Bridge Type Selection Report

Multnomah County | Earthquake Ready Burnside Bridge

Portland, OR

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Earthquake Ready Burnside Bridge Project

Bridge Type Selection Report

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Acronyms, Initialisms, and Abbreviations

ADA	Americans with Disabilities Act
API	Area of Potential Impact
BES	City of Portland Bureau of Environmental Services
CRD	Columbia River Datum
CSO	Combined Sewer Overflow
CSZ	Cascadia Subduction Zone
DEQ	Department of Environmental Quality
EIS	Environmental impact statement
EPA	Environmental Protection Agency
EQRB	Earthquake Ready Burnside Bridge
FLAC	Fast Lagrangian Analysis of Continua
FODE	Full Operation Design Event
LODE	Limited Operation Design Event
LRT	Light rail transit
MASH	Manual for Assessing Safety Hardware
MLK	Martin Luther King Jr.
NEPA	National Environmental Policy Act
NHS	National Highway System
O-cell	Osterberg cell
O-D	Origin-destination
OCS	Overhead Catenary System
ODOT	Oregon Department of Transportation
OSD	Orthotropic steel deck
PBOT	City of Portland Bureau of Transportation
PCFC	Pacific Coast Fruit Company
RCT	Rose City Transportation
ROW	Right-of-way
RSA	Response Spectra Analysis
SDC	Seismic Design Criteria
SDEIS	Supplemental Draft Environmental Impact Statement
TCE	Temporary construction easement
TL-4	Test level

UPRR	Union Pacific Railroad
USCG	United States Coast Guard

Purpose

In preparation for the Earthquake Ready Burnside Bridge (EQRB) Project's Final Design phase, this Bridge Type Selection Report (TSR) serves to document the technical aspects of the Preferred Alternative studied during the Project's National Environmental Policy Act (NEPA) phase. The Preferred Alternative, identified herein and within the various NEPA documents as the Refined Long-span Alternative, is described in Section 2.1. For a comprehensive discussion of all other alternatives evaluated but not selected as the Preferred Alternative, refer to the *EQRB Draft Environmental Impact Statement (EIS)* (Multnomah County 2021b) and the *EQRB Supplemental Draft Environmental Impact Statement (SDEIS)* (Multnomah County 2022k).

This TSR summarizes the criteria and technical considerations for the bridge replacement options studied, documents identified impacts and their conceptual solutions, and establishes the basis for final type selection as part of the Final Design phase. Information herein does not represent a final decision by Multnomah County; rather, serves as a documentation of preliminary structural, impacts, and risk analyses conducted to select the bridge types within the Preferred Alternative. All recommendations will be validated and refined as part of the Final Design phase.

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Executive Summary

The narrative that follows provides a summary of the major structural element types selected as part of the Preferred Alternative. A synopsis of these elements is included in Table ES-1, and described further below and throughout this TSR.

Table ES-1. Preferred Alternative Major Structural Elements

Structural Element	Preferred Alternative
West Approach	• One abutment and two supports west of Naito Parkway, one with three columns and the other with two columns; two supports, each with two columns, in Waterfront Park. • Slab/girder bridge type between Abutment 1 and Bent 5, consisting of a prestressed slab span over 1st Avenue, and steel girder spans over a City-owned parking lot, Naito Parkway, and Waterfront Park. • Bents to be supported by columns founded on 8-foot or 10-foot diameter drilled shafts.
Main River Spans	• Two in-river pier supports. • Girder bridge type for Span 5, starting over Waterfront Park and landing on Pier 6 (the west in-river pier). • Bascule bridge type for Span 6 with four girders between Piers 6 and 7. • Replace all in-river piers with deep foundations, likely consisting of large-diameter drilled shafts [(8)-10-foot diameter shafts per pier within this TSR].

East Approach	• One two-column support east of the UPRR tracks, one four-column support on the west side of 3rd Avenue, and one abutment east of 3rd Avenue.
	• Long-span bridge type consisting of either a cable stayed or tied arch type, starting at the east in-river pier and extending as follows:
	  ○ One-Span Tied arch Bridge Option – Support located to the west of 2nd Ave with girder spans continuing eastward to the abutment.
	  ○ Two-Span Cable stayed Bridge Option – Support tower located between the UPRR tracks and 2nd Ave and the end of the second cable stayed span located on the west side of 3rd Avenue; a box beam span continuing eastward to the abutment.
	• Bents to be supported by columns founded on 8-foot or 10-foot diameter drilled shafts.
	• Possible need to stabilize soils below the cable stayed option tower support located in the geologic hazard zone (between the UPRR tracks and 2nd Avenue).

Westside Access to 1st Avenue	• Range of options including multiple possible configurations of stairs and ramps, ADA-accessible elevators, and sidewalk improvements on both sides (north and south) of the bridge. Conversely, options may include no additional connection (i.e., using improved sidewalks to access the bridge). Decision on the need for and type of access at this location to be made during the Final Design phase.
Vera Katz Eastbank Esplanade Access	• Maintain existing City of Portland–owned staircase connecting south side of the bridge to the Eastbank Esplanade. Staircase to be protected in place during demolition of the existing bridge and reconstruction of the new bridge. Access to existing stairs would be provided after bridge construction phase completed. City or others may pursue new, independent connection as separate project with its own purpose, funding, and permitting.

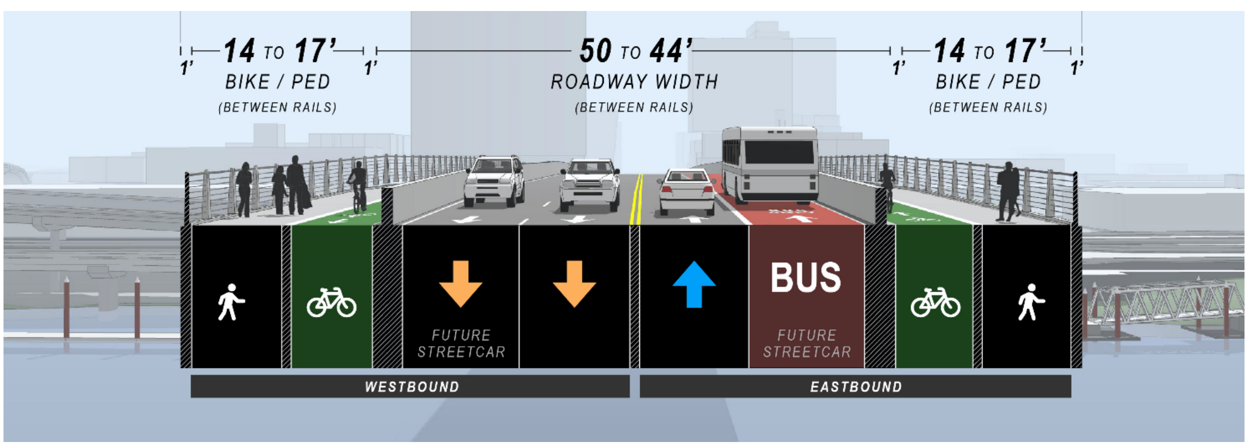
Bridge Geometry

The proposed replacement bridge is placed at approximately the same location as the existing bridge. The total bridge length is approximately 2,290 feet, which is comparable to the existing bridge. The West Approach abutment is located approximately 80 feet east of the current abutment, and the East Approach abutment is located approximately 30 feet east of the existing abutment.

The height of the bridge deck is at approximately the same elevation as the existing bridge, and the proposed vertical profile grade is set to approximately 4.6 percent, which is slightly steeper than the existing bridge vertical profile grade of 3.86 percent.

The Preferred Alternative would provide approximately 78 feet of usable width for vehicle lanes, bicycle lanes, and pedestrians (see Figure ES-1), which is comparable to the existing bridge. The Preferred Alternative would accommodate four vehicle lanes. The City of Portland, on July 20, 2022, declared its preferred lane configuration as two westbound lanes (general-purpose) and two eastbound lanes (one general-purpose and one bus-only lane). The NEPA phase evaluated a range of widths for the travel lanes (summed to between 50 – 44 feet), and a combined sidewalk and bicycle lane (summed to between 14 – 17 feet on each side of the bridge) (see Figure ES-1). The precise width of each lane will be determined in the Final Design phase. Physical barriers between vehicle lanes and the bicycle lanes would be included and would be in addition to the lane dimensions provided above. For the East Approach span, additional width would be required for the above-deck superstructure members, such as arch ribs or cables.

Figure ES-1. Preferred Alt Lane Configuration (West Approach Shown; Others Similar)



The Preferred Alternative would accommodate a westbound bus dwell space on the west end of the bridge between Bent 1 and Bent 4. Similarly, additional vehicular lane queue length in the eastbound direction has been added to enable smoother merging between Bent 1 and Bent 4.

Table ES-2. Bridge Width per Approach Location

Bridge Element	Approximate Bridge Width
West Approach	• Span 1: Varies from approximately 112 feet to 103 feet • Span 2: Approximately 103 feet • Spans 3 and 4: Approximately 82 feet
Main River Spans	• Span 5 (girder span): Approximately 82 feet (although additional width is provided at Piers 6 and 7 for overlooks and operator houses) • Span 6 (bascule movable span): Approximately 82 feet (although additional width is provided at the fixed portions of Piers 6 and 7 for overlooks and operator houses)
East Approach (Tied arch Bridge Option)	• Span 7 (tied arch span): Varies from approximately 82 feet to 93 feet • Span 8 (girder span): Varies from approximately 93 feet to 104 feet • Span 9 (girder span): Varies from approximately 104 feet to 112 feet
East Approach (Cable stayed Bridge Option)	• Span 7 (cable stayed span): Varies from approximately 82 feet to 112 feet • Span 8 (cable stayed span): Varies from approximately 90 feet to 112 feet • Span 9 (girder span): Varies from approximately 112 feet to 115 feet

Bridge Type

The Preferred Alternative consists of three bridge components: the West Approach, the Main River Span, and the East Approach. The Preferred Alternative does not make a bridge type selection between a cable stayed or tied arch option for the East Approach, and carries both bridge type options forward into the Final Design phase so that the bridge type decision can be informed by more detailed cost information and estimates developed by a future contractor.

The selected bridge types are illustrated in Figure ES-2 and Figure ES-3, with a summary to follow after these illustrations.

Figure ES-2. Preferred Alt with Bascule Movable Span (Tied arch East Approach)

Figure ES-3. Preferred Alt with Bascule Movable Span (Cable stayed East Approach)

West Approach

The Preferred Alternative includes a girder bridge type for the West Approach, which would be about the same width as the existing bridge. It avoids an adverse effect on the Skidmore/Old Town Historic District National Historic Landmark (NHL). The Preferred Alternative would require two sets of larger bridge columns in the park (versus four with the existing bridge). They are located to provide the necessary horizontal offsets from Naito Parkway and the Willamette Greenway Trail that each traverse under the bridge.

Movable Span

The Preferred Alternative has a bascule bridge as its movable span. The movable span will satisfy the required USCG horizontal and vertical navigational clearances for the main span; the requirements include enabling 100 percent of vessel traffic to safely transit under the bridge. The minimum clearances that will allow all vessel traffic to safely transit the bridge are as follows:

- Minimum Vertical Clearance (movable span in the raised position): Elevation 167.0 (NAVD88 datum). This would provide approximately 147 feet of vertical clearance above the ordinary high water mark surface elevation of 20.1 (NAVD88).
- Minimum Vertical Clearance (movable span in the closed position): Elevation 69.0 (NAVD88 datum). This would provide approximately 49 feet of vertical clearance above the ordinary high water mark surface elevation of 20.1 (NAVD88).
- Minimum Horizontal Clearance (permanent condition): 205 feet wide
- Minimum Horizontal Clearance (temporary construction condition): 165 feet wide

The movable span will be supported by "delta piers," or trapezoid-shaped piers sized to accommodate a bascule counterweight within the interior void of the pier. The piers will also be equipped with starlings, which are in-water structures that divide and deflect river water and floating debris on the upstream (south) side of the bridge. While these are currently anticipated to be formed starlings, they may alternatively be a smaller structure of equivalent function, such as a dolphin.

East Approach

The Preferred Alternative identified a long-span bridge type for the East Approach but left open the decision for a cable stayed or tied arch bridge type option.

For the Tied Arch option, the Long-span Alternative includes a span length that minimizes the risks and reduce costs associated with placing a pier and foundation in the geologic hazard zone that extends from the river to about E 2nd Avenue. The tied arch option places the eastern pier of the tied arch span farther east, thereby increasing the length of the tied arch span but reducing the length and depth of the subsequent girder span to the east.

For the cable stayed option, the tower is placed as reasonably close to the UPRR tracks as permissible, with the assumption that geotechnical ground improvements are necessary to mitigate the seismic geologic hazards. This results in differing cable stayed span lengths. Based on the current tower location, UPRR pier protection is not required.

Ancillary Elements

West Side Access to 1st Avenue

Near the west end of the existing bridge, there are County-owned stairs on both sides of the bridge that connect the existing on-bridge bus stop to West 1st Avenue (under the bridge) where the existing Skidmore Fountain MAX station is located. The NEPA phase evaluated replacing the stairs with ADA-accessible elevators combined with stairs, a ramp, and improving the sidewalks between the end of the bridge and West 1st Avenue to create a safer and more ADA-accessible surface-level pedestrian route. In addition to improving the sidewalks, the range of supplemental connection options includes no additional connection (i.e., using the improved sidewalks to access the bridge); stairs on one or both sides of the bridge; a ramp on the south side of the bridge; or elevators on one or both sides of the bridge. There could also be combinations of these connection types. The Preferred Alternative does not include a final selection of access to West 1st Avenue; and a decision on the need for and type of access at this location would be made during the Final Design phase.

Vera Katz Eastbank Esplanade Access

The Preferred Alternative maintains the existing City of Portland–owned staircase that currently connects the south side of the bridge by permit to the Vera Katz Eastbank Esplanade located about 50 feet below the bridge. The staircase would be protected in place during the demolition of the existing bridge and the reconstruction of the new bridge. Access to the existing stairs would be provided after the bridge construction phase is completed.

1 Introduction

The following summarizes the Earthquake Ready Burnside Bridge (EQRB) Project (Project) background, the Project's Purpose and Need, the structural issues being resolved, and the proposed solution.

Multnomah County (County) directed the study and development of an Environmental Impact Statement (EIS) as part of the National Environmental Policy Act (NEPA) assessment for the Earthquake Ready Burnside Bridge (EQRB) river crossing . As a result, multiple bridge replacement alternatives were studied and have been summarized herein to assist in the decision-making for bridge type selection.

1.1 History of the Burnside Bridge

Burnside Street, which extends from Washington County to Gresham and crosses the Willamette River via the Burnside Bridge, has been designated as a "lifeline" transportation route, meaning it will be expected to enable emergency response, evacuation, and recovery after a major disaster.

Built in 1926, the Burnside Bridge is an aging structure requiring increasingly frequent and significant repairs and maintenance. The existing Burnside Bridge carries a total of 35,000 vehicles per day, and crosses the Willamette River, multiple City of Portland (City) streets, parking lots, parks, TriMet Max lines, and other facilities along Burnside Street. The existing bridge carries three eastbound and two westbound lanes of vehicle traffic as well as bike lanes and sidewalks in each direction. The total bridge length is approximately 2,307 feet and consists of three separate structures:

- West Approach Bridge (Br. No. 00511A) spans 602 feet
- Main River Bridge (Br. No. 00511) spans 856 feet
- East Approach Bridge (Br. No. 00511B) spans 849 feet

The bridge is designated a historically significant structure and is listed on the National Register of Historic Places.

Figure 1. Burnside Bridge Main River Span Bridge over the Willamette River, Portland, Oregon

1.2 Project Purpose and the Need for Seismic Resilience

Geologically, Oregon is located in the Cascadia Subduction Zone (CSZ), making it subject to some of the world's most powerful recurring earthquakes. The last major earthquake in Oregon occurred over 300 years ago, in 1700, a timespan that exceeds 75 percent of the intervals between the major earthquakes to hit Oregon over the last 10,000 years. There is a significant risk that the next event will occur relatively soon. The next major earthquake is expected to cause moderate to significant damage to the aging downtown bridges, including the existing Burnside Bridge, rendering them potentially unusable immediately following the earthquake. In their existing condition, all of the downtown bridges and/or approaches fail to provide communities and the region with timely and reliable critical emergency response, evacuation, and recovery functions. In response to this risk from a future seismic event, Multnomah County completed its 20-year *Willamette River Bridges Capital Improvement Plan 2015-2034* (Multnomah County 2015); which identified seismic resiliency of the Burnside Bridge as a top priority for Multnomah County in the next 20 years.

Burnside Bridge is designated as the only County-owned Primary Emergency Transportation Route across the Willamette River in downtown Portland in a 1996 report to Metro's Regional Emergency Management Group. This group was formed by intergovernmental agreement among the region's cities, counties, Metro, and the Red Cross to improve disaster preparedness, response, recovery, and mitigation plans and programs. (Metro 1996).

The Burnside Street emergency route is approximately 18.7 miles in length and extends from SW 57th Avenue in Washington County to US Highway 26 in Gresham, crossing the Willamette River via the Burnside Bridge.

Other agency plans have also identified Burnside Street as an important lifeline route. For example, the City's Citywide Evacuation Plan addresses evacuation needs for general disasters. The Plan identifies Burnside Street as a secondary east-west evacuation route and an emergency transportation route (PBEM 2017).

The primary purpose of the Project is to create a seismically resilient Burnside Street lifeline crossing of the Willamette River that would remain fully operational and accessible for vehicles and other modes of transportation immediately following a major CSZ earthquake. A seismically resilient Burnside Bridge would support the region's ability to provide rapid and reliable emergency response, rescue, and evacuation after a major earthquake, as well as enable post-earthquake economic recovery. In addition to ensuring that the crossing is seismically resilient, the purpose is also to provide a long-term, low-maintenance safe crossing for all users.

1.3 History of the Earthquake Ready Burnside Bridge Project

In 2015, the *Willamette River Bridges Capital Improvement Plan* 2015–2034 (Multnomah County 2015) prioritized creating a Burnside Street river crossing that can withstand a major earthquake. The adoption of the improvement plan led to the process to identify and screen alternatives which began in 2016 with the EQRB Feasibility Study documented in the *EQRB Feasibility Study Report* (Multnomah County 2018).

The EQRB project team worked with community and agency stakeholders to develop project objectives and a problem statement, build project awareness through early engagement, and analyze more than 100 options for creating an earthquake ready Willamette River crossing. Screening criteria were developed and applied (see the *EQRB Alternatives Screening Technical Memorandum*[1]) with the Project's Stakeholder Representative Group, and the results were shared with other project committees (the Senior Agency Staff Group and the Policy Group), as well as with the public through online events and in-person open houses. Following public input, the feasibility study was completed in November 2018, and the Multnomah County Board of Commissioners adopted the draft project purpose and need statement and the range of alternatives for further study

This process led to the recommendation to advance select bridge alternatives for further study in the environmental process. Following the feasibility study, the project team conducted additional analysis and gathered stakeholder input to further evaluate and refine the project alternatives prior to initiating an EIS. To comply with NEPA, an EIS was developed that studied the seven alternatives described in Section 2.1.

Following almost 2 years of coordination, analysis, and input, in June 2020, the Project's Community Task Force (CTF) recommended that the Draft EIS Long-span Approach Alternative and the No Temporary Bridge Option comprise the Draft EIS Preferred Alternative (see descriptions of this alternative and option in Section 2.2). The CTF's process to reach that recommendation included identifying the community's values, defining evaluation criteria and measures, and reviewing the performance and impacts of

[1] *EQRB Feasibility Study Report*, Appendix C. Multnomah County. 2018.

the various alternatives and options. It also considered the input from the project team's technical experts, from resource agencies and other participating agencies, and from other stakeholders including the public. In August 2020, the project team solicited input on the CTF's recommendation from multiple stakeholder groups, agencies and the public through online open houses, an online survey and web meetings. This input, which indicated broad support (85 percent) for the Draft EIS Preferred Alternative recommendation, was provided back to the CTF who then reconfirmed their recommendation in September 2020. The recommendation was then unanimously endorsed by the voting members of the Project's Policy Group on October 2, 2020. The Multnomah County Board of Commissioners adopted a resolution on October 29, 2020, expressing approval for the recommended Draft EIS Preferred Alternative. Input received during the Draft EIS comment period confirmed that there was considerably more public support for the Draft EIS Long span Alternative than for any of the other Draft EIS alternatives.

Following the issuance of the Draft EIS, additional cost and funding analysis identified a substantial risk. It was determined that construction costs of any of the build alternatives studied would be too high to reasonably fund. This risk led the County to direct the project team to identify ways to reduce construction costs while still meeting the Project's purpose and need. This additional refined evaluation was conducted and presented in a Supplemental Draft EIS. Initial findings regarding the cost savings, impacts, and tradeoffs of these potential revisions were provided to the public in November and early December 2021. Project committees endorsed the refinements to the Draft EIS Preferred Alternative, and the Multnomah County Board of Commissioners passed a resolution adopting the refinements on March 17, 2022. Elements that were considered as refinement within the SDEIS included:

- A reduction in bridge width (which eliminated one of the existing vehicular lanes and reduced the width of the combined sidewalk / bicycle lane as compared to the Draft EIS cross-section).
- The selection of a conventional slab on girder structure type for the West Approach bridge type.
- The selection of a bascule bridge type as the Main River Span movable bridge type.

2 Project Alternatives Studied

During the Feasibility phase, more than 100 options were evaluated and narrowed to the seven Build and No-Build Alternatives discussed in Section 2.1.

These seven alternatives were advanced through preliminary engineering which consisted of refined profile and horizontal alignments to meet vertical clearance needs, evaluation of pier placement to minimize impacts to the built environment, considered feasible bridge types for span ranges defined, and structural modeling to identify appropriate substructure and foundation sizing.

2.1 Alternatives Evaluated in the EIS and SDEIS

1. Movable Bridge Replacement with Short-span West Approach and Long-span East Approach (Long-span Alternative) ***(Selected as the Preferred Alternative)***

- Alternative includes a refinement of the Draft EIS Long-span Alternative.
- Low-profile bridge on the existing alignment of Burnside Street with a movable bridge span over the primary navigation channel, several short, fixed bridge spans on the West Approach, and a long fixed-bridge span for the East Approach.
- Vertical lift and bascule movable span types were evaluated.

Other Alternatives were studied during the NEPA phase but eventually dismissed. For a comprehensive description and evaluation of the alternatives listed below, refer to the Draft EIS, SDEIS, and related technical reports in Section 15.

2. No Build Alternative (Dismissed)

- Implement standard preservation and maintenance to the existing bridge but no seismic retrofit work.

3. Enhanced Seismic Retrofit (Dismissed)

- Retrofit the existing bridge to make it seismically resilient.

4. Fixed Bridge Replacement on Existing Alignment (Dismissed)

- High-profile fixed bridge on the existing alignment of Burnside Street.

5. Movable Bridge Replacement with Short-span Approaches (Dismissed)

- Low-profile bridge on the existing alignment of Burnside Street with a movable bridge span over the primary navigation channel and short fixed bridge spans for the East and West Approaches.
- Vertical lift and bascule movable span types were evaluated.

6. Movable Bridge Replacement with Long-span Approaches on both the West and East Approaches (Dismissed)

- Low-profile bridge on the existing alignment of Burnside Street with a movable bridge span over the primary navigation channel and long fixed bridge spans for the East and West Approaches.
- Vertical lift and bascule movable span types were evaluated.

7. Movable Bridge Replacement with Couch Extension (Dismissed)

- Low-profile bridge on the existing alignment of Burnside Street on the West Approach. The East Approach alignment splits into one-way connections on E Burnside Street and NE Couch Street. Movable bridge span over the primary navigation channel and short or long fixed bridge spans for the East and West Approaches.
- Vertical lift and bascule movable span types were evaluated.

2.2 Preferred Alternative Advanced for Type Selection

As part of the NEPA phase, the CTF recommended the Movable Bridge Replacement with Long-span Approaches (Long-span Alternative) identified in Section 2.1 as the Preferred Alternative. However, the associated construction cost for the recommended alternative was deemed too expensive to reasonably fund. This risk led the County to direct the project team to identify potential design modifications that could meet the Project's purpose and need while reducing the projected cost. This evaluation was conducted and presented in a SDEIS.

Evaluation and refinements to the recommended alternative, conducted during the SDEIS phase, demonstrated that a revised Long-span Alternative would be more cost-effective while achieving the Project's performance goals. These refinements which will be discussed herein, included a reduction in bridge width, a decision to implement conventional slab on girder bridge types for the West Approach spans, and a bascule bridge for the movable span. Project committees endorsed the refinements, and the Multnomah County Board of Commissioners passed a resolution adopting the refinements. As identified by the County, the Long-span Alternative has been chosen as the preferred alternative to be carried forward to bridge type selection and will be the primary focus in the subsequent sections of this report.

3 Bridge Design Criteria

3.1 Development of Design Criteria

Burnside Bridge is designated as the only County-owned Primary Emergency Transportation Route across the Willamette River in downtown Portland. Additionally, other agency plans have also identified Burnside Street as an important lifeline route. Thus, the primary purpose of the Project is to create a seismically resilient Burnside Street lifeline crossing of the Willamette River that would provide the region with timely and reliable critical emergency response, evacuation, and recovery functions. This includes satisfying the "Full Operation (FO)" performance criteria following the Magnitude 8+ CSZ earthquake, and the "Limited Operation (LO)" performance criteria following an even greater event.

The complexity of the Project's performance goals required establishing a planned decision-making process to set project criteria and draw in technical insights. Multiple working groups, consisting primarily of technical experts from various local, state, or federal agencies, provided detailed input and work products to the Project Management Team in their respective areas of expertise. This helped ensure that the proposed bridge design criteria and specifically seismic design criteria met the performance goals for the Project.

Early bridge and seismic design criteria were established in the feasibility phase. This criterion continued to be refined throughout the Draft EIS and SDEIS phases. Refinements were generated by technical discussions and input during seismic working group meetings which included technical experts from: PBOT, ODOT, Portland State University, FHWA, Multnomah County, and the project team.

3.2 Bridge Design Criteria Overview

As part of the NEPA phase, two project-specific preliminary bridge replacement design criteria were developed: *EQRB Revised Bridge Design Criteria* (Multnomah County 2022e) and *EQRB Revised Seismic Design Criteria* (Multnomah County 2022h). The purpose of the bridge design criteria is to provide design loading and specific clearance requirements, while the seismic design criteria identifies the Project's minimum requirements for seismic design. These documents will be finalized during the Final Design phase.

As articulated in the Project's Purpose and Need statement, seismic resiliency is the primary focus of the Project. Therefore, the suite of seismic performance goals defined for the Project generally exceed the standard criteria for ordinary bridges in the same seismic zones. The performance goals are listed below and shall be achieved based on the criteria set forth in the *EQRB Revised Seismic Design Criteria* (Multnomah County 2022h).

Full Operation Design Event (FODE)

Full Operation (full functionality). Damage sustained is negligible. Essentially elastic for all primary structural components, movable spans remain operable to open and close. Only minimal repairs and maintenance activities will be required post-earthquake without interruption to traffic. All traffic modes are able to use the bridge, including river navigation, immediately after the earthquake.

Limited Operation Design Event (LODE)

Limited Operation (limited functionality). Damage sustained is minimal. Limited inelastic behavior to substructure components; the bridge allows for emergency vehicles (after inspection and removal of debris). Movable components may not be operable without repairs. Damage is repairable but may impact traffic. Limited permanent deformation may occur.

3.3 Roadway Design Criteria Overview

Roadway design standards were developed to support safety and mobility goals. Roadway deficiencies have a critical impact on the safe and efficient use of the road by all travelers. The deficiencies of existing Burnside Bridge and approach roadway have been identified in the *EQRB Existing Roadway Deficiency Memo* (Multnomah County 2021d) (Appendix A). The proposed roadway geometrics for each replacement alternative have been defined in the *EQRB Facilities Standards List* (Multnomah County 2021e) (Appendix A) by using applicable AASHTO, Oregon Department of Transportation (ODOT), and County design standards and will be discussed in the subsequent sections.

4 Roadway Geometrics

A roadway deficiency analysis was conducted and documented in the *EQRB Existing Roadway Deficiency Memo* (Multnomah County 2021d). This analysis surveyed the existing roadway and bicycle/pedestrian conditions on and near the Burnside Bridge. Geometric deficiencies were identified in the following facilities:

- Vertical clearance beneath the bridge
- Pedestrian sidewalk facilities
- Accommodation for bicycle facilities
- ADA-compliance

The deficiencies have a critical impact on the safe and efficient use of the road by all travelers. The proposed roadway geometrics were developed to support the safety and mobility goals of the Project starting with providing a bridge width and cross-section allocation serving vehicular, multi-modal and transit travelers.

The Project drew on multiple working groups, consisting of a diverse group of project committees representing a wide range of community and agency interests, technical experts, and the project team to set the bridge width and associated cross-section allocations. Initial bridge widths studied for the Project provided the maximum width available between adjacent buildings and exceeded the existing width when no obstructions were present. This initial bridge width, evaluated in the EIS, provided the largest width for vehicular, transit, bike and ped traffic. Following the EIS evaluation, however, additional cost and funding analysis identified a substantial funding risk for the Project. As such, the reduced bridge width was studied and accepted as part of the Preferred Alternative.

4.1 Summary of Cross-sections Studied

4.1.1 Bridge Width

The total width of the bridge is driven by the multimodal cross-section allocation and bridge type. Table 1 provides the comprehensive out to out bridge widths studied on a per span basis (span configurations to be discussed in subsequent sections). Note that spans 7 and 8 vary depending on long-span bridge type selected (bridge types discussed in Section 5).

Wider bridge widths were taken into consideration in initial phases of the EIS to provide at least 20-foot-wide bicycle/pedestrian paths and maintain the five existing lanes on the bridge (two westbound general-purpose, two eastbound general-purpose, and one eastbound bus-only lane). These widths were found to be cost prohibitive and therefore have been excluded from further consideration at the time of this report. Reference the EIS, SDEIS and associated technical reports for a full evaluation on supplementary bridge widths studied.

Table 1. Preferred Alternative Bridge Width (per Span)

Span Number	Out to Out Bridge Width [feet]	
	Long-Span: Tied arch	Long-Span: Cable stayed
1	Varies: 112’ to 103’	Varies: 112’ to 103’
2	103’	103’
3	82’	82’
4	82’	82’
5	82’	82’
6	82'*	82'*
7	Varies: 82’ to 93’	Varies: 82’ to 111’
8	Varies: 93’ to 104’	Varies: 89.5’ to ~112’
9	Varies: 104’ to ~112’	Varies: ~112’ to ~115’
*Does not include additional width provided at Bents 6 and 7 for overlooks and Operator Houses		

The refined bridge width will accommodate four vehicle lanes and shoulders. Vehicular lane widths will measure between 10 and 12 feet, subject to the assigned vehicle being carried. As determined during the NEPA phase, vehicles that must be accommodated by the structure include:

- Standard passenger vehicles
- Conventional emergency vehicles (ambulance, fire trucks, etc.)
- Freight vehicles (inclusive of permit vehicles and Emergency vehicles)
- Post-earthquake vehicles (Large emergency response vehicles, Heavy haul vehicles, etc.)
- Transit (Bus and future Streetcar) vehicles

The combined bicycle and pedestrian paths on each side of the bridge will be separated by physical bridge barrier and will measure between 14 and 17 feet. As determined during the NEPA phase, non-vehicular modes that must be accommodated by the structure within the combined bike/ped space include:

- Bicycles (including recreational, commuters, and bike trailers)
- Pedestrians (including ADA provisions for impaired users)
- Other wheeled mobility devices (i.e., scooters, roller blades, etc.)

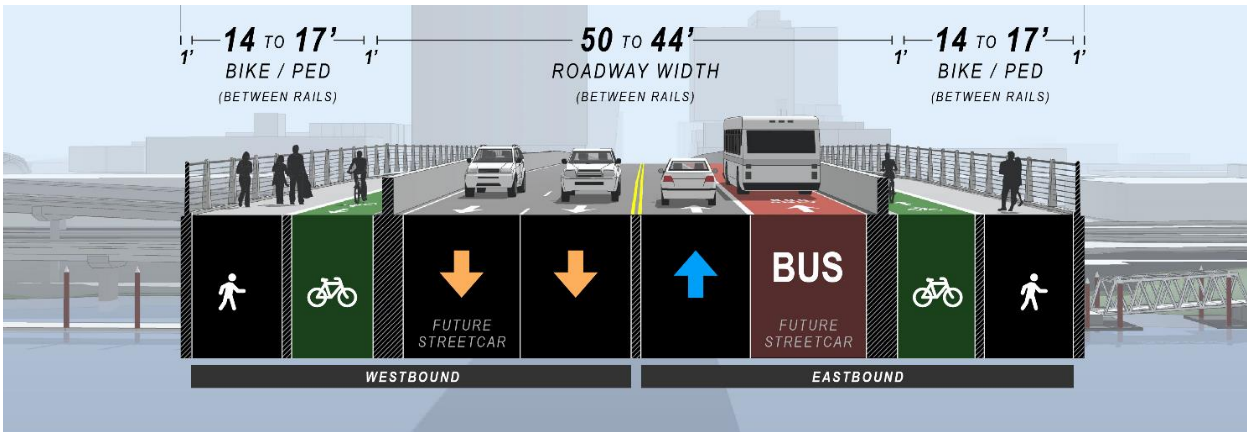
Precise widths for lanes, shoulders, medians, and bicycle/pedestrian paths will ultimately be determined during Final Design. For the purposes of this TSR, however, assumed dimensions within those ranges were used to illustrate type selection features.

4.1.2 Bridge Cross-section

Four lane allocation options were developed as part of the NEPA phase. Each option was analyzed for traffic operations and roadway geometry by the project team (See the

EQRB Transportation Supplemental Memorandum (2022l) for a full evaluation of each lane option). The traffic analysis was shared with cooperating and participating agencies, local stakeholders, and public outreach throughout multiple working group meetings. The City of Portland recommended Lane Option 1 (Balanced) because it has two westbound lanes, which provides the flexibility to convert one of those lanes into a westbound bus-only lane in the future. Based on the traffic analysis, at least 96 percent of traffic is served during each peak hour commute with this configuration. This option is depicted in Figure 2.

Figure 2. Preferred Alternative Lane Configurations (West Approach Show; Others Similar)



For this TSR, the preliminary bridge widths applied to each bridge type option are provided in the Roadway plans (Appendix A) and the Bridge Plans (Appendix B).

4.2 Horizontal Alignment

Early phases of the Project investigated various horizontal alignments for the bridge replacement alternative, including realignments to the north or south, split alignments, and even a tunnel. Eventually, the alignment options reduced to two for the NEPA evaluations, as follows:

- Existing Alignment
- Northeast Wishbone (identified as the Couch Extension)

During the NEPA phase, it was determined that Northeast Wishbone (Couch Extension) was the highest-cost alternative and possessed the most impacts to land use, construction duration, temporary closures, and other environmental resources. Replacement on the existing Burnside Street alignment was identified to be the most cost-effective option with the least impacts.

4.2.1 Approach Transitions

The four-lane cross-section options discussed above apply to the movable span and majority of the East and West Approach spans. Exceptions occur where the lanes transition to tie into the existing at grade street system to the west of Naito Parkway and east of E 2nd Avenue. The following discusses the needs for wider cross sections at the approaches.

West Approach Transition

After multiple discussions with TriMet and the City of Portland it was decided that the existing TriMet westbound bus stop would move west, off the bridge structure. This adjustment eliminated the need for multiple bus pullouts on the bridge and eliminates rider queues within the bridge multi-use path. One of the two TriMet bus pullouts on the existing Burnside Bridge was included in the new design just before the westbound right-turn lane. This bus pullout accommodates TriMet's existing operational need for some buses to dwell outside active traffic lanes before going into service.

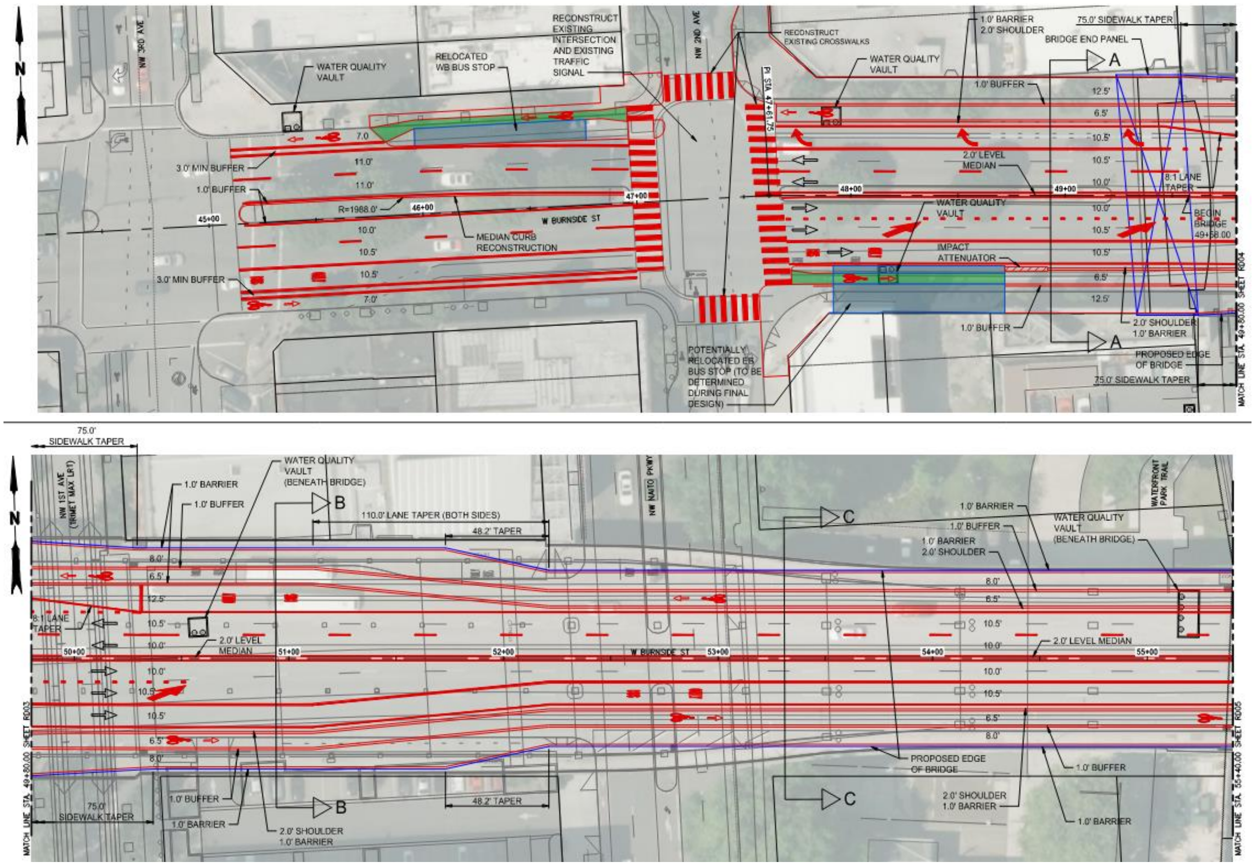
Additionally, a relocation of the eastbound bus stop was discussed by the Project team, City, and TriMet. The existing stop is located just west of 2nd Avenue, and the proposed relocation would be just east of 2nd Avenue before the start of the bridge end panel. Further coordination with TriMet and PBOT will be required during the Final Design phase to make a decision on whether this bus stop will be relocated.

Other geometry required for transitioning to reduced vehicular lanes and reduced sidewalk width off the bridge is listed below:

- Transitions from six lanes and four lanes between NW 1st Avenue and NW Naito Parkway.
- Eastbound Direction – There are three existing lanes (two general purpose and one bus-only) at NW 2nd Avenue. For options that reduced to two eastbound lanes on the bridge, the merge needed to occur east of NW 2nd Avenue due to traffic signal operations. This merge extended onto the West Approach due to merging distance requirements.
- Westbound Direction – Two general purpose lanes and a right-turn lane need to start on the West Approach due for traffic signal operations at NW 2nd Avenue.
- Trees within the median between NW 1st Avenue and NW 2nd Avenue are assumed to be removed to provide wider bicycle and pedestrian facilities. At this location, extra space for pedestrians is important for the patrons that queue within the NW sidewalk at the Portland Rescue Mission building entrance.

See Figures 3a and 3b for a snapshot of the lane transitions at the west approach, and see Appendix A for the full-scale plan sheets.

Figures 3a and 3b. West Approach Lane Transitions: Westbound Bus Dwell Space and Eastbound Lane Taper



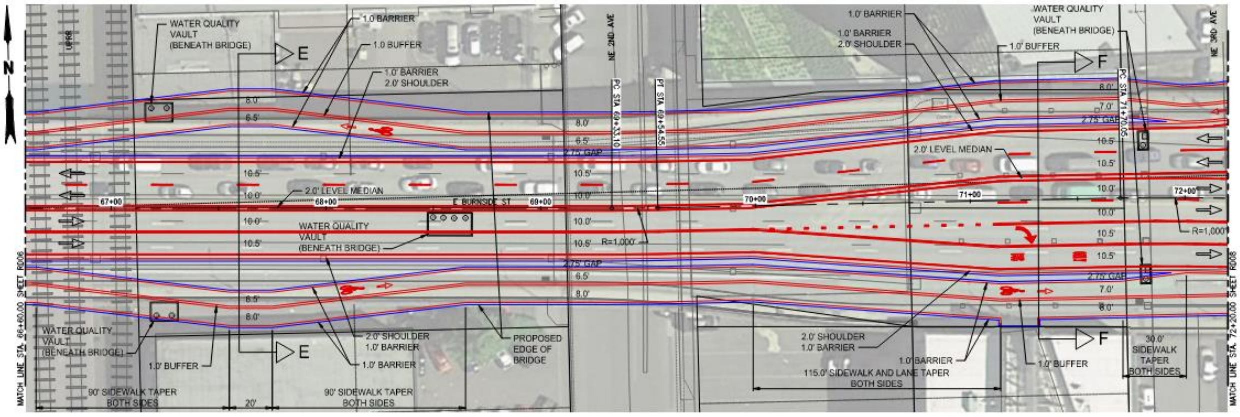
East Approach Transition

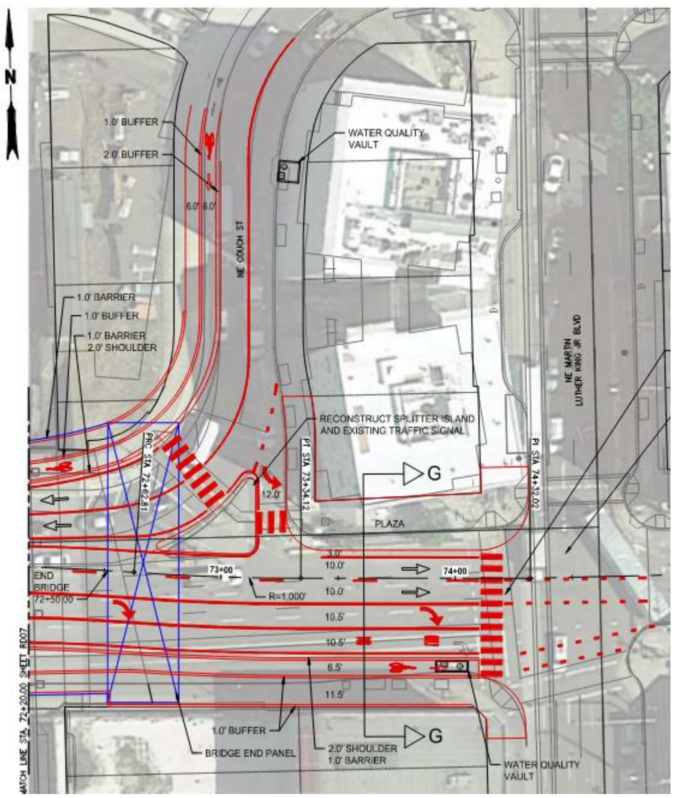
Geometry required for transitioning to additional vehicular lanes and reduced sidewalk width off the bridge are listed below:

- Transitions from four lanes and six lanes between NE 2nd Avenue and NE 3rd Avenue.
- Eastbound Direction: East end of the East Approach needs to widen to four eastbound lanes (two general purpose lanes, a right-turn lane, and a bus-only lane) due for traffic signal operations at NE Martin Luther King Jr. (MLK) Boulevard.
- Westbound Direction: There are two existing lanes at NE Couch Street. For options that reduced to one westbound lane on the bridge, the merge needed to occur west of NE Couch Street due to traffic signal operations. This merge extended onto the East Approach to avoid requiring lane changes in the existing sharp “S” curves west of NE Couch Street.

See Figures 4a and 4b for a snapshot of the lane transitions at the east approach, and see Appendix A for the full-scale plan sheets.

Figures 4a and 4b. East Approach Lane Transitions





4.2.2 Recommended Preferred Horizontal Alignment

Several road alignments were evaluated in previous phases of the Project and narrowed down to two alignments for study in the NEPA phase. One preferred alignment was carried forward into type selection.

The preferred horizontal alignment would generally maintain the existing alignment of Burnside Street across the entire bridge. The existing one-way couplet of NE Couch Street for westbound traffic and E Burnside Street for eastbound traffic would be maintained, including the existing “S” curves for NE Couch Street. Minor alignment differences between Long-span structure types on the East Approach were necessary to accommodate structural components (tied arch ribs and cables), avoid existing buildings on both sides of the river, and to tie into lane transitions for the approach roadway. For this TSR, the preliminary horizontal alignment applied to each bridge type option is shown in the Roadway plans (Appendix A).

4.3 Summary of Vertical Profiles Studied

Various profiles were developed for a low movable bridge alternative located on the existing alignment. The objective of the chosen vertical profile is to maintain or slightly exceed the existing closed bascule span clearance over the navigation channel and satisfy other land transportation mode clearances (see Table 2 for a summary of vertical clearance requirements).

Additionally, the profile needs to maintain existing sidewalk access to adjacent buildings west of NW 1st Avenue, and east of SE 2nd Avenue. Furthermore, profiles studied focused on maximizing vertical clearances over Tom McCall Waterfront Park in order to provide emergency vehicle access within the park. It is also important to minimize grade as much as possible to encourage walking, biking, and rolling on the bridge. Lastly, for the bascule movable span, it is desirable that the high point of the vertical crest curve be placed at the toe/center of the bascule span to ensure stormwater runoff flows away from the open joint at the center of the span.

This resulted in profiles with a maximum grade of 4.97 percent. While this meets the 5 percent maximum grade requirement for Americans with Disabilities Act (ADA) accessibility, less steep grades are typically desired by the ADA community.

4.3.1 Recommended Vertical Profiles for Future Phases

Continued design development evaluated opportunities to reduce grade while ensuring the high point was located at the center of the movable span and vertical clearance requirements were met. Two viable profiles were identified to address the objectives:

Profile Option 1

- Maximum grade of 4.6 percent.
- Provides emergency access clearances within Tom McCall Waterfront Park.
- Utilizes compound vertical crest curve (two adjacent crest curves).
- High point of the profile located at the center of the bascule span.
- Western and eastern crest curve is symmetrical on the bascule span creating structural and geometric symmetry for the bascule leaves.
- Grade is relatively flat within the movable span therefore requiring drainage inlets.

Profile Option 2

- Maximum grade of 4.75 percent.
- Provides emergency access clearances within Tom McCall Waterfront Park.
- Utilizes single vertical crest curve.

- High point at the center of the bascule span. This allows for the stormwater runoff to drain away from the open joint located at the centerline of the span.
- The crest curve is not symmetrical on the bascule span. Symmetrical geometry between the west and east bascule leaf is advantageous for detailing and design of the movable span and movable bents. Therefore, this is less desirable in comparison to Option 1.
- Grade is steeper than Option 1, therefore drainage inlets are not required on the movable span.

For this TSR, the preliminary bridge profile grades applied to each bridge type option are provided in the Roadway plans (Appendix A).

4.4 Vertical and Horizontal Clearance Requirements

Table 2 identifies the vertical clearance requirements and preferred clearances taken into consideration for vertical profile, span configuration, and superstructure type. Both of the vertical profile options discussed in Section 4.3.1 above meet both the preferred and required vertical clearances listed in Table 2 below.

Table 2. Vertical Clearance Requirements

Facility	Required Vertical Clearance
City Streets - NW Naito Pkwy and NE 2nd Ave	18’-0”
City Streets - NE 3rd Ave	13’-7” (provide at least as much as existing)
City Sidewalks	12’-0”
TriMet LRT (NW 1st Ave)	15’-6” above top of rail (provide at least as much as existing)
Tom McCall Waterfront Park	14’-0”
Burnside Skatepark	Maintain existing
Interstate 5	17’-3” (required) 18’-0” (preferred)
Interstate 84	17’-3” (required) 18’-0” (preferred)
Union Pacific Railroad	23’-6”
River Navigation	147’ above ordinary high water (open position) 49’ above ordinary high water (closed position)

Table 3 identifies horizontal clearance requirements taken into consideration for span configuration and interior bent layout.

Table 3. Horizontal Clearance Requirements

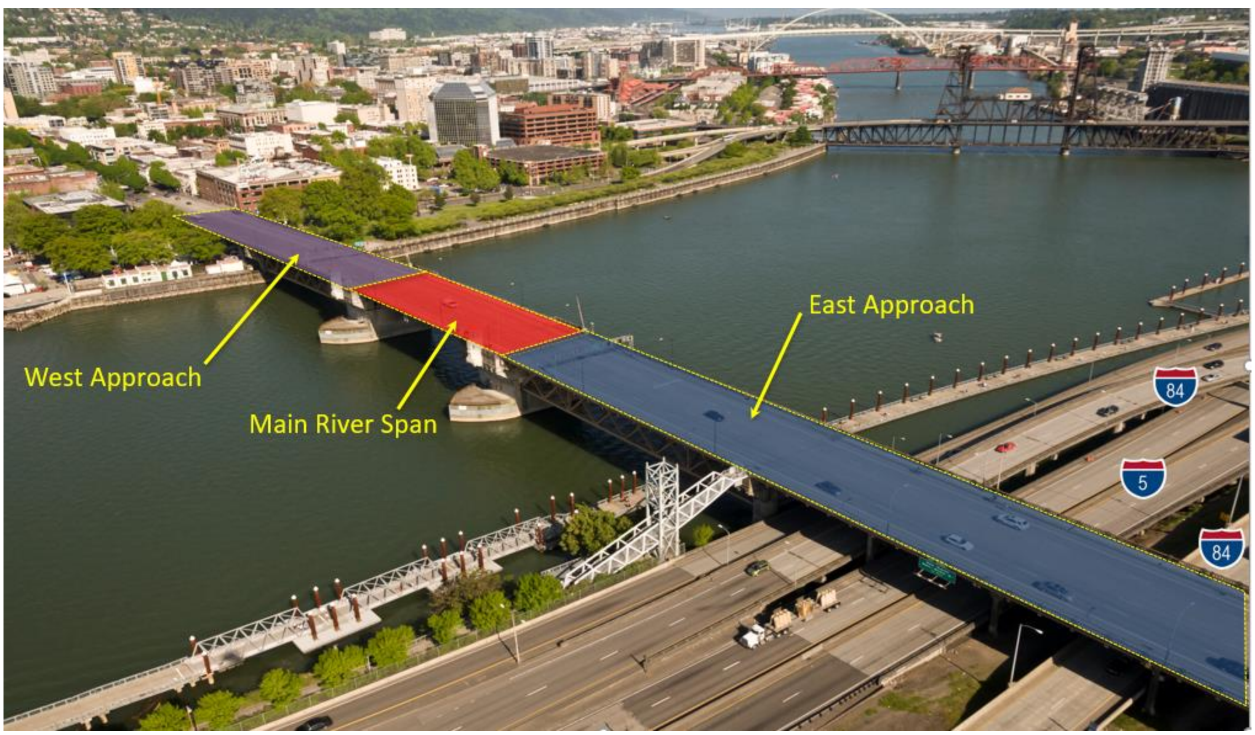
Facility	Required Horizontal Clearance
Existing Buildings	2'-0"
Combined Sewer Overflow Line	26' (measured from CL pipe)
Union Pacific Railroad	27'-0"
River Navigation	205' (permanent condition) 165' (temporary construction condition)

5 Long-span Development

5.1 Preferred Alternative (Long-span) Description

The Long-span Alternative measures 2,292 feet in total length and is comprised of three identified bridge segments: The West Approach, Main River Span and East Approach. Sections 5.2 through 5.4 will discuss the bridge types and options development within each of these segments.

Figure 5. Burnside Bridge Segments



5.1.1 Span Configuration Options Evaluated

Several constraints identified throughout the project site and were taken into consideration for bridge layout and span configuration. Bridge substructure and foundations were kept clear of these key constraints, identified in Table 4.

Table 4. Key Span Layout Constraints and Features

Region	Key Constraints
West Approach	Tom McCall Waterfront Park, Japanese Memorial, Better Naito Parkway, TriMet LRT, CSO Line, building access, City streets, right-of-way
Within the River	River navigation (Main Channel, Subsidiary West, and East Channel)
East Approach	Vera Katz Eastbank Esplanade, freeway facilities, UPRR, City streets, Burnside Skatepark, building access, CSO Line, right-of-way

As part of the bridge options evaluation, multiple span configurations were considered. Attempts were made to balance the span lengths of the structure, while reducing the number of intermediate supports. Two main options are considered for type selection as identified in Table 5. Span layout considerations will be discussed in detail in subsequent sections.

Table 5. Span Configurations Per Option Evaluated

Identifier	Span 1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7	Span 8	Span 9
Bascule + Arch	75’	140’	162’	138’	292’	278’	720’	285’	80’
Lift + Arch	Option dismissed prior to Type Selection								
Bascule + Cable	75’	140’	162’	138’	292’	278’	600’	405’	80’
Lift + Cable	Option dismissed prior to Type Selection								

For this TSR, the preliminary bridge layout for each bridge type option is provided in the Bridge plans (Appendix B).

As noted in the Table 5, a movable lift bridge option was considered as part of the NEPA phase. However, this structure type was dismissed prior to type selection. As the Long-span Alternative evaluation progressed during the NEPA phase, it was determined by the County and project stakeholders that a below-deck structure, matching existing, was preferred to preserve the historic and existing visual sightline across the Willamette River. The lift bridge has been eliminated from further consideration, due its cost, the visual impact of the above deck features, and the limitation of the vertical clearance associated with a lift bridge.

The subsequent sections will focus on bridge types and elements related to a movable bascule bridge type only.

5.1.2 Bridge Appurtenances

Interior Bridge Rail

Based on County commitments made during the NEPA phase, an interior bridge rail designed to resist vehicular impact will be provided between the roadway and the multi-use paths.

The current roadside safety crash test standard is the *Manual for Assessing Safety Hardware 2nd Edition* (MASH) (American Association of State Highway and Transportation Officials (AASHTO) 2016). All bridges on the National Highway System (NHS) must meet MASH testing requirements. In Oregon, bridges on the NHS require a minimum crash test rating of Test Level 4 (TL-4). The Project is on the NHS and therefore must comply with this regulation.

The 42-inch ODOT standard Vertical Concrete Parapet railing is proposed for the Project. It complies with the MASH TL-4 requirement and is one-foot-wide, accommodating the desired roadway cross-section width.

Exterior Bridge Rail

The exterior bridge rail is considered bicycle-and-pedestrian-only rail and therefore is not subject to vehicular collision loads and does not need to comply with MASH testing requirements.

To accommodate the desired roadway cross-section width, a one-foot-wide rail will be provided. This bridge rail can be designed to meet the aesthetic requirements for the Project.

Illumination

The new bridge will include illumination for all modes of transportation. To avoid narrowing the multi-use paths, all illumination poles are anticipated to be mounted outside of the exterior bridge rail through means of a “blister” or “pedestal.”

Future Overhead Catenary System

As will be discussed in the Section 8.2, the Project must consider future Portland Streetcar systems on the bridge. Streetcar requires an overhead catenary system (OCS) to supply electricity to the car. These overhead wires would span the width of the bridge and be supported on independent poles or could be supported by the proposed illumination poles. Therefore, illumination blisters/pedestals mentioned above would need to be designed to accommodate future streetcar OCS.

5.1.3 Geotechnical Considerations

Shannon & Wilson, Inc. has prepared the *EQRB Preliminary NLTH Geotechnical Report* (Multnomah County 2022d) and companion document *EQRB Final NEPA Geotechnical Report* (Multnomah County 2022b) based on geotechnical investigations and analysis of the project site. The following sections provide a summary of their findings.

Field Explorations

The Project field exploration program includes explorations performed in multiple phases; conducted between September 2016 and November 2021. Thirty-three geotechnical borings and eight cone penetration tests have been collected to form an interpretive subsurface profile.

The region generally consists of a highly variable layer of fill present at the ground surface underlaid with Fine-grained Alluvium, Sand/Silt Alluvium, and Gravel Alluvium. Underlying the Fill and Alluvium units is more competent material identified as the Upper and Lower Troutdale Formation. A weaker Sandy River Mudstone layer was encountered in borings below the Troutdale Formation on the western half of the project. Groundwater was encountered throughout the site and should be expected to fluctuate seasonally.

Seismic Ground Motions

The Project criteria identify two seismic design events: ground motions defined as probabilistic with a 1,000-year return period, and deterministic mean motions for a CSZ full rupture event. Design and target spectra were first developed, and then earthquake time histories that are consistent with those target spectra were established using Probabilistic Seismic Hazard Analysis and Deterministic Seismic Hazard Analysis methodologies.

Site-response Analysis and Ground Improvement Recommendations

Site response analysis was performed to evaluate the seismic hazards and permanent ground displacements at the site. Seismic hazards considered in the evaluation include ground shaking, liquefaction, and associated effects (e.g., flow failure, lateral spreading, and settlement), ground surface fault rupture, tsunami, and seiche. It was determined that the potential for fault rupture is low and the potential for seismically induced tsunami and seiche is very low. However, the potential for liquefaction and liquefaction-related effects is high for the project site. The 2-dimensional (2D) Fast Lagrangian Analysis of Continua (FLAC) software was used for the site-response analysis. The 2D FLAC modeled the site-specific soil profile that varied both vertically and laterally along the bridge alignment, as well as considered existing key features like the harbor wall along the west riverbank, and existing Pier 1 foundations. The remaining regions only considered free-field soil response. Models for both with and without ground improvement within the eastern approach were analyzed to facilitate ongoing design efforts of the East Approach foundations.

It was identified that the project site is susceptible to significant liquefaction and liquefaction-induced lateral spreading at both approaches and potentially within the river channel (though additional evaluation within the channel taking into account the post-construction conditions is expected to indicate that liquefaction-induced lateral spreading within the channel is negligible). Therefore, mitigation measures in the form of ground improvement were explored. Possible ground improvement methods include excavation and replacement, soil densification, (e.g., vibro-compaction, deep dynamic compaction), drainage (e.g., EQ Drain), soil cementation (e.g., jet grouting, deep soil mixing), or a combination of these methods. The selection of an appropriate mitigation method(s) for a site depends on factors such as soil type, site access, right-of-way (ROW) constraints, cost, environmental concerns, and vibration impacts on existing facilities. Based on the project site conditions, soil cementation by a specialized type of deep soil mixing (cutter method) is the anticipated ground improvement method. Deep soil mixing is only considered feasible when obstructions, such as timber piles, are removed in advance of the operation. It is assumed that this will be performed in advance of the operation. Site specific ground improvement recommendations within each region of the bridge will be discussed in subsequent Sections 5.2.5, 5.3.10 and 5.4.6.

Foundation Recommendations

Foundation selection for the proposed structure will need to support significant static and seismic vertical and lateral loads. Foundation design will also need to address liquefaction and liquefaction-induced lateral spreading, settlement, and downdrag loading effects. Due to these factors, and due to the deep depths to reach the competent Troutdale Formation soil layer, deep foundations are recommended for the entire project.

Bridge Abutments

Based on the anticipated range of design loads, small diameter drilled shafts are suitable. Driven piles are not preferred due to the potential vibration impacts to adjacent existing structures and underground utilities.

Land Bents

Based on the anticipated range of design loads, large diameter drilled shafts bearing on the Lower Troutdale Formation are considered the most economical and feasible foundation solution. Groups of driven piles are not preferred due to the potential vibration impacts to the existing structures and underground utilities.

In-Water Piers

Foundations considered for the in-water piers supporting the movable spans were large diameter driven pile groups, caissons, and large diameter drilled shafts. Advantages and disadvantages of the three improvement types considered are listed below and summarized in Figure 6:

- Driven Pile – Not considered structurally feasible due to anticipated design loads, in particular uplift demands. Additionally, hard driving conditions within the gravel alluvium and Lower Troutdale Formation layers are expected. This could require augmented driving with an impact hammer. Extended driving periods with impact hammers could be subject to greater environmental considerations.
- Sunken caisson – Constructed by using a series of sequentially placed precast or cast-in-place concrete sections, then sunk to the planned tip elevation by the self-weight of the sections. Typically, the interior cells of the caisson are dredged. This option requires complete removal of the existing foundations as they are in conflict. In addition, variable subsurface conditions underlying the in-water foundations could cause tilting or misalignment of the caisson during the installation process.
- Large diameter drilled shafts – Based on the anticipated range of design loads, large diameter drilled shafts bearing in the Lower Troutdale Formation are considered the

most economical and feasible foundation solution. A permanent steel casing is provided within the water column and can be terminated in alluvium layers.

Figure 6. Excerpt from Geotechnical Report Comparison of Foundation Alternatives at In-Water Bents 6 and 7

Foundation Type	Advantages	Disadvantages
Sunken Caisson	• Sections may be precast on land in a controlled environment • Pile cap is not required • Large cross-sectional area is beneficial in resisting scour effects	• Installation may be challenging due to variable subsurface conditions • Very sensitive to differential settlement • Requires complete removal of existing bascule piers • Requires removal of all existing timber pile foundations within caisson footprint
Drilled Shaft Group	• Shafts can be designed for variable subsurface conditions • Existing pile removal limited to proposed drilled shaft locations • Does not require complete removal of existing pile caps	• Drilled shaft quality control will be both challenging and critical to foundation performance • Difficult to construct large diameter drilled shafts on a temporary work bridge in the river, especially using an oscillator for shaft construction • Requires construction of a pile cap

2022. Multnomah County. EQRB Preliminary NLTH Geotechnical Report. Exhibit 10-1. Page 126.

Testing Recommendations

As previously stated, drilled shaft foundations are recommended to be tipped in the Lower Troutdale Formation. This layer has significant strength and can develop high foundation resistances. The Lower Troutdale Formation resistance and load deformation properties based on axial load test data from nearby projects including the Tilikum Crossing Bridge and the I-5 Columbia River Crossing were evaluated as an additional source of data for the Project. Based on the comparison of Standard Penetration Test resistance, shear wave velocity measurements, and material descriptions, it is anticipated that the Lower Troutdale Formation encountered at the project has equal or greater strength compared to that of the Tilikum Crossing Bridge and I-5 Columbia River Crossing test sites.

Given this information, recommended nominal unit side and base resistances for the project have been calibrated for these reference load tests. Higher values could likely be developed at the project site. Since these design properties are calibrated to load tests from nearby projects, a project-specific testing program is recommended, using bi-directional load testing methods such as an Osterberg-cell (O-cell) testing on sacrificial test shafts loaded to failure.

5.1.4 Summary of Type Selection Analysis

To develop bridge option member sizes and support the bridge type selection process, a limited structural analysis was performed in this phase. The project-specific performance requirements and design acceleration response spectra extend beyond standard code-based requirements. This added level of performance expectation results in significant seismic demands on the structure. Designing the structure for these demands may require non-standard solutions compared to those typically seen for bridge structures within the region. The analysis conducted within this phase is preliminary in nature and not exhaustive for every load demand and load combination.

Preliminary Design and Analysis Approach

Initial conceptual component sizing was established using empirical methodology based on general guidelines for span to depth ratios and previous experience with similar design projects. Then, preliminary strength and service limit state analyses were conducted to refine the initial component sizing. This sizing then became the basis for the more comprehensive seismic analyses conducted at this stage.

Following the initial component sizing, preliminary extreme limit state analysis was done to verify the substructure and foundations would satisfy the Project's performance criteria discussed in Section 3. A linear-dynamic analysis method, Response Spectra Analysis (RSA), was used to measure the mode of vibration of the structure to determine the seismic response of the bridge. Seismic displacement and force demands were determined by subjecting the bridge to three orthogonal design spectra and then combined the response in one orthogonal direction with 30 percent of the response in the other two directions.

Baseline RSA models were developed to capture the global behavior of the conceptual bridge options discussed in Section 5.1.1 (Figure 7 and Figure 8).

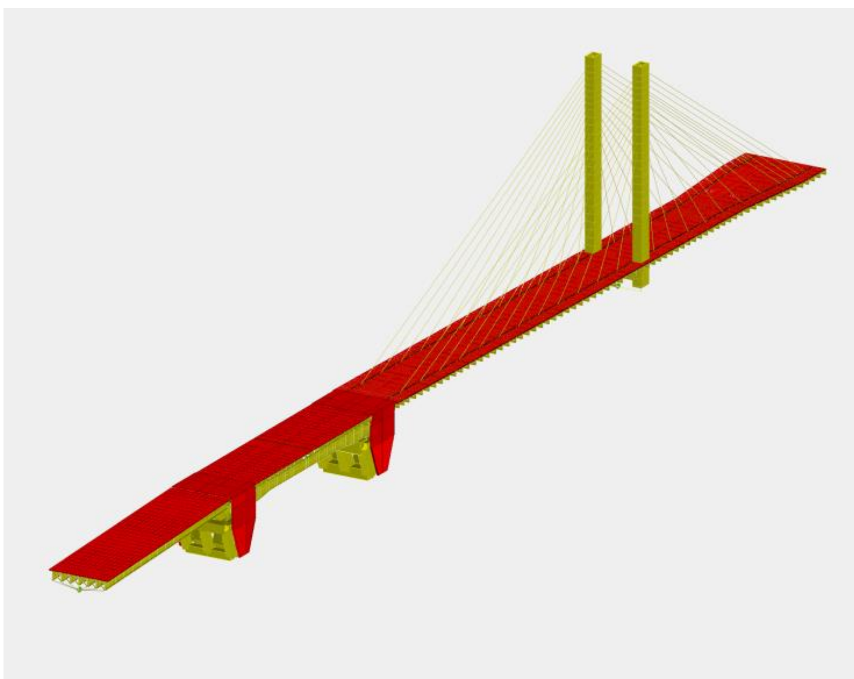
Regions of the structure were modeled as applicable, as noted below:

- West Approach Conventional Spans: Spans 1 through 4
- West PL Girder + Bascule + Tied arch: Span 5 through 7
- West PL Girder + Bascule + Cable stayed: Span 5 through 8

The resulting elastic seismic demands were used to verify the proposed substructure and foundation configurations to be discussed in subsequent sections. See Section 5.2 through 5.4 for more in-depth discussion of the analysis conducted to provide a basis for the bridge type selection.

Figure 7. Baseline LARSA 4D RSA Model: Bascule with Tied arch

Figure 8. Baseline LARSA 4D RSA Model: Bascule with Cable stayed



5.2 West Approach

The West Approach extends from west of 1st Avenue to the western in-water bent within the Willamette River. The West Approach spans over a range of facilities: City of Portland streets, TriMet light rail (LRT), Better Naito Parkway, Tom McCall Waterfront Park, West CSO, parking facilities, and subsidiary river navigation routes.

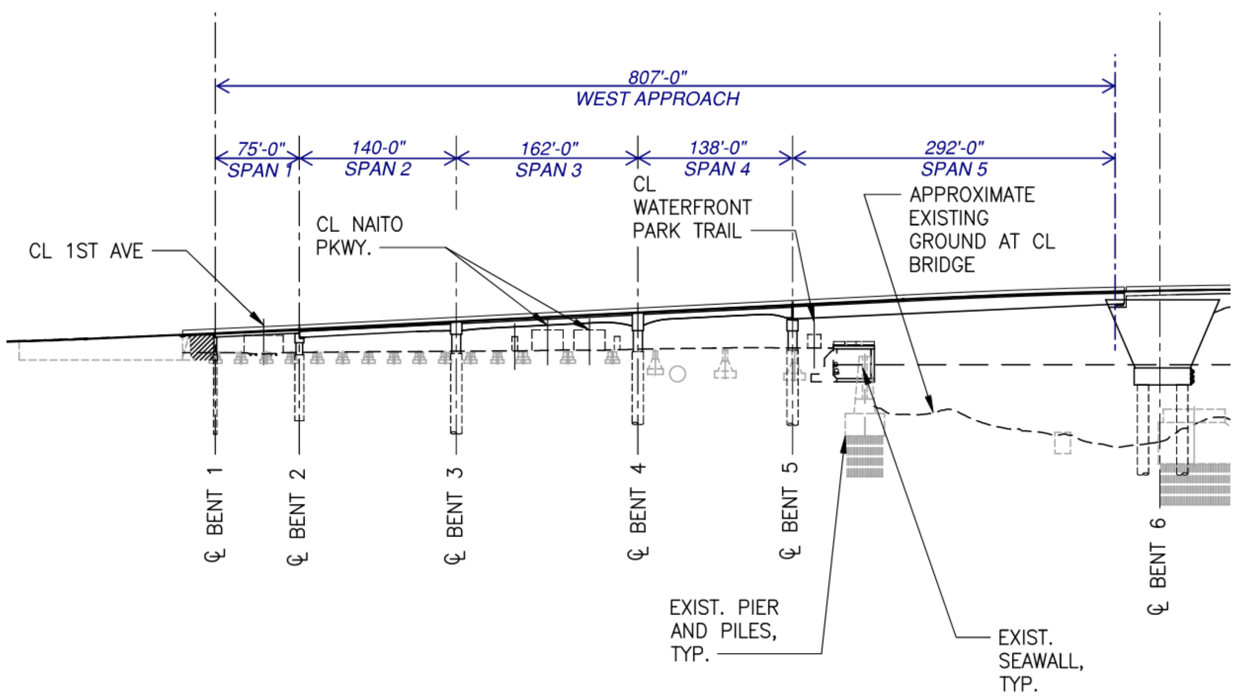
The total length of the West Approach is 807 feet in length and is the same for either bridge option chosen on the East Approach. Multiple bridge types were considered for the West Approach including initial long-span options. However, during the SDEIS, limiting the West Approach bridge types considered to conventional slab on girder type structures resulted in a lower cost structure and reduced impacts to the surrounding built environment.

Although an above deck structure results in longer spans and fewer intermediate bents, it would be more costly and would have greater impacts to the visual experience within the downtown corridor. Conventional slab on girder bridge types, which preserve the open views at the deck level and of the adjacent historic buildings, are more cost effective and avoid these adverse effects to the Skidmore/Old Town Historic District NHL.

It was still very important, though, to reduce the number of supports within Tom McCall Waterfront Park in comparison to the existing structure in order to provide a more enhanced urban design experience for facilities such as the Portland Saturday Market and the Japanese American Historical Plaza.

Conventional superstructure types considered are discussed in subsequent sections.

Figure 9. West Approach Spans



5.2.1 Conventional Spans

Layout and Configuration

The conventional span arrangement and span lengths for the West Approach are primarily driven by the surrounding building, roadway, and park constraints. Span length considerations sought to balance vertical clearance demands underneath the bridge while reducing the number of intermediate bents in comparison to the existing bridge. Several span configurations were evaluated for the West Approach including conventional span lengths as well as a mixture of conventional and longer spans which would require above deck structures. Reference the *EQRB Revised Bridge Replacement Technical Report* (Multnomah County 2022f) for a full evaluation of all span lengths considered.

The CTF along with other Project stakeholders discussed the importance of protecting the integrity of the historic and visual resources of downtown Portland through the Burnside Street corridor. This led to the decision to limit significant above deck features. Since longer spans would require above deck structural components (i.e., tied arch, truss, etc.) a decision was made to limit the west spans to common span ranges suitable for conventional below deck superstructure types; ultimately eliminating consideration of long span structures for the West Approach.

Thus began a process to narrow down the preferred conventional span arrangement that would best accomplish the following objectives:

- Reduction of supports, specifically within Tom McCall Waterfront Park in order to increase sight distance and safety for recreational park users. Additionally providing vertical clearance within Tom McCall Waterfront Park for emergency access vehicles. Taking advantage of the structural efficiency of continuous girder spans.
- Constructing the new abutment in front of the existing allowing for easier construction access. The existing abutment would remain in place to retain the roadway embankment.
- Elimination of existing bent within the TriMet LRT tracks at 1st Avenue.
- Reasonable span lengths and construction considerations for girder transport and erection over City streets and next to adjacent existing buildings.
- Providing a superstructure option that is suitable for aesthetic treatment like girder haunching.
- Avoiding impacts to the west combined sewer overflow (CSO) line that runs underground through Tom McCall Waterfront Park.
- Clear spanning between the Seawall and the west movable in-water bent in order to eliminate obstructions to river navigation.
- Ensuring access to the White Stag building garage.
- Ensuring parking lot functionality (ingress and egress) below the bridge to the west of Naito Parkway.

Taking into consideration the above objectives and the constraints identified in Section 5.2, the bent placement shown in Figure 8 above is the recommended span configuration for the West Approach.

Span 1 near the TriMet Light Rail (LRT) Station spans both the eastbound and westbound tracks, which is an improvement to the existing condition. Spanning both tracks and eliminating an intermediate support between tracks, allows for easier construction and less obstructions to the LRT. Additionally, the adjacent bents are located at the back of sidewalks in order to increase the width of the LRT platform. This initial span is also as long as feasible while still providing adequate vertical clearance underneath the bridge; spans lengths longer than proposed would require a deeper superstructure.

Spans 2 through 4 were arranged to eliminate impacts to Naito Parkway, the west CSO line, and the existing harbor wall. Additionally, Bent 5 has been located to limit impacts to the existing pedestrian sidewalks and general multi-modal connectivity throughout Tom McCall Waterfront Park.

This has resulted in a longer span length for Span 5; however, it is still within the limits of a conventional superstructure type. Span 5 spans the subsidiary west navigation channel under the bridge. This eliminates the need for temporary and permanent impacts to the Willamette River.

Superstructure

For span lengths within this range, the following conventional superstructure types were considered feasible.

Cast-in-Place Post-tensioned Slab (Span 1 only)

- Cast-in-place concrete offers flexibility to accommodate any alignment or profile.
- Added construction complexity for prestressing the superstructure onsite.
- Requires access to install and remove falsework for superstructure construction.
- Increased construction duration due to falsework placement, concrete cure time, and falsework removal.

Precast/Prestressed Concrete Voided Slabs (Span 1 only)

- Grade control is more difficult compared to cast-in-place options.
- Falsework is not needed to erect the precast slabs, only to construct the structural deck topping.
- Shorter field construction time compared to cast-in-place options thereby reducing service disruptions to transit underneath the bridge.

Precast/Prestressed Concrete Bulb Tee Girders (Spans 2 through 4)

- Minimal/no falsework supports required to erect girders. However, significantly heavier than steel thus heavier lifting weights for erection.
- Deeper structure depths in comparison to steel options. Reduces vertical clearance above key facilities on the West Approach.
- Significantly heavier than steel options thereby increasing demands to substructure and foundations resulting in increased foundation costs.
- Grade control is more difficult compared to steel options.
- Historically, concrete material prices more stable than steel.
- Decreased aesthetic opportunities in comparison to steel plate girders. Cannot efficiently accommodate aesthetic girder haunching at the supports as efficiently as steel.

Steel Plate Girders (Spans 2 through 4)

- Minimal / no falsework supports required to erect girders. Girders are typically lighter than concrete options. Ability to field splice allows for easier girder transport to the site and lighter lifting weights for erection.
- Typically, shallower structure depth than precast bulb tee, increasing vertical clearances over facilities on the West Approach.
- Lighter structure weight compared to concrete options, thus reducing demands to substructure and foundations resulting in more cost-effective foundations.
- Future maintenance costs could be more than concrete options if steel girder painting is required.
- Historically, steel material prices can be more variable than concrete.
- Steel plate girders can be haunched at the intermediate supports to meet aesthetic requirements for the project.

Steel Plate Girders (Span 5 only)

- Lower fabrication cost in comparison to steel tub girders for span lengths like Span 5.
- Lighter structure weight in comparison to steel tub girders, thus reducing demands to substructure and foundations resulting in more cost-effective foundations.
- Lighter lifting weights for erection in comparison to steel tub girders.
- Decreased aesthetic opportunities for plate girders.
- Increased opportunities for bird nesting habitat which may require mitigation in the field.

Steel Tub (Box) Girders (Span 5 only)

- Greater fabrication cost in comparison to steel plate girders for span lengths like Span 5.
- Higher lifting weights for erection in comparison to steel plate girders.
- Increased aesthetic opportunities for steel tub birders.
- Painting/coating required on inside surfaces of the box for corrosion and inspection.
- Access into tubs required for maintenance and inspection of interior surfaces.

Precast/Prestressed Concrete Box or I-Girders (Span 5 only)

- For span lengths like Span 5, superstructure will need to be spliced and post-tensioning thereby increasing construction complexity.
- Higher structure weight in comparison to steel options, thus increasing demands to substructure and foundations resulting in increased costs.
- Falsework required for superstructure construction.

Preferred Recommended Structure Types

Given the opportunities and constraints noted with the structure types described above, Precast/Prestressed concrete voided slabs (Span 1) and steel plate girders (Spans 2 through 5) are the preferred superstructure types, respectively. For this TSR, the preliminary bridge layout is provided in the Bridge plans (Appendix B).

Since Span 1 traverses the TriMet LRT tracks, limiting temporary disruptions to the transit service due to construction is important. Therefore, cast-in-place options are not preferred due to the extensive falsework required to construct, as well as its longer construction time required for concrete curing. Within this span, precast bridge construction such as precast superstructure elements are recommended to reduce the impacts to transit. It is recommended that a spread slab configuration be used due to the variable cross slope of the cross-section between the multi-use path and vehicular travel way. This spread slab configuration will require a structural cast-in-place deck, but will beneficially reduce the number of slabs required and eliminate the need for transverse post-tensioning between slabs.

Spans 2 through 4 have vertical clearance requirements over Naito Parkway and Tom McCall Waterfront Park. Concrete superstructure types are deeper than steel options and will not satisfy the Project’s vertical clearance criteria. Further, steel plate girders are lighter in weight, which is highly desirable for reducing the size of its foundations – especially due to seismic demands. Additionally, the Project’s aesthetic aspirations for the West Approach include superstructure depth haunching at the supports, which can be accommodated with steel girders without adding much dead load. Due to these objectives, continuous steel plate girders are recommended for these three spans.

The length of Span 5 exceeds the limits of concrete superstructures such as standard precast/prestressed girders. While splicing of concrete girders is an option, this concept would add needless weight and extra construction duration without any notable benefit. As such, concrete superstructures are not recommended for this span. Regarding steel type options, steel plate girder superstructure types are considered the most feasible for this span length. Steel plate girders are recommended over steel tub girders due to their lower cost and reduced structure weight.

Deck Joints

The deck joints for the West Approach are sized to accommodate moderate to large displacements from seismic and lateral spreading loads expected at Bent 5. Closed expansion joints like a strip seal system are anticipated at Bents 1 and 2. Due to the anticipated movements resulting from seismic and lateral spreading, a modular joint seal assembly type is proposed at Bent 5, though finger joints could be utilized if preferred by the County. A more robust assessment for the joint type will be made during the Final Design phase, in combination with the contractor, and will include noise and maintenance considerations.

Bearings Assemblies

Elastomeric bearings will be used where appropriate to accommodate moderate movements, axial, and lateral loadings. Bearing assemblies will be utilized for bents where significant seismic movement is expected to occur. Base isolation bearings were not considered during the Type Selection phase as they were deemed unnecessary given the preliminary member sizing and expected increase in cost for the West Approach bents.

5.2.2 Substructure and Foundation Considerations

The recommended foundation type for the West Approach foundations is multi-column concrete bents founded on oversized drilled shafts.

- Due to the wider structure width at the roadway approach transition, the proposed configuration for Bent 2 is a seat-type crossbeam and three column/shaft configuration. Preliminary analysis has confirmed 6-foot diameter columns and 8-foot shaft.
- The proposed configuration for Bents 3 and 4 is an integral crossbeam supported on a two column/shaft configuration. Preliminary analysis has confirmed 8-foot diameter column and 10-foot shaft. Crossbeams integral with the superstructure at Bents 3 and 4 result in shallower depths in comparison to seat-type crossbeams. This proposed configuration was required to satisfy vertical clearance requirements at these locations.
- Due to the change in structure depth between Span 4 and 5, a non-integral substructure is required for Bent 5. The proposed configuration for Bent 5 is a seat-type crossbeam and two column/shaft configuration. Preliminary analysis has confirmed 8-foot diameter column and 10-foot shaft. Although a two-column bent would likely require larger diameter columns and shafts than a three-column bent, it was important to minimize the number of columns within Tom McCall Waterfront Park, thereby providing enough horizontal clearance between columns for emergency operations (36-feet is currently provided). Consideration will be given to dapping the ends of the Span 5 girders if required to meet vertical clearances at Bent 5.
- The structural modeling of Bent 5 did not take into consideration the presence of the Seawall. However, the 2D FLAC modeling of the subsurface profile included considerations for the existing Seawall and the Seawall foundation zone and included sensitivity studies assuming no contribution from the Seawall foundations. The 2D FLAC modeling and associated sensitivity studies indicated that the presence of Seawall has the potential to reduce the estimated permanent ground displacements along the western bank.

It is recommended that the West Approach be founded on drilled shafts that extend through the liquefiable soil layers and minimally embedded into the competent Troutdale Formation layer.

Due to liquefaction-induced lateral spreading anticipated to occur near the existing Seawall, the bridge articulation at Bent 5 has been released longitudinally for both adjacent spans. This reduces the inertial seismic demands on Bent 5, which can then be designed for the anticipated lateral spreading demands without ground improvement. Additionally, it is proposed that existing Pier 1 be left in place to further reduce lateral spreading demands anticipated at this bent. Preliminary soil-structure interaction analysis has indicated that the stiffness of Pier 1 in place is beneficial to reducing liquefaction-induced lateral spreading in this region. An alternative approach that can be considered at a later design phase is to provide an oversized casing for column/shaft isolation to accommodate a reasonable amount of soil displacement.

Lastly, Bents 1 through 5 would be designed to accommodate anticipated downdrag loads caused by liquefaction-induced settlements and to provide adequate uplift resistance.

Preliminary Analysis and Design

Preliminary design and analyses were performed on the West Approach as part of the Type Selection phase. The objective of this work was to establish reasonable member sizes for the superstructure, which informed type selection considerations such as cost estimates, constructability reviews, and aesthetics. The design development level of this work can be categorized as proof of concept for comparative analysis of structure types at a similar development level. While the preliminary seismic design was primarily targeted at substructure and foundation sizing, the mass and stiffness characteristic of the superstructure is an important component.

The conceptual design was performed in accordance with *AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition* (AASHTO 2011), *ODOT Bridge Design Manual (BDM)*, and *AASHTO LRFD Bridge Design Specifications, 8th Edition* (AASHTO 2017).

Superstructure analysis was conducted for the precast prestressed voided slabs, continuous steel plate girder spans and the simply supported steel plate girder span. Beam line analysis utilizing MDX software was used to evaluate the steel plate girder spans and develop an effective plate girder section for Spans 2 through 5. Full width analysis utilizing PG Super Software was used to evaluate the precast prestressed voided slabs and develop an effective prestressed strand layout for Span 1.

A global analysis model was developed using CSiBridge software to determine force and deformation effects in various components of the West Approach spans. Displacements and force demands were post-processed through design worksheets to evaluate demand to capacity performance ratios, bearing reactions, and displacement ductility. The global coordinate system is an orthogonal XYZ Cartesian coordinate system, with X axis in bridge longitudinal direction pointing East, Y axis in bridge transverse direction pointing North, and Z axis in upward direction. The coordinate system is based on the alignment stationing and elevation (NAVD88) of the structure.

The conceptual design considered dead, live, thermal, and seismic loads as follows:

- Dead Loads
  - Concrete and steel unit weights consistent with the project-specific design criteria.
  - Steel member sizes with a factor to account for connections and miscellaneous attachments.
  - 8.5-inch-thick concrete deck at Span 1, 9.5-inch-thick concrete deck at Spans 3 through 5.
  - Four bridge rails at 400 plf. The value is conservative as pedestrian rails at multi-use path will be substantially less than the assumed value.
  - 40 psf future wearing surface consistent with project-specific design criteria (and ODOT BDM).

- Live Loads:
  - HL-93 truck and lane loads per AASHTO LRFD. Force demands considered both influence line to individual vehicular lanes and influence area to the full roadway surface.
  - Pedestrian live load at 75 psf consistent with project-specific design criteria (and ODOT BDM).
- Thermal Loads:
  - Uniform temperate applied to full structure with rise, fall, and mean per ODOT BDM.
- Seismic Loads:
  - Site specific acceleration response spectra for both a Full Operation Design Event and Limited Operation Design Event, developed in accordance with the project-specific design criteria.
  - Permanent loads were considered as excitable seismic mass.

Given the objectives of the conceptual design, a series of assumptions were made to simplify the design work. This includes utilizing:

- Boundary conditions effecting the longitudinal response of the structure.
- Bearing stiffness at simply supported spans.
- Assumed foundation depth for fixity.

5.2.3 Stairway Connection Structures

The Project assumes the existing stairway connection structures on the West Approach at 1st Avenue will be removed and not be replaced. Instead, sidewalk improvements to NW Couch Street and SW Ankeny Street between 2nd Avenue and 1st Avenue will be constructed. A discussion on existing conditions and alternative connections studied during the NEPA phase can be found in Section 8.3.

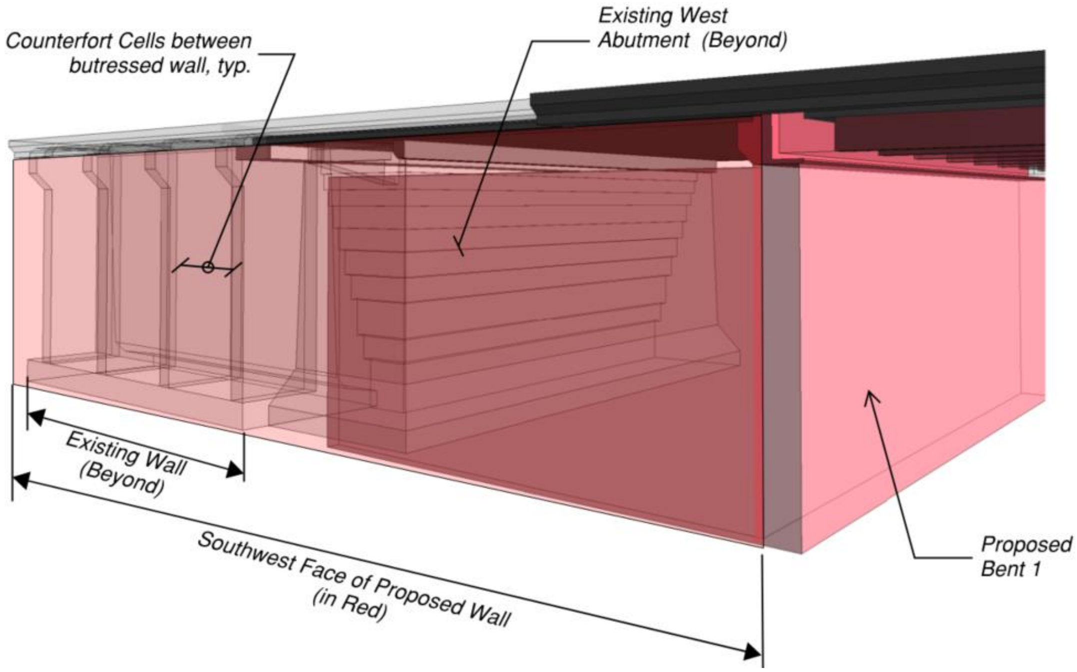
5.2.4 Retaining Wall Systems

Existing Conditions

There are existing retaining walls at both the NW and SW quadrant of the bridge extending between W 1st Avenue and W 2nd Avenue.

- Based on the existing as-Builts and site visits, the northwest wall is a concrete cantilever wall that abuts or fuses with the adjacent building. The sidewalk above, is built on retained fill.
- The southwest wall is a concrete counterfort/buttressed wall with “cells” or “openings” into the basement of the adjacent building. The sidewalk above, cantilevers off the stem wall and spans the buttressed cells.

Figure 10. Isometric View of Existing West Abutment and Walls with Proposed Elements



Proposed Southwest Wall

- Southwest building adjacent to bridge, to be demolished and removed.
- It is proposed that the existing counterfort wall remain in place to retain the West Approach fill to help facilitate construction.
- A proposed structural retaining wall system will be placed south of the existing wall footing and will function structurally to retain fill when the existing wall fails. Cells of the existing counterfort system will be backfilled.
- New wall heights range from 10 to 20 feet, which typically require a tieback system. Tiebacks would be placed through the counterfort cells extending into the approach embankment. Therefore, a soldier pile wall with tiebacks is proposed, although other precast options with or without tiebacks, such as a precast counterfort system, could also be used. All retaining wall options will be re-evaluated in the Final Design phase.

Proposed Northwest Wall

- Northwest building adjacent to the bridge to be protected and remain in place.
- The existing cantilever wall west of the existing abutment appears to be used by the existing building as the exterior wall of its basement. Given this, it is imperative that this wall, to the maximum extent possible, be protected in place to preserve the structural integrity and exposure of the existing building. Excavation in this region will need to be kept to a minimum; likely limited to constructing the new sidewalk and roadway section above the retained fill.
- Since the new western abutment will be in front of the existing abutment, a new structural retaining system is required between the existing and proposed

abutments. Wall heights up to 20 feet are expected. Therefore, a mechanically stabilized earth wall is proposed, with flowable fill or other backfill material placed behind the abutment to allow for easy placement and self-compaction. Other abutment wall options will be re-evaluated in the Final Design phase.

5.2.5 Geotechnical Seismic Hazards and Proposed Mitigation

For a general discussion of site geology and subsurface conditions, see Section 5.1.3.

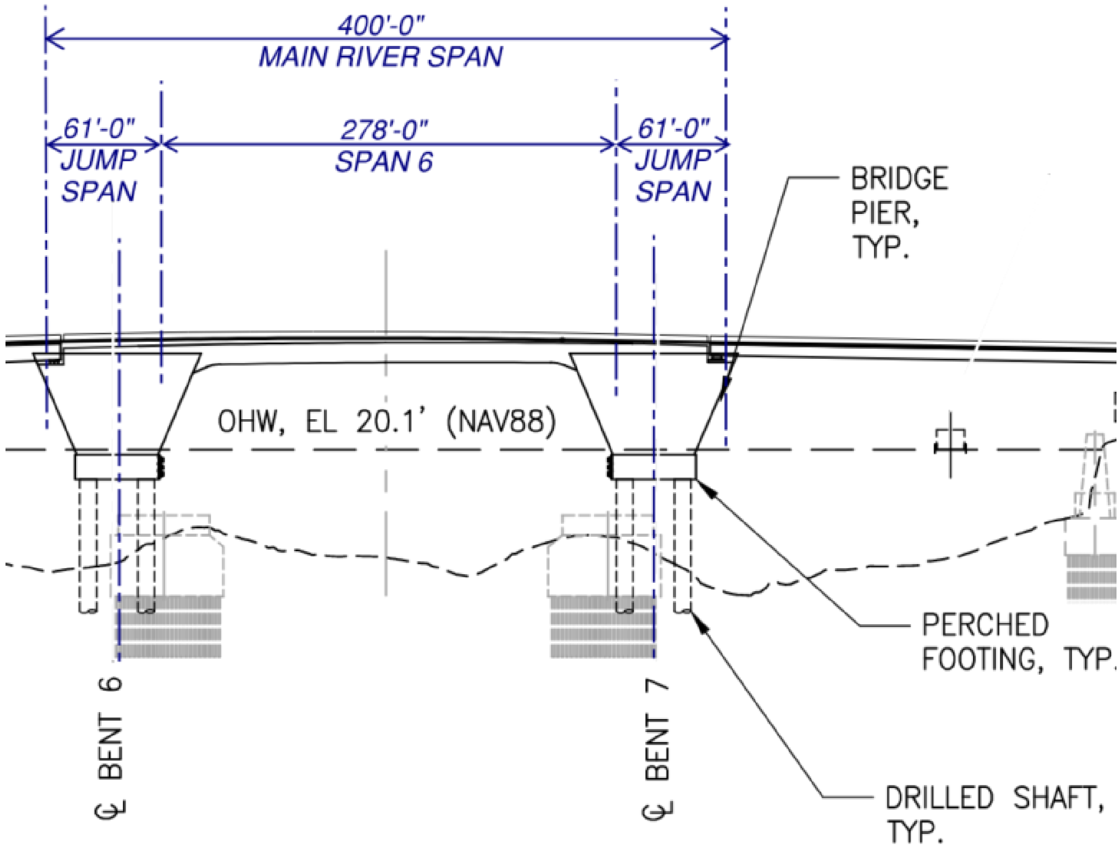
Based on the nonlinear site response analysis for the 1,000-year probabilistic hazard level, seismically induced permanent ground deformations on the order of five inches maximum are expected at Bent 5. The primary zone of permanent deformation at this location within the Sand/Silt Alluvium layer between approximate Elevation 35.0 and -40.0 feet (NAVD88).

As briefly discussed in Section 5.2.2, seismic hazard mitigation in the form of ground improvement is not required at the West Approach bents. It is anticipated that the foundations will be designed to withstand seismic ground hazards and associated effects.

5.3 Main River Span

The main river span section occurs within the Willamette River and is comprised of the two in-water bents that support the movable span over the primary navigation channel. The main river span measures 278 feet in length between trunnions, and 400 feet in total when accounting for the jump spans (See Figure 11). The jump span is the structural decking (span) that serves as the lid of the pier box above the counterweight. It extends from the bascule span joint to the adjacent fixed approach span joint, and is approximately the length of the movable bent between trunnion and approach bearings.

Figure 11. Main River Span



5.3.1 River Navigation

Glosten prepared the *EQRB Preliminary Navigation Study* (Multnomah County 2022) and *EQRB Allision Analysis* (Multnomah County 2022) based on a preliminary navigation study and allision analysis conducted of the project site. The following provides a summary of their findings.

Navigation Study

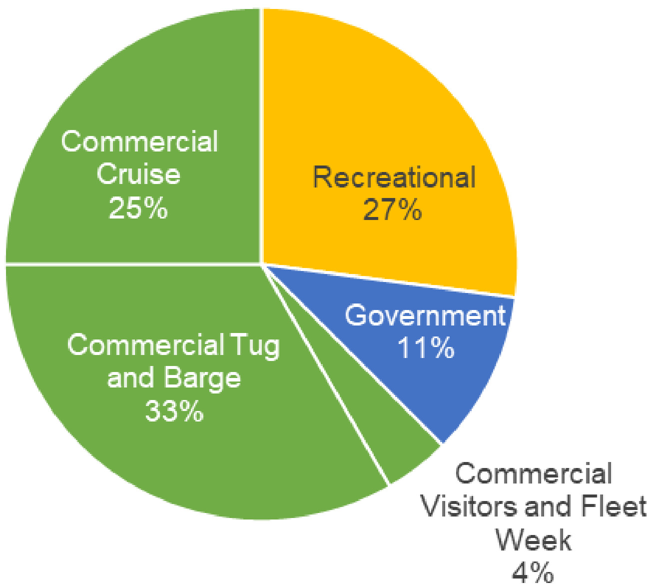
The purpose of the navigation study was to summarize the impacts to vessel navigation under the bridge during temporary construction, to proposed permanent bridge replacement clearance objectives, and describe bridge protection features such as in-water starlings.

River Users

In the navigation study, a river user is defined as a public or private entity expected to transit the Burnside Bridge in a vessel during and/or after bridge modification. A river user may be an individual (such as a private vessel owner) or a group (such as a company, marina, or organization).

As part of the study, 84 river users potentially affected by a change in bridge clearance were contacted or researched. Elevations and horizontal clearance requirements were ultimately obtained for 47 river users. These 47 users are a representative subset of the thousands of actual river users who may transit under the bridge. They fall into three main types: commercial, recreational, or government, as shown in Figure 12.

Figure 12. Distribution of River Users



Vertical and horizontal clearance requirements were provided by the river users themselves, and represent their stated minimum space needed to safely transit the bridge. The basis for these requirements, such as the season and water surface elevation, varies from river user to river user. These clearance requirements were combined to form a clearance window for the Project.

The objective of the study was to determine minimum clearance requirements independent of bridges or any other man-made obstructions. However, many river users could not articulate their clearance requirements without a starting point to consider. This starting point was provided as a set of “Bridge Design States,” representing minimum existing and proposed clearances. All bridge designs fall into one of three states:

- Existing: The current Burnside Bridge. This bascule bridge has different vertical clearances in the lowered and raised positions.
- Temporary: A temporary construction phase consisting of limited clearances.
- Permanent Replacement: The permanent design for a replacement Burnside Bridge with permanent changes to existing clearances.

