALL SCORE		625	725	720	775	675	485
RANKING		5	2	3	1	4	6



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