Recommended Clearances

The USCG requirement to enable 100 percent of vessel traffic to safely transit under the bridge drives the clearance recommendations within the study. The recommendations herein reflect the minimum clearances that will allow all vessel traffic to safely transit the bridge.

- Minimum Vertical Clearance (movable span in the raised position): Elevation 167.0 (NAVD88 datum). This provides approximately 147 feet of vertical clearance above the ordinary high water (OHW) surface elevation (OHW EL. = 20.1 NAVD88).
- Minimum Vertical Clearance (movable span in the closed position): Elevation 69.0 (NAVD88 datum). This provides approximately 49 feet of vertical clearance above the ordinary high water (OHW) surface elevation (OHW EL. = 20.1 NAVD88).
- Minimum Horizontal Clearance (Permanent condition): 205 foot wide
- Minimum Horizontal Clearance (temporary construction condition): 165 foot wide.

The recommended vertical clearance is based on the maximum air draft of all known river users above ordinary high water (OHW), the water level accepted as a design elevation by the USCG and USACE.

For short-term reductions to these clearances during construction, it is reasonable to assume that the USCG will grant temporary deviations to these clearance dimensions, as evidenced by the many recent rehabilitation projects. These temporary deviations, however, are on a case-by-case basis only and should be limited to days and a few weeks rather than months. Temporary deviations may require agreements from affected river users.

Allision Analysis

An allision, or vessel collision, analysis was conducted for vessel traffic transiting under the bridge. Following the method prescribed by AASHTO, the annual frequency of collapse of a bridge due to vessel impacts was calculated. The allision analysis was conducted with the goal of determining the recommended horizontal resistance (H_{des}) of the in-water bent substructure. The *EQRB Allision Analysis* (Multnomah County 2022) is included with the TSR as Appendix D.

Design Vessel Allision

The analysis was conducted with a conservative approach for categorizing and defining design vessels to ensure the methodology was comprehensive in its accounting of vessel traffic. The first step of the allision analysis was to identify users of the waterway that transit under the bridge. Sources for this information include previous studies and publicly available Automatic Identification System (AIS) data.

Annual vessel counts from 2015 – 2017 and 2019 were used to provide general vessel traffic data for the purpose of the allision analysis. Data for 2018 was available for use but was not categorized by vessel type so could not be directly applied to this analysis.

The percentage of vessel type counts in the total vessel counts for 2017 and 2019 were averaged and applied to the 2018 total vessel count to estimate the counts for each vessel type in 2018. It was assumed that data sets from 2020 and 2021 are not indicative of typical traffic patterns due to the COVID-19 pandemic.

Several trends suggest that past traffic data is a conservative estimate of future traffic passing under the bridge. While recreational traffic has steadily increased in recent years, these smaller vessels have a negligible effect on the annual frequency of collapse of the bridge. However, impact forces from small recreational craft should still be considered in design.

The results of the allision analysis indicate that for the “Critical or Essential” designated EQRB, it is recommended that the proposed in-water bents be designed to have a horizontal resistance (H_{des}) of 4,995 kips.

Operating Vessel Impact

In addition to design vessels and methodology used for the allision analysis, impact forces from a designated operating vessel should be considered for movable bridges. This is due to movable bridges having a relatively high rate of allisions from vessels smaller than those governing the annual frequency of collapse. The proposed operating vessel is a 9 meter (29.5 foot) recreational powerboat, reflective of typical recreational vessel traffic on the Willamette River.

The results of the analysis indicate the equivalent static vessel impact force (P_s), from the designated operating vessel is 390 kips.

5.3.2 Movable Bascule Span Configuration

In order to accommodate all river traffic, the movable span length was set to exceed the minimum 205 feet of horizontal clearance required by river users identified in the *EQRB Preliminary Navigation Study* (Multnomah County 2021d). At this length, the width of the channel is prohibitive for a single leaf bascule bridge; thus, a double leaf bascule bridge is being recommended as part of this TSR.

A double-leaf bascule bridge consists of two opposing moving leaves with the leaf toe located in the center of the main navigation channel. A trunnion style double leaf bascule is being considered for this location. The trunnions, located inside the bascule bents act as the point of rotation for the span. The proposed 278-foot span is measured between trunnions of the opposing leaves. This span length was established to provide a sufficient clearance window for the navigation channel defined by both horizontal and vertical parameters in the navigation study, as well as to provide sufficient space for the bascule bents that house the electrical and mechanical machinery that allow the bridge to operate.

Vertical clearance was also considered when determining the initial layout of the span. Bascule girders vary in depth with the shallowest section at the toe or center of the channel and the deepest section at the trunnion support inside the bent. In the closed position the deepest section of the girder controls the vertical clearance for vessels in the channel. The geometry was arranged such that a minimum of 50 feet of vertical clearance above OHW is available for the full 205-foot width of the channel. To provide sufficient vertical clearance for vessels in the waterway, the leaves must open to an angle of approximately 57 degrees.

Taking the location of the existing bridge foundations into account, span arrangements longer than 278 feet were considered. To avoid potential conflicts between new and existing foundations, a longer movable span would locate the foundations behind (away from the navigation channel) the existing footing locations. However, a longer movable span would increase the requirements for the mechanical operations, increase the size of the bascule girders, and require a more robust substructure and foundation to support the additional weight of the span. In consultation with the Multnomah County Owner Representative's constructability team, an in-depth cost analysis was performed, weighing the cost associated with the additional span length against the construction cost associated with foundation conflicts. It was determined that movable spans longer than the proposed 278-foot arrangement did not provide a cost-effective solution. Therefore, longer movable spans that avoid foundation conflicts were eliminated from further consideration.

Preliminary Design

Preliminary design was performed for the bascule span as part of the Type Selection phase. The objective of this work was to establish approximate proportions for the bascule span, which informed type selection considerations such as cost estimates, constructability reviews, and aesthetics. The design development level of this work can be categorized as a "proof of concept" analysis.

The following features of existing bascule bridges were studied:

- Span length from trunnion to toe
- Bascule girder type (box girder vs plate girder) and size
- Bascule girder spacing and cantilever length
- Deck type and weight

An average forward weight per square foot was determined from four similar style bascule bridges with exodermic decks. The average weight was used to approximate the total forward weight of the proposed span. An approximate unit weight for the counterweight, that also derived from similar style bascules, was used to proportion the rear length of the bascule girders and the required size of the counterweights. The resultant moment from the forward span was balanced about the center of trunnion with the rear moment of the counterweight.

Based on the siting of the movable bridge components, details were developed to assist with the seismic design of the substructures by providing main element framing and sizing, trunnion locations, and counterweight size and its center of gravity location. Critical features such as the span locks, bearings, and tail locks were also located.

5.3.3 Movable Span Superstructure

The bascule span superstructure will consist of four parallel bascule girders with traditional stringer and floor beam framing. The girders will be arranged in pairs, each with their own set of operating machinery. Each pair of connected girders will be connected to the parallel pair with floor beams to form a span containing four girders that act as a single unit. Each girder will be supported by a steel trunnion shaft and bearings. These bearings may be supported on individual steel towers or concrete pedestals within the bascule bent. The trunnion support structures will be designed to provide restraint for lateral movement during a seismic event.

The forward weight of the superstructure will be balanced by rear counterweights. Each pair of girders will have its own counterweight. A shorter span would weigh less than the longer span, requiring smaller counterweights and machinery to balance or operate the span respectively. The size and weight of the counterweight is determined by the length of the rear arm relative to the forward portion of the span. The rear length is controlled by the available span within the per, both horizontal and vertical. The proposed span arrangement was developed using forward to rear weight that are characteristic of similar bascule bridges. This is important since the overall span weight is heavily influenced by the counterweight ratio which can be in range of 2 to 4 times the weight of the forward portion of the span.

Overall, the weight of the movable span is significant not only for the machinery system design but also for the design of the bent and the foundations. Due to the high potential for large seismic events, minimizing seismic mass is of particular importance to help minimize movement of the bent. The potential for movement of the bent is unavoidable during seismic events, however minimization of inelastic differential movements between each of the in-water bents is important since small differential movements can produce alignment and operational challenges for movable bridges.

The steel framing will support multiple deck types, each having characteristics that are beneficial. As noted above, the overall weight of the span is a primary factor in the design development. As a result, the selection of a deck type is a balance between long term performance and weight. Two deck systems, open and closed, were taken into consideration:

- Open Grid Decks: In some instances, open grid decks are used on movable bridges, as this is one of the lightest weight options. However, there are detriments to this type of deck, the riding surface is not smooth nor skid resistance for vehicles. Additionally, the open grid allows runoff and debris to pass through the deck which is an advantage in terms of drainage on the roadway surface but does not meet the environmental objectives of the Project.
- Closed Decks: Closed deck options are more common as they provide a solid riding surface for all multimodal users. A solid deck often weighs more than an open or partially filled deck, but will provide a more durable, safer, and quieter riding surface. Furthermore, they are conducive for directing and collecting stormwater runoff for treatment.

Due to the environmental constraints of the Project, it is required that all stormwater runoff be collected and treated prior to redistribution into the waterway. Therefore, it is proposed that a closed deck system be used for the movable span. All closed deck types considered are feasible, but will require localized modification in order to accommodate future Portland Streetcar tracks across the movable span. Types of closed decks and their merits are discussed below.

Types of Closed Decks for Consideration

Full Concrete Deck

This is the most traditional deck used for bridges, but is less frequently used for movable bridges due to the weight. Concrete decks have a long history of performance and are a viable solution provided the overall span weight can be managed.

Concrete Filled Grid Deck

This type of deck uses a combination of a structural steel grid system and concrete infill. The grid is typically 5 inches in depth and can be filled full depth or partially filled to half-depth. A partially filled deck will decrease the deck weight compared to the full concrete deck type. These systems typically have a wearing surface that extends above the top of the grid that permits future removal and replacement without impacting the core grid structure.

Exodermic Grid Deck

Like the grid deck, an exodermic deck uses a combination of a structural steel grid system and concrete infill. Exodermic decks have a more robust steel grid structure with a structural deck of limited thickness cast compositely with the steel. The deck is typically 7 inches thick and can be precast into panels to facilitate installation. Exodermic decks, due to their composite action, have more structural capacity than filled grid decks and permit wider spacing between steel support members.

Orthotropic Steel Deck

This consists of a deck plate that is stiffened with steel ribs that are either open or closed sections. The orthotropic steel deck (OSD) is typically made integral with the floor beams (crossbeams) to provide a light multi-directionally stiffened deck system. The top of the deck plate is coated with a friction resistant wearing surface. OSDs offer a high strength to weight ratio and are useful on movable bridges due to their lighter weight. However, there are design and fabrication details that must be addressed in the use of OSDs since the welded construction can result in fatigue challenges if not properly detailed and fabricated.

Below deck, steel-supported walkways that extend from the counterweights to the leaf tips will be provided. This walkway system would be used to access counterweight pockets, span locks, and navigation lights, as well as to facilitate routine inspections. All walkways and platforms on the span, in electrical rooms, and around drive machinery in the bent would be sized and equipped with adequate lighting to satisfy all safety requirements.

Deck Joints at the Movable Span

Deck joints will be required at the toe between the opposing movable leaves and at the heel of the leaves between the movable and approach spans. Deck joints will be designed to accommodate movement during a seismic event.

Longitudinal and transverse deck joints between the movable span and approach spans will be located to avoid placement over the operating machinery and bascule support steel. Due to the movable operations (opening and closing of the joint), an open joint such as a finger joint is required. Finger joints are comprised of pairs of independent elements with parallel teeth that accommodate any bridge deck expansion.

At the toe joint, a special assembly will be necessary to limit the maximum joint width for normal use while simultaneously accommodating large-scale relative deflections between the bascule leaves anticipated during a seismic event. An example of such a system includes overlapping elements between the leaf tips that would engage as the leaves are seated. Sacrificial and/or energy-dissipating features may also be included to minimize or eliminate contact between the leaves during an earthquake, but have not been fully investigated at this time. The overlap may require a sequence of operation with one leaf seating ahead of the other (like rolling lift bridges with jaw-and-diaphragm span locks), but it would be effective in reducing or eliminating a potential gap in the roadway, sidewalk, and bikeway areas. Considering the span length, it is anticipated that moment locks will be installed at the joint between the opposing leaves. The moment locks will be pairs of lock bars that assist in transferring not only shear but moment from live loads from one span to the other across the center joint. This is critical in minimizing deflections under live load especially if transit loads are added in the future. Additionally, the moment locks provide additional rigidity to the bridge system for seismic loads.

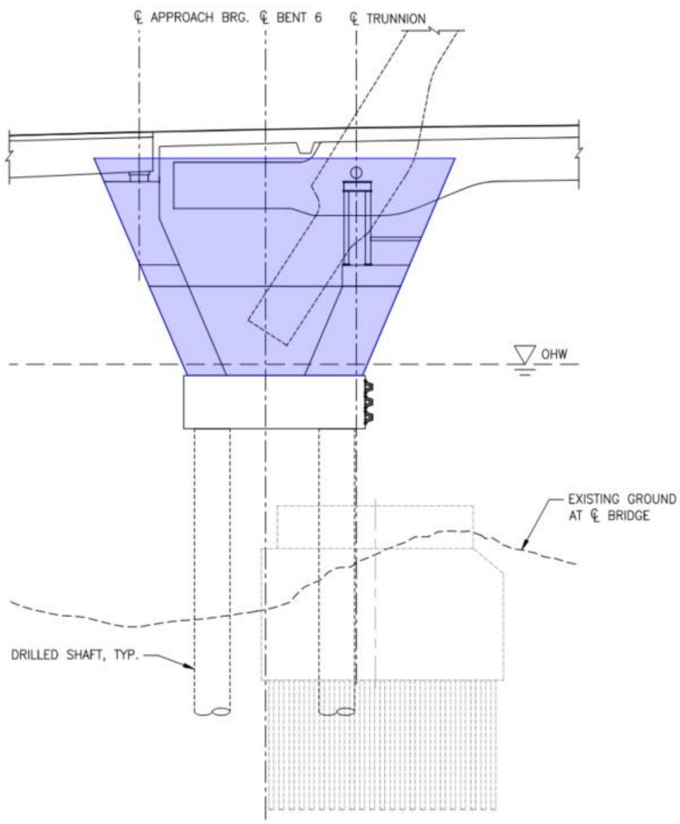
5.3.4 Substructure, Mechanical and Electrical Systems

In-water Bent Substructure

The bascule bents will house the bridge operating machinery, electrical equipment, operator's house/facilities, and the rear counterweight for the span. The bents have been sized to allow for the counterweights to rotate with the span when the bridge is opened. The bent fascia will be fully enclosed to prevent the counterweight from being submerged in water when opening and to protect the machinery.

Opposed to a traditional "box-type" bent, like the existing bridge, a delta bent shape (i.e., an inverted trapezoid) is being considered (Figure 13). Not only does this delta shape provide aesthetic appeal, but it also provides a functional advantage for the structural and mechanical operations of the movable span. Two opposing cantilevered inclined arms will rise from the foundation to support the movable structure on one side and the approach span on the other. The delta geometry reduces the eccentricity between the centerline of the bent and the centerline of the trunnion, thereby reducing the eccentric loading to the foundation. This ultimately reduces the design forces for the foundation. Additionally, the inclined substructure also allows for slightly shorter bascule spans while maintaining navigational clearances over the channel.

Figure 13. Bascule Delta Bent Geometry



BENT 6 ELEVATION

Mechanical and Electrical Systems

Mechanical operating machinery and electrical systems will be like other traditional bascule bridges. Each girder will be driven by a rack and pinion gear shaft connected to a motor, motor brake, primary reducer, and secondary reducer. Each pair of girders will share a single system of connected machinery. This machinery will be located inside the bascule bent in the machinery room, in between the bascule girders. Auxiliary motors may also be used to provide redundancy in the system during emergencies. The two side-by-side bridges will be structurally connected by the floor system as described above, so the adjacent machinery systems will be synchronized through the control system. Additionally, this redundancy in the controls will permit the spans to be operated from one set of machinery, even in a state of emergency. This will also permit future repair or replacement of one set of machinery while maintaining bridge operation.

Maintenance considerations for the mechanical and electrical systems, illustrated in the TSR Movable Bridge Plans (Appendix C), include:

- Underdeck inspection/maintenance platforms for span locks that can be accessed from bascule piers directly.
- Secured and environmentally controlled electrical equipment rooms.

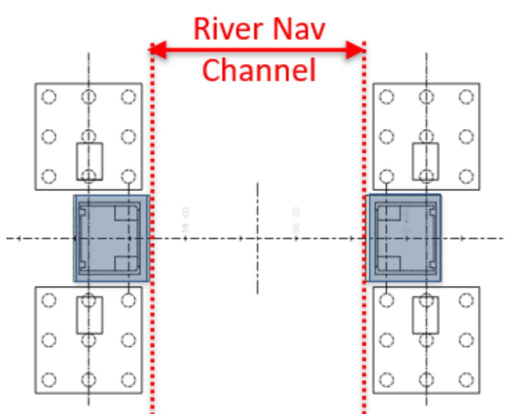
- Separate machinery enclosures in bascule piers.
- Safe access for maintenance of electrical and mechanical equipment.
- Provisions for access to remove and replace electrical and mechanical equipment for routine and long-term maintenance.

5.3.5 Movable Span Foundations

The movable span will be supported on a group of large diameter shafts connected to a large footing cap. Rather than the traditional in-ground foundations at the mudline, which require significant cofferdams to facilitate construction, perched foundations are proposed for the Preferred Alternative (see Replacement Bridge Plans in Appendix B). Raising the footing cap to be perched within the water column requires a less significant cofferdam and associated temporary works, which thereby reduces construction cost and impacts.

Multiple shaft configurations have been evaluated, including combined and split footing configurations. The split footing arrangement was initially evaluated to avoid conflicts with the existing foundation. After consultation with the Multnomah County Owner Representative's constructability team, however, this concept was not carried forward into type selection due to its construction cost and technical challenges associated with a bascule bridge type. Reference the *EQRB Revised Bridge Replacement Technical Report* (Multnomah County 2022f) for a full evaluation of the split footing configurations.

Figure 14. Dismissed Split Footing Concept (Plan View) with Lift Movable Bridge



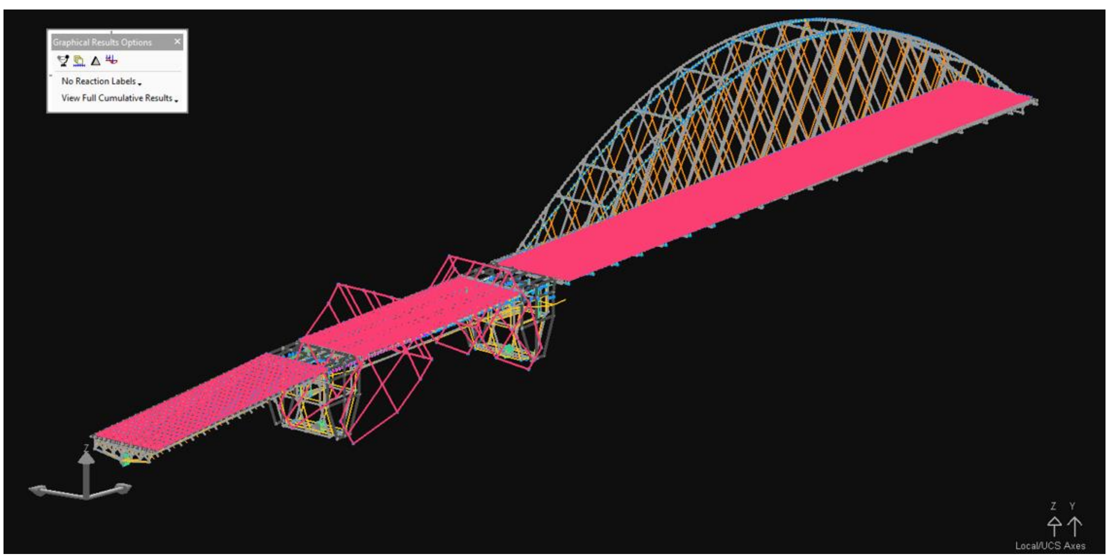
For the perched foundation type advanced into type selection, the preliminary structural analysis resulted in a 2 x 4 configuration of 10-foot diameter shafts (total 8 shafts) at each bent. The eight drilled shaft group is connected to a footing cap with an approximate out to out dimension of 51-foot x 124-foot. To minimize shaft group reduction factors for design, shaft center-to-center spacing has been set at 3.5 shaft diameters (3.5D). Shaft cap dimensions are based on this spacing coupled with 8-foot extensions beyond the end of the shafts to facilitate development of reinforcement while reasonably limiting shaft cap dimensions. Different shaft diameter sizes were evaluated; but based on the preliminary analysis, 10-foot diameter shafts provided the most structurally efficient and cost-effective configuration.

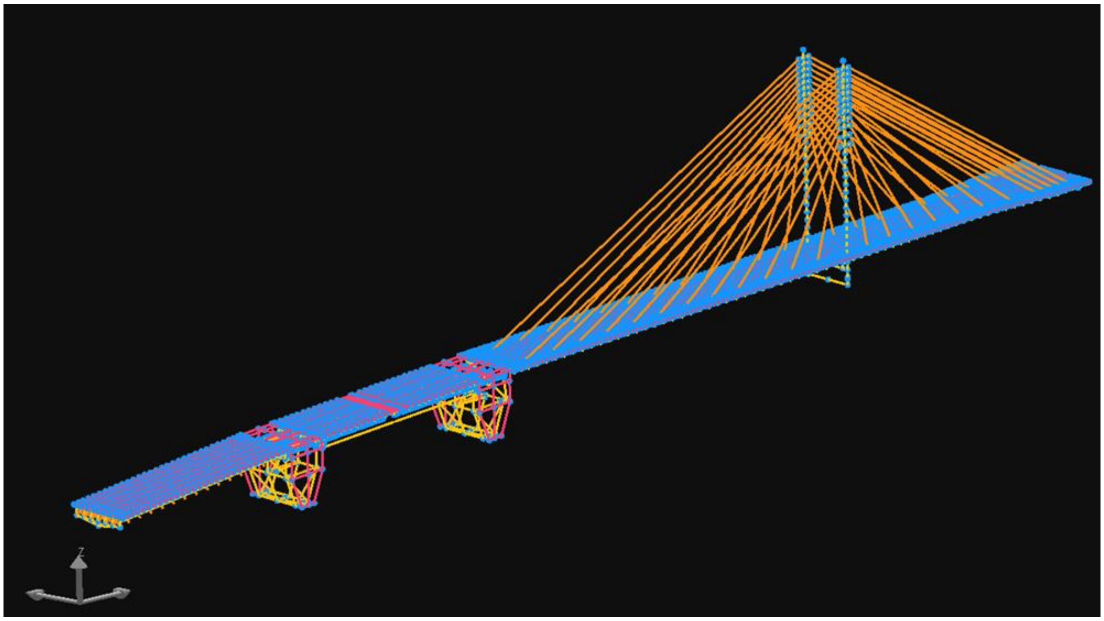
Preliminary Analysis and Design

Preliminary design and analyses were performed for the movable span and flanking West and East Approach structures. The objective of this work was to establish reasonable member sizes for the bascule pier substructure and the drilled shaft foundation, which informed type selection considerations such as cost estimates, constructability reviews, and aesthetics. The design development level of this work can be categorized as proof of concept for comparative analysis of various substructure and drilled shaft configurations at a similar development level. While the preliminary design of the substructure and foundation sizing was controlled by seismic loading, dead and live load demands were also evaluated for various strength and service load combinations.

Due to the different East Approach options, two global analysis models were developed: Bascule with Tied Arch option and Bascule with Cable Stay option. The global analysis models were developed using LARSA 4D to determine force and deformation effects in substructure. The global coordinate system is an orthogonal XYZ Cartesian coordinate system, with X axis in bridge longitudinal direction pointing East, Y axis in bridge transverse direction pointing North, and Z axis in upward direction. The coordinate system is based on the alignment stationing and elevation (NAVD'88) of the structure. Separate models and were developed for the cable stayed and tied arch East Approach spans, both of which are discussed in further detail in Section 5.4.

Figure 15a and 15b. LARSA 4D Global Models with Tied Arch and Cable Stay Options





The preliminary seismic design is based on a response spectrum analysis and utilized a 6x6 foundation spring at the base of each bent foundation. The analysis program FB-MultiPier was used to capture foundation behavior and soil-structure response. Iterations were performed between the LARSA and FB-MultiPier until converged within acceptable tolerances. This process considers all foundation softening effects from concrete cracking, steel yielding, and soil response softening in determining a secant foundation stiffness allowing the linear-elastic seismic analysis to approximate non-linear behavior.

Substructure elements were evaluated and sized to meet the project-specific performance-based strain limits to attain the necessary axial compression and tension uplift resistance for drilled shafts embedded into the Troutdale Formation.

5.3.6 Vessel Collision and Bent Protection

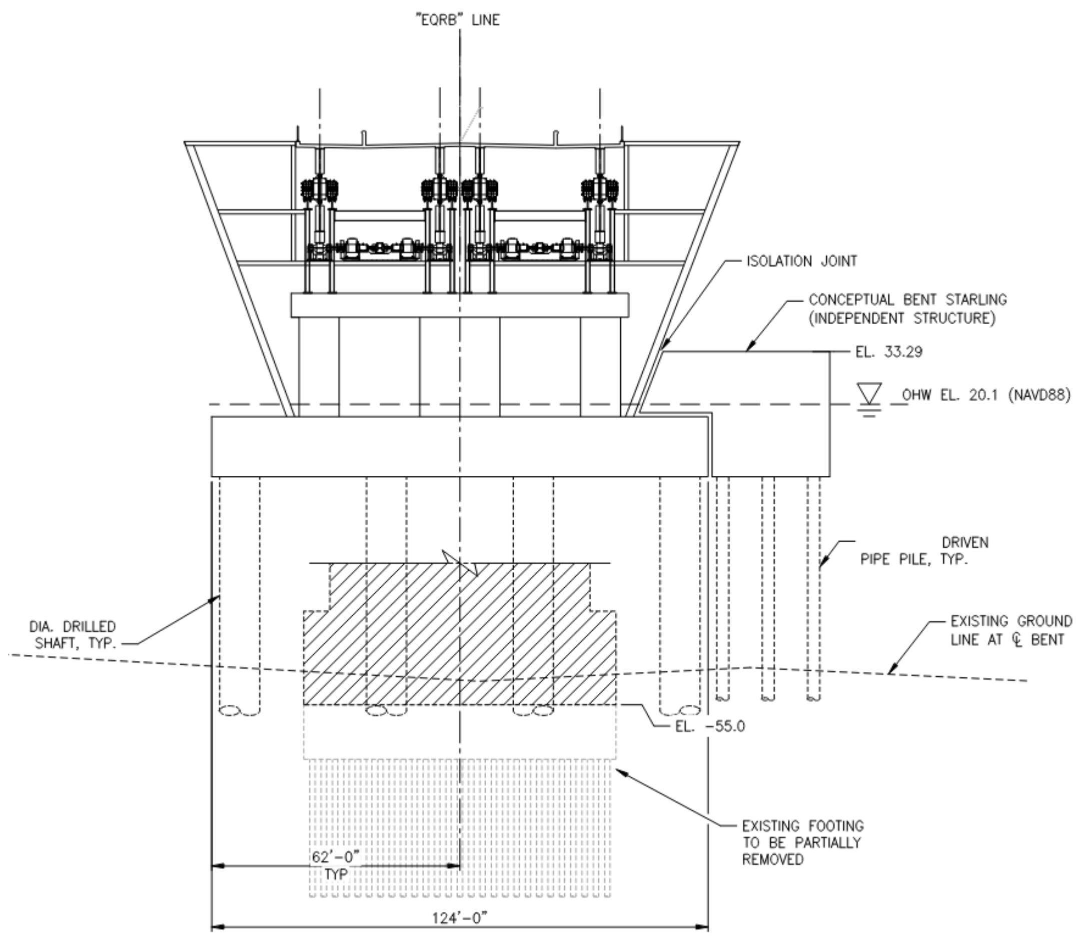
Due to the substantial foundation system needed to resist seismic demands, the proposed foundations will also be designed in accordance with the *Guide Specifications for Vessel Collision Design of Highway Bridges* (AASHTO 2009), using the Allision loading described in Section 5.3.1. By doing so, an independent protection system will not be necessary, and less obstructions within the river will result.

5.3.7 Bent Starlings

The upstream (south) face of the in-water foundations of the movable span has a natural tendency to collect debris. This is particularly true of large blunt faces that are perpendicular to the waterway. A non-structural debris fender is not anticipated due to the proposed “rounded” shape of the substructure which can direct debris flow around the bent. However, the Project has begun consultation with the United States Coast Guard (USCG) which has directed the Project to include a navigational aide starling structure on the upstream (south) face of the in-water bents. The direction from the USCG is that this feature be of similar scale and height as the existing starlings.

Additional structural mass imposed on the in-water bent foundations would have a negative impact on the forces and displacements of the shafts and bent. Therefore, in order not to influence the proposed foundations, this pier starling will be designed as an independent free-standing structure that abuts the south face of each in-water bent (See Figure 16). Similar to the existing starling, the proposed starling would be linked to the face of the bent through means of a pinned connection and will be founded on several driven steel pipe pile. The facing or sheathing of the starling will be required to extend to the 100-year flood elevation and terminate at the bottom of the proposed footing cap which is below the mean low water elevation for the Willamette River. It should be noted that while starlings are shown as the current concept, they may alternatively be a smaller structure of equivalent function, such as a dolphin. Starlings are not designed for vessel collision whereas dolphins typically are designed to resist vessel collision loads.

Figure 16. Bent Elevation (Looking East) with Starling Concept



5.3.8 Gates, Signals, and Overhead Signs

To meet the recommendations of the AASHTO Movable Bridge Design Specifications, it is anticipated that both warning gates and barrier gates will be provided on both the East and West Approaches to the movable span. Gates will cross the full width of the roadway as well as the multi-use paths. Warning gates will direct traffic to stop and queue while the bridge opens. They will be marked in accordance with the MUTCD and have red signal lights mounted on them. Traffic signals with supplemental bells or gongs will also serve to warn users of a bridge opening. Barrier gates will be located closer to the movable span and serve to resist any traffic that may surpass the initial warning gates. They will be marked similarly to the warning gates with red lights and will designed to resist vehicle impact. Pedestrian Gates will be located at both ends of each multi-use path to better control pedestrian flows. Overhead sign structures will be placed before the movable span to close vehicular operations during a bridge lift, similar to the existing structure signage. These sign structures will contain signs guiding traffic, and could contain County banners and traffic signals. Coordination with PBOT and ODOT will be required during Final Design to identify types and locations of sign structures and other signage.

5.3.9 Movable Span Drainage

Environmentally, the Project cannot allow drainage to directly discharge into the Willamette River. Instead, all deck runoff must be collected and treated before discharging. Therefore, the vertical profile of the bridge has been set with the crest of a vertical curve coinciding with the centerline of the movable span. This, coupled with the 2 percent cross slope of the bridge, will encourage stormwater collection within the shoulders of the roadway section. Due to the grades of the profile and the requirements of spread along the shoulder, it is anticipated that inlets would be located in each quadrant of the movable span. A piping system to tie them into the approaches will be necessary. Because the movable span requires open joints, water cannot be conveyed across the joints. In these situations, a drainage trough can be located under and parallel to the expansion joint to collected water and transfer it to the piping system.

5.3.10 Operator House Systems

The existing Burnside bridge has an operator's house on each bascule pier. The operator house on the west pier controls both leaves of the bridge and is the primary control for bridge openings. The house on the east pier controls the east leaf and would only be utilized as a backup in the event that communication/control between leaves was not functioning. This configuration will be matched on the new bridge. It was determined that the south corners of the bascule span provide the best sightlines of both the river and roadway. The operator houses will be elevated above the roadway and can be accessed via the southern sidewalk on the bridge. The operator houses will contain the operator's desk to control both the roadway gate, signals, bridge open/close, and provide shelter for the County Bridge Operator. See Appendix C for plans of the conceptual movable bent and operator house.

The design and aesthetic of operator houses can range from simple to ornate. The look of the operator house will be of significant importance as bridge aesthetics develop in future phase.

Maintenance and Operation considerations that will factor in the design (highlighted in the Appendix C) include:

- Provision for external walk-around balcony for window maintenance and improved site lines

- Site lines and control layout emphasizing pedestrian control
- Parking for Operator Vehicles
- Security

5.3.11 Geotechnical Seismic Hazards and Proposed Mitigation

For a general discussion of site geology and subsurface conditions, see Section 5.1.3.

Based on the preliminary nonlinear site response analysis for the 1,000-year probabilistic hazard level, seismically induced permanent ground deformations were initially anticipated for Bents 6 and 7. The primary zone of permanent deformation at these bents is within the Alluvium layers between approximate Elevation -43.0 and -100.0 feet (NAVD88). However, additional evaluation within the channel considering post construction conditions is expected to indicate that liquefaction-induced lateral spreading within the channel is negligible.

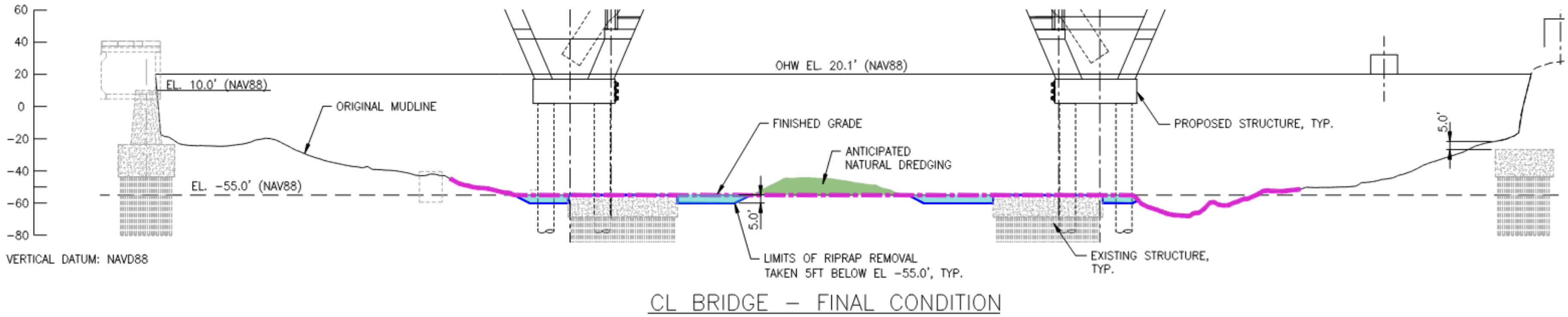
Due to the group shaft configuration proposed, it is anticipated that the in-water foundations will be structurally designed to accommodate the effects of permanent ground deformations and liquefaction-induced downdrag if they were to occur. Additional site-response modeling will be conducted in the Final Design phase. Therefore, seismic hazard mitigation in the form of ground improvements is not anticipated at these bents nor does the dynamic soil structure interaction analysis consider any improvements at these locations.

5.3.12 River Channel Grading

As will be discussed in the subsequent Construction Considerations Section 14, rip rap and riverbed material around the existing piers are required to be removed. Removal of this material is required to place temporary piling used to support the in-water work bridges used to facilitate construction. Additionally, access below the riverbed is required to remove the existing pier footings down to EL -55.0 (NAVD88).

The existing channel bed elevation patterns indicate localized scour at the existing Burnside Bridge. Furthermore, the proposed in-water bents are expected to result in an increased scour potential. See Section 6 for a full discussion on scour potential at the project site. Following the removal of the existing pier, the Project proposes to backfill the regions around the existing piers with clean sand to EL -55.0 (NAVD88) so as not to create a potential discontinuity that is susceptible to scour and could exacerbate hydraulic jump. The backfilled regions are limited to the excavated footprint around the existing piers and will transition into the existing channel bed elevations both east and west of the existing piers. Over time, it is assumed that natural channel dredging will erode the middle of the riverbed to be consistent with the backfilled elevation around the existing piers. Figure 17 demonstrates the assumed final river channel profile at the centerline of the bridge.

Figure 17. River Channel Grading

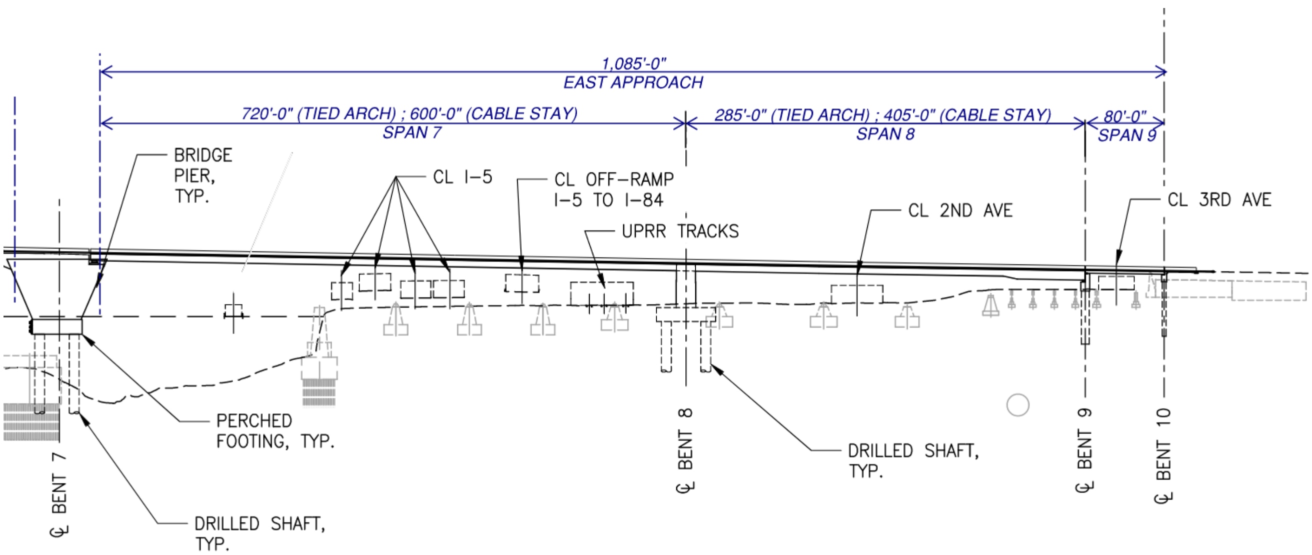


5.4 East Approach

The East Approach extends from the eastern in water bent within the Willamette River to just beyond the existing Burnside Bridge abutment. The total length of the East Approach measures 1085 feet in length and is comprised of three spans that range in length, depending on the structure type. Within the East Approach region, a long span coupled with conventional flanking spans were evaluated. As shown in Figure 18, two long-span bridge types were evaluated: a 720-foot-long tied arch and a 1,005-foot-long cable stayed.

The bridge types considered for the long span and conventional span portions of the East Approach are discussed in subsequent sections, and details can be found in the Bridge Plans (Appendix B).

Figure 18. East Approach Spans



Regardless of bridge type discussed, the East Approach spans over a range of facilities that dictate the potential span arrangement and support location. The following key layout constraints and considerations were used as a basis of the bridge layout provided in this TSR:

- East CSO Pipe
- Subsidiary Willamette River Navigation Channel
- Vera Katz Eastbank Esplanade
- Interstate Highways
- Union Pacific Railroad (UPRR)
- City streets
- Burnside Skatepark
- Existing Bridge Piers

- Potential seismic hazards of the east embankment
- Structural efficiency

The primary benefits for an East Approach long span structure are that it:

- Reduces the number of intermediate supports within the eastside seismic hazard zone, thereby reducing the potential need for ground improvement at supports between the river and E 2nd Avenue.
- Eliminates intermediate bents in the waterway, thereby reducing the environmental impacts within Willamette River.
- Eliminates intermediate bents between the existing I-5 and I-84 structures, thereby eliminating impacts to any potential future freeway widening improvements.
- Spans the UPRR right of way envelope.
- Maintains the Burnside Skatepark.

5.4.1 Tied arch Span

Layout and Configuration

The proposed tied arch structure, measuring 720 feet, spans from the eastern jump span of the bascule structure over the I-84 and I-5 structures, and over the UPRR tracks. The tied arch's east bent is located to the west of E 2nd Avenue, which also supports a 285-foot steel girder span to the east. Unlike the cable stayed bridge type, a conventional tied arch structure is not capable of fully spanning over E 2nd Avenue, the Burnside Skatepark and the East CSO pipe. A conventional flanking girder span is therefore required to the east of the tied arch span and will be discussed in depth in subsequent sections. In addition to addressing the key constraints discussed in Section 5.4, the following objectives were considered for locating the east termination bent:

- Minimize the length of the east flanking conventional steel girder span. The proposed span length was established based on vertical clearance requirements over the Burnside Skatepark and general fabrication, shipping, and erection considerations to ensure a cost-effective steel girder span.
- Minimize the number of east side bents. The proposed configuration utilizes a single bent between UPRR and E 2nd Avenue. While a shorter arch span could be utilized with an additional steel girder span and corresponding bent foundation, it was decided that a detailed cost-benefit assessment should be reserved for the Final Design phase with input from the Construction Manager/General Contractor.
- Locate the east bent foundation within the geological hazard zone while not requiring ground improvement. The east embankment region from the river to E 2nd Avenue is prone to seismic hazards like liquefaction and liquefaction-induced lateral spreading. The hazard and associated demands become more significant the further west the bent is located. Preliminary analysis has determined that the proposed span configuration would meet the Project's seismic design performance requirements without ground improvement costs.
- Avoid impacts with the existing bridge's timber pile foundations.

Prior to the Type Selection phase, additional span configurations were evaluated for the tied arch option. These configurations, which were ultimately dismissed, considered longer arch spans that located the east bent at or near the Burnside Skatepark; refer to the *EQRB Revised Bridge Replacement Technical Report* (Multnomah County 2022f).

Superstructure

Given the objective of type selection to establish a reasonable baseline configuration for comparison against other structure types, the tied arch superstructure utilizes a conventional configuration to provide a structurally efficient and cost-effective solution. The typical Final Design development process will include detailed cost-benefit evaluations for each component of the tied arch structure to establish the optimum solution for the project with considerations such as cost, constructability, maintenance, and aesthetics. The baseline configuration for type selection was established based on a preliminary assessment of various components and characteristics of the tied arch structure as listed and discussed below.

Arch Geometry

The proposed structure has a parabolic arch rib shape with a 5.0 to 1.0 span to arch crown height ratio. This arch geometric definition provides a structurally efficient design that minimizes vertical bending moments in the arch and is representative of similar tied arch structures. A preliminary study was performed on a shallower tied arch with a 6.5 to 1.0 span to rise ratio, which confirmed a reduction in structural efficiency that resulted in increased steel weight.

The proposed structure has solid web arch ribs oriented in a vertical plane. While inclined, or basket-handle, arch ribs are found in many structures, the more common vertical orientation was assumed for type selection.

Cable Pattern

The proposed tied arch structure utilizes a network cable pattern. This cable configuration, versus a vertical configuration, provides the most structurally efficient arrangement because it minimizes vertical bending moments and deflections in the arch while providing increased redundancy for the overall system.

Arch Bracing System

The proposed structure utilizes an X-type lateral bracing system between the arch ribs. This bracing system provides a structurally efficient design that minimizes lateral bending moments and maximizes transverse stiffness of the arch. An alternative Vierendeel bracing system was considered in parallel as part of the preliminary seismic evaluation of the bridge. This preliminary evaluation demonstrated that either bracing system could be utilized at the future Final Design phases without significantly impacting the cost or performance.

Given the 720-foot span length, the preliminary evaluation did not consider unbraced arch ribs. If driven by aesthetic considerations, it is expected that a reduction in arch span length will be required to make an unbraced arch rib configuration viable and economical.

Floor System

The proposed structure utilizes a transverse floor beam and longitudinal stringer system that is fully composite with the reinforced concrete bridge deck. This floor system provides a structurally efficient design that maximizes vertical stiffness, allows for composite design of the transverse floor beams, and provides the best opportunity for a redundant longitudinal load path between tie girder and concrete deck. An alternative sub-stringer system in which the transverse floor beams are not composite with the reinforced concrete deck is sometimes employed for tied arch structures in this span range, but the more typical fully composite system has been chosen as the baseline configuration.

Deck Joints

The deck joints for the tied arch are sized to accommodate large displacements from seismic and lateral spreading loading. A modular joint seal assembly type is proposed, though finger joints could be utilized if preferred by the County. A more robust assessment for the joint type will be made during the Final Design phase, in combination with the contractor, and will include noise and maintenance considerations.

Bearing Assemblies

The bearing assemblies for the tied arch are sized to accommodate axial and lateral loadings. Traditional high-load multi-rotational disc bearings are proposed. To potentially reduce seismic demands on bent foundations, base isolation bearings were evaluated during the Type Selection phase but were deemed unnecessary given the preliminary member sizing and the likelihood that it would result in higher costs for the East Approach.

Substructure and Foundations

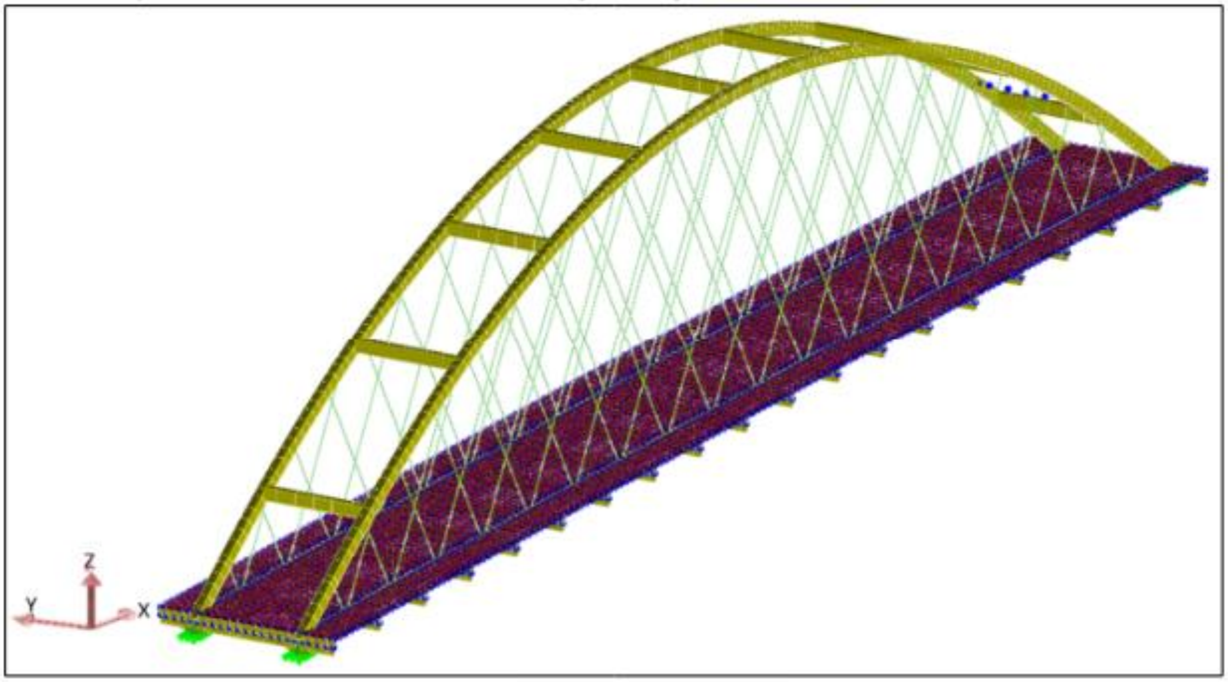
The tied arch will be supported on a seat-type crossbeam and multi-column concrete bent founded on drilled shafts. Preliminary analysis has confirmed a two-column configuration with a 10-foot diameter column and 10-foot diameter shaft. While various drilled shaft sizes were evaluated, 10-foot diameter shafts provided the most efficient configuration and met the Project’s seismic design criteria. Drilled shaft are founded with minimum embedment into the Lower Troutdale formation, which provides sufficient resistance for both strength and seismic loading.

The foundation analysis evaluated seismic inertial demands in combination with lateral spreading demands for cases with and without ground improvement mitigation. These preliminary investigations determined that the shafts could meet the Project’s seismic design criteria without ground improvement.

Preliminary Analysis and Design

Preliminary design and analysis was performed on the tied arch option as part of the Type Selection phase. The objective of this work was to establish reasonable member sizes for the arch superstructure, which informed type selection considerations such as cost estimates, constructability reviews, and aesthetics. The design development level of this work can be categorized as proof of concept for comparative analysis of structure types at a similar development level. While the preliminary seismic design was primarily targeted at substructure and foundation sizing, the mass and stiffness characteristic of the arch superstructure is an important component. In order to establish reasonable key member sizes, a global analysis model was developed using LARSA 4D to determine force and deformation effects in various structural components of the tied arch span.

Figure 19. LARSA 4D Tied arch Analysis Model



The conceptual design of the tied arch superstructure considered dead, live, and thermal loads consisting as follows:

- Dead Loads
  - Concrete and steel unit weights consistent with the project-specific design criteria.
  - Steel member sizes with a factor to account for connections and miscellaneous attachments.
  - 8.25-inch-thick concrete deck.
  - Six bridge rails at 400 plf. The value is conservative as pedestrian rails at multi-use path will be substantially less than the assumed value.
  - 40 psf future wearing surface consistent with project-specific design criteria (and ODOT BDM).
- Live Loads:
  - HL-93 truck and lane loads per AASHTO LRFD. Force demands considered both influence line to individual vehicular lanes and influence area to the full roadway surface.

- Pedestrian live load at 75 psf consistent with project-specific design criteria (and ODOT BDM).
- Thermal Loads:
  - Uniform temperature applied to full structure with rise, fall, and mean per ODOT BDM.

The dead, live, and thermal loading combinations considered resulted in the conceptual design being driven by the AASHTO load combinations Strength I, Strength IV, and Service II. Based on experience with similar projects, these combinations generally reflect the controlling force combinations for primary components of tied arch bridges.

Loads not considered include wind on structure, wind on live load, time dependent creep/shrinkage of concrete deck, temperature gradient, permit live loads, and seismic design forces. Other effects such as cable loss and cable replacement were not considered. While other loads and associated AASHTO combinations may control member sizing at local locations, the general sizing of the primary members is not expected to differ substantially.

The member sizing design component of the preliminary work was based on the provisions of *AASHTO LRFD Bridge Design Specifications* (AASHTO 2017). Force demand to capacity evaluations were performed on the following primary members of the tied arch span as part of the conceptual design process:

- Arch Rib and Tie Girder:
  - Primary load carrying components of a tied arch structure.
  - Accounts for approximately 60 percent of the total steel quantity based on a review of similar tied arch structures.
- Network Hanger Cables:
  - Primary load carrying component of a tied arch structure.
  - Most expensive component of a tied arch structure on a per pound basis.
- Typical Transverse Floor Beams
  - Most significant component of total steel dead load after arch rib and tie girder.
  - The end floor beam was not designed as part of the conceptual design process.

The following components were not analyzed and designed as part of the conceptual design process:

- Arch Rib Bracing:
  - While a key component of the structure, the bracing design is typically controlled by the wind on structure loading and a buckling analysis that was not considered at the preliminary design development level.
  - Accounts for approximately 5 percent of the total steel quantity based on a review of similar tied arch structures.
  - The Vierendeel system used in the analysis model and material quantities was empirically sized-based review of similar tied arch structures.

- Bottom Lateral Bracing:
  - While an important component of the structure, the bracing design is typically controlled by the wind on structure loading that was not considered given the design development level.
  - Accounts for approximately 3 percent of the total steel quantity based on a review of similar tied arch structures.
  - The brace system used in the analysis model and material quantities was empirically sized based on a review of similar tied arch structures.
- Longitudinal Stringers:
  - The stringer system used in the analysis model and material quantities was empirically sized based on a review of similar tied arch structures.
- Splices, Connections, Diaphragms, and other Miscellaneous Steel Components:
  - Unit weight of steel was increased by a factor to account for these items, which is at the higher end based on detailed quantity take offs of similar projects at released-for-construction level.
- Knuckle Joint:
  - Complex joint region typically evaluated via a detailed finite element analysis which is outside the bounds of conceptual design.
  - Arch rib and tie girder members in the model extend to intersection joint, which increase steel dead load due to artificial member overlap.

Given the objectives of the conceptual design basis, a series of assumptions were made to simplify the conceptual design work. These assumptions include the following:

- Construction Staging:
  - The steel structure is assumed to be constructed on falsework and released in a single construction stage.
  - The concrete bridge deck is assumed to be constructed in a single stage, although a deck placement sequence within that stage will be determined as part of the Final Design phase.
  - Time-dependent effects are not considered.
- Cable Tuning:
  - A detailed hanger cable tuning exercise was not performed. Based on an initial review of the analysis, the simplified construction staging resulted in a generally well-balanced force distribution for the hanger cables.
- Stringer Axial Stiffness:
  - Based on an initial review of the analysis, the assumed construction staging method resulted in axial forces within the longitudinal stringer system that were deemed reasonable and consistent with other constructed tied arch structures. Given that the design basis did not include an evaluation of the stringer

members, their axial stiffnesses were significantly reduced to concentrate the tensile tie forces in the tie girder.

- Buckling Analysis:
  - A buckling analysis was not performed. For purposes of arch rib member design, axial capacity and moment magnification are based on critical buckling length based on cable hangers (vertical buckling) and brace locations (transverse buckling).

5.4.2 Cable Stayed Span

Layout and Configuration

The proposed cable stayed spans from the eastern movable bent, over the I-84, I-5 structures and UPRR tracks, with spans measuring 600 feet and 405 feet in length. In addition to avoiding impacts to the key constraints discussed in Section 5.4, the cable stayed tower's proposed location was chosen to produce a reasonable span balance, which results in structural efficiency. The cable stayed tower's location results in a back span/main span ratio of 405/600 = 0.68. Span ratios between 0.50 and 1.00 are desirable for single-tower cable stayed bridges because they generally lead to structurally efficient designs. Span ratios in this range result in lower axial loads in the back span stay cables and smaller cable sizes; lower tower loads (moment and shear) and more efficient tower designs; and lower back span uplift loads and more modest tie-down elements.

Superstructure

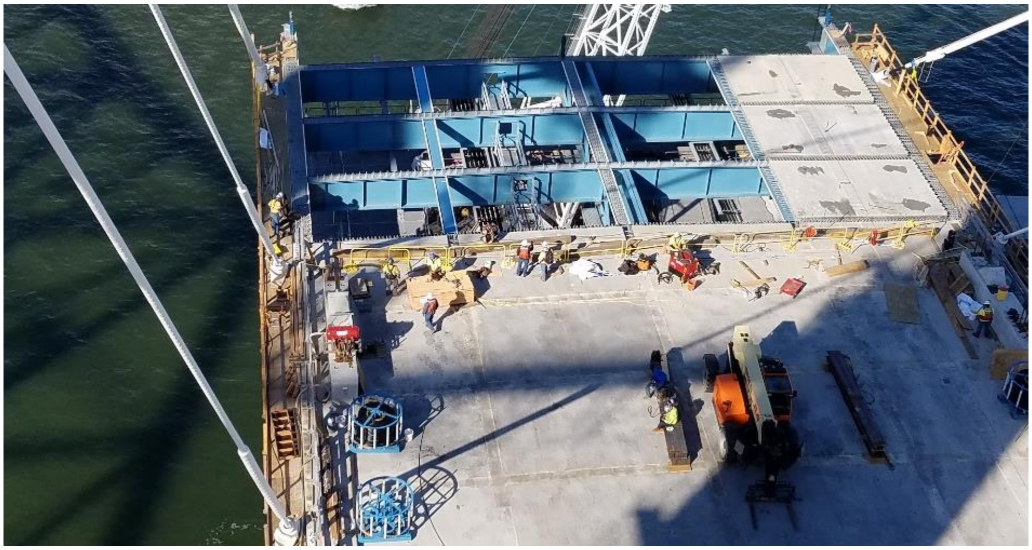
The proposed structure utilizes a composite steel I-Girder edge girder system with precast deck panels (Figure 20). The system includes transverse steel I-girder transverse floor beam that span between the two longitudinal edge girders.

Composite Steel I-Girder

This type possesses the following general characteristics:

- Lighter weight than concrete box or edge girders: Beneficial for in-service and seismic demands, also less and/or smaller cables than concrete superstructures.
- Faster construction: Longer prefabricated sections can be quickly erected (bolted) into place, use of precast concrete deck panels.
- Lighter (less expensive) construction equipment: Lighter equipment usually results in less expensive erection costs.
- Good durability, but may require some maintenance (painting): weathering steel can be used in lieu of painting to reduce maintenance needs.

Figure 20. Composite Steel I-Girder Example



A variety of other superstructure deck girder types were considered for the cable stayed spans, as listed below.

Concrete Edge Girder

This type possesses the following general characteristics:

- Heavy weight: Adds significant seismic mass, leading to larger tower and foundations, also requires more and/or larger cables
- Good durability/low maintenance: Does not require repainting
- Longer construction time associated with casting/erection: Requires additional steps in erection process to post-tension and place concrete

See Figure 21 below.

Figure 21. Concrete Edge Girder Example

Orthotropic Steel Box Girder

This type possesses the following general characteristics:

- Lighter weight than concrete box or edge girders: Beneficial for in-service and seismic demands, also less and/or smaller cables than concrete superstructures.
- Faster construction: Longer prefabricated sections can be quickly erected (bolted) into place.
- Good durability, but may require some maintenance (painting): weathering steel can be used in lieu of painting to reduce maintenance needs.
- Not used much in the United States: Generally unfamiliar to domestic contractors and usually results in much higher fabrication cost relative to steel plate girder options.

Concrete Box Girder

This type possesses the following general characteristics:

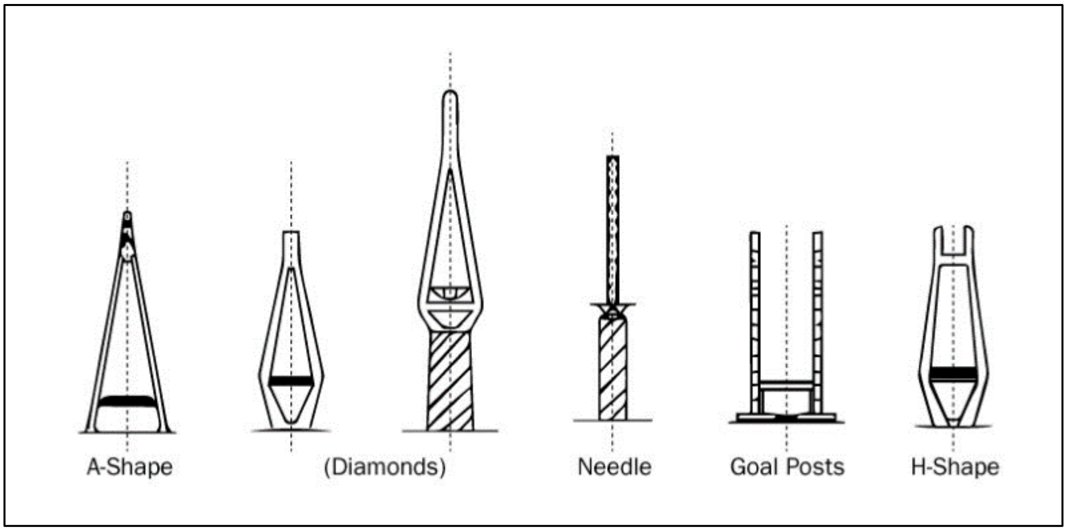
- High torsional stiffness: Beneficial for bridges with a single plane of cables.
- Heavy weight: Adds significant seismic mass, leading to larger tower and foundations, also requires larger and/or more cables.
- Good durability/low maintenance: Does not require repainting.
- Longer construction time associated with casting/erection: Requires additional steps in erection process to post-tension and place concrete.
- Deeper section depth likely required: As compared to other deck girder types.

Cable stayed Tower

The following tower types were considered as part of the Type Selection phase, with an illustration of each in Figure 22:

- A-Shape
- Diamond
- Single Tower (Needle)
- Goal Posts
- H-Shape

Figure 22. Example of Tower Types



Generally, the most efficient tower height is approximately 40 percent of the main span length (20 percent of equivalent main for 3-span cable stayed). However, to understand the effect of shorter towers if desired for aesthetic purposes, a tower height range equivalent to 40 percent (upper limit) and 32 percent (lower limit) of the main span were investigated.

A-Shape, Diamond, and H-Shape towers (Figure 22) are generally used to achieve a particular aesthetic look, when structurally required for items such as aeroelastic stability, or when a smaller foundation footprint is needed (Diamond). Vertical tower leg alternatives, such as goal posts and single towers, generally offer the simplest and most cost-effective construction. For this Type Selection phase, a Goal Post type was selected due to its economy and the desire to maintain an unobstructed roadway width for post-earthquake emergency response and debris clearing.

Deck Joints

The deck joints for the East Approach cable stayed are sized to accommodate large displacements from seismic and lateral spreading loads. Due to the anticipated movements resulting from seismic and lateral spreading, a modular joint seal assembly type is proposed at Bents 7 and 9, though finger joints could be utilized if preferred by the County. A more robust assessment for the joint type will be made during the Final

Design phase, in combination with the contractor, and will include noise and maintenance considerations.

Foundations

The cable stayed tower (Bent 8) will be supported on a single-footing cap with a group of large diameter shafts. Preliminary analysis has confirmed a 2 x 3, 10-foot diameter shaft group with an approximate out-to-out 60 x 100-foot footing cap. To minimize shaft group reduction factors for design, shaft center-to-center spacing has been set at four shaft diameters (4D). Shaft cap dimensions are based on this spacing coupled with 5-foot extensions beyond the end of the shafts to facilitate development of reinforcement while reasonably limiting shaft cap dimensions.

While various drilled shaft sizes were evaluated, 10-foot diameter shafts provided the most efficient configuration and met the Project's design criteria. Drilled shafts are founded with minimum embedment into the Lower Troutdale Formation, which provides sufficient resistance for both strength and seismic loading.

Foundation analysis considered cases with and without ground improvement mitigation for seismic ground hazards such as liquefaction and liquefaction-induced lateral spreading. These preliminary investigations determined that the Bent 8 foundation may be capable of resisting structural inertia loading with liquefaction and lateral spreading effects without ground improvement. Additional evaluation in the Final Design phase is required to definitively eliminate the need for ground improvement. Until that analysis can be completed, ground improvement for the cable stayed Bent 8 foundations has been assumed. The limits and type of this anticipated ground improvement is discussed in Section 5.4.6.

Regarding the depth of the tower foundation embedment, multiple configurations of the Bent 8 footing cap embedment have been evaluated:

- Standard Full Embedment: Soil cover over the footing cap, the footing would not be visible from the parking lot.
- Partial Embedment: The footing could extend 5 to 10 feet above ground with a large concrete mass of the footing visible from (and obstructing the use of) the parking lot adjacent to the Pacific Coast Fruit Company.
- Zero Embedment: The footing could be placed completely above ground, approximately 14 feet thick, with a large concrete mass of the footing visible from (and obstructing the use of) the parking lot adjacent to the Pacific Coast Fruit Company.

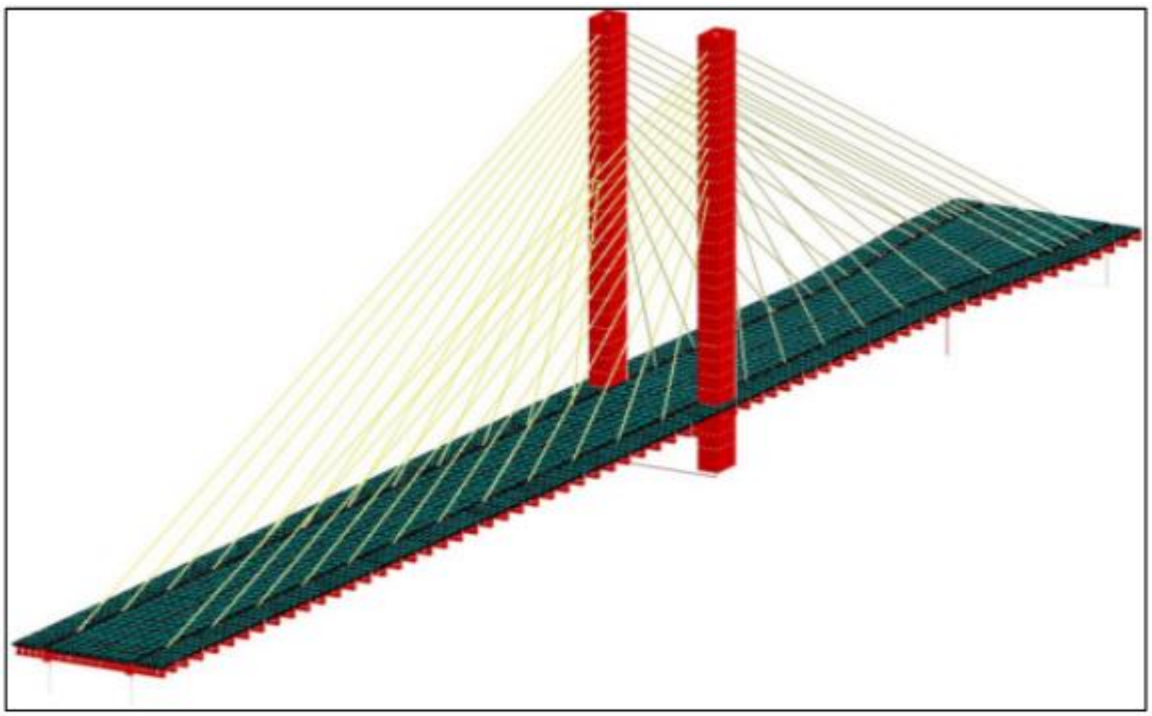
For this TSR, the full embedment option has been employed.

The terminating span for the cable stayed structure will be supported by Bent 9 on a seat-type crossbeam/pier wall founded on four drilled shafts. Preliminary analysis has confirmed that four 8-foot diameter shafts are adequate to resist the various loading combinations. Drilled shafts are founded with embedment into the Lower Troutdale Formation, which provides sufficient resistance for both strength and seismic loading. Due to the cable stayed span arrangement, a vertical tie-down is likely needed to prevent uplift for some load combinations. Bent 9 is east of the anticipated seismic hazards and will not require ground improvement mitigation.

Preliminary Analysis and Design

Preliminary design and analyses were performed on the cable stayed option as part of the Type Selection phase. The objective of this work was to establish reasonable member sizes for the cable stayed superstructure, tower, cables, and foundations, which informed type selection considerations such as cost estimates, constructability reviews, and aesthetics. The design development level of this work can be categorized as proof of concept for comparative analysis of structure types at a similar development level. While the preliminary seismic design was primarily targeted at tower and foundation sizing, the mass and stiffness characteristics of the cable stayed superstructure and cables are important considerations. In order to establish reasonable key member sizes, a global analysis model was developed using LARSA 4D to determine force and deformation effects in various structural components of the cable stayed spans.

Figure 23. LARSA 4D Cable stayed Analysis Model



The conceptual design of the cable stayed bridge considered dead, live, wind, and thermal loads as follows:

- Dead Loads
  - Concrete and steel unit weights consistent with the project-specific design criteria.
  - Steel member sizes with a factor to account for connections and miscellaneous attachments.
  - 10-inch-thick concrete deck.
  - Six bridge rails at 400 plf. The value is conservative as pedestrian rails at multi-use path will be substantially less than the assumed value.

  - 40 psf future wearing surface consistent with project-specific design criteria (and ODOT BDM).
- Live Loads:
  - HL-93 truck and lane loads per AASHTO LRFD. Force demands considered both influence line to individual vehicular lanes and influence area to the full roadway surface.
  - Pedestrian live load at 75 psf consistent with project-specific design criteria (and ODOT BDM).
- Wind Loads:
  - Preliminary wind loads on the tower were estimated using ASCE 7, considering height and flexibility of the towers.
- Thermal Loads:
  - Uniform temperature applied to full structure with rise, fall, and mean per ODOT BDM.

Without considering wind and seismic loading in the superstructure design, AASHTO Strength I Limit State load combination was used as a tool to verify the conceptual member sizes that were developed based on experience with similar projects.

Loads not directly analyzed include wind on live load, time dependent creep/shrinkage of concrete deck, temperature gradient, and permit live loads, and seismic design forces in the superstructure. Other effects such as cable loss and cable replacement were not analyzed at this stage. While other loads and associated AASHTO combinations may control member sizing at local locations, the general sizing of the primary members is not expected to differ substantially.

The member sizing design component of the preliminary work was based on the provisions of *AASHTO LRFD Bridge Design Specifications* (AASHTO 2017) . Force demand to capacity evaluations were performed on the following primary members of the cable stayed span as part of the conceptual design process:

- Edge Girder
  - Primary load carrying component in cable stayed superstructure.
  - Accounts for a significant portion of the total steel quantity based on a review of similar cable stayed structures.
- Stay Cables
  - Primary load carrying component of a cable stayed structure.
  - Most expensive component of a cable stayed structure on a per pound basis.
- Tower
  - Primary load carrying component of a cable stayed structure.
  - Most expensive concrete component of a cable stayed structure.

The following components were not analyzed and designed as part of the conceptual design process:

- Transverse Floor Beams
  - Floor Beams used in the analysis model and material quantities were empirically sized based on a review of similar cable stayed structures.
- Center Strut
  - Center Strut used in the analysis model and material quantities was empirically sized based on a review of similar cable stayed structures.
- Splices, Connections, Diaphragms, and other Miscellaneous Steel Components
  - Unit weight of steel was increased by a factor to account for these items, which is at the higher end based on detailed quantity take offs of similar projects.

Given the objectives of the conceptual design basis, a series of assumptions were made to simplify the design work. These assumptions include the following:

- Construction Staging
  - Erection of individual field sections is not considered in separate model stages; significant groups of field sections are added/erected in fewer overall model stages.
  - Time dependent effects are not directly considered.
- Cable Tuning
  - A detailed cable tuning exercise was not performed for each erected field segment. Approximate cable tuning was performed based on the larger grouping of field sections discussed above. Based on an initial review of the analysis, the simplified construction staging resulted in reasonable cable sizes when compared to other similar cable stayed bridges.

5.4.3 Conventional Spans

Layout and Configuration

The conventional span layout for the East Approach is determinate on which long-span superstructure type is chosen, tied arch or cable stayed.

Tied arch

With the tied arch, two conventional flanking spans are needed. The Burnside Skatepark and the east CSO line are located between E 2nd Avenue and E 3rd Avenue. Impacts to both facilities must be avoided. Therefore, the most feasible location for an intermediate support is immediately west of E 3rd Avenue. This requires a conventional girder span length of 285 feet for Span 8.

Span 9, the eastern most span of the bridge, is required to span over E 3rd Avenue and measures 80 feet in length.

Cable stayed

With the cable stayed, only one conventional flanking span is needed. This eastern most span of the bridge, Span 9, spans over E. 3rd Avenue and measures 80 feet in length (the same as for the tied arch described above).

Superstructure

With the two span configurations described above, suitable superstructure types are somewhat limited.

Steel Plate Girder, Steel Tub (Box) Girder, Precast/Prestressed Concrete Box, or I-Girders (Span 8, Tied arch Only)

- A comprehensive comparison between these three structure types is provided in the Span 5 superstructure discussion in Section 5.2.1.

Cast-in-Place Concrete Box (Span 9 Only)

- Offers flexibility to accommodate any alignment or profile.
- Requires access to install and remove falsework for superstructure construction.
- Increased construction duration due to falsework placement, concrete cure time, and falsework removal.

Precast/Prestressed Concrete Box Girders (Span 9 Only)

- Grade control is more difficult compared to cast-in-place options.
- Falsework is not needed to erect the precast girders.
- Shorter field construction time compared to cast-in-place options thereby reducing service disruptions to the City street underneath the bridge.

Preferred Recommended Structure Types

Based on the comparisons above, steel plate girders and precast/prestressed concrete box girders are the recommended superstructure types for Span 8 and 9, respectively.

- Due to the span length of Span 8, concrete superstructures are not recommended. Steel plate girders are the most suitable structure type for this span due to cost and reduced structure weight. While a temporary bent is likely needed to splice the girders near or within the Burnside Skatepark, this operation has been deemed viable.
- Since Span 9 traverses E 3rd Avenue, cast-in-place options are not preferred due to the falsework required to construct. Within this span, precast bridge construction such as precast superstructure elements are recommended to reduce the impacts to traffic operations. Due to the vertical clearance requirements above E 3rd Avenue, a shallower superstructure depth is required. Standard ODOT precast/prestressed box girders can accommodate this span length and will be cost-effective for this span.

Deck Joints

The deck joints for the East Approach are sized to accommodate moderate to large displacements from seismic and lateral spreading loads. Closed expansion joints like a strip seal system are anticipated at Bent 10. Due to the anticipated movements resulting from seismic and lateral spreading, a modular joint seal assembly type may be required at Bent 9 (tied arch only). A more robust assessment for the joint type will be made during the Final Design phase, in combination with the contractor, and will include noise and maintenance considerations.

Bearings Assemblies

Elastomeric bearings will be used where appropriate to accommodate moderate movements, axial and lateral loadings. Bearing assemblies will be utilized for bents where significant seismic movement is expected to occur. Base isolation bearings were not considered during the Type Selection phase for Bents 9 and 10 as they were deemed unnecessary given preliminary member sizing and would result in higher costs for the East Approach bents.

5.4.4 Vera Katz Eastbank Esplanade Connection Structure

The Project assumes that the existing stairway connecting the bridge to the Vera Katz Eastbank Esplanade will be protected in-place and reattached to the new Span 7 once construction is complete. A discussion on existing conditions and alternative connections studied during the EIS can be found in Section 8.3.

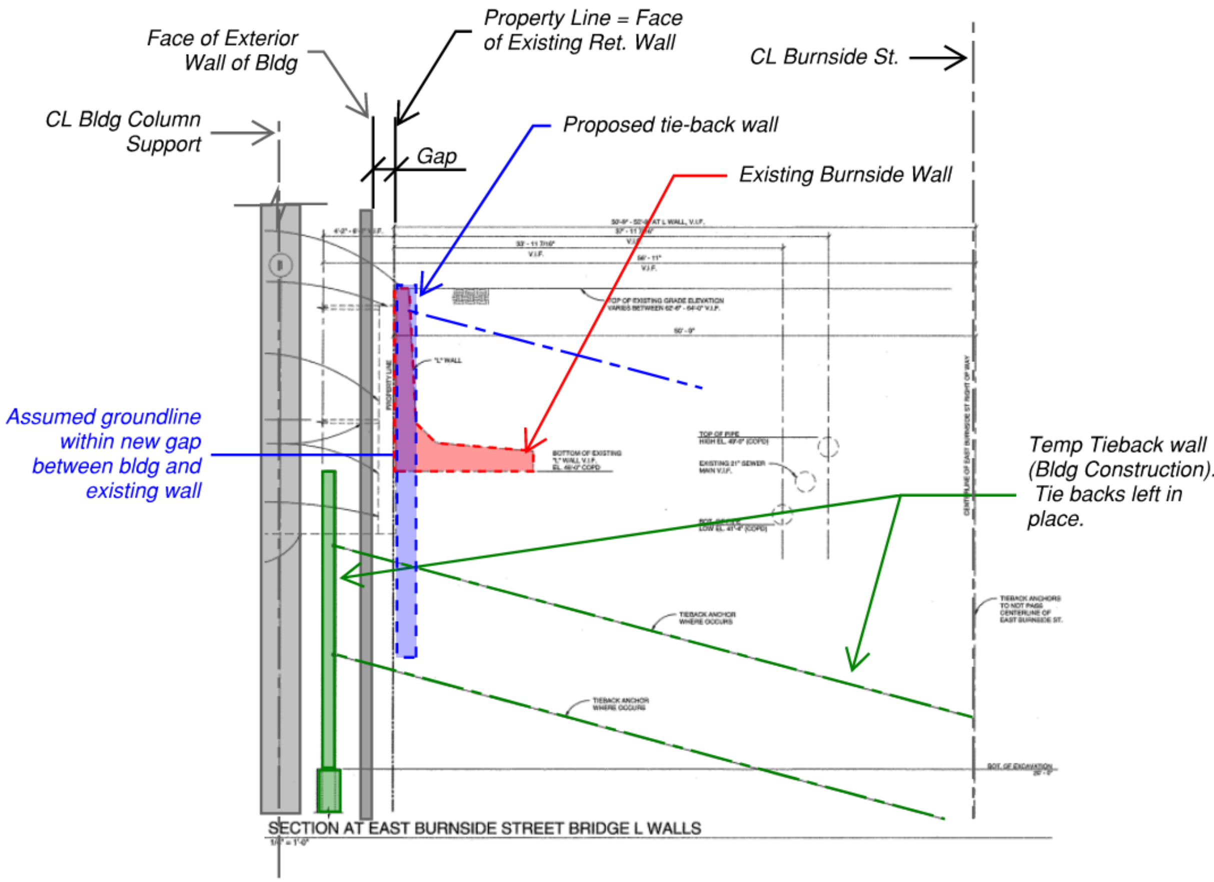
If in the future a new connection structure is to be considered, careful evaluation into the foundations and the performance requirements of the new structure will be required. This region of the east riverbank is particularly prone to extreme seismic hazards such as liquefaction, liquefaction-induced lateral spreading, and bank stability.

5.4.5 Retaining Wall Systems

Existing Systems

- The exact details of the existing northeast retaining wall system is currently unknown. Photos of the wall, prior to the recent construction of a concrete staircase as part of the Sideyard development, imply that it is a cast-in-place wingwall extending to the east from the existing bridge abutment. This wall could be partially impacted by the new bridge construction.
- The southeast walls are a combination of a semi-gravity concrete counterfort wall and a semi-gravity "L" shaped concrete wall. The retaining walls start from the existing bridge abutment and extend to the corner of E MLK Blvd. With the new construction of the 5MLK Building at the SE corner, a small gap has been provided between the external building façade and the existing walls. Additionally, temporary tieback walls used to construct the building have been left in place. These tiebacks extend into Burnside Street (see Figure 24).

Figure 24. Southeast Retaining Wall - Section Looking West



Proposed Northeast Wall

- New wall height is within range for a standard concrete retaining wall type.
- The proposed retaining wall system is a standard ODOT concrete cast-in-place wall.
- To minimize ROW acquisition in this region, it is recommended that an "L" shaped wall be investigated during Final Design.

Proposed Southeast Wall

- Prior to the construction of the new 5MLK Building at the SE corner, the building and the existing walls were fused together. The As-constructed plans of the new building now show a small gap between the building's external façade and the existing walls (Figure 24).
- Since the structural supports of the new building are inset from the property line, placing embankment fill up against the face of the building facade is not recommended (due to applying surcharge loading on the building). It is recommended that the gap be preserved, and a new retaining wall system retain the east roadway embankment.
- New wall heights could require a tieback system.

- Due to the proximity of the existing building, it is imperative that care be taken when installing the new wall foundation. Proposed foundations and tiebacks will have to be weaved in between the existing building temporary walls left in place.

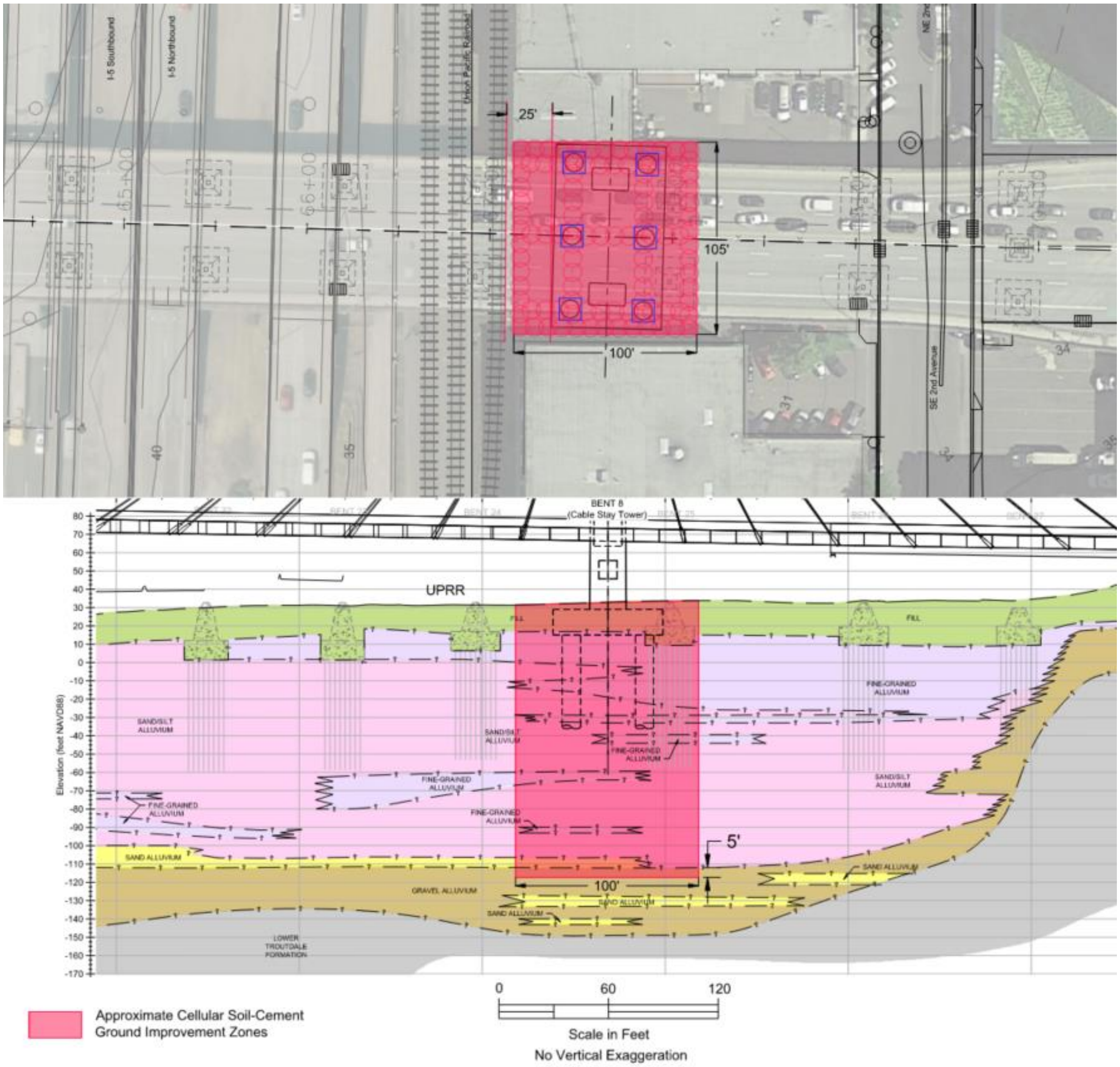
5.4.6 Geotechnical Seismic Hazards & Proposed Mitigation

For a general discussion of site geology and subsurface conditions, see Section 5.1.3.

Based on the nonlinear site response analysis for the 1,000-year probabilistic hazard level, a seismically induced permanent ground deformation on the order of 11.5 inches is expected at the cable stayed option's Bent 8, and 4.5 inches is expected at the tied arch option's Bent 8. The primary zone of permanent deformation at the cable stayed bridge tower location is within the mixed Sand / Silt Alluvium layer between approximate elevations 0 and -105.0 feet (NAVD88). The primary zone of permanent deformation at the tied arch Bent 8 is within the Alluvium layer between approximate elevations 31.0 and -100.0 feet (NAVD88).

Based on the results of the seismic hazard evaluation, ground improvement mitigation at the east embankment may be needed to achieve the required performance criteria for the cable stayed foundations due to the foundations being further closer to the river (see Figure 25). Preliminary analysis of the tied arch foundations has indicated that ground improvement mitigation is not required due to the foundations being further east, away from the compromised subsurface region.

Figure 25. Ground Improvements Associated with Cable stayed



To reduce permanent deformations, ground improvement at the cable stayed foundation is recommended until further analysis concluded that it can be eliminated. Ground improvement methods typical for seismic hazard mitigation include excavation and replacement, soil densification, drainage, soil reinforcement, or a combination of the above methods. The following three ground improvement alternatives have been considered the most feasible and practical to implement at this site:

- Stone columns – improves soil strength and performance of the soil by densifying the zones susceptible to seismic deformation.
- Jet grouting – improves soil strength and performance of the soil by reinforcing the zones susceptible to seismic deformation.
- Cement deep soil mixing – improves soil strength and performance of the soil by reinforcing the zones susceptible to seismic deformation.

The selection of appropriate mitigation methods for a particular site depends on soil type, site access, geometric constraints, environmental concerns, and impacts to adjacent facilities. Figure 26, provided from the *EQRB Preliminary NLTH Geotechnical Report* (Multnomah County 2022d), provides the advantages and disadvantages of the three improvement types considered.

Figure 26. Excerpt from Geotechnical Report Comparison of Ground Improvement Options

Exhibit 9-1: Comparison of Ground Improvement Alternatives

Alternative	Description	Advantages	Disadvantages
Stone Columns	Install stone columns in the Fine-grained Alluvium and the Sand/Silt Alluvium to densify and reinforce the native soils, in a square or triangular pattern. The typical area replacement ratio is at least 25 percent.	▪ Lower up front construction costs. ▪ Relatively simple construction quality control. ▪ Relatively conventional ground improvement construction.	▪ Densification is not feasible due to the relatively high percentage of fines in the soils. ▪ Larger ground improvement area is required which is not available due to constrained site conditions. ▪ Potential for vibration impacts on existing railroad and buildings.
Improved Soil Mass (Jet Grouting)	Construct continuous jet grout columns in the Fine-grained Alluvium and the Sand/Silt Alluvium in a grid pattern. The typical area replacement ratio is at least 50 percent.	▪ Improves soil shear strength much more effectively than stone columns; therefore, provides much more resistance within relatively a small area compared to stone columns. ▪ Can penetrate dense gravel layers. ▪ Better precision for grouting near existing foundations compared to deep soil mixing.	▪ Construction generates significant surface spoils. ▪ Potentially difficult environmental permitting. ▪ Relatively difficult construction quality control. ▪ Most expensive alternative. ▪ Potential negative impact on the existing railroad, such as heaving concerns. Careful design and construction approach is required.
Improved Soil Mass (Deep Soil Mixing)	Construct continuous soil mixing columns or rectangular elements in the Fine-grained Alluvium and the Sand/Silt Alluvium in a grid pattern. The typical area replacement ratio is at least 50 percent.	▪ Improves soil shear strength much more effectively than stone columns; therefore, provides much more resistance within relatively a small area compared to stone columns. ▪ Relatively low construction cost compared to jet grouting.	▪ Construction generates significant surface spoils. ▪ Potentially difficult environmental permitting. ▪ Relatively difficult construction quality control. ▪ Existing timber pile foundations will be obstructions for the soil mixing equipment. ▪ DSM columns may not be feasible for required depths. Soil mixed rectangular elements formed using cutter soil mixing or similar methods may be required.

2022. Multnomah County. EQRB Preliminary NLTH Geotechnical Report. Exhibit 9-1. Page 110-111.

Due to the high fines content of the soil, stone columns will not sufficiently densify the soils and, therefore, is not recommended.

Based on an evaluation of the different methods described above, deep soil mixing is the preferred ground improvement alternative for the cable stayed option Bent 8 location. It should be noted that the construction of conventional deep soil mixed “columns” may not be feasible for the required ground improvement depths. Instead, deep soil mixed rectangular elements (also called “barrettes”) constructed using cutter soil mixing or similar methods may be required. The existing Bridge Bent 25, partially within the proposed improved soil mass area, is supported on timber piles and timber piles or other buried obstructions may be present near the railroad. Deep soil mixing is only feasible within the existing timber pile areas once the conflicting piles and cap are removed completely. For a full evaluation on the design recommendations of improved soil mass, reference the *EQRB Final NEPA Geotechnical Report* (Multnomah County 2022b) and *EQRB Preliminary NLTH Geotechnical Report* (Multnomah County 2022d).

6 Hydraulic Considerations

As a part of the NEPA phase, hydraulic impacts within the Project’s Area of Potential Impact (API) were evaluated. The subsequent sections are a summary of the hydraulic impact analysis, which evaluated channel hydraulics, scour, sediment transport, bent impacts and encroachment (as they relate to hydraulics), and flood elevation impacts for the Willamette River. The evaluation includes review of federal, state, and local regulations that provide the legal requirements applicable to hydraulic impact analysis in the API, as well as a review of local plans, policies, and manuals that provide additional guidance. The *EQRB Hydraulic Impact Analysis Technical Report* (Multnomah County 2021c) provides a comprehensive list of regulations, standards, and full discussion of the hydraulic impact analysis.

Floodplains can provide fish and wildlife habitat, flood water storage and conveyance, water quality protection, and groundwater recharge. This area of the Willamette River floodplain has been highly modified by urban development over the past 100 years, and most of the original natural and beneficial floodplain values have been modified or diminished. Therefore, the floodplain and hydraulic impacts analysis focuses mainly on the potential for base flood increase and scour compared to the existing bridge and channel.

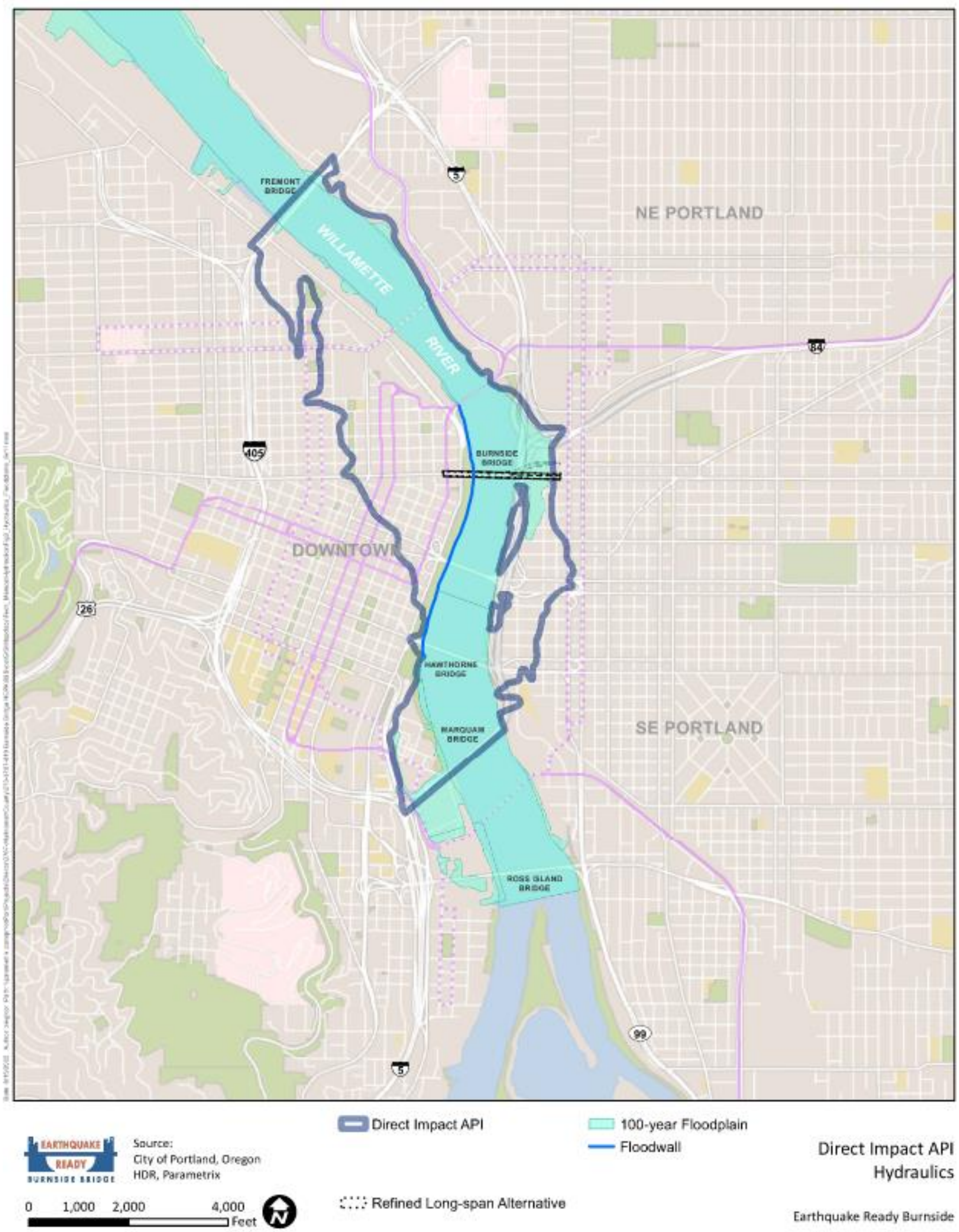
The NEPA phase hydraulic impact analysis within the *EQRB Hydraulic Impact Analysis Supplemental Memorandum* (Multnomah County 2022c), qualitatively compares the proposed geometry of the Long-span Alternative against the geometry of the existing bridge, focusing on the elements (such as lateral surface area in the floodway and openings between columns) that affect how flow would move around in-water bents and footings and the potential for hydraulic changes that could impact scour or base flood elevation.

6.1.1 Base Flood

As the Draft EIS and SDEIS analyses are qualitative and the Final EIS analysis is still under development, no quantitative analysis results are available at the time of this report. However, the characteristics of the existing floodplain are useful points of reference to evaluate the proposed alternative impacts.

The study area includes a Federal Emergency Management Agency Special Flood Hazard Area (designated as Zone AE), also known as the 100-year floodplain. The width of the 100-year floodplain is shown on Figure 27.

Figure 27. Willamette River 100-year Floodplain Within Project API



The Long-span Alternative includes a narrower bridge with narrower in-water bents than other alternatives and would result in less floodway encroachment. Compared to previous alternatives studied, the Long-span Alternative would have the lowest potential for increasing the base flood elevation. Compared to other alternatives studied during the NEPA phase, the preliminary hydraulic modeling estimates a reduction in the base flood elevation throughout most of the API, with a potential base flood elevation increase of approximately 0.5 inch at the immediate downstream edge of the bridge.

6.1.2 Flow Dynamics, Scour Considerations, Contaminant Mobilization

The proposed bridge replacement is expected to result in an increase of scour potential, which could result in the mobilization and transport of sediments present in the riverbed. Scour is the erosion of streambed material caused by flow around structures and through the channel that can cause instability for structures anchored in the streambed. The threshold for scour depends on several factors including bed material grain size and water velocity. The risk of scour is usually increased during the construction phase of in-water work. The hydraulic impacts analysis considers the three primary components of total scour: Long-term degradation, contraction scour and local scour.

Streambed scour is of additional concern when it can mobilize pollutants where sediment contamination is present. The Willamette River, within the API, is identified on the Oregon Department of Environmental Quality (DEQ) Section 303(d) List as an impaired waterbody for multiple metals and other toxic substances[2] (DEQ 2018a). The north end of the API is part of the Portland Harbor Superfund Site, which extends from river mile 1.9 near the mouth of the Willamette River upstream to river mile 11.8 near the Broadway Bridge. A Pre-Remedial Design Investigation was implemented for the site between March 2018 and May 2019 to provide baseline sampling, and results demonstrate significant recovery since the last comprehensive sampling in 2004. Concentrations of the focused contaminants of concern[3] have decreased in surface water, surface sediment, and fish tissue, and areas of elevated concentrations have not migrated substantially (EPA 2019). DEQ is also conducting sampling and sediment cleanup at multiple locations throughout the API.

Velocities at the existing Burnside Bridge are generally low and are tidally influenced by the downstream Columbia River and Pacific Ocean. United States Geological Survey gauge data at the Broadway Bridge (approximately 3,800 feet downstream of the Burnside Bridge) generally indicate velocities in the outflow (downstream/northerly) direction are higher in the winter months, but inflow (upstream/southerly) velocities influenced by the tide are higher in the summer. Based on the United States Army Corps of Engineers Lower Willamette River Federal Navigation Channel maintenance dredging

[2] 303(d) listing includes copper; iron; lead; aldrin; chlordane; cyanide; dichlorodiphenyltrichloroethane and its derivatives (DDx); dieldrin; dioxin (2;3;7;8-TCDD); hexachlorobenzene; pentachlorophenol; polychlorinated biphenyls (PCBs); and polynuclear aromatic hydrocarbons (PAHs) (DEQ 2018a).

[3] The focused contaminants of concern are total PCBs; total PAHs; DDx; and three dioxin/furan congeners (2,3,7,8-tetrachlorodibenzo-p-dioxin; 1,2,3,7,8-pentachlorodibenzo-p-dioxin; and 2,3,4,7,8-pentachloro-dibenzofuran) (EPA 2019).

program (EPA 2020)[4], the low velocities may be causing aggradation in this reach of the Willamette River.

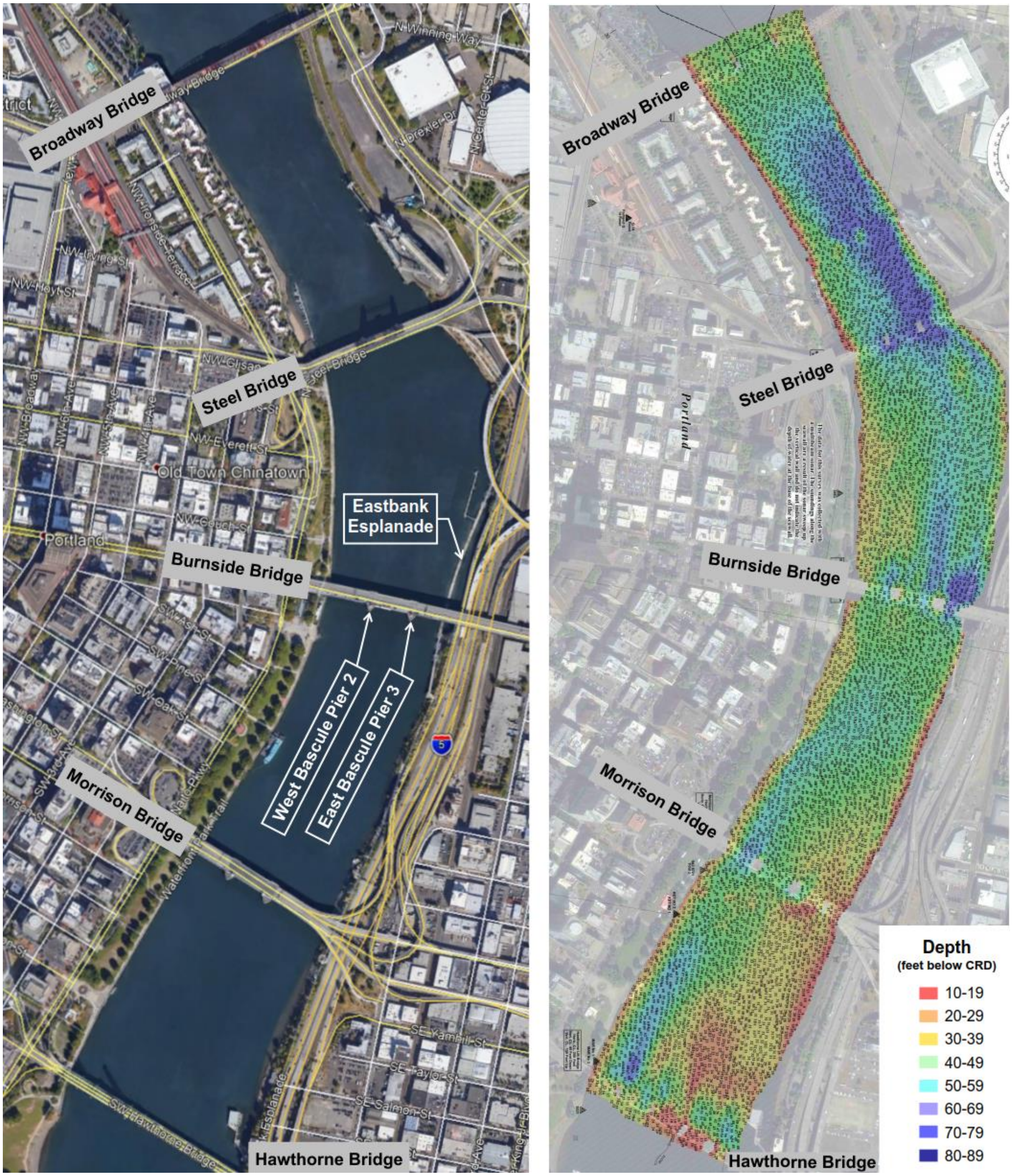
Channel bed elevation patterns are shown in Figure 28. At approximately 50 feet below the Columbia River Datum (CRD),[5] the channel's natural centerline, or thalweg, is visible. A thalweg typically runs down the center of a channel at straight segments and curves closer to the outer bank at riverbends, where the flows are deepest, and velocities are highest. Elevation patterns indicate localized scour at the existing Burnside Bridge; however, the channel bed elevation self-corrects before reaching the Steel Bridge. Also visible in Figure 28 is the increase in the local Burnside Bridge scour at the Vera Katz Eastbank Esplanade columns that likely create a flow constriction at the thalweg and create associated eddy (circular water movements in the opposite direction of main channel flow) scour at the riverbend. Continuation of these scour patterns at the Vera Katz Eastbank Esplanade could lead to pier instability of the existing bridge and have the potential to mobilize sediments, some of which have been identified as contaminated.

Based on the NEPA phase analysis, updates in the footing design configuration for the Long-span Alternative result in longer footings in the direction of the flow. These longer footings could increase the potential for bent scour. Quantitative scour analysis was performed as part of the NEPA phase modeling.

[4] Portland Sediment Evaluation Team (PSET), U.S. Environmental Protection Agency's Region 10 Cleanup Program (EPA Cleanup) and Oregon Department of Environmental Quality's Cleanup Program (ODEQ Cleanup) joint Level 2A dredged material suitability determination for the Corps' maintenance dredging of the Post Office Bar and Albina Turning Basin in the Lower Willamette River (LWR) Federal Navigation Channel (FNC). EPA-Region 10 Water Division, Wetlands and Oceans Section. September 19, 2020.

[5] The CRD is a gradient vertical datum that changes relative to the North American Vertical Datum of 1988 (NAVD88) by river mile above the Columbia. The Burnside Bridge is located approximately at Willamette River mile 12.4, where CRD = NAVD88 - 5.35 feet (DEA 2016).

Figure 28. Willamette River Depths and Scour Patterns



Source: Google Earth Pro; USACE 2019
Note: CRD (Columbia River Datum) at Burnside Bridge = NAVD88 – 5.35 feet (DEA 2016)

6.1.3 Mitigation Considerations

The NEPA phase modeling consisted of detailed quantitative evaluation of potential impacts to the base flood elevation, scour at the bents or related in-water structures, and the potential to mobilize contaminated sediments. However, the level of seismic resiliency incorporated into the new bridge foundations is expected to be insensitive to effects from local scour. If shown to be necessary from the model analysis, countermeasures will be incorporated in the design as needed to minimize the resulting hydraulic impacts.

There are limited opportunities to mitigate hydraulic encroachment impacts associated with the Project because encroachment offsets generally need to occur at the same location as the encroachment. The minimization measures would focus on limiting an increase in base flood elevation and reducing scour potential that could impact habitat and mobilize contaminated sediment.

Because the NEPA phase modeling showed that the Project would result in an unavoidable small increase to the base flood elevation, the project team may need to request a variance to the Portland Municipal Code no-rise standard based on PMC 24.50.060(D) Floodways and PMC 24.50.070 Appeals and Variances and could supply the City with information to apply to the Federal Emergency Management Agency for a Conditional Letter of Map Revision. Further analyses are recommended as part of the Final Design phase to assess whether this small rise can be avoided.

7 Environmental Considerations

The environmental approval process is currently underway for the Project. Several federal, state, and local regulations and permits are applicable to the Project. Because the Project is federally funded, it needs to comply with the National Environmental Policy Act (NEPA). An EIS was determined to be required to analyze and document proposed alternatives and potential environmental impacts. A Final EIS is forthcoming as well as a Record of Decision, anticipated in late 2022 or early 2023.

The Project will require several permits after completing the NEPA phase. Government agencies have been involved throughout the NEPA process and will continue to coordinate with the project team during the permitting process to ensure permit compliance is met. Temporary impacts caused by construction activities could affect fish and wildlife species within the Willamette River and in its riparian area. Vegetation impacts are also anticipated to be affected during construction through removal for access and staging. After construction is completed, permanent impacts are anticipated to fish and wildlife habitat, as well as stormwater.

The Project has been designed to minimize environmental impacts to the extent possible. Because some impacts to regulated resources cannot be avoided, mitigation will be required and implemented for the Project. Mitigation is anticipated in the form of mitigation bank credits for in-water impacts, and vegetation impacts will be mitigated through riparian restoration. During construction, best management practices will be implemented to minimize impacts.

8 Multimodal and Transit Considerations

Transportation modes evaluated are automobiles, bus, light rail, streetcar, freight, bicycles, and pedestrians. Direct effects caused by proposed alternatives were evaluated within the direct impact area, whereas the indirect impact area was used to evaluate broader transportation implications for all modes during construction. See Figure 29 and Figure 30 for direct and indirect areas of potential impact studied as part of the NEPA phase.

Figure 29. Direct Areas of Potential Impact

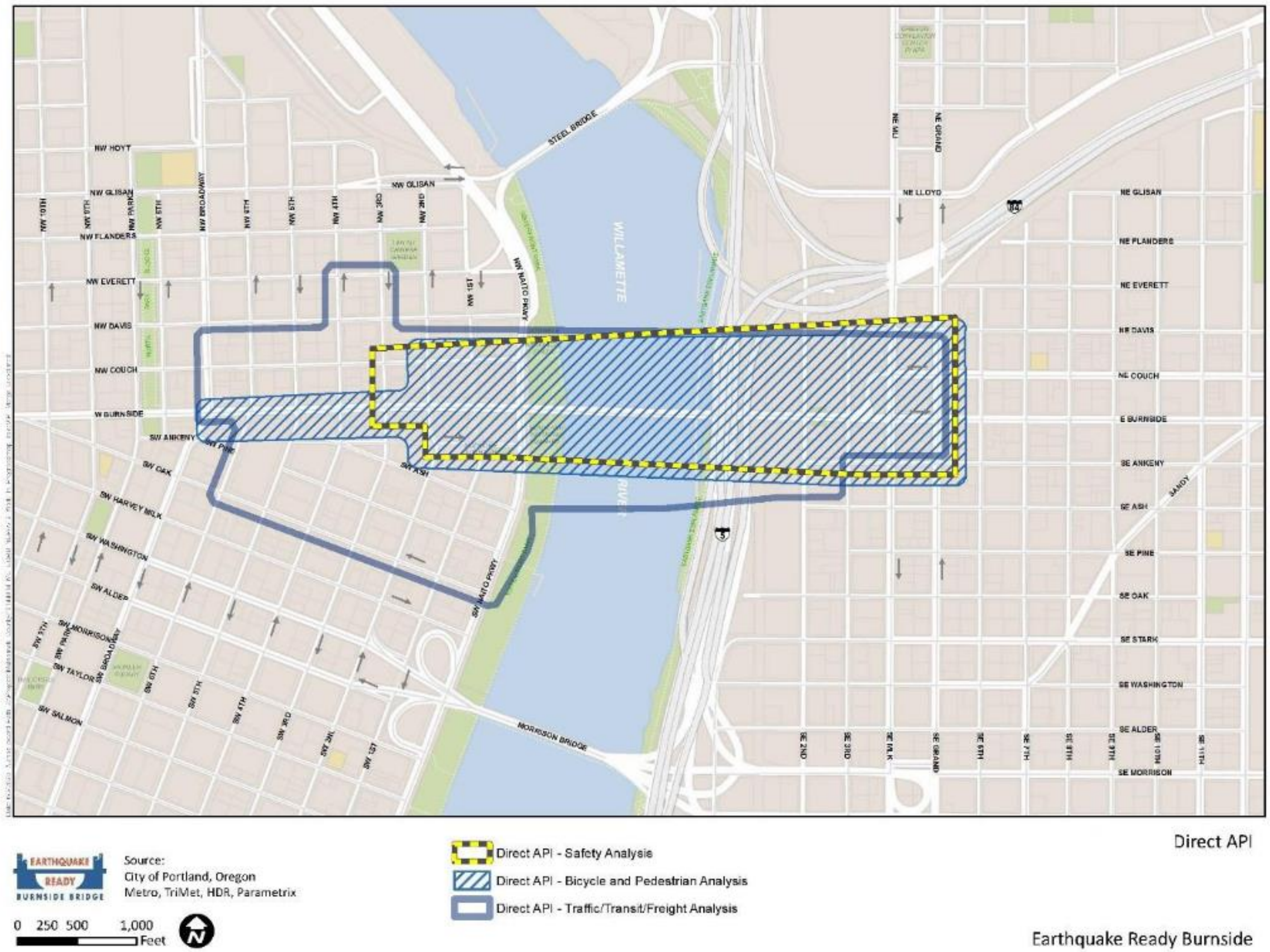
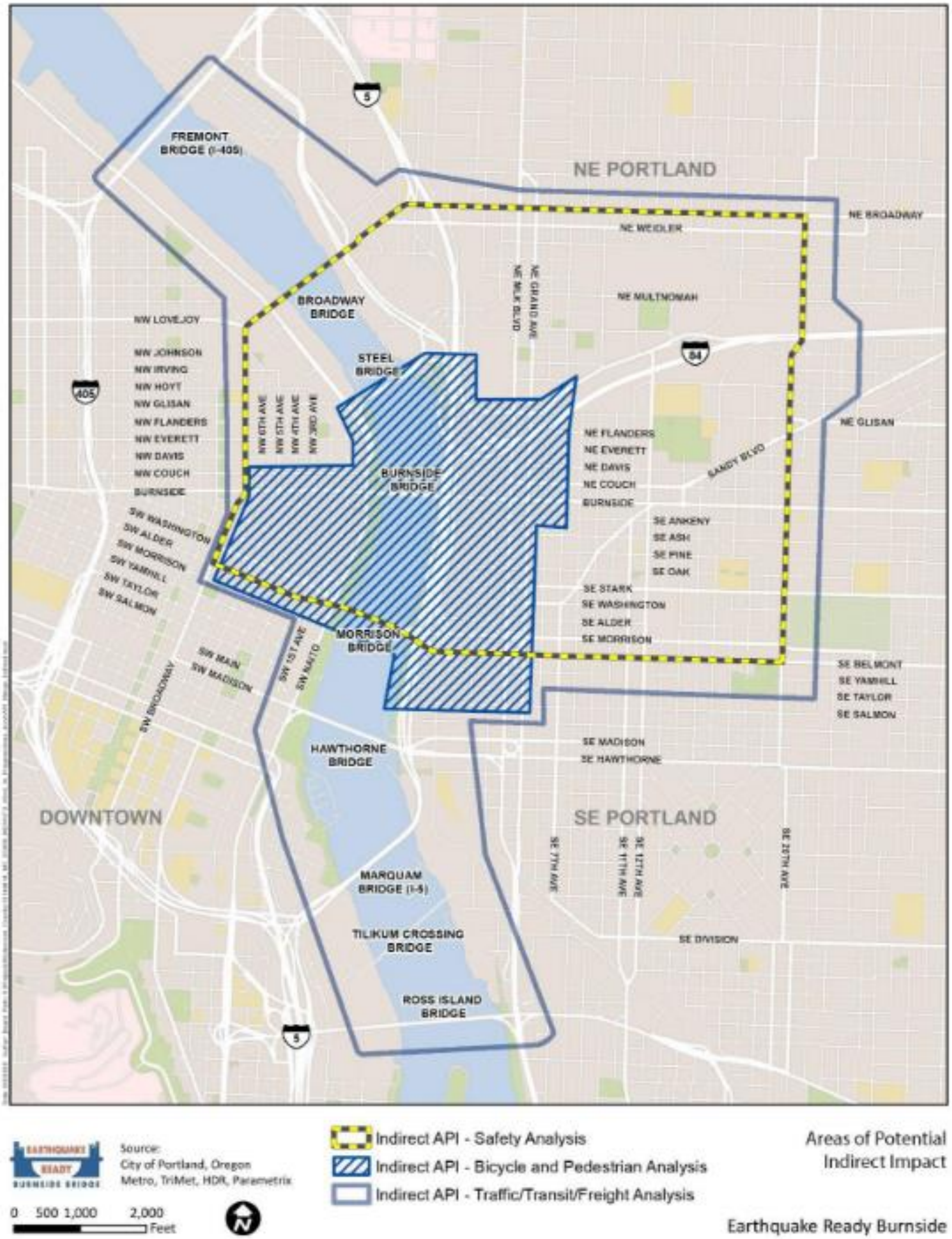


Figure 30. Indirect Areas of Potential Impact



8.1 TriMet MAX Light Rail

The existing light rail system crosses under the existing bridge at NW 1st Ave near the western abutment. The Skidmore Fountain MAX station is directly under Burnside Bridge. The existing bridge has columns between the existing tracks, and within both station platforms. Span 1 of the new bridge will remove these columns and completely span over the MAX station while maintaining the existing vertical clearance. The western abutment (Bent 1) will be relocated to be in line with the eastern building face of the Portland Rescue Mission, and Bent 2 will be placed at the back of the platform to maximize visibility and minimize obstructions for the station.

In addition to permanent changes discussed above, there will also be temporary impacts to the MAX during construction.

- Temporary closure of the Skidmore Fountain MAX station is required for the duration of construction. MAX riders can use nearby stations to access transit during the station closure.
- Intermittent temporary short-term MAX line closures are required to demolish the existing bridge and construct Span 1 over the line. Bus bridges are anticipated to move MAX riders between the two sides of the temporary closures.

8.2 Portland Streetcar

The Burnside Bridge is included on some of the priority routes for future streetcar in the City of Portland according to the *Portland Streetcar System Concept Plan* (PBOT 2009). All replacement options will accommodate future streetcar routes on the bridge, making it “Streetcar Ready” when the facility is constructed. The bridge deck will be designed to allow installation of embedded track in the outside lanes in both directions on the bridge.

8.3 Bicycle/Pedestrian Connections

Existing bicycle and pedestrian connections were evaluated between the proposed bridge and the TriMet MAX light rail on NW/SW 1st Avenue, and between the proposed bridge and the Vera Katz Eastbank Esplanade multi-use path on the east side of the Willamette River.

The Project approach is to protect in place the existing stairway structure at the Vera Katz Eastbank Esplanade. The West Approach stairway access at 1st Avenue could be removed, but this decision is deferred until the Final Design phase. Alternative options that were studied included different combinations of stairs, ramps, and elevators as described in Sections 8.3.1 and 8.3.2.

8.3.1 West Approach Connections

At NW/SW 1st Avenue, there are existing stairs from the north and south bridge sidewalks to the western NW/SW 1st Avenue sidewalk, but no ADA accessible connections. New ramp connections were studied, but space for ramps is limited by existing buildings constructed to the edge of ROW, and the City of Portland’s desire to reserve all space currently occupied by existing parking lots for future redevelopment.

New stairs and elevators connections were studied on the west side of the NW/SW 1st Avenue ROW but would use up most of the available sidewalk space, providing a narrow remaining space for the sidewalk and MAX platform. The existing sidewalk network was also studied on both sides of Burnside to determine if “around the block” routes could provide accessible routes. All curb ramps and some segments of the sidewalk on both “around the block” routes would need to be reconstructed to meet ADA requirements.

TriMet indicated that few riders transfer between the MAX on NW/SW 1st Avenue and the bus lines on W Burnside Street. Walking distances also indicated that “around the block” routes were similar in distance to ramps. Currently, the TSR assumes that the only improvements will be to construct the “around the block” routes, with no ramps, stairs, or elevators. The actual connection will be determined during the Final Design phase.

8.3.2 East Approach Connection

There are existing stairs from the south bridge sidewalk to the Vera Katz Eastbank Esplanade, but no ADA functioning accessible connections. There are no connections from the north bridge sidewalk. Currently, the Project assumes that the existing stairway connection will be protected in-place during construction.

9 Union Pacific Railroad

The project site is located over UPRR tracks within the extents of the East Approach. At the time of this report, railroad coordination and input has not been initiated by the Project team. Once coordination begins, items to discuss include, but are not limited to:

- Temporary access to facilitate demolition of the existing bridge adjacent to and over the UPRR tracks.
- Temporary track crossings to facilitate construction of the proposed replacement bridge.
- UPRR flagging requirements and third-party inspector at project site.
- Temporary and permanent horizontal clearances to anticipated ground improvements to occur just east of the tracks.
- Ancillary improvements necessitated by UPRR to obtain Railroad approvals and/or the Construction and Maintenance Agreement.

10 Traffic Considerations

10.1 Maintenance of Traffic

Initial evaluation in the EIS and SDEIS included two methods for construction and traffic staging:

- Divert traffic to an onsite temporary bridge.

- Close the existing Burnside Bridge for the duration of construction and reroute all traffic to adjacent river crossings.

The Project's selected approach is to close the Burnside Bridge crossing (from E MLK Boulevard to W 2nd Avenue) to all modes of transportation for the duration of construction. This is due to the significant impacts associated with an on-site temporary movable bridge (construction cost, impacts to adjacent stakeholders, construction timeline, additional environmental impacts, etc.). The bridge closure is anticipated to last a total of 4.5 - 5 years, see Section 14.6 for the anticipated construction phasing.

Detour routes will be finalized to route multimodal traffic to adjacent river crossings during the Final Design phase. This approach allows the contractor to demolish the existing bridge and construct the new bridge without concerns for staging traffic. All other facilities crossed by Burnside Street (e.g., I-5, various City streets, and TriMet MAX lines) will have to be maintained and protected, except for short term closures for construction activities such as girder erection and deck placement.

10.1.1 Vehicular Traffic/Freight

Increased congestion is expected to occur on major arterial streets adjacent to and leading to the Burnside Bridge and the other bridges crossing the Willamette River. Specific detour routes would be planned to direct vehicles around the Burnside Bridge closure and routed across other bridges across the Willamette River. Signed detour routes would seek to avoid major transit delays where the additional detoured traffic volumes could significantly impact transit operations, including the Steel Bridge and the Rose Quarter Transit Center.

For further details on the specific detours, see the *EQRB Transportation Supplemental Memorandum* (Multnomah County 2022l).

10.1.2 Transit

For bus transit, routes for lines 12, 19, and 20 will be detoured away from the closed bridge and likely over the Steel Bridge, although other detour routes are possible. These detours will include closures of several bus stops in or near the construction zone. It is assumed that these bus lines would be impacted throughout the full extent of construction. To minimize impacts to transit riders due to detours, traffic detour routes should be considered that do not impact transit detour routes.

Construction during this Full Closure scenario will disrupt MAX Blue and Red Line service as outlined in the *EQRB Revised Construction Approach Technical Report* (Multnomah County 2022g). To mitigate impacts to service disruptions, TriMet is planning on operating a temporary bus bridge using the Steel Bridge connecting disrupted MAX service across the Willamette River. The extent of the bus bridge will run approximately 1.25 miles from the Rose Quarter Transit Center to the Yamhill and 1st Avenue stop.

For further details on the transit detours, see the *EQRB Transportation Supplemental Memorandum* (Multnomah County 2022l).

10.1.3 Active Transportation

During the Burnside Bridge closure for construction, active transportation users looking to cross the river would need to divert their trip to another bridge – most likely the Steel, Morrison, or Hawthorne Bridges. Active transportation would also be impacted with periods where the Vera Katz Eastbank Esplanade and the Tom McCall Waterfront Pathway are closed at the Burnside Bridge.

Construction will also close a section of the Vera Katz Eastbank Esplanade within the vicinity of bridge for an intermittent total period of 18 months. Commuters may switch modes or divert their trip around the closure. The detour route for bicyclists is to cross the river using the Morrison Bridge, then use Naito Parkway and cross back to the east side of the river at the Steel Bridge.

Pedestrians could take several routes to divert around the closure. The shortest detour route for a trip from the Vera Katz Eastbank Esplanade at SE Salmon Street to the east side of the Steel Bridge is for pedestrians to cross the river using the Morrison Bridge and then use Naito Parkway and/or the Waterfront Pathway to cross back to the east side of the river at the Steel Bridge.

Construction will also require staging under the west side of the bridge, which will close that section of the Waterfront Pathway during the period of construction. PBOT's Better Naito Forever Project was constructed in 2022. It formalizes pedestrian and bike facilities along Naito Parkway and provides an alternate route around the closure of the Waterfront Pathway. This route is minimally out-of-distance and is not expected to have major impacts on usage and volumes.

For further details on the specific detours, see the *EQRB Transportation Supplemental Memorandum* (Multnomah County 2022l).

10.2 Signs and Signals

Three existing traffic signals near the Burnside Bridge are assumed to be replaced due to lane configuration changes and curb/sidewalk/ramp reconstruction. This includes the existing full signals at W Burnside Street/W 2nd Ave and E Burnside Street/E MLK Blvd, and the partial signal at E Burnside Street/NE Couch Street. For further details, see the TSR Roadway plans (Appendix A). Additionally, the new bridge would likely include traffic signals in advance of the movable span in both directions to control traffic during bridge openings, like the existing bridge. These signals would need to be supported by new mast arms or sign bridges that are mounted outside of the bridge rail to avoid narrowing the bicycle/pedestrian paths on both sides of the bridge.

Bridge illumination will be included for all modes of transportation, see Section 5.3.1 for additional discussion.

Sign and illumination locations, types, and sizes have not been identified at this time. Sign and illumination design will need to be advanced during final design.

11 Utilities

Existing public and private utility information was collected from known utility providers within the Project limits and assessed for impacts for each Project alternative. The utility impacts are similar in nature for each replacement alternative.

Impacts were assessed based on one-call survey mapping, as-built drawings, and discussions with utility providers. Reference the *EQRB Revised Utilities Technical Report* (Multnomah County 2022i) for a full evaluation of the anticipated utility impacts and possible mitigation measures not discussed herein.

11.1 Utilities Within Project API

The API for the utilities analysis includes the Project Area and anticipated areas of construction staging. The API also includes the adjacent roadways and ROW where utility relocation is likely to occur beyond the improvement footprint.

The utility owners were identified by contacting the Oregon Utility Notification Center (One-call, 811, 800-332-3244) and submitting a pre-design survey, "mapping-only," ticket request for the Project Area through the online ITIC program.[6] The identified utilities are in Table 6. The only utility owners on the bridge include Level 3 (now Lumen) and Multnomah County. PGE and PWB provide services for the bridge, but the lines are owned by Multnomah County once on the bridge (beyond the service provider meters).

Table 6. Identified Utilities Within API

Utility Owners	Impact Expected?
Comcast	Yes
Electric Lightwave, Inc. (now Zayo)	Yes
Henkels & McCoy	Yes
Level 3 (Now Lumen, referred to as Lumen National)	Yes
Multnomah County Bridge Section	Yes
MCI (now Verizon)	Yes
NW Natural	Yes
Oregon Department of Transportation Electrical	Yes
Portland General Electric	Yes
City of Portland, Bureau of Maintenance	Yes
Pacific Power	Yes
City of Portland, Portland Streetcar	Yes
City of Portland (Water Bureau, Bureau of Environmental Services, Bureau of Transportation, Bureau of Technology Services)	Yes
City of Portland, Parks & Recreation	Yes
AT&T Local Network Services (referred to as AT&T LNS	Yes

[6] Ticket 19234729 dated August 22, 2019, (Oregon Utility Notification Center, 2019)

Utility Owners	Impact Expected?
TriMet	Yes
Wave Broadband	Yes

11.2 Impacts Assessment

The analysis considers all known or mapped utilities within the Project Area, including those located along the river bottom. The Long-span Alternative was assessed for likely utility impacts from the bridge work, based on the current design assumption for foundation placement and assumed excavation limits for foundation work.

For details on the utility impacts assessment, see the *EQRB Utilities Technical Report* (Multnomah County 2022i).

11.2.1 Short-Term and Long-Term Impacts

Long-term operational impacts to the utilities are not expected; however, short-term impacts have been assumed to occur for every utility within the work area until design is sufficiently detailed to show where avoidance or protection is feasible, or relocation required.

Utility relocation prior to and during construction may result in interruptions of service. Potential disruptions are expected to be minimal for most of the utilities, with utility providers scheduling outages to accommodate cutovers. Temporary connections likely would be established before relocating the utility conveyances.

Impacts from stormwater and mitigation sites are not yet known and have not been evaluated. Additional temporary impacts from staging areas, crane placement, work access, work bridges, etc., have not yet been determined.

Utility facilities that would affect a large part of the Portland metropolitan region in the event of a service disruption, and those that warrant special consideration during design, are as follows:

- Bureau of Environmental Services (BES) 24-inch and larger utility infrastructure could pose a design challenge due to the conveyance volumes involved. Service disruptions to these facilities could affect a large part of the City of Portland metro area. Where feasible, mitigation measures would be implemented to avoid or minimize impacts to affected facilities.
- BES 42-inch and 30-inch sewer lines landside of the west bank sea wall require protection unless relocation is determined feasible by engineering analysis and confirmed by BES. Any required relocation of these two sewer lines riverside of the west bank sea wall is expected to warrant a complete pipe replacement from the Ankeny Pump Station to each pipe's outfall at NE Lloyd Blvd, on the eastern side of the river.
- The replacement alternative will require relocation of Lumen Local's submarine cable. The three large fiber cables on the bridge may serve Federal Aviation Administration and 911 circuits, which are critical. Lumen likely will not relocate back onto the bridge, due to the nature and duration of the relocation work, therefore it will

require at least 2 years to complete the design, permitting, and construction of the relocation off the bridge.

- Design features that require relocation of NW Natural's 20-inch high-pressure line should be avoided if possible. Further evaluation will be needed as the design develops, to determine if it can be protected. NW Natural will require 12 months or more to relocate the 20-inch line.
- PGE provides and maintains power to the existing bridge. The Project is responsible for the costs associated with relocating or providing power to the bridge service vaults. PGE will require 18 months for planning, budgeting, and designing relocations.

12 Right-of-Way

The Refined Long-span Alternative will require acquisition of ROW and potential non-residential and personal property relocations. Subsequent sections discuss the anticipated ROW impacts and compare differences in impacts between the tied arch and cable stayed superstructure types.

Reference the *EQRB Right-of-Way Technical Report* (Multnomah County 2021e) for a comprehensive evaluation of the ROW process, schedule, associated cost, and possible mitigation measures for impacted properties not discussed herein.

12.1 Long-Term Acquisition Impacts

There are several proposed fee acquisition areas. Per Multnomah County direction, permanent rights for bridge improvements are to be acquired as permanent easements. The tied arch and cable stayed structure types include various types of acquisitions from properties, varying in size and duration. See Appendix E for a summary of potentially impacted properties for both the tied arch and cable stayed structure types. Reference the *EQRB Right-of-Way Supplemental Memorandum* (Multnomah County 2022j) for a comprehensive list of impacted properties.

Additionally, an easement for bridge facilities over UPRR property and along its tracks is required on the East Approach. Negotiations with UPRR have historically taken at least 12 months, which will need to be accounted for in the Project schedule, and permanent rights are likely to take longer to acquire from the railroad than temporary rights.

Use of ODOT's I-5 and I-84 ROW at the East Approach will be handled via permitting process with ODOT. This agreement is no longer considered temporary and includes a Permanent Easement.

12.2 Short-Term Acquisition Impacts

Construction impacts within the API can be split into two categories: construction and staging area closures and access closures. Construction and staging area closures are defined by locations where construction equipment is staged or where construction activities are occurring and would need to be closed for safety. Access closures are defined as properties where building accesses would be closed temporarily or permanently due to street closures or other construction activity. In the following short-term construction impacts, access closures are only counted for properties where no other temporary construction easements (TCE) are required for construction and staging area closures.

Temporary construction impacts associated with the bridge replacement impact have been assumed as approximately 18 properties, although the number of impacted properties could be adjusted based on the construction approach determined in the Final Design phase. During construction of either bridge type selected, approximately 51 doorways and garage/parking lot entrances could be temporarily affected. These access closures could require three additional TCEs to allow the County to compensate property owners for building modifications that are necessary to provide alternate access during construction. All ROW impacts will be finalized after collaborating with the contractor during the Final Design phase.

At the time of this report, it is assumed that access accommodations will be made for sidewalk construction and other short-term access impacts. However, if this were to change, several temporary easements for access closures will be needed. See *EQRB Acquisitions and Displacements Supplemental Memorandum* (Multnomah County 2022a) for updated access and parking impact maps or the East and West Approaches.

The contractor may elect to use off-site construction staging for the duration of construction. The use of such sites will be the choice of the contractor and therefore the actual site or sites is not known at this time. Four potential sites (A, B, C and D) have been identified as possible options, see Appendix E for location of these sites. These locations would be used for construction staging or access and returned to their current use following the Project. No business displacements are anticipated for staging sites. Potential construction staging site locations are shown the *EQRB Acquisitions and Displacements Technical Report* (Multnomah County 2021a).

12.3 Relocations

Impacts to personal property and anticipated relocations occur on both the west and east bridge approaches. See Appendix E for an illustration of the properties potentially impacted by the Project. Except for the potential impact to a portion the Pacific Coast Fruit Company's building on the north side of the bridge, there are no other significant differences in relocation impacts between the tied arch and cable stayed bridge types. Residential relocations are not anticipated; however, five non-residential relocations and up to two personal properties are likely to be impacted, as identified below.

1. Saturday Market Administration Office (west – Map ID 5): This building will be demolished as part of the Project. Except for some limited permanent easements, the property ownership will be retained by the current owner.
2. Pacific Coast Fruit Company (PCFC) (east – Map ID 16): The cable stayed bridge option has the potential for an impact to the PCFC building on the east approach, while the tied arch option likely eliminates this impact.
3. Rose City Transportation (RCT) freight business (east – Map ID 17): Impacts to the RCT building are minimized to a small section to the north of the bridge. This portion of the building is currently used by PCFC and will be required to be demolished for

bridge construction. Therefore, no impacts to RCT operations are assumed. However, impacts to PCFC operations, personal property relocation and re-routing of PCFC's rooftop conveyor system is anticipated. A full business relocation is not required.

4. Nemarnik Family commercial parking lot (east - Map ID 22): This property is leased by RCT for their freight trucks. The parking lot would be temporarily closed for the duration of the Project. It is considered a temporary personal property relocation.
5. Produce Row property (AMR Building) (east - Map ID 18): It is anticipated that this property is being cleared for the Project. A portion of this parcel can be used to mitigate impacts to PCFC truck parking during construction. Except for some limited permanent easements, the property ownership will be retained by the current owner.

13 Aesthetics and Urban Design

Due to the location and history of the Burnside Bridge, it carries a both civic and cultural significance to the City of Portland. As such, architectural aesthetics and context for the Project will be vital.

The architectural process started with an in-depth study of the existing bridges over the Willamette River, searching for commonalities and differences between structures and how they impact the personal experience of users. An observation has been made that the experience the Willamette bridges provide to their users are each unique. As the epicenter of the city, the Project aims to provide the community with a deck and street-level experience that is equal to or greater than the existing structure.

13.1 Summary of Urban Design and Aesthetics Working Group (UDAWG) Discussions

To inform and advise the Community Task Force (CTF) and the project team on key bridge architectural and urban design issues, the NEPA phase formed the Urban Design and Aesthetics Work Group (UDAWG). The stated purpose of the UDAWG was to:

- Provide informed insights and opinions on the visual features for each bridge option
- Recommend measures to enhance aesthetic opportunities or mitigate potential visual impacts
- Represent urban design and aesthetic interests
- Reflect the character of Portland by suggesting place-making opportunities

The UDAWG convened for nine working sessions between September 2020 and September 2021. As a result of those sessions, and in collaboration with the CTF, three key themes emerged, with clarifying values for each theme:

1. Human Experience and Bridge Surroundings
    - Clear views in all directions
    - Bridge surface for public events

- Intrinsic gateway and a sense of arrival to and from bridge
- Enhanced on-bridge experience
- Enhanced in-water uses
- Connectivity with river from under / around the bridge
- Complements & responds to the character of the Old Town / Chinatown and Downtown neighborhoods
- Complements & responds to the character of Kerns and Buckman neighborhoods and Central Eastside Industrial District
- Complements and responds to the character of the existing Willamette River bridges, while being distinctive in its own right

2. Overall Look and Feel of the Bridge
    - Creates a look of balance, unity, and flow from multiple viewpoints
    - Balance the desire for a minimized visual mass, especially in the river, while providing seismic stability and reliability
    - Capture elements of the existing historic bridge
    - Reflect the best practices in modern technologies, engineering, and architecture
    - An identifiable beacon of safety, a landmark, and a destination within the city during the day and after dark
    - Enhances the natural environment
3. Cost and Construction Impacts to Users
    - Minimize total project cost to plan, design, and construct the bridge
    - Minimize long-term costs and support future needs after construction
    - Minimize impacts to the traveling public and surrounding property owners / tenants during construction
    - Minimize impacts to adjacent properties during construction

Aided by these themes, the bridge types provided in the Preferred Alternative were selected.

14 Construction Considerations

Given the quantity and diversity of stakeholders impacted by the Project as well as the complexity of the design and construction needed to achieve a seismically resilient crossing at this site, constructability considerations have been a focus throughout the NEPA phase. These considerations are discussed in detail in the *EQRB Revised Construction Approach Technical Report* (Multnomah County 2022g).

14.1 Constructability Constraints and Drivers

The following constructability constraints and drivers were identified for the West and East Approach and within the river. As part of the Final Design phase, refinements to the construction sequencing and phasing will be sought in collaboration with the contractor. Through this collaboration, impacts are expected to lessen as design and construction innovations are employed.

14.1.1 West Approach

- Protect adjacent buildings north and south of the bridge between W 2nd Avenue and W 1st Avenue and the north block between W 1st Avenue and W Naito Parkway. Only the Portland Saturday Market building south of the bridge at W 1st Avenue will be demolished, the remainder of the buildings will be protected in place.
- Maintain the secure entrance for the Portland Rescue Mission on the north side deck of the existing bridge throughout construction. The end spans of the West Approach were modified to help minimize impacts to this operation as described in Section 5.2.
- Relocate/demolish the retail space provided by the University of Oregon located underneath the bridge, which currently blocks access to the existing west abutment and Bent 2. The proposed west abutment will eliminate this space.
- Except for short-term closures, protect TriMet LRT operations that runs along W 1st Avenue. Up to 8 service disruptions are expected. It is also expected that the Skidmore Fountain MAX stop directly underneath span 1 of the bridge will be closed throughout construction.
- Reconstruct the parking lot under the bridge between W 1st Avenue and W Naito Parkway.
- Utilize a portion of the Tom McCall Waterfront Park east of Naito Parkway for contractor staging and access.
- Relocate the Portland Saturday Market during construction which inhabits the Tom McCall Waterfront Park underneath the bridge every Saturday spring through fall.
- Protect and maintain the steel canopy structure immediately south of the bridge within Tom McCall Waterfront Park.
- Protect and maintain the Japanese American Historical Plaza and cherry blossom trees which are located within Tom McCall Waterfront Park just north of the bridge.
- Protect and maintain access to the Ankeny Pump Station and the existing sewer pipes running adjacent to the harbor wall.

14.1.2 In-River Spans

- Construct temporary work bridges for access to the main river piers from Waterfront Park and the Vera Katz Eastbank Esplanade.
- Generally, protect and maintain the Vera Katz Eastbank Esplanade east of the east in-water bent when possible. Within the 4.5 - 5 years of construction intermittent

temporary disruptions are expected. Removed portions to be removed and stored onsite for no more than a total of 18 intermittent months.

- Maintain the channel navigability throughout the duration of construction. It is assumed large vessels and recreation vessels will need to be accommodated throughout the duration of construction.
- Adhere to yearly general in-water work windows (July 1st to October 31st) and pile driving work windows (July 10th to October 15th).

14.1.3 East Approach

- Protect and maintain the existing interstate highways that run north to south under the bridge. Intermittent, short-term closures of the freeways should be expected throughout the duration of construction. Approvals from ODOT will be required to cross or temporarily close the ODOT facilities.
- Protect and maintain the UPRR tracks run north to south under the bridge. Intermittent impacts to the tracks are expected throughout the duration of construction. Approvals from UPRR will be required to cross or temporarily close the tracks.
- Except for a small portion of the Pacific Coast Fruit Company building north of the bridge, protect the existing buildings between UPRR tracks and E MLK Boulevard.
- Demolish the AMR building south of the bridge between UPRR tracks and 2nd Avenue.
- Protect and maintain all other buildings on the East Approach besides those listed above.
- Generally, protect and maintain the Burnside Skatepark, located under the bridge between E 2nd Avenue and E 3rd Avenue. As part of demolition and construction activities, short-term temporary closures could be experienced and reconstruction activities, should partial removal be needed, must be performed. Permanent impacts must be avoided.

14.2 Construction Access and Staging

Multiple construction access points and staging areas will be required for construction. For access and staging discussion in Section 14.2.1 through 14.2.3, see Figure 31.

14.2.1 West Approach

Access to the structure on the west side is anticipated from City streets such as W Naito Parkway, W 2nd Avenue and/or W 1st Avenue along the TriMet LRT tracks (if approvals are granted TriMet).

Access to the river from the west side will occur just north of the bridge within Tom McCall Waterfront Park. Access widths will be limited in order to minimize impacts to the Japanese American Historical Plaza.

The parking lot located underneath Spans 1 and 3, and regions within Tom McCall Waterfront will be used for staging, equipment placement, and to facilitate girder erection.

14.2.2 In-River Spans

To construct the in-water bents and superstructure, access to the river will be provided through means of temporary work bridges within the subsidiary navigation channel. To access these work bridges, land connection points have been assumed from both the west and east side of the channel. On the west side, a land connection point will be located north of the bridge within Tom McCall Waterfront Park. On the east side, temporary work bridge could be constructed parallel to the Vera Katz Eastbank Esplanade traveling north to the intersection under the I-5 highways where land can be accessed. It has been determined that at this location the highways provide enough overhead clearance for construction equipment to travel underneath and onto the temporary work bridge. The Project also anticipates that some amount of barge access may be provided, but the extent of this will be determined by the contractor during Final Design.

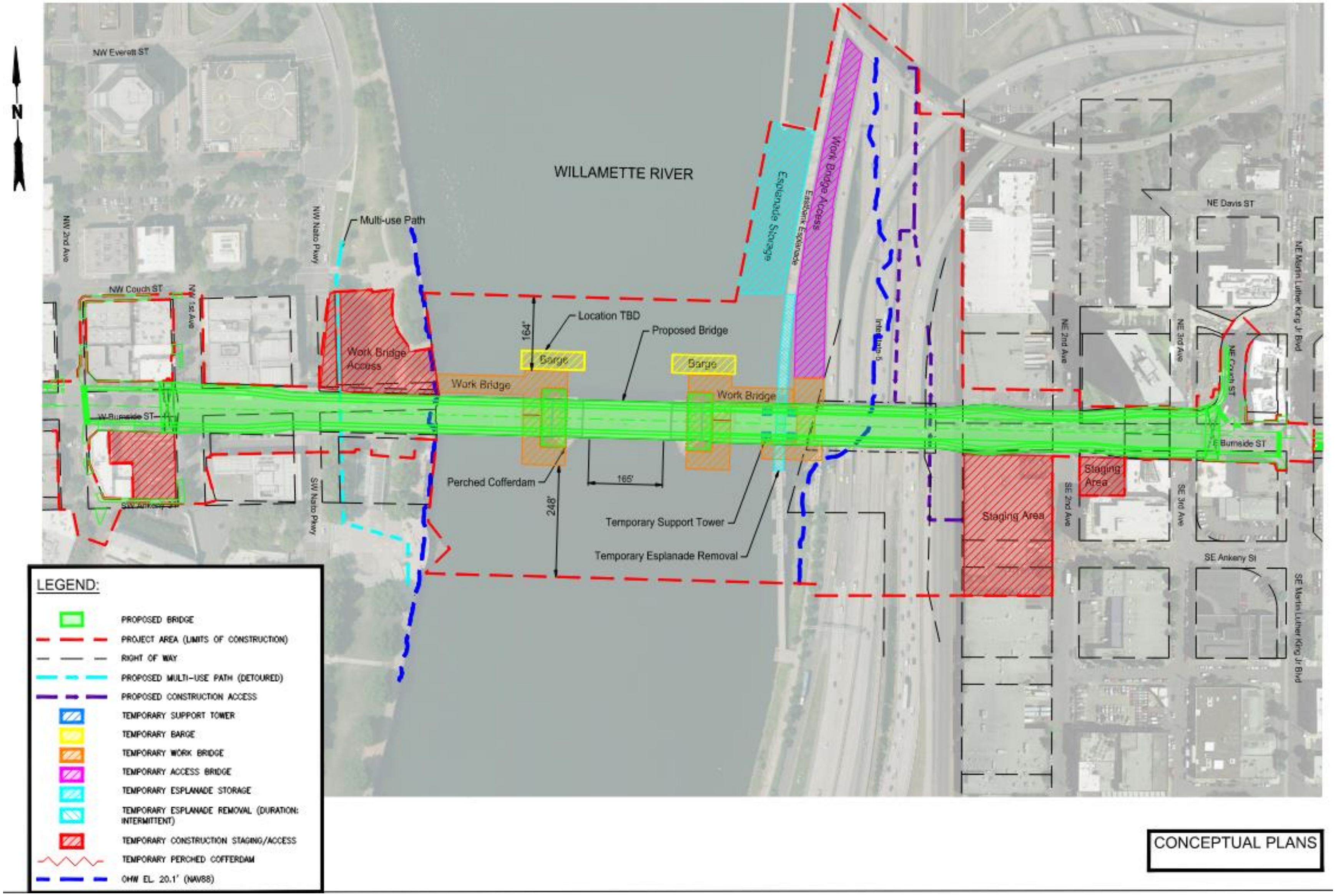
Due to limited onsite space available for equipment and material storage, it is expected that the contractor could need supplemental staging areas. Barges moored within the channel provide large areas to store material and equipment and allow the contractor the ability to move the barges to work locations as needed.

14.2.3 East Approach

Access to the structure on the east side is anticipated from City streets such as E 2nd Avenue. Ultimately, access to the in-water temporary work bridges will need to be provided. The existing ODOT access road has been identified as a means of accessing the in-water work bridges. To utilize the ODOT access road, the Contractor will have approach from E 2nd Avenue through the southern parcel and cross the UPRR tracks through means of a temporary crossing.

It is anticipated that the southern parcel between the UPRR tracks and E 2nd Avenue, including the parking lot south of the bridge, will be acquired for staging and to provide access to the river.

Figure 31. Conceptual Construction Plan and Access



14.2.4 Offsite Staging Areas

Due to limited space onsite, it is anticipated that the contractor could require an offsite storage yard. It is expected that that an offsite storage yard would need to have a dock or riverfront access with potential to construct a temporary dock to provide access to in-water barges the contractor may elect to use.

14.3 Temporary Work Bridges

A substantial network of temporary work bridges will be required to facilitate construction within the channel. The main river channel is required to remain navigable, hence the work bridges will be located behind the existing piers. Figure 31 provides a conceptual work bridge layout the contractor may elect to use.

Due to the significant torque and loading from construction activities, the temporary work bridges will require a significant amount of temporary pile supports and cross bracing. Installation of the in-water piles through means of barge mounted equipment can only occur within the in-water work window established for the Willamette River, July 10th through October 15th each year. Additional impact hammer restrictions for pile driving apply, impacts/strikes for pile driving has been limited to 12,000 per day for the Project. Due to this restriction, it seems likely the contractor will elect to use a combination of vibratory and driving methods to install the temporary work bridges.

14.4 Bridge Removal and Dredging Within the Channel

14.4.1 Riprap Removal

Through bathymetry survey, existing riprap has been identified around the existing in water piers and along the east riverbank. Prior to installing temporary work bridge piling or permanent structure, any riprap in the vicinity of the temporary work bridges will need to be removed.

Crane barges using a clam shell bucket will be used to remove the riprap out of the channel. Riprap around the in-water bents will not be replaced for the permanent condition. However due to concerns of bank stability, the riprap removed along the east riverbank will be replaced in kind for the permanent condition.

For the removal limits stated above, see Figure 32.

14.4.2 Existing Pier 1 and Pier 4 Removal

Existing Pier 1 is the westernmost in-water pier supporting the existing bridge. This pier is located extremely close to the existing Seawall. Due to its proximity, a complete removal of Pier 1 is not recommended. Removing the pier below the mudline could expose and undermine the Seawall foundations. Therefore, it is recommended that most of Pier 1 remain in place. The portion of pier to be removed will be above the waterline which is assumed to require typical structure removal methods with a containment system. As an alternative, wire sawing could be employed, similar to that anticipated for Piers 6 and 7.

Existing Pier 4 is the easternmost in-water pier supporting the existing bridge. This pier does not conflict with any existing structure and therefore will be removed five feet below the mudline as required by the USCG. It is likely the contractor will dredge below the mudline around the existing piers to provide access to a "cut line" for wire sawing, or via another removal methods, of the existing footing/seal.

For the removal limits stated above, see Figure 32.

14.4.3 Existing Piers 2 and 3 Removal

Existing Piers 2 and 3 are the movable bascule piers that will need to be removed prior to constructing the new bents. It is proposed that these piers be removed down to El. - 55.0 (NAVD88).

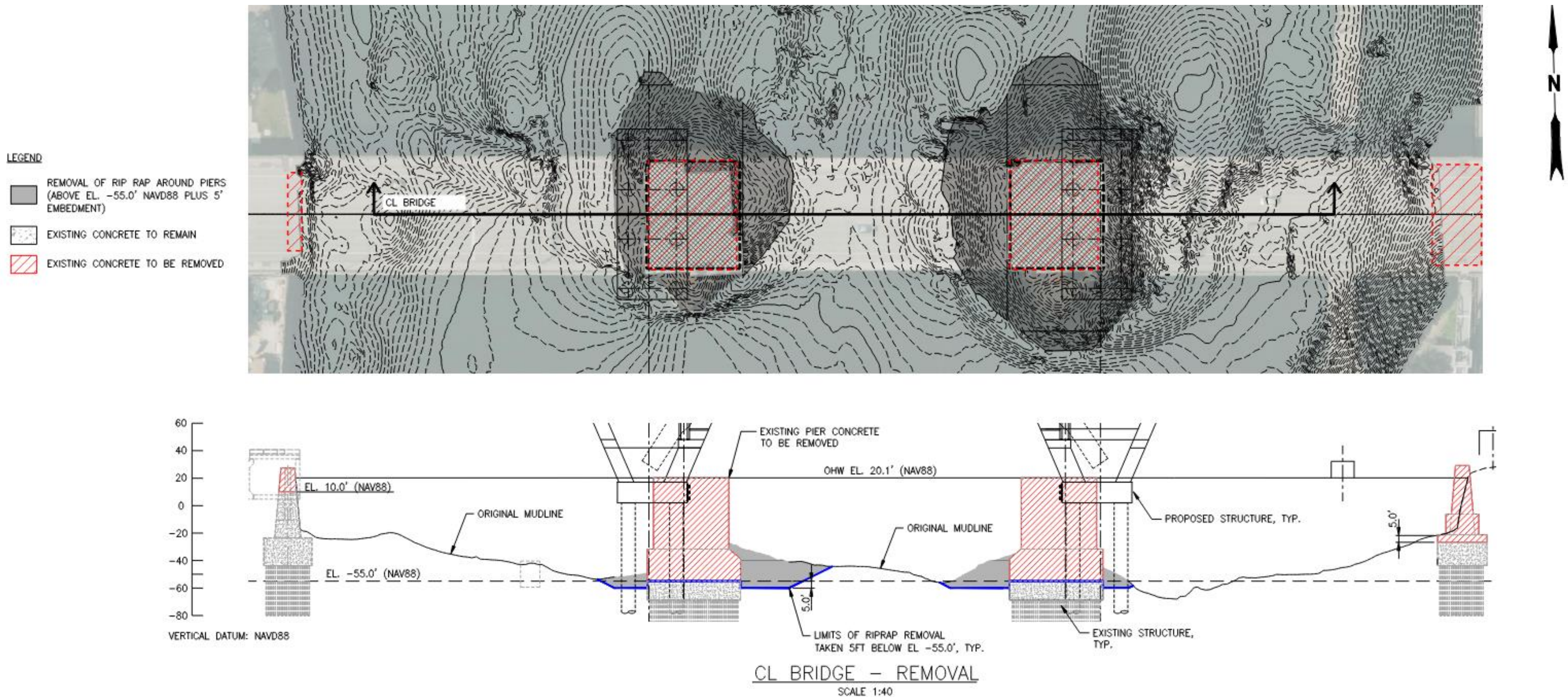
It is likely the contractor will dredge 5-feet below the mudline around the existing piers to provide access to a "cut line" for wire sawing, or via another removal methods, of the existing footing/seal (see Figure 32). The requirement for 5-feet removal depth below the mudline is derived from the USCG permit requirements.

Additional existing pier removal will be required for installation of the proposed shafts that are in conflict. It is likely the contractor will core through the existing footing using an oversized hole in comparison to the proposed shaft size. Additionally, the coinciding timber pile that will be in conflict will be pulled prior to commencing drilling for the new shaft. Based on the proposed footing and shaft configuration discussed in Section 5.3.5, two shafts per pier will be in conflict.

The existing starling located on the upstream face of Piers 2 and 3 will also need to be removed. This structure is supported on several timber piles that will need to be pulled prior to commencing drilling for the new shafts.

For the removal limits stated above, see Figure 32.

Figure 32. Anticipated Dredging and Existing Pier Removal Within the Channel



14.5 Construction of the Perched Foundation

A perched foundation configuration is proposed for in-water Bents 6 and 7. The foundation is supported by a group of drilled shafts, as discussed in Section 5.3.4 and 5.3.5. These shafts extend out of the river bottom and are anchored into a shaft cap or footing, which is perched within the water column. The primary advantage of perched foundation is that it is constructed without a traditional deep cofferdam system, which require extensive excavation and removal of the existing bridge foundations, large seal pours, more substantial structural members to accommodate larger hydraulic demands, and larger substructure that must extend down to the river bottom. Other advantages include a reduction in construction schedule and opportunities to incorporate accelerated bridge techniques with prefabricated components. As examples, the two most recent bridge projects over the Willamette River in the Portland vicinity, the Tilikum Crossing Bridge and the Sellwood Bridge, used perched foundations for similar reasons.

Perched foundations typically rely on sheet pile walls and a concrete bottom soffit (or floor) to form the closed box perched cofferdam. The perched cofferdam is lowered into place in the water column to create a dry space to continue the remainder of the construction, see Figure 33. There are two primary ways the perched foundations can be constructed through means of placing a perched cofferdam, with either one of them being equally suitable for the bridge concepts shown in this TSR:

Method 1

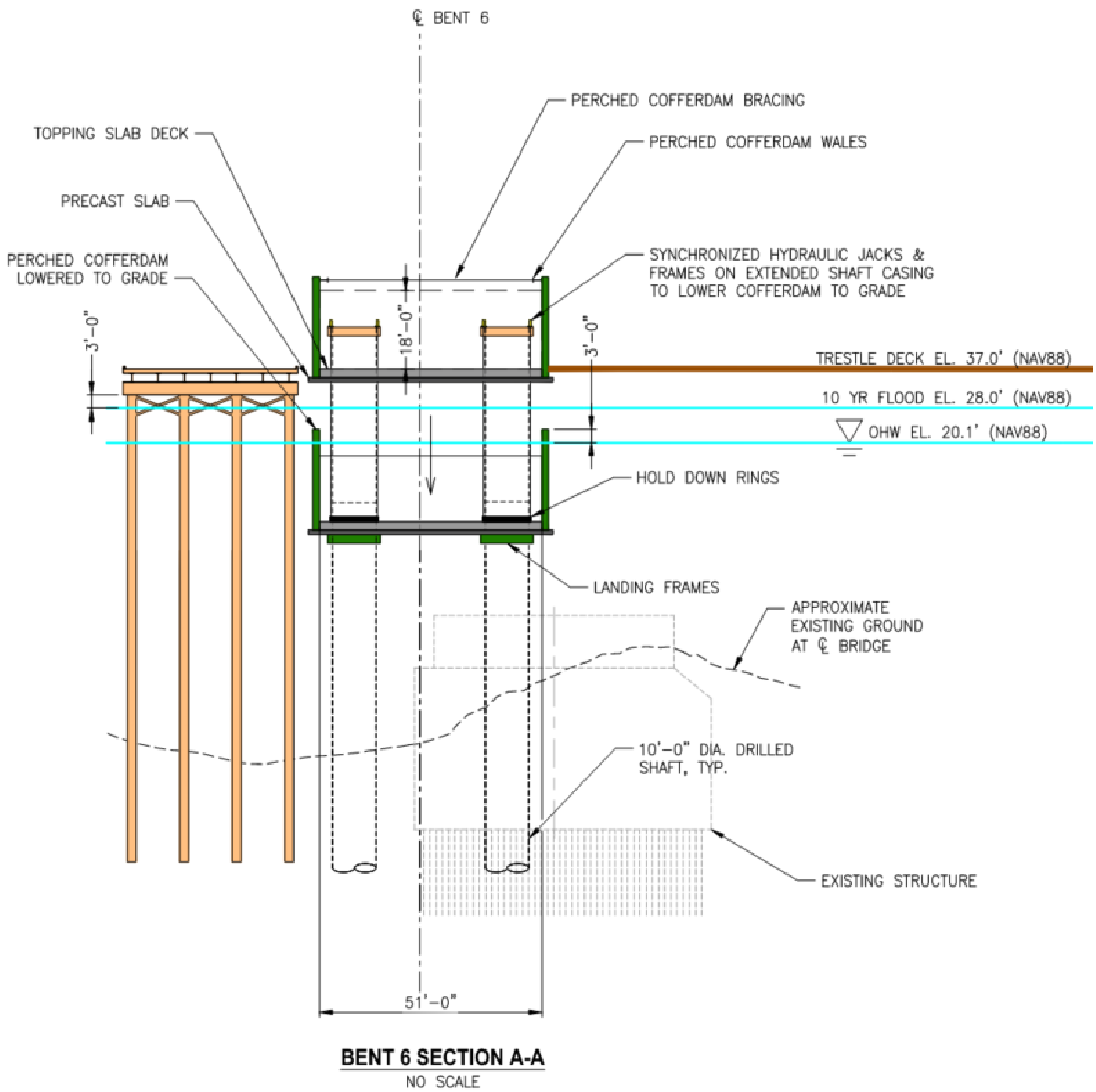
- The perched cofferdam is either fully constructed offsite and floated in or it is constructed onsite with the cast-in-place concrete floor constructed on falsework. Holes are provided within the bottom floor at each shaft location.
- The perched cofferdam is then lowered via hydraulic jacks around the previously constructed group of shafts, which have permeant casing extending above the waterline.
- The space between the bottom floor holes and drilled shaft casings are then sealed via an underwater grouting and/or welding operation.
- Dewatering can then begin, and the remainder of construction can occur.
- After the construction of the perched footing and substructure within the waterway, the cofferdam sheets would then be cut off and removed at the base of the perched foundation.

Method 2

- Utilize precast flooring and sides to create the perched cofferdam.
- The subfloor of the perched cofferdam would be made up of multiple precast slab pieces that would be incrementally installed over the drilled shafts.
- Like Method 1, the space between the shaft casings and holes would need to be grouted and sealed.

- Once all the precast sections were placed and post-tensioned together to form a singular unit, the box would be dewatered, and construction could commence.

Figure 33. Conceptual Perched Cofferdam



14.6 General Construction Phasing

The following is general overview of a potential construction phasing for the Project. While this has been assumed as a reasonable basis for the Type Selection phase, the actual construction schedule will be dependent on the contractor's means and methods and the accepted design solutions. As shown below, the phasing indicates starting with construction of the east in-water Bent 7 then Bent 6, however the contractor can elect to modify this sequencing as it sees fit. Ultimately, the construction sequencing and approach will be dependent upon the input by the contractor during the Final Design phase.

Year 1

- Close bridge to traffic, Spring of year 1
- Begin river channel rip-rap removal around the existing Piers 2 and 3
- Begin demolition of existing bridge superstructure
- Install West Approach work bridge from Seawall to existing Pier 2
- Install East Approach work bridge from Eastbank to existing Pier 3
- Begin demolition of existing west bascule Pier 2 substructure and wire sawing of the footing. Work bridge not required; barge work anticipated
- Install work bridge platform around Bent 7
- Begin installation of Bent 7 shafts. This work will extend into year 2 in-water work windows
- Demolish Pier 1 substructure
- Begin demolition of existing east bascule Pier 3 substructure and wire sawing of the footing. Work bridge not required; barge work anticipated. This work will likely extend into year 2

Year 2

- Complete in-water work bridge installation
- Complete demolition of existing east bascule Pier 3 substructure and wire sawing of the footing
- Demolish Pier 4 substructure and wire sawing of the footing
- Continue installation of Bent 7 shafts
- Complete demolition of existing east bascule Pier 3 substructure and wire sawing of the footing. Work bridge not required; barge work anticipated
- Install work bridge platform around Bent
- Begin installation of Bent 6 shafts. This work will extend into year 3 in-water work window
- Install East Approach ground improvements
- Install minor land foundations and substructure
- Begin erecting East Approach girder span(s)

Year 3

- Complete installation of Bent 6 shafts

- Construct and install Bent 6 and 7 perched cofferdams
- Begin erecting West Approach girder spans
- Construct East Approach long-span foundation and substructure.

Year 4

- Construct Bent 6 and 7 substructures
- Float in and install west bascule leaf
- Complete West Approach girder spans
- Erect East Approach long-span superstructure

Year 5

- Complete East Approach spans
- Float in and install east bascule leaf
- Open new bridge to traffic (Total closure: approximately 4.5 years)
- Remove in-water work bridges
- Project Complete

This approach would close the Burnside Bridge crossing (from E MLK Boulevard to W 3rd Avenue) to all modes of transportation for the duration of construction. Detour routes would be established to route multimodal traffic to adjacent river crossings. This approach would allow the contractor to demolish the existing bridge and construct the new bridge without concerns for staging traffic. All other facilities crossed by Burnside Street (e.g., I-5, various city streets, and TriMet MAX lines) would have to be maintained and protected, except for short term closures for construction activities such as demolition, girder erection, and deck placement.

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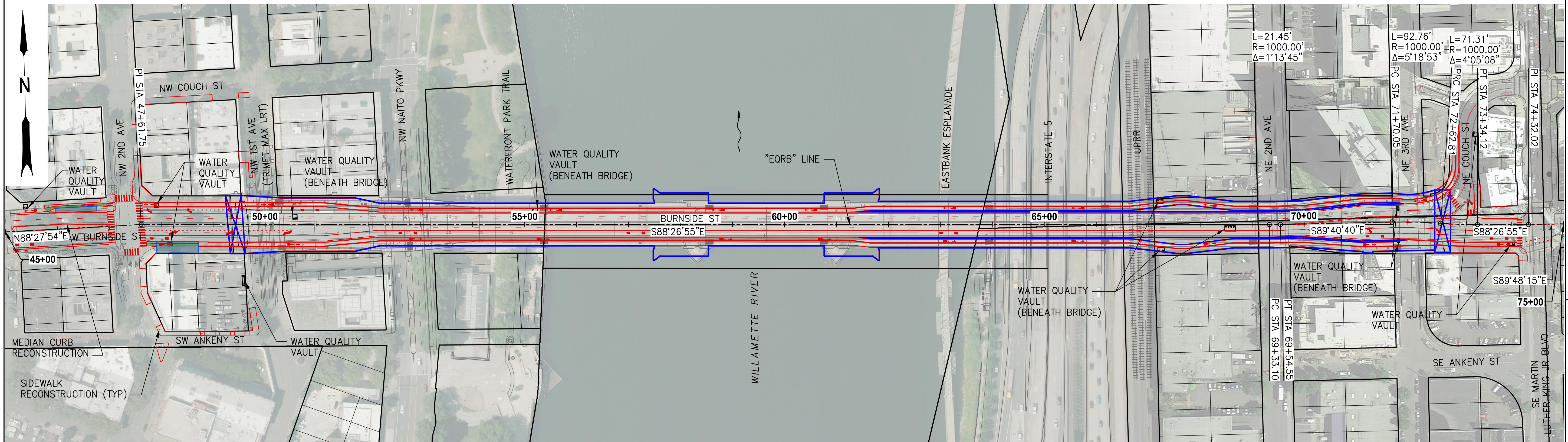
Appendix A. Replacement Roadway Plan Sheets



PLAN

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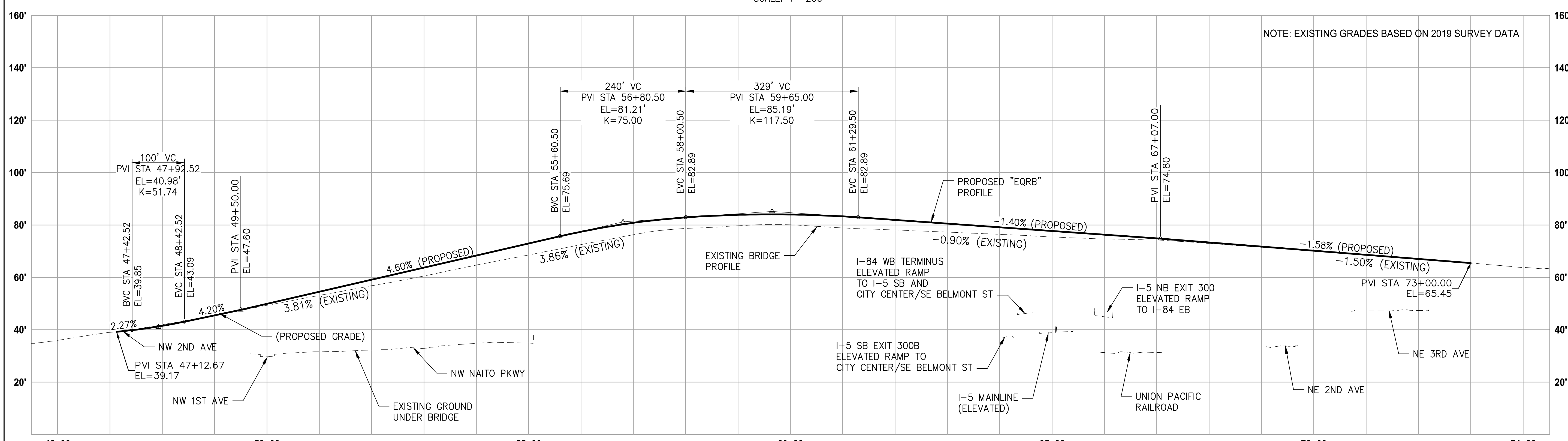

ELEVATION

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VERTICAL SCALE: 1"=40'

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CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation

PROJECT NO:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

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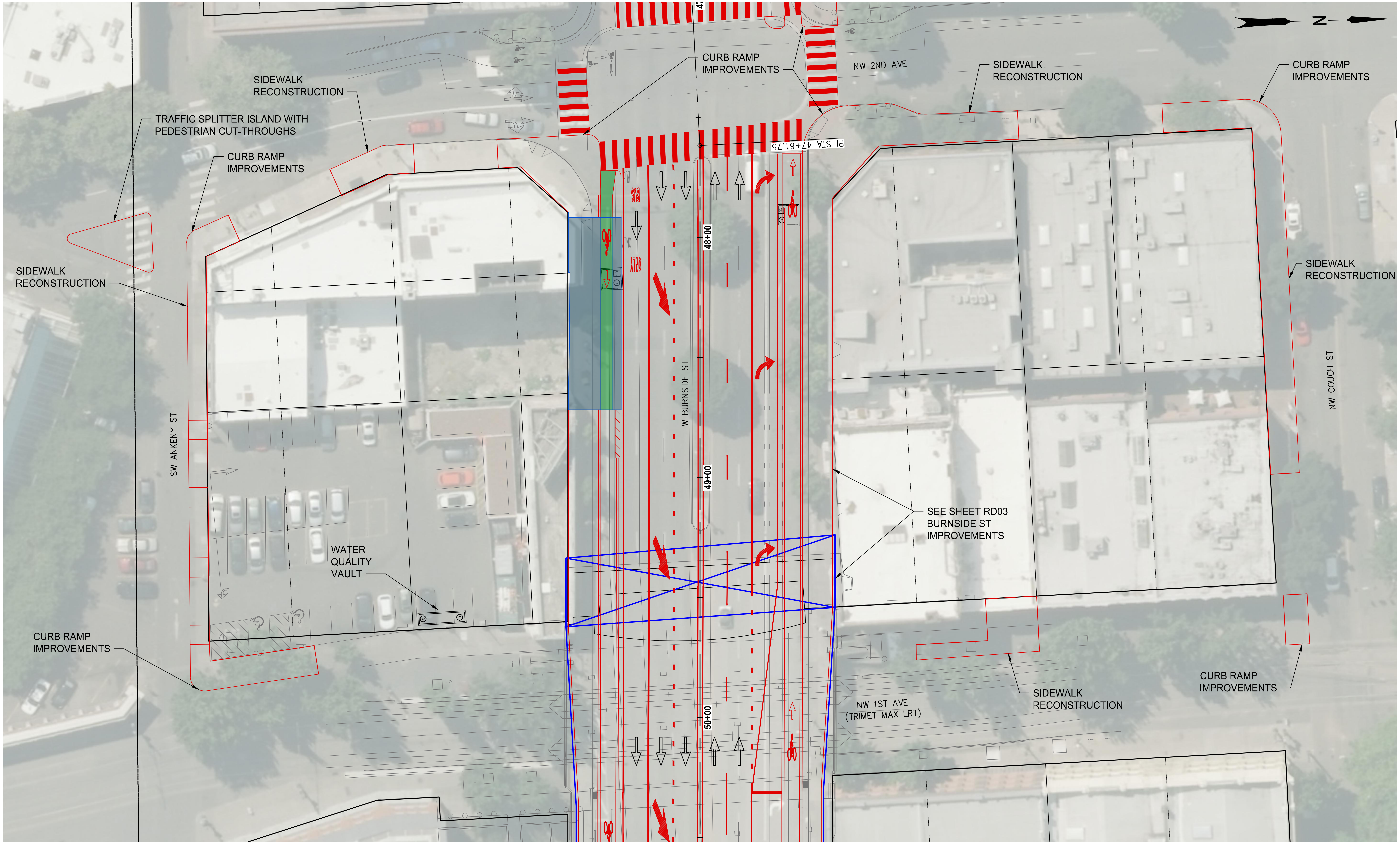

PLAN

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Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Roadway Details - 1

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

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CONCEPTUAL PLANS
SEPTEMBER 2022

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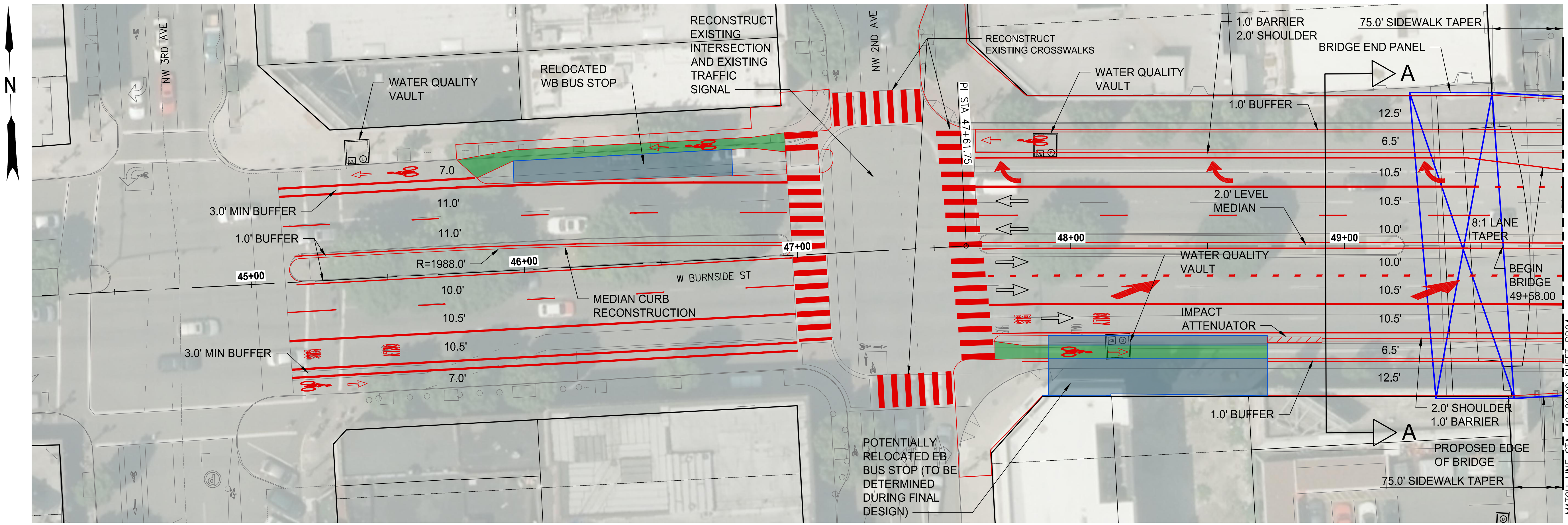

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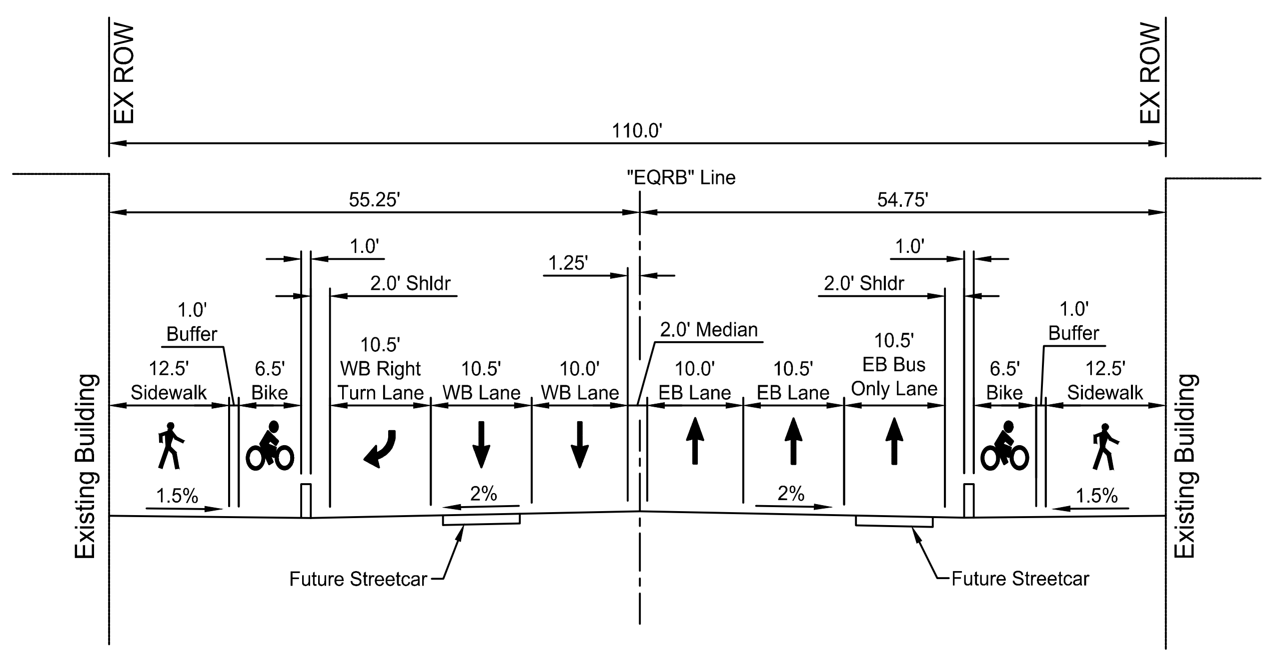

TYPICAL SECTION A

WEST APPROACH ON FILL
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE
2. BURNSIDE ST RETAINING WALLS NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge Bascule with Cable Stay Approach Roadway Details -2

PROJECT NO:

DATE: *9/2022*

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

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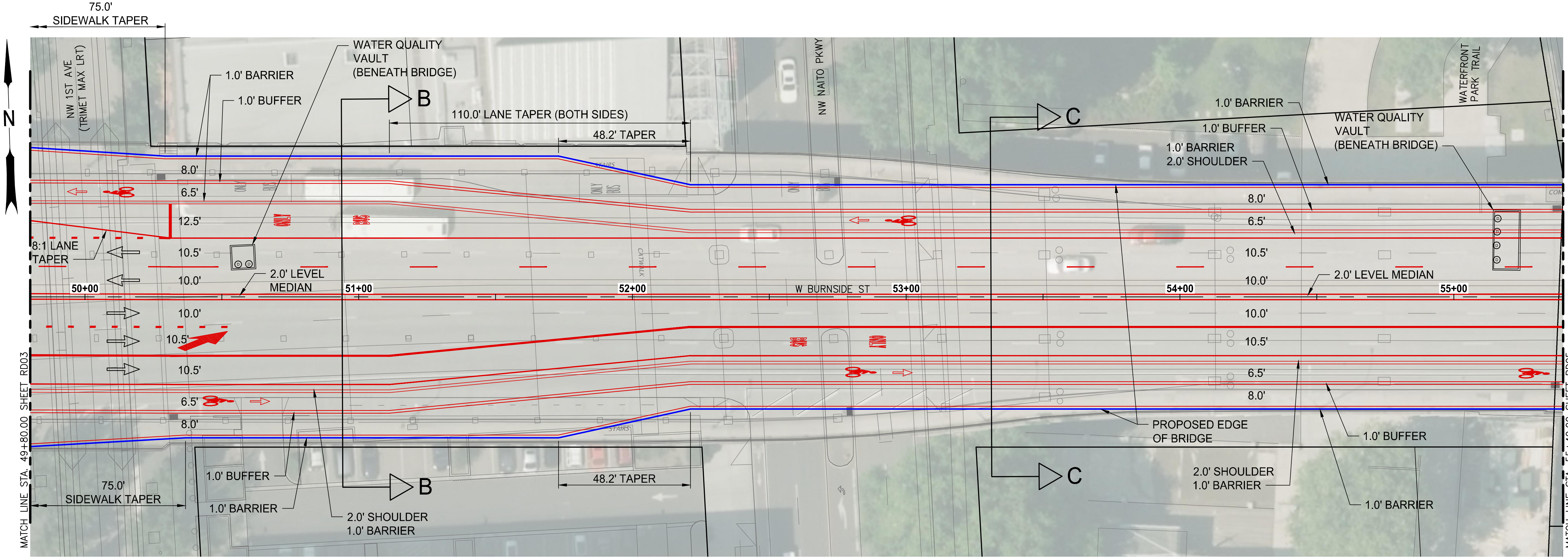

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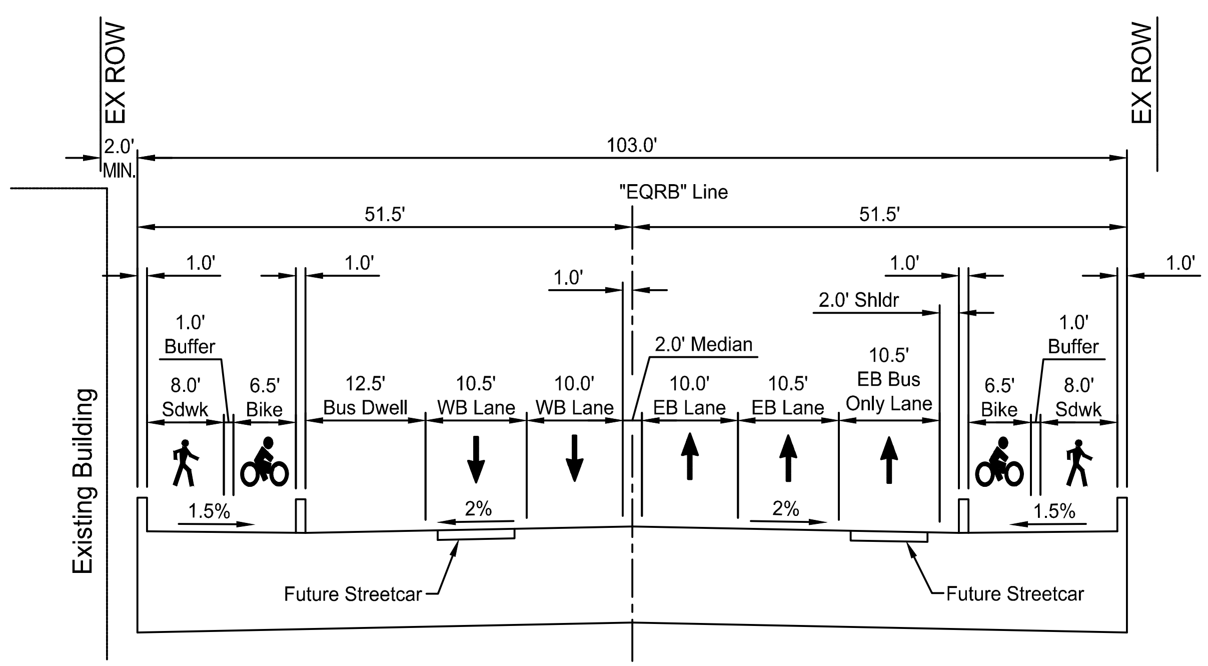

TYPICAL SECTION B

WEST APPROACH CONVENTIONAL BRIDGE SPAN
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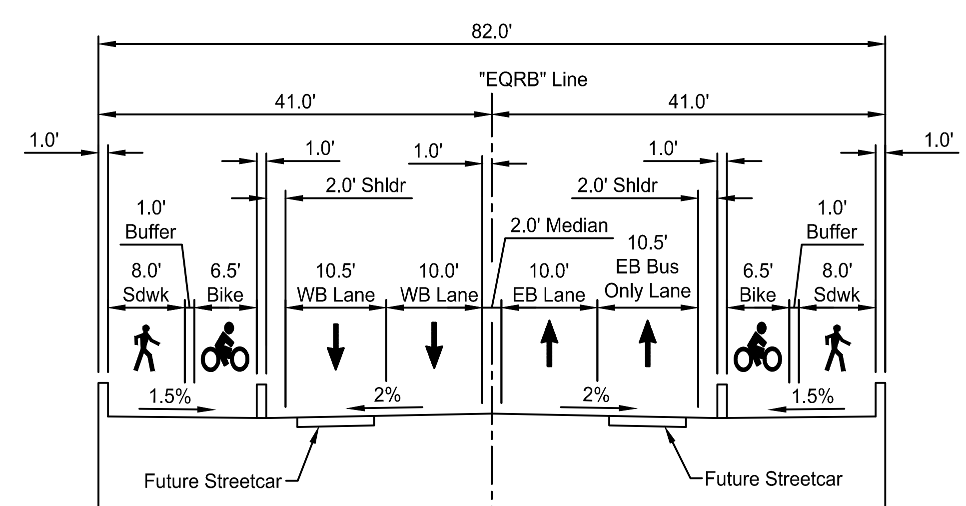

TYPICAL SECTION C

WEST APPROACH CONVENTIONAL BRIDGE SPANS
LOOKING EAST – NO SCALE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Roadway Details – 3

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

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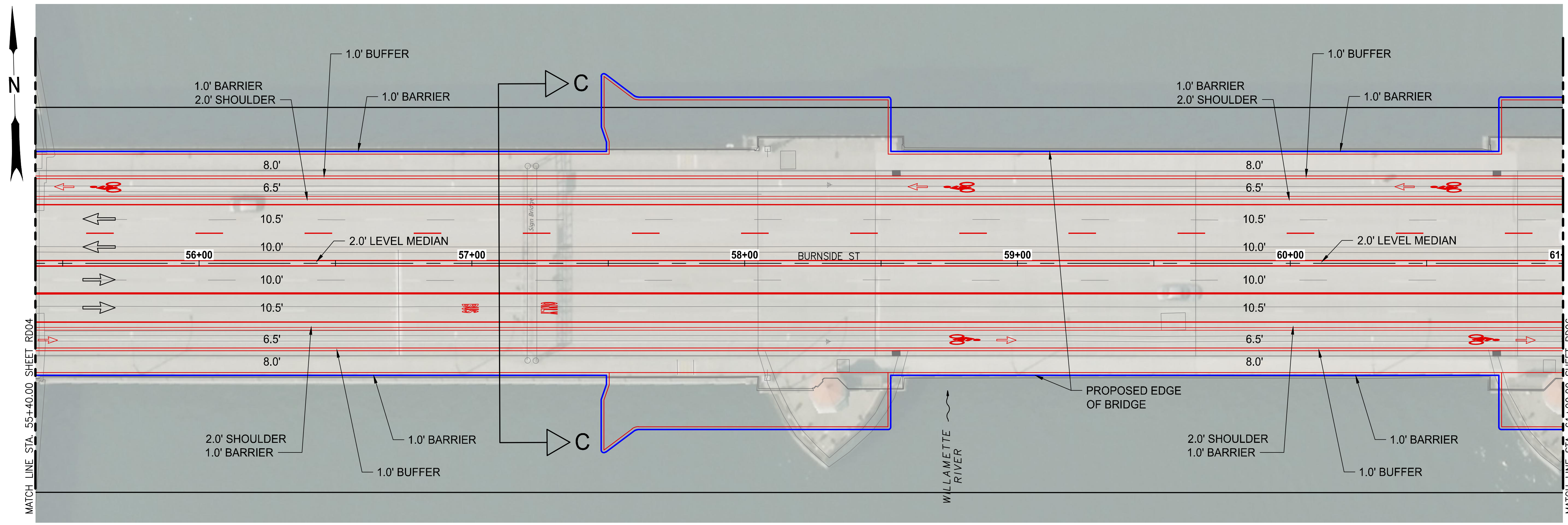

PLAN

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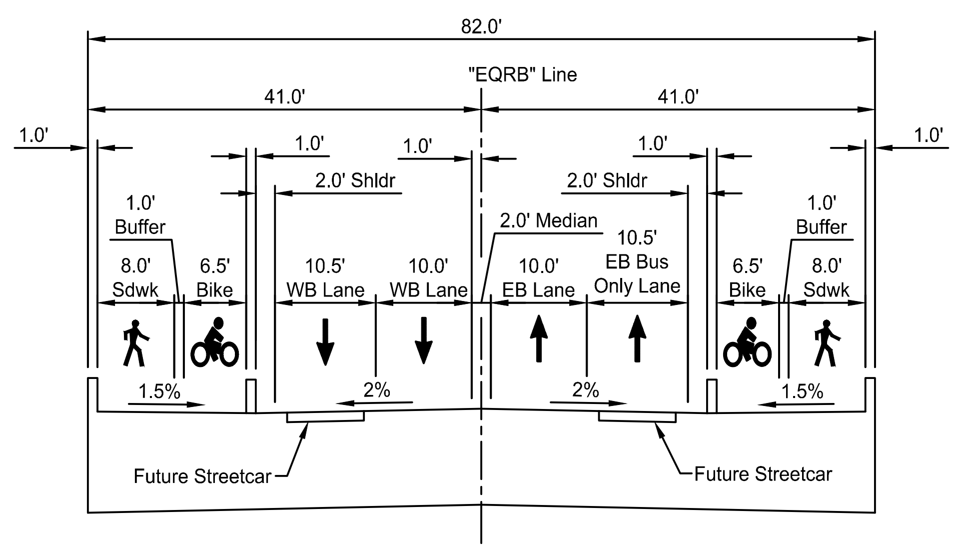
SCALE IN FEET



TYPICAL SECTION C

WEST APPROACH CONVENTIONAL BRIDGE SPANS
AND MOVABLE SPAN
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Roadway Details -4

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

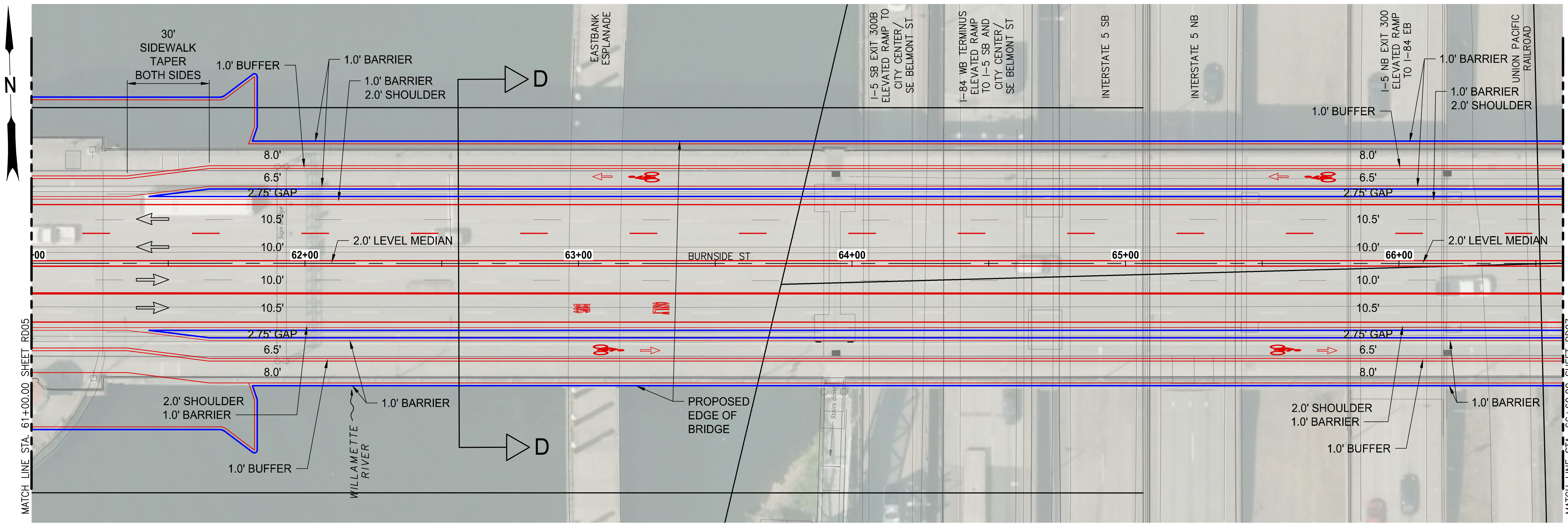
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:			

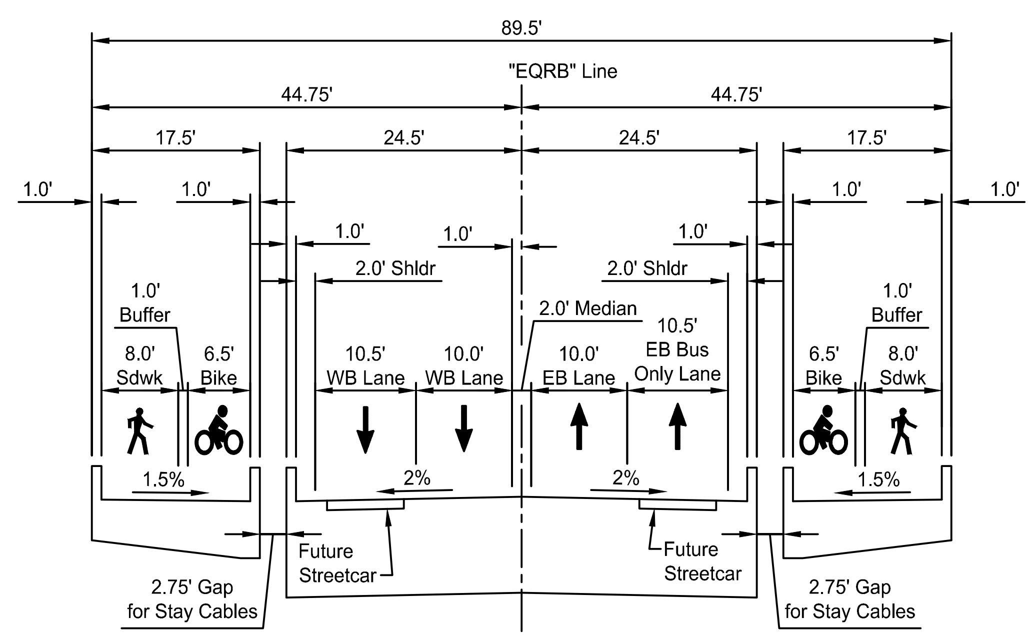
Sheet No. RD05



PLAN

SCALE: 1"=40'

20 SCALE 0 IN 20 FEET



TYPICAL SECTION D

EAST APPROACH CABLE–STAYED BRIDGE SPAN
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Roadway Details –5

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

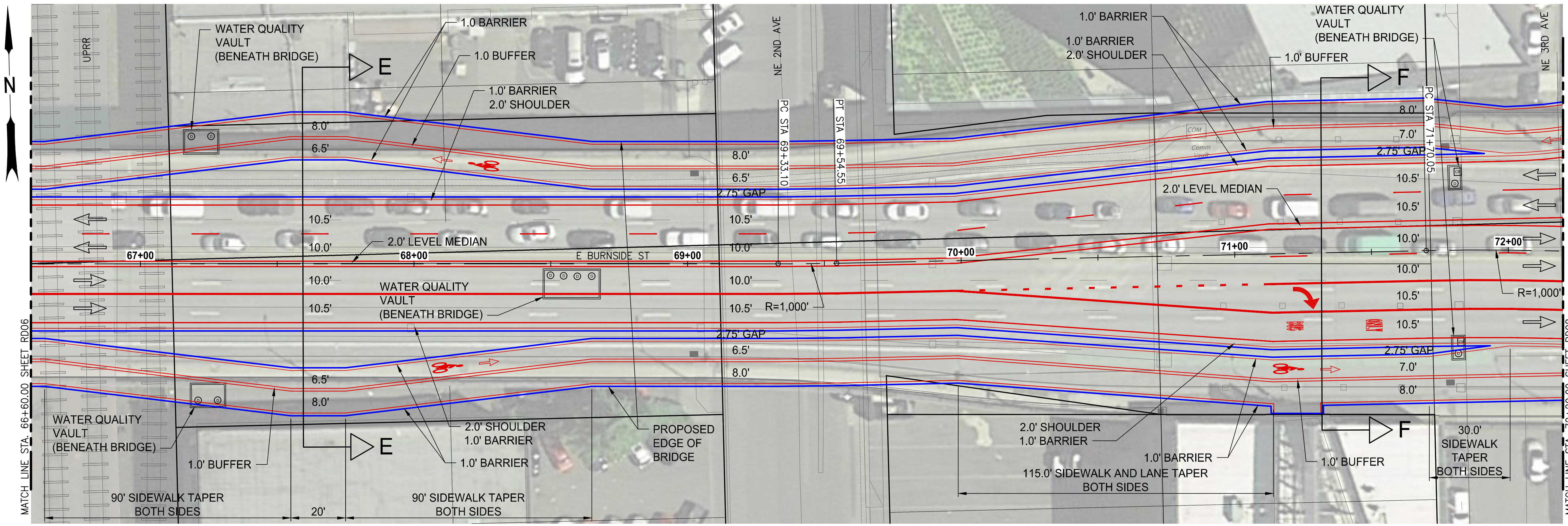
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:		

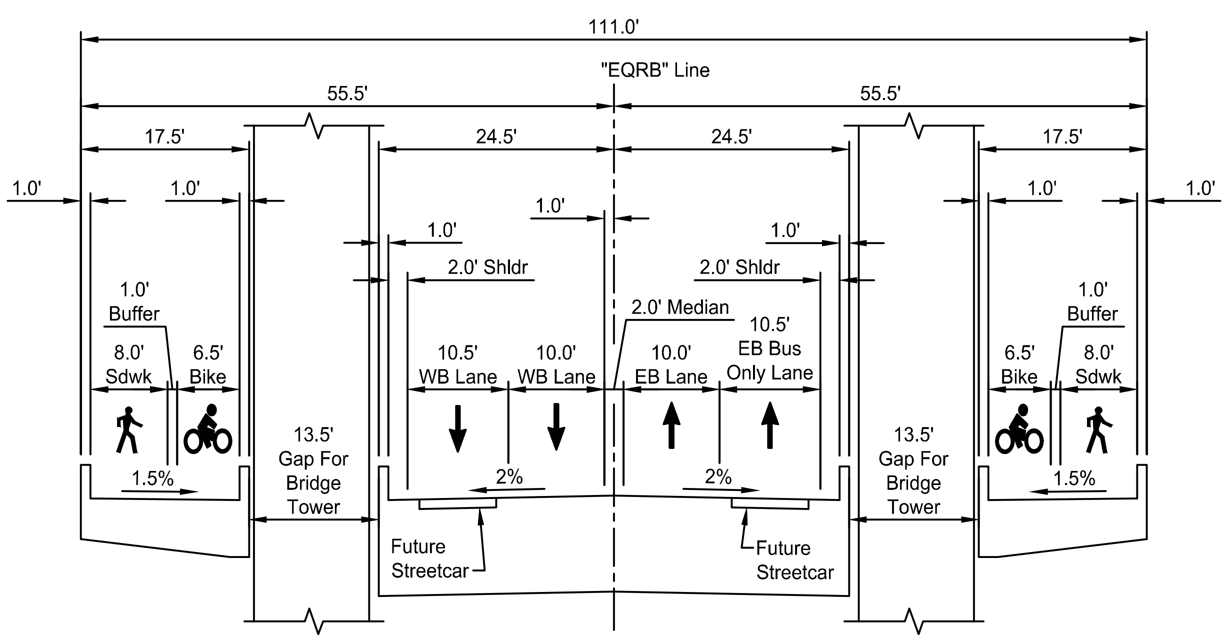
Sheet No. RD06



PLAN

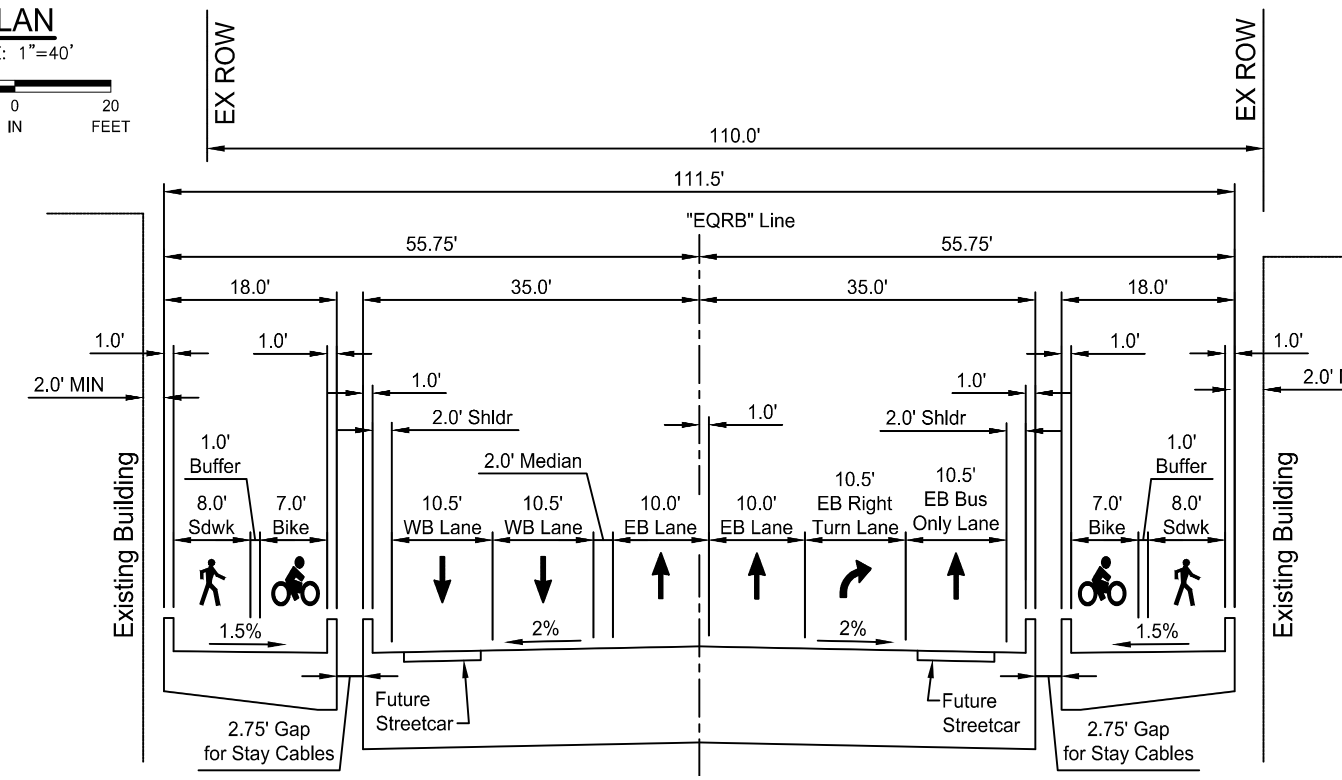
SCALE: 1"=40'

20 0 20
SCALE IN FEET



TYPICAL SECTION E

EAST CABLE-STAYED BRIDGE SPAN
AT SUPPORT TOWER
LOOKING EAST - NO SCALE



TYPICAL SECTION F

EAST APPROACH CABLE-STAYED BRIDGE SPAN
SIX-LANE ROADWAY
LOOKING EAST - NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY.
FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Roadway Details -6

PROJECT NO:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

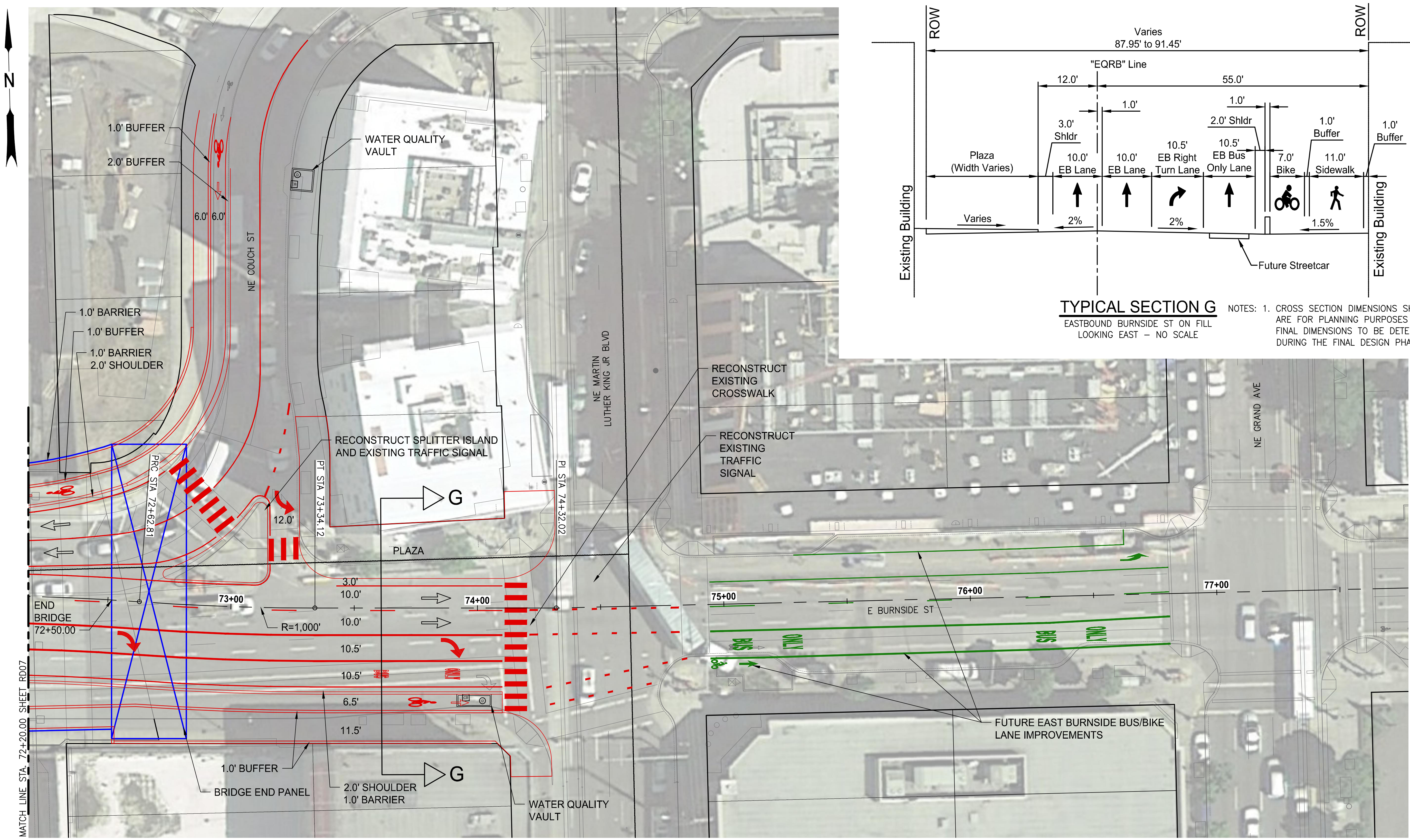
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:

Sheet No. RD07



TYPICAL SECTION G

EASTBOUND BURNSIDE ST ON FILL
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

PLAN

SCALE: 1"=40'

20 0 20
SCALE IN FEET

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Roadway Details - 7

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

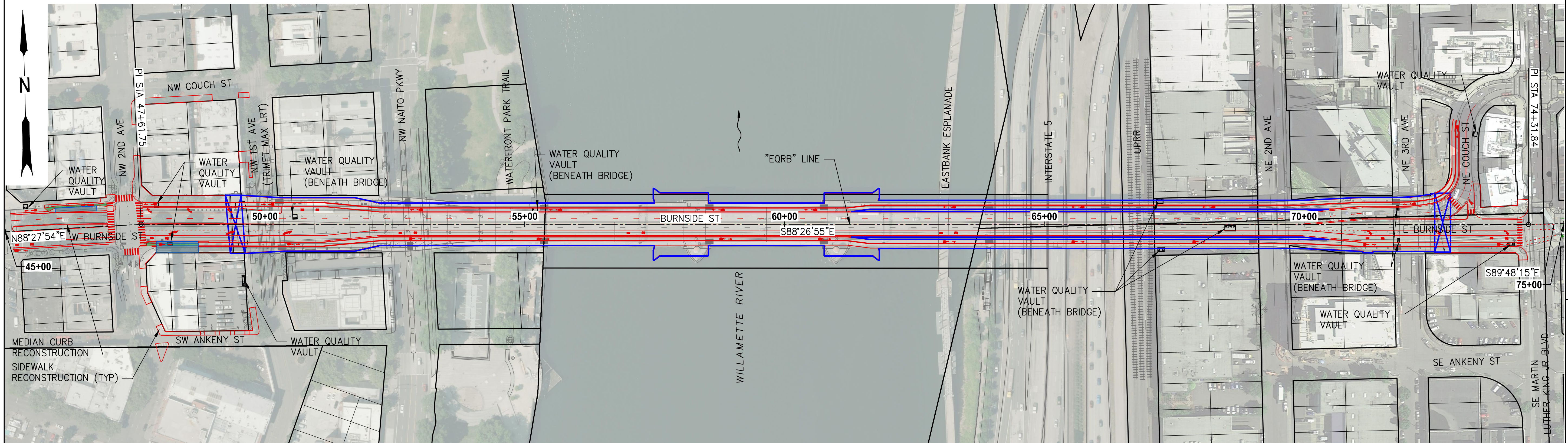
DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:

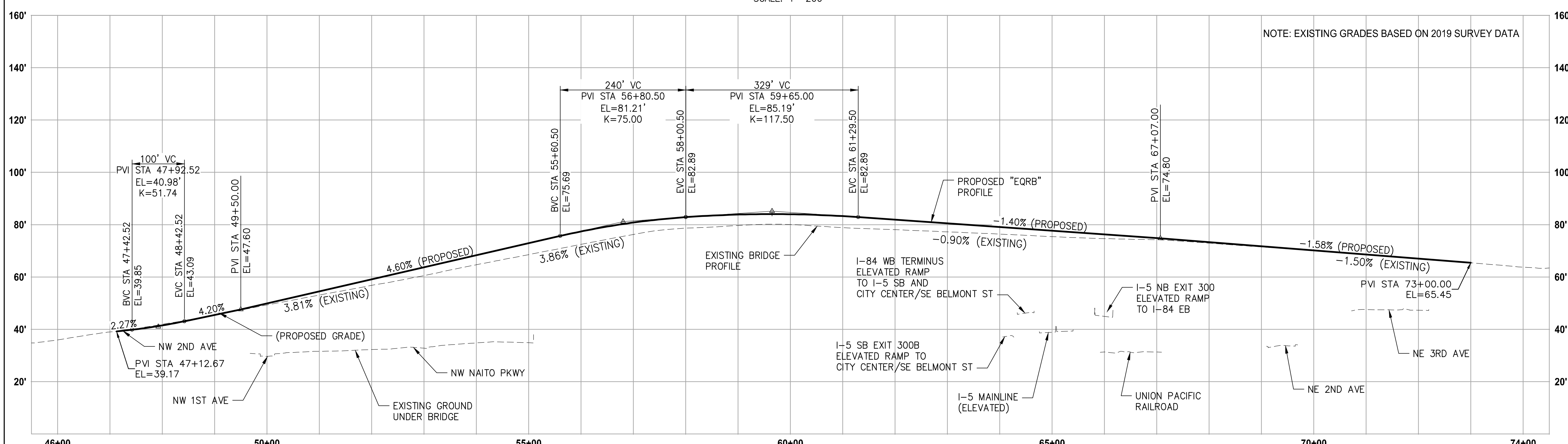
CONCEPTUAL PLANS
SEPTEMBER 2022

Sheet No. RD08



PLAN

SCALE: 1"=200'



ELEVATION

HORIZONTAL SCALE: 1"=200'
VERTICAL SCALE: 1"=40'

20 10 0
100 0 100
SCALE IN FEET

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Plan and Elevation

DATE: 9/2022
PROJECT NO.:

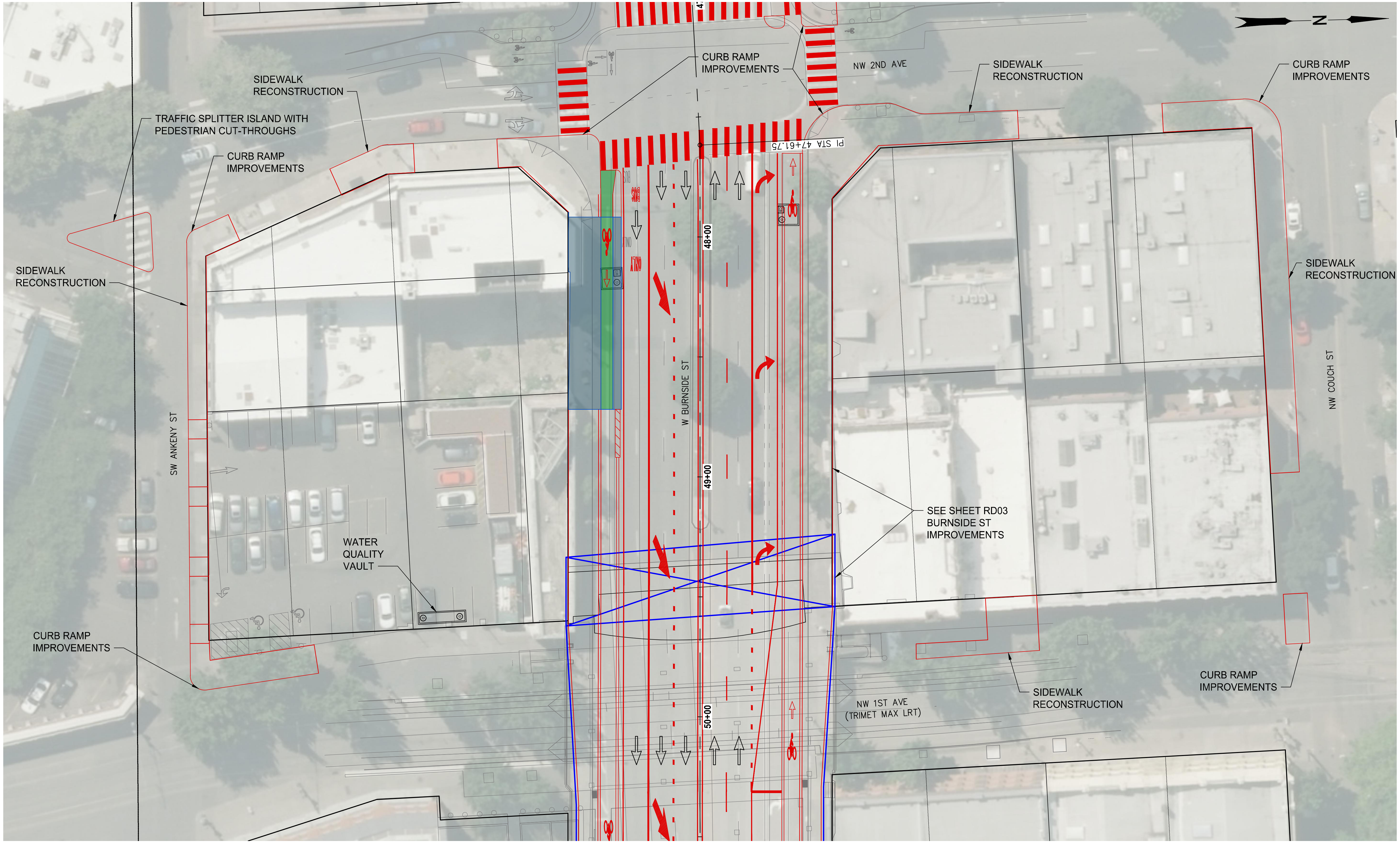
MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:

Sheet No.
RD01



PLAN

SCALE: 1"=40'

20 0 20
SCALE IN FEET

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Roadway Details - 1

DATE: 9/2022

PROJECT NO:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

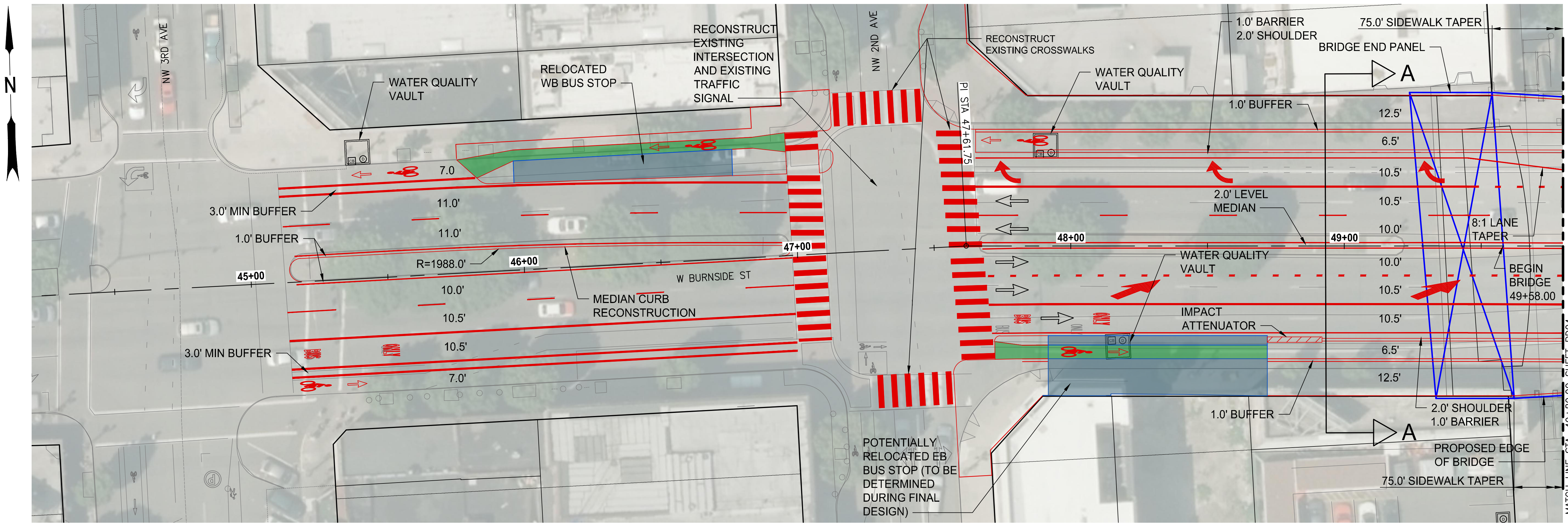
DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO.	DATE:

CONCEPTUAL PLANS
SEPTEMBER 2022

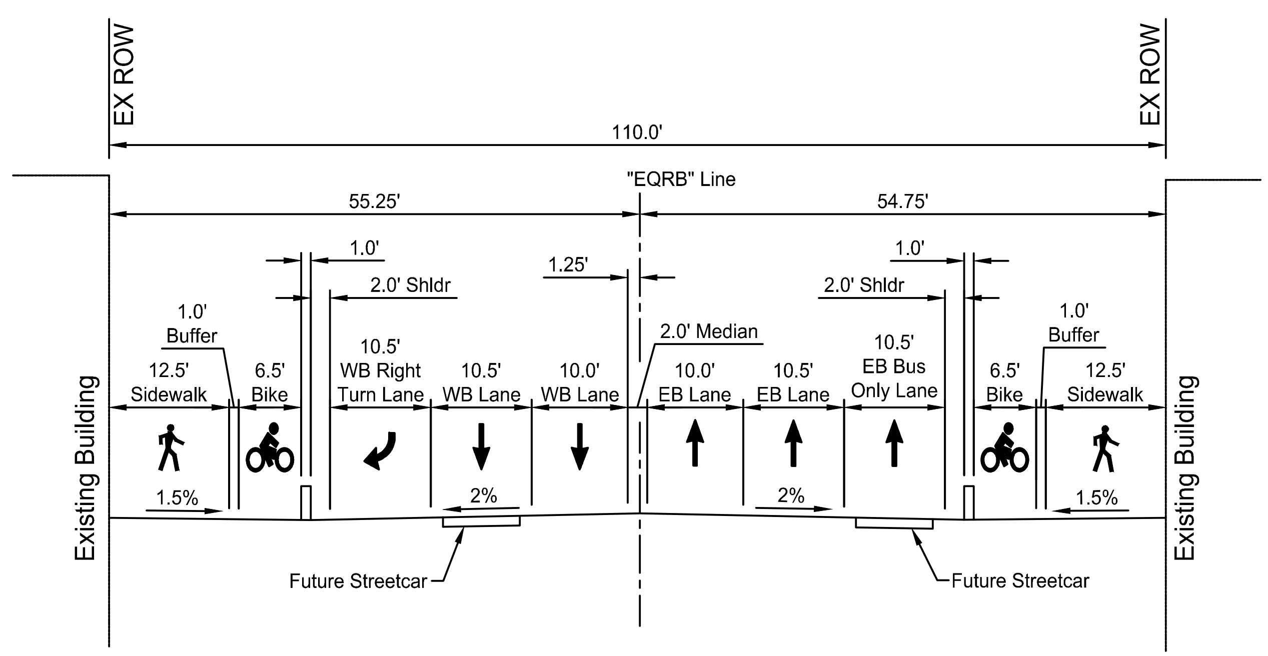
Sheet No. RD02



PLAN

SCALE: 1"=40'

20 SCALE 0 IN 20 FEET



TYPICAL SECTION A

WEST APPROACH ON FILL
LOOKING EAST – NO SCALE

NOTES:
1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE
2. BURNSIDE ST RETAINING WALLS NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge Bascule with Tied Arch Approach Roadway Details -2

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

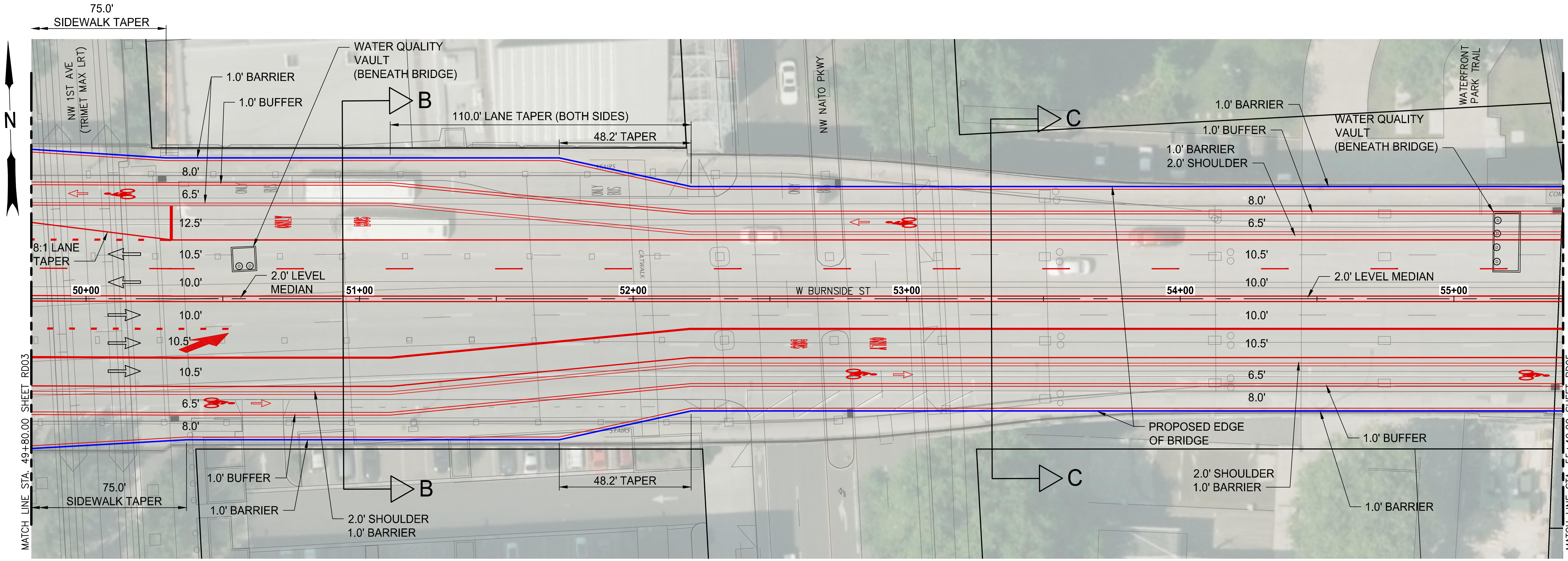
JON HENRICHSEN, COUNTY ENGINEER

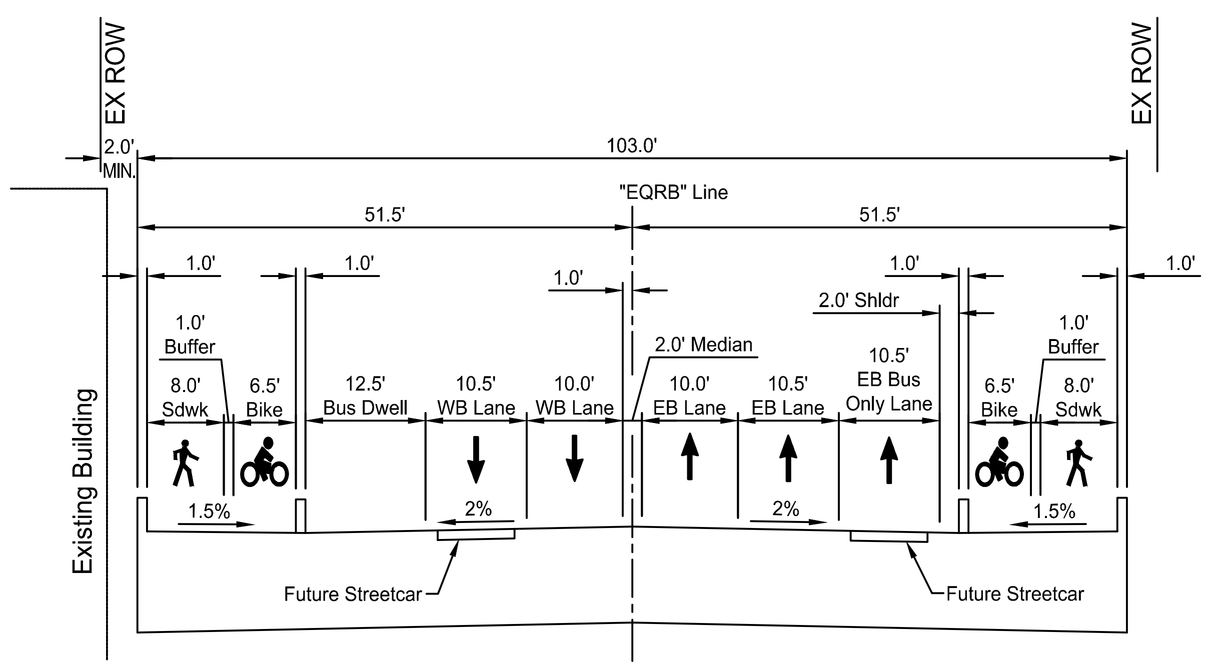
DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO. DATE:

Sheet No. RD03

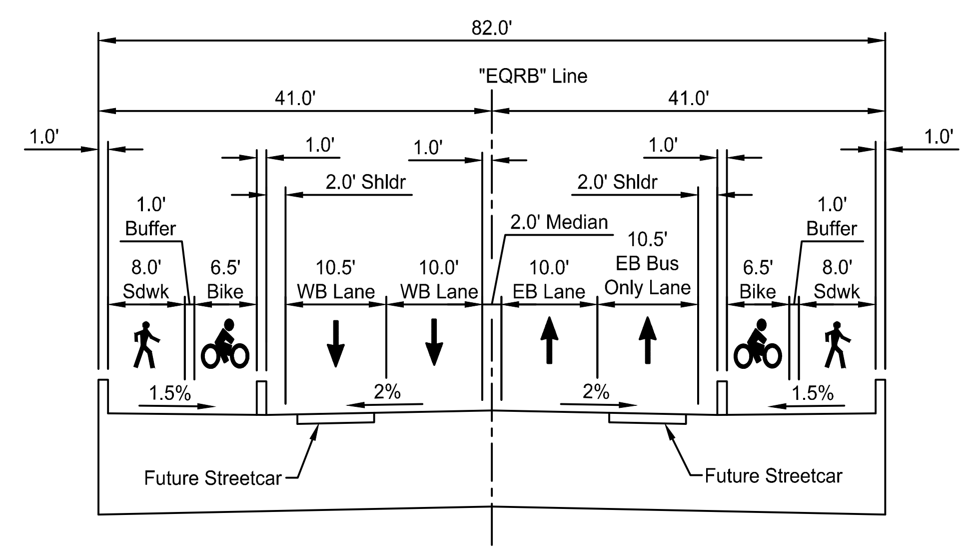




TYPICAL SECTION B

WEST APPROACH CONVENTIONAL BRIDGE SPAN
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE



TYPICAL SECTION C

WEST APPROACH CONVENTIONAL BRIDGE SPANS
LOOKING EAST – NO SCALE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Roadway Details -3

PROJECT NO.:
DATE: 9/2022

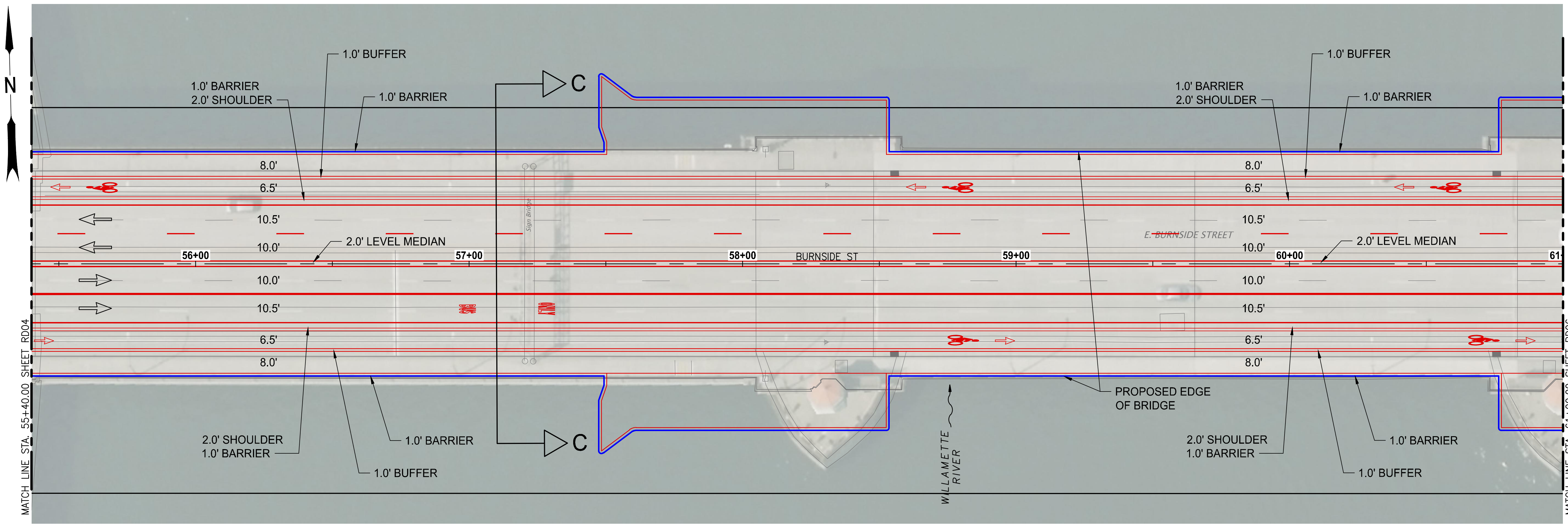
MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:		

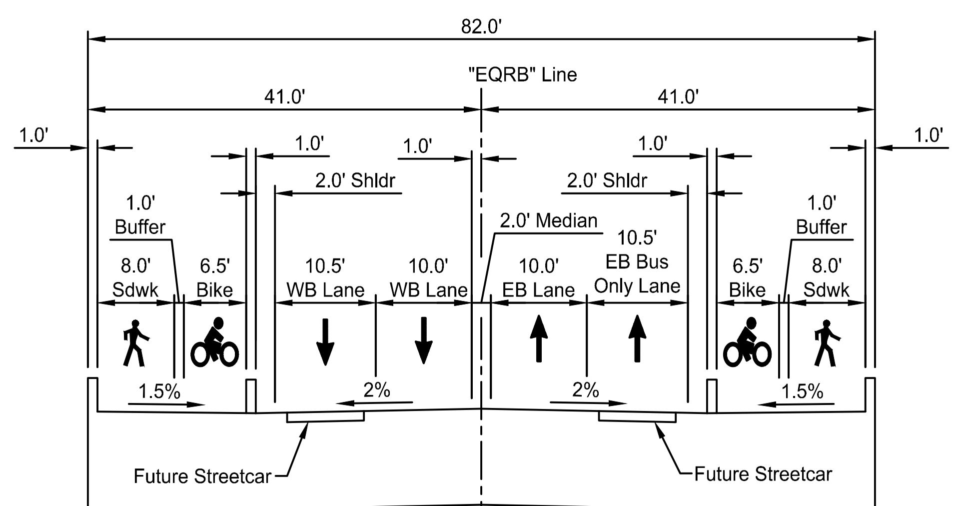
Sheet No. RD04



PLAN

SCALE: 1"=40'

20 SCALE 0 IN 20 FEET



TYPICAL SECTION C

WEST APPROACH CONVENTIONAL BRIDGE SPANS AND MOVABLE SPAN
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge Bascule with Tied Arch Approach Roadway Details – 4

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

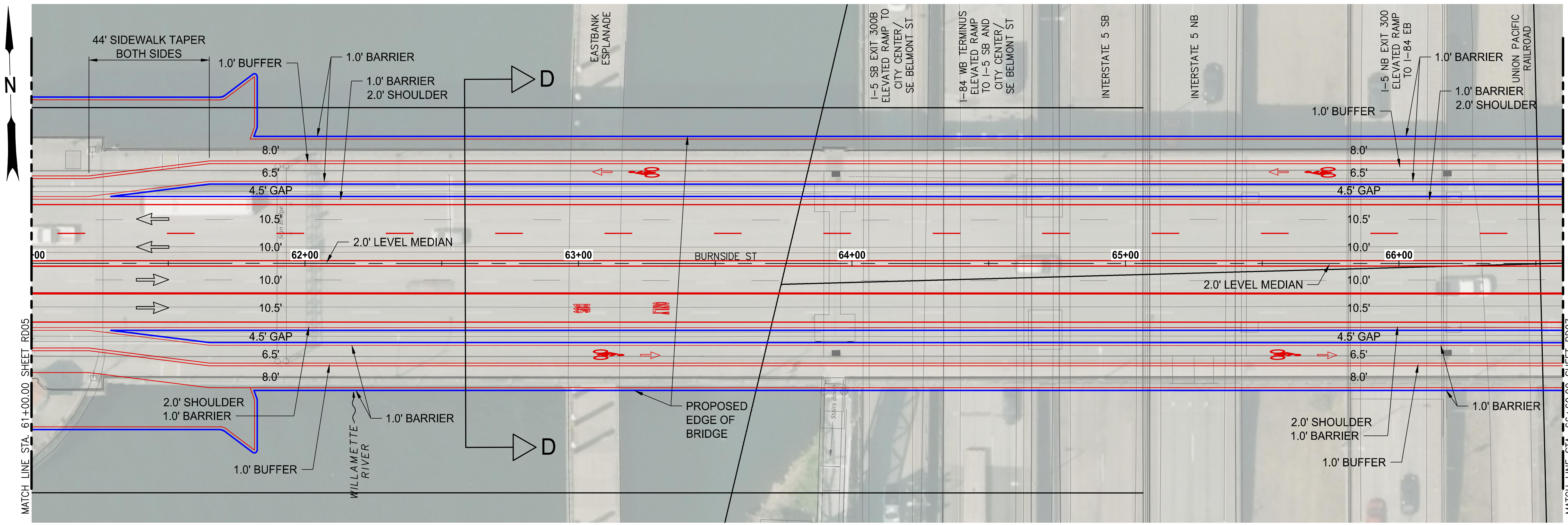
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

REVISIONS

NO	DATE:			

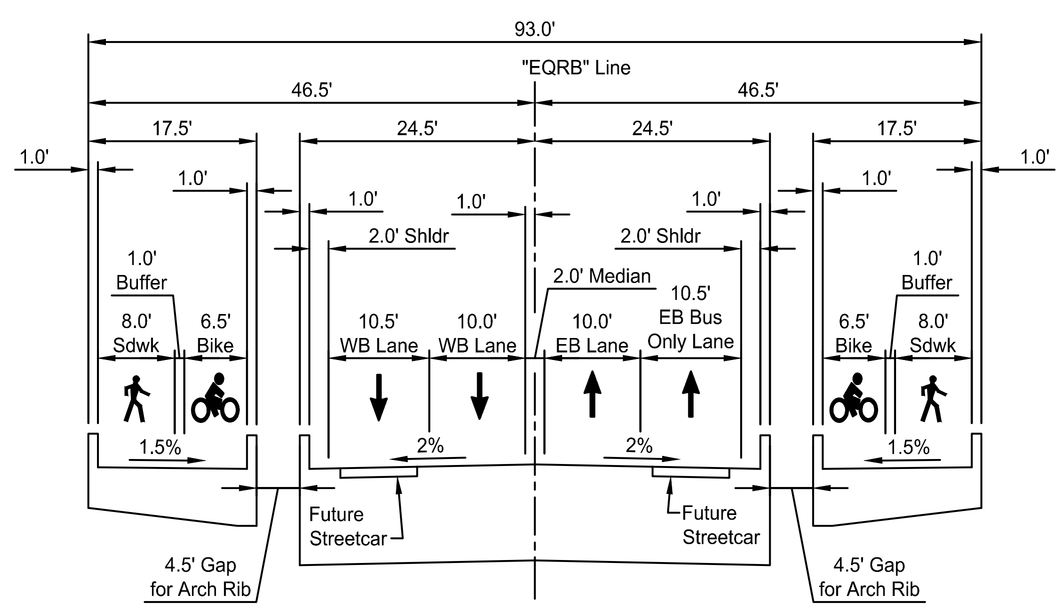
Sheet No. RD05



PLAN

SCALE: 1"=40'

20 SCALE | 0 IN | 20 FEET



TYPICAL SECTION D

EAST APPROACH TIED ARCH BRIDGE SPAN
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Roadway Details -5

PROJECT NO:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: PMX
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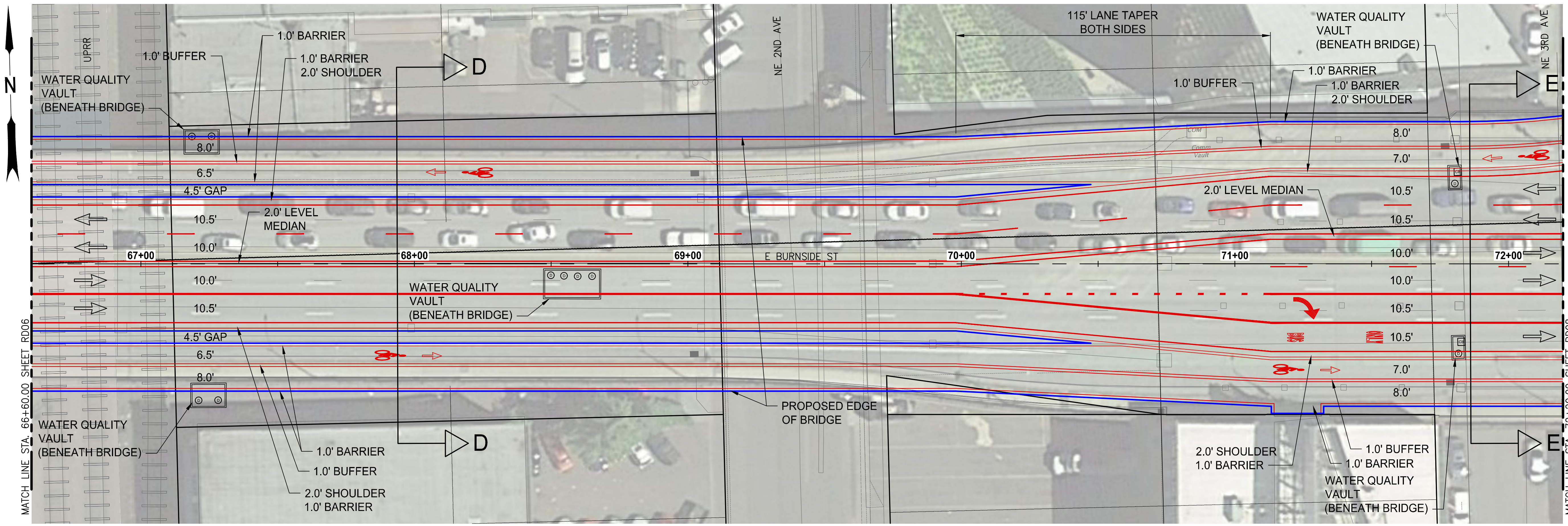
CHECKED BY: PMX

REVISIONS

NO	DATE:			

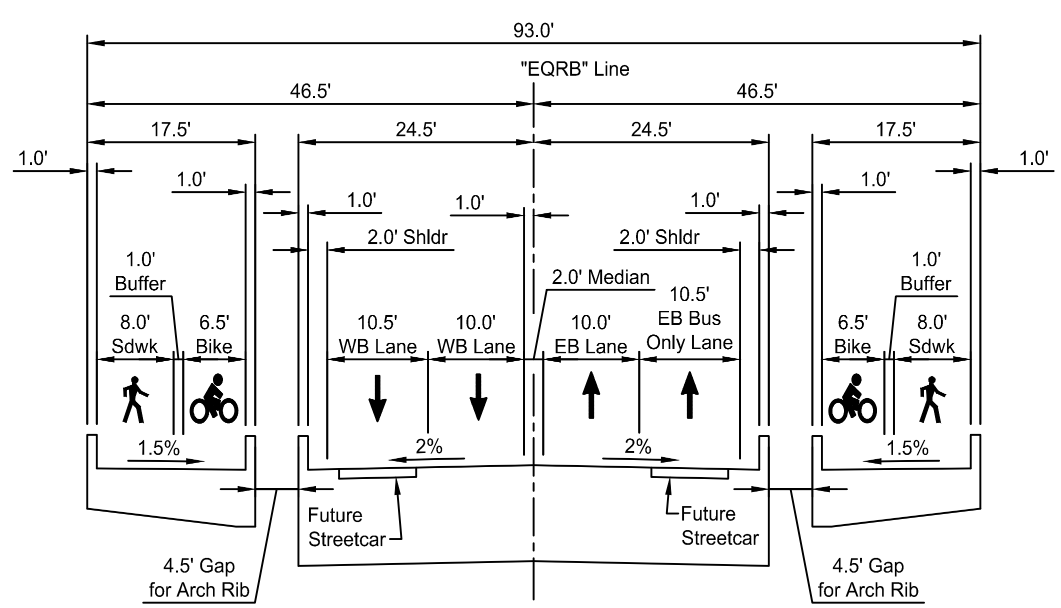
Sheet No. RD06



PLAN

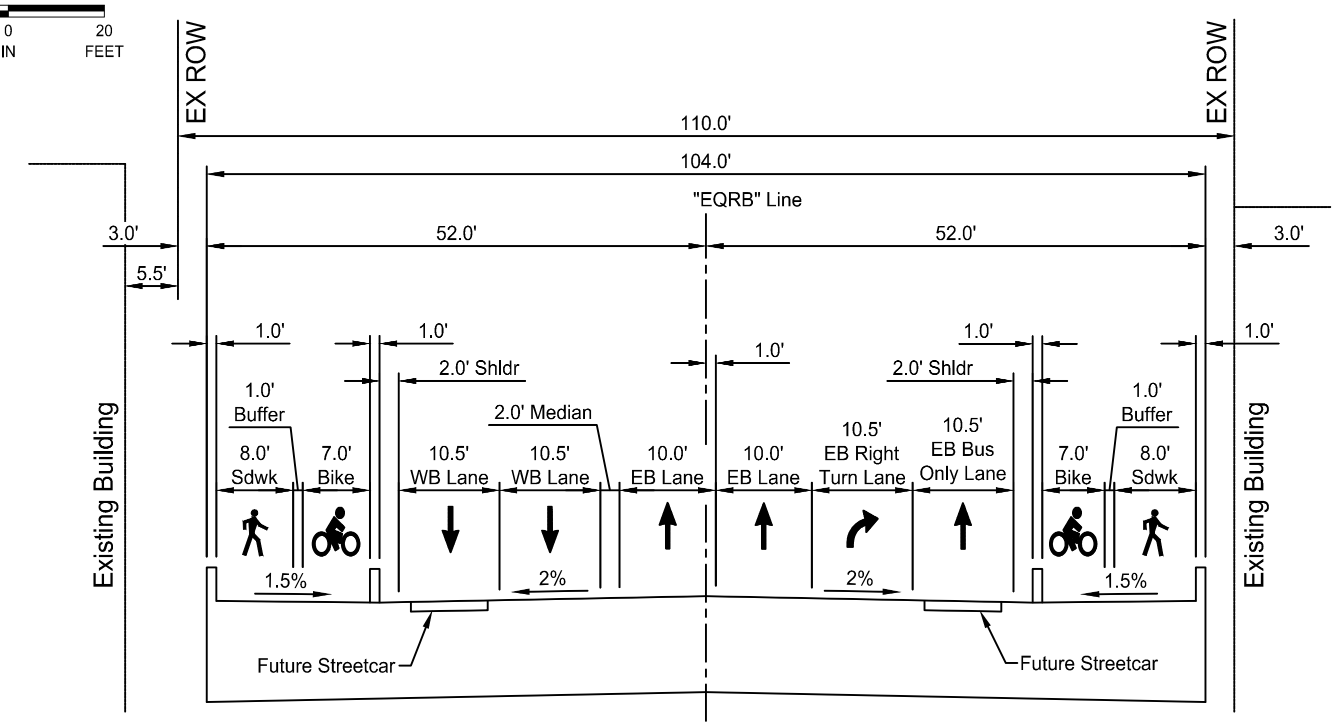
SCALE: 1"=40'

20 SCALE 0 IN 20 FEET



TYPICAL SECTION D

EAST APPROACH TIED ARCH BRIDGE SPAN
LOOKING EAST – NO SCALE



TYPICAL SECTION E

EAST APPROACH CONVENTIONAL BRIDGE SPANS
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Roadway Details -6

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

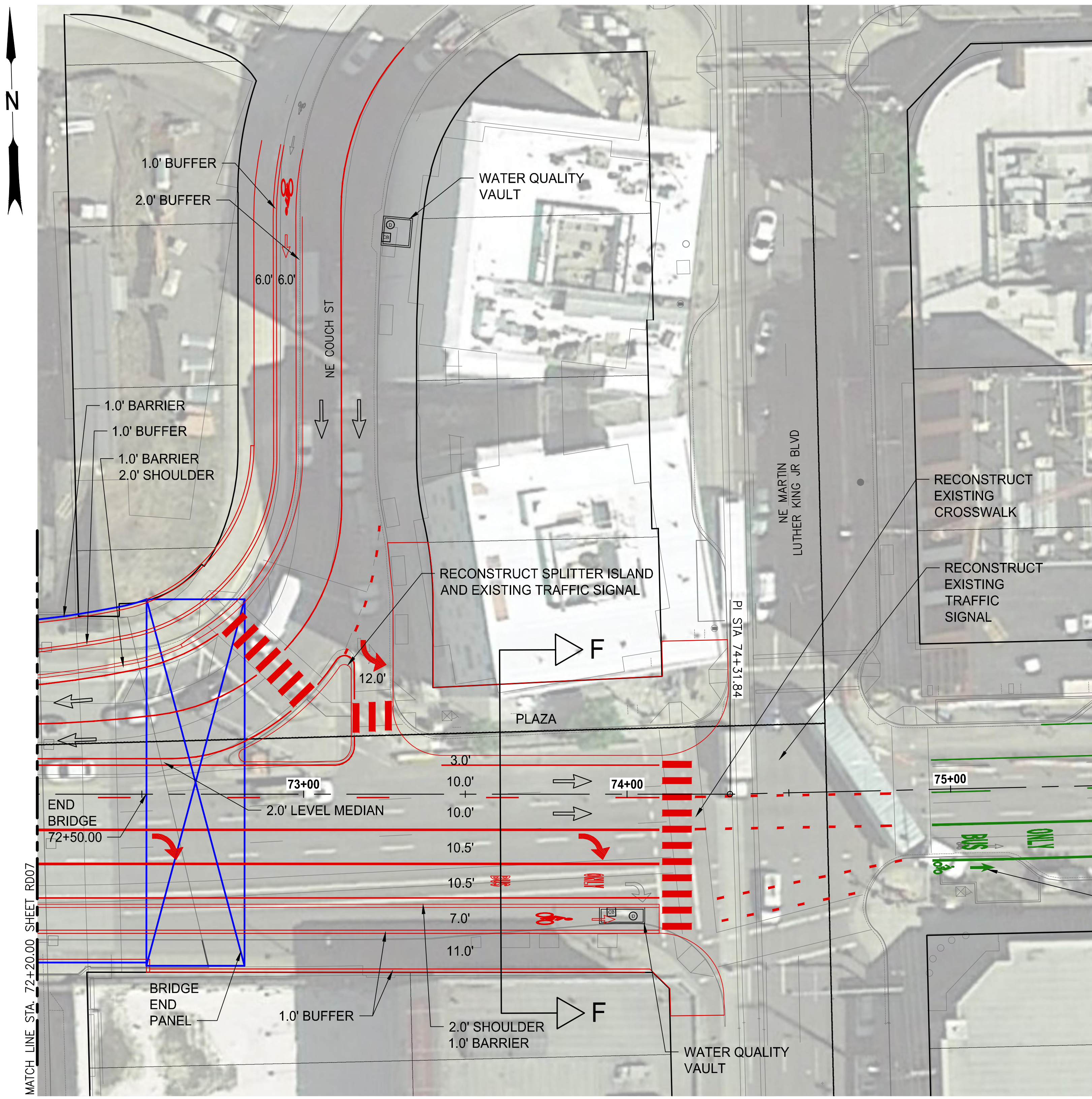
DESIGNED BY: PMX
DRAFTED BY: PMX
CHECKED BY: PMX

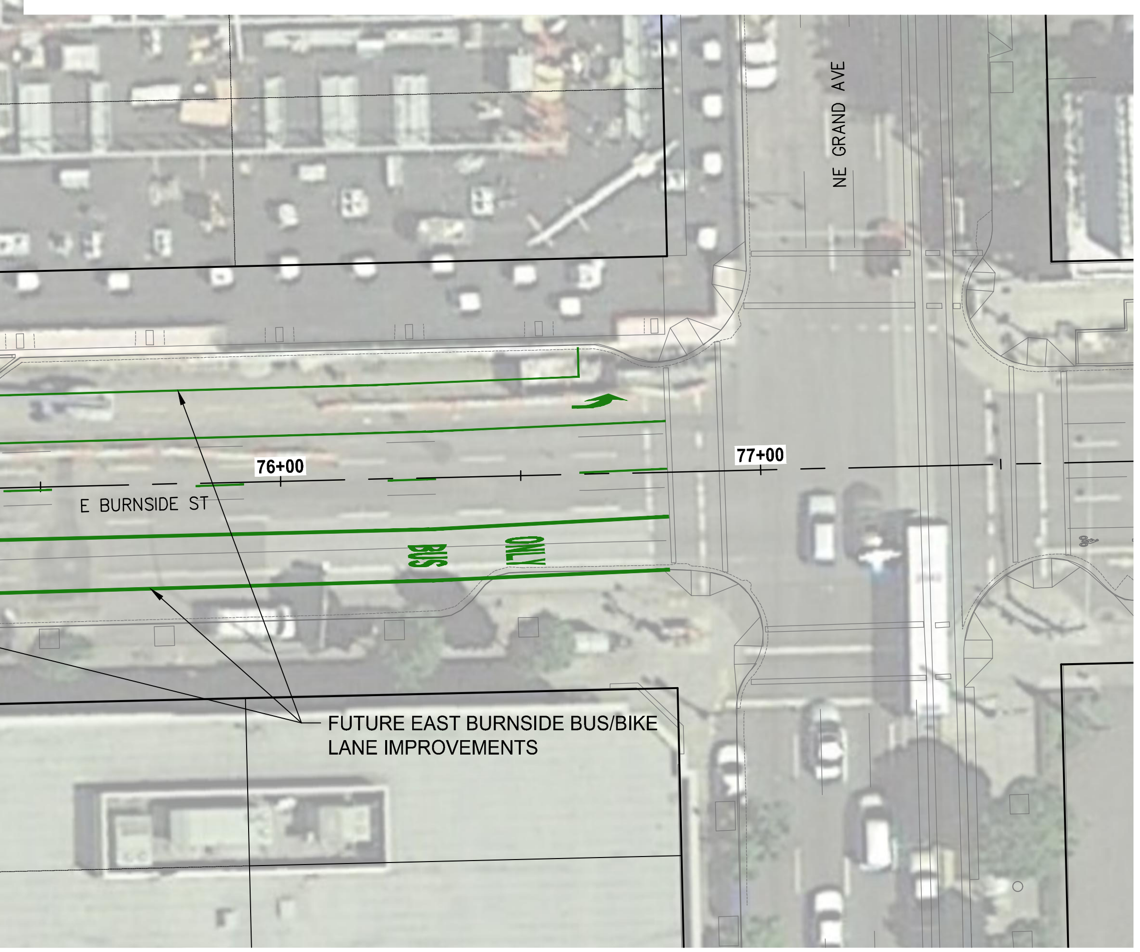
REVISIONS

NO DATE:

CONCEPTUAL PLANS
SEPTEMBER 2022

Sheet No. RD07

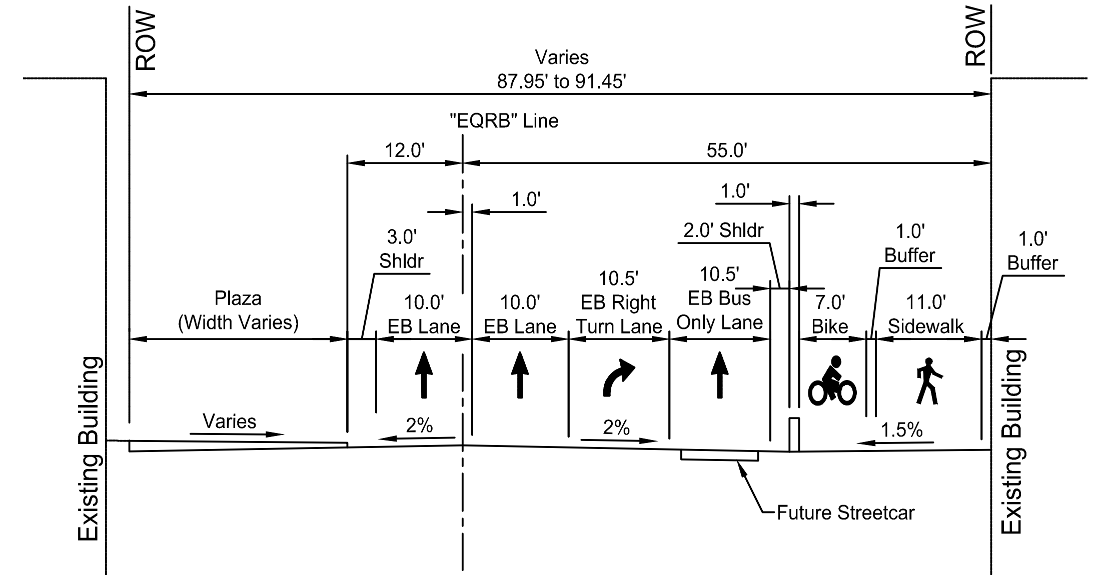




PLAN

SCALE: 1"=40'

20 0 20
SCALE IN FEET



TYPICAL SECTION F

EASTBOUND BURNSIDE ST ON FILL
LOOKING EAST – NO SCALE

NOTES: 1. CROSS SECTION DIMENSIONS SHOWN ARE FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Roadway Details - 7

PROJECT NO.:

DATE: *9/2022*

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

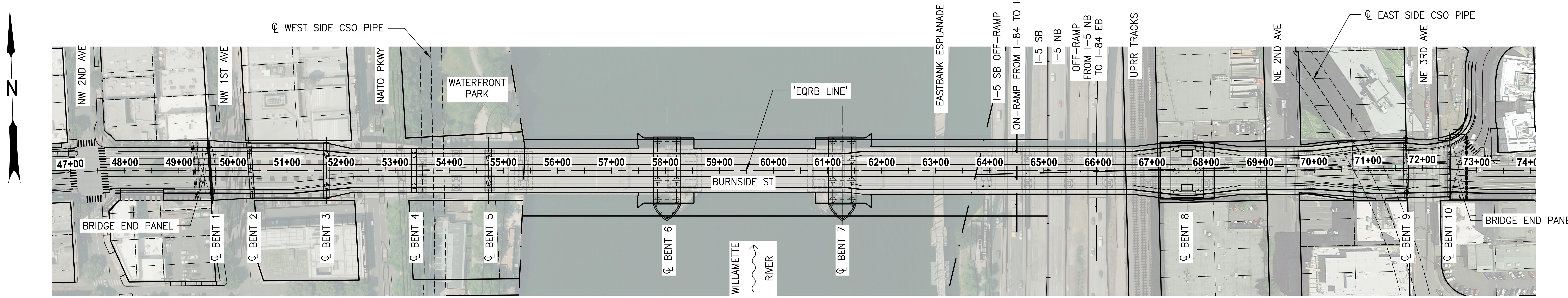
DESIGNED BY: *PMX*
DRAFTED BY: *PMX*
CHECKED BY: *PMX*

REVISIONS

NO.	DATE:	

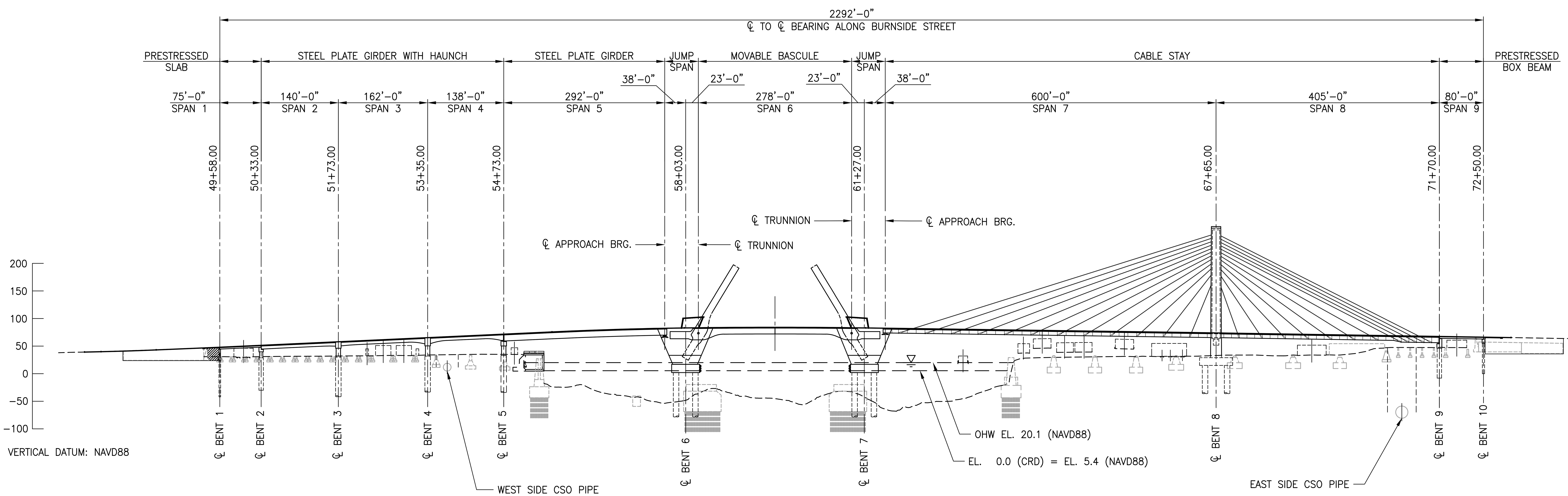
Sheet No. *RD08*

Appendix B. Replacement Bridge Plan Sheets



PLAN

SCALE: 1"=100'



ELEVATION

SCALE: 1"=100'

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
General Layout

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

NO.	DATE:	

Sheet No.
BR01

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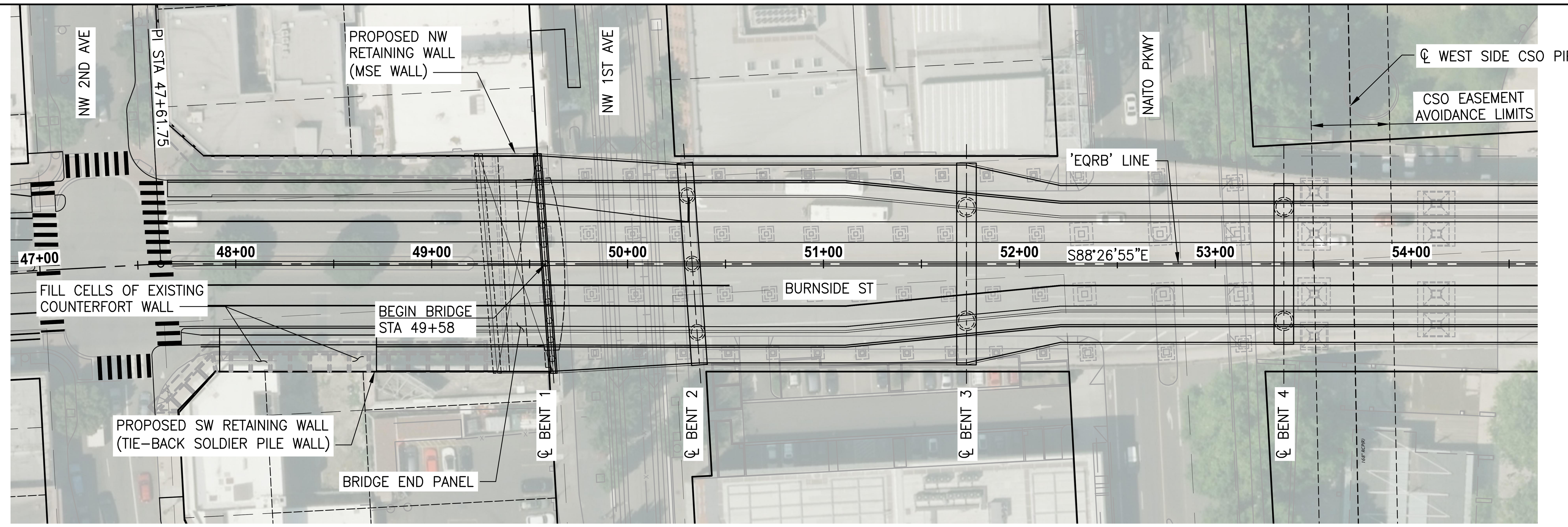
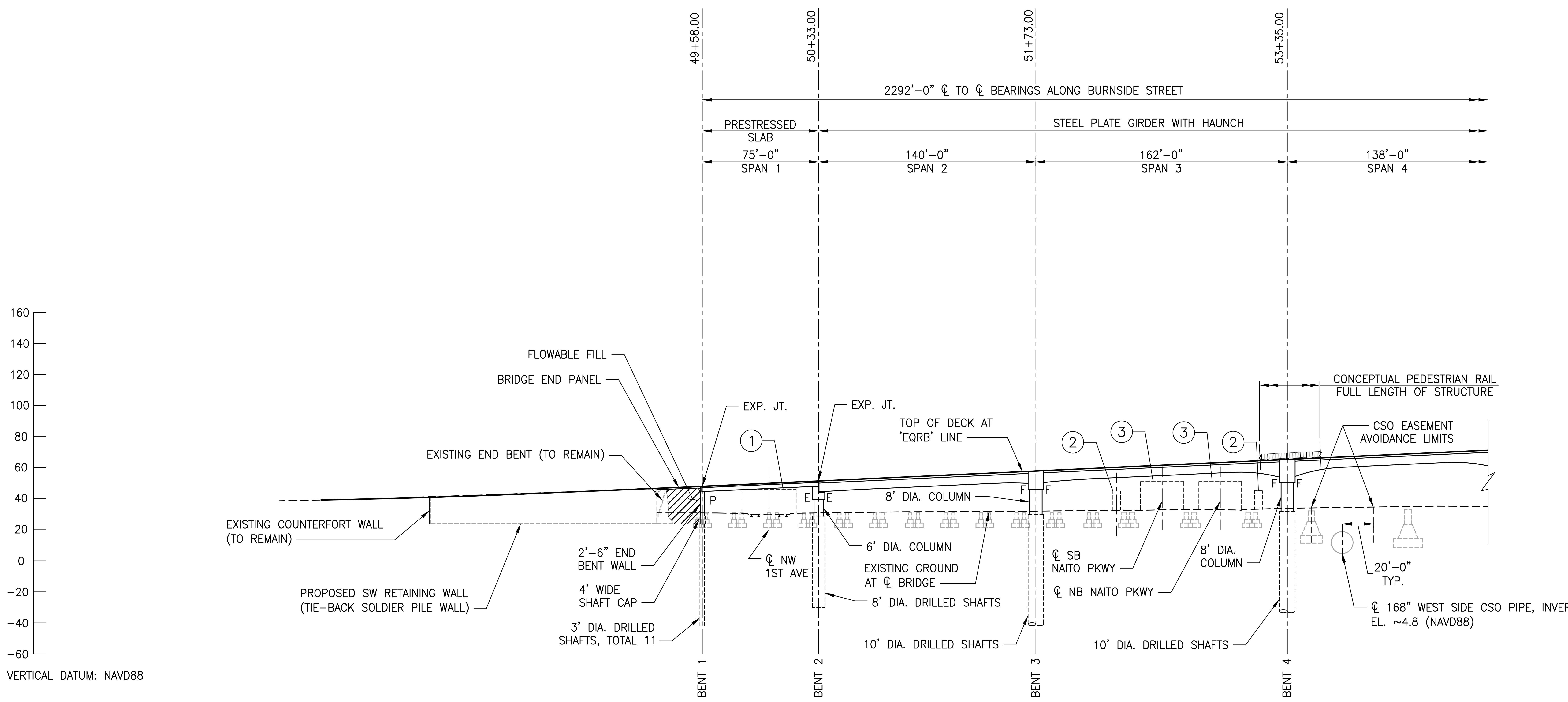


PLAN

SCALE: 1"=40'



ELEVATION

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

1	TRIMET LRT	15'-6"
2	PEDESTRIAN	12'-0"
3	CITY STREET	18'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation - 1

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

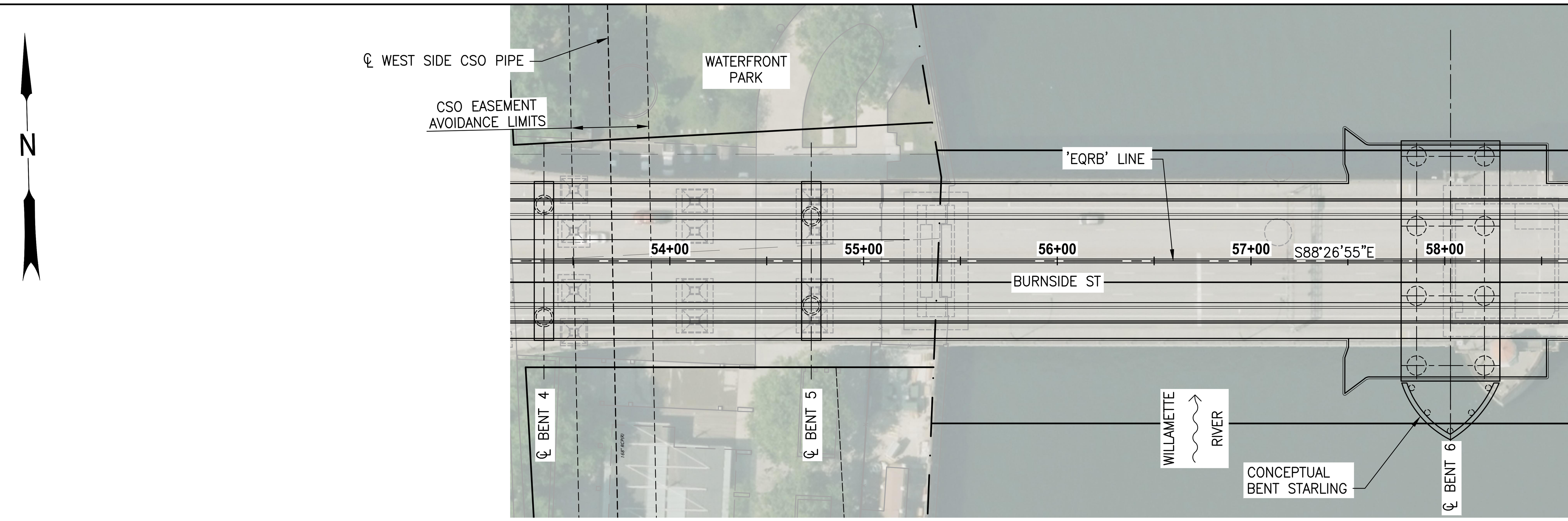
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

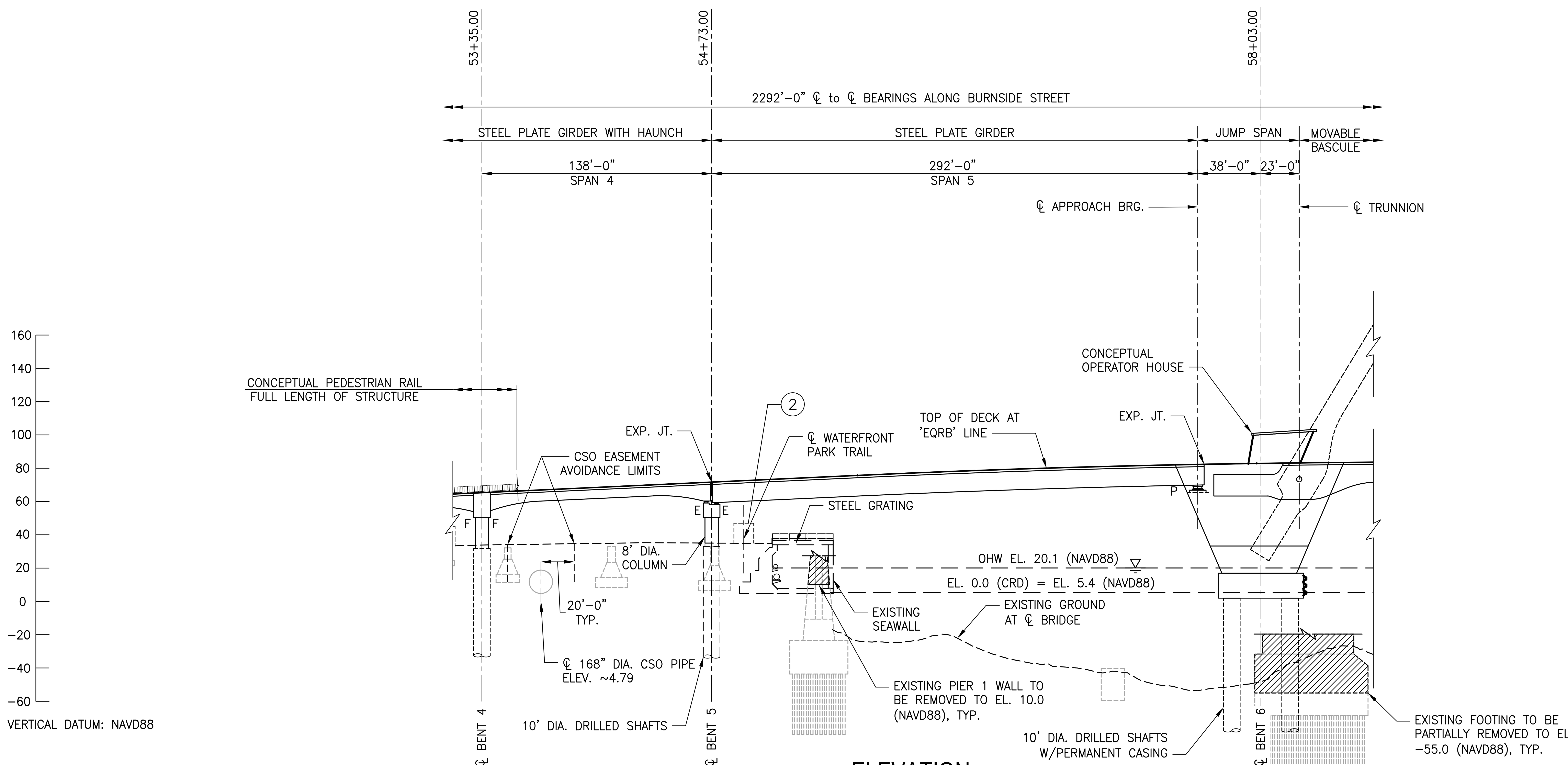
REVISIONS

NO	DATE:	

Sheet No. BR02



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

(2) PEDESTRIAN 12'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation -2

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

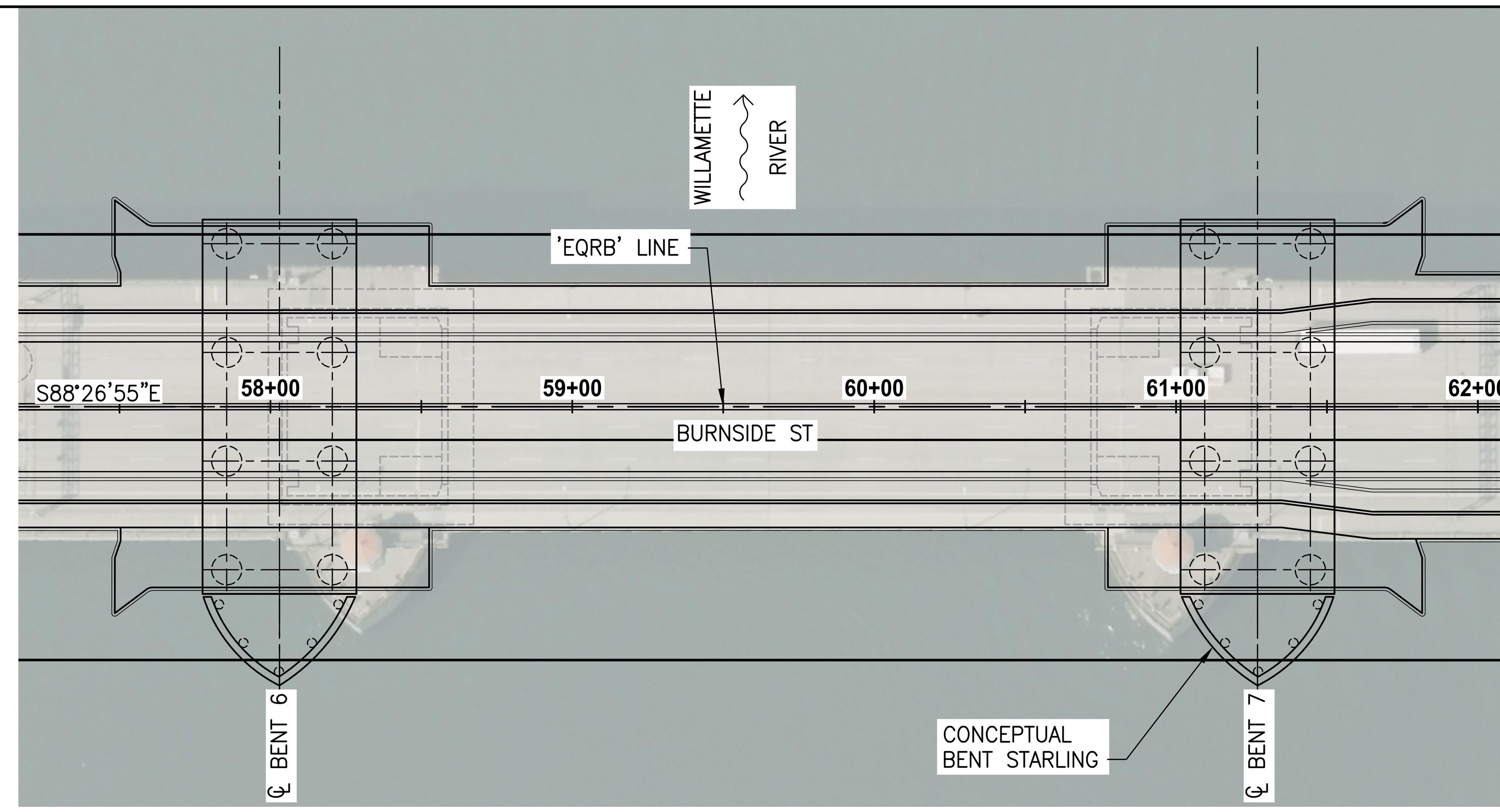
DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS

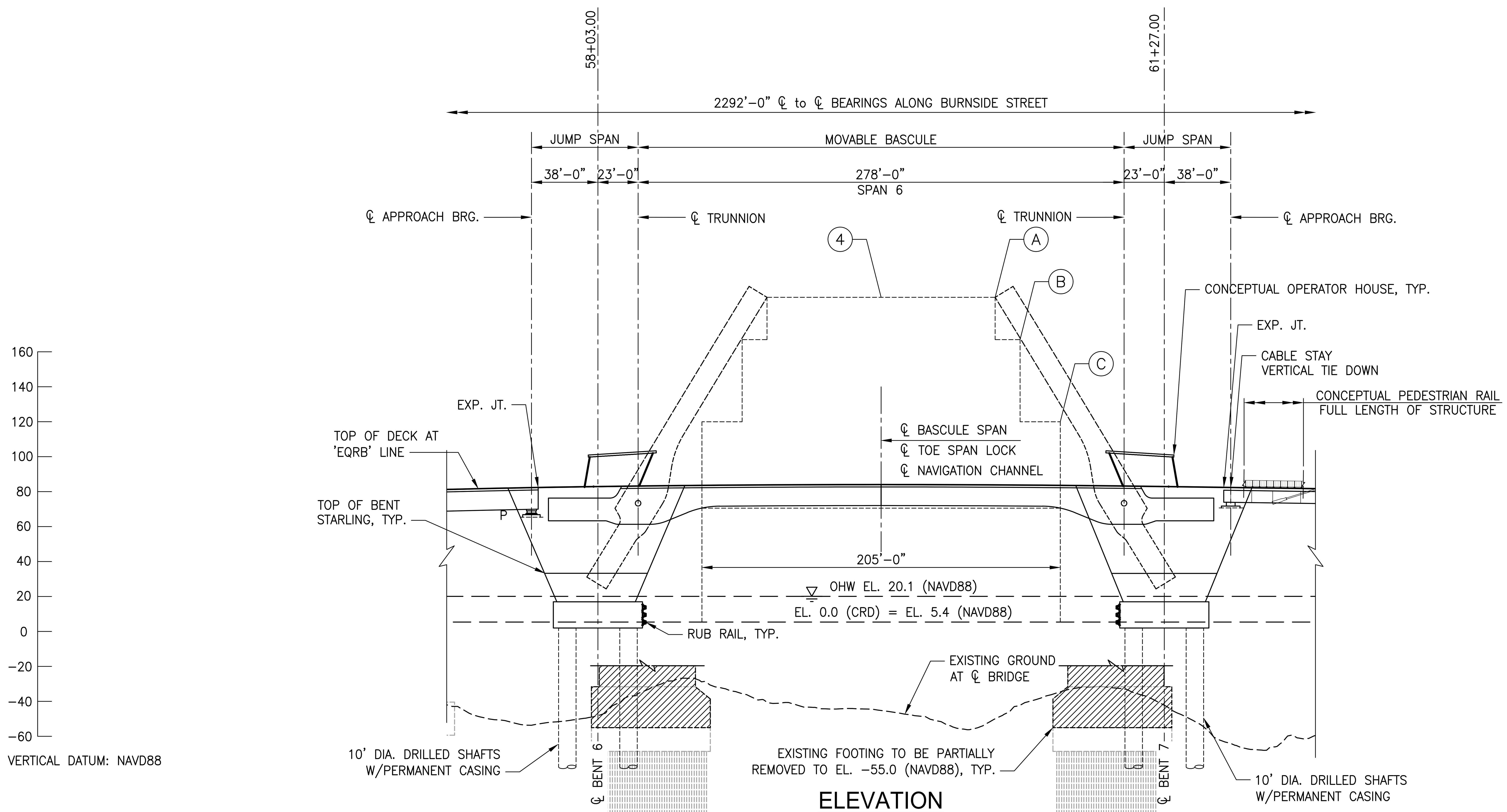
NO.	DATE:	

Sheet No. *BR03*

N



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

NAVIGATION CLEARANCE ENVELOPE LEGEND

4 NAVIGATION ENVELOPES		
ENVELOPE	VERTICAL CLEARANCE TO CRD	HORIZONTAL CLEARANCE
OPEN A	INFINITE	130'-6"
OPEN B	161'-7"	159'-0"
OPEN C	114'-7"	205'-0"
CLOSED	65'-2"	205'-0"

CRD: COLUMBIA RIVER DATUM

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation -3

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

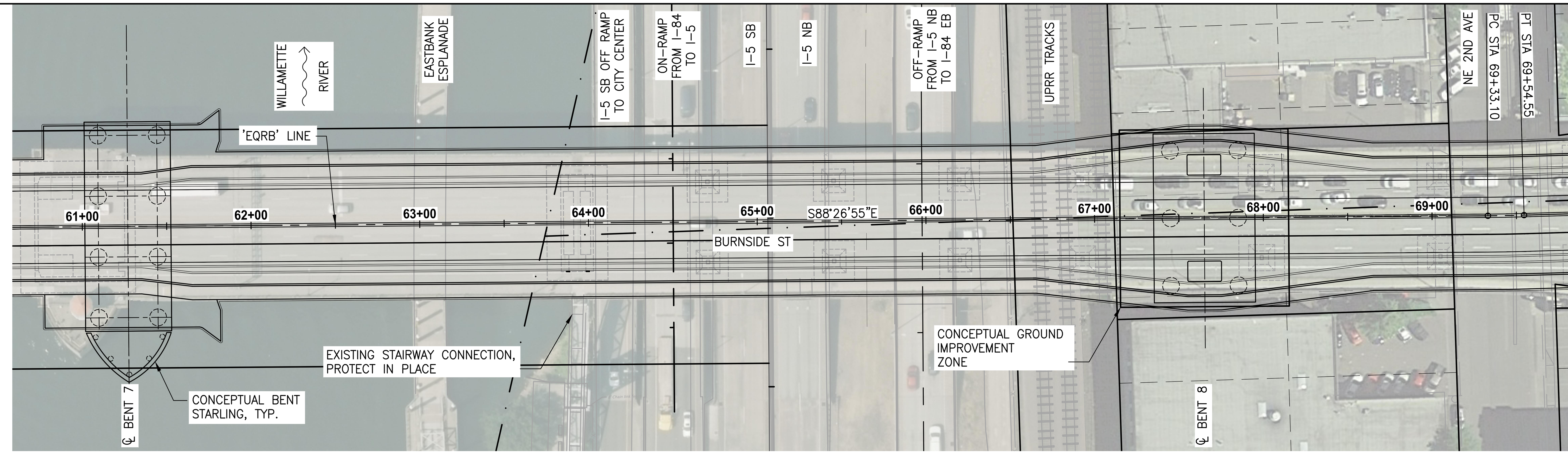
REVISIONS

NO.	DATE:				

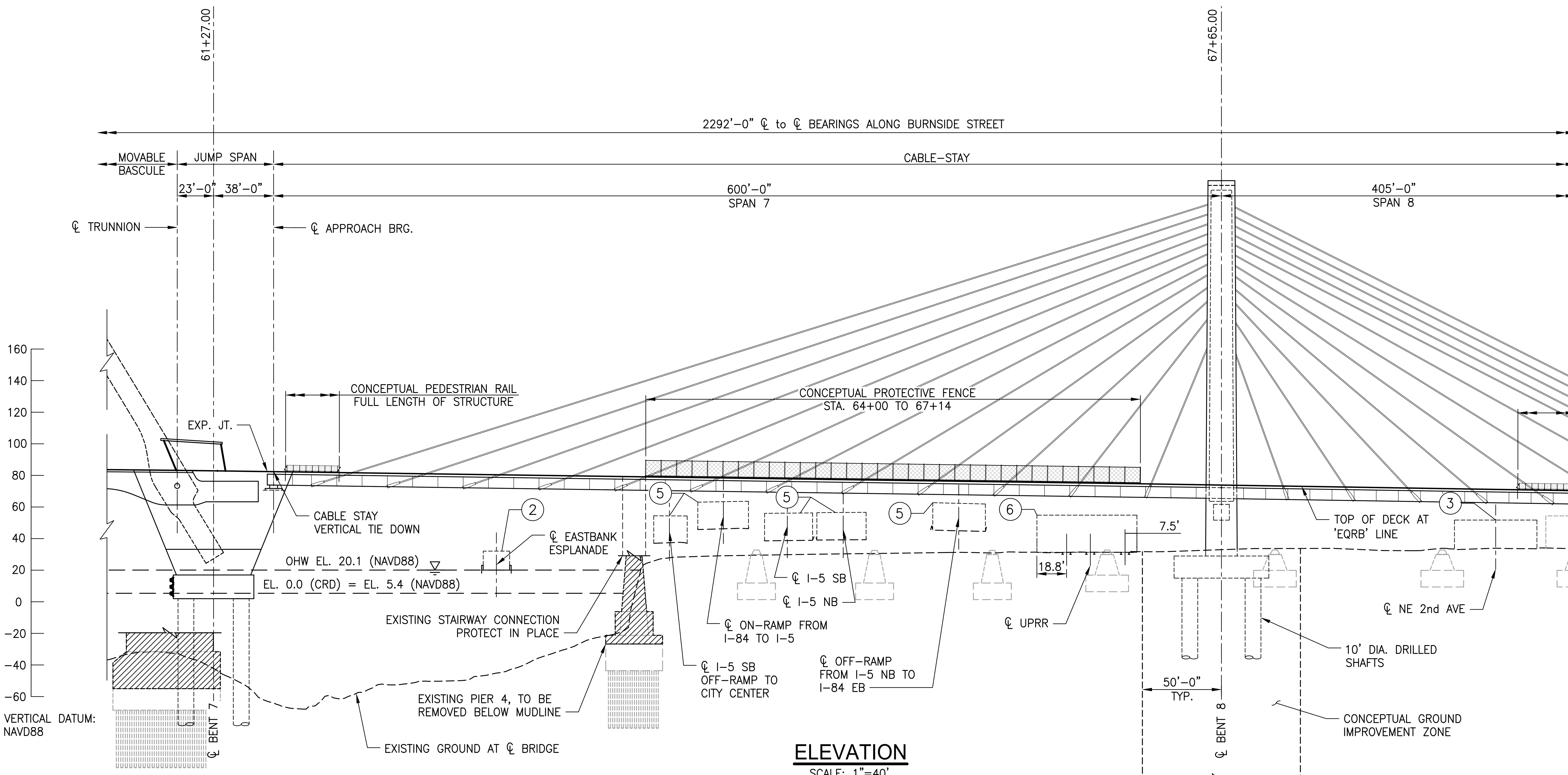
Sheet No. *BR04*

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation -4



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

2	PEDESTRIAN	12'-0"
3	CITY STREET	18'-0"
5	I-5	17'-4"
6	UPRR	23'-6"

LEGEND

BRIDGE REMOVAL

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

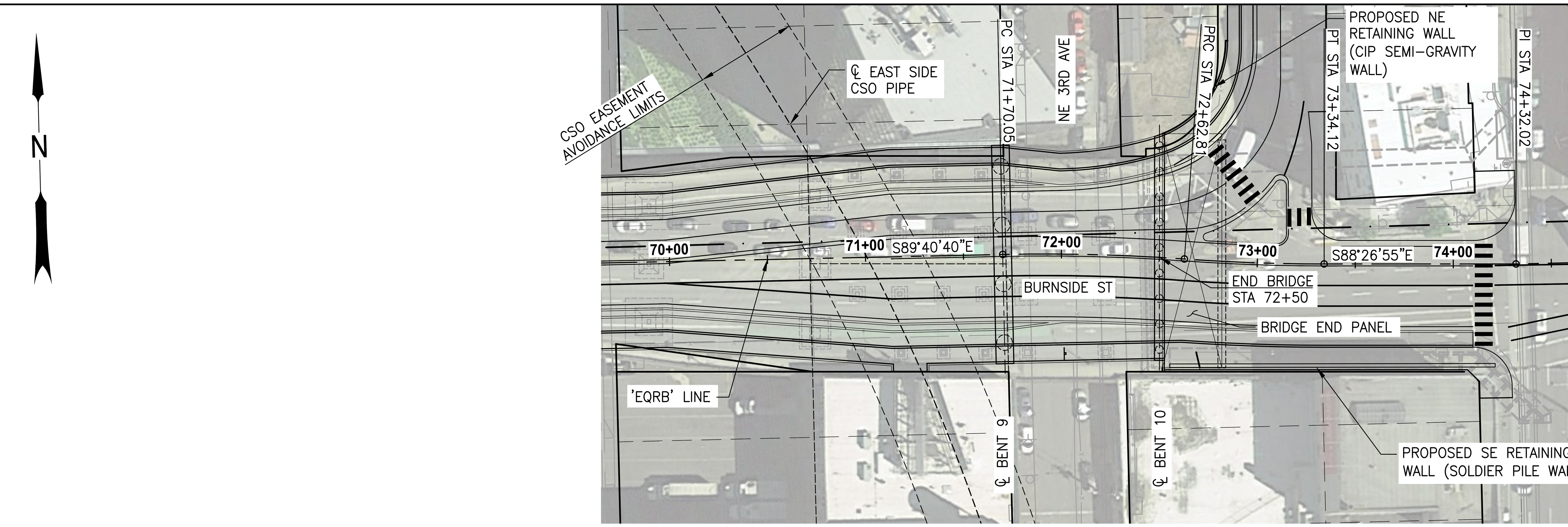
DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

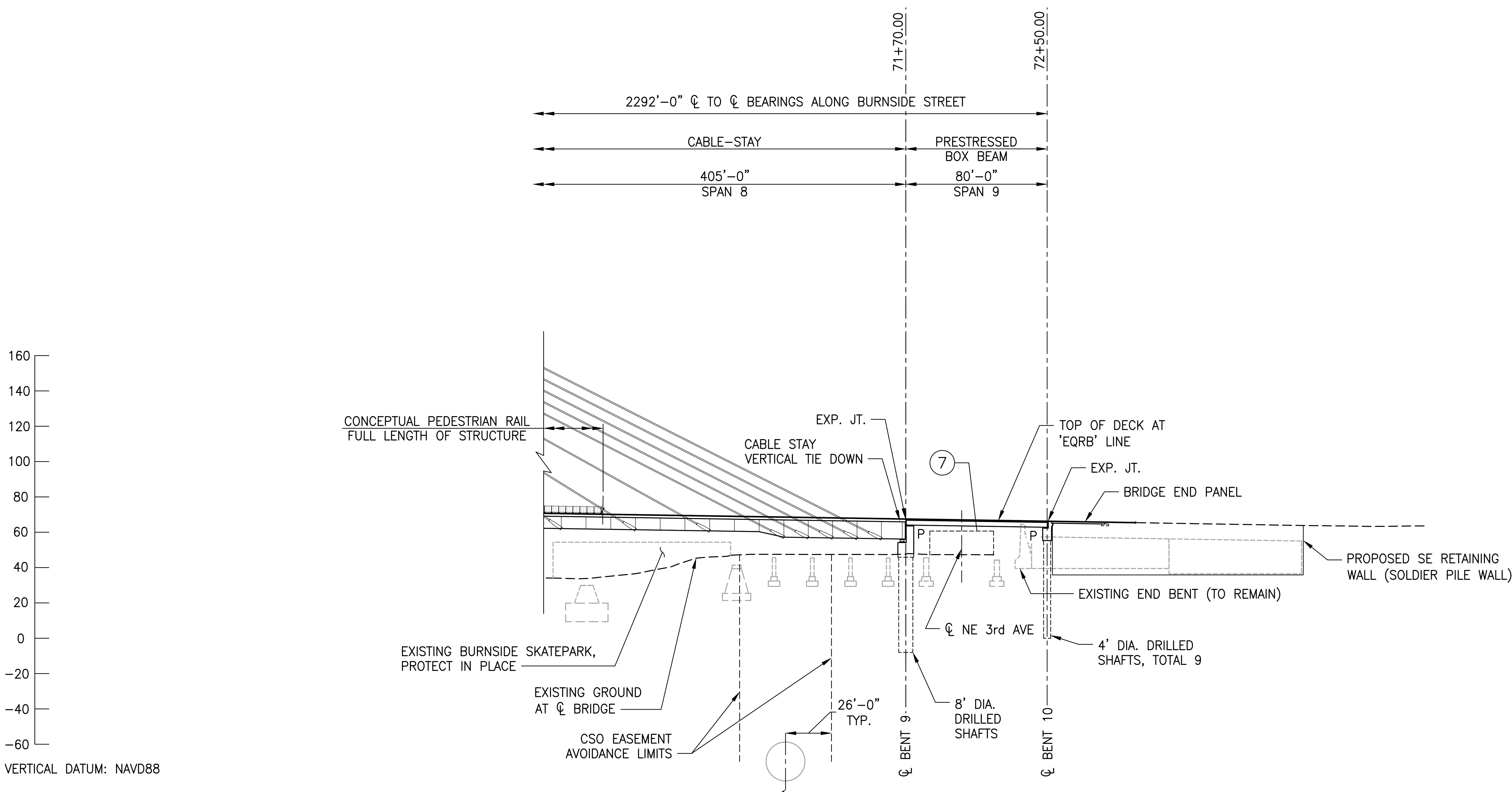
NO.	DATE:	

CONCEPTUAL PLANS
SEPTEMBER 2022

Sheet No. BR05



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

7	CITY STREET @ NE 3rd AVE	13'-8"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation - 5

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

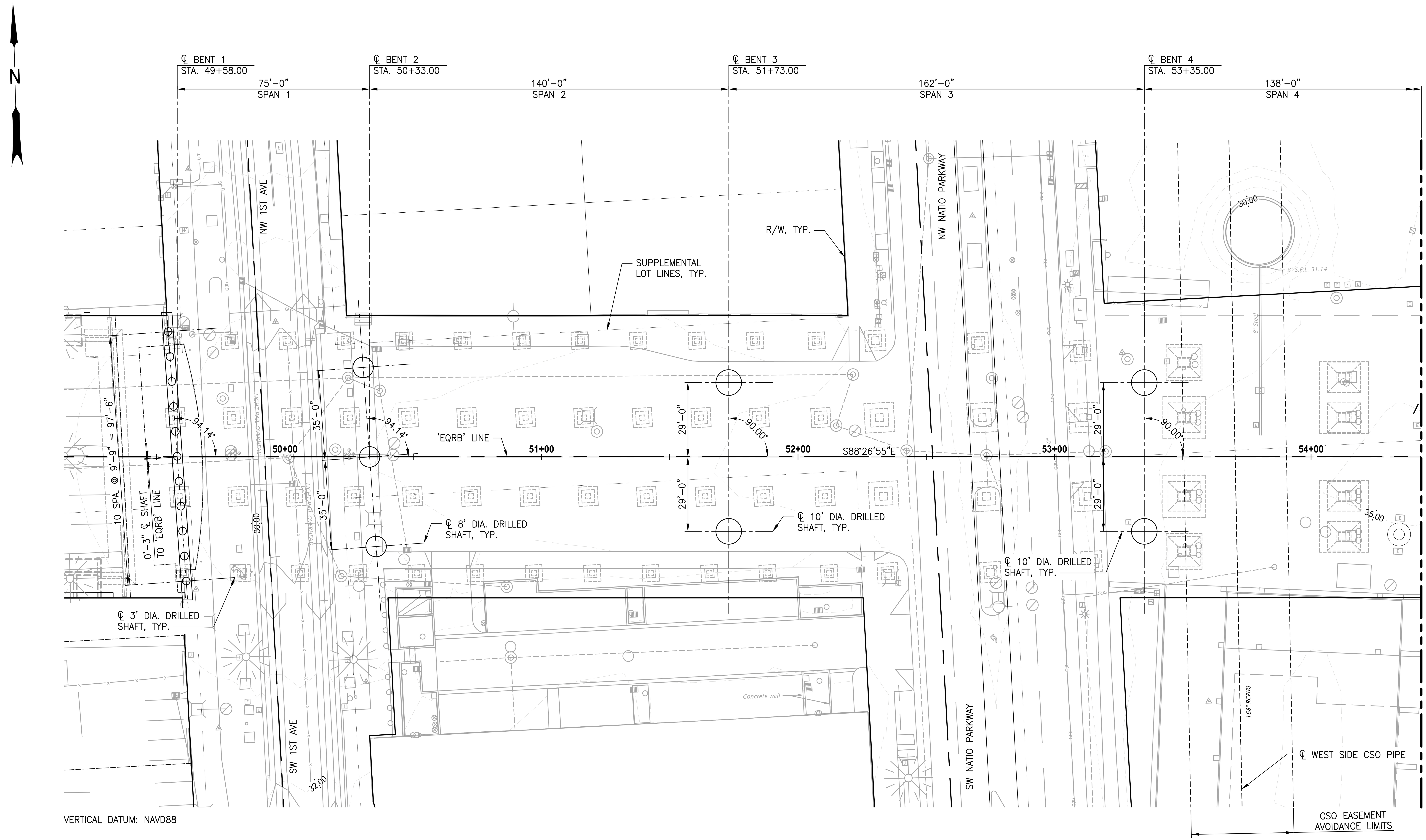
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

NO	DATE:			

Sheet No. BR06



VERTICAL DATUM: NAVD88

FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16-BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan - 1

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR

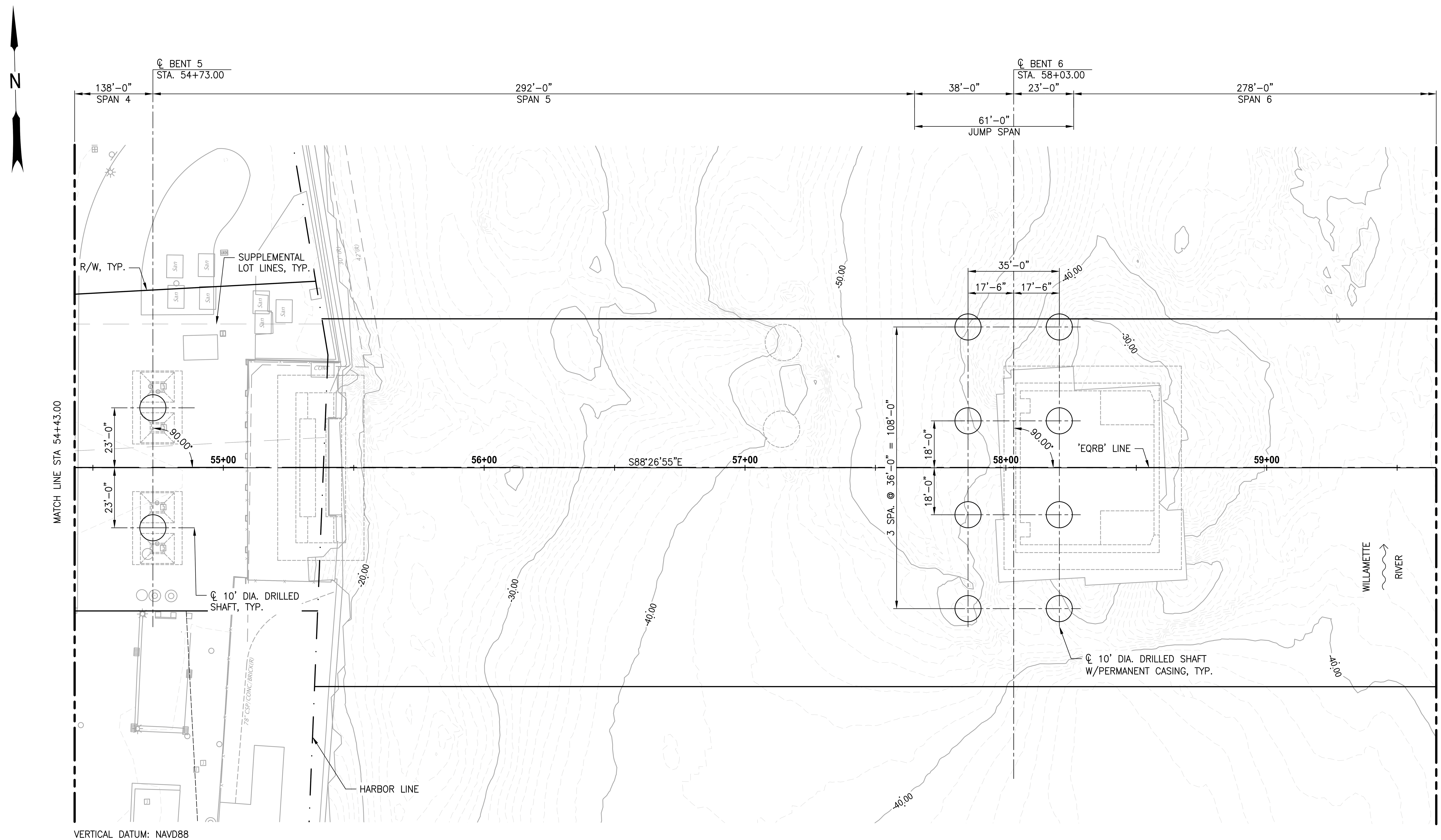
DRAFTED BY: HDR

CHECKED BY: HDR

REVISIONS

NO	DATE:

Sheet No. BR07



FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25
2. CONCEPTUAL BENT STARLING FOUNDATION NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan -2

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

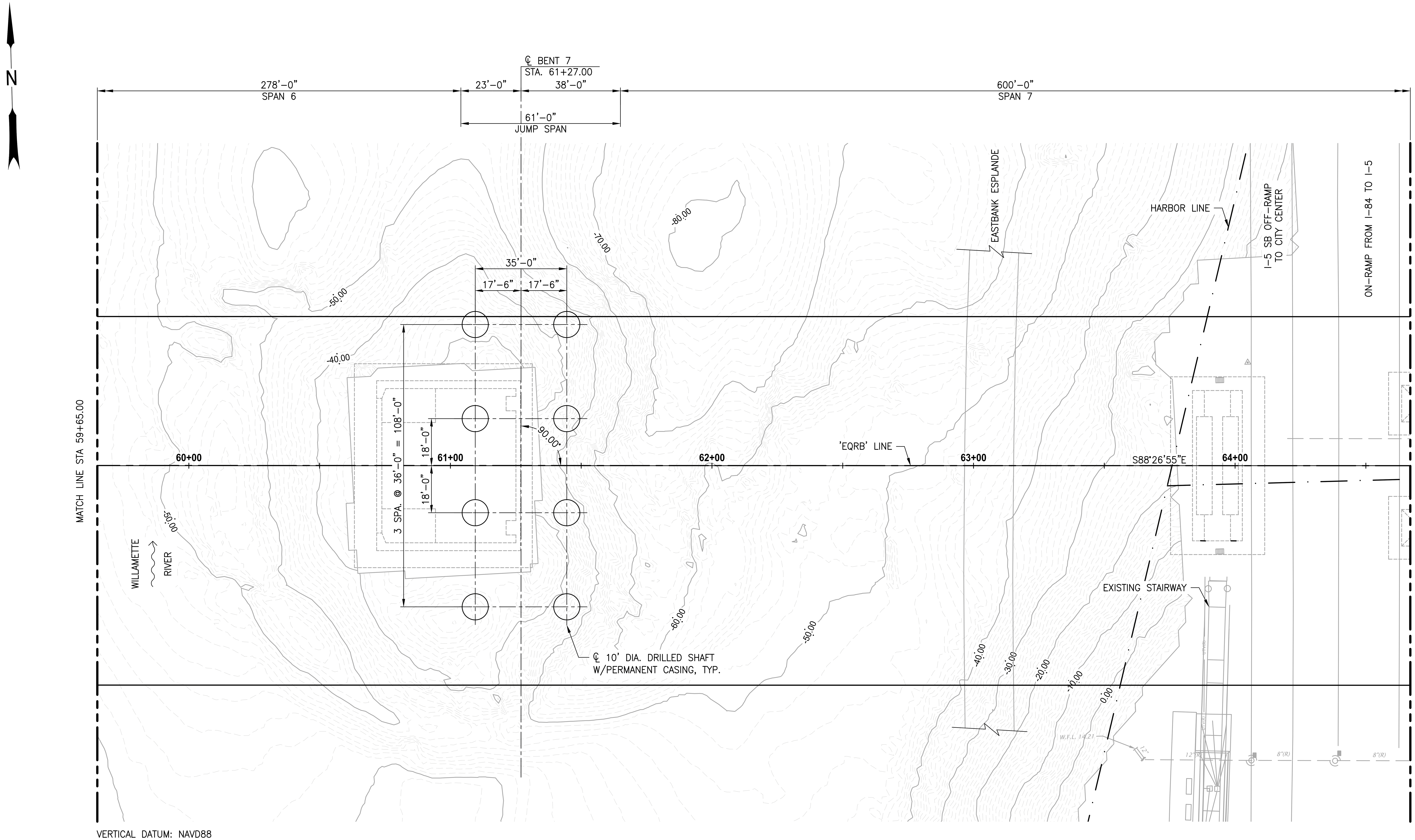
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS

NO.	DATE:			

Sheet No. *BR08*



NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16-BR25
2. CONCEPTUAL BENT STARLING FOUNDATION NOT SHOWN

FOUNDATION PLAN

SCALE: 1"=20'

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan -3

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

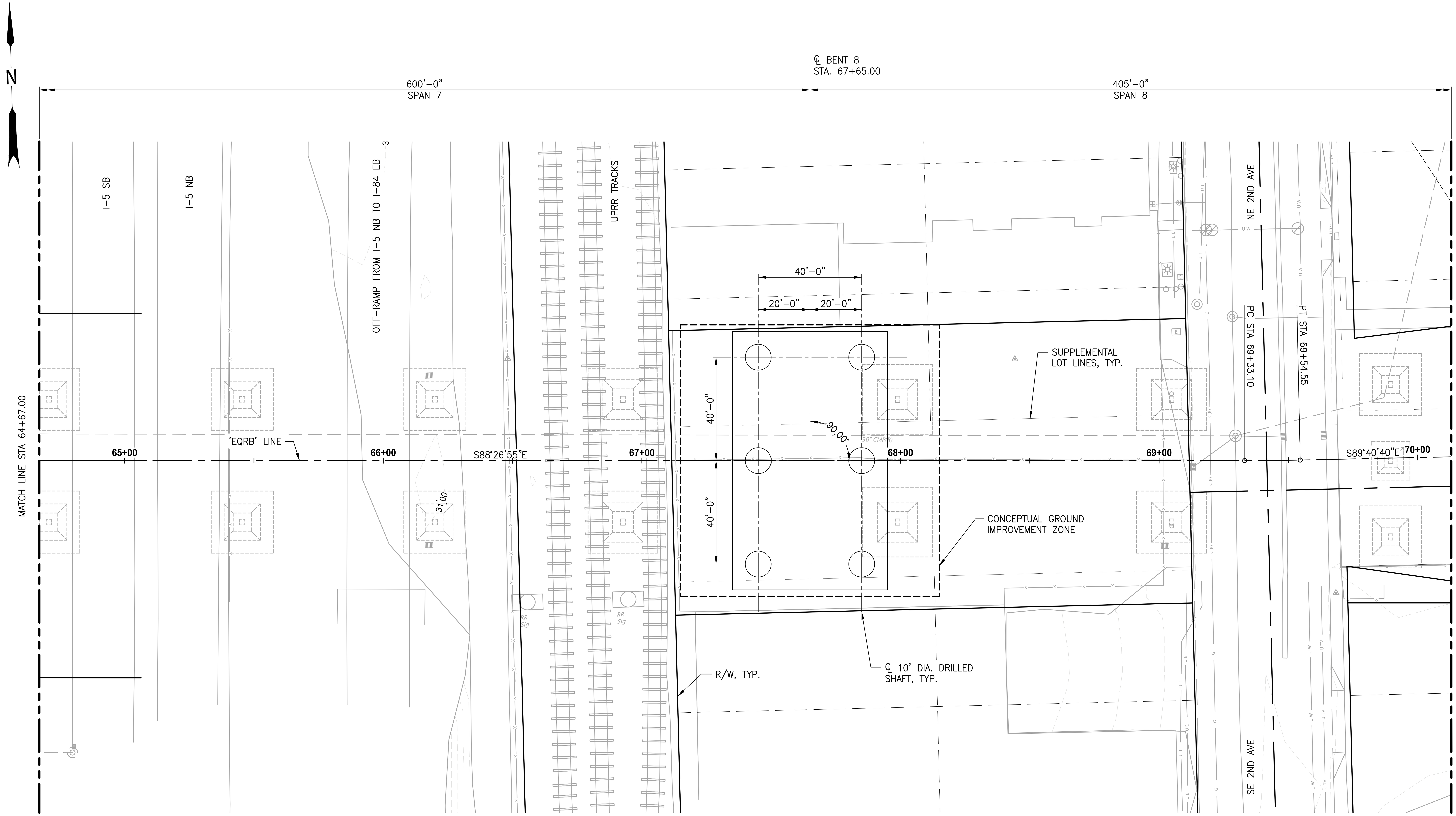
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

NO.	DATE:				

Sheet No. BR09



VERTICAL DATUM: NAVD88

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16-BR25

FOUNDATION PLAN

SCALE: 1"=20'

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan -4

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

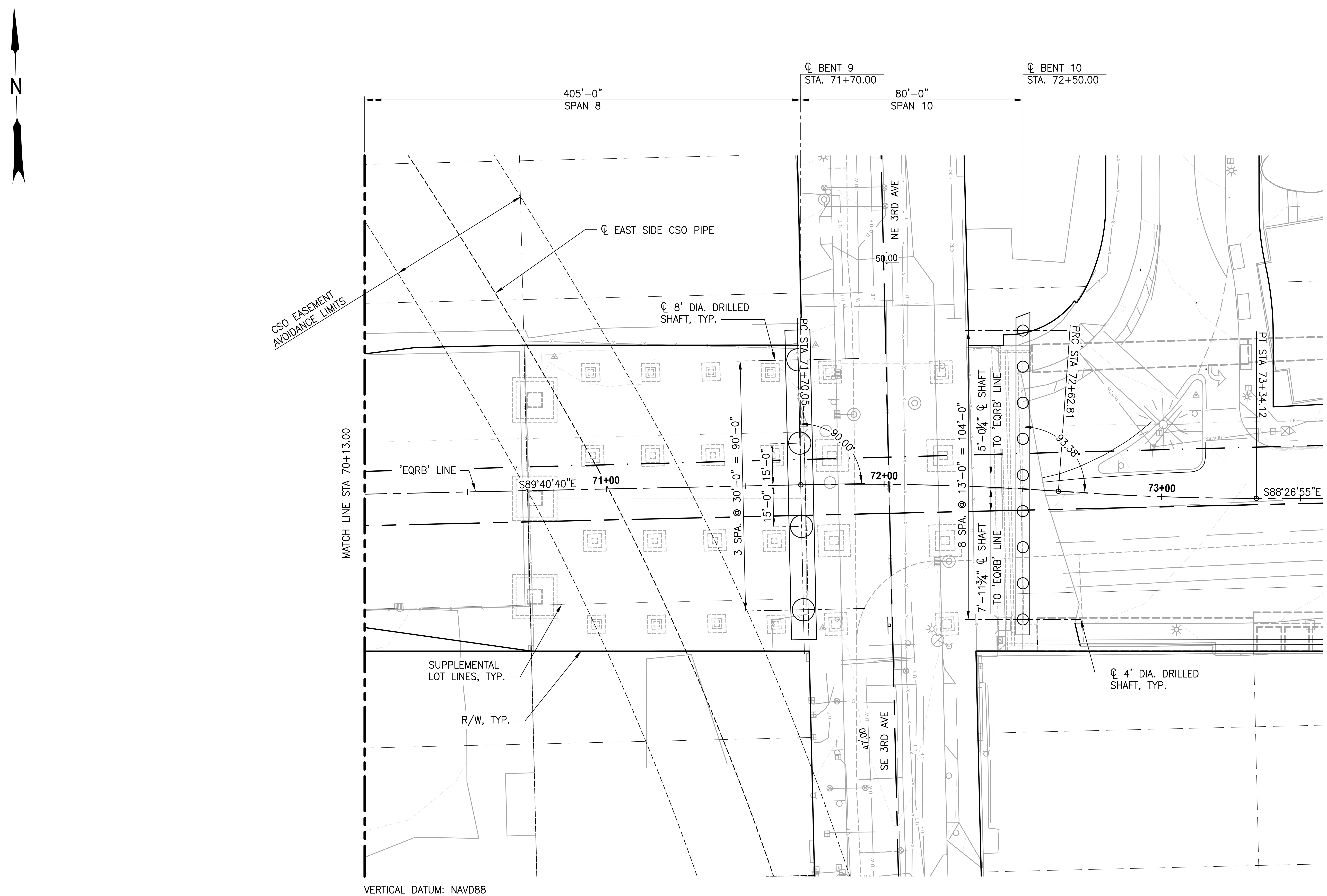
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS

NO.	DATE:

Sheet No. *BR10*



FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan -5

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

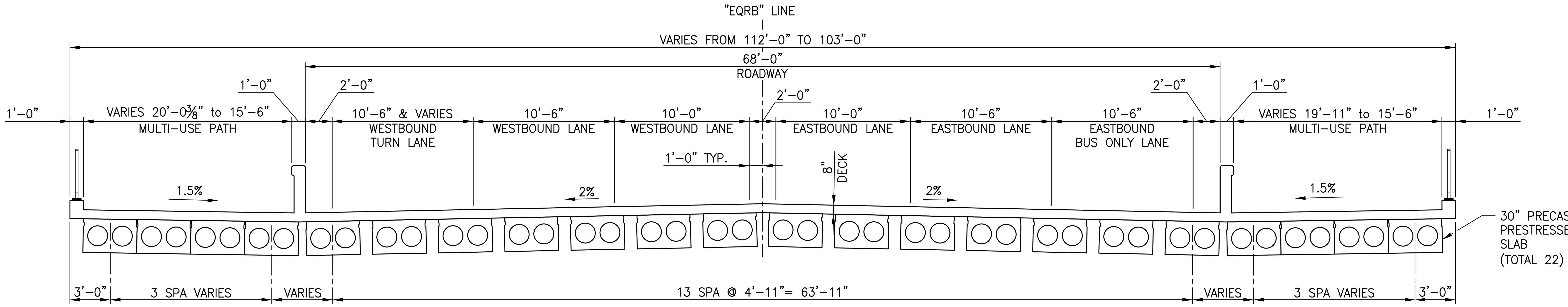
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

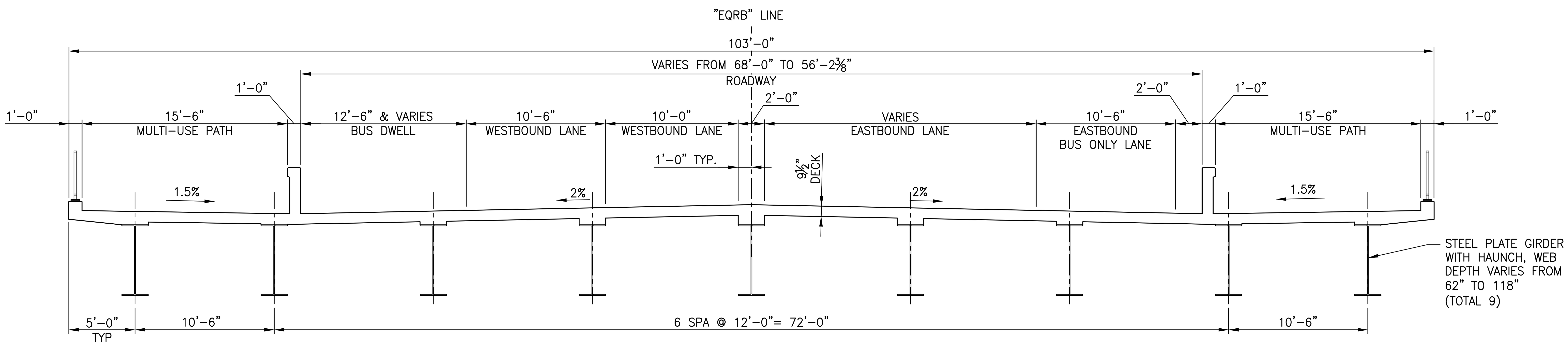
REVISIONS

NO.	DATE:	

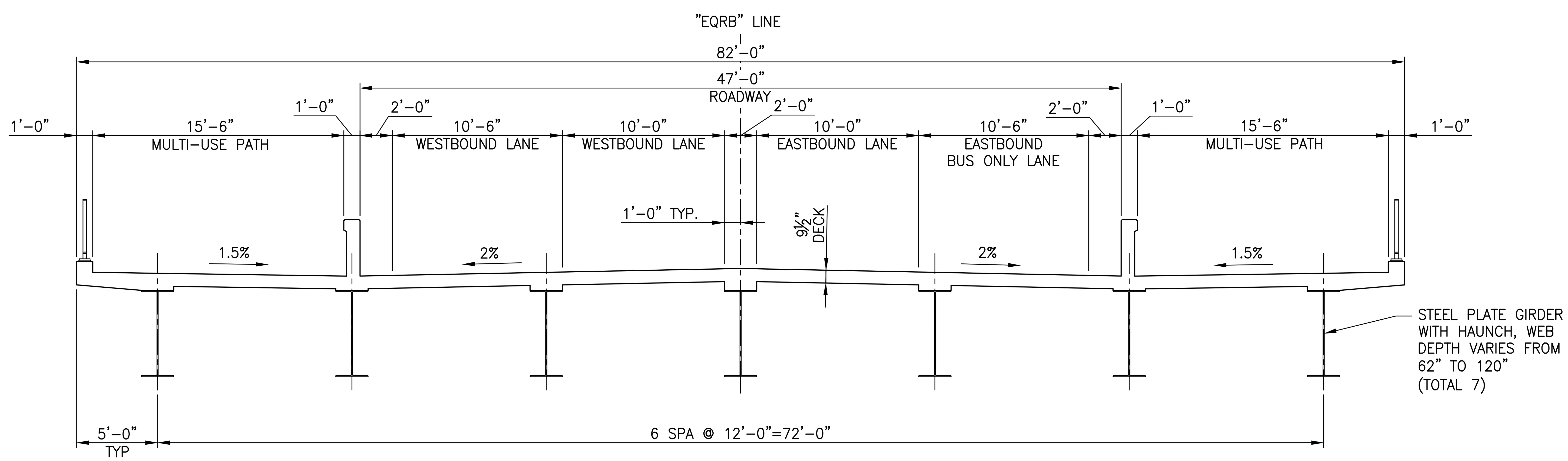
Sheet No. BR11



TYPICAL SECTION - SPAN 1
SCALE: 1" = 5'-0"
(AT BENT 2)



TYPICAL SECTION - SPAN 2
SCALE: 1" = 5'-0"
(AT BENT 3)



TYPICAL SECTION - SPAN 3 THRU 4
SCALE: 1" = 5'-0"
(MIDSPAN)

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Cable Stay Approach
Typical Sections -1

DATE: 9/2022
PROJECT NO.:

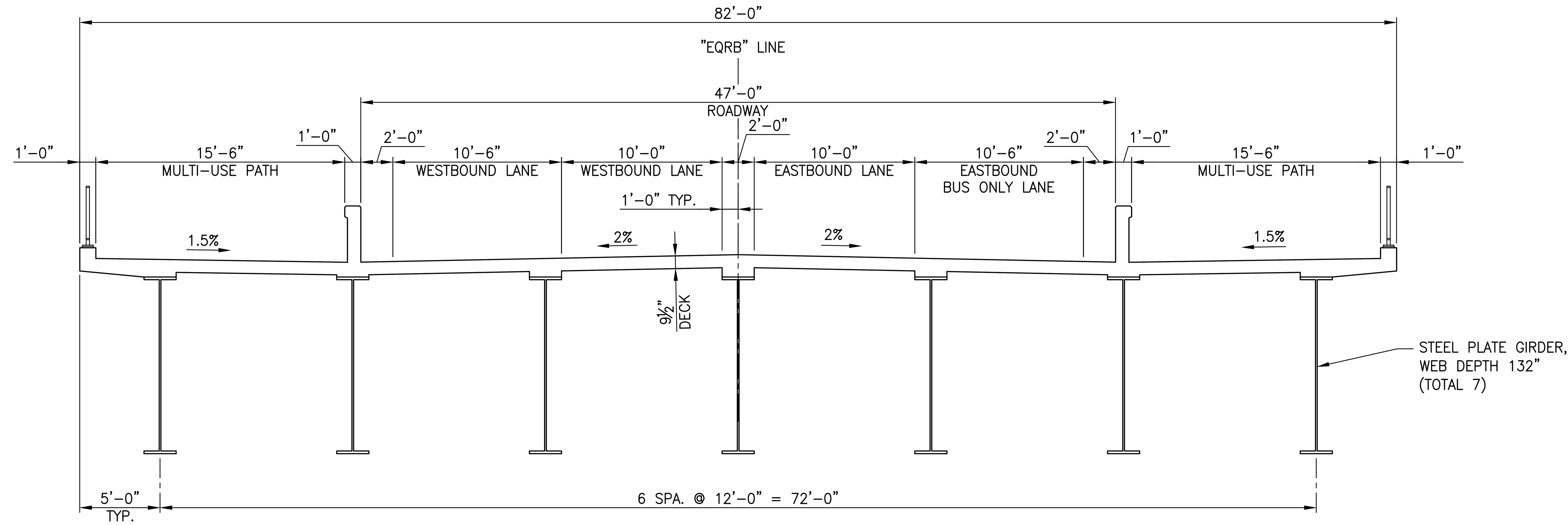
MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

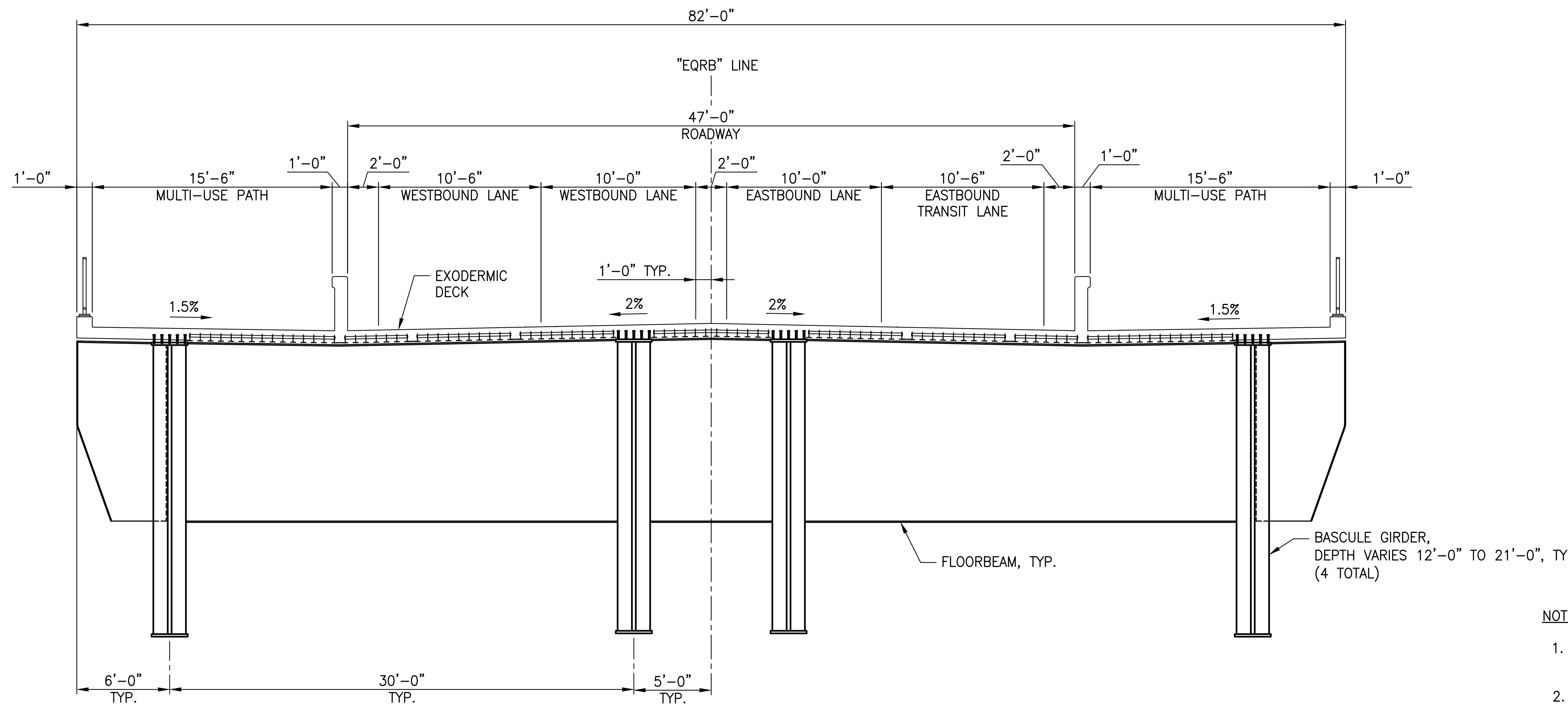
NO	DATE:			

Sheet No. BR12



TYPICAL SECTION - SPAN 5

SCALE: 1" = 5'-0"



NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.
3. ADDITIONAL BRIDGE WIDTH WITHIN EXTENTS OF PIER 6&7 NOT SHOWN.

TYPICAL SECTION - BASCULE SPAN

SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Typical Sections -2

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

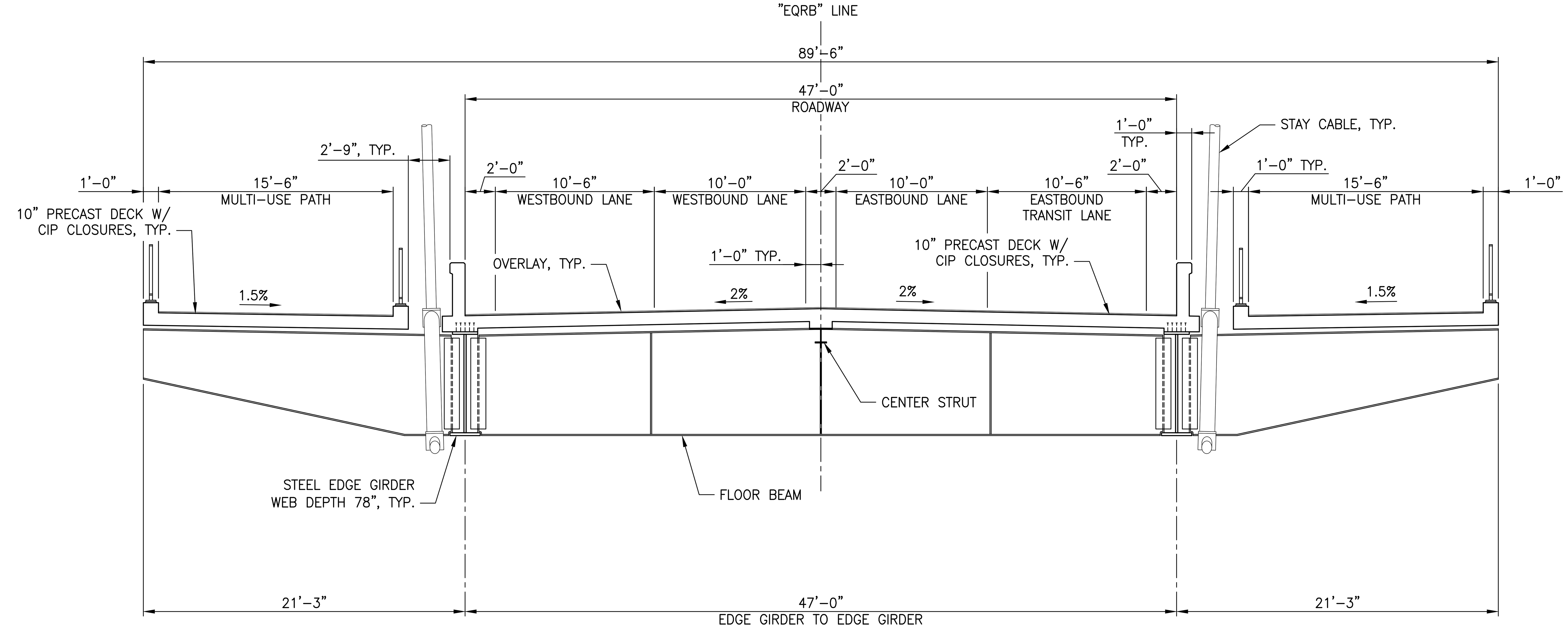
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

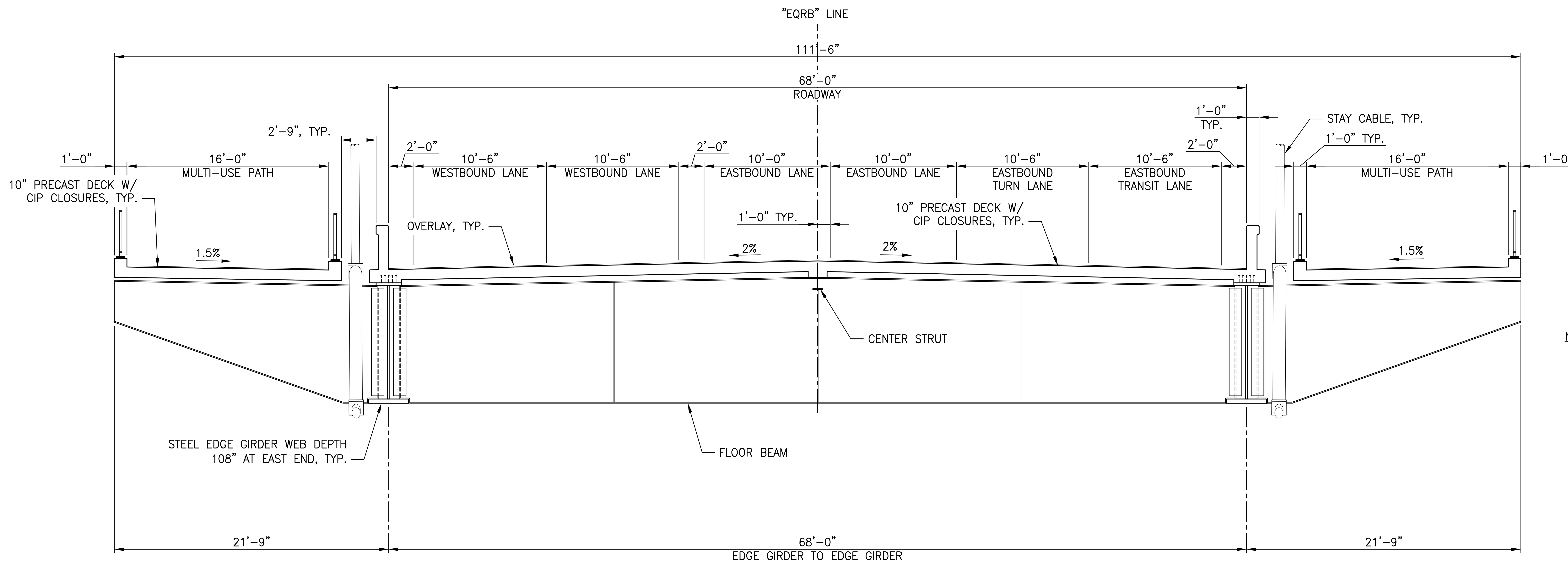
NO	DATE:			

Sheet No. BR13



4-LANE TYPICAL SECTION - CABLE-STAY SPAN (MINIMUM WIDTH)

SCALE: 1" = 5'-0"



6-LANE TYPICAL SECTION - CABLE-STAY SPAN (MAXIMUM WIDTH)

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.
3. BRIDGE WIDTH VARIES THROUGHOUT SPANS 7&8 DUE TO ADDITION OF TOWERS, TURN LANES, AND BICYCLE LANE TRANSITIONS.
4. ADDITIONAL MULTI-USE PATH WIDTH FOR BELVEDERES NOT SHOWN.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Typical Sections -3

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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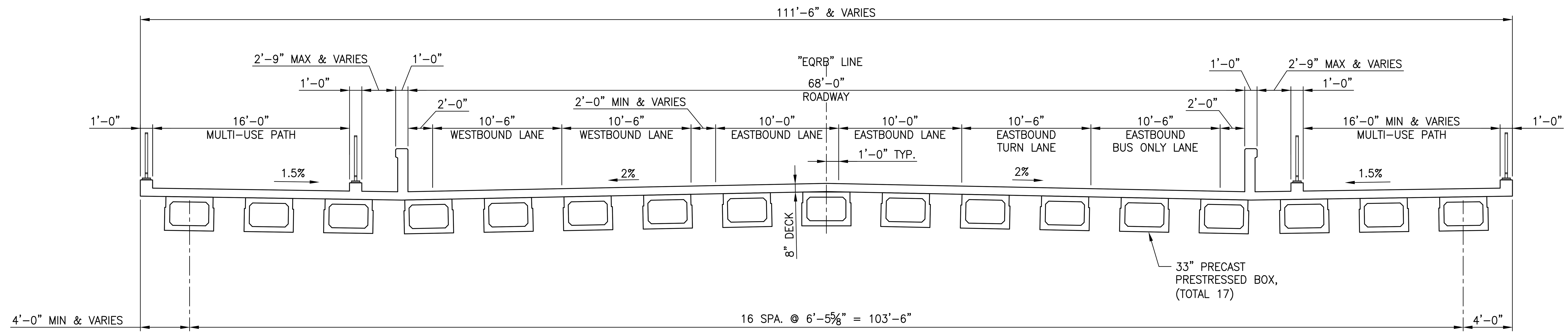
CHECKED BY: *HDR*

REVISIONS

NO	DATE:			

Sheet No. *BR14*



TYPICAL SECTION - SPAN 9

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Typical Sections -4

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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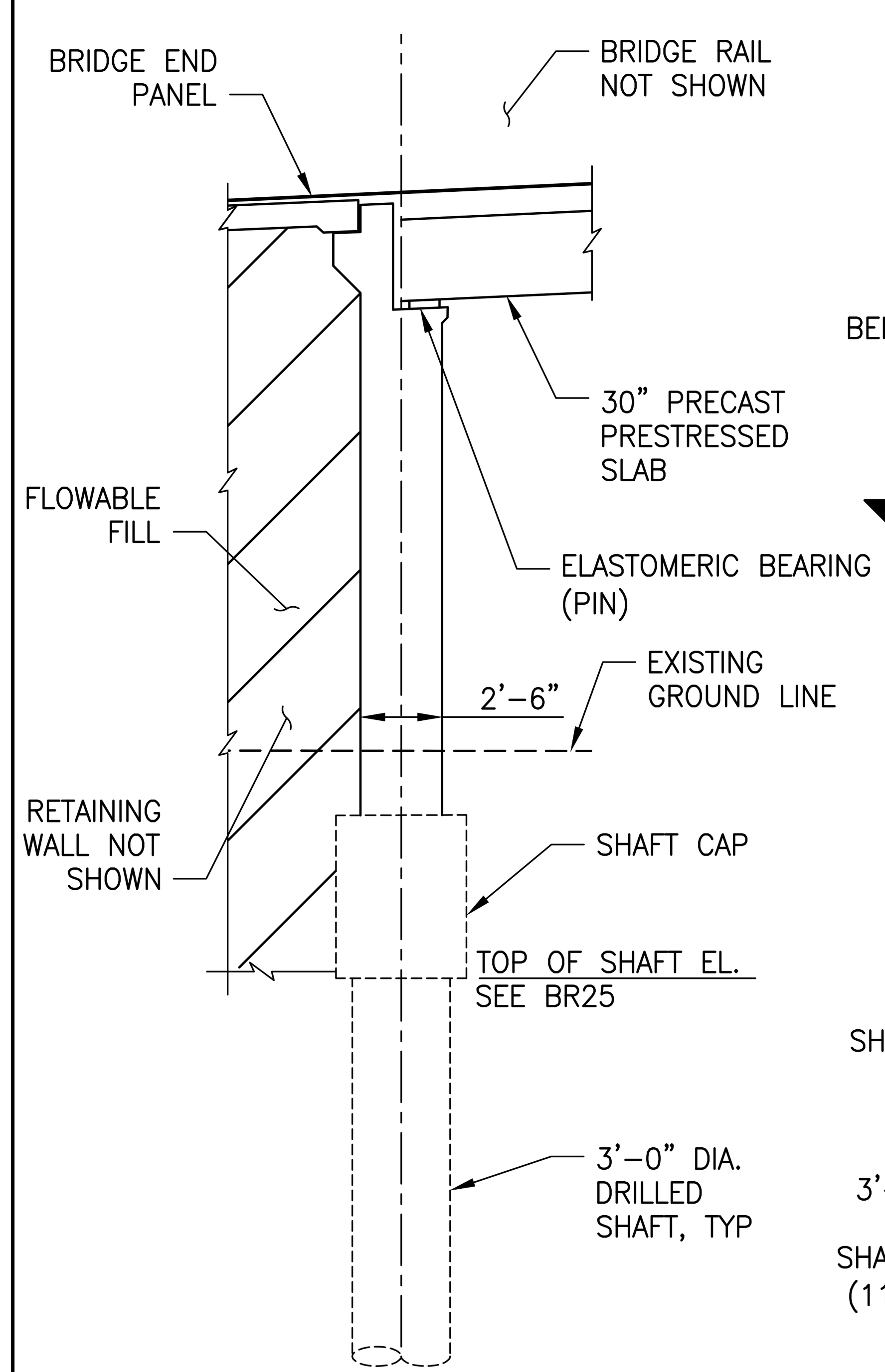
CHECKED BY: HDR

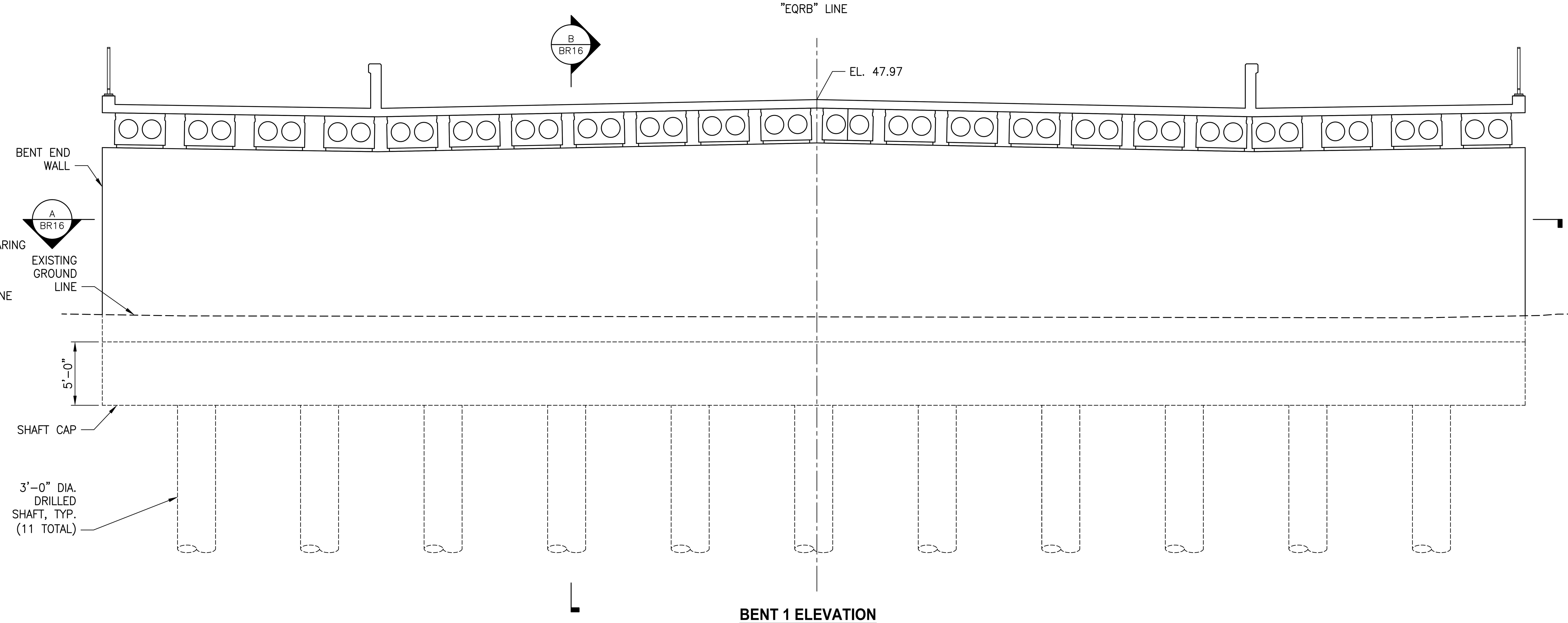
REVISIONS

NO	DATE:				

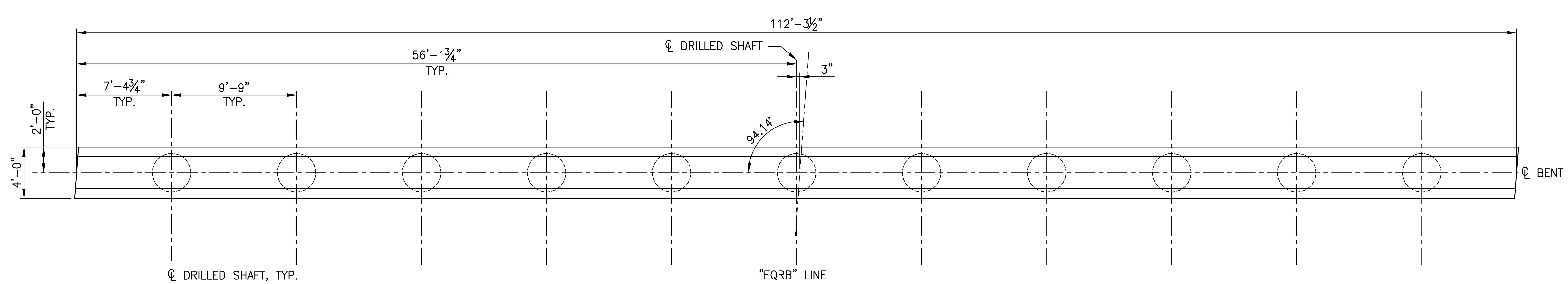
Sheet No. BR15



SECTION B
SCALE: 1" = 5'-0"



BENT 1 ELEVATION
SCALE: 1" = 5'-0"
(LOOKING BACK ON STATION)



SECTION A
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 1 Details

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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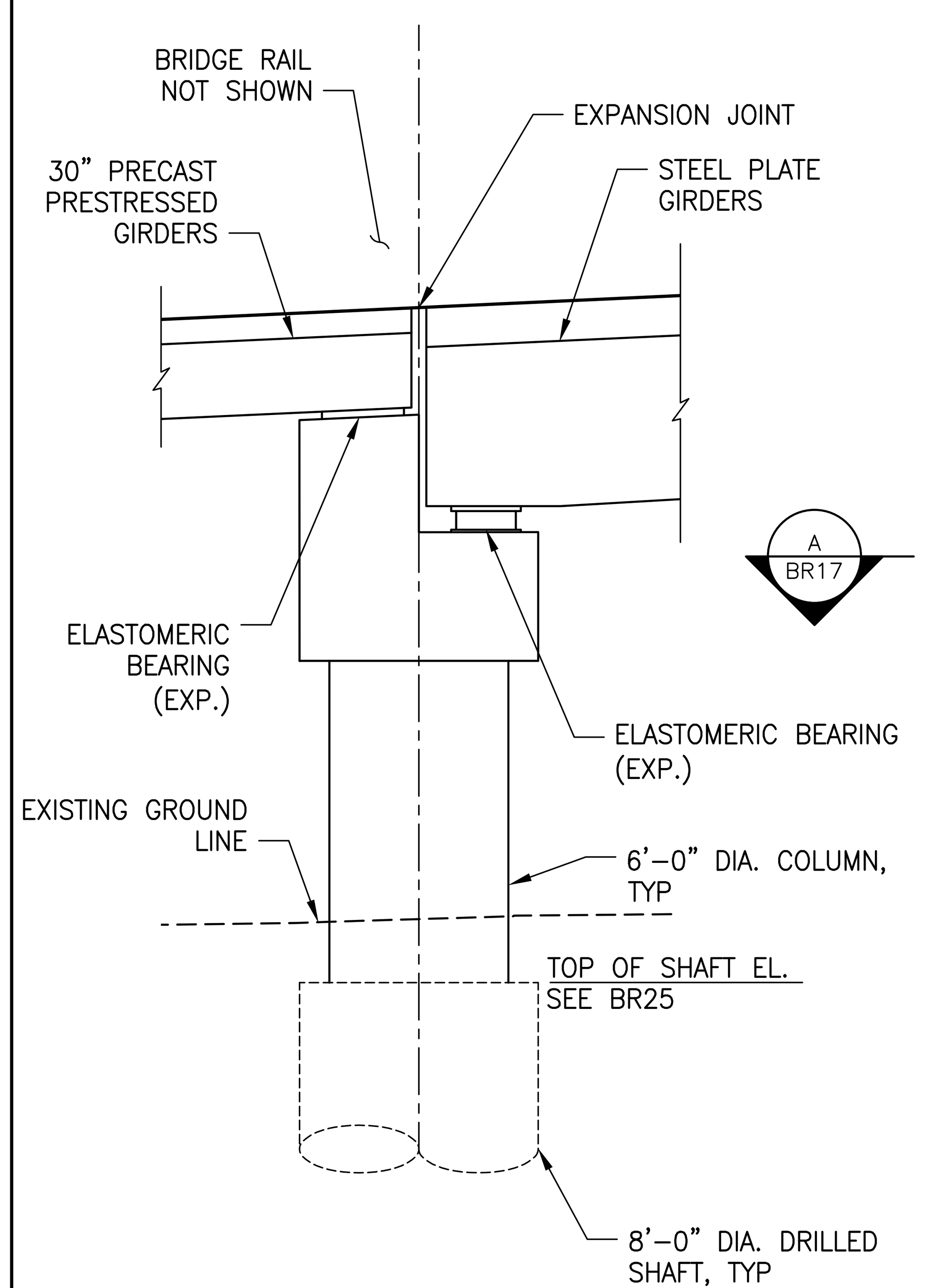
CHECKED BY: HDR

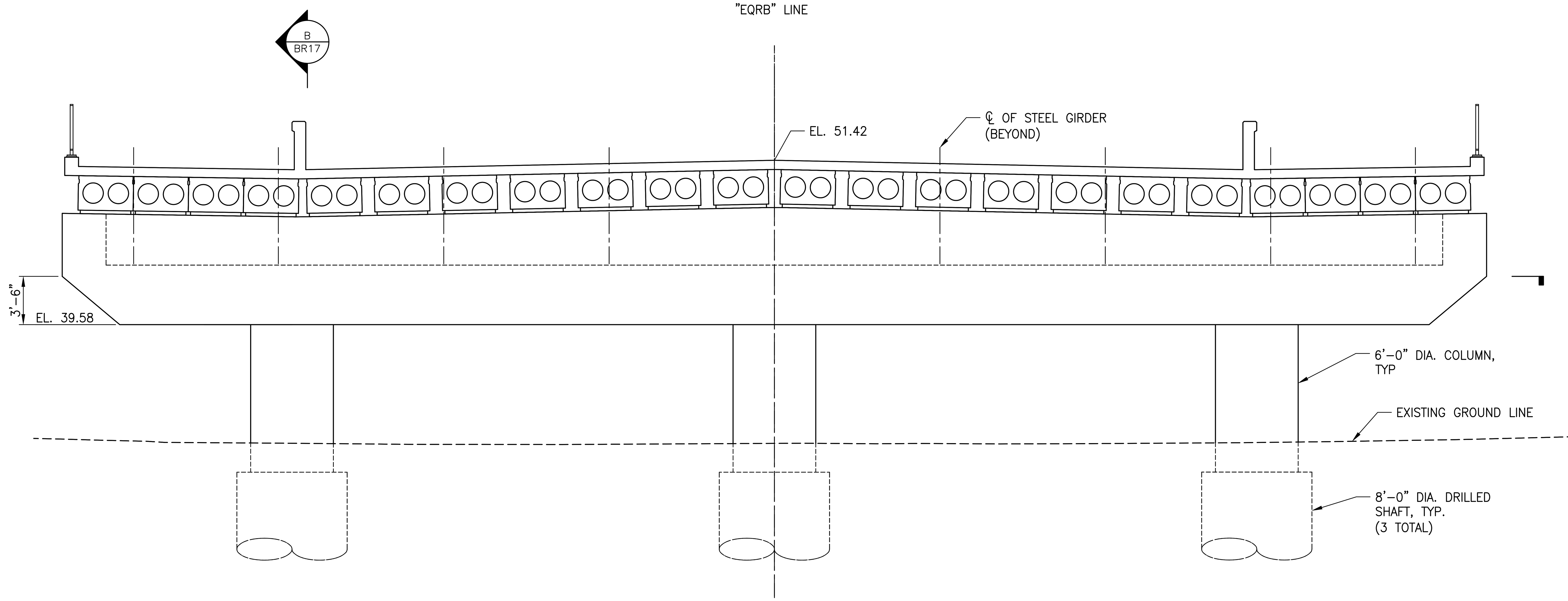
REVISIONS

NO | DATE:

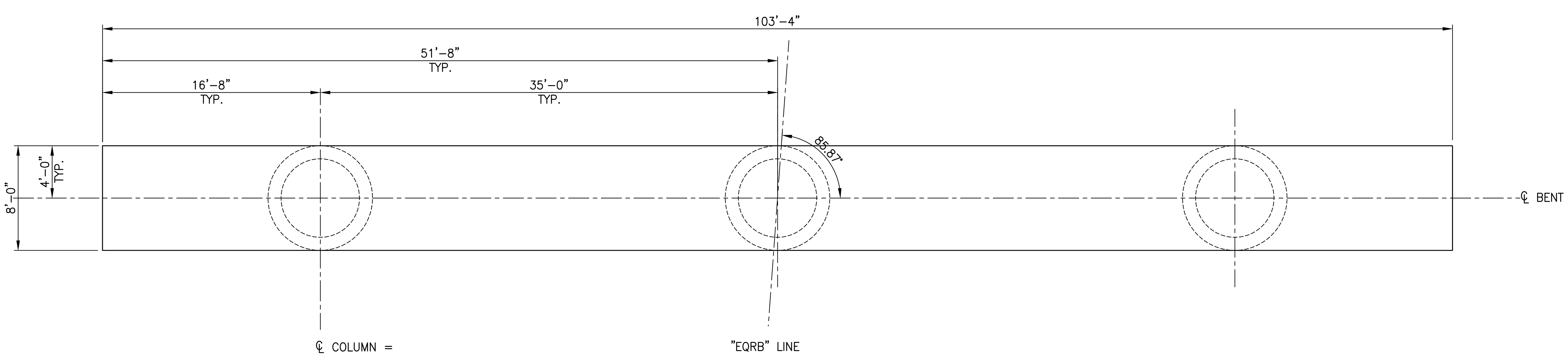
Sheet No. BR16



SECTION B
SCALE: 1" = 5'–0"



BENT 2 ELEVATION
SCALE: 1" = 5'–0"
STEEL PLATE GIRDERS OMITTED FOR CLARITY



SECTION A
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 2 Details

PROJECT NO.:
DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
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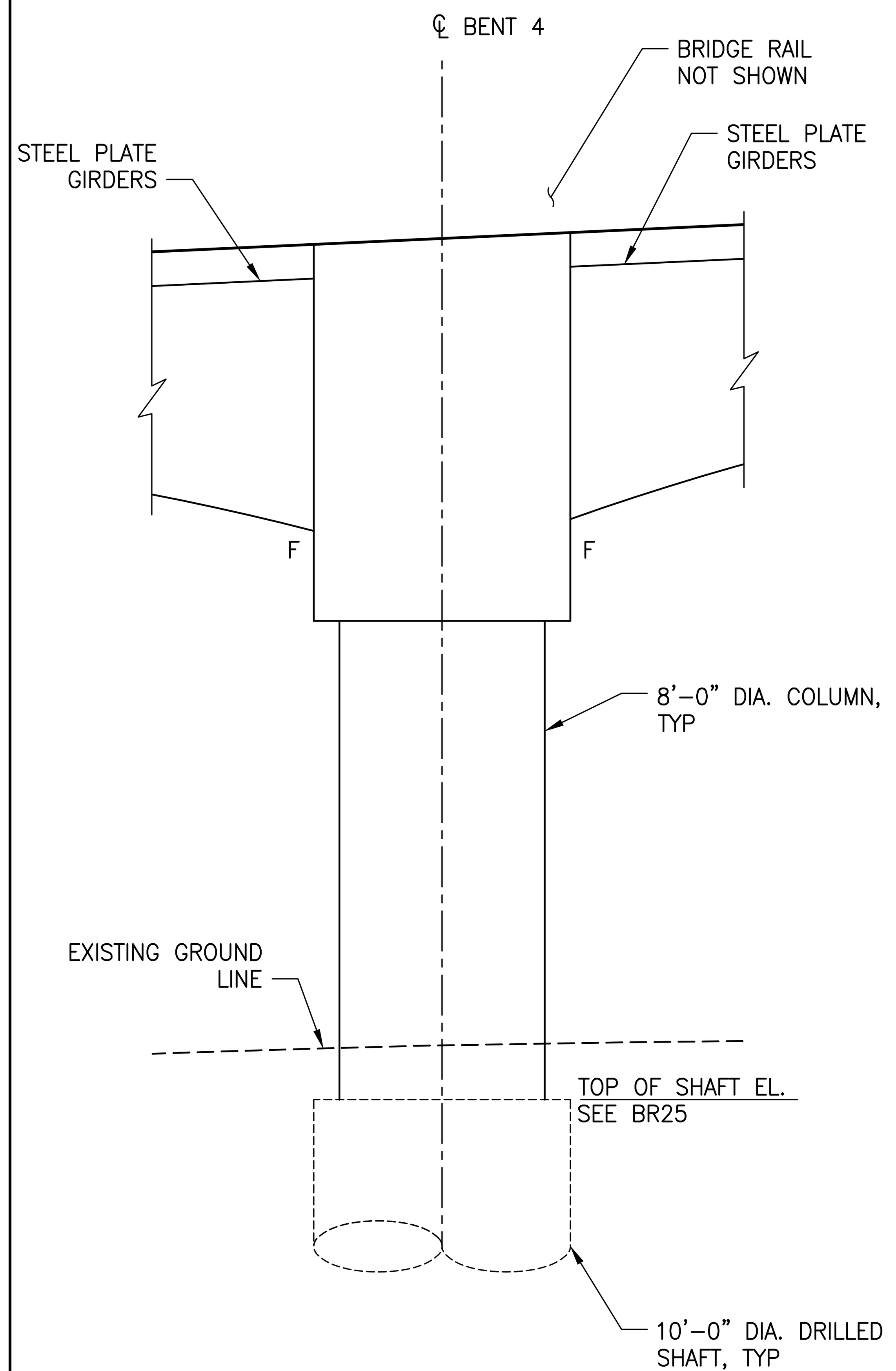
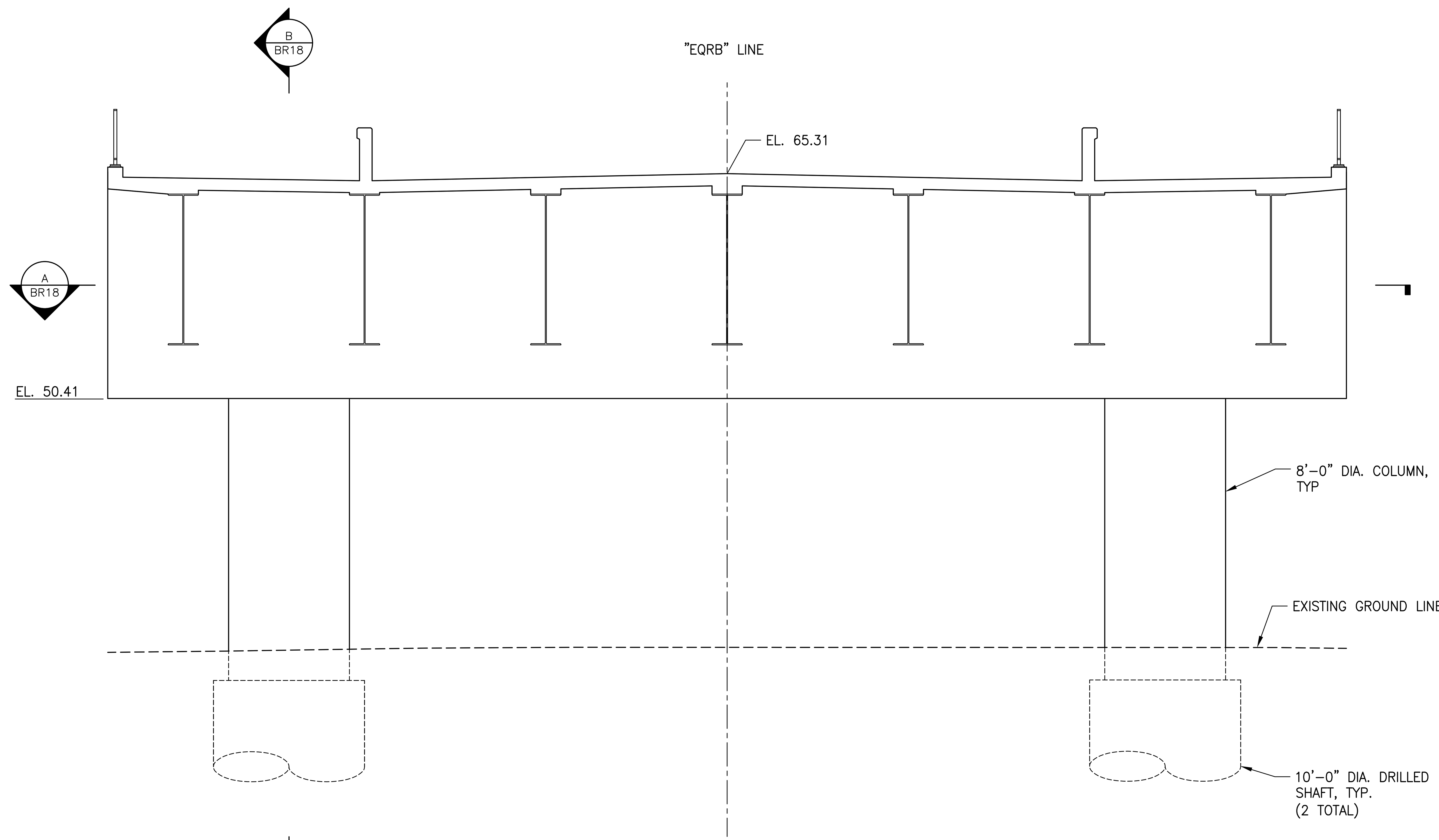
REVISIONS

NO	DATE:				

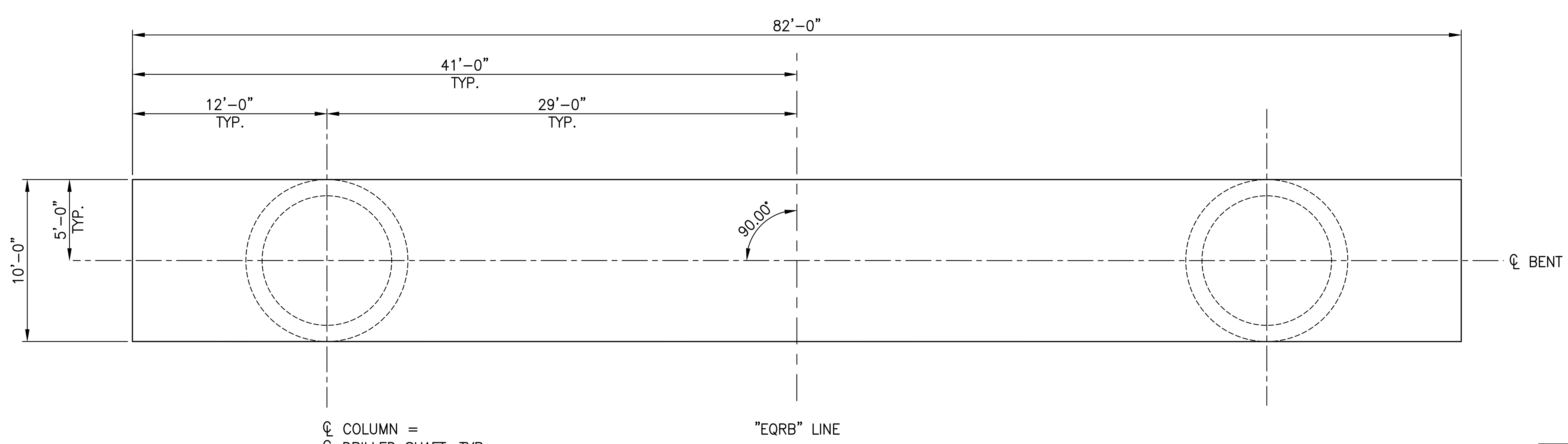
Sheet No. *BR17*



SECTION B
SCALE: 1" = 5'-0"
(BENT 3 SIMILAR)



BENT 4 ELEVATION
SCALE: 1" = 5'-0"
(BENT 3 SIMILAR)



SECTION A
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 3 and 4 Details

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

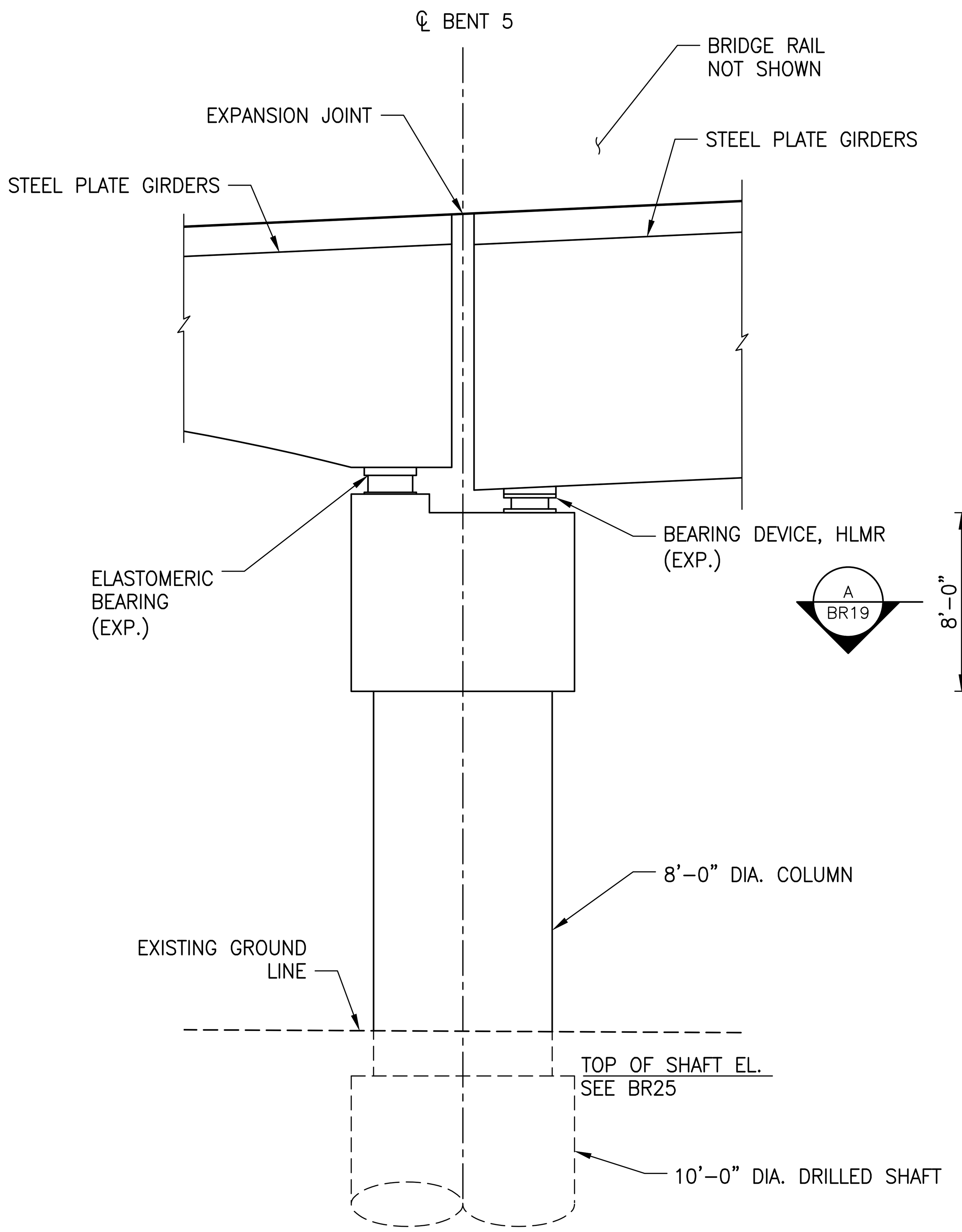
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

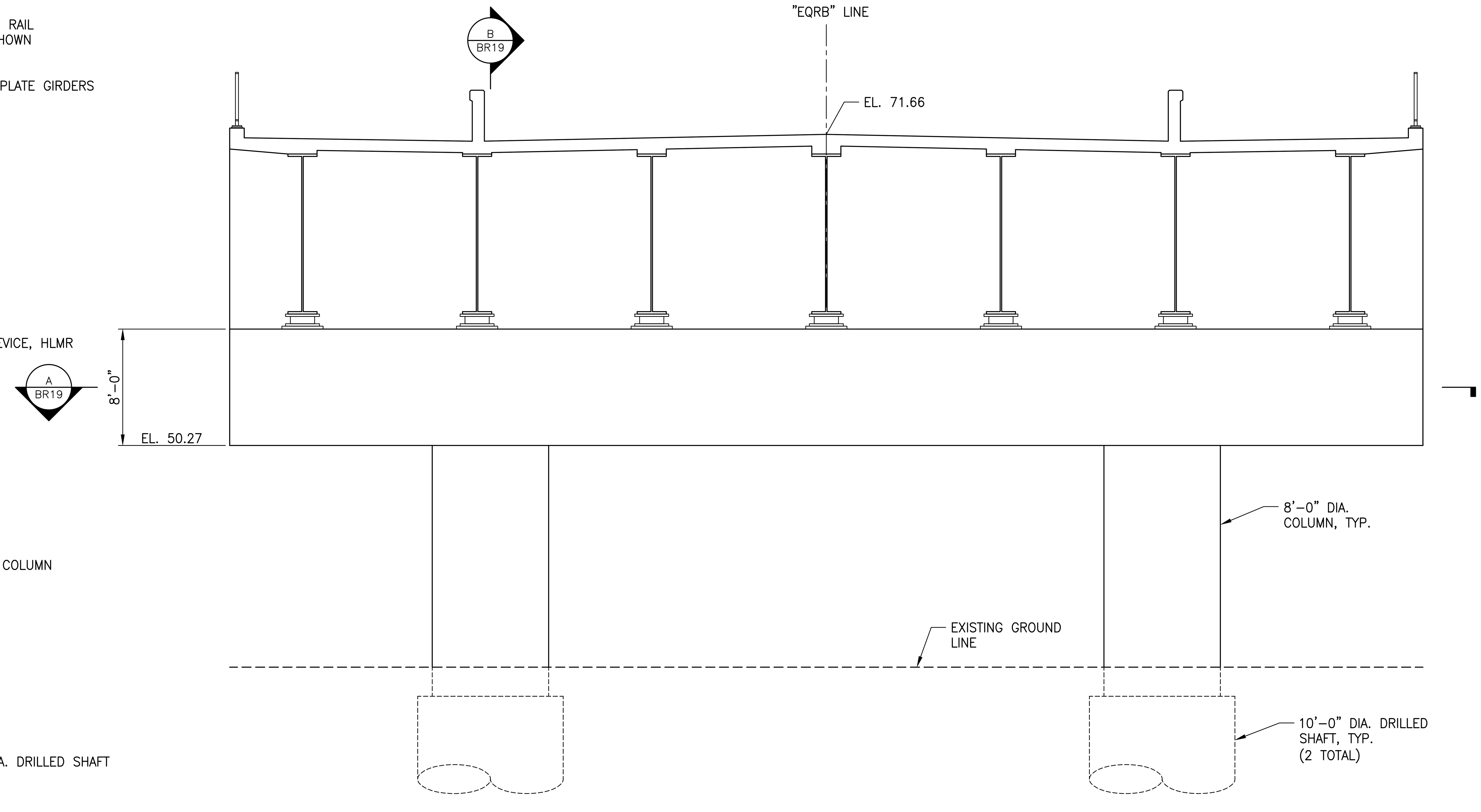
REVISIONS

NO	DATE:			

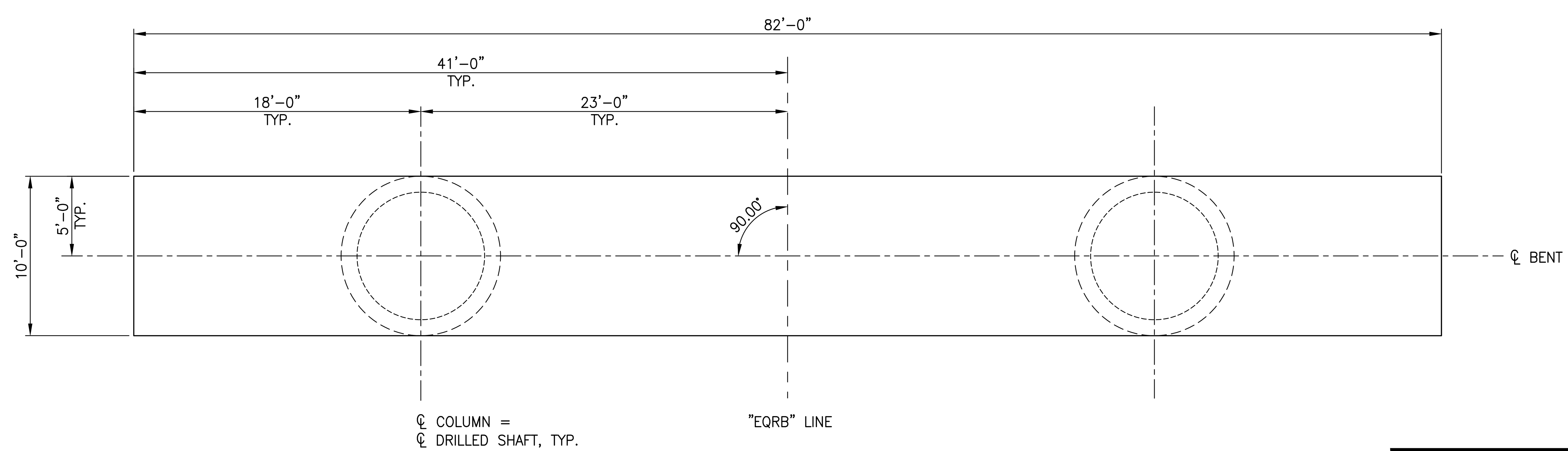
Sheet No. *BR18*



SECTION B
SCALE: 1" = 5'–0"



BENT 5 ELEVATION
SCALE: 1" = 5'–0"
(LOOKING BACK ON STATION)



SECTION A
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 5 Details

DATE: 9/2022 | PROJECT NO:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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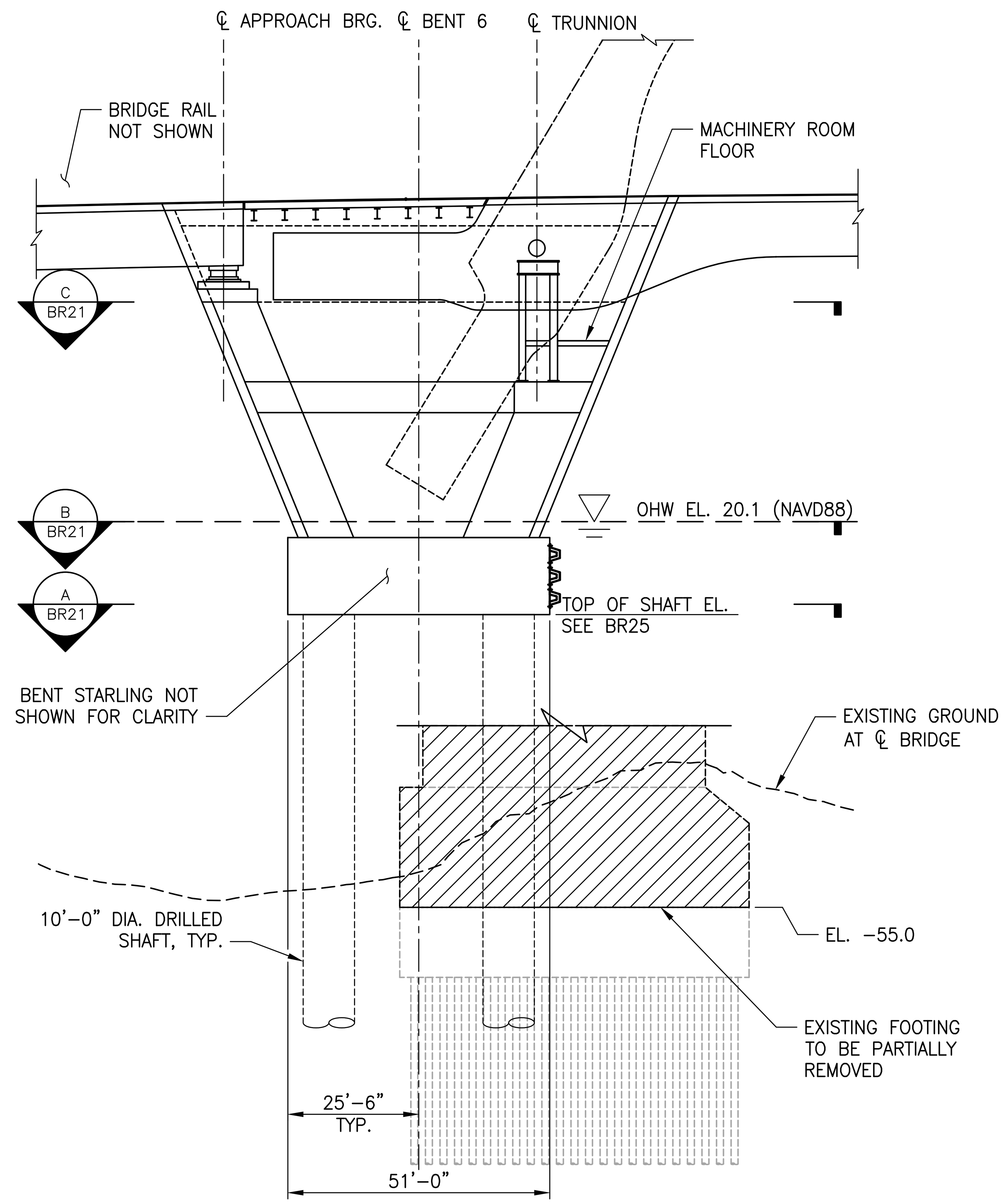
REVISIONS

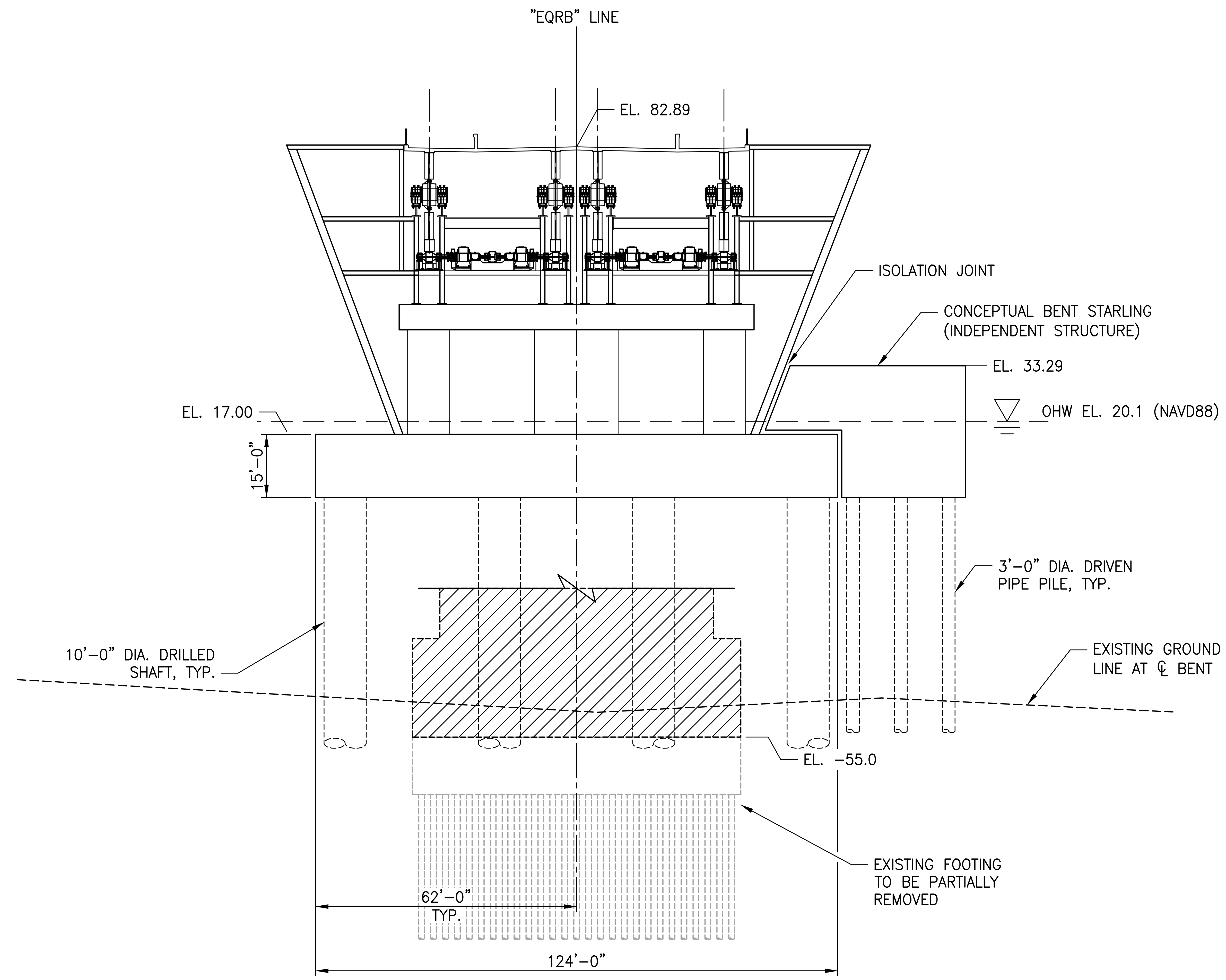
NO | DATE:

Sheet No. BR19



BENT 6 ELEVATION

SCALE: 1" = 20'–0"
(LOOKING NORTH, BENT 7 SIMILAR BUT MIRRORED)



BENT 6 SIDE ELEVATION

SCALE: 1" = 20'–0"
(BENT 7 SIMILAR BUT MIRRORED)

NOTES:

1. CONCEPTUAL OPERATOR HOUSE NOT SHOWN.
2. FOR ADDITIONAL DETAIL SEE ARCHITECTURAL DRAWINGS.

LEGEND

BRIDGE REMOVAL

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 6 and 7 Elevations

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

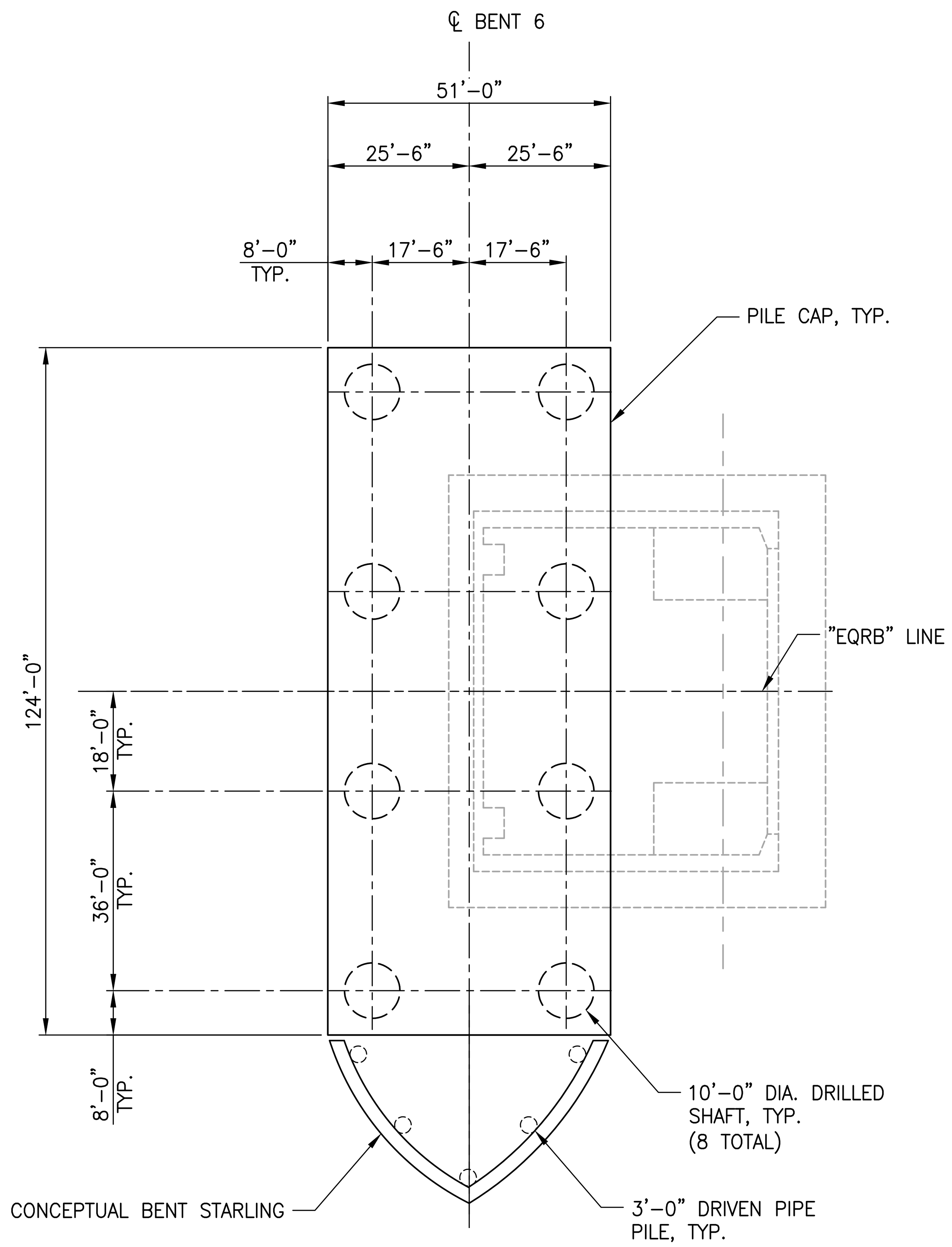
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

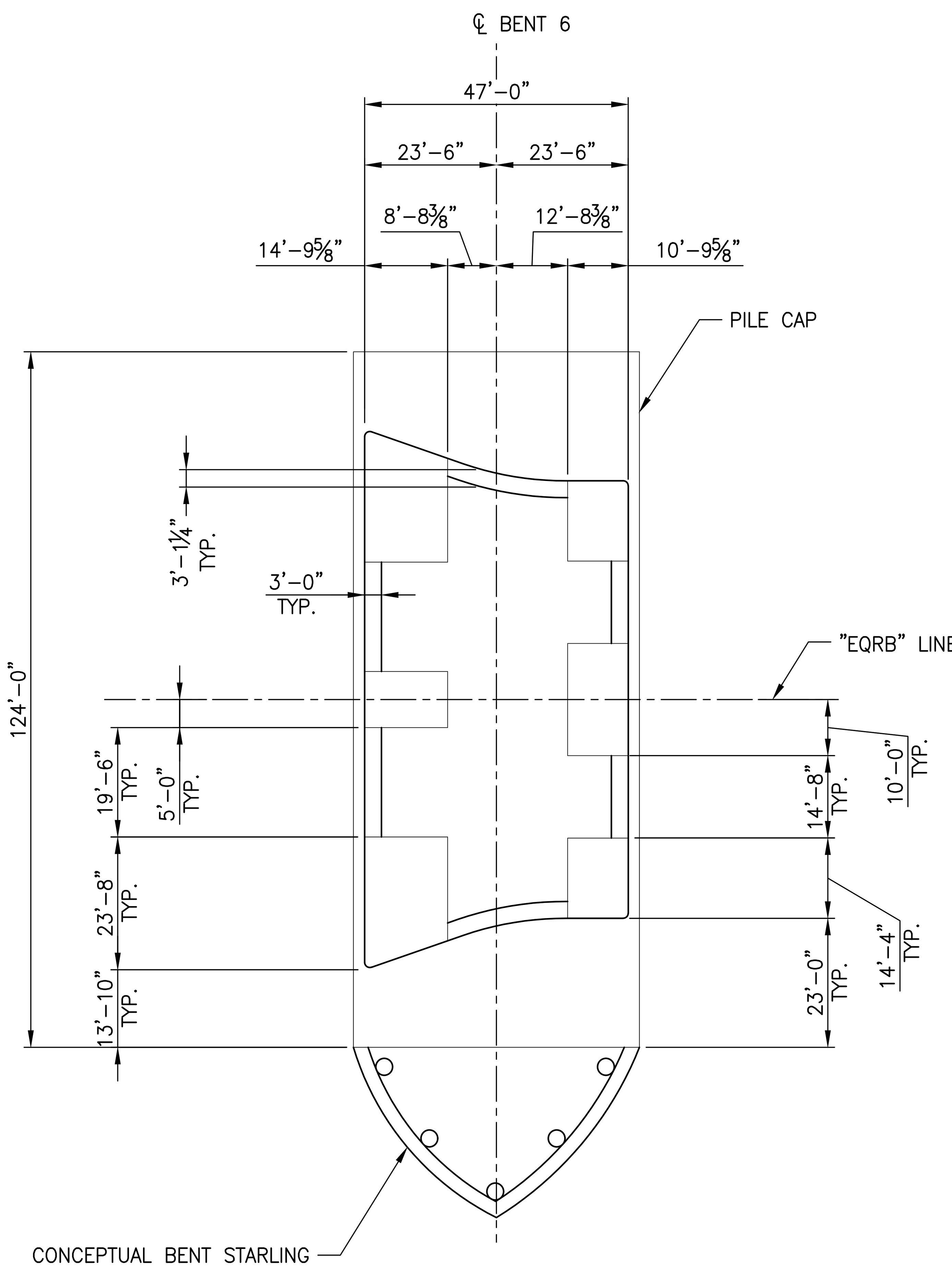
REVISIONS

NO	DATE:			

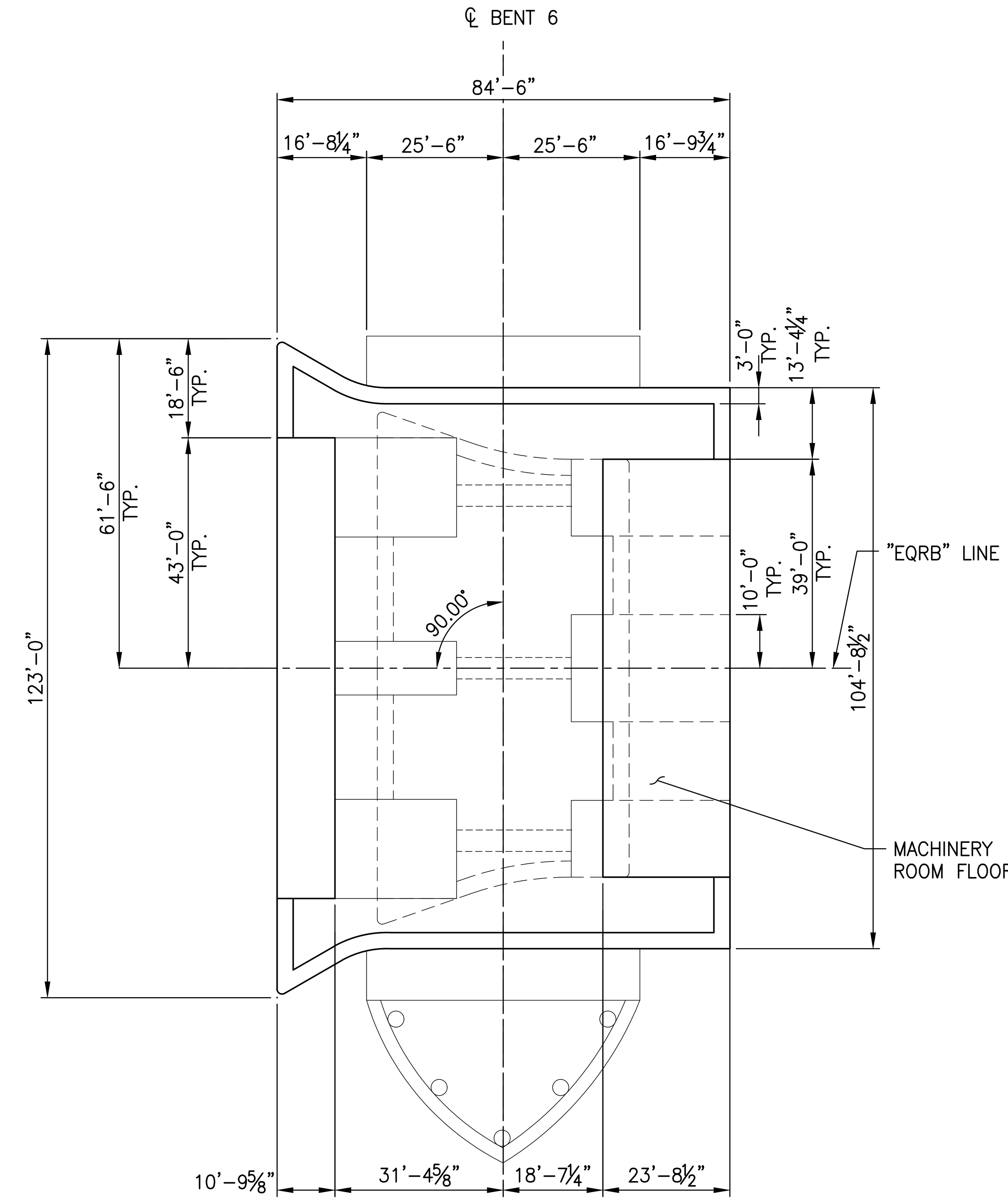
Sheet No. BR20



SECTION A
SCALE: 1" = 10'-0"



SECTION B
SCALE: 1" = 10'-0"



SECTION C
SCALE: 1" = 10'-0"
(AT MACHINERY ROOM FLOOR)

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 6 and 7 Sections

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

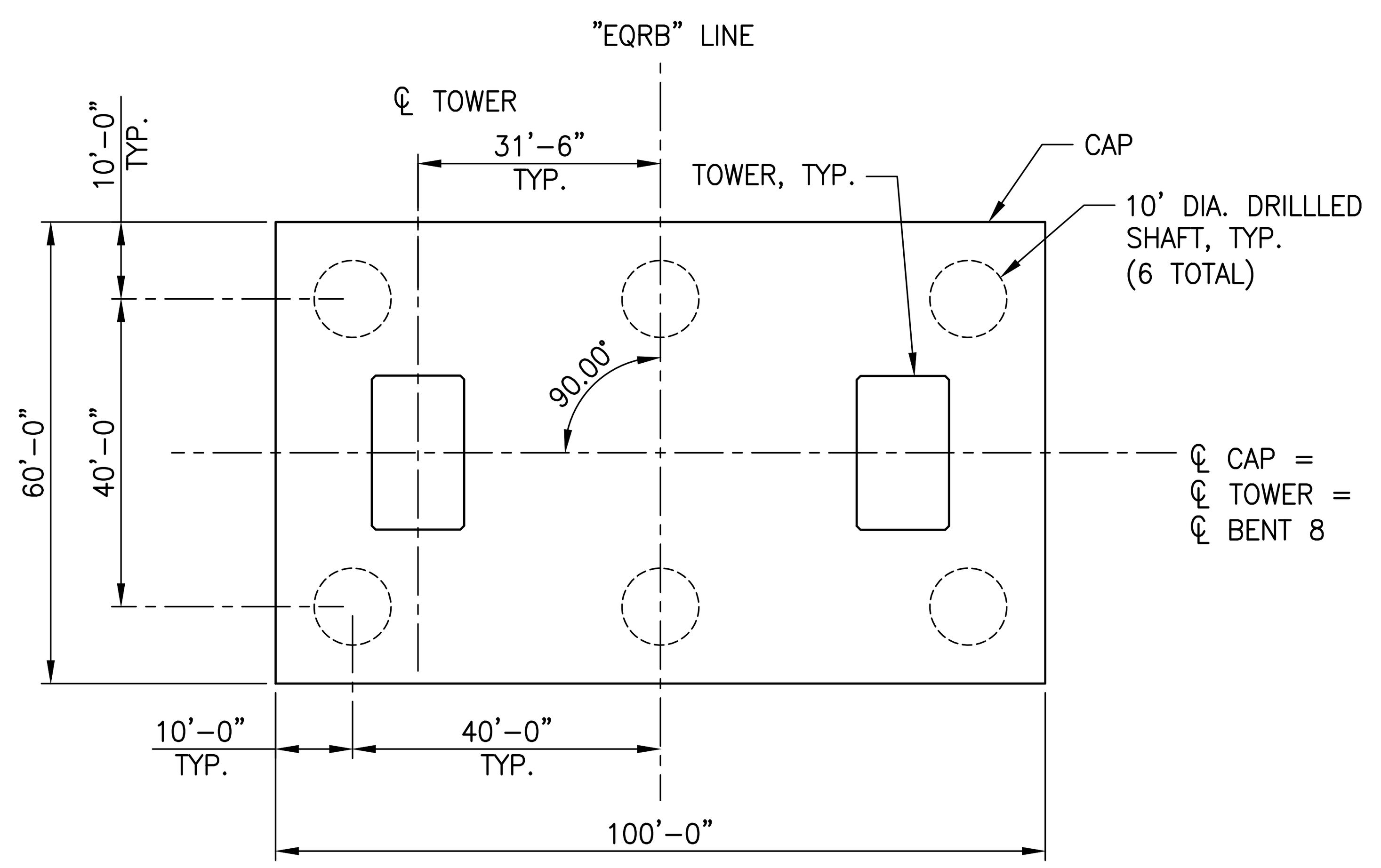
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

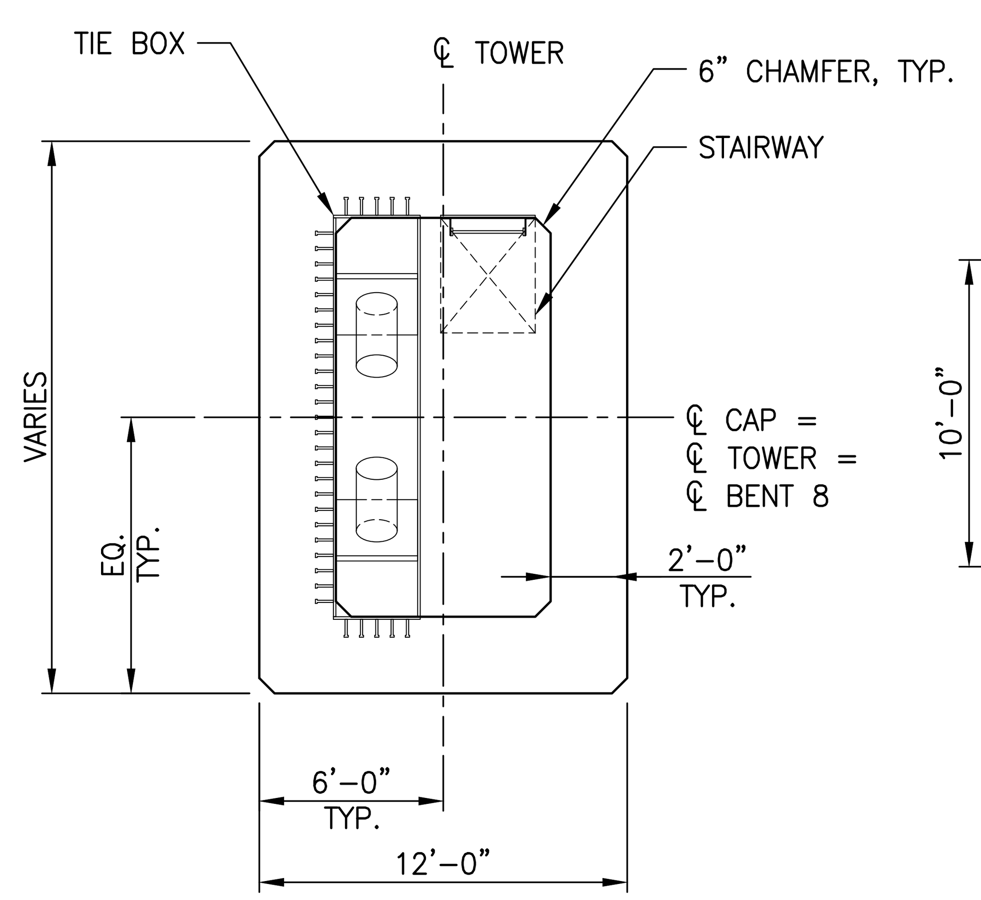
REVISIONS

NO	DATE:

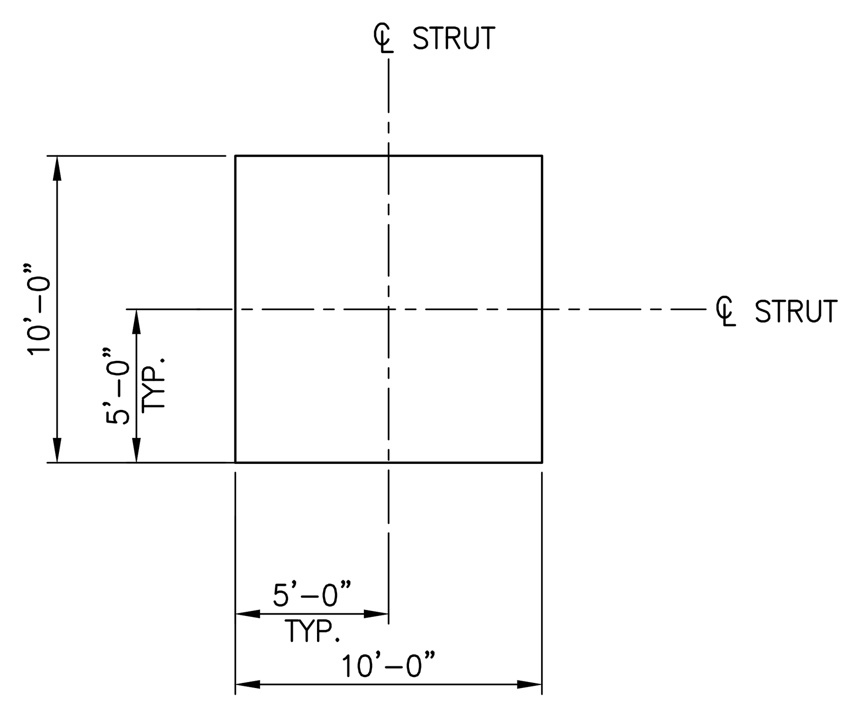
Sheet No. *BR21*



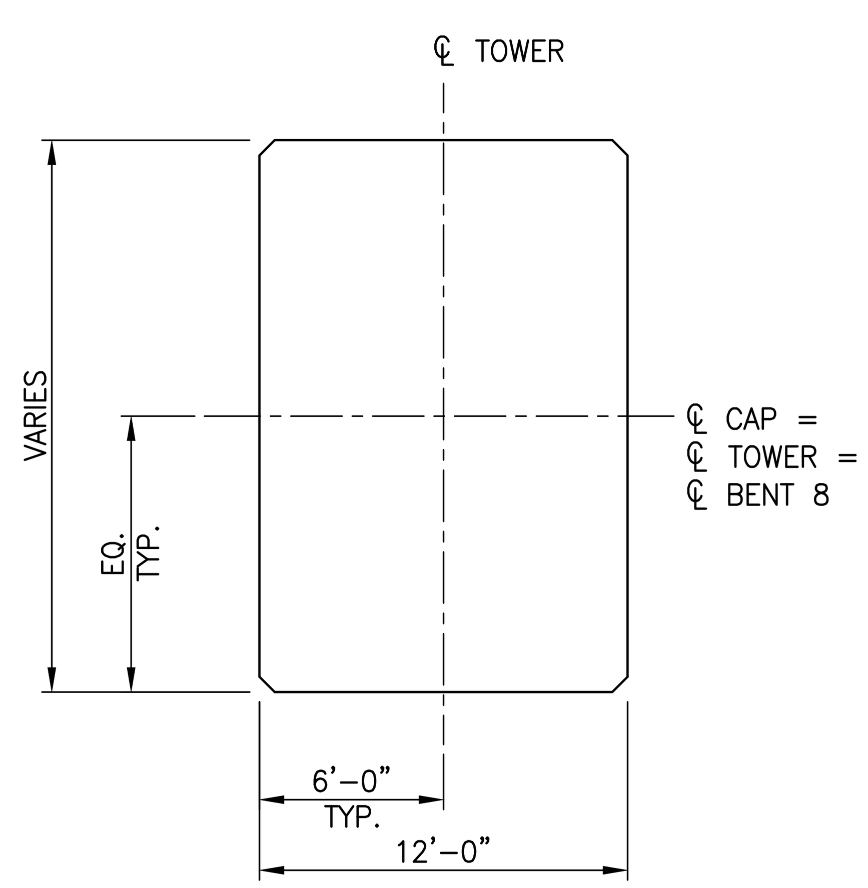
BENT 8 PLAN
SCALE: 1" = 20'-0"



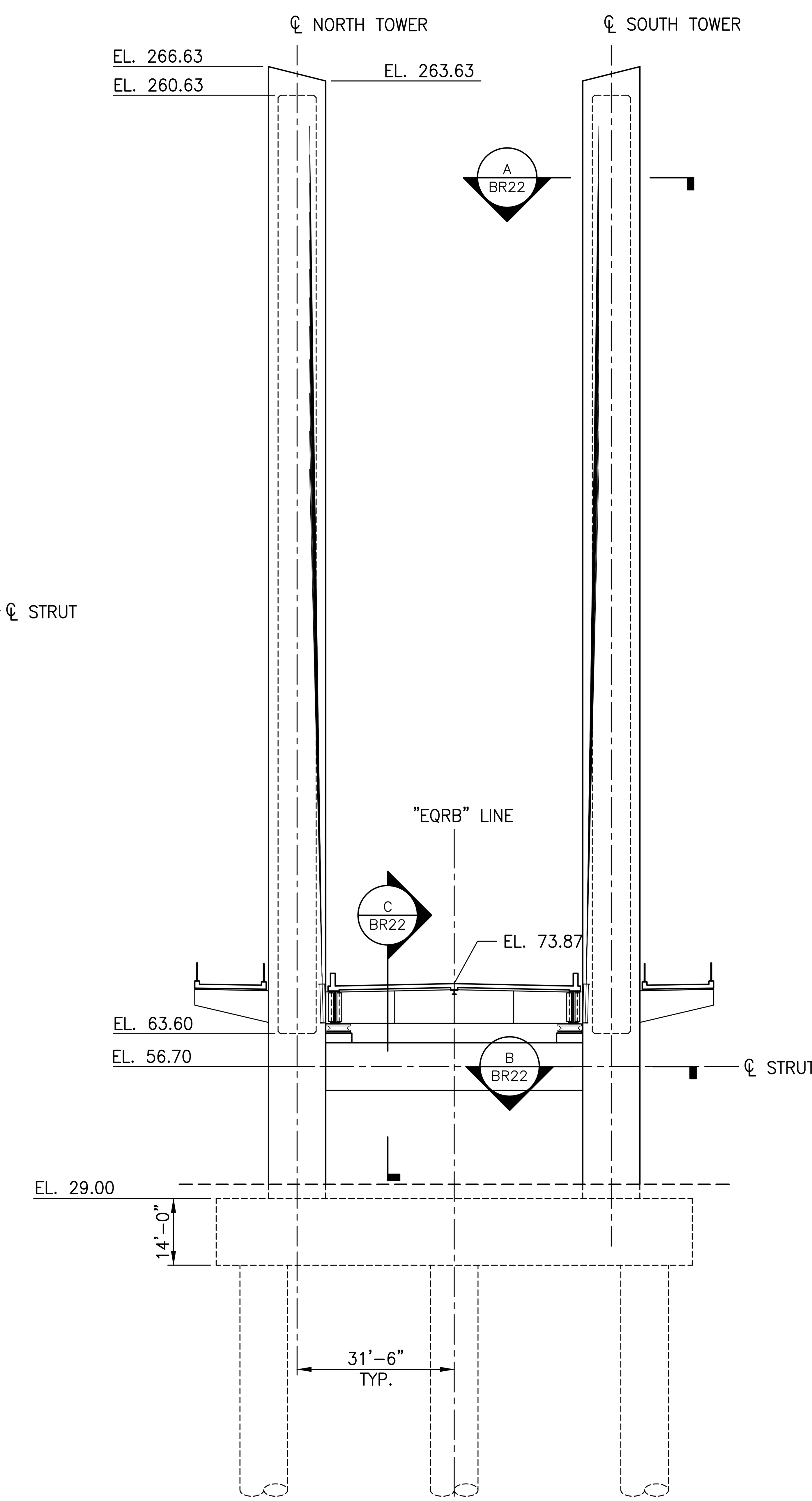
SECTION A
SCALE: 3/16" = 1'-0"



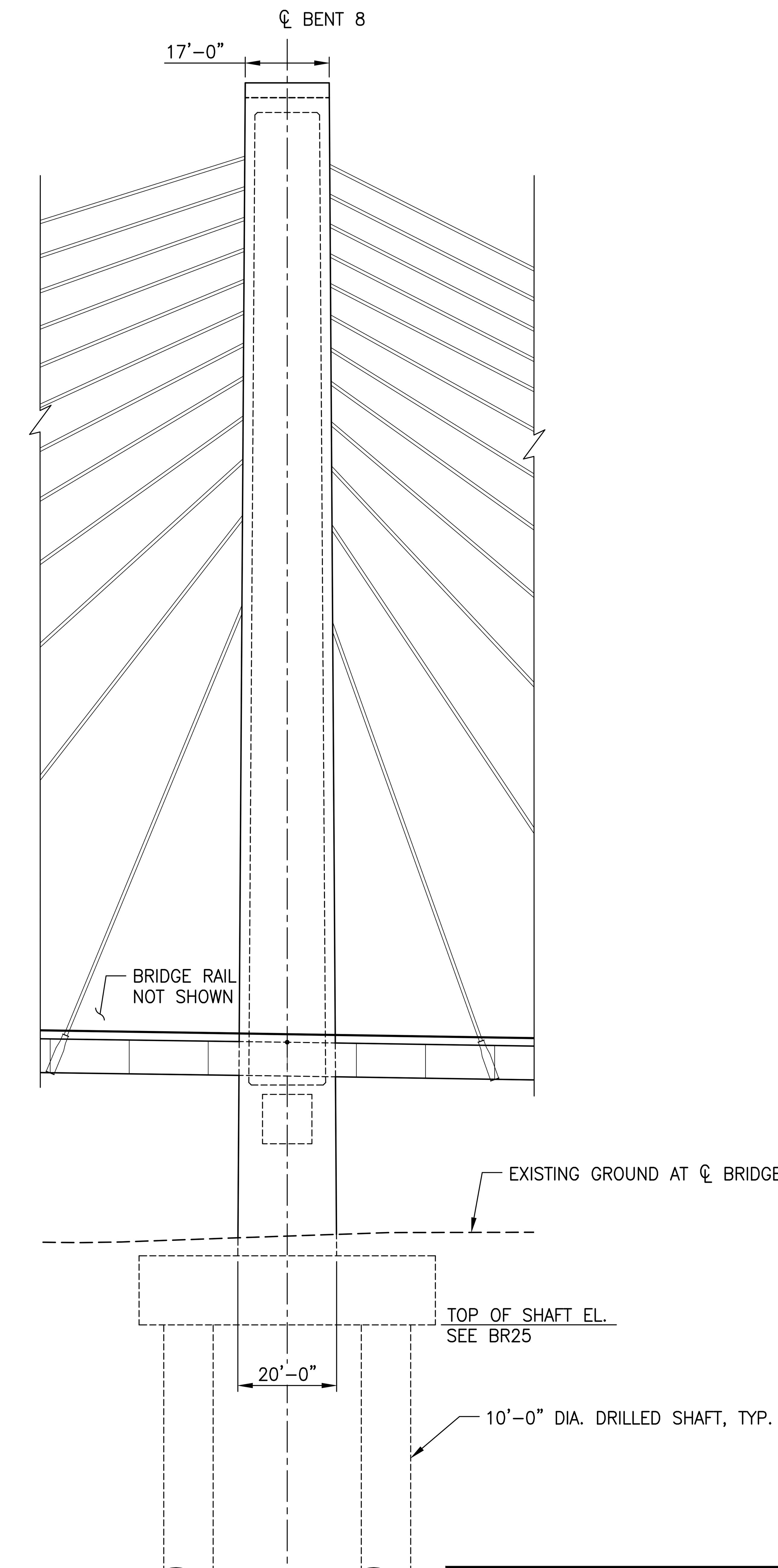
SECTION C
SCALE: 3/16" = 1'-0"



SECTION B
SCALE: 3/16" = 1'-0"



BENT 8 ELEVATION
SCALE: 1" = 20'-0"



BENT 8 SECTION
SCALE: 1" = 20'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 8 Details

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

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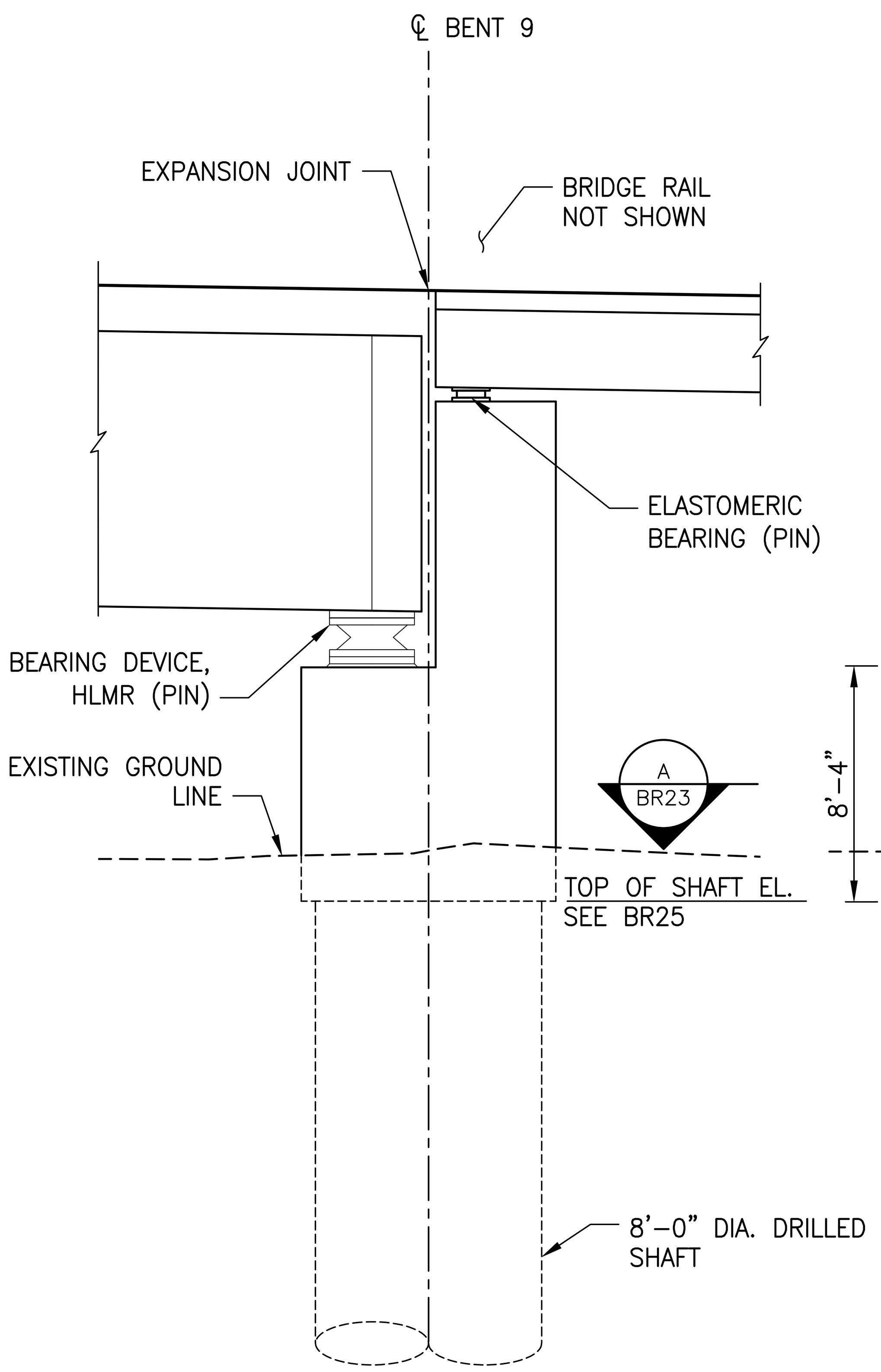
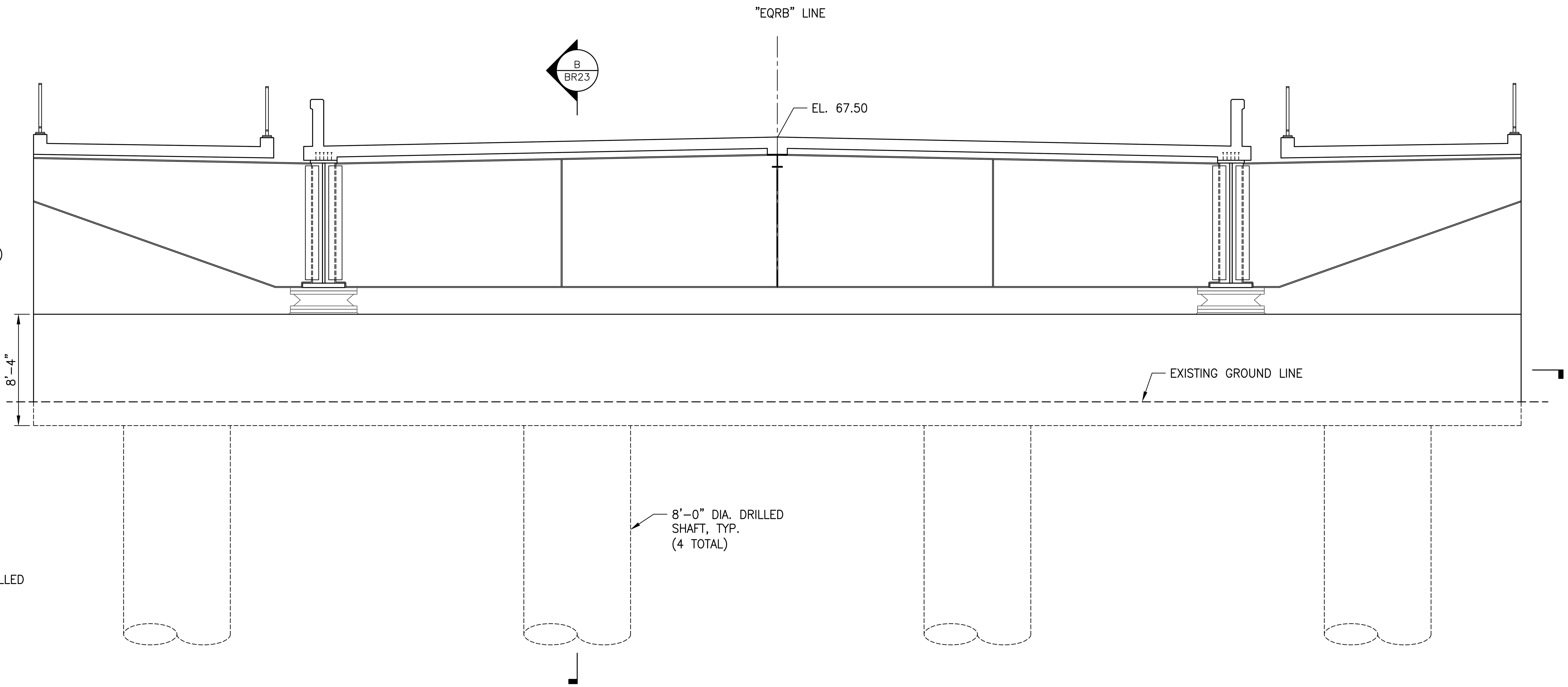
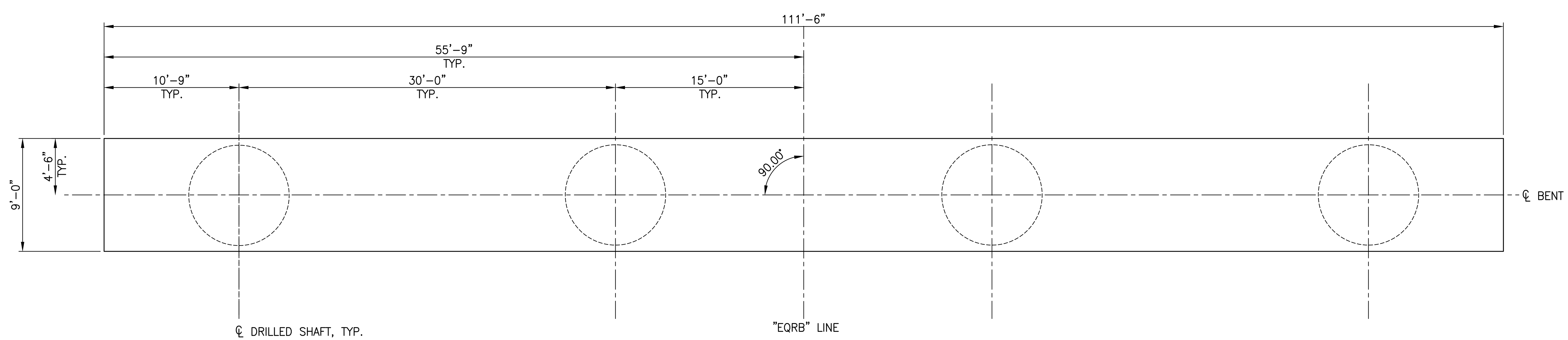
Sheet No.
BR22



SECTION B
SCALE: 1" = 5'-0"



BENT 9 ELEVATION
SCALE: 1" = 5'-0"



SECTION A
SCALE: 1" = 5'-0"

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 9 Details

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

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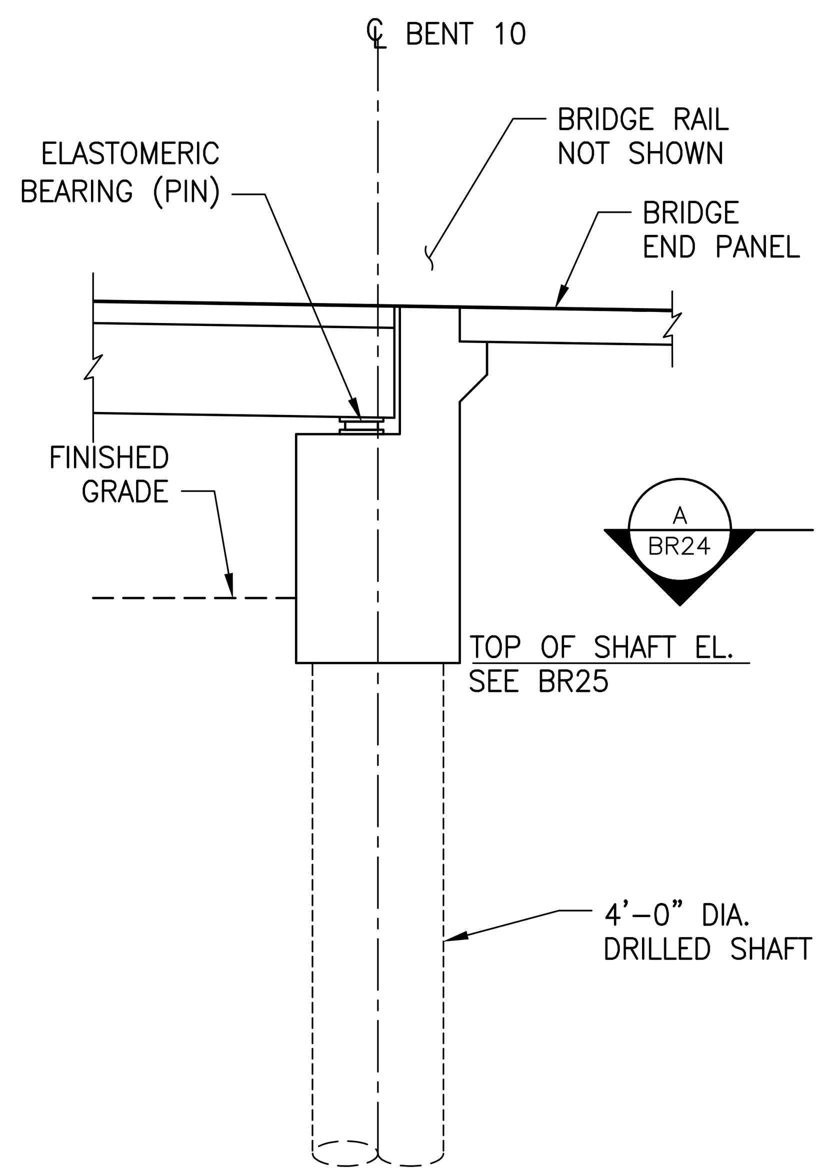
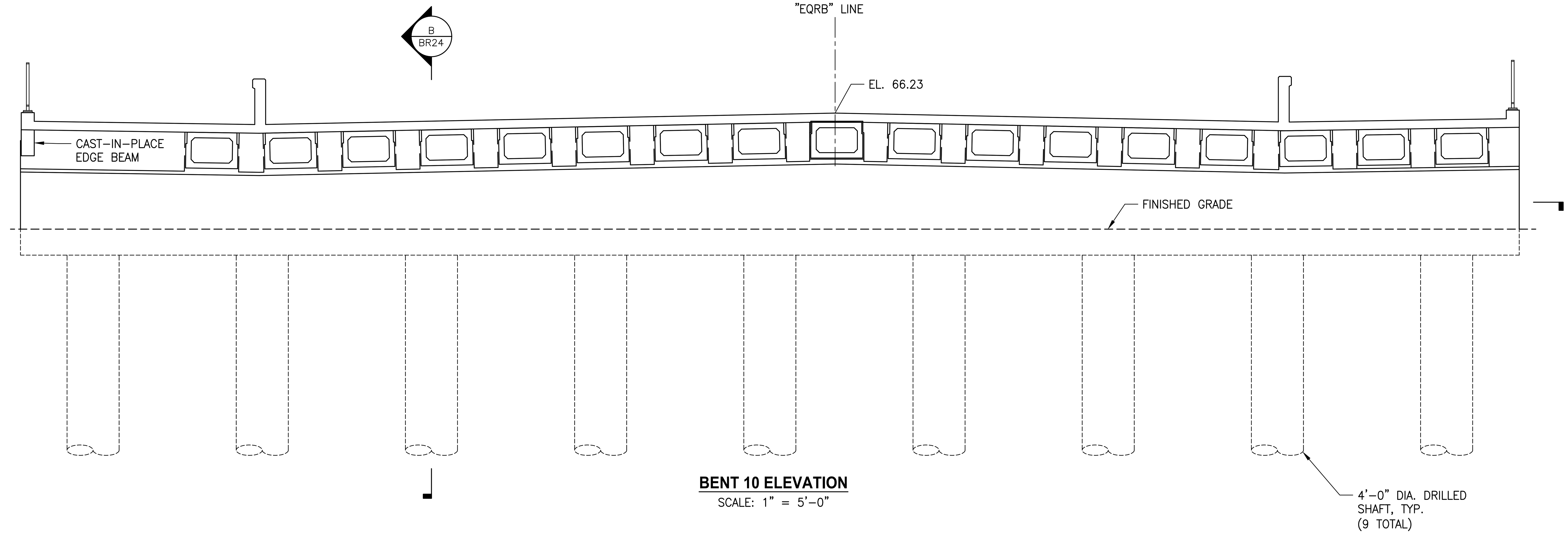
NO	DATE:

CONCEPTUAL PLANS
SEPTEMBER 2022

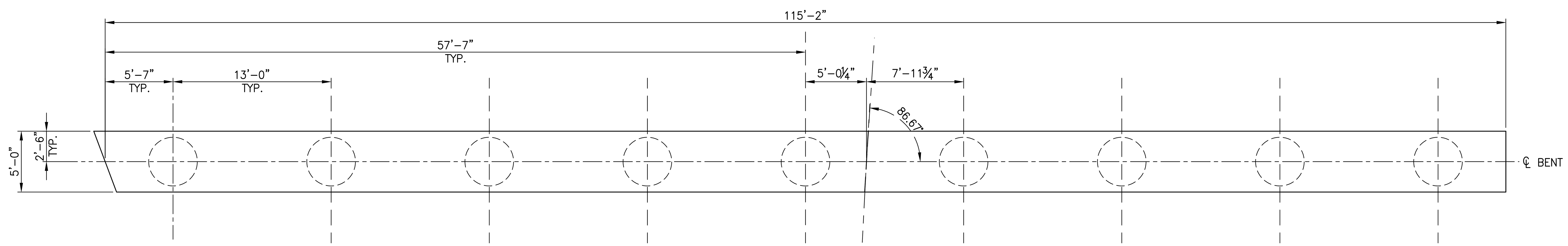
Sheet No. BR23



SECTION B
SCALE: 1" = 5'–0"



BENT 10 ELEVATION
SCALE: 1" = 5'–0"



SECTION A
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 10 Details

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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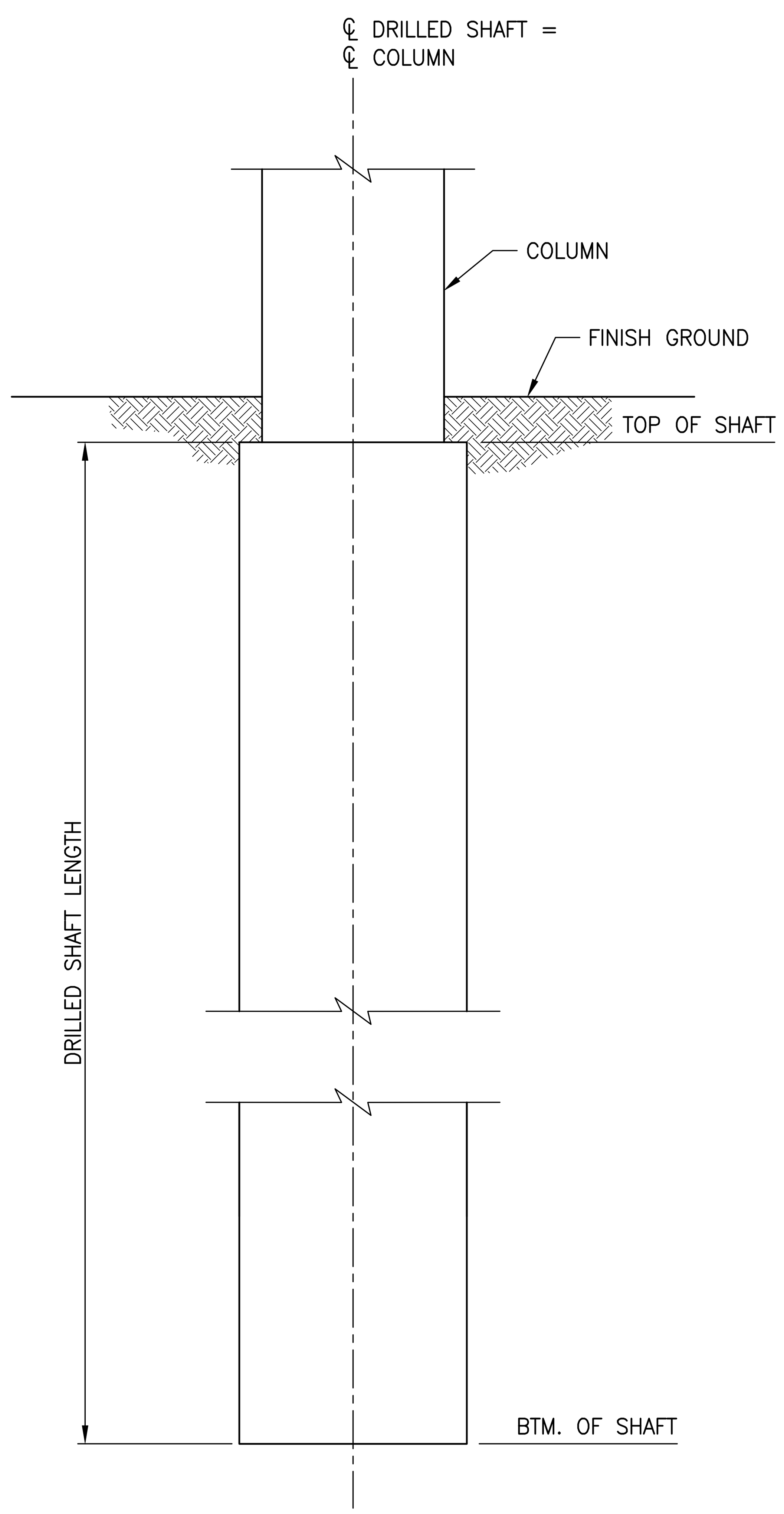
CHECKED BY: HDR

REVISIONS

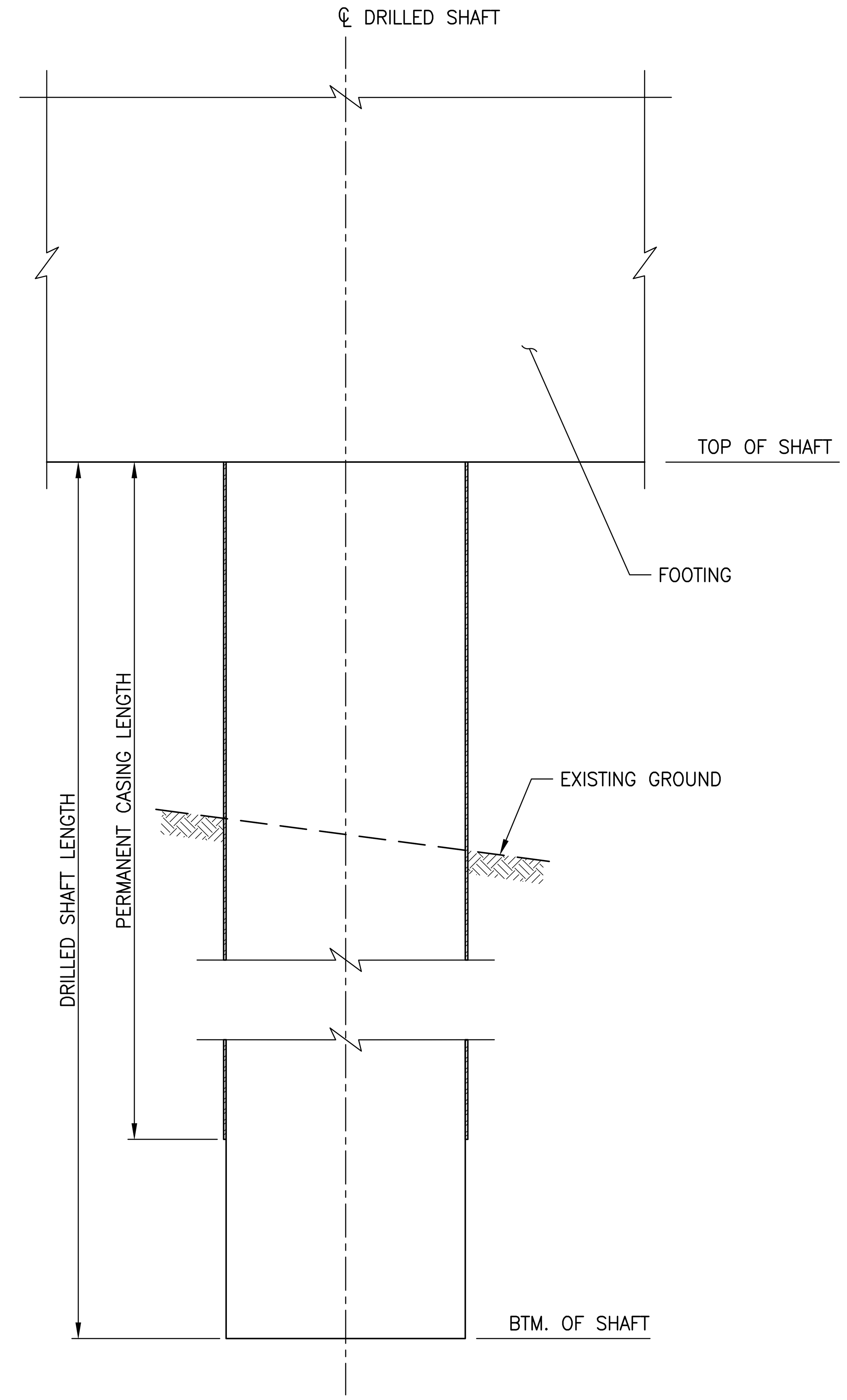
NO.	DATE:			

Sheet No. BR24



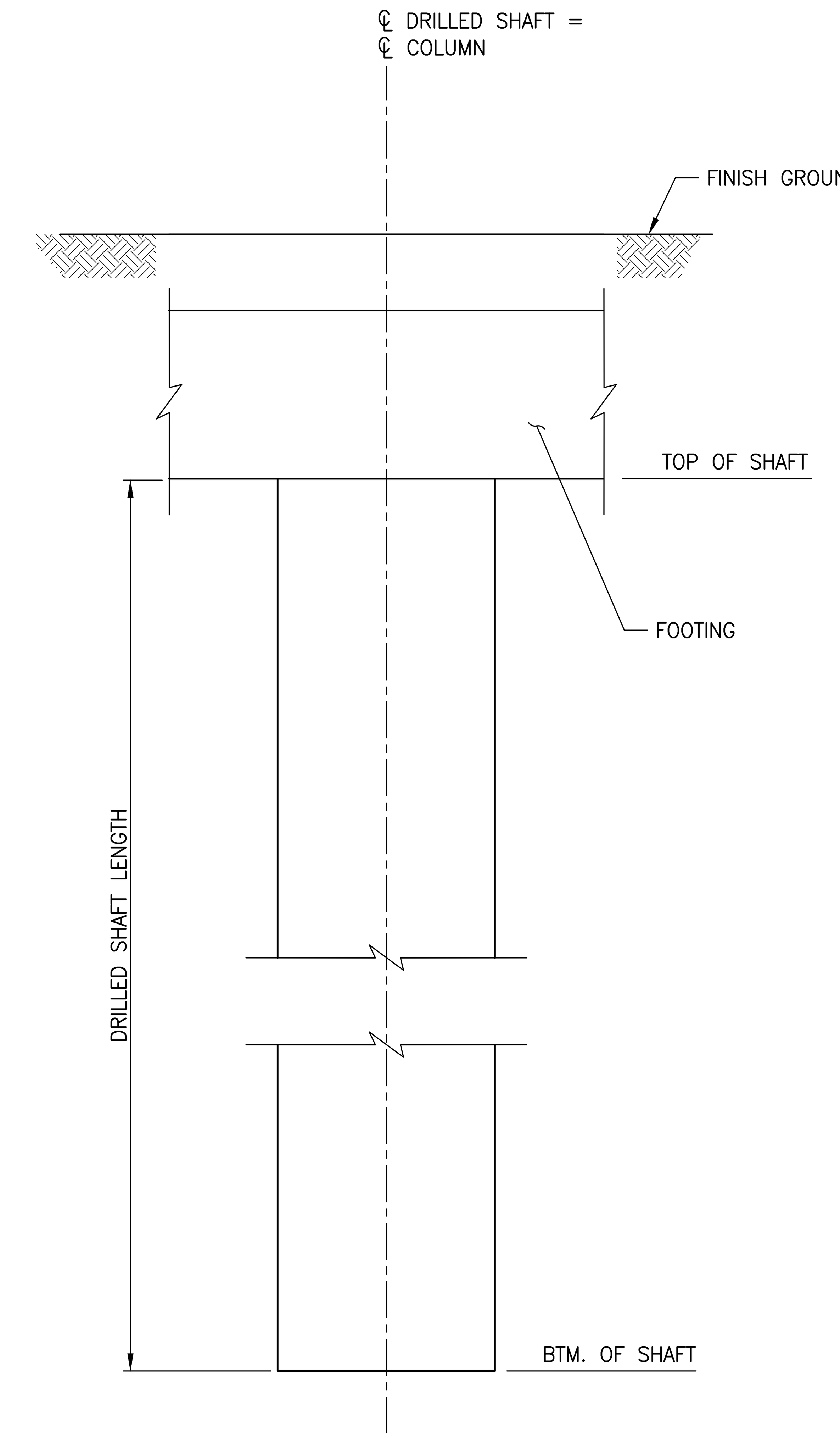
DRILLED SHAFT DETAIL - BENTS 1 - 5, 9 & 10

NOT TO SCALE



DRILLED SHAFT DETAIL - BENTS 6 & 7

NOT TO SCALE



DRILLED SHAFT DETAIL - BENT 8

NOT TO SCALE

BENT	SHAFT DIAMETER (FT)	NUMBER OF SHAFTS	ELEVATIONS (NAVD88)					SHAFT LENGTH (FT)	CASING LENGTH (FT)
			FINISH GROUND	ESTIMATED ROCK*	TOP OF SHAFT	BOTTOM OF CASING	BOTTOM OF SHAFT		
1	3.00	11	31.52	−26.47	24.52	NA	−42.00	66.52	NA
2	8.00	3	31.50	−33.85	29.50	NA	−65.00	94.50	NA
3	10.00	2	32.02	−41.63	30.02	NA	−65.50	95.52	NA
4	10.00	2	33.67	−43.01	31.67	NA	−62.50	94.17	NA
5	10.00	2	34.97	−57.43	32.97	NA	−74.00	106.97	NA
6	10.00	8	−55.00	−105.00	2.00	−77.50	−126.00	128.00	79.50
7	10.00	8	−55.00	−130.00	2.00	−77.50	−153.00	155.00	79.50
8	10.00	6	32.65	−148.80	15.00	NA	−155.00	170.00	NA
9	8.00	4	48.00	2.79	46.00	NA	−8.00	54.00	NA
10	4.00	9	57.00	14.06	55.00	NA	0.00	55.00	NA

* ESTIMATED ROCK ASSUMED AS TOP OF LOWER TROUTDALE SUBSURFACE LAYER

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Drilled Shaft Details

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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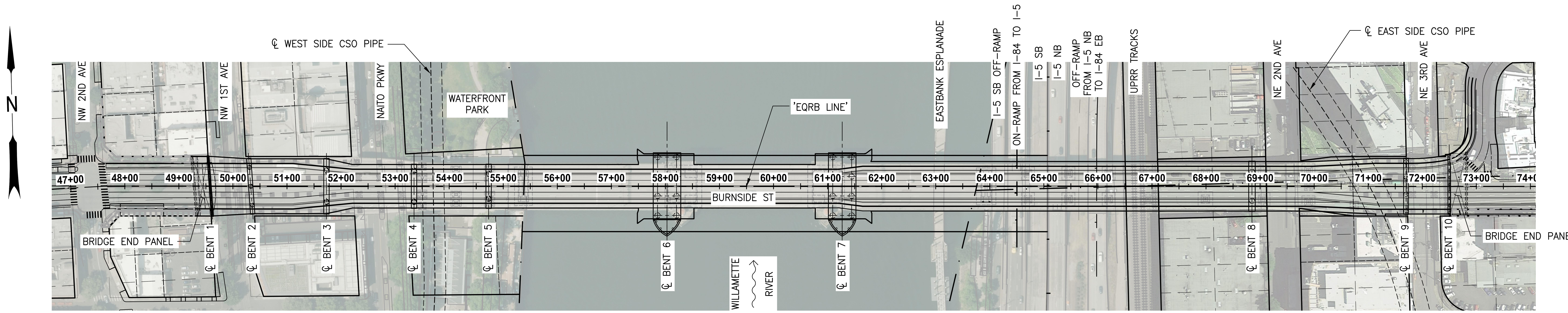
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

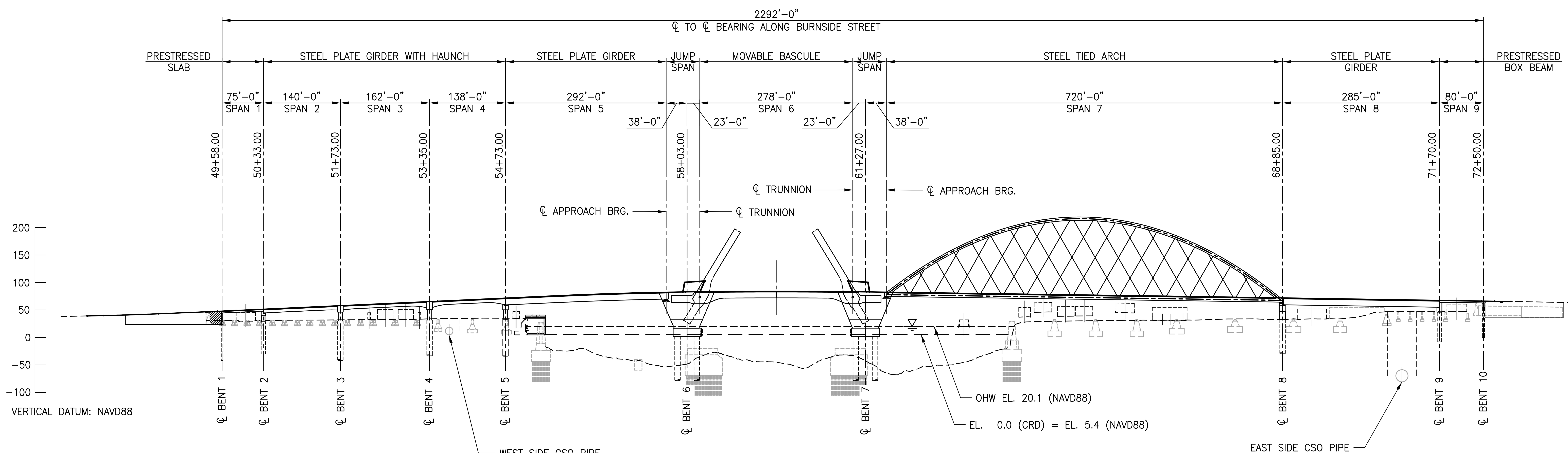
REVISIONS

NO	DATE:			

Sheet No. *BR25*



PLAN
SCALE: 1"=100'



ELEVATION
SCALE: 1"=100'

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
General Layout

PROJECT NO.:

DATE: *9/2022*

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
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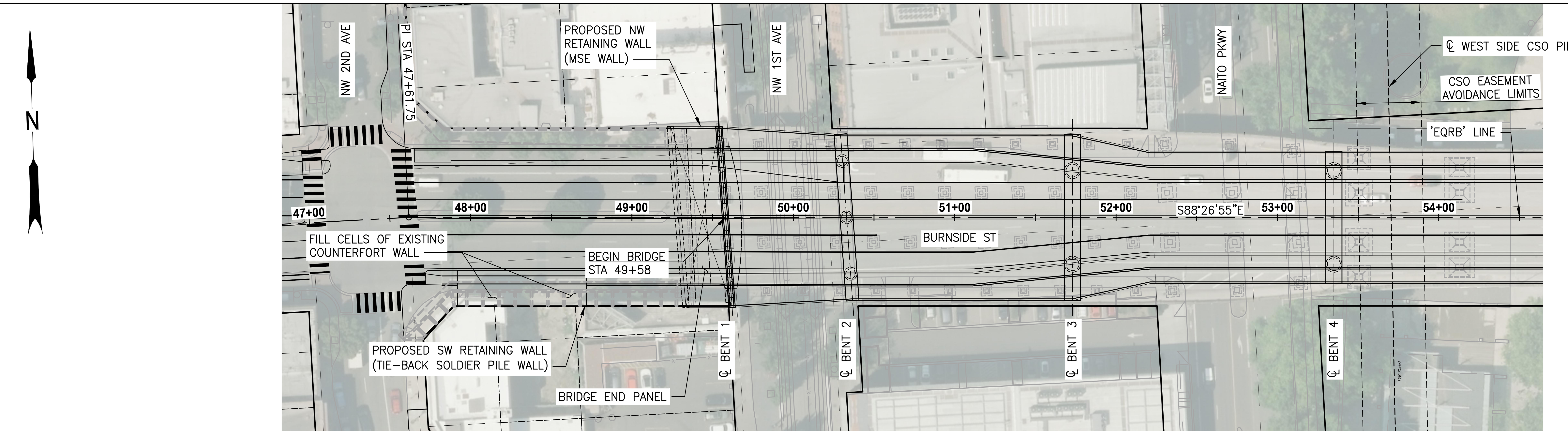
CHECKED BY: *HDR*

REVISIONS

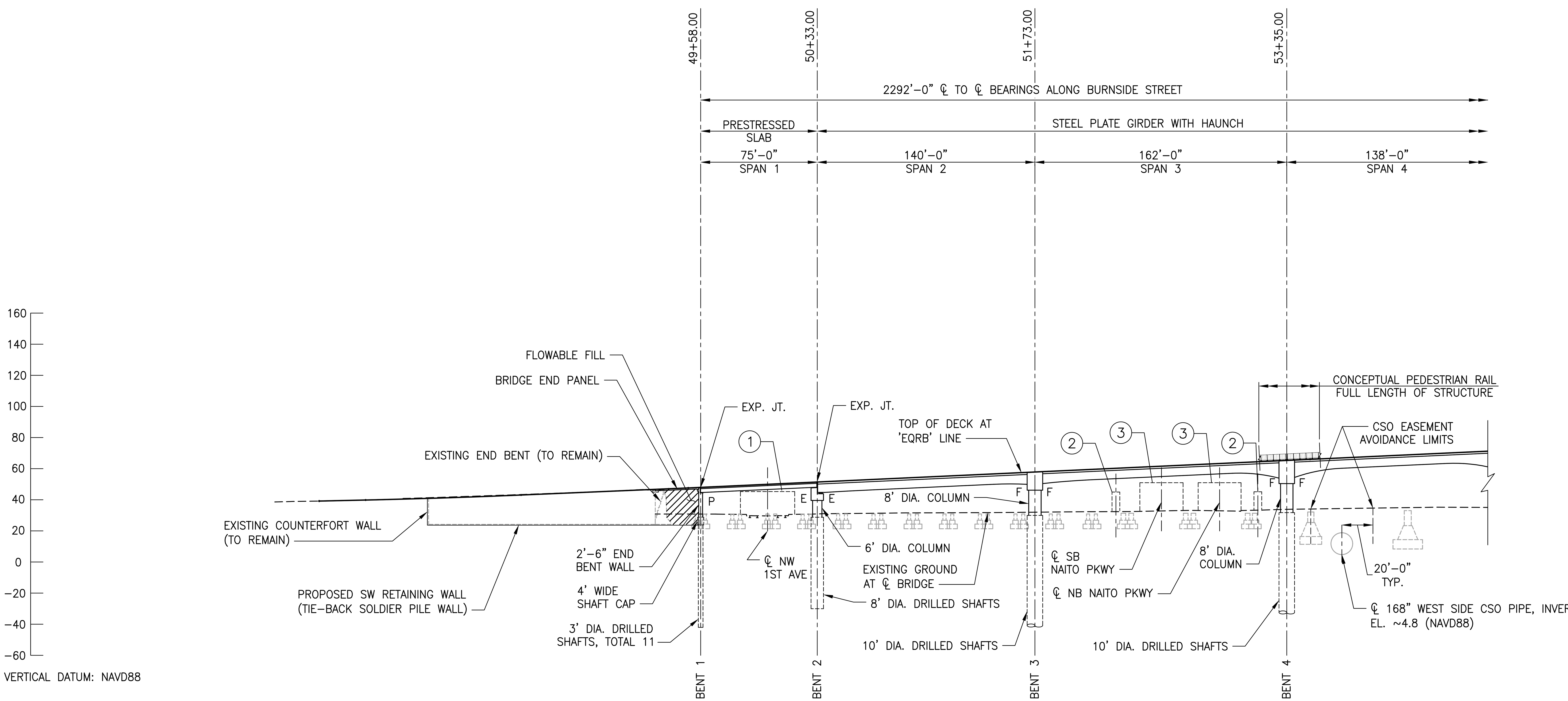
NO.	DATE:			

Sheet No. *BR01*



PLAN

SCALE: 1"=40'



ELEVATION

SCALE: 1"=40'

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

1	TRIMET LRT	15'-6"
2	PEDESTRIAN	12'-0"
3	CITY STREET	18'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Plan and Elevation - 1

DATE: 9/2022
PROJECT NO:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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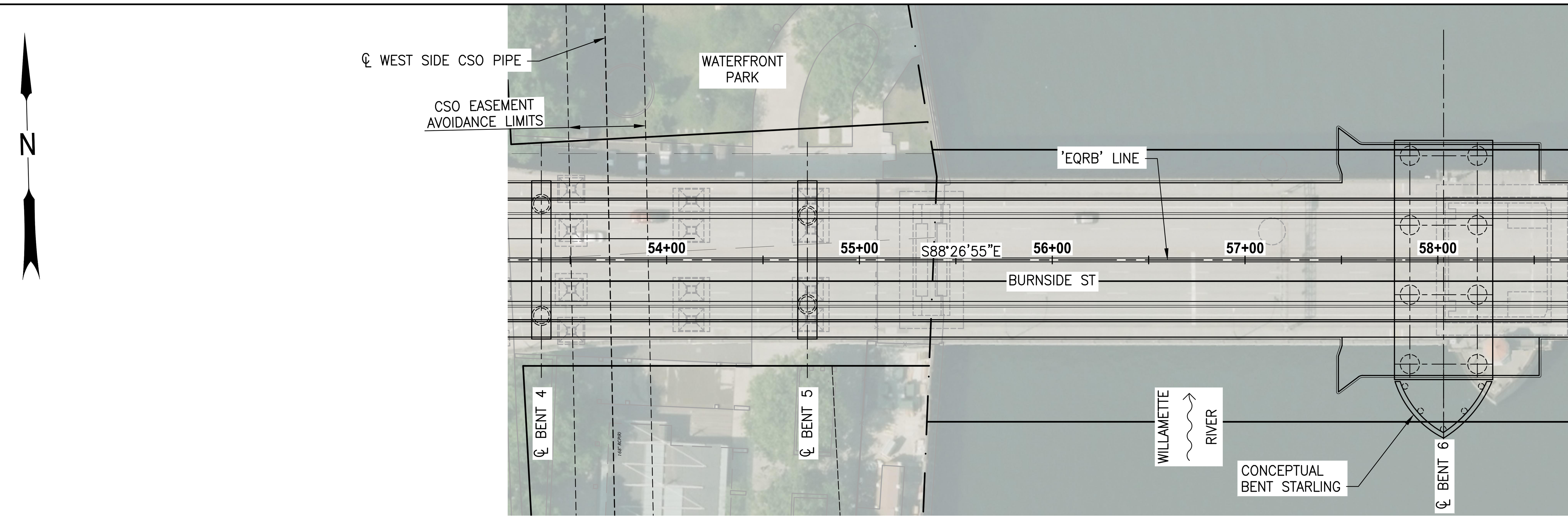
CHECKED BY: HDR

REVISIONS

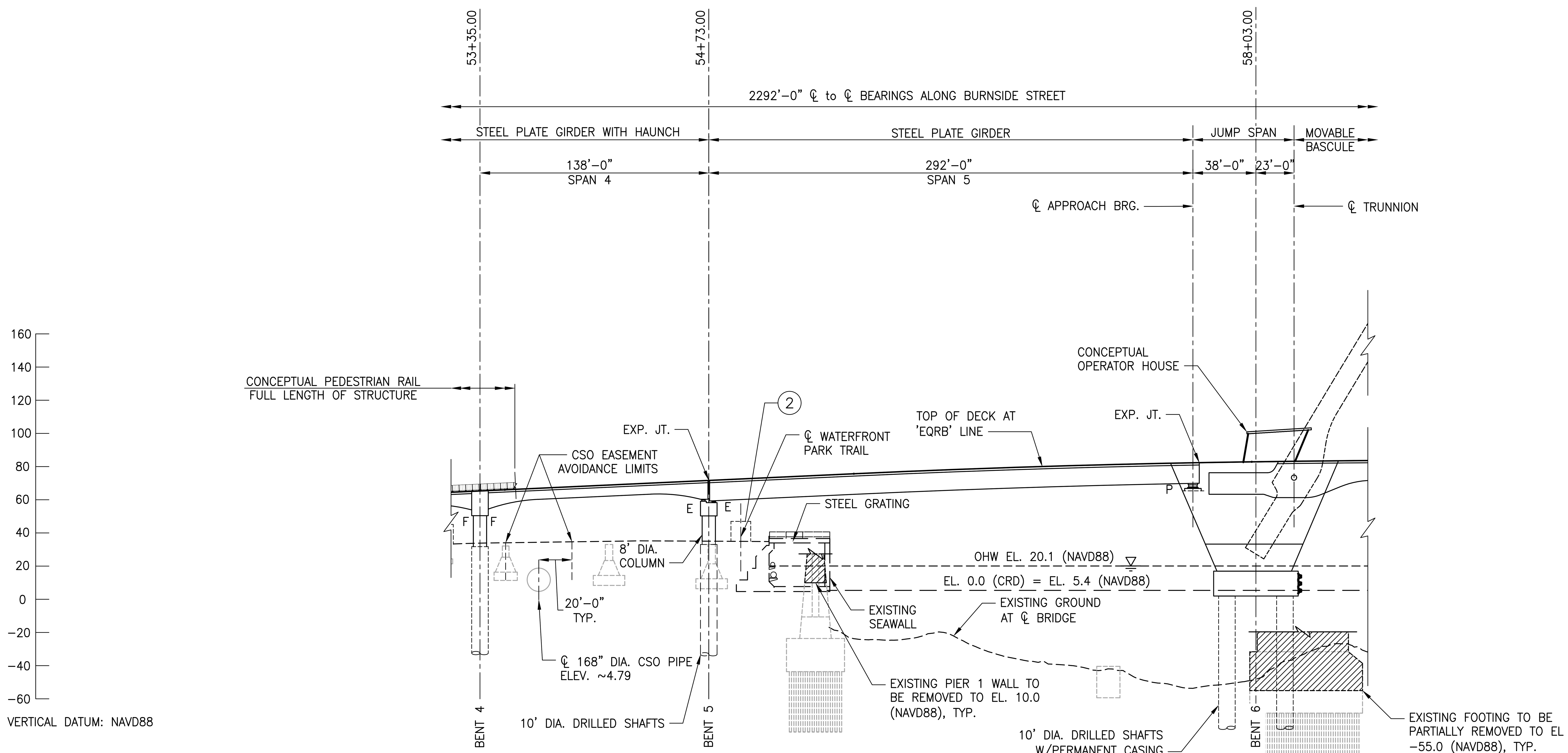
NO. DATE:

Sheet No. BR02



PLAN

SCALE: 1"=40'



ELEVATION

SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

2	PEDESTRIAN	12'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Plan and Elevation -2

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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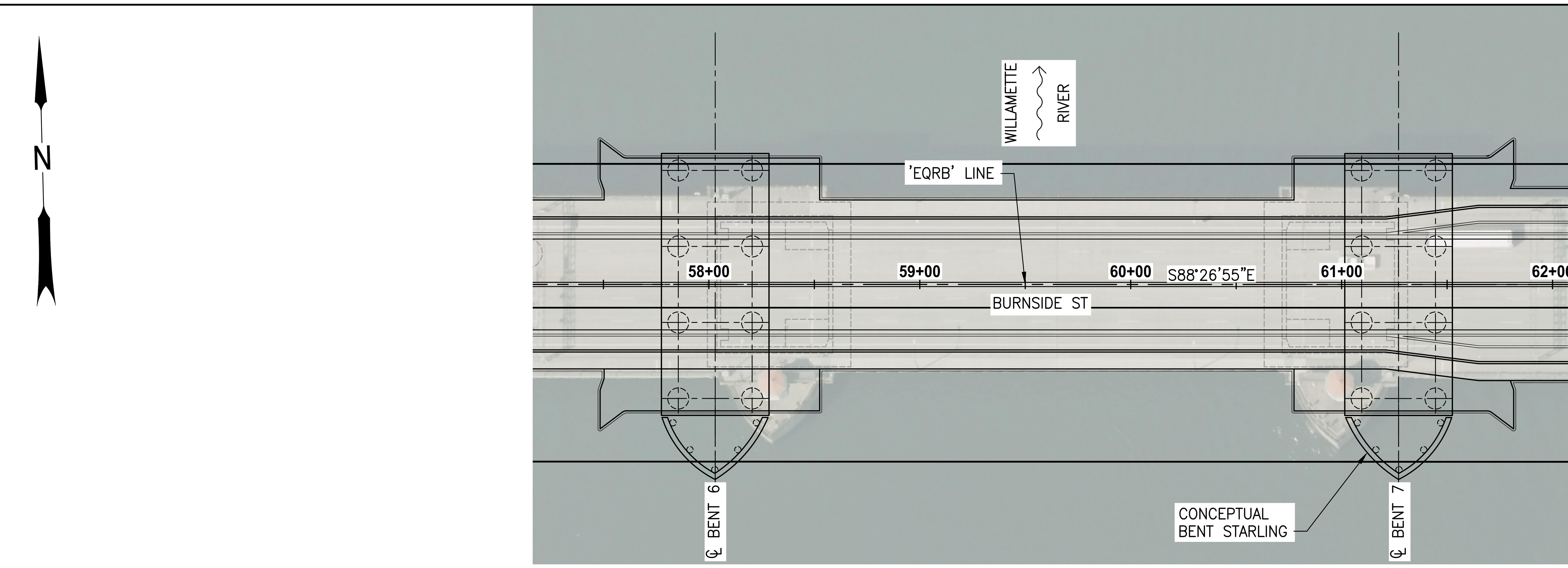
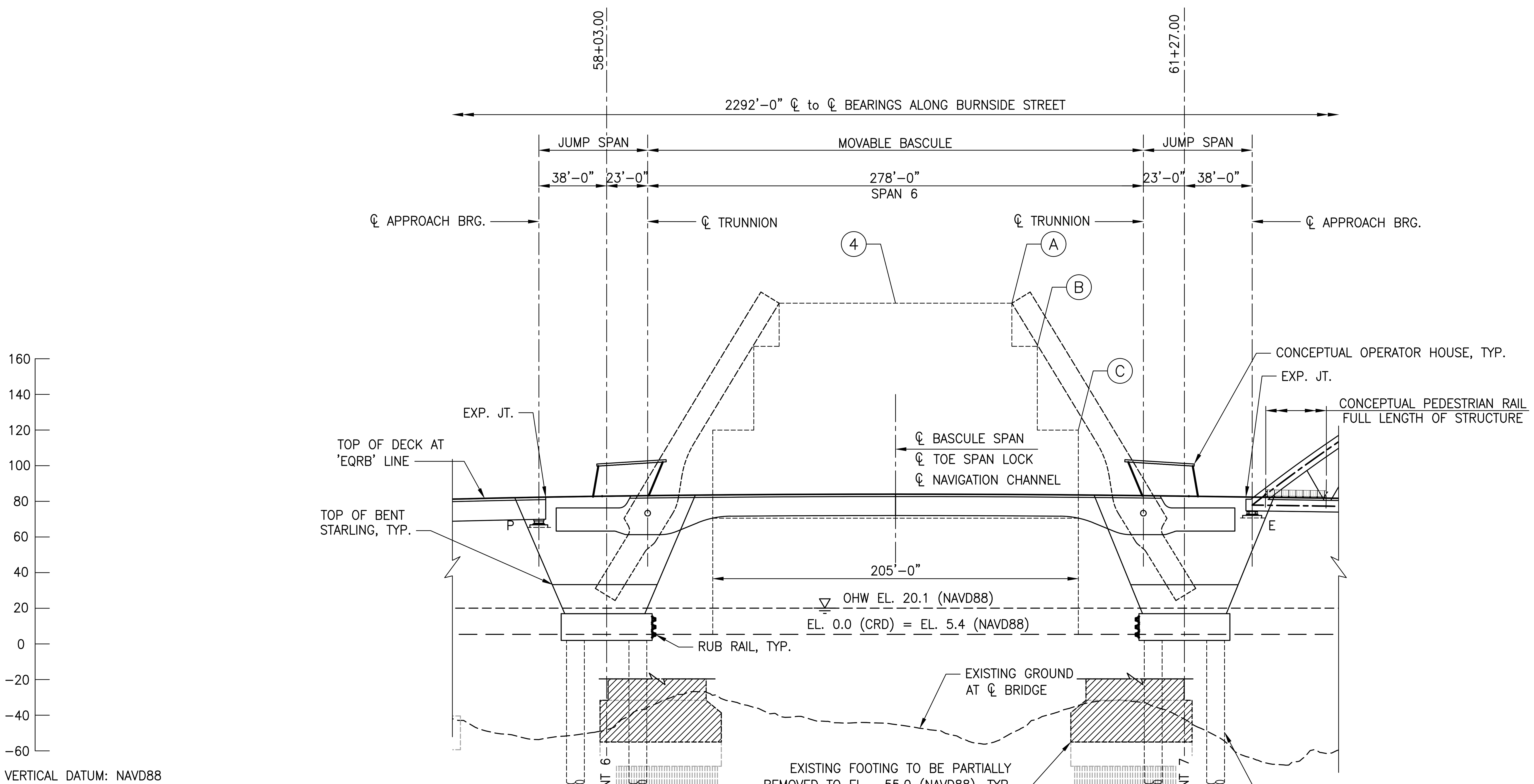
REVISIONS

NO. DATE:

Sheet No. BR03



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

NAVIGATION CLEARANCE ENVELOPE LEGEND

4 NAVIGATION ENVELOPES		
ENVELOPE	VERTICAL CLEARANCE TO CRD	HORIZONTAL CLEARANCE
OPEN A	INFINITE	130'-6"
OPEN B	161'-7"	159'-0"
OPEN C	114'-7"	205'-0"
CLOSED	65'-2"	205'-0"

CRD: COLUMBIA RIVER DATUM

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Plan and Elevation - 3

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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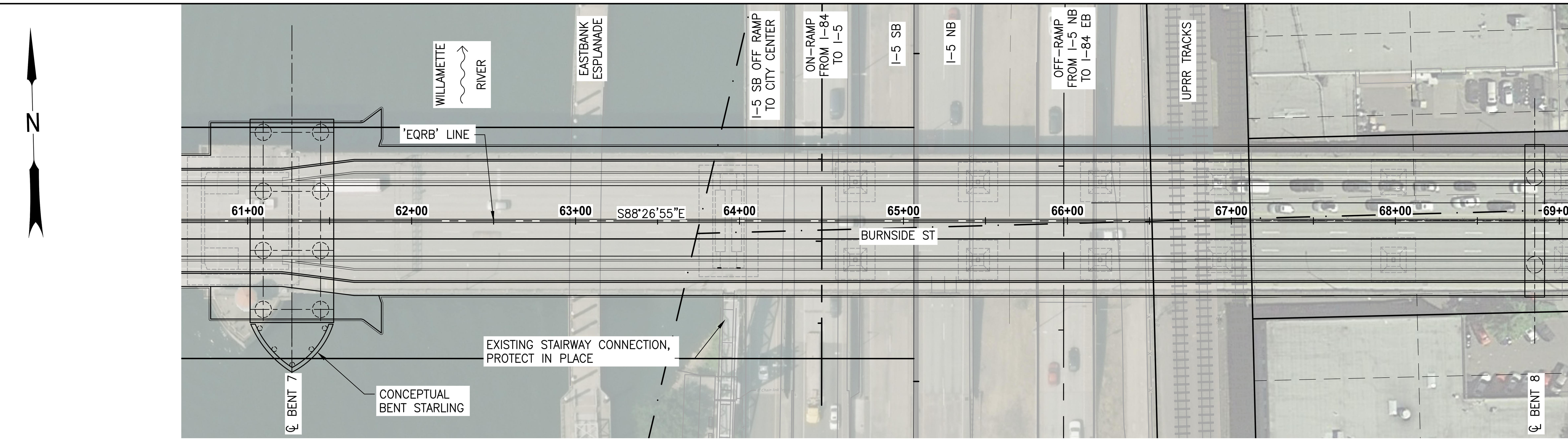
CHECKED BY: HDR

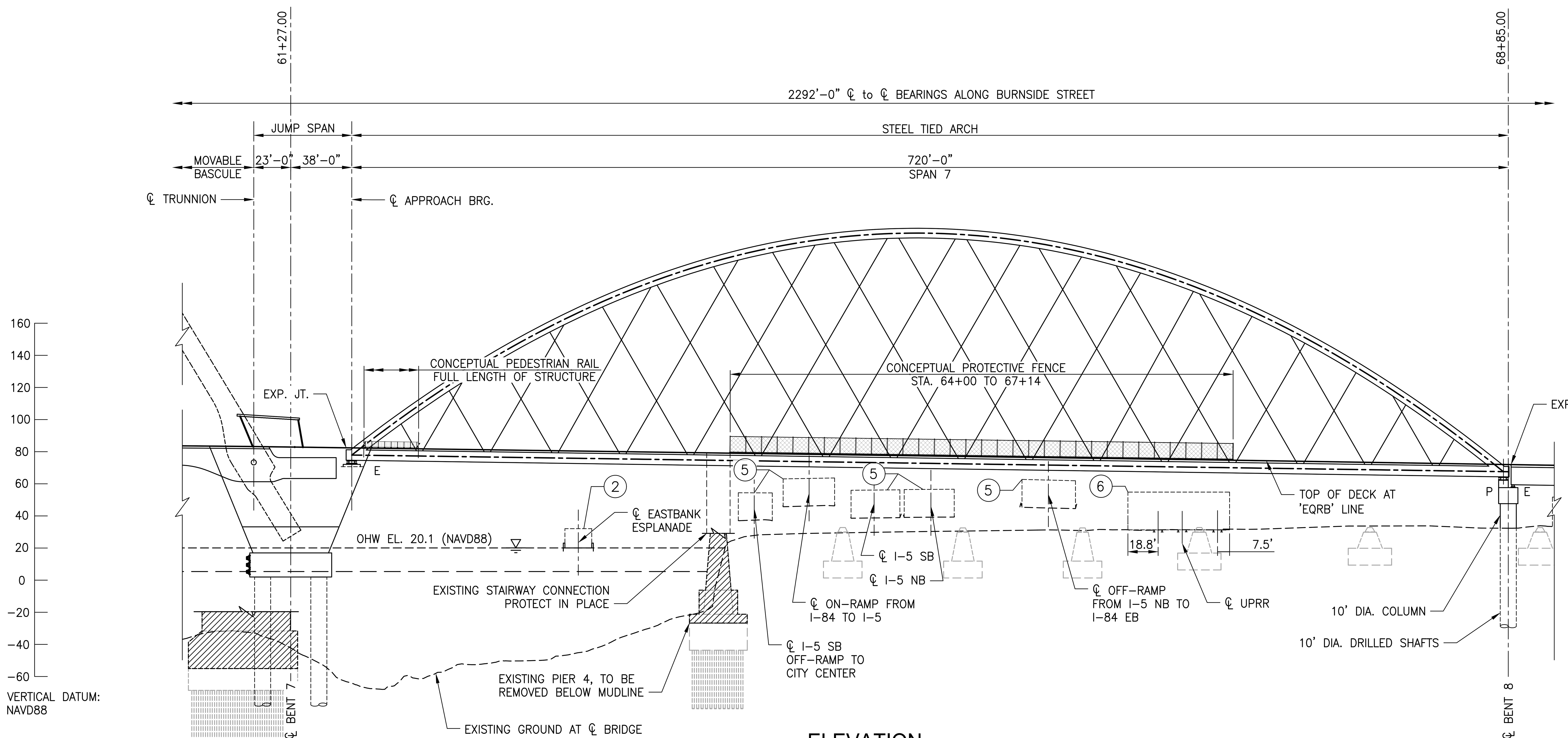
REVISIONS

NO.	DATE:				

Sheet No. BR04



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

2	PEDESTRIAN	12'-0"
3	CITY STREET	18'-0"
5	I-5	17'-4"
6	UPRR	23'-6"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Plan and Elevation -4

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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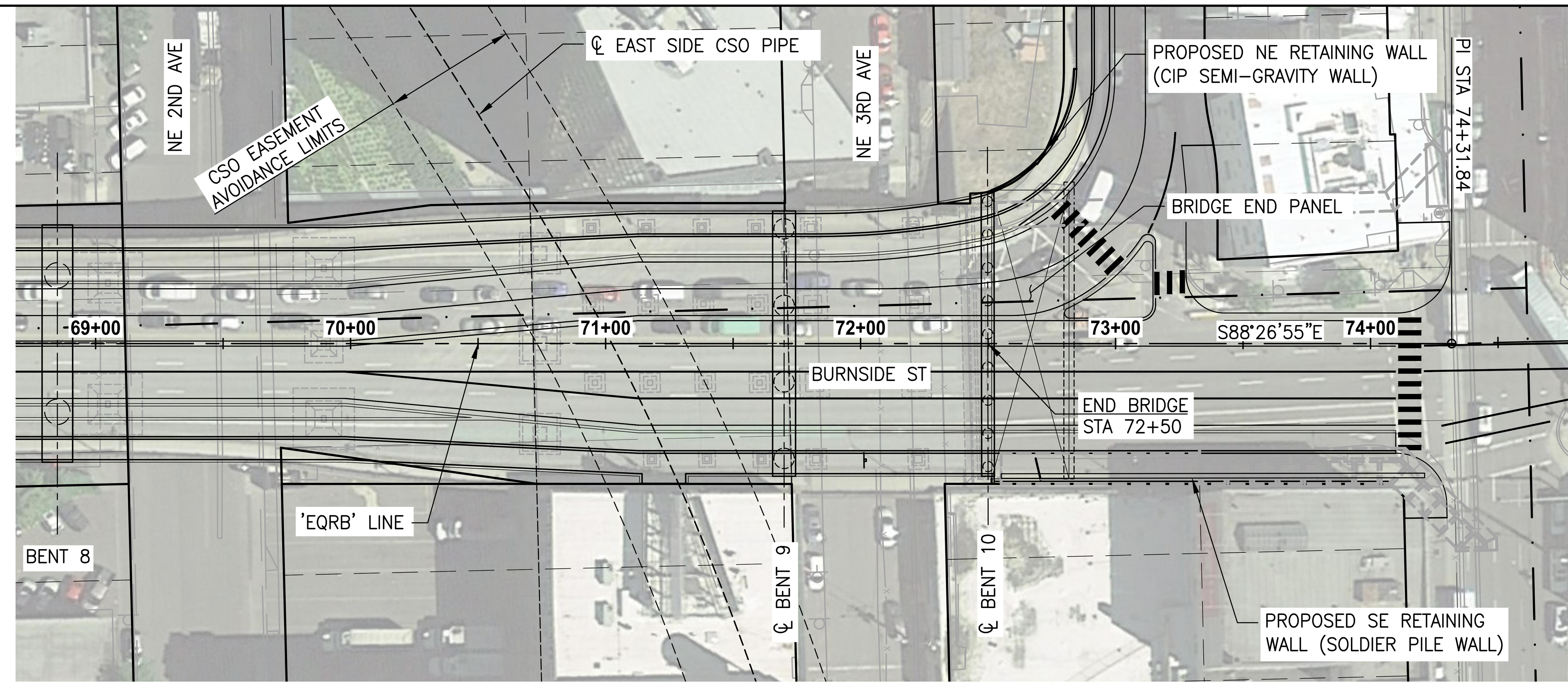
CHECKED BY: HDR

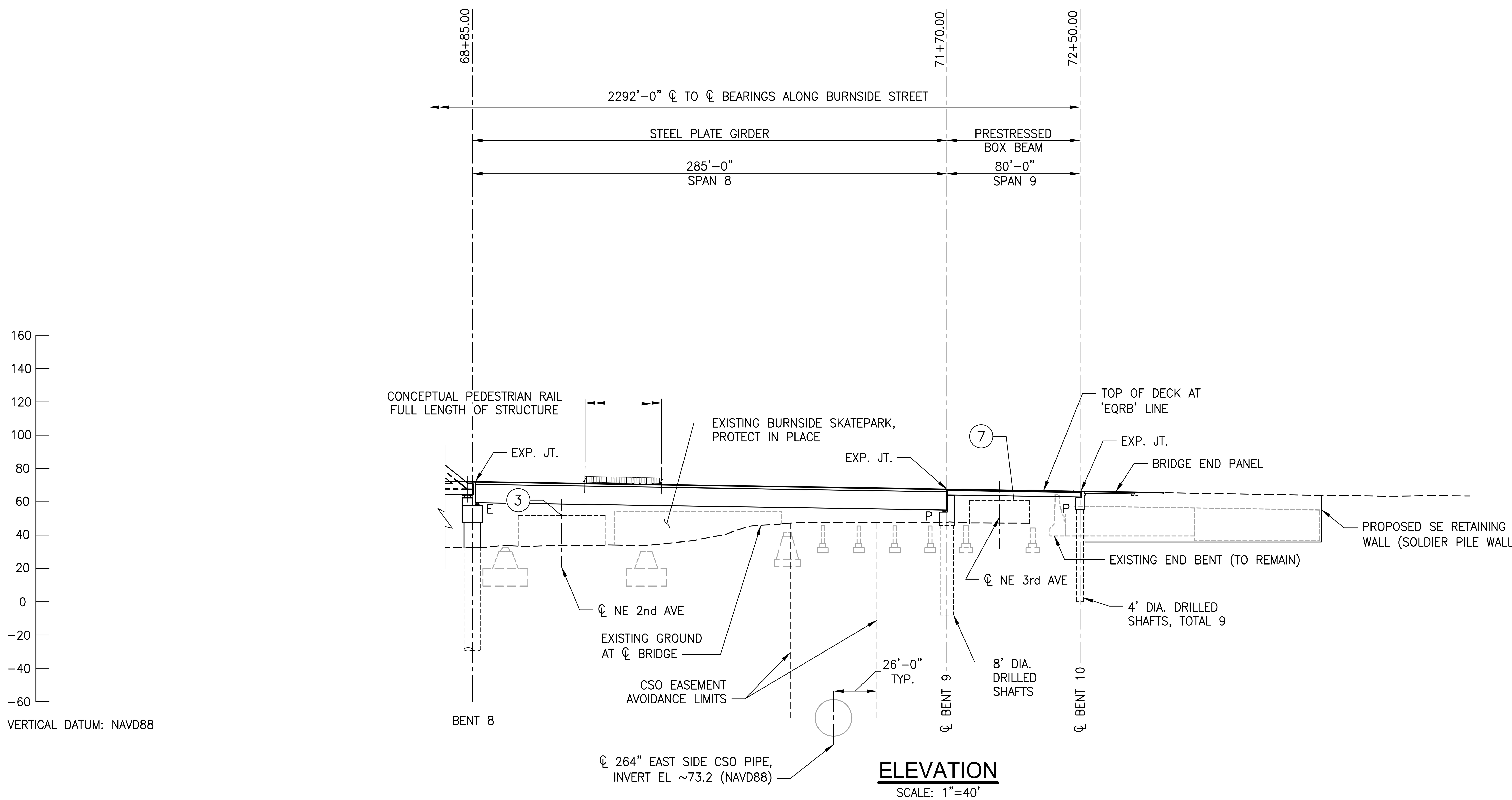
REVISIONS

NO.	DATE:	

Sheet No. BR05



PLAN
SCALE: 1"=40'



ELEVATION
SCALE: 1"=40'

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

3	CITY STREET	18'-0"
7	CITY STREET @ NE 3rd AVE	13'-8"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Plan and Elevation - 5

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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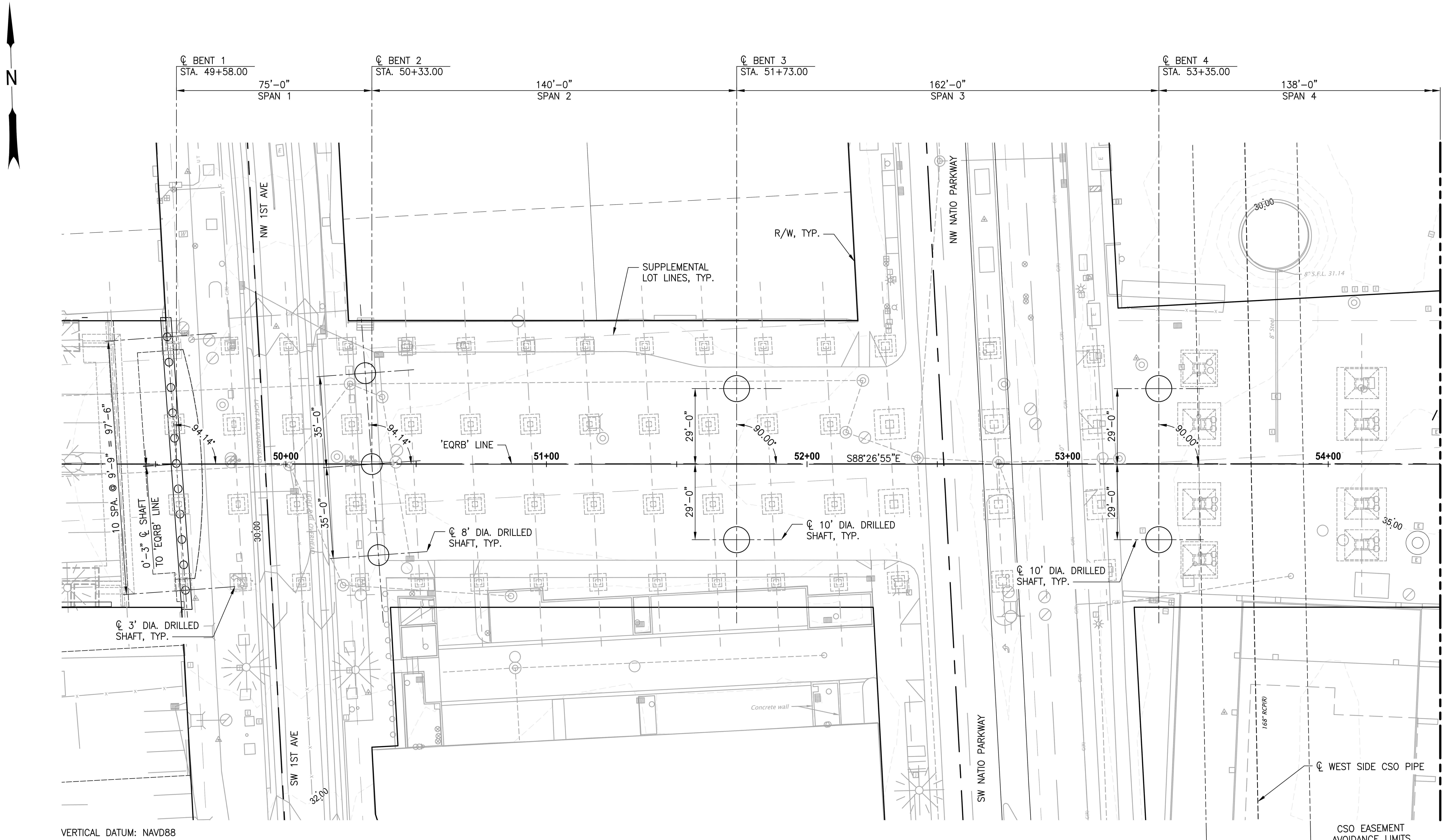
REVISIONS

NO.	DATE:	

Sheet No. *BR06*



VERTICAL DATUM: NAVD88

FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Foundation Plan - 1

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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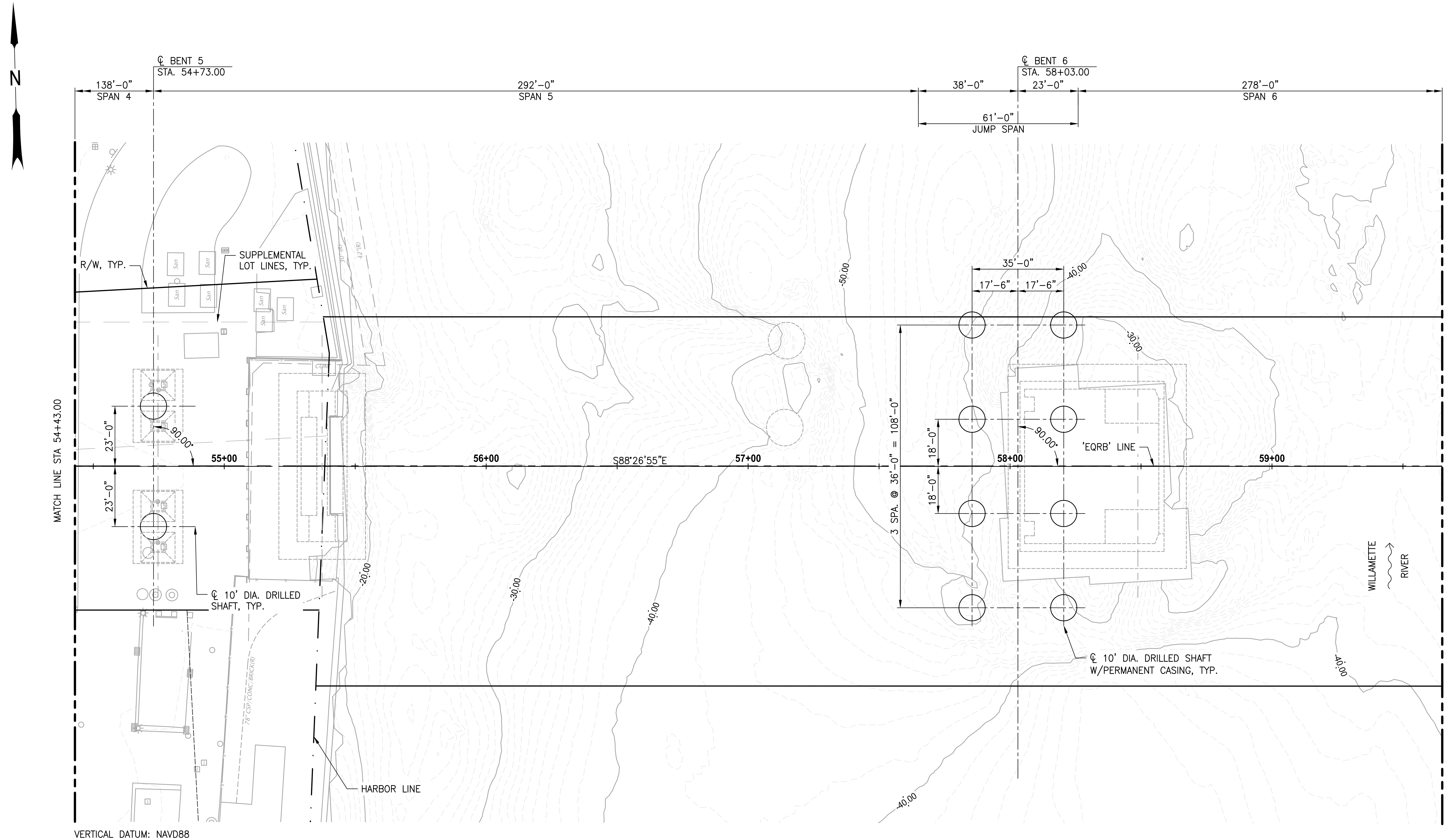
CHECKED BY: HDR

REVISIONS

NO.	DATE:			

Sheet No.
BR07



FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16-BR25
2. CONCEPTUAL BENT STARLING FOUNDATION NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Foundation Plan -2

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

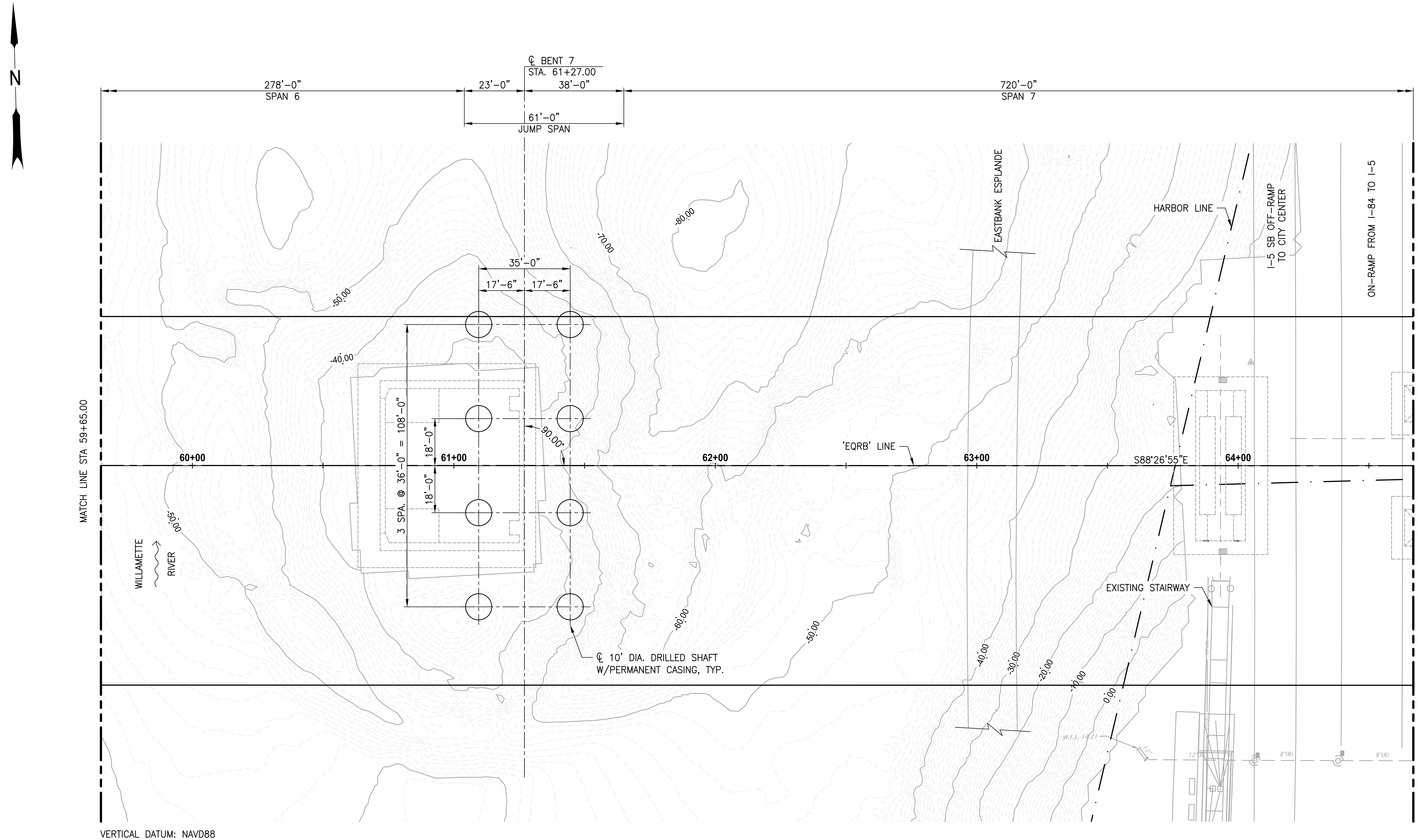
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

NO.	DATE:

Sheet No. BR08



FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25
2. CONCEPTUAL BENT STARLING FOUNDATION NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Foundation Plan -3

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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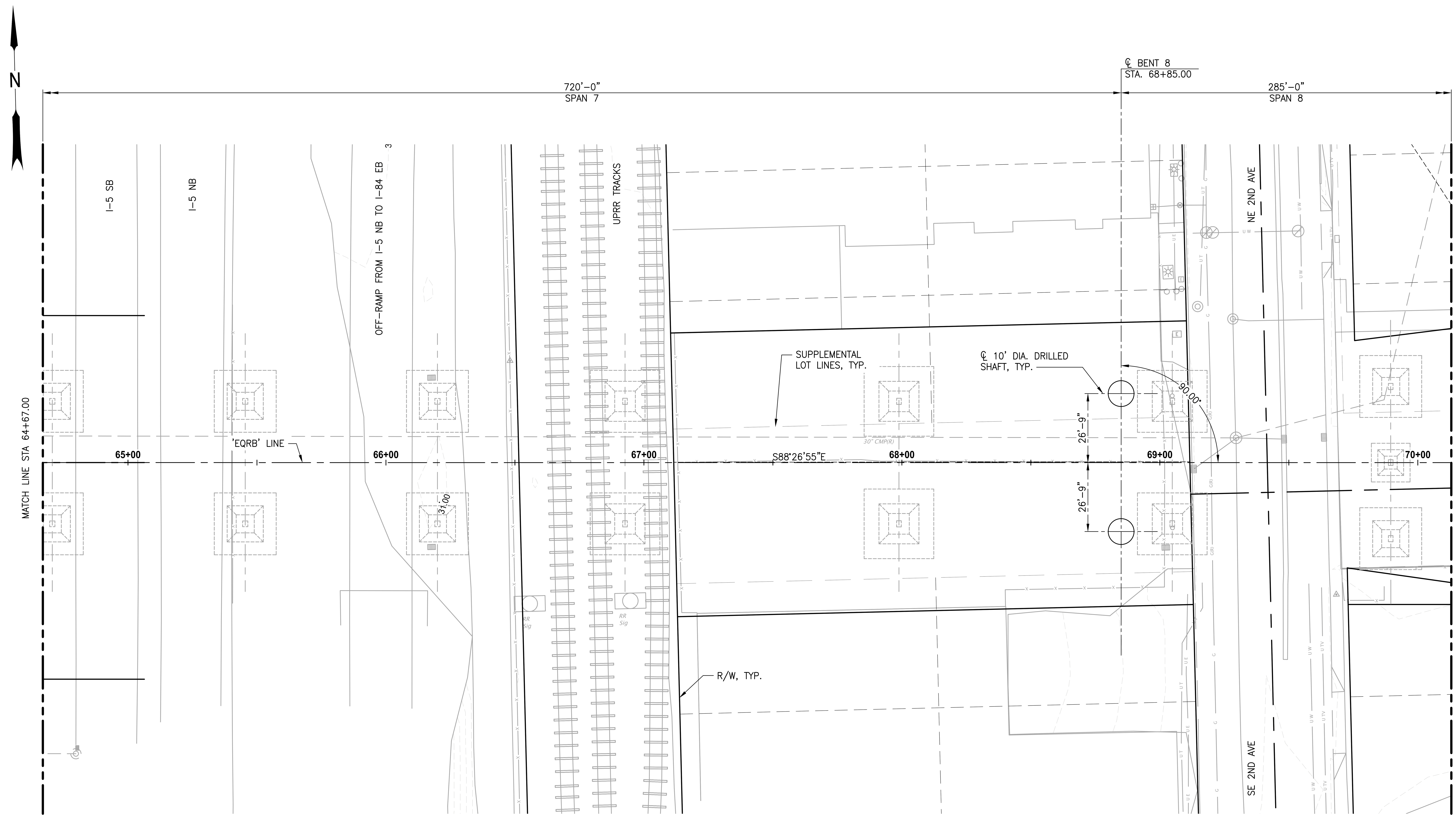
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS

NO	DATE:

Sheet No. *BR09*



VERTICAL DATUM: NAVD88

FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Foundation Plan -4

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

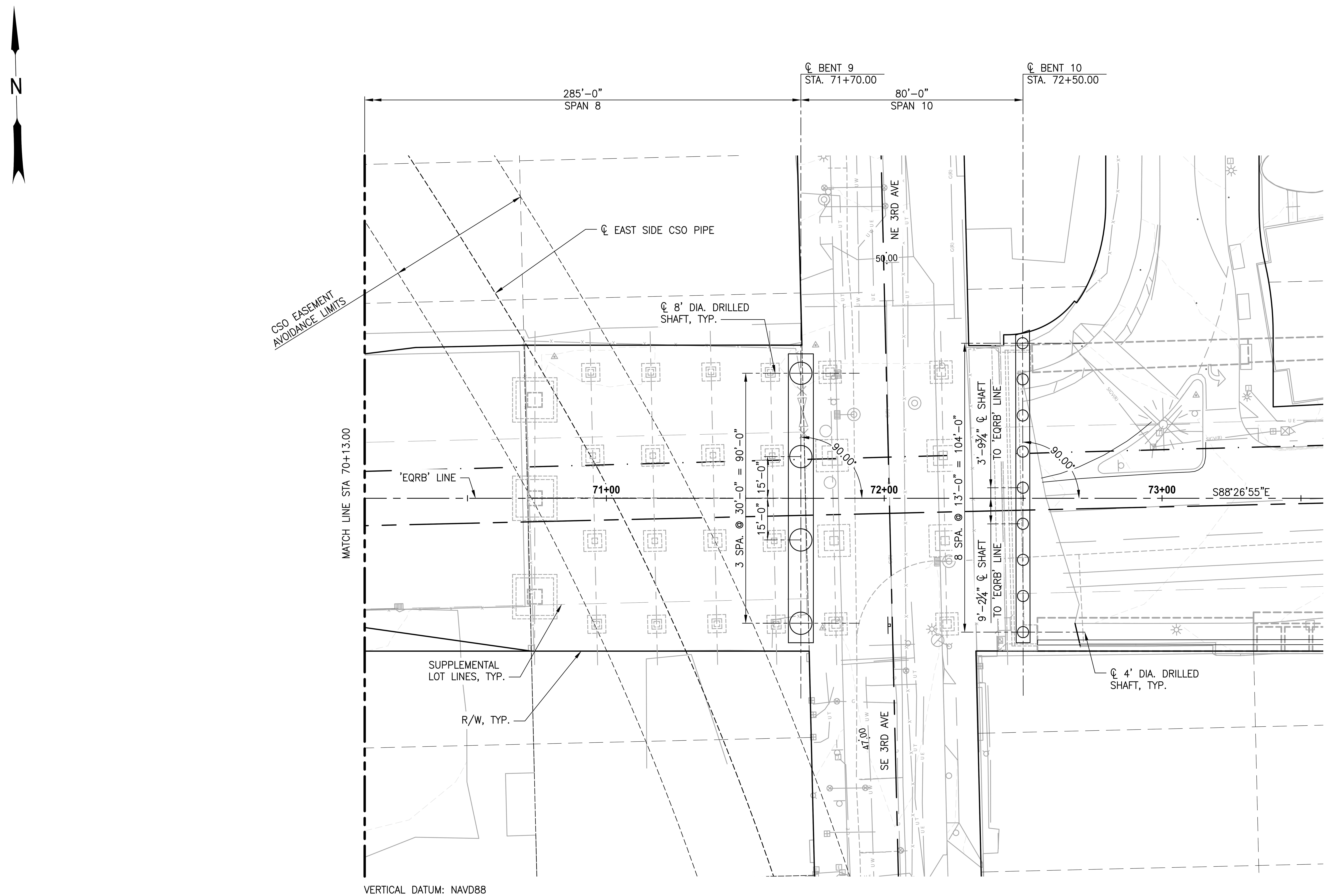
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

NO.	DATE:	

Sheet No.
BR10



FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Foundation Plan -5

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

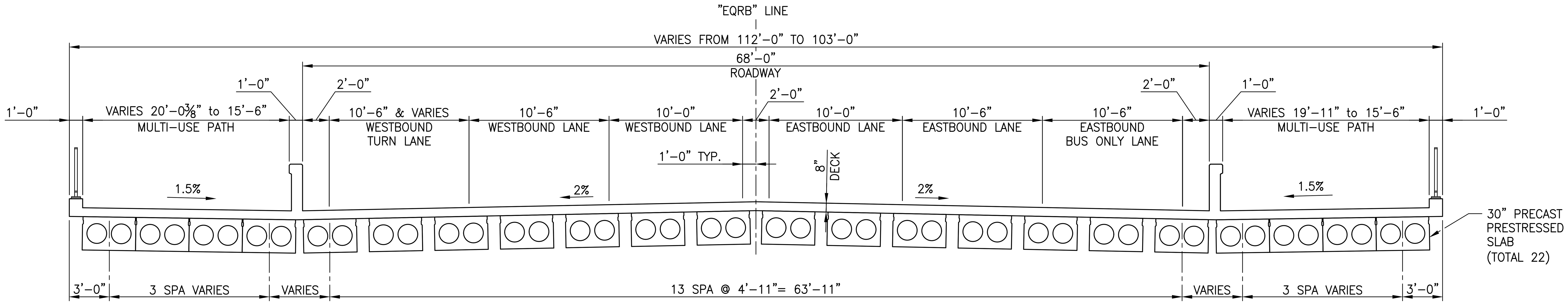
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

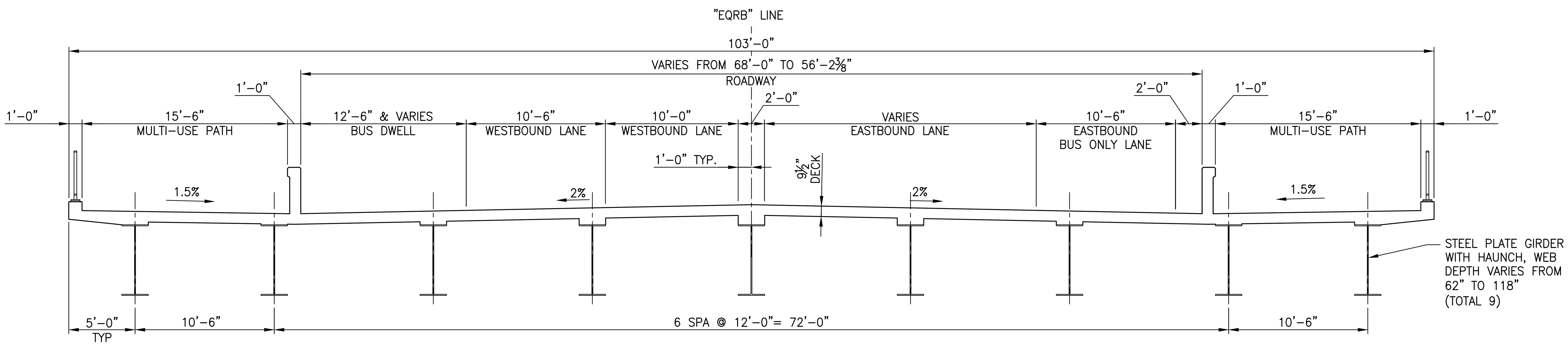
NO	DATE:			

Sheet No. BR11



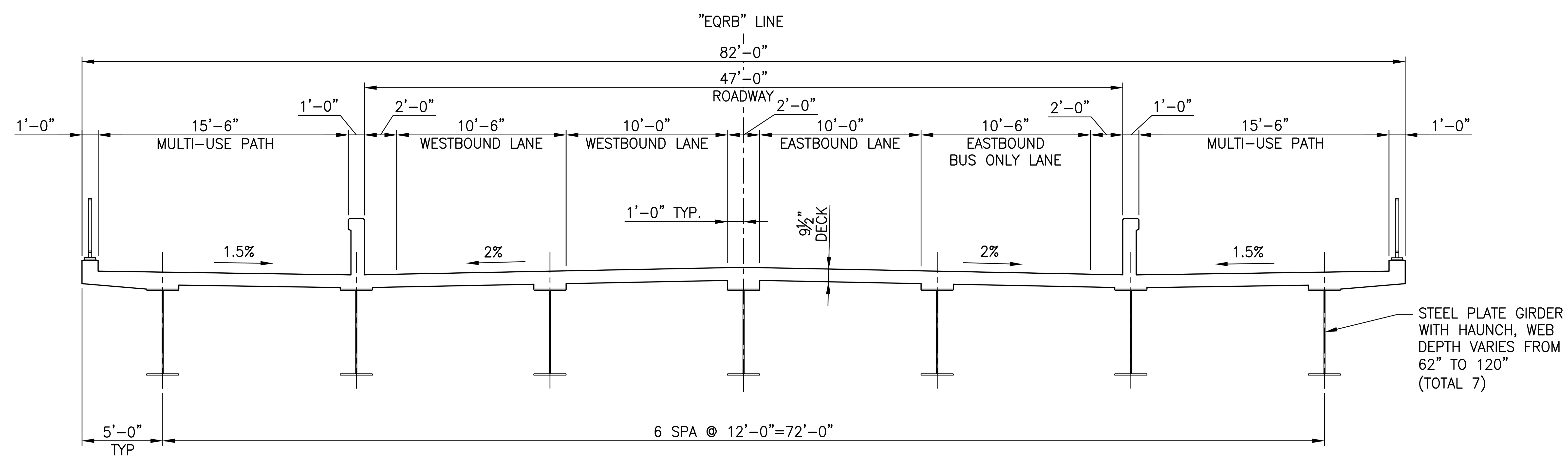
TYPICAL SECTION - SPAN 1

SCALE: 1" = 5'-0"
(AT BENT 2)



TYPICAL SECTION - SPAN 2

SCALE: 1" = 5'-0"
(AT BENT 3)



TYPICAL SECTION - SPAN 3 THRU 4

SCALE: 1" = 5'-0"
(MIDSPAN)

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Typical Sections -1

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

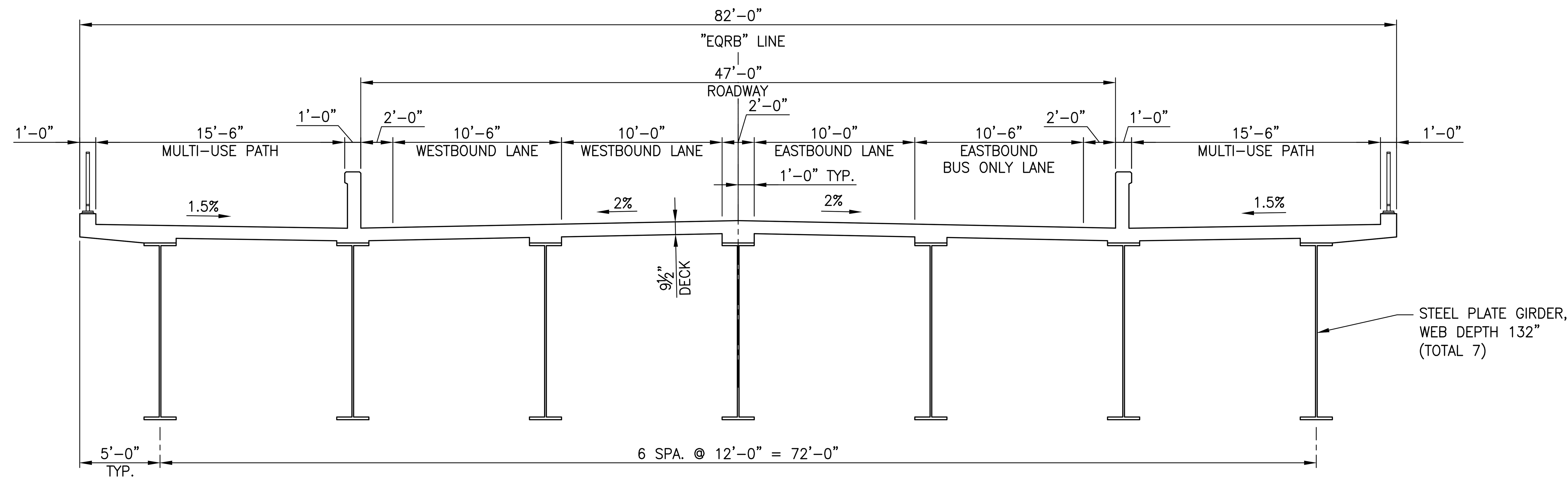
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS

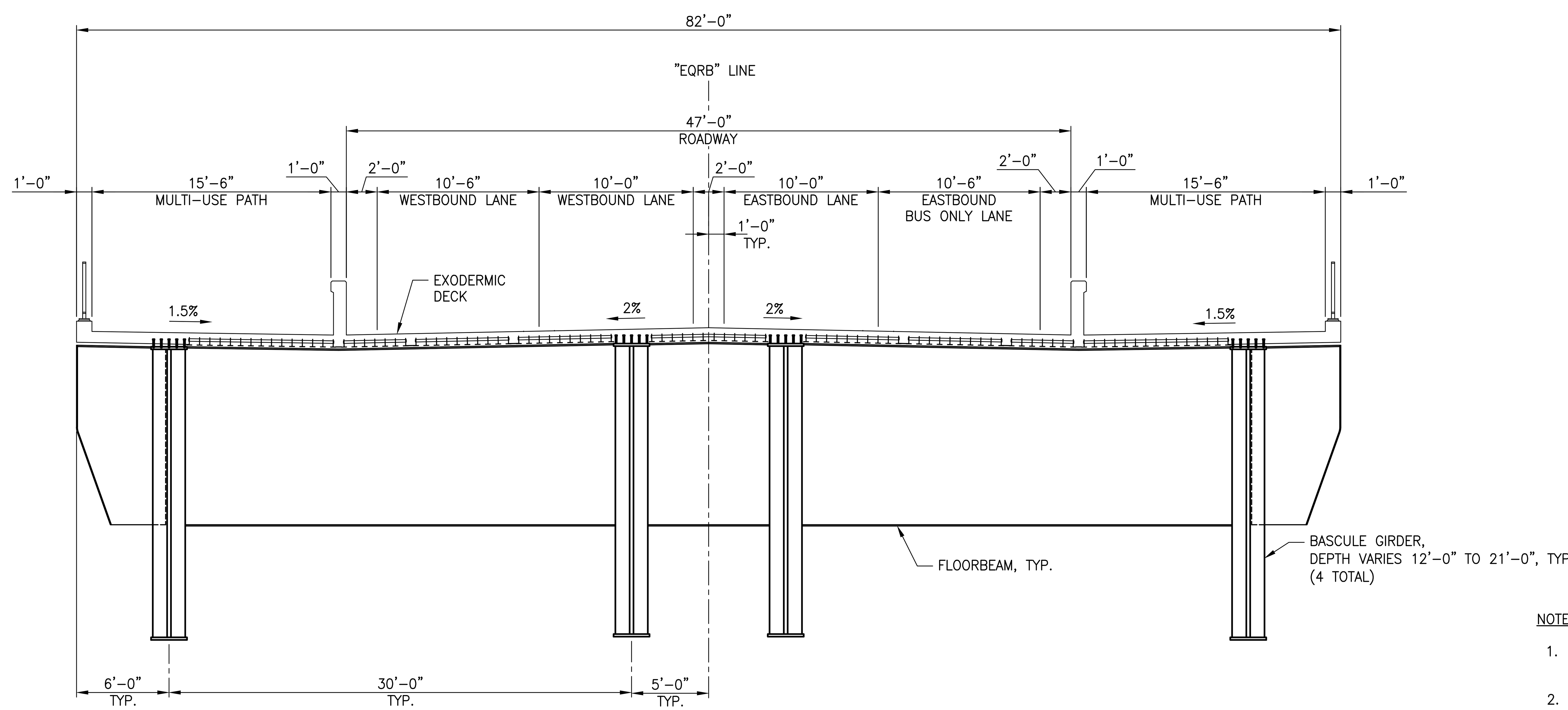
NO	DATE:				

Sheet No. *BR12*



TYPICAL SECTION - SPAN 5

SCALE: 1" = 5'-0"



TYPICAL SECTION - BASCULE SPAN

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.
3. ADDITIONAL BRIDGE WIDTH WITHIN EXTENTS OF PIER 6&7 NOT SHOWN.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Typical Sections -2

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR* DRAFTED BY: *HDR* CHECKED BY: *HDR*

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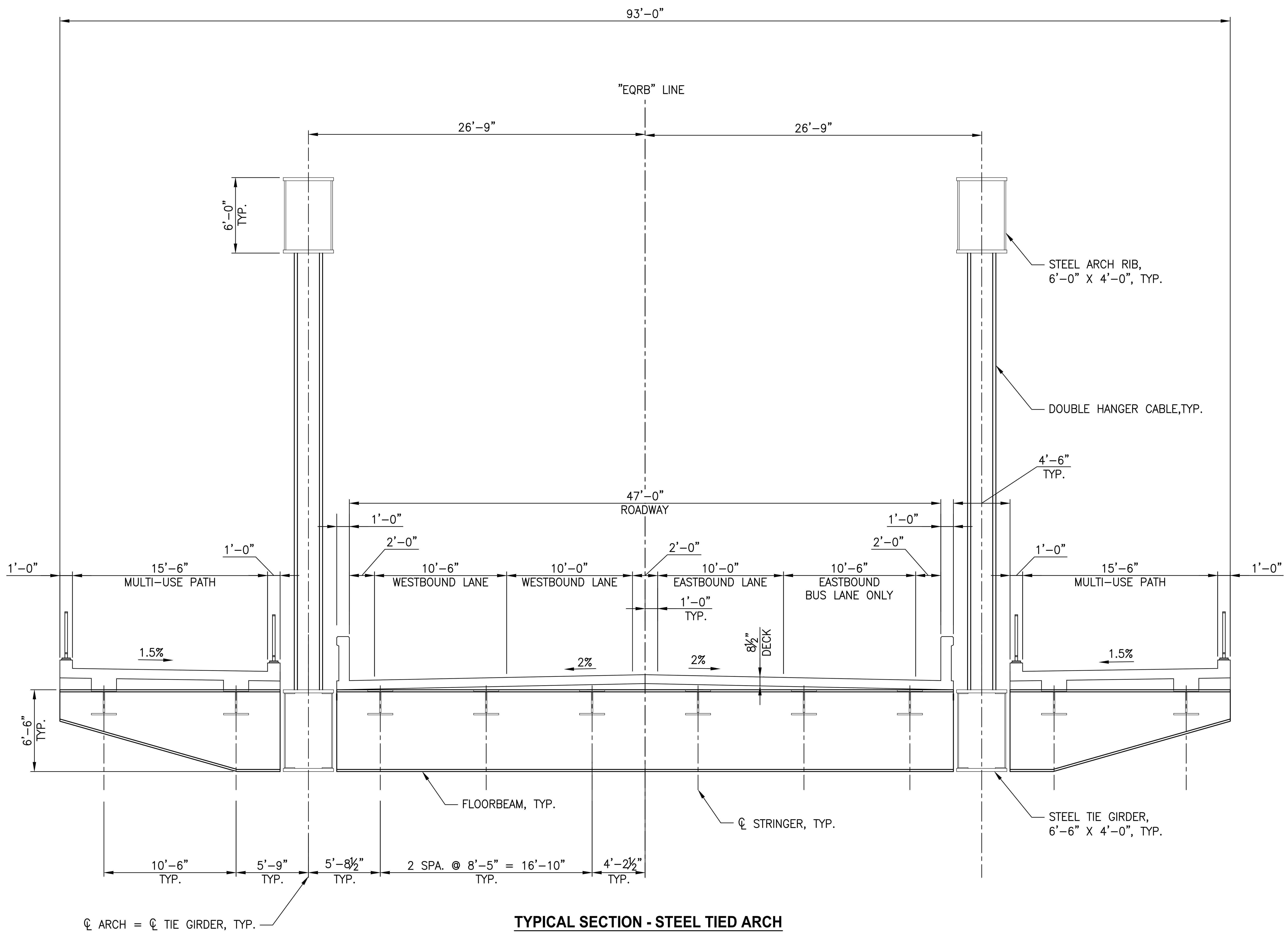
NO.	DATE:			

Sheet No. *BR13*



TYPICAL SECTION - STEEL TIED ARCH

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Typical Sections -3

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

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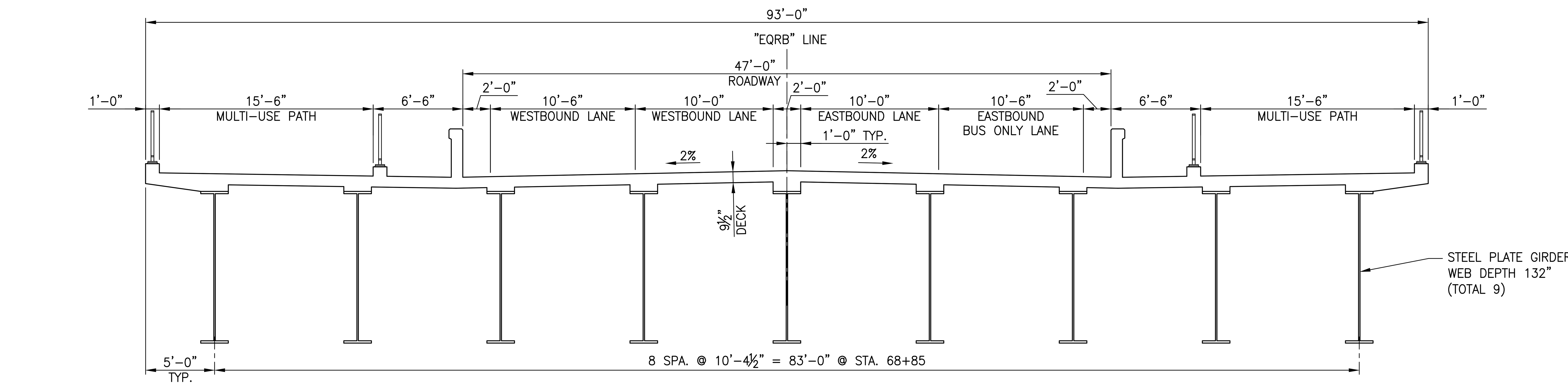
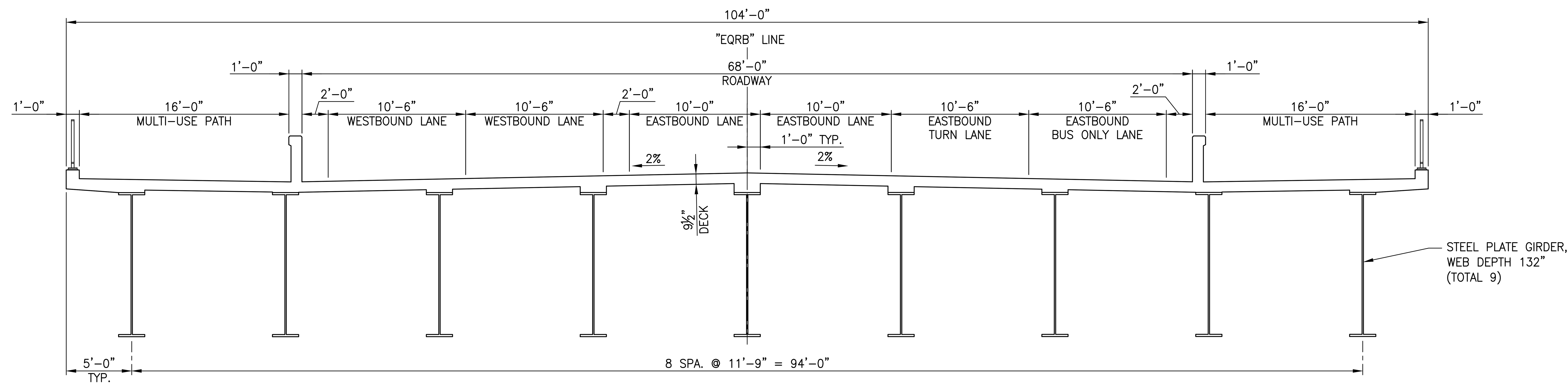


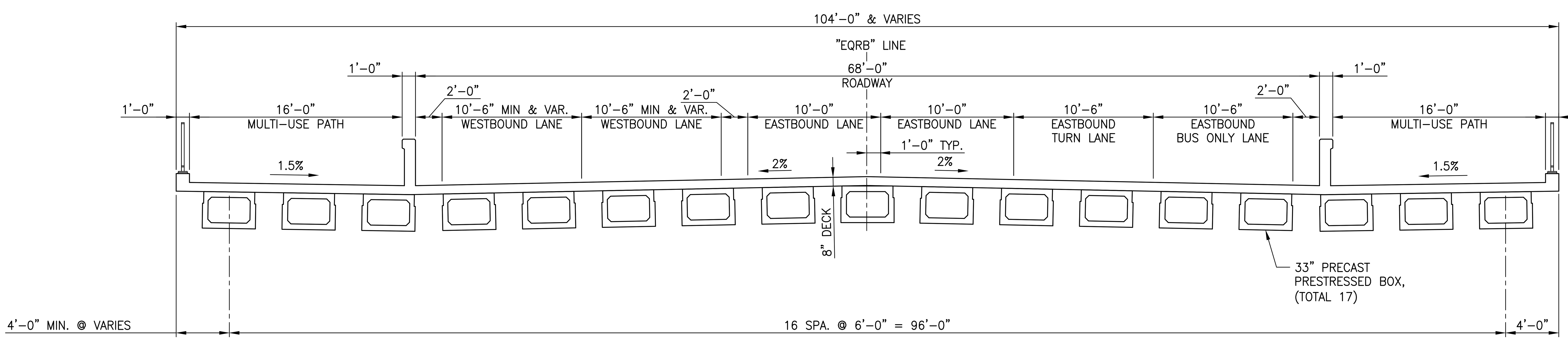
TYPICAL SECTION - SPAN 8

SCALE: 1" = 5'-0"
(AT BENT 8)



TYPICAL SECTION - SPAN 8

SCALE: 1" = 5'-0"
(AT BENT 9)



TYPICAL SECTION - SPAN 9

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.
3. BRIDGE WIDTH VARIES THROUGHOUT SPAN 8 DUE TO ADDITION OF TURN LANES & BICYCLE LANE TRANSITIONS.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Typical Sections -4

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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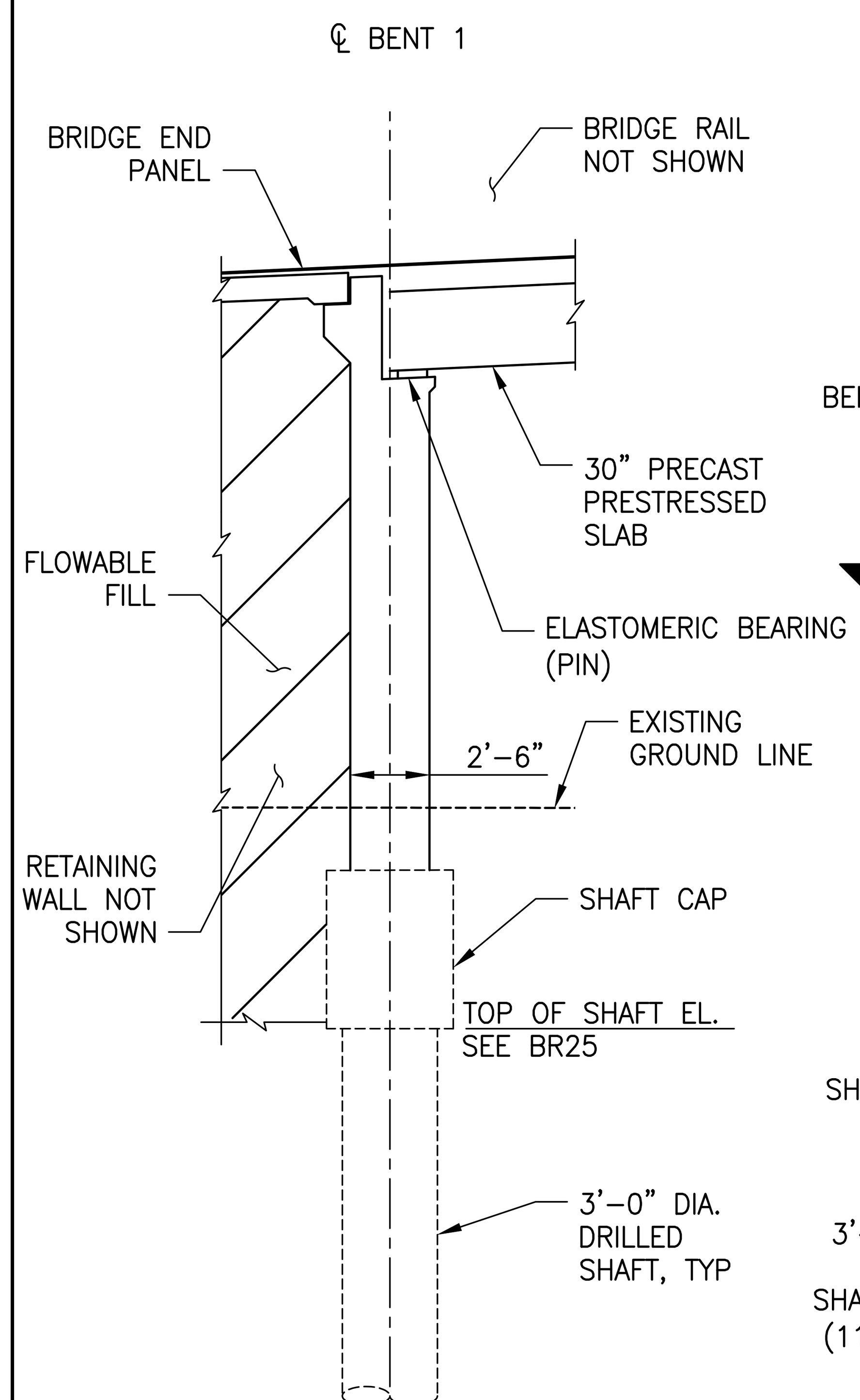
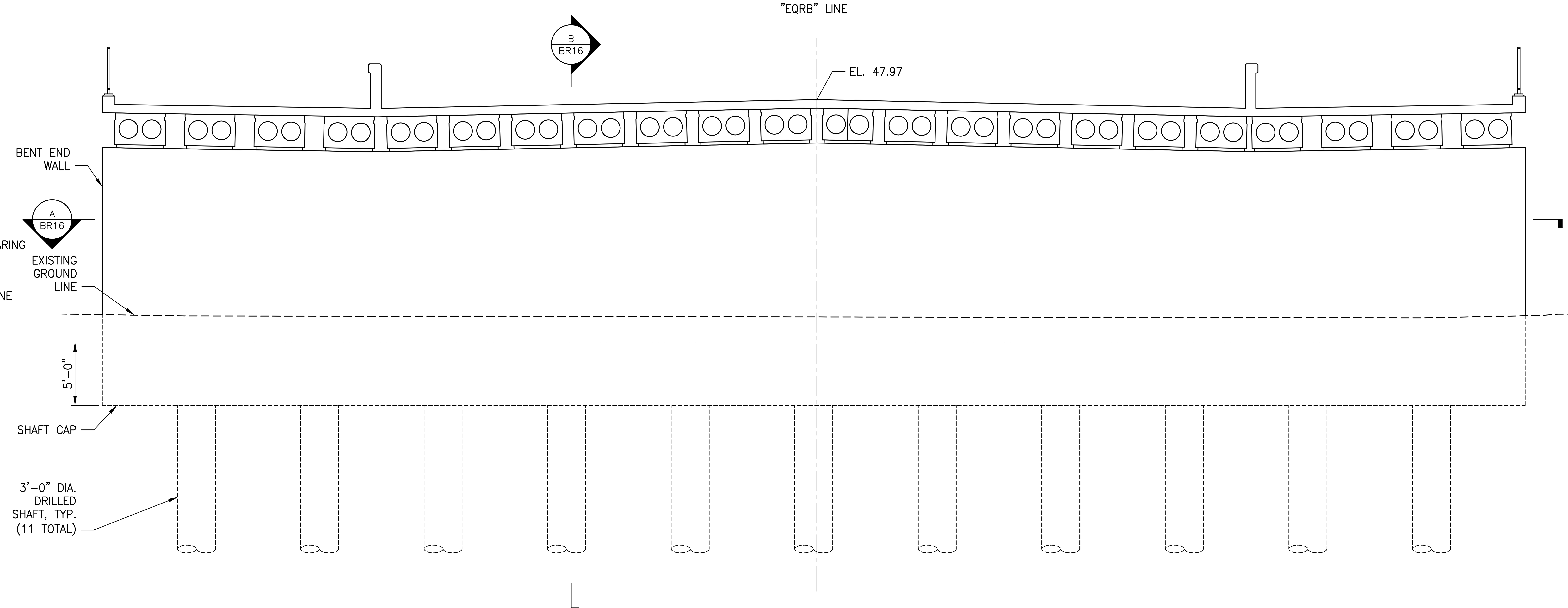
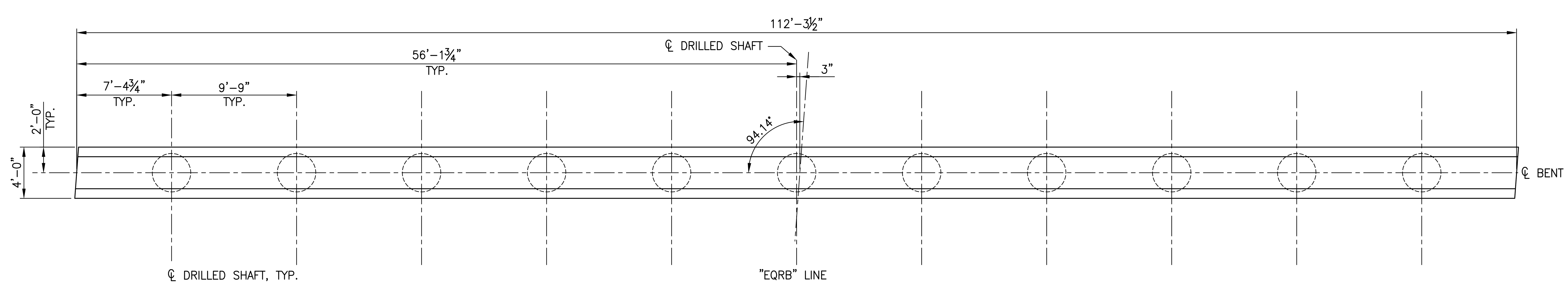
Sheet No. *BR15*



SECTION B
SCALE: 1" = 5'-0"



BENT 1 ELEVATION
SCALE: 1" = 5'-0"
(LOOKING BACK ON STATION)



SECTION A
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 1 Details

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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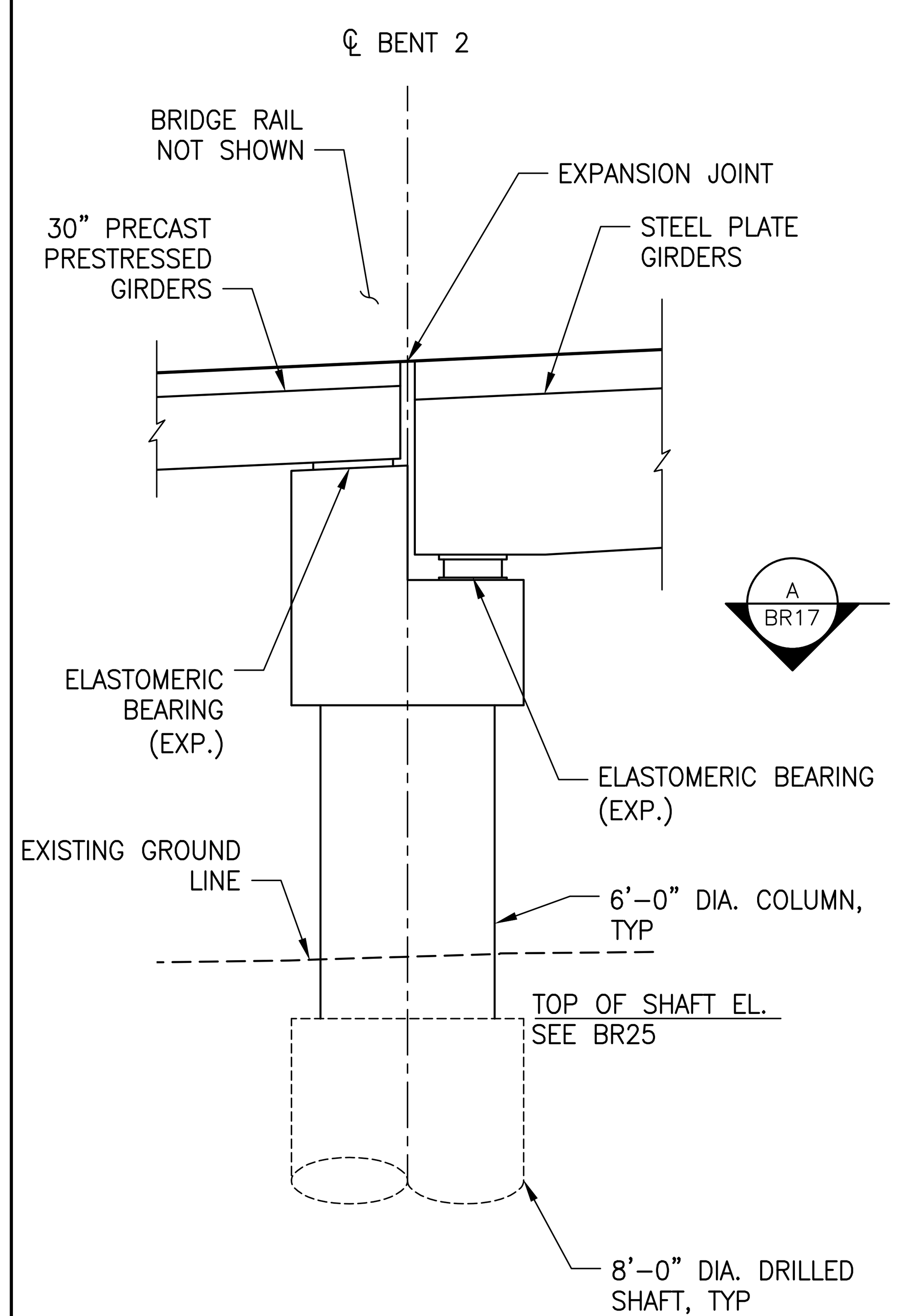
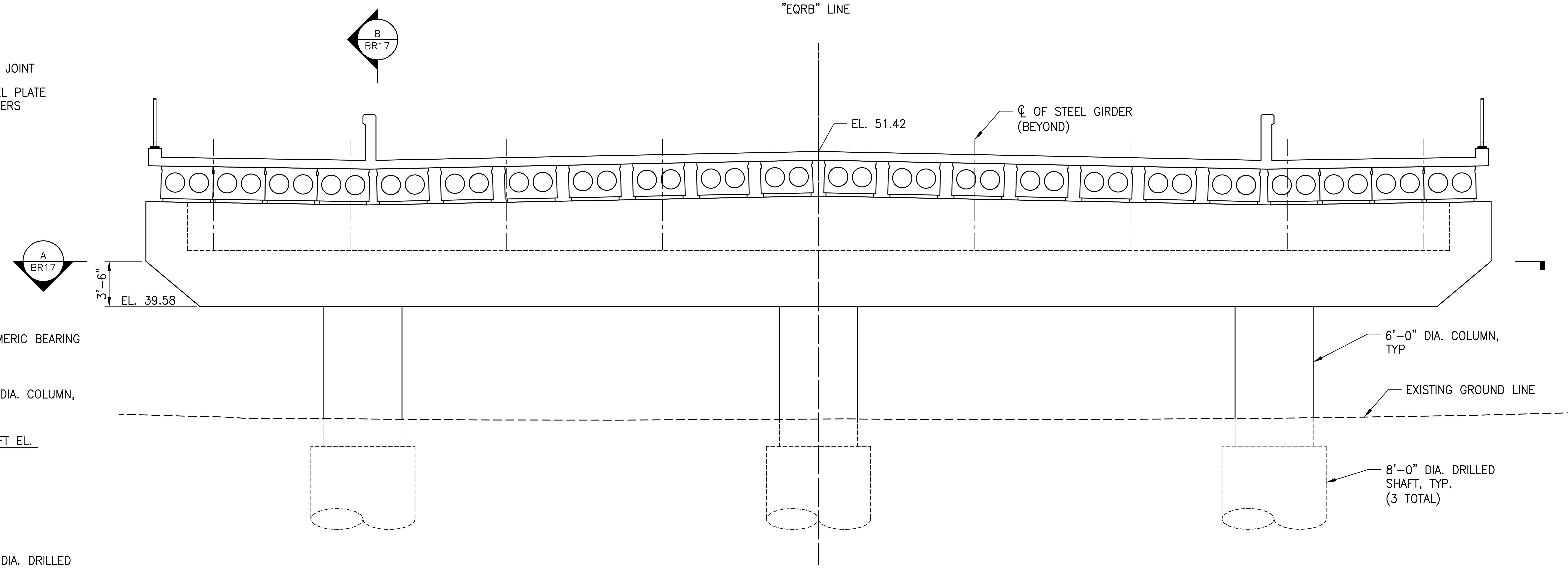
NO	DATE:

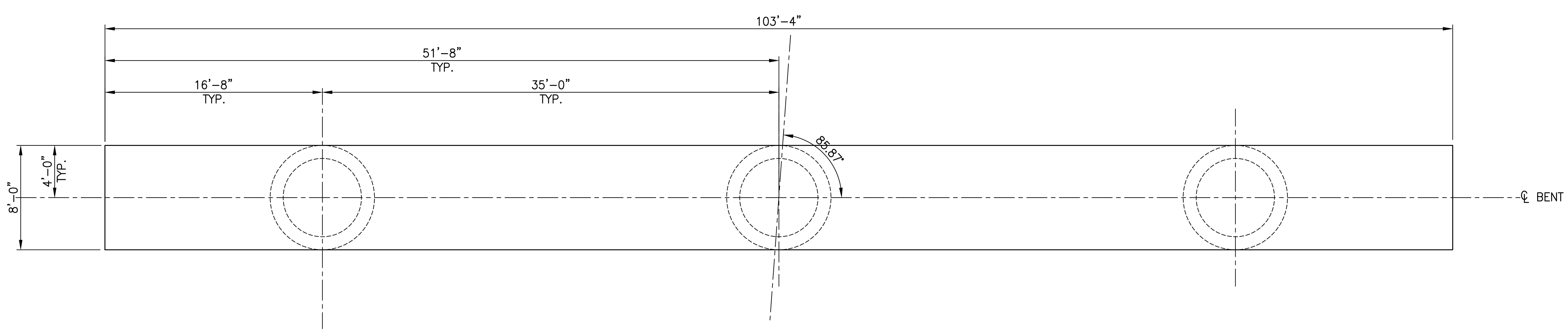
Sheet No. BR16



SECTION B
SCALE: 1" = 5'–0"



BENT 2 ELEVATION
SCALE: 1" = 5'–0"
STEEL PLATE GIRDERS OMITTED FOR CLARITY



SECTION A
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 2 Details
PROJECT NO.:
DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999
JON HENRICHSEN, COUNTY ENGINEER

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CHECKED BY: HDR

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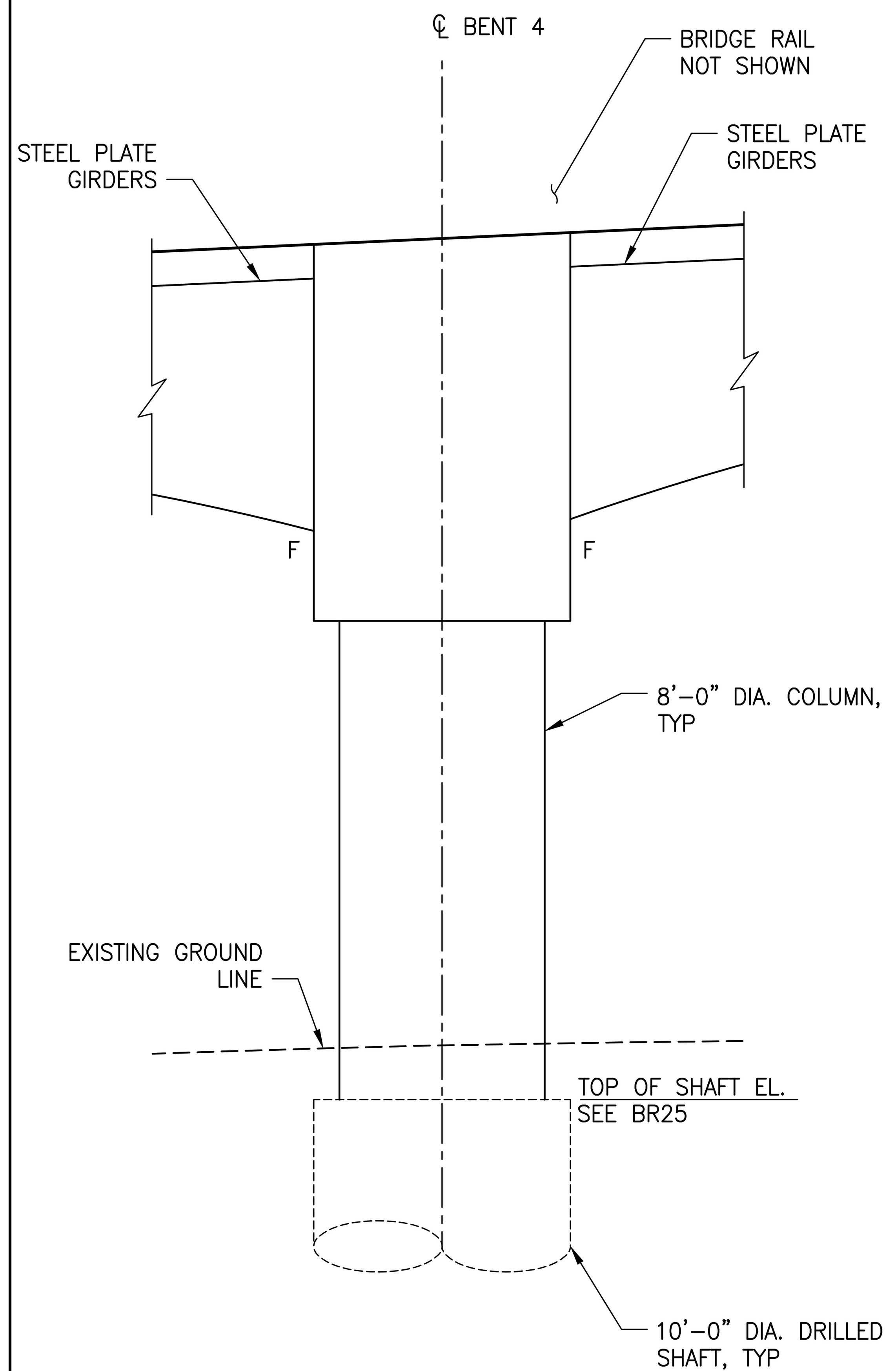
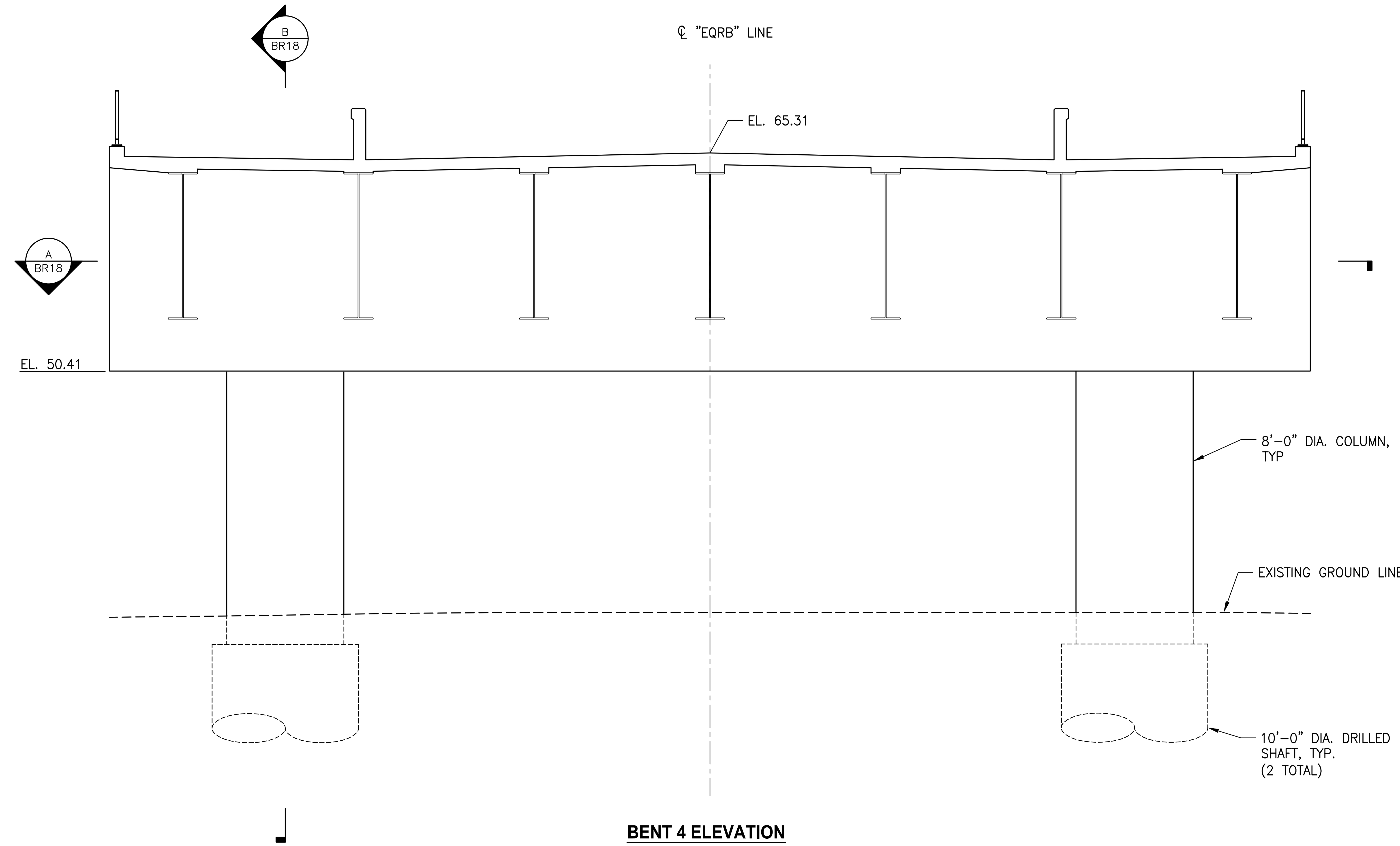
NO | DATE:

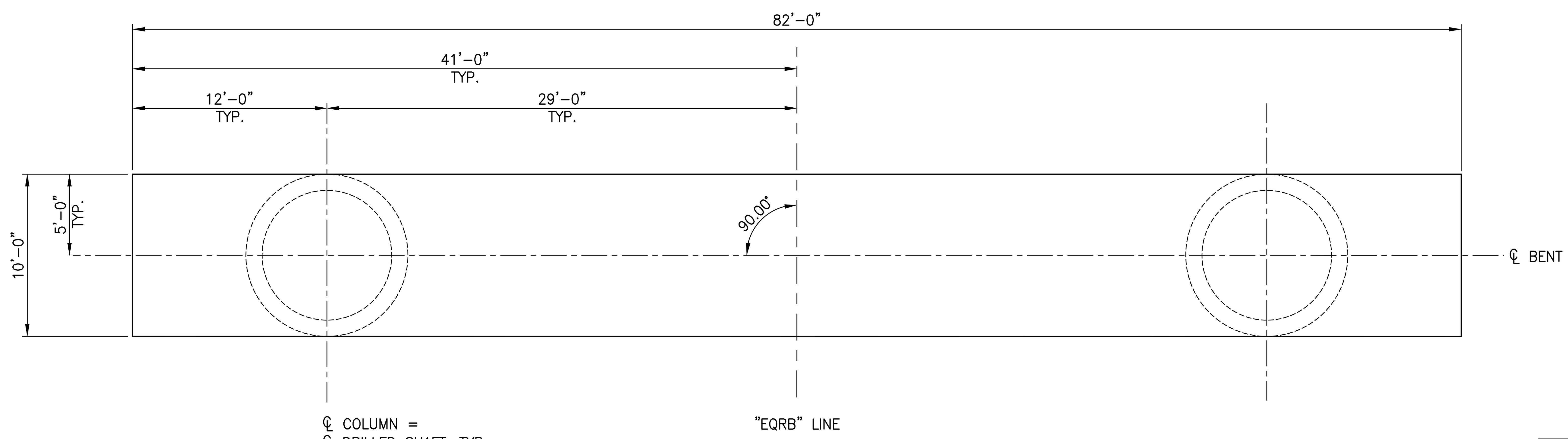
Sheet No. BR17



SECTION B
SCALE: 1" = 5'-0"
(BENT 3 SIMILAR)



BENT 4 ELEVATION
SCALE: 1" = 5'-0"
(BENT 3 SIMILAR)



SECTION A
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 3 and 4 Details
DATE: 9/2022
PROJECT NO.:

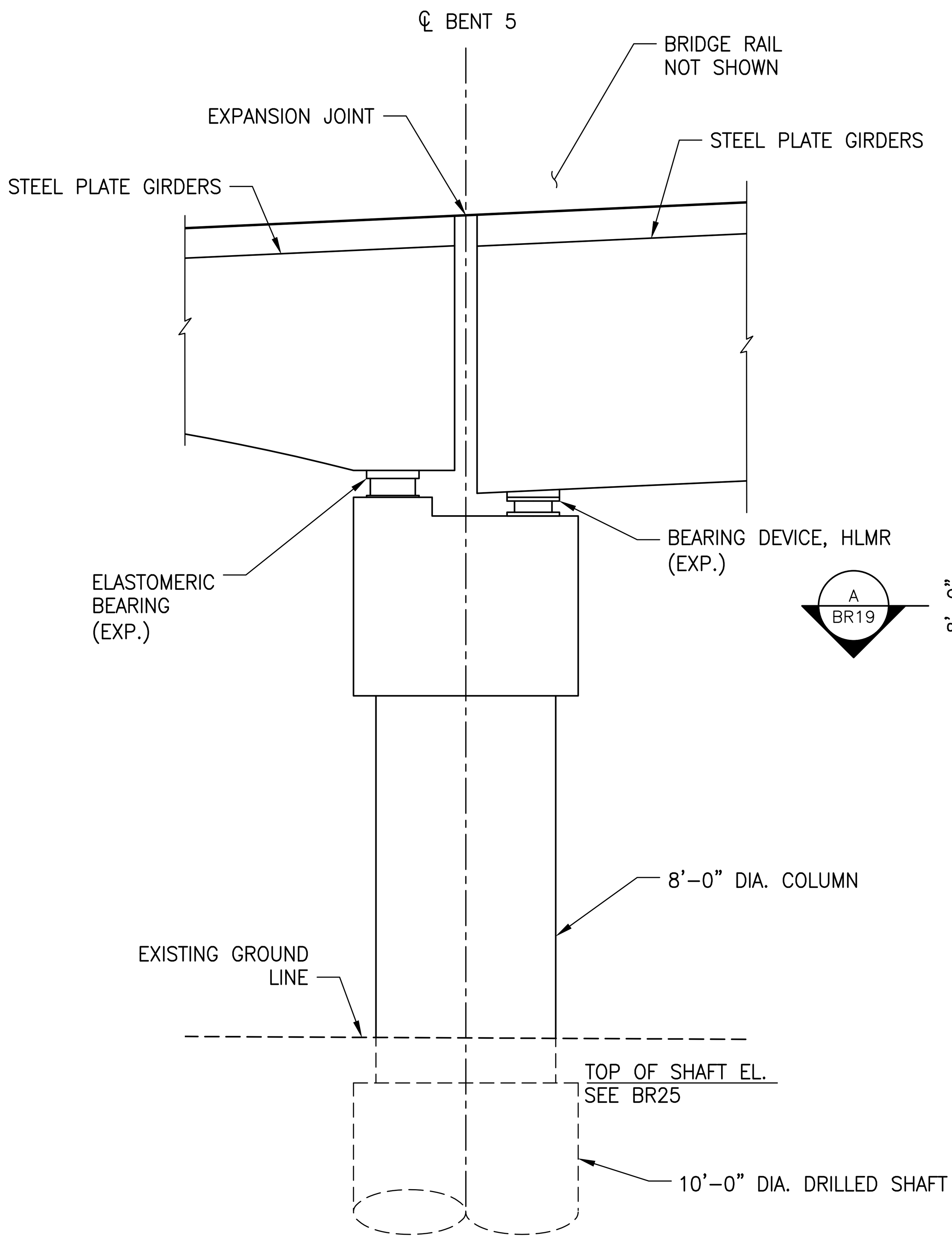
MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

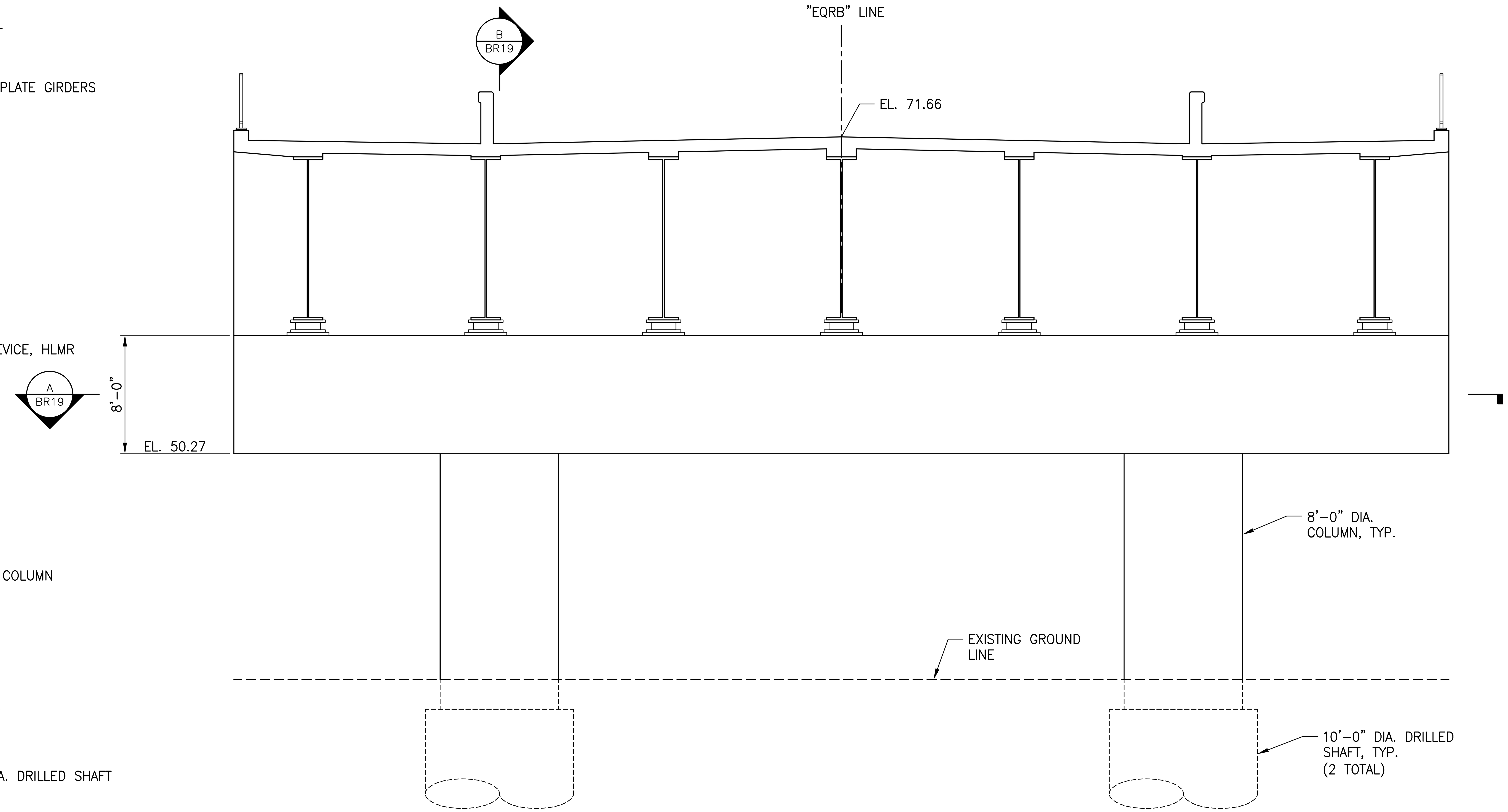
REVISIONS

NO	DATE:				

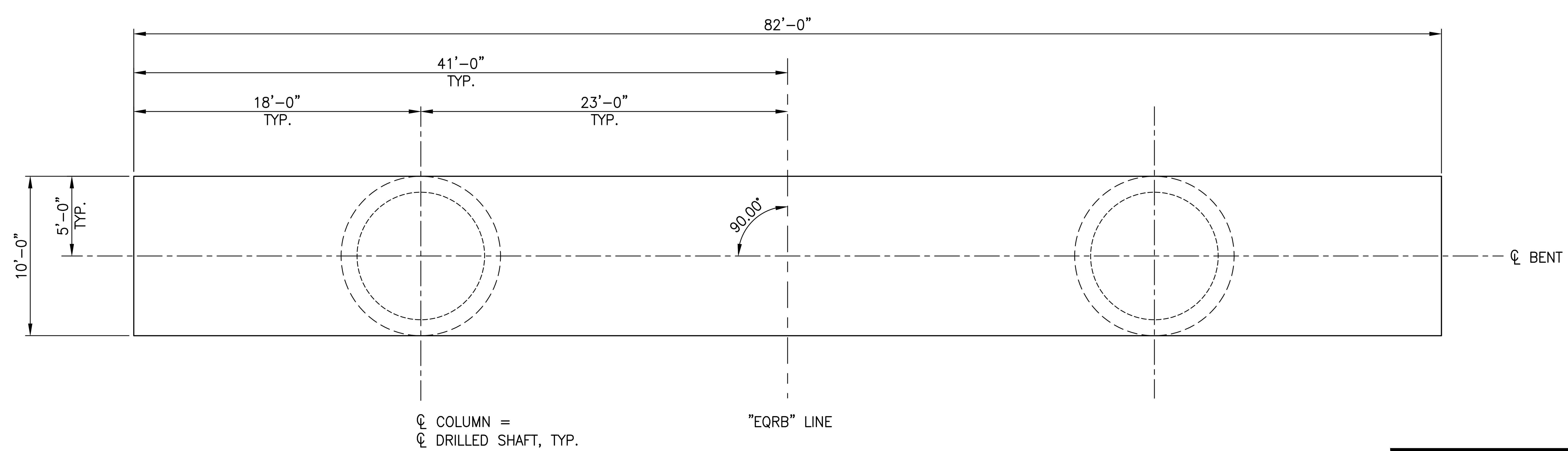
Sheet No. BR18



SECTION B
SCALE: 1" = 5'-0"



BENT 5 ELEVATION
SCALE: 1" = 5'-0"
(LOOKING BACK ON STATION)



SECTION A
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 5 Details

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

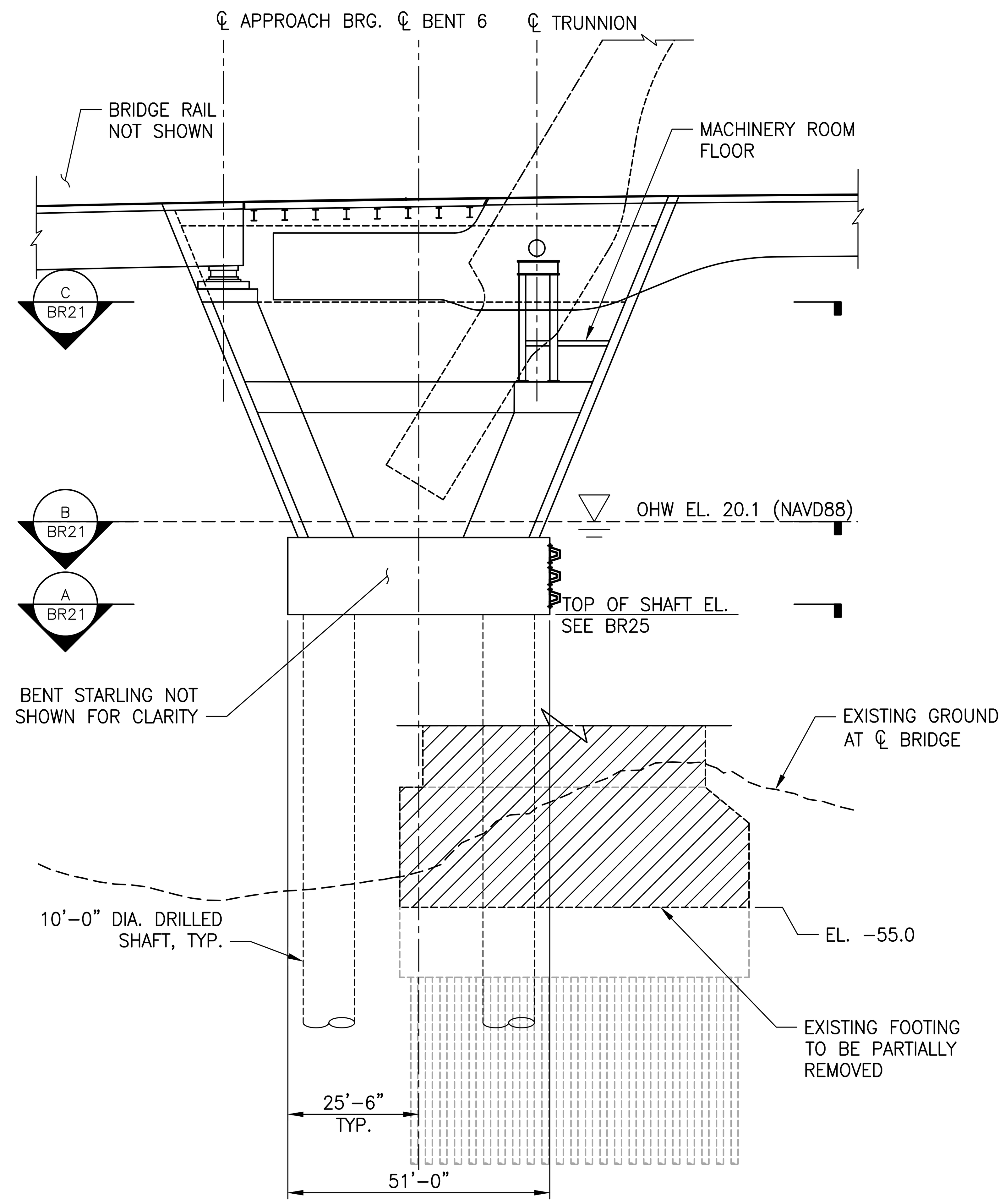
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

REVISIONS

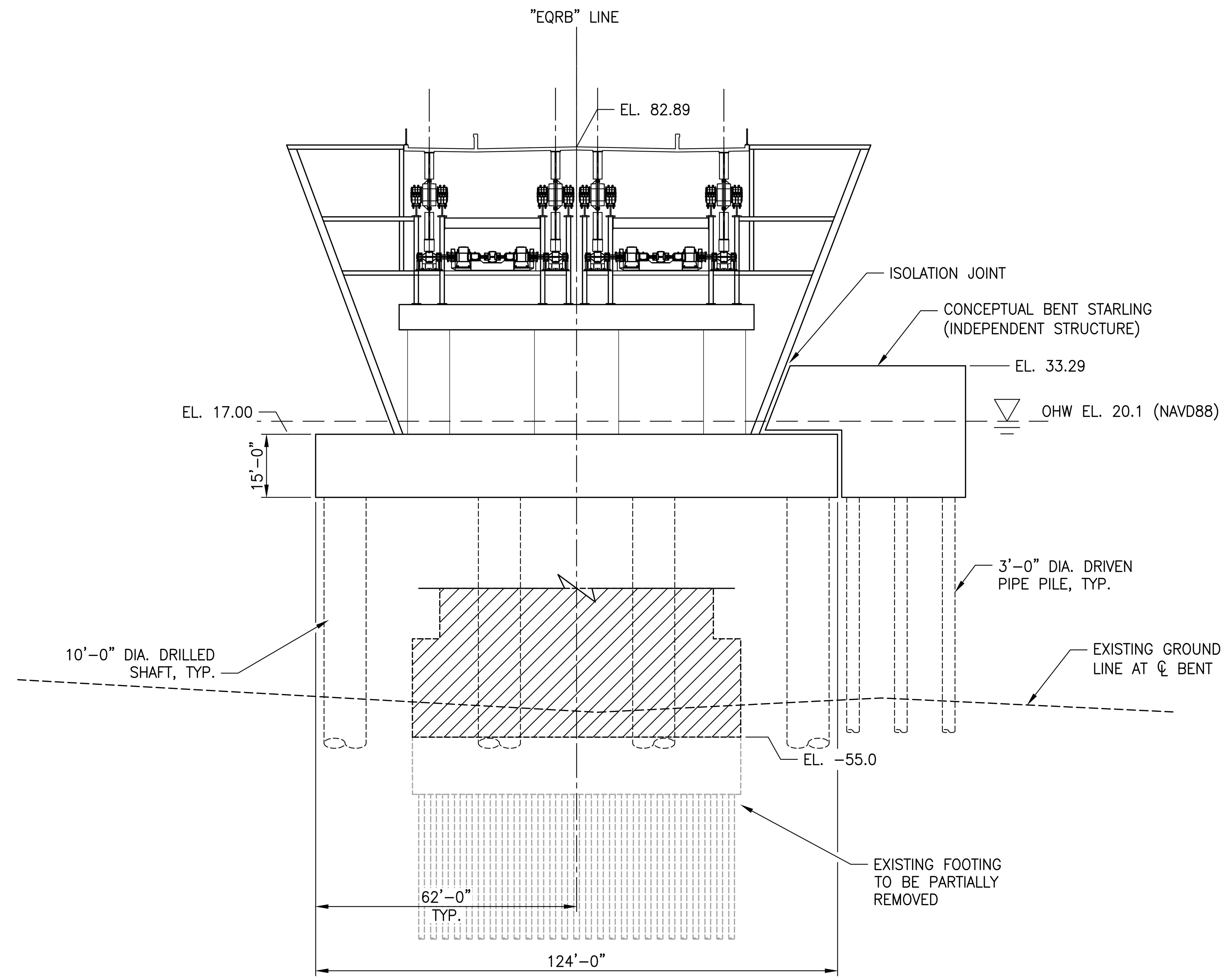
NO	DATE:

Sheet No. BR19



BENT 6 ELEVATION

SCALE: 1" = 20'–0"
(LOOKING NORTH, BENT 7 SIMILAR BUT MIRRORED)



BENT 6 SIDE ELEVATION

SCALE: 1" = 20'–0"
(BENT 7 SIMILAR BUT MIRRORED)

NOTES:

1. CONCEPTUAL OPERATOR HOUSE NOT SHOWN.
2. FOR ADDITIONAL DETAIL SEE ARCHITECTURAL DRAWINGS.

LEGEND

BRIDGE REMOVAL

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 6 and 7 Elevations

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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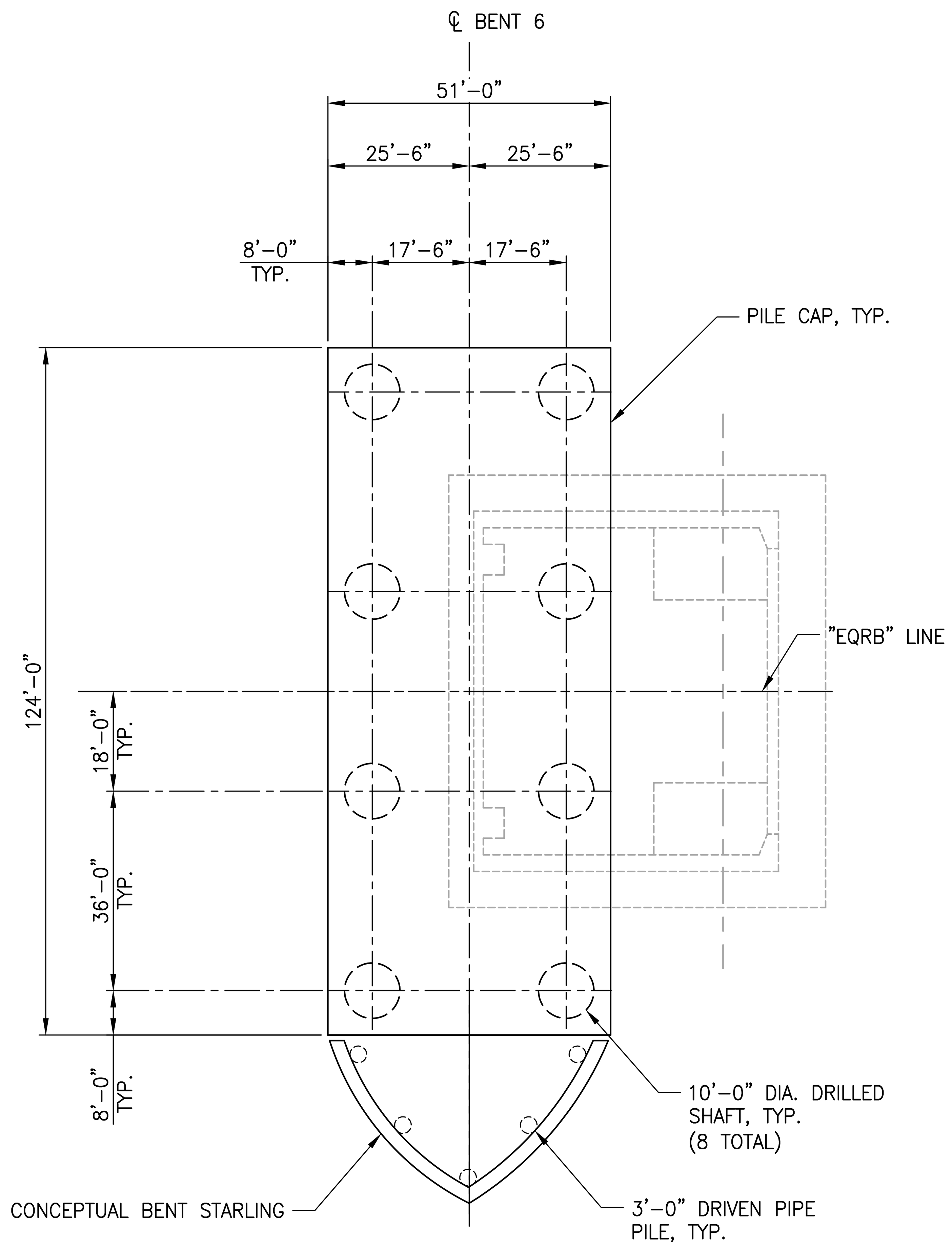
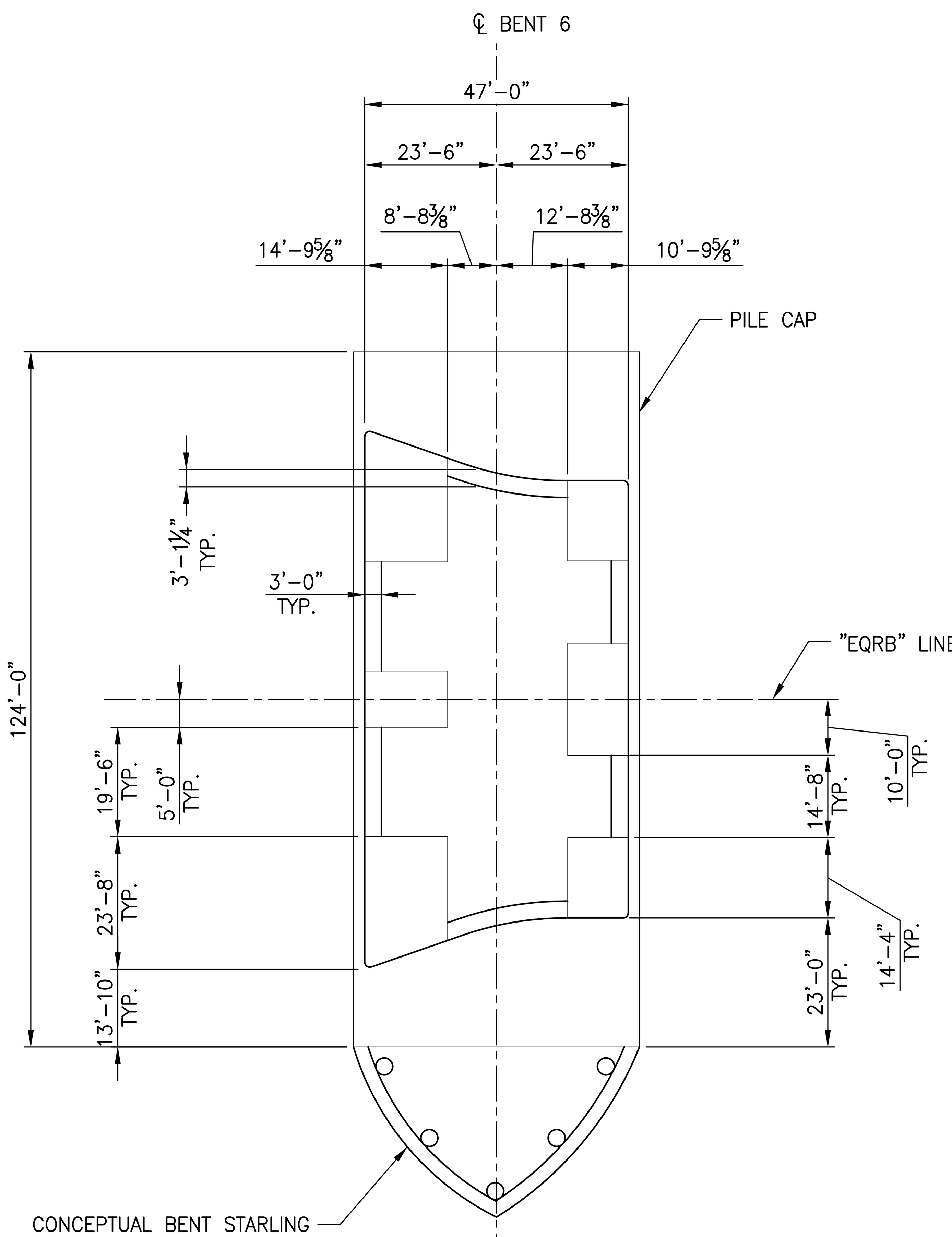
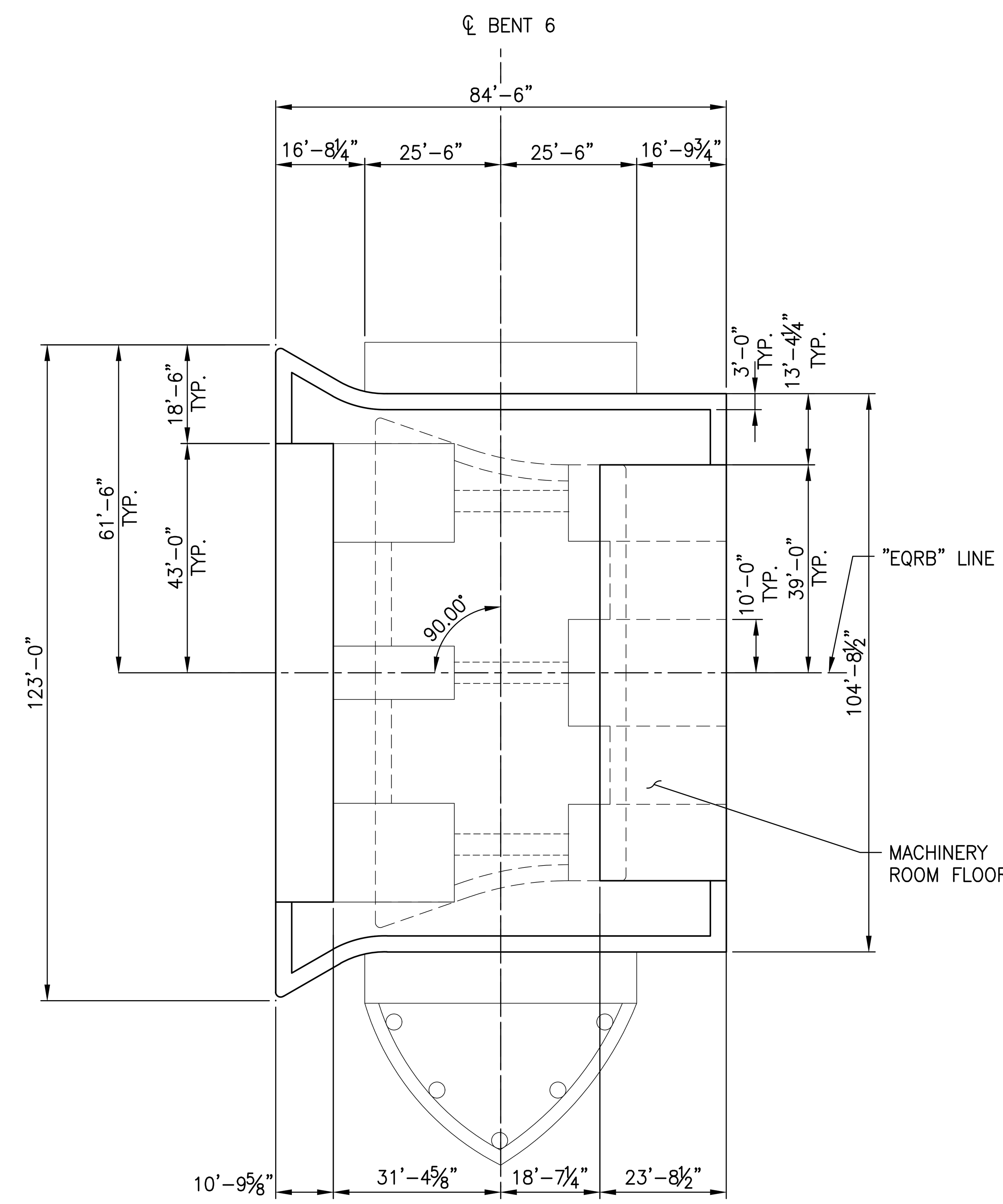


SECTION A
SCALE: 1" = 10'-0"



SECTION B
SCALE: 1" = 10'-0"



SECTION C
SCALE: 1" = 10'-0"
(AT MACHINERY ROOM FLOOR)

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 6 and 7 Sections

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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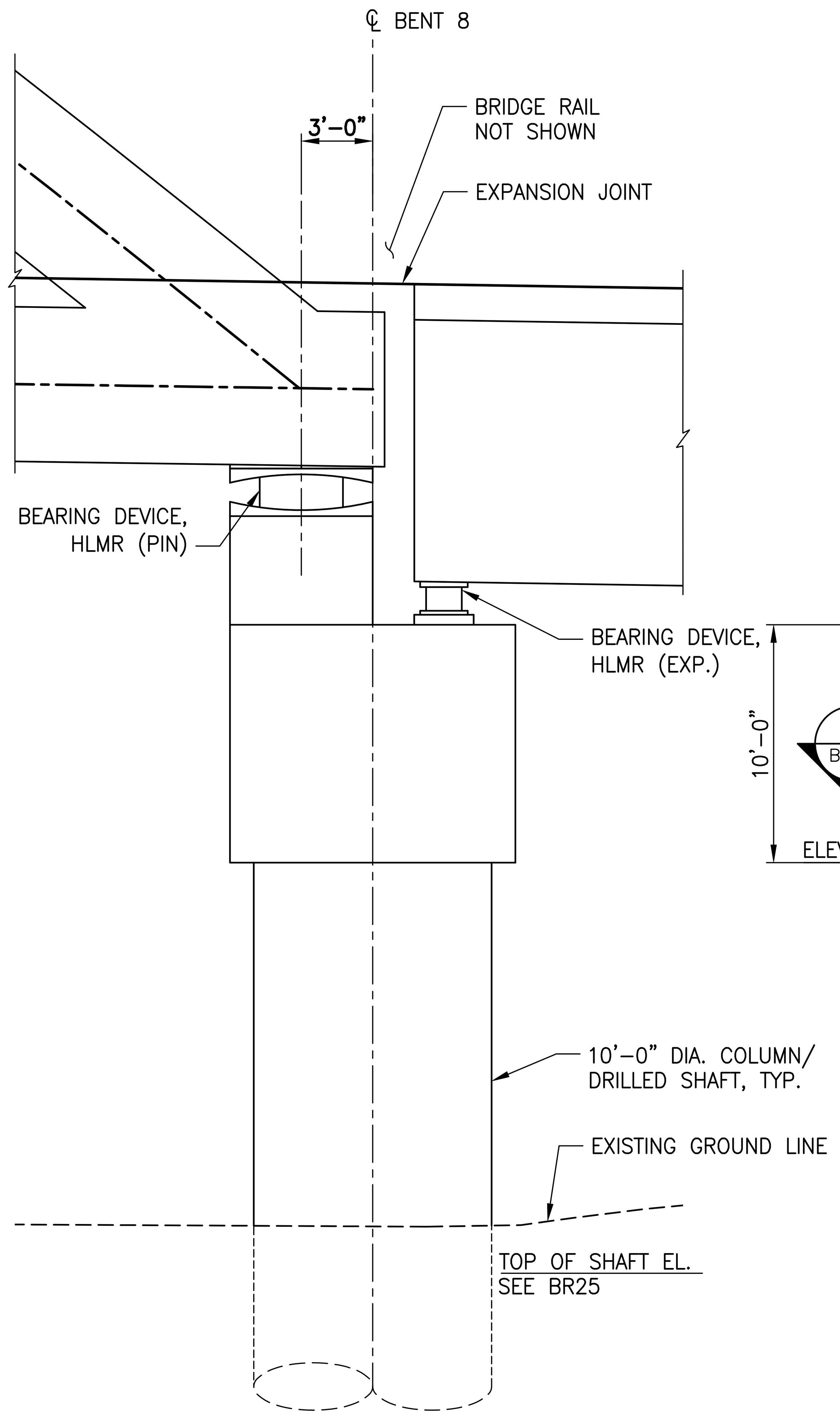
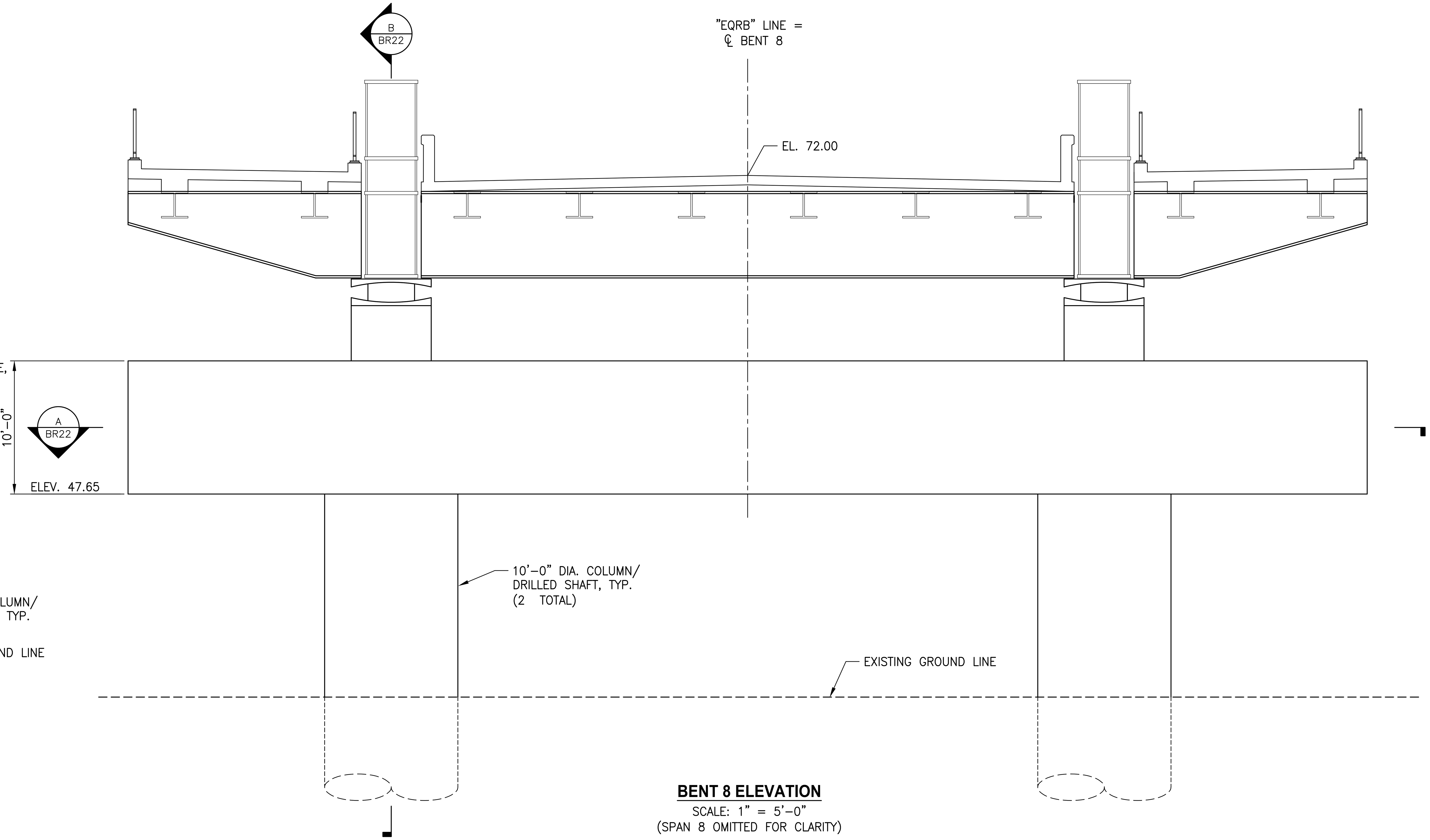
NO	DATE:

Sheet No. BR21

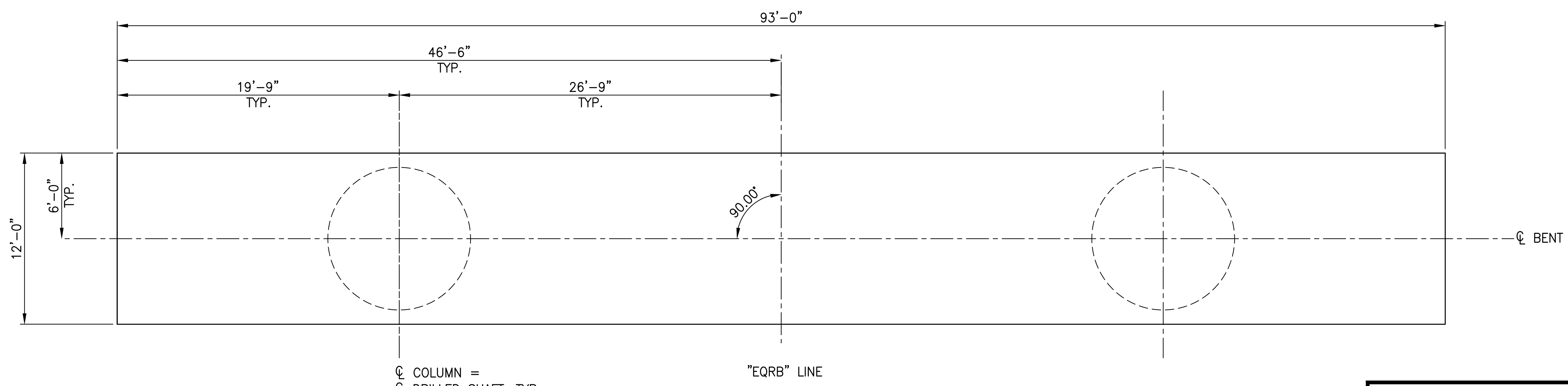
CONCEPTUAL PLANS
SEPTEMBER 2022



SECTION B
SCALE: 1" = 5'–0"



BENT 8 ELEVATION
SCALE: 1" = 5'–0"
(SPAN 8 OMITTED FOR CLARITY)



SECTION A
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 8 Details

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

JON HENRICHSEN, COUNTY ENGINEER

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CHECKED BY: HDR

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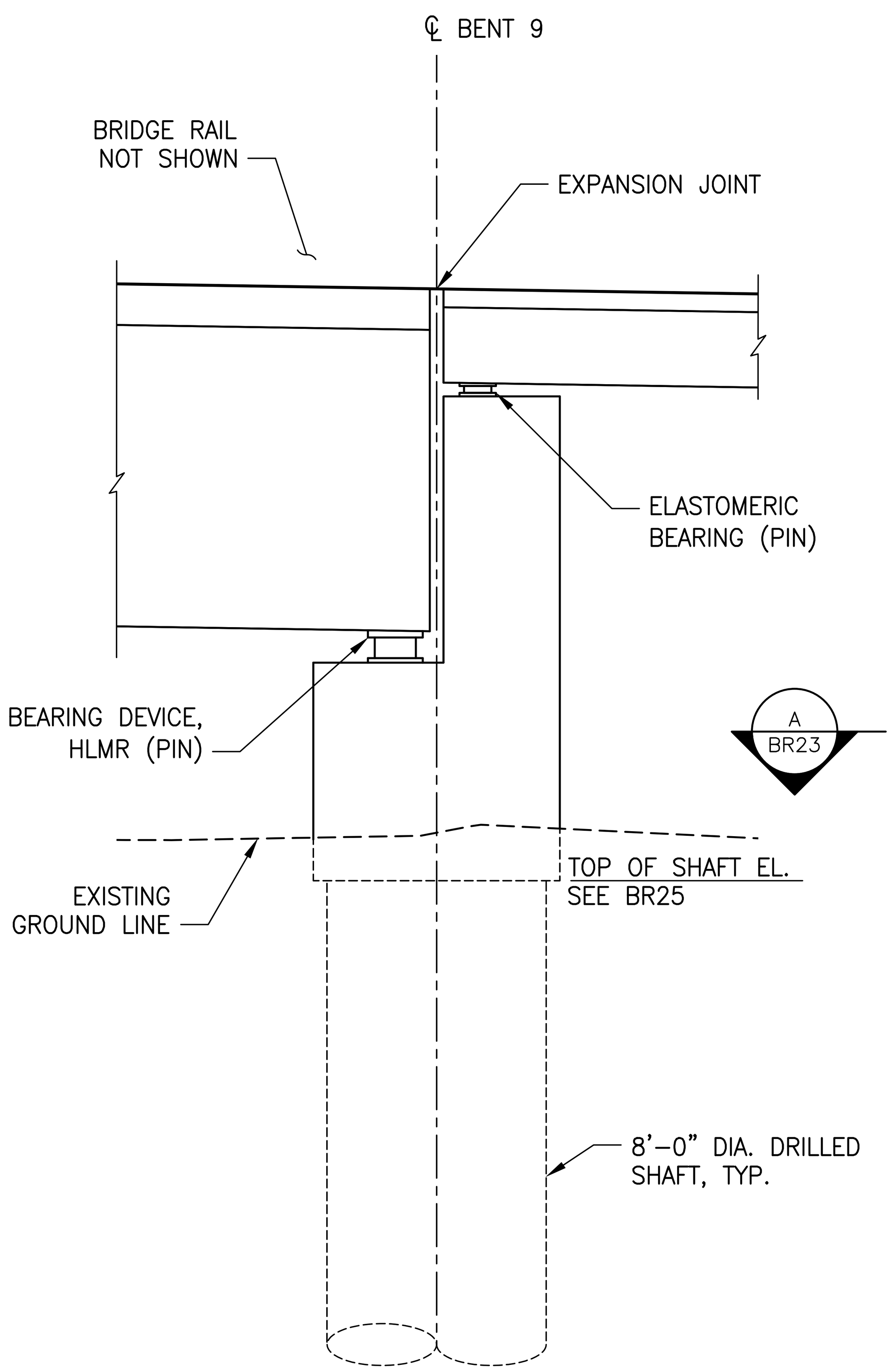
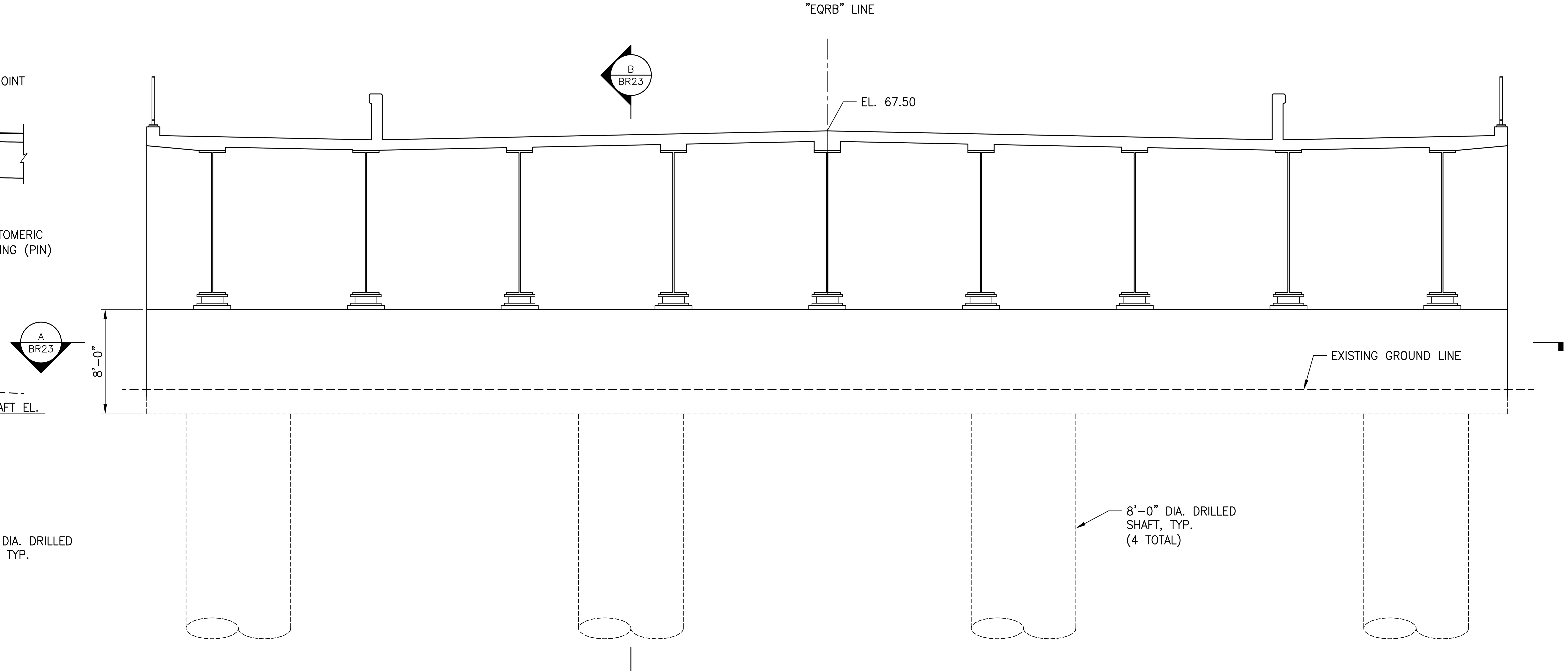
NO	DATE:			

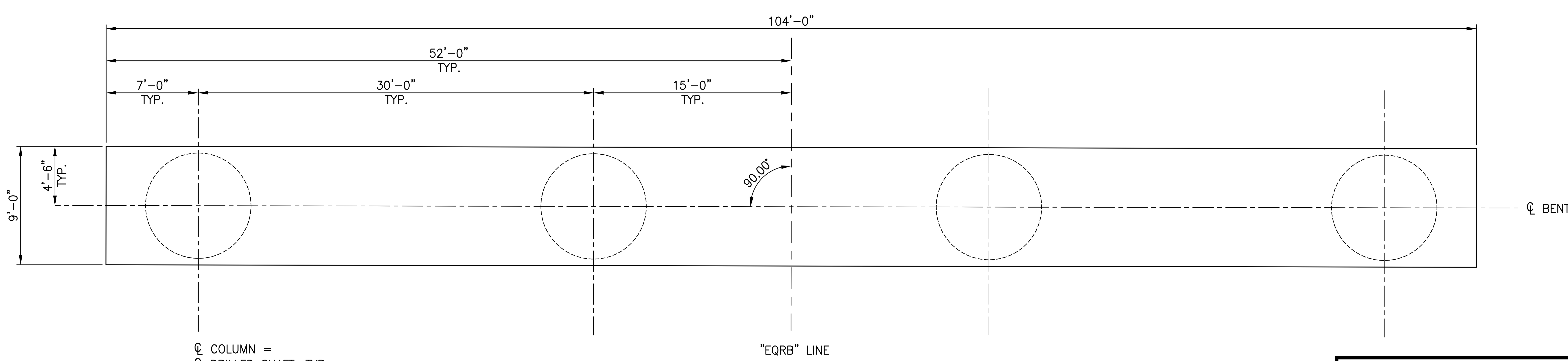
Sheet No. BR22



SECTION B
SCALE: 1" = 5'-0"



BENT 9 ELEVATION
SCALE: 1" = 5'-0"



SECTION A
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 9 Details

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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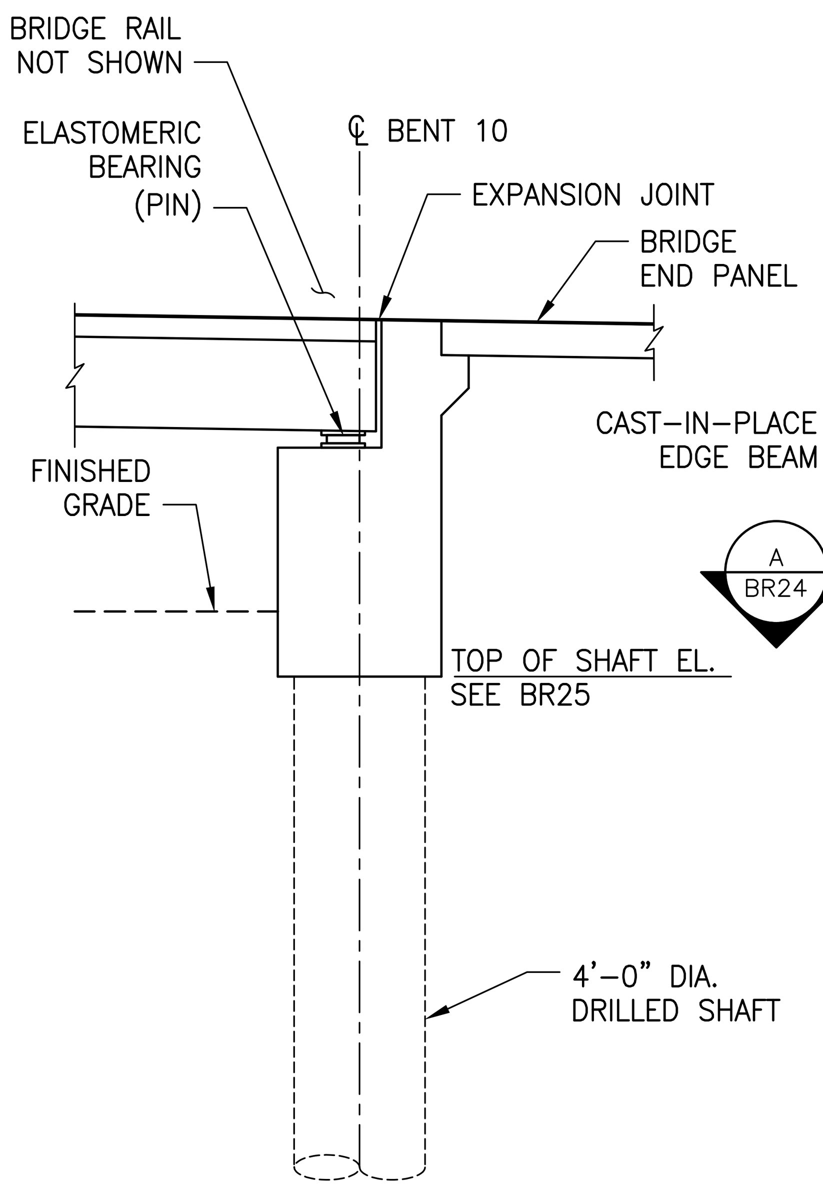
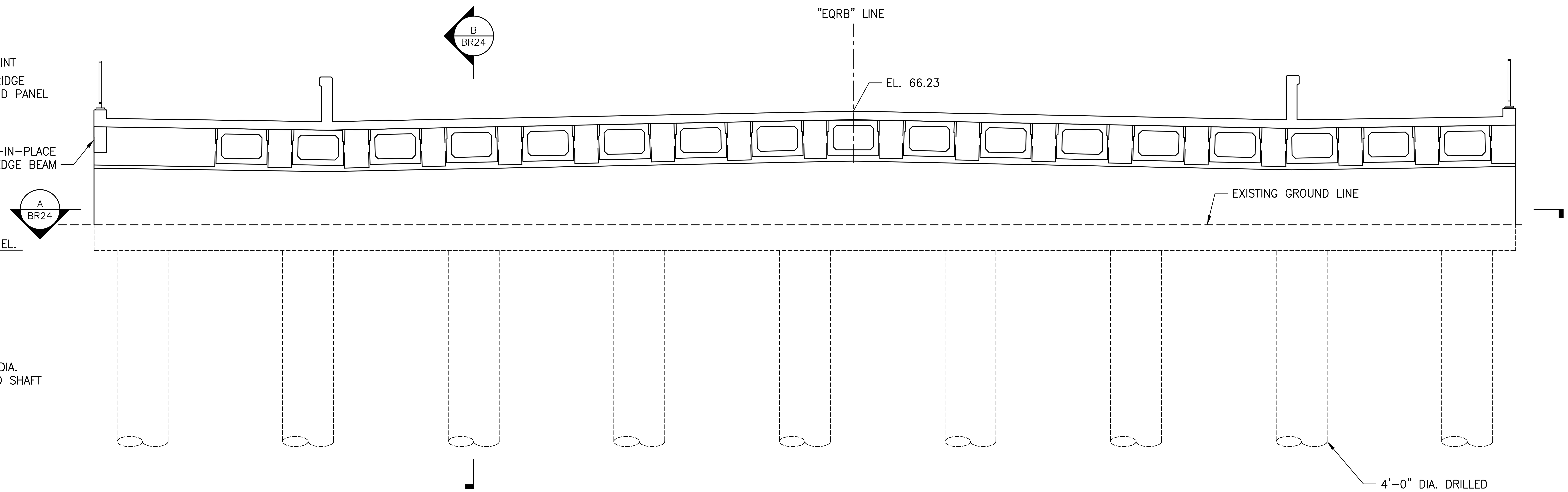
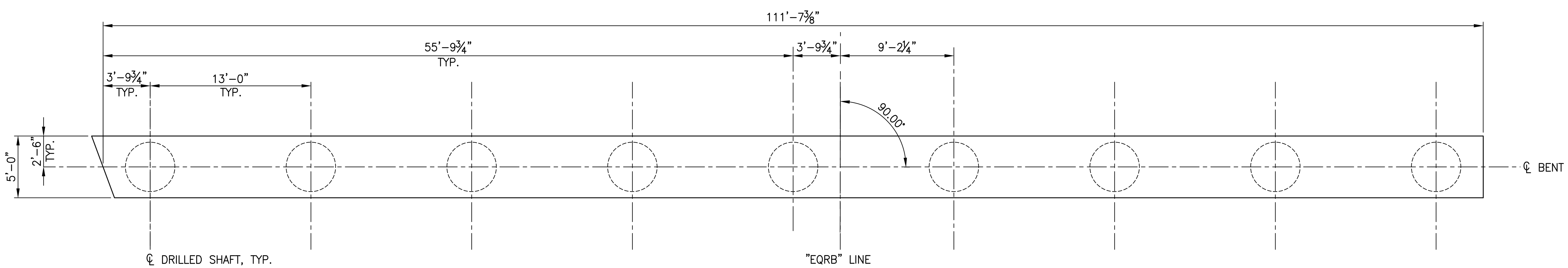
Sheet No. BR23



SECTION B
SCALE: 1" = 5'–0"



BENT 10 ELEVATION
SCALE: 1" = 5'–0"



SECTION A
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Tied Arch Approach
Bent 10 Details
DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

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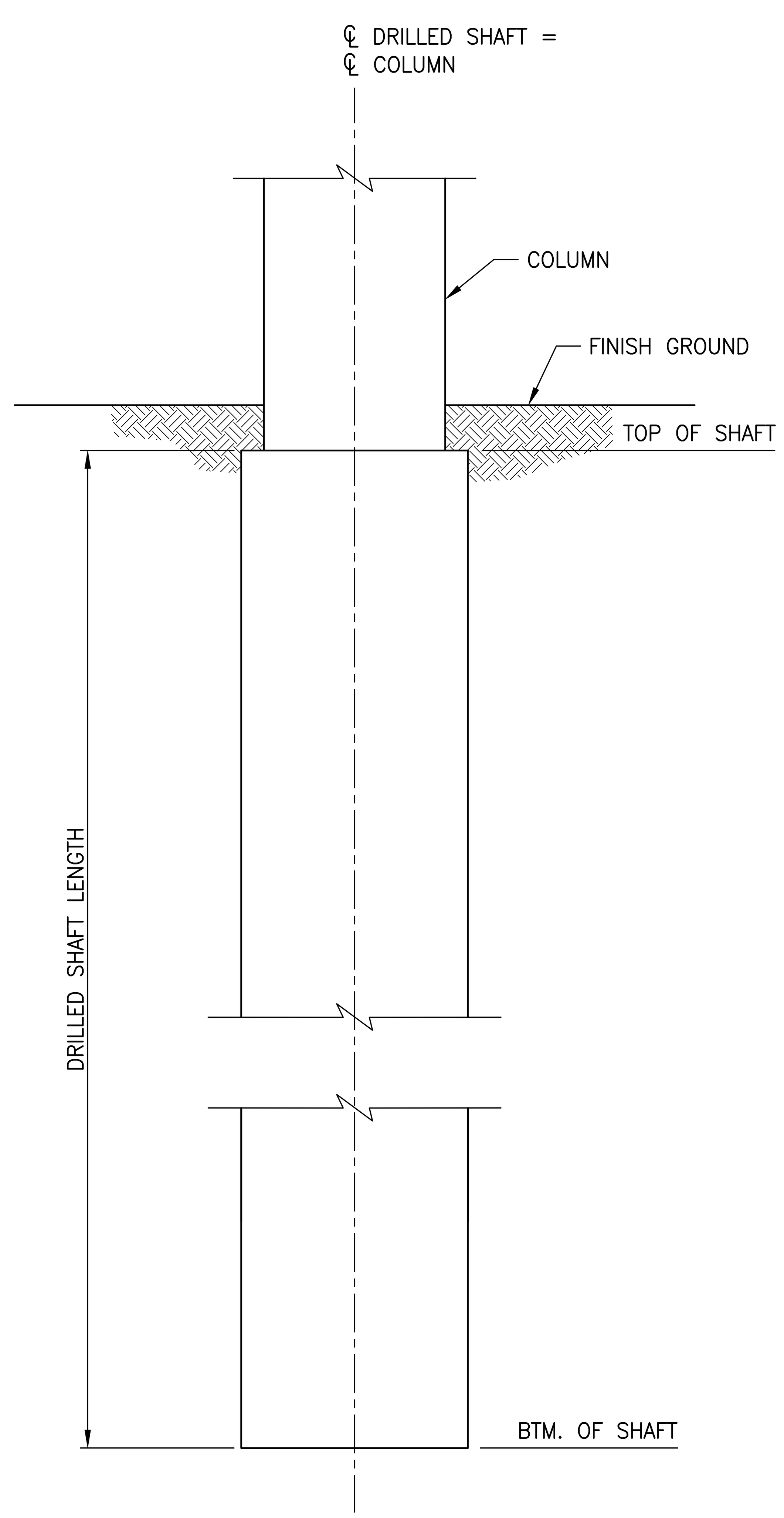
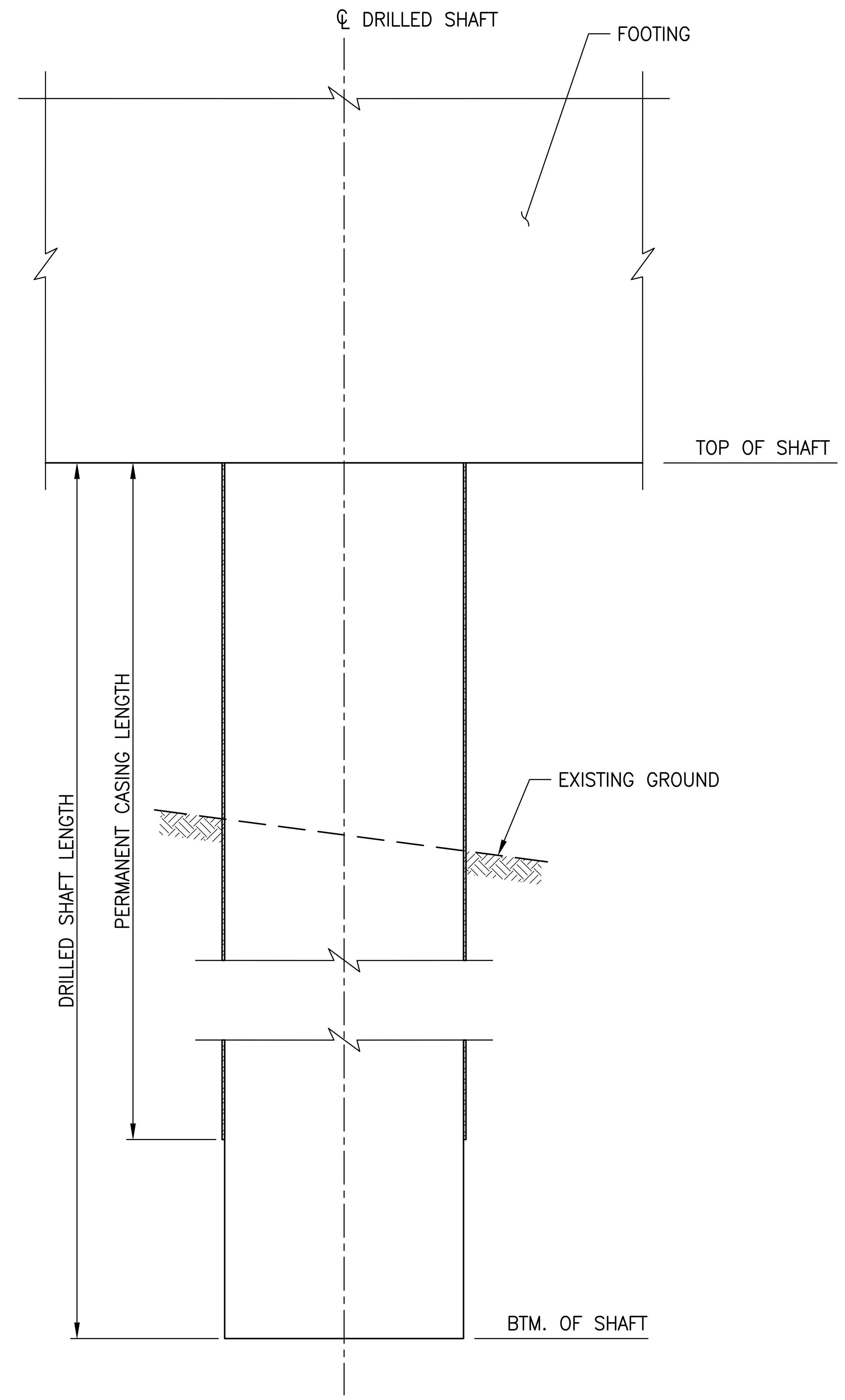
NO	DATE:				

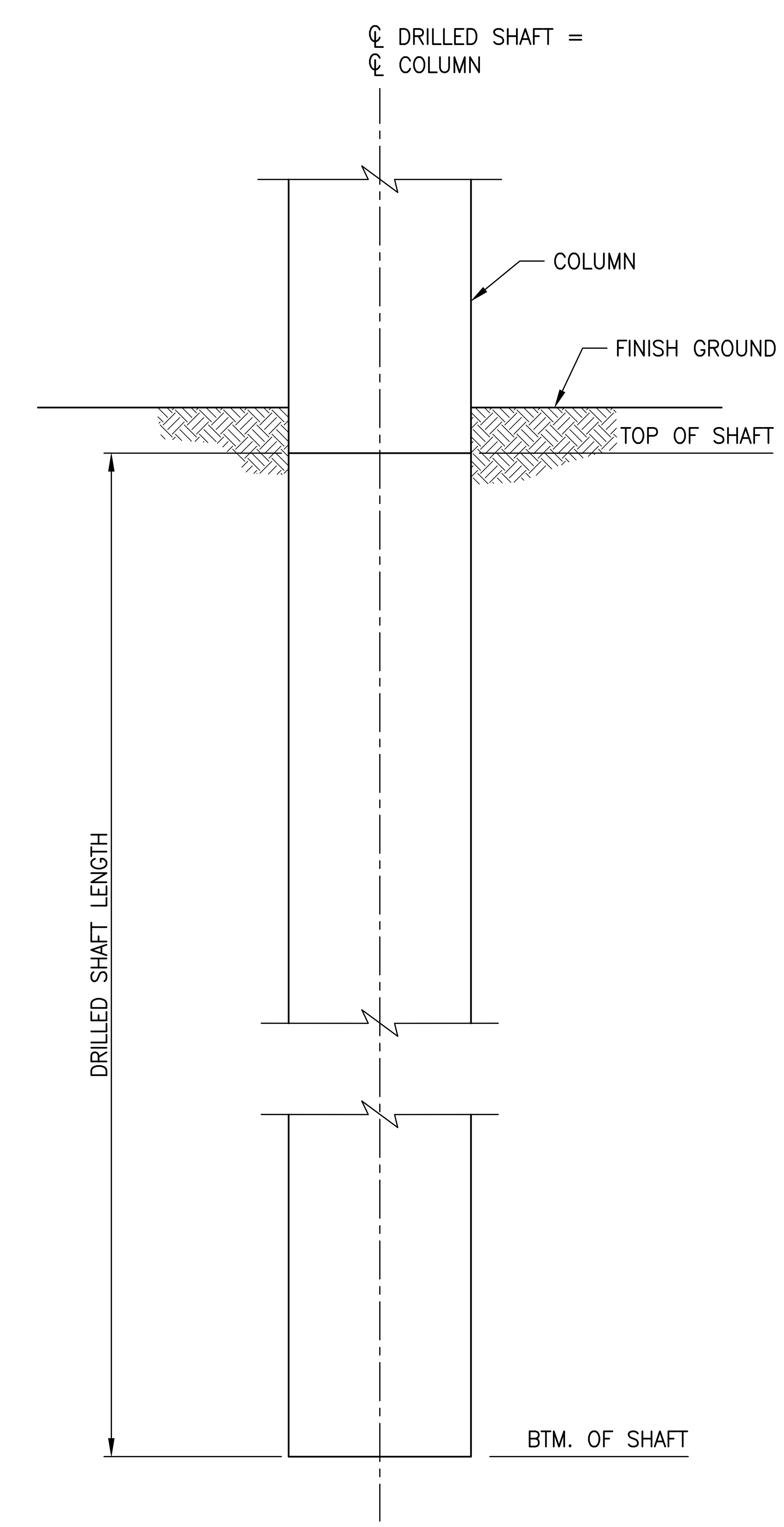
Sheet No. *BR24*



DRILLED SHAFT DETAIL - BENTS 1 - 5, 9 & 10
NOT TO SCALE



DRILLED SHAFT DETAIL - BENTS 6 & 7
NOT TO SCALE



DRILLED SHAFT DETAIL - BENT 8
NOT TO SCALE

BENT	SHAFT DIAMETER (FT)	NUMBER OF SHAFTS	ELEVATIONS (NAVD88)					SHAFT LENGTH (FT)	CASING LENGTH (FT)
			FINISH GROUND	ESTIMATED ROCK*	TOP OF SHAFT	BOTTOM OF CASING	BOTTOM OF SHAFT		
1	3.00	11	31.52	−26.47	24.52	NA	−42.00	66.52	NA
2	8.00	3	31.50	−33.85	29.50	NA	−65.00	94.50	NA
3	10.00	2	32.02	−41.63	30.02	NA	−65.50	95.52	NA
4	10.00	2	33.67	−43.01	31.67	NA	−62.50	94.17	NA
5	10.00	2	34.97	−57.43	32.97	NA	−74.00	106.97	NA
6	10.00	8	−55.00	−105.00	2.00	−77.50	−126.00	128.00	79.50
7	10.00	8	−55.00	−130.00	2.00	−77.50	−153.00	155.00	79.50
8	10.00	2	33.67	−128.21	31.67	NA	−150.00	181.67	NA
9	8.00	4	48.00	2.79	46.00	NA	−8.00	54.00	NA
10	4.00	9	57.00	14.06	55.00	NA	0.00	55.00	NA

* ESTIMATED ROCK ASSUMED AS TOP OF LOWER TROUTDALE SUBSURFACE LAYER

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge
Replacement Movable Bridge
Bascule with Tied Arch Approach
Drilled Shaft Details
DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

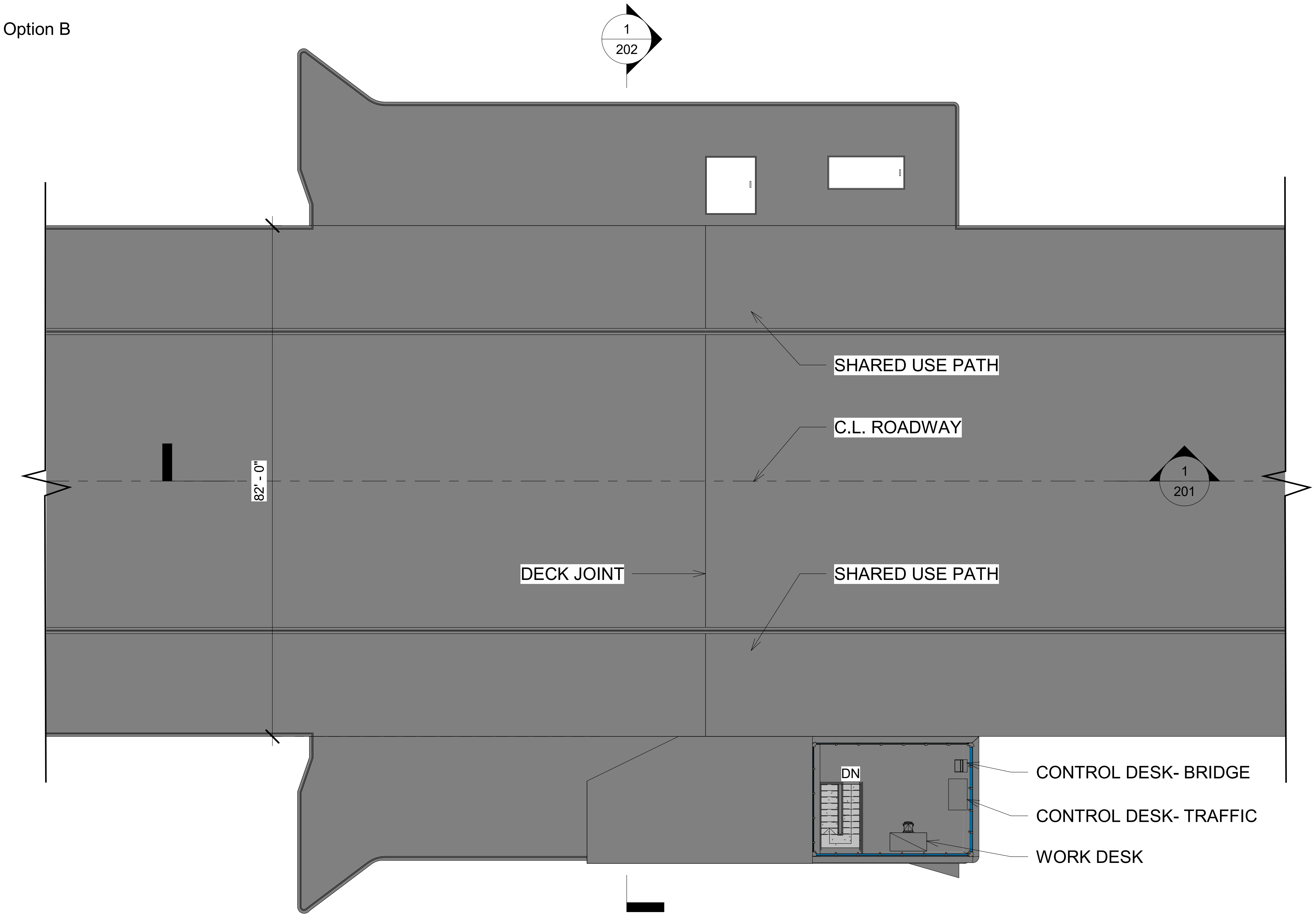
DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS
NO. DATE:

Sheet No. *BR25*

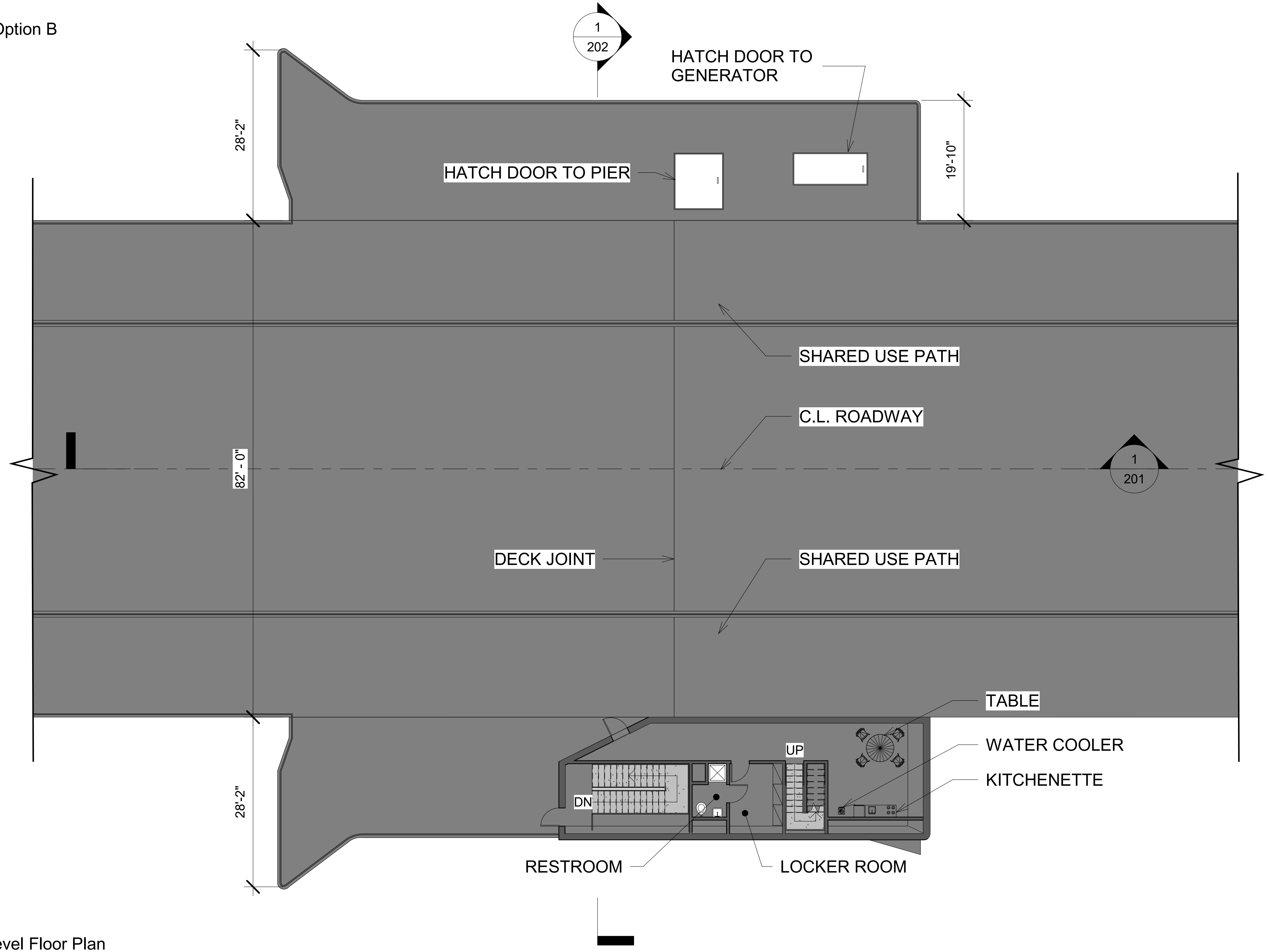
Appendix C. Movable Bent Plan Sheets

Control House Option B



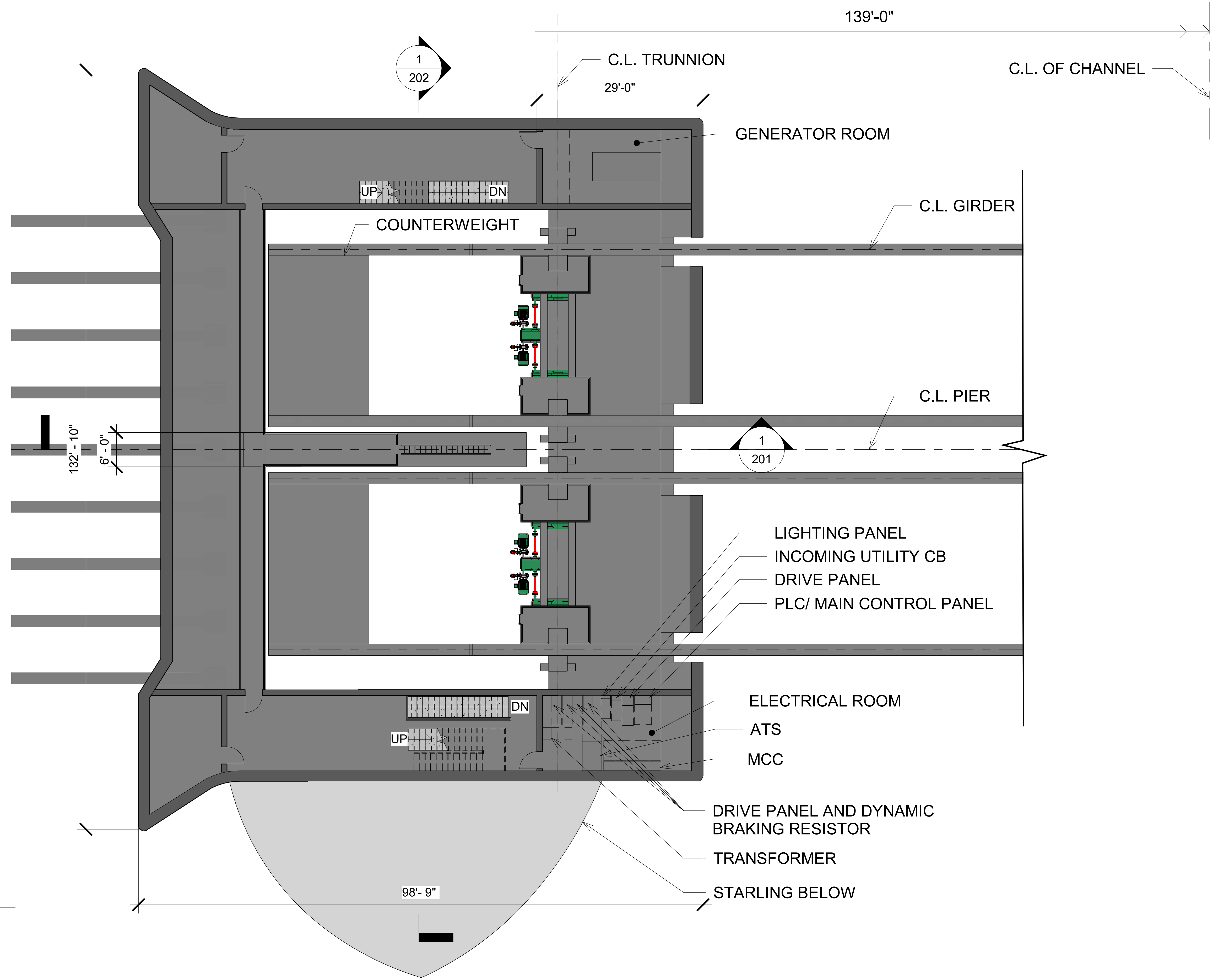
1 Operator's Level Floor Plan
1/16" = 1'-0"

Control House Option B



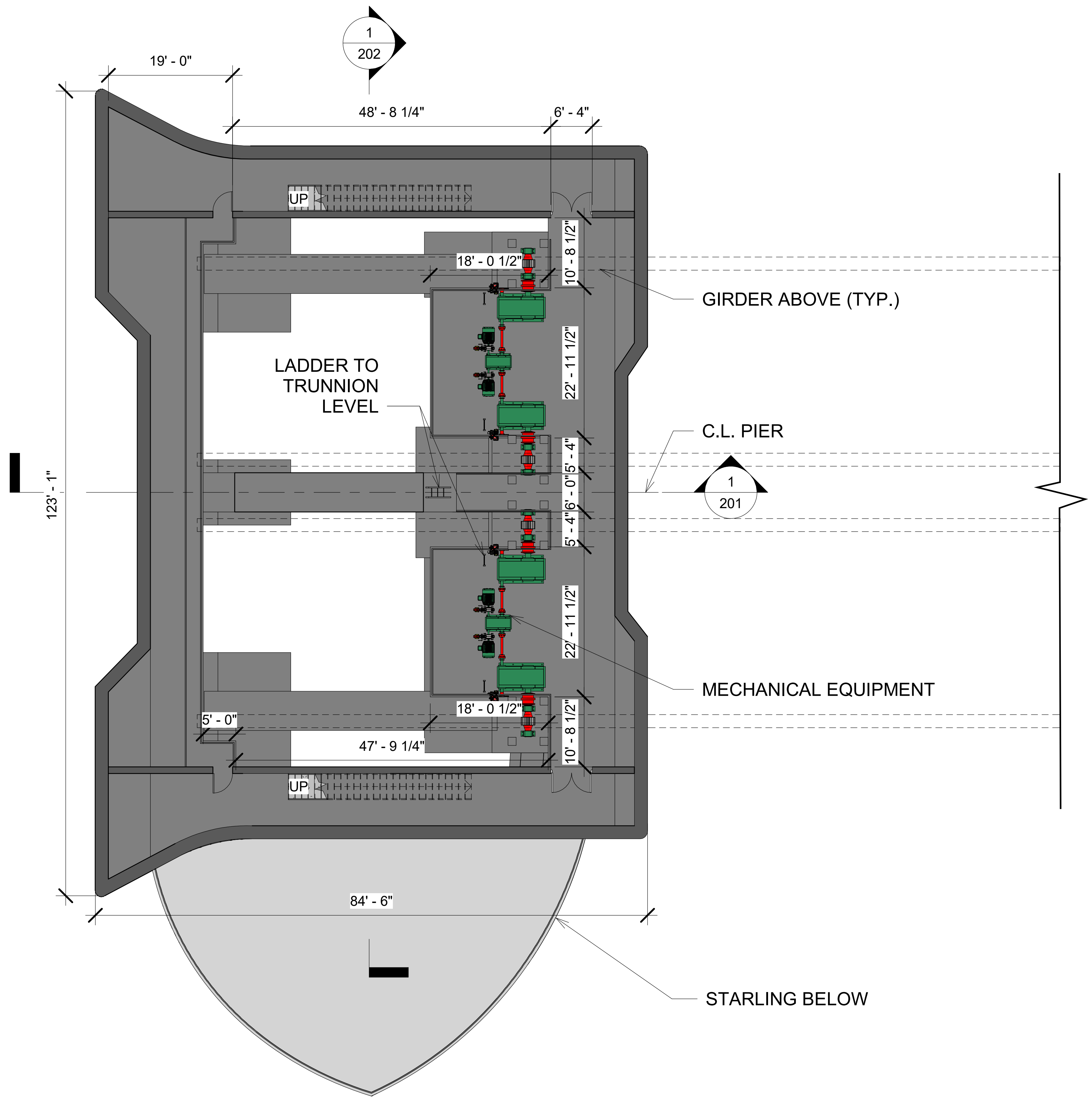
1 Deck Level Floor Plan
1/16" = 1'-0"

Control House Option B



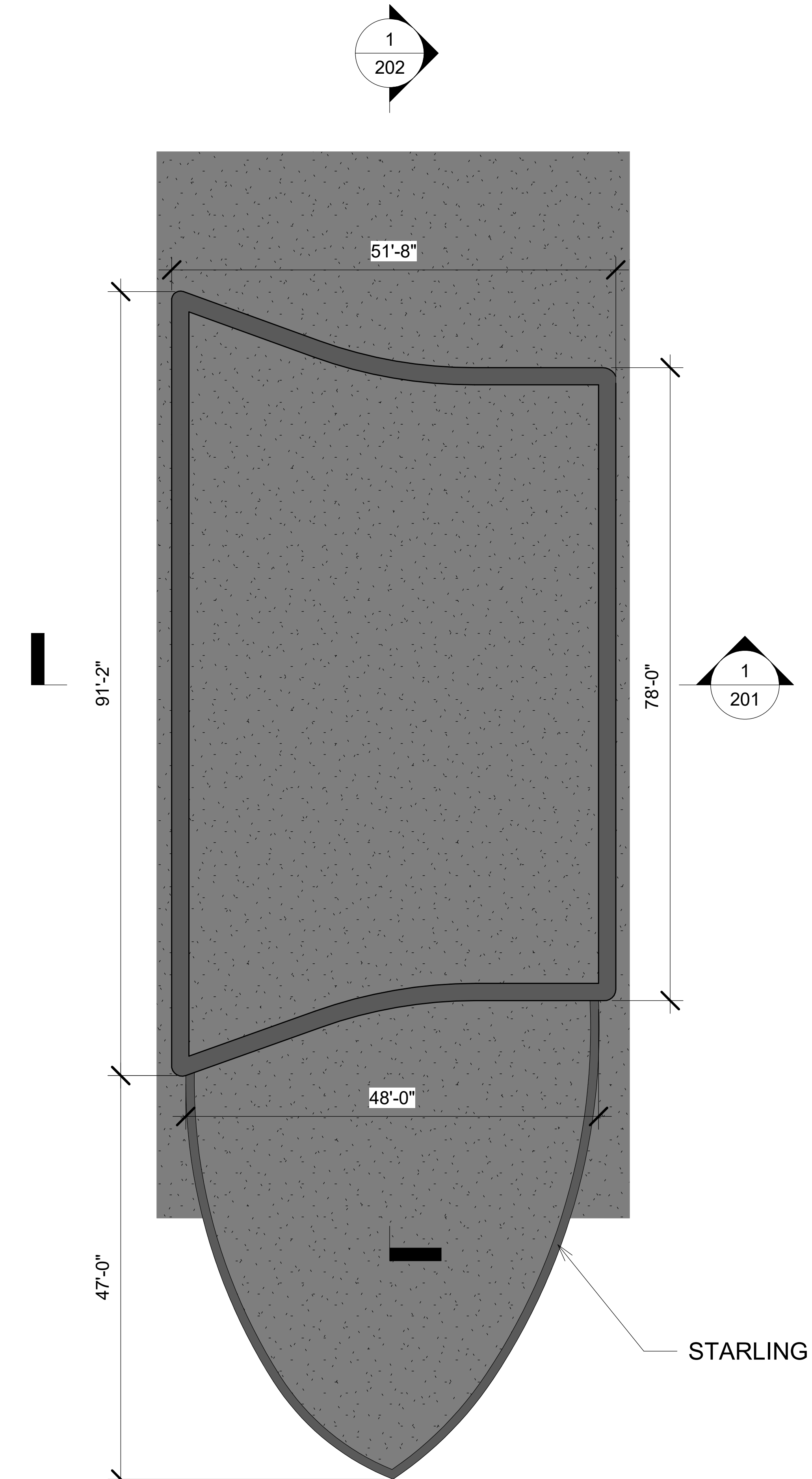
1 Trunnion Level Floor Plan
1/16" = 1'-0"

Control House Option B



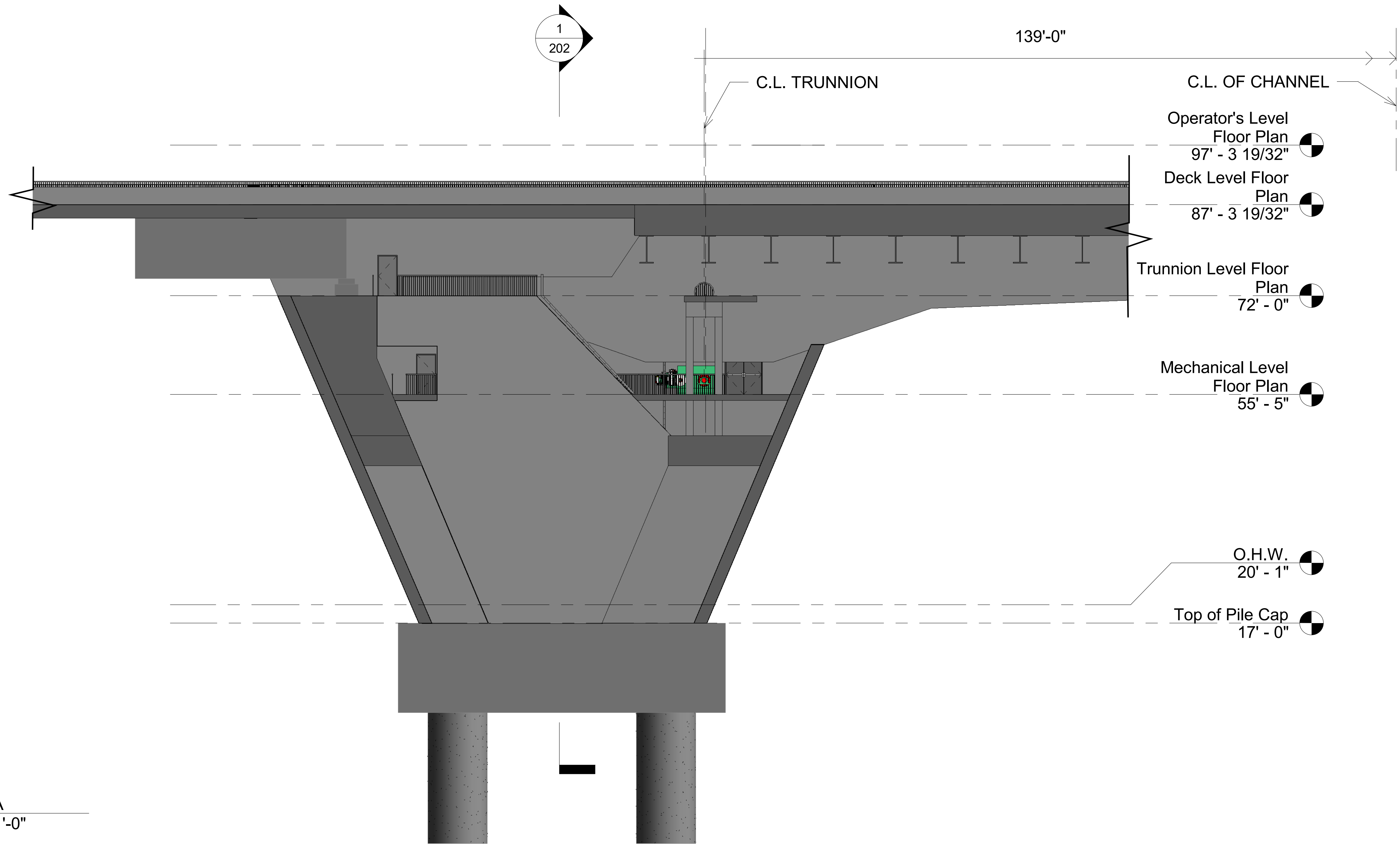
1 Mechanical Level Floor Plan
1/16" = 1'-0"

Control House Option B



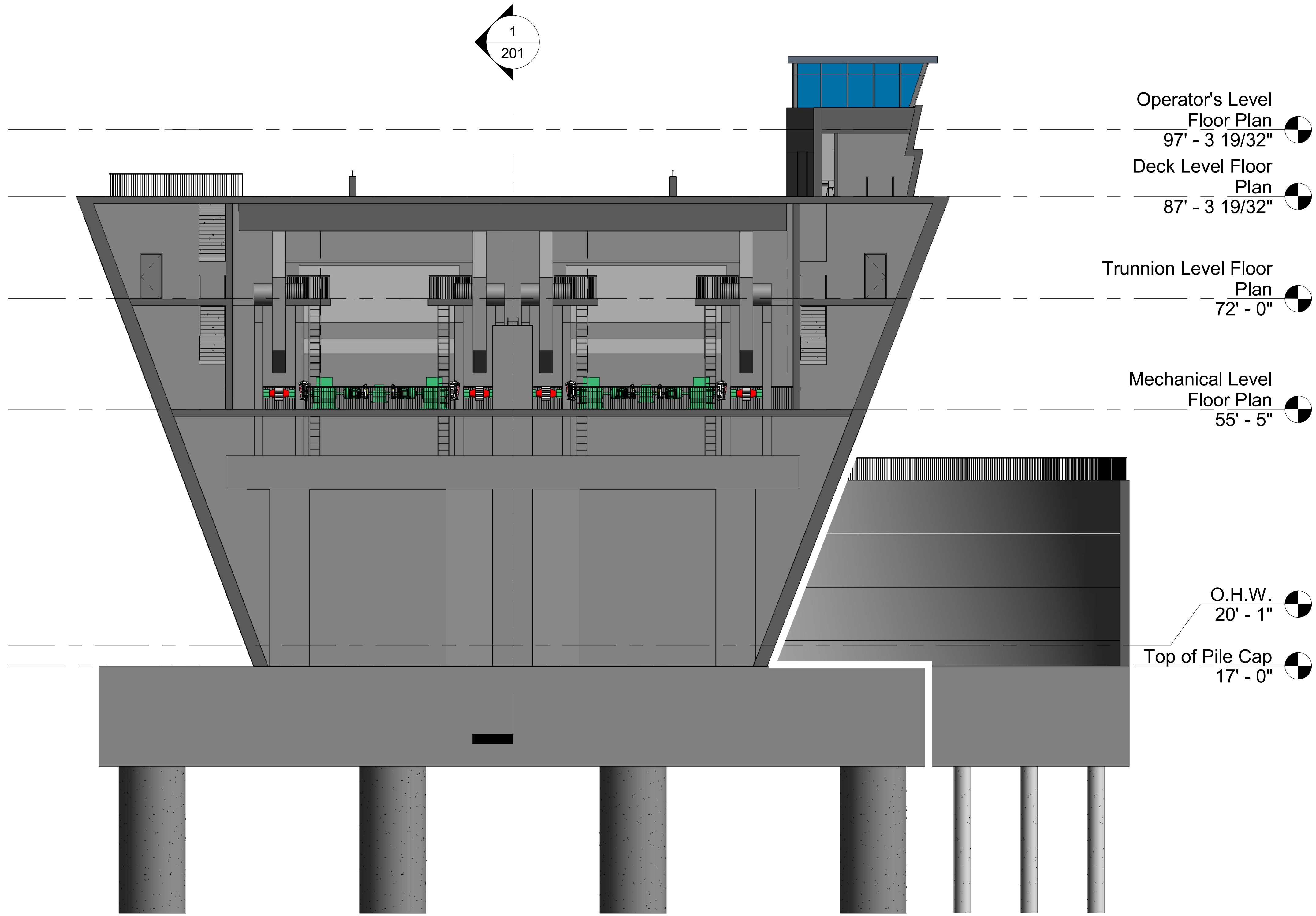
1 Top of Pile Cap
1/16" = 1'-0"

Control House Option B



1 Section A
1/16" = 1'-0"

Control House Option B



1 Section B
1/16" = 1'-0"

Appendix D. EQRB Allision Analysis

Glosten

EARTHQUAKE READY BURNSIDE BRIDGE

ALLISION ANALYSIS

PREPARED FOR

HDR
PORTLAND, OR

25 OCTOBER 2021
FILE NO. 19010.01
REV. -

PREPARED	CHECKED	APPROVED
ANDY WHEELER, PE	**MATTHEW LANKOWSKI, PE**	**JUSTIN M. MORGAN, PE**
ENGINEER	SENIOR ENGINEER	PRINCIPAL-IN-CHARGE

Table of Contents

Executive Summary **1**

Section 1 Introduction **2**

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Revision History

Section	Rev	Description	Date	Approved
All	-	Initial release.	10/25/2021	JMM

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Executive Summary

An allision analysis was conducted on vessel traffic transiting under the Burnside Bridge. Following the method prescribed by the American Association of State Highway and Transportation Officials (AASHTO), the Annual Frequency of Collapse of a bridge due to vessel impacts was calculated. The allision analysis was conducted with the goal of determining the recommended horizontal resistance, H_{des}, of the bridge substructure for the new Earthquake Ready Burnside Bridge (EQRB) Short-span Approach Bascule design option (Reference 1).

The analysis was conducted with a conservative approach for categorizing and defining design vessels to ensure the methodology was comprehensive in its accounting of vessel traffic.

Table 1 shows the recommended resistance of the bridge substructure to a horizontal force, depending on a bridge classification of 'typical' or 'critical or essential'.

Table 1 Recommended values for H_{des} based on bridge classification

Bridge Classification	H_{des} (kip)	
Typical	3,268	see Appendix A
Critical or Essential	4,995	see Appendix B

Section 1 Introduction

The AASHTO method contained in *AASHTO LRFD Bridge Design Specifications* § 3.14.5 (Reference 2) defines the annual frequency of collapse of a bridge component from vessel collision as:

$$AF = \sum N_i \times PA_i \times PG_i \times PC_i \times PF_i$$

where, for vessel or vessel type *i*:

AF = annual frequency of bridge component collapse due to vessel collision.

N_i = the annual number of vessels, classified by type, size, and loading condition.

PA_i = the probability of vessel aberrancy.

PG_i = the geometric probability of a collision between an aberrant vessel and a bridge pier or span

PC_i = the probability of bridge collapse due to a collision with an aberrant vessel.

PF_i = adjustment factor to account for potential protection of the piers from vessel collision due to upstream or downstream land masses or other structures that block the vessel.

Depending on bridge classification, the maximum allowable value of *AF* shall be either 0.001 (typical bridges) or 0.0001 (critical or essential bridges). Typically, classification as a 'typical bridge' or 'critical or essential bridge' is determined by the bridge owner.

Section 2 Waterway Users

The first step of the allision analysis was to identify users of the waterway that transit under the Burnside Bridge. Sources for this information include previous studies and publicly available Automatic Identification System (AIS) data.

References 3, 4, and 5 contain information about vessel traffic transiting under the current Burnside Bridge, and on the Willamette River and nearby waterways such as the Columbia River. These studies identify the largest and most frequent users of the waterway, which have an outsize impact on the results of the analysis. Attempts were made to contact high impact waterway users identified in the previous studies to verify and update information.

To ensure the analysis is comprehensive and accounts for all large vessels, AIS data was utilized to determine the total amount of vessel traffic that typically transits beneath the Burnside Bridge based on vessel type. All vessels over 150 GT are required to have a functioning AIS transponder onboard per USCG requirements. Therefore, AIS vessel counts are assumed to be a comprehensive source for marine traffic data of significant size. Many recreational, commercial, and government users operating smaller craft also operate AIS transponders even if not required to do so by USCG regulations. AIS data was obtained from Reference 6.

The AIS vessel count data sets provide vessel counts for individual cells sized 100m × 100m (Figure 1). Vessel counts are obtained from the 100m × 100m cell at the centerline of the waterway underneath the Burnside Bridge and both cells adjacent to the centerline cell, towards the edges of the waterway. A vessel is counted each time it enters a cell or starts/stops within a cell.

Figure 1 Typical AIS vessel count data on the Willamette River, with cells underneath the Burnside Bridge highlighted

Annual vessel counts from 2015 – 2017 and 2019 were used to provide general vessel traffic data for the purpose of the allision analysis. Data for 2018 was available for use but was not categorized by vessel type so could not be directly applied to this analysis.

The percentage of vessel type counts in the total vessel counts for 2017 and 2019 were averaged and applied to the 2018 total vessel count to estimate the counts for each vessel type in 2018. It was assumed that data sets from 2020 and 2021 are not indicative of typical traffic patterns due to the COVID-19 pandemic. Yearly vessel counts obtained from AIS data are presented in Appendix C.

2.1 Frequent Large Users

Large vessels and vessels that most frequently transit beneath the bridge have the largest impact on the annual frequency of collapse. Most frequent large users that transit under the current Burnside Bridge can be grouped into the following categories:

- *Cruise:* River users that transport paying passengers for day or overnight cruises, such as Portland Spirit Cruises, which operates multiple cruises daily. Larger overnight river cruise vessels operate in the waterway but rarely transit under the Burnside Bridge; however, given the size of these vessels, they were considered significant for the purposes of the allision analysis. Such vessels were assumed to transit under the Burnside Bridge 10 times per year unless specific information was available from the vessel owners.
- *Tug and barge*: River users that operate tugboats, barges, and other large marine assets to support towing, shipyard, and construction projects. Notable tug and barge users include Shaver Transportation, Combined Forestry & Marine Services, and Advanced American Construction.
- *Visitors and Fleet Week*: Visitors are defined as large vessels that transit the Burnside Bridge and require permitting through the harbor master. Fleet Week refers to the annual celebration in Portland that occurs in June. Large vessels operated by the United States Coast Guard (USCG), the Royal Canadian Navy, and private owners visit Portland during the celebration and pass under the bridge.

Vessels that were identified as frequent large users were grouped into the above categories and treated as individual vessels for the allision analysis. Vessel dimensions were obtained from owner's websites, AIS records, and publicly available industry cut sheets. Vessel deadweight tonnage (DWT) was calculated by interpolating values found in Reference 7 using known vessel dimensions (length overall [LOA] and breadth [B]).

Barge lightship displacements were estimated using parametric equations found in Reference 8. Lightship displacements were increased by a factor of 4 to represent the operational displacement of the barges. This is consistent with the displacement values found in Reference 9, which represent a typical derrick barge. It should be noted that all frequent large users classified as barges are derrick barges.

2.2 General Vessel Types

Data on vessel traffic obtained from the river user survey (Reference 3) does not include frequency of transit, which is required for the AF calculation.

Annual vessel counts compiled from AIS data provide vessel counts by vessel type for a given area in a year. Vessel types include cargo, fishing, passenger, pleasure/sailing, and tug and tow. These vessel types, along with a sixth type representing government vessels, were used in the allision analysis. Conservative estimates were made to define each vessel type's dimensions, tonnage, and cruising speed. These estimates are summarized in Table 2, and discussed below.

Table 2 General vessel type and dimensions for use with AIS vessel counts

Vessel Type	LOA (ft)	B (ft)	DWT (tonne)
Cargo	472.5	63.6	9,333
Fishing	131.2	23.0	200
Passenger	150	32	428
Pleasure craft – sailing	49.2	12.1	13
Pleasure craft – powerboat	49.2	13.1	16.5
Pleasure craft – large powerboat	78.7	18.0	50
Tug and tow – single barge	200.0	40.0	1712 (disp.)*
Tug and tow – two barge	200.0	80.0	3424 (disp.)*
Government	98.4	17.4	85

***The allision analysis requires the input of displacement when calculating barge impact forces, rather than DWT.**

2.2.1 Cargo

A small number of vessels classified as 'Cargo' appeared on annual AIS vessel counts transiting beneath the Burnside Bridge. Vessel dimensions and tonnages were obtained from Reference 7 using dimensions for cargo vessels. The largest dimensions for a general cargo vessel were used for the vessels in the 'Cargo' category.

2.2.2 Fishing

Based on the AIS vessel counts, a small number of vessels classified as 'Fishing' transit beneath the Burnside Bridge. Groundfish trawlers are the largest commercial fishing boats operating along the Oregon coast (Reference 10) and have a maximum length of approximately of 95' (Reference 11).

As a conservative estimate, dimensions and tonnage for the smallest fishing vessel described in Reference 12, which defines typical fishing vessel dimensions, were used for this vessel type. These dimensions are larger than the typical maximum dimensions for a groundfish trawler.

AIS vessel counts in nearby waterways show that commercial fishing vessels in the area primarily operate on the Columbia River. In addition, AIS data shows that annual commercial fishing traffic passing under the Burnside Bridge has steadily declined in recent years. Given that this historical data is used in the analysis despite the observed decline, this approach is conservative.

2.2.3 Passenger

It was assumed that vessel counts classified as 'Passenger', which were not accounted for as frequent large users, are day-cruise vessels. This assumption was made after reviewing waterway user surveys and investigating typical routes of cruise operators in the area. It was found that no ferries or large cruise ships regularly transit under the bridge, and that day-cruise operators often offer multiple cruises a day that do transit under the bridge. Thus, the majority of passenger traffic identified in the AIS vessel counts is assumed to be day-cruise vessels. The dimensions of the *Portland Spirit* day-cruiser will be used for the vessels in this category, as it represents the largest identified day-cruise vessel that regularly passes under the Burnside Bridge (Figure 2).

Figure 2 The *Portland Spirit*, a typical day-cruise vessel that transits under the Burnside Bridge frequently (https://www.portlandspirit.com/portlandspirit.php)

2.2.4 Pleasure/Sailing

Several recreational marinas, sailing clubs, and yacht clubs are near the Burnside Bridge on the Willamette and Columbia Rivers. Maximum slip sizes at recreational boating facilities in the vicinity and upstream of the Burnside Bridge are typically 40'-50' in length. Imagery from Google Earth suggests that most of the larger vessels moored at these facilities are powerboats rather than sailing craft (Figure 3).

Figure 3 Google Earth imagery of Waverly Marina, depicting typical recreational vessels moored in the area

Based on a review of Google Earth imagery of marinas in the vicinity and upstream of Burnside Bridge, it is assumed that 70% of vessels classified as 'Pleasure/Sailing' in the AIS vessel counts under the Burnside Bridge are powerboats of up to 50', 20% are sailing craft of up to 50', and 10% are very large recreational vessels (see next paragraph). The dimensions used for the powerboat and sailing craft vessel type subcategories are taken from the values presented in Reference 12 for vessels with a LOA of 16 m (49.2'), which represents the largest recreational vessels moored on the Willamette River based on available slip sizes.

Very large recreational vessels occasionally transit under the Burnside Bridge. It is assumed that these very large recreational vessels make up 10% of recreational traffic passing under the bridge. Dimensions and deadweight tonnage for this vessel subcategory (large powerboat) are assumed to be those of a powerboat with a LOA of 24 m (78.7') as given in Reference 12, which is the largest recreational powerboat size listed.

2.2.5 Tug and Tow

Combined Forestry and Marine Services frequently transits under the Burnside Bridge with two 200' × 40' barges side-by-side, for a combined footprint of 200' × 80'. It is assumed that barges transiting under the bridge are operating in a loaded condition, such that the barge's draft is at 80% of the barge's depth. Breadth and displacement tonnage were halved to approximate a single barge tow.

It is assumed that tug and tow traffic consists of 50% two-barge tows and 50% single-barge tows. This is conservative, as a large portion of tug and tow traffic in the vessel count data likely consist of tugs not transporting barges.

Two major historical sources of barge traffic transiting under the Burnside Bridge have ceased operations in recent years: Ross Island Sand & Gravel and Zidell Marine Corporation. These closures, combined with the decline of Oregon's forest product industry, have resulted in a decrease in barge traffic transiting under the bridge. It was assumed that this type of commerce may return to the waterway in the future, so historical vessel counts including those operations were used in the analysis.

2.2.6 Government

Government users typically account for 7% of river users (Reference 3).

Dimensions of an 87-ft class USCG cutter were used as a conservative estimate for the dimensions of this vessel type, which is representative of both USCG and US Navy vessels. US Navy vessels visiting the area for Fleet Week dock downstream of the bridge, and thus rarely transit underneath it (Reference 3).

Section 3 Annual Frequency of Collapse

3.1 AF

It is assumed that the new Burnside Bridge design will be classified as a 'critical or essential' bridge, but calculations were also performed for classification as a 'typical' bridge. Therefore, the required horizontal resistance, H, of the bridge components is determined by establishing acceptance criteria such that $AF = 0.0001$ and $AF = 0.001$.

The annual frequency of collapse is calculated by applying the acceptance criteria to a single main support located at Bent 6 or 7 per Reference 1 (Figure 4).

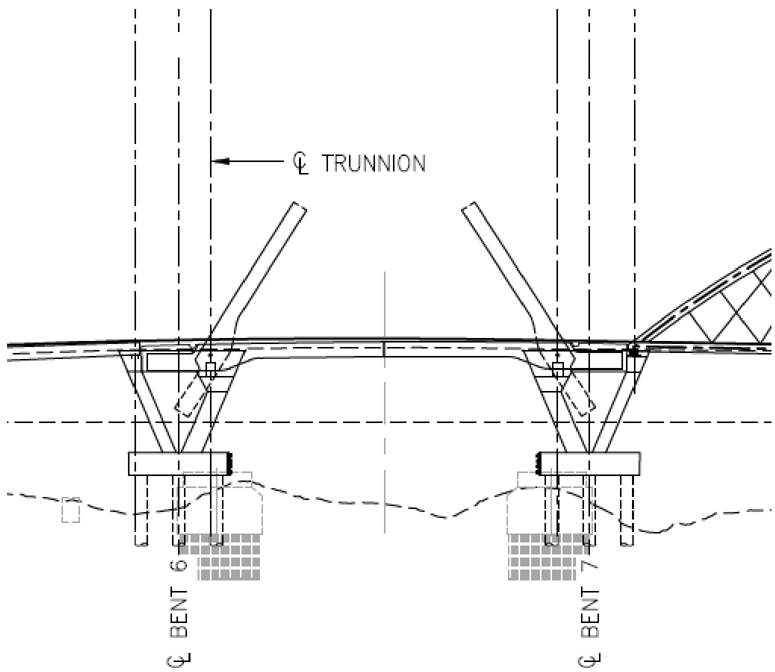


Figure 4 Excerpt from Reference 1 showing Bents 6 and 7 at the moveable bascule section of the EQRB

3.2 N_i

For known frequent large users of the waterway, the annual number of vessel transits, N, was established individually for each known vessel. These values were established primarily from previously conducted river user surveys.

Known Fleet Week vessels that transited under the bridge from 2008-2018 were assigned an N value based on the average number of annual visits over the 11-year period. It is assumed that these vessels traveled under the bridge twice for each visit (inbound and outbound).

Once values for N were established for known frequent users of the waterway, these values were subtracted from the corresponding vessel type counts obtained from AIS data.

In addition to vessel count data categorized by vessel type, a separate 'All Vessels' data set was included in the AIS data, which was greater than the sum of vessel type counts each year. Vessel type counts were scaled proportionally such that the sum of vessel type counts equaled ‘All

Vessel' count. It was assumed that 7% of these vessels were government and other users (Reference 3).

Passenger and recreational vessel traffic have steadily increased in recent years based on AIS data. The highest annual recorded vessel count for these two types was used.

Averages of the vessel count values for 2016-2019 were used for the remaining vessel types.

Table 3 AIS vessel counts, *N*, taken from AIS data with frequent large users removed

Vessel Type	*N*	Note
Cargo	4	Avg. of 2016 – 2019 values
Fishing	9	Avg. of 2016 – 2019 values
Passenger	702	2019 value used
Pleasure/sailing	*332*	2019 value used
Pleasure – powerboat	232	70% of *N*
Pleasure – sailing	66	20% of *N*
Pleasure – lrg. powerboat	33	10% of *N*
Tug and tow	*246*	Avg. of 2016 – 2019 values
Singe barge tow	123	50% of *N*
Double barge tow	123	50% of *N*
Government	180	Avg. of 2016 – 2019 values

3.3 PA_i

Using the approximate method described in Reference 1, the probability of aberrancy is taken as:

$$PA = (BR)(R_B)(R_C)(R_{XC})(R_D)$$

where:

PA = probability of aberrancy

BR = aberrancy base rate

R_B = correction factor for bridge location

R_C = correction factor for current acting parallel to vessel transit path

R_{XC} = correction factor for cross-currents acting perpendicular to vessel transit path

R_D = correction factor for vessel traffic density

The base rate, BR¸ of aberrancy is taken as:

$BR = 0.6 \times 10^{-4}$ for ships

$BR = 1.2 \times 10^{-4}$ for barges

The correction factor for bridge location, R_B, is based on location of the bridge in one of three waterway locations, and is taken as:

$$R_B = 1.0 \qquad \text{for straight regions}$$

$$R_B = \left(1 + \frac{\theta}{90°}\right) \qquad \text{for transition regions}$$

$$R_B = \left(1 + \frac{\theta}{45°}\right) \qquad \text{for turn/bend regions}$$

where:

θ = angle of turn or bend in waterway at bridge location

The Burnside Bridge is situated over a bend region in the Willamette River (Reference 13). A value for θ is taken as:

θ = 56°

This value was determined by measuring the angle in the waterway as shown in Figure 5.

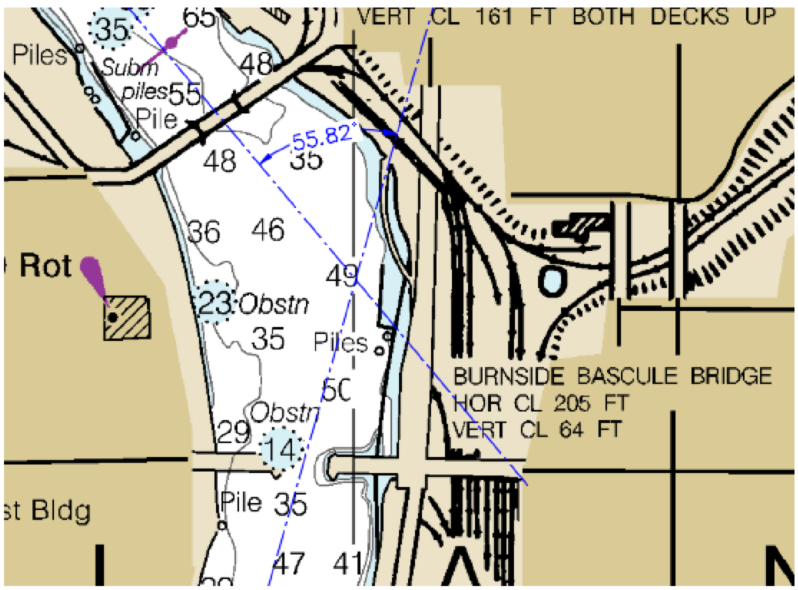


Figure 5 - Excerpt from NOAA navigation chart (Reference 13), noting θ

The correction factor, R_C , for currents acting parallel to the vessel transit path in the waterway is taken as:

$$R_C = \left(1 + \frac{V_C}{10}\right)$$

where:

R_C = correction factor for currents acting parallel to the vessel transit path

V_C = current velocity component parallel to the vessel transit path in knots

Annual Willamette River stream flow data at the Morrison Bridge (milepost 12.8) from 1973 - 2017 was used to calculate values for mean flow rate of the waterway (Reference 3 & Reference 14). The cross-sectional area of the waterway under the Burnside Bridge was estimated using the waterway profile shown in Reference 1 and the average river elevation at the nearby Morrison Bridge (taken from Reference 3). The mean flowrate and cross-sectional area were then used to determine a value for the velocity component.

The value for the velocity component, V_C, is taken as:

$$V_C \quad = \quad 0.46 \text{ kts}$$

The correction factor, R_{XC}, for cross-currents acting perpendicular to the vessel transit path is taken as:

$$R_{XC} = (1 + V_{XC})$$

where:

R_{XC}	=	correction factor for currents acting perpendicular to the vessel transit path
V_{XC}	=	current velocity component perpendicular to the vessel transit path (knots)

Since nearly all non-recreational traffic will transit underneath the bridge traveling parallel to the river's current velocity, it is assumed that:

$$V_{XC} \quad = \quad 0 \text{ kts}$$

thus:

$$R_{XC} \quad = \quad 1$$

The correction factor, R_D, vessel traffic density is taken as:

R_D	=	1.0	for low traffic density waterways
R_D	=	1.3	for average traffic density waterways
R_D	=	1.6	for high traffic density waterways

Reference 1 defines an average traffic density waterway as a waterway in which "vessels occasionally meet, pass, or overtake each other in the immediate vicinity of the bridge."

Large commercial vessel traffic in the region primarily travels on the Columbia River, or only utilizes Port of Portland facilities located downstream of the bridge on the Willamette River. It is assumed that the section of the Willamette River at the bridge location is an average traffic density waterway.

3.4 PG_i

The geometric probability, *PG*, of collision by an aberrant vessel and bridge pier is determined using the normal distribution approach described in Reference 1. The approach assumes a normal probability distribution function (*PDF*) for vessel position relative to the centerline of the waterway while transiting under the bridge. PG_i is taken as the area under the normal probability distribution curve between x_1 and x_2, as illustrated in Figure 6.

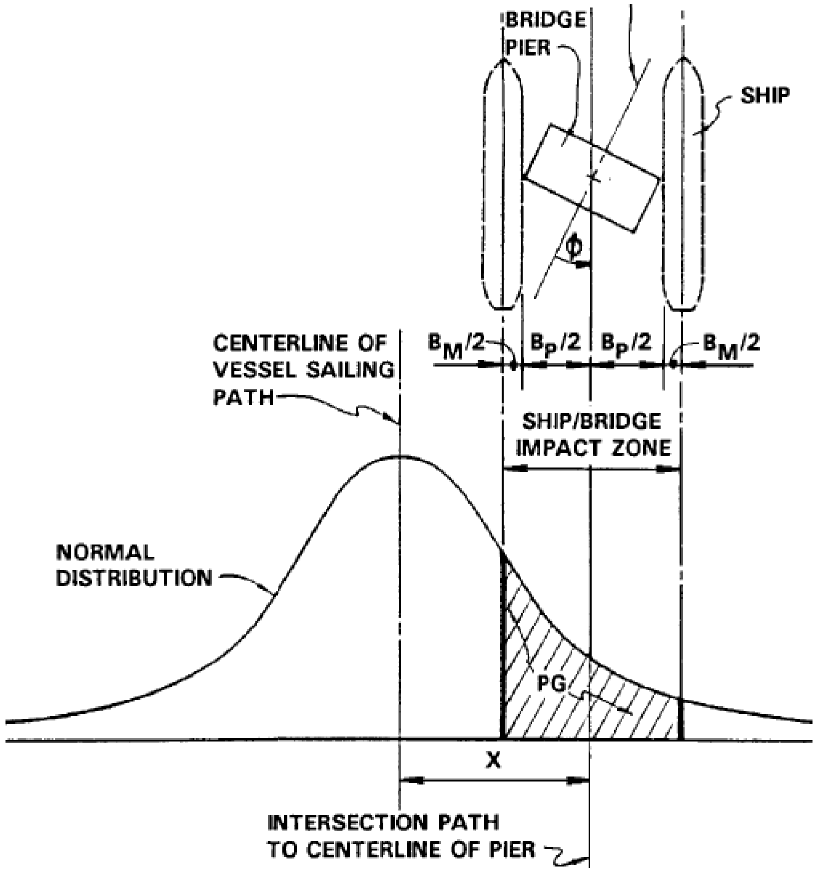


Figure 6 - Geometric probability of pier collision from Reference 1

PG_i is taken as:

$$PG_i = \int_{x_1}^{x_2} \frac{1}{\sigma_i \sqrt{2\pi}} e^{\left(-\frac{(x-\mu)^2}{2\sigma_i^2}\right)} dx$$

where:

σ_i	=	standard deviation, for vessel *i*
μ_i	=	position of vessel *i* between bridge piers, from centerline of the waterway

The most probable position, μ, of an aberrant vessel is midway between the bridge piers with a standard deviation, σ, of the distribution taken as one vessel length. Thus:

$$\sigma_i = \text{LOA of vessel } i$$

$$\mu_i = 0$$

The upper and lower limits of the integral are then defined as:

$$x_1 = x_P - \left(\frac{B_P}{2} + \frac{B_{Mi}}{2}\right)$$

and

$$x_2 = x_P + \left(\frac{B_P}{2} + \frac{B_{Mi}}{2}\right)$$

where:

B_P	=	width of the bridge pier
B_{Mi}	=	width of the vessel i
x_P	=	location of the center of the bridge pier relative to centerline of waterway

As shown in Reference 1, the moveable bascule span of the proposed Burnside Bridge is 329' (centerline of bent 6 to centerline of bent 7) and the channel is assumed to be the full width of the main span. The width of each pier on either side of moveable bascule span is taken as 80'-0".

Thus:

$$x_P = \frac{329\ ft}{2} = 164.5\ ft$$

$$B_P = 80\ ft$$

3.5 PC_i

The probability of collapse, *PC*, is taken as:

$$PC = 0.1 + 9\left(0.1 - \frac{H}{P}\right) \qquad \text{if } 0.0 \le H/P < 0.1$$

$$PC = 0.111\left(1 - \frac{H}{P}\right) \qquad \text{if } 0.1 \le H/P < 1.0$$

$$PC = 0.0 \qquad \text{if } H/P \ge 1.0$$

where:

H	=	resistance of bridge pier to horizontal force (kip)
P	=	vessel impact force (kip)

The piers' resistance to horizontal force, *H*, is assumed to be unknown and will be determined by setting the value of *AF* to 0.0001 and 0.001 to calculate the required design value.

Vessel collision energy, *KE,* is taken as:

$$KE = \frac{C_H W V^2}{29.2}$$

where:

KE	=	vessel collision energy (kip-ft)
W	=	vessel displacement tonnage (tonne)
C_H	=	hydrodynamic mass coefficient
V	=	vessel impact velocity (ft/s)

Vessel displacement tonnage, W, is determined independently for each design vessel and vessel type, as previously described in this report.

Vessel impact velocity, V, was taken as the cruising speed of each vessel or vessel type, as described in Reference 1. If a vessel's cruising speed was unknown, it was assumed to be 80% of the vessels maximum speed. If no information on vessel speed was available, a cruising speed was estimated based on the cruising speeds of similar vessels identified in this analysis.

Studies have shown that impact velocity generally decreases as collisions occur further away from the center of the waterway (Reference 1). Given that the locations of the piers at bents 6 and 7 are directly adjacent to the waterway's centerline at the edges of the waterway, the maximum value is used for this analysis.

The hydrodynamic coefficient, C_H, is taken as:

$C_H = 1.05$ if under-keel clearance exceeds 0.5 × draft

$C_H = 1.25$ if under-keel clearance is less than 0.1 × draft

For cases in which under-keel clearance falls between the two conditions, values are to be interpolated based on under-keel clearance.

Vessel impact force is determined for various collision events. The head-on ship collision impact force on a pier is taken as:

$$P_S = 8.15V\sqrt{DWT}$$

where:

P_S	=	equivalent static vessel impact force (kip)
DWT	=	deadweight tonnage of vessel (tonne)
V	=	vessel impact velocity (ft/s)

It should be noted that head-on ship collision force (P_S) is not dependent on vessel collision energy, KE. Therefore, the hydrodynamic coefficient, C_H, only needs to be determined for barge collision events.

As shown in Reference 12 (Figure 5), the waterway beneath the bridge is approximately 35' in depth on average. Therefore, the minimum barge draft that requires a value of C_H other than 1.05 can be calculated as follows:

$$UK_{min} = 0.5 \times D_{min}$$

$$35 - D_{min} = 0.5 \times D_{min}$$

$$35 = 1.5 \times D_{min}$$

$$D_{min} = \frac{35}{1.5} = 23.33$$

where:

UK_{min} = minimum under-keel clearance at which $C_H = 1.05$ (feet)

D_{min} = minimum barge draft at which $C_H = 1.05$ (feet)

Thus, only barges with a draft of over 23.33' would require a value of C_H other than 1.05. Given the relatively small draft of barges when compared to ship-shaped vessels, it is assumed that this value can be used for all cases.

To determine equivalent head-on collision impact force for barges, P_B, it is necessary to first determine the horizontal length of a barge's bow crushed by impact with a rigid object, which is taken as:

$$a_B = 10.2\left(\sqrt{1+\frac{KE}{5{,}672}}-1\right)$$

where:

a_B = barge bow damage length (ft)

KE = vessel collision energy (kip-ft)

Barge collision force, PB, is taken as:

$$P_B = 4{,}112 a_B \qquad \text{if } a_B < 0.34$$

$$P_B = 1{,}349 + 110 a_B \qquad \text{if } a_B \geq 0.34$$

where:

P_B = equivalent static barge impact force (kip)

a_B = barge bow damage length (ft)

3.6 PF_i

As defined in Reference 1 the protection factor, *PF*, is taken as:

$$PF = 1 - \frac{Percent\ Protection\ Provided}{100}$$

As depicted in Reference 2 the Short-span Approach (Bascule) replacement alternative of the EQRB has no system in place to provide protection to the main piers at Bents 6 and 7, such as dolphins or other structures. Therefore the protection factor, *PF,* is then taken as:

$$PF = 1.0$$

3.7 Additional Assumptions

Additional assumptions govern the allision analysis:

- Influences such as wind, navigation aids, pilotage, etc. are not directly considered in the analysis. As described in Reference 1, the methodology does not include these influences due to the difficulty in quantifying them. However, these influences are indirectly included as the empirical equations were developed from accident data in which these factors had a part.
- Vessel allisions will not contact bridge superstructure due to the proposed bascule bridge design.

3.7.1 Future Traffic

Several trends suggest that past traffic data is a conservative estimate of future traffic passing under the bridge, specifically:

- A steady decline in commercial traffic transiting under the bridge, shown in AIS data for cargo vessels, fishing vessels, and tug and tows (Reference 6)
- The permanent closure of the Willamette Falls Locks in 2010, which resulted in a decline of barge traffic transiting under the bridge (Reference 3, waterway user surveys)
- The continued concentration of commercial traffic downstream of the Burnside Bridge and on the Columbia River (Reference 6)
- Port of Portland terminals on the waterway being located downstream from the bridge

While recreational traffic has steadily increased in recent years, these smaller vessels have a negligible effect on the annual frequency of collapse of the bridge. However, impact forces on the bridge from small recreational craft should be considered for design purposes, as described in Section 3.8.

3.8 Operating Vessel Impact

In addition to design vessels and methodology used for the allision analysis required by Reference 2, impact forces from a designated operating vessel should be considered for moveable bridges (Reference 15). This is due to moveable bridges having a relatively high rate of allisions from vessels smaller than those governing the annual frequency of collapse calculations. Understanding impact forces from the operational vessel can help to mitigate the consequences of low-level impacts and aid in rational design of bridge components and fendering systems.

As described in Reference 15, the operating vessel shall be specified by the owner or selected based on the following minimum criteria:

- The annual number of passages of vessels larger than the operating vessel is under 50 percent of the total vessel passages per year
- The vessel speed is representative of typical transit conditions

Based on these criteria, the proposed operating vessel is a 9-meter (29.5') recreational powerboat from Reference 7, reflective of typical recreational vessel traffic on the Willamette River. It should be noted that vessels of this size are not required to have AIS transmitters onboard, and thus are likely not included in the vessel counts shown in Appendix C. The operational vessel impact force, P_s, is calculated using the head-on ship collision impact force equation (Page 15).

Results were generated for the proposed operational vessel as well as all the vessels evaluated in the annual frequency of collapse calculation, should the owner choose to use a different vessel. See Section 4.1 for results.

Section 4 Results

Based on the results of the allision analysis, it is recommended that the main piers of the new EQRB be designed to have a horizontal resistance, H_{des}, as follows:

Table 4 Recommended values for H_{des} based on bridge classification

Bridge Classification	H_{des} (kip)	
Typical	3,268	See Appendix A
Critical or Essential	4,995	See Appendix B

Results of the AF calculations can be found in Appendices A and B.

4.1 Operating Vessel Impact

The equivalent static vessel impact force, P_s, from the designated operating vessel, a 29.5' recreational powerboat, is calculated to be 390-kip.

The calculated impact forces for all vessels used in annual frequency of collapse calculations are shown in Appendices A & B, for the bridge owner's consideration.

Appendix A Calculation Results for 'Typical Bridge' Classification

Calculations for 'Typical Bridge'

		LOA (ft)	B (ft)	DWT	Disp. (tonne)	V (kts)	*N*	*PA*	*PG*	*PC*	*PF*		*AF*	P_S (kip)
Cargo	Ship	646	94	40000	51100	4.5	4.0	0.000183159	0.103586087	0.081706890	1.0	->	0.000006201	12381
Fishing	Ship	131	23	200	200	15.0	6.0	0.000183159	0.144657853	0.000000000	1.0	->	0.000000000	2918
Passenger - Day Cruiser	Ship	150	32	428	360	15.0	830.0	0.000183159	0.163956682	0.026047814	1.0	->	0.000649244	4269
Pleasure Craft - Powerboat	Ship	49	13	16.5	16.5	20.0	232.0	0.000183159	0.008261090	0.000000000	1.0	->	0.000000000	1118
Pleasure Craft - Sailing	Ship	49	12	13	13	20.0	66.0	0.000183159	0.008021267	0.000000000	1.0	->	0.000000000	992
Pleasure Craft - Large Powerboat	Ship	79	18	50	50	15.0	33.2	0.000183159	0.067898068	0.000000000	1.0	->	0.000000000	1459
Tug & Tow - Single Barge	Barge	200	40	-	1712	4.5	123.0	0.000366319	0.169836169	0.000000000	1.0	->	0.000000000	N/A
Tug & Tow - Double Barge	Barge	200	80	-	3424	4.5	123.0	0.000366319	0.225570748	0.000000000	1.0	->	0.000000000	N/A
Government	Ship	87	20	92	92	12.0	184.0	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1583
Alert	Ship	210	34	1000	759	14.4	1.0	0.000183159	0.158591717	0.053104408	1.0	->	0.000001543	6265
Henry Blake	Ship	175	36	1126	855	12.0	1.0	0.000183159	0.169616162	0.045541722	1.0	->	0.000001415	5541
Bluebell	Ship	100	25	130	168	7.0	26.0	0.000183159	0.116353458	0.000000000	1.0	->	0.000000000	1098
Blackfin	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Edmonton	Ship	181	37	1304	990	12.0	0.4	0.000183159	0.170094004	0.050168288	1.0	->	0.000000625	5962
Whitehorse	Ship	181	37	1304	990	12.0	0.3	0.000183159	0.170094004	0.050168288	1.0	->	0.000000469	5962
Hawiian Chieftain	Ship	103	22	85	64	5.0	20.0	0.000183159	0.117034660	0.000000000	1.0	->	0.000000000	634
Lady Washington	Ship	112	22	99	210	5.0	20.0	0.000183159	0.128265697	0.000000000	1.0	->	0.000000000	684
Fir	Ship	225	46	2635	2000	12.0	0.8	0.000183159	0.169973109	0.068201097	1.0	->	0.000001699	8474
Tern	Ship	87	20	85	92	20.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	2537
Blue Shark	Ship	87	20	85	92	20.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	2537
Redlinger	Ship	59	24	40	30.4	28.8	0.6	0.000183159	0.027877655	0.000000000	1.0	->	0.000000000	2507
Active	Ship	210	34	1000	759	14.0	0.2	0.000183159	0.158591717	0.051450248	1.0	->	0.000000299	6091
Saskatoon	Ship	181	37	1278	970	12.0	0.4	0.000183159	0.170094004	0.049544357	1.0	->	0.000000617	5902
Adelie	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Oriole	Ship	102	19	92	0	10.0	0.8	0.000183159	0.111825087	0.000000000	1.0	->	0.000000000	1320
Cuttyhunk	Ship	110	21	221	168	15.0	0.2	0.000183159	0.124697892	0.000000000	1.0	->	0.000000000	3070
Waesche	Ship	418	54	5673	4306	22.4	0.2	0.000183159	0.117933881	0.095374143	1.0	->	0.000000412	23211
Wahoo	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Swordfish	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Orcas	Ship	110	20	221	168	12.0	0.4	0.000183159	0.123370812	0.000000000	1.0	->	0.000000000	2456
Ironwood	Ship	180	37	1232	935	10.8	0.4	0.000183159	0.170274581	0.041449650	1.0	->	0.000000517	5215
Brandon	Ship	181	37	1304	990	12.0	0.2	0.000183159	0.170094004	0.050168288	1.0	->	0.000000313	5962
Steadfast	Ship	211	34	1000	759	14.0	0.2	0.000183159	0.158443545	0.051450248	1.0	->	0.000000299	6091
Nanaimo	Ship	181	37	1304	990	12.0	0.2	0.000183159	0.170094004	0.050168288	1.0	->	0.000000313	5962
Regina	Ship	440	54	6219	4720	24.0	0.2	0.000183159	0.112919448	0.097070144	1.0	->	0.000000402	26037
SS Legacy	Ship	192	40	1084	912	11.0	10.0	0.000183159	0.171980292	0.038205148	1.0	->	0.000012035	4982
American Empress	Ship	360	82	10201	6756	13.0	10.0	0.000183159	0.160653542	0.090920945	1.0	->	0.000026754	18063
American Pride	Ship	257	55	2998	2269	13.0	10.0	0.000183159	0.169590062	0.073961889	1.0	->	0.000022974	9792
American Song	Ship	328	56	4693	3379	13.0	10.0	0.000183159	0.145055524	0.081396752	1.0	->	0.000021626	12252
Queen of the West	Ship	232	50	2157	1689	13.0	10.0	0.000183159	0.172728783	0.067334386	1.0	->	0.000021303	8306
American Harmony	Ship	301	56	4086	2981	13.0	10.0	0.000183159	0.154326222	0.079273990	1.0	->	0.000022408	11432
Portland Spirit	Ship	150	32	428	360	13.0	475.0	0.000183159	0.163956682	0.012978247	1.0	->	0.000185126	3700
Willamate Star	Ship	93	20	174	146	13.0	475.0	0.000183159	0.098584547	0.000000000	1.0	->	0.000000000	2359
Crystal Dolphin	Ship	84	24	91	77	13.0	475.0	0.000183159	0.085261230	0.000000000	1.0	->	0.000000000	1706
Sea Lion/Sea Bird/Sea Quest	Ship	164	30	500	421	13.0	20.0	0.000183159	0.161787350	0.020305774	1.0	->	0.000012034	3999
LCI 713	Barge	160	23	238	200	4.5	50.0	0.000366319	0.151950164	0.000000000	1.0	->	0.000000000	N/A
Millenium Derrick Barge	Barge	282	78	-	2408	4.5	4.0	0.000366319	0.186933836	0.041530707	1.0	->	0.000011376	N/A
DB125 Derrick Barge	Barge	117	52	-	424	4.5	4.0	0.000366319	0.175513180	0.000000000	1.0	->	0.000000000	N/A
DB4100	Barge	120	60	-	350	4.5	4.0	0.000366319	0.190153859	0.000000000	1.0	->	0.000000000	N/A
DB4000	Barge	105	60	-	316.4	4.5	4.0	0.000366319	0.171296640	0.000000000	1.0	->	0.000000000	N/A
DB4041	Barge	100	50	-	254	4.5	4.0	0.000366319	0.149001570	0.000000000	1.0	->	0.000000000	N/A
Crane Barge Lucy	Barge	120	36	-	240	4.5	60.0	0.000366319	0.155547223	0.000000000	1.0	->	0.000000000	N/A
Ross Island Dredge	Barge	177	30	-	270.4	4.5	6.0	0.000366319	0.159898145	0.000000000	1.0	->	0.000000000	N/A

Hdes	3267.496011	kip
ΣAF	0.0010000	

Appendix B Calculation Results for 'Critical or Essential Bridge' Classification

Calculations for 'Critical or Essential Bridge'

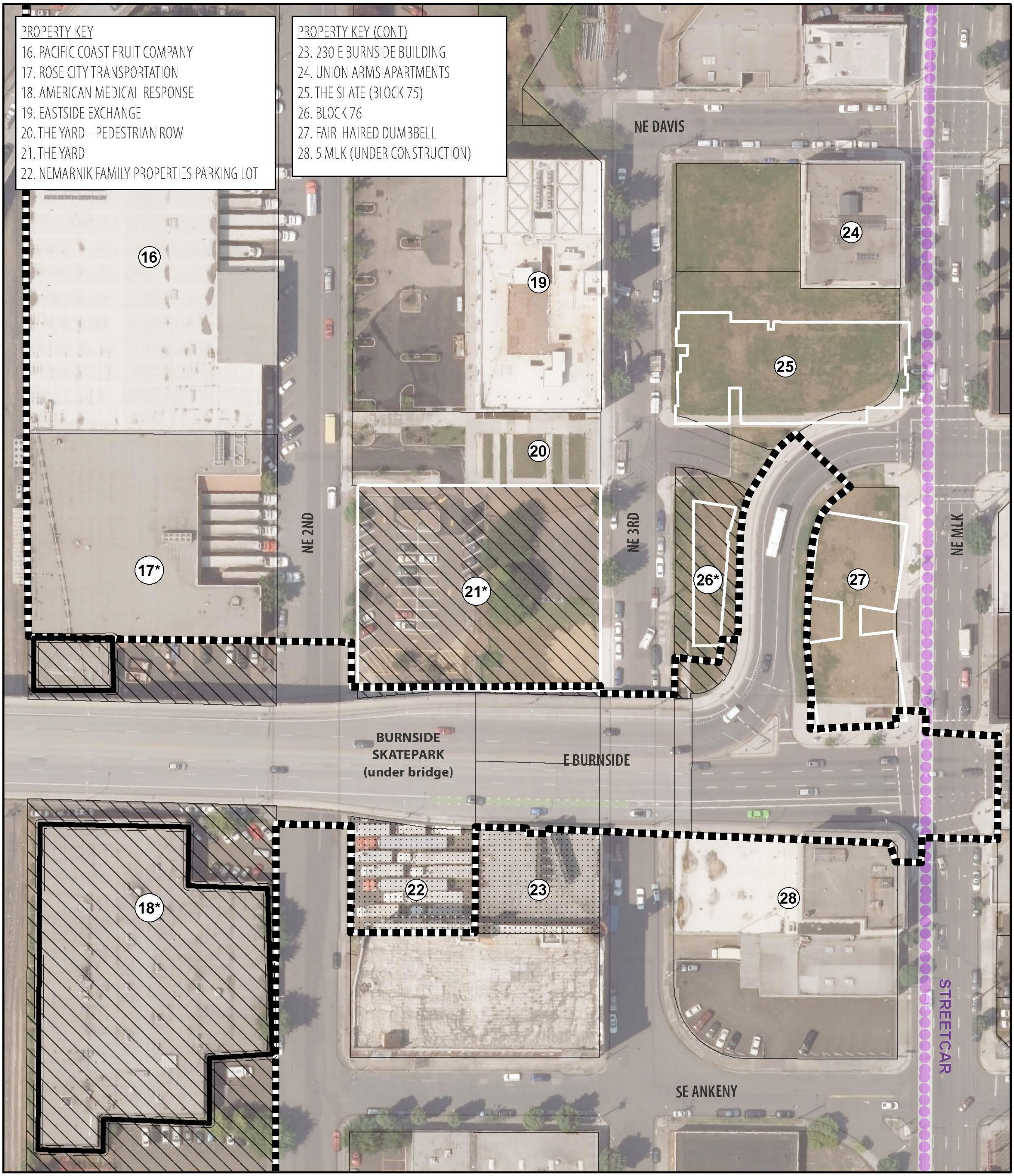
Hdes 4994.664206 kip
ΣAF 0.0001000

		LOA (ft)	B (ft)	DWT	Disp. (tonne)	V (kts)	*N*	*PA*	*PG*	*PC*	*PF*		*AF*	P_S (kip)
Cargo	Ship	646	94	40000	51100	4.5	4.0	0.000183159	0.103586087	0.066222823	1.0	->	0.000005026	12381
Fishing	Ship	131	23	200	200	15.0	6.0	0.000183159	0.144657853	0.000000000	1.0	->	0.000000000	2918
Passenger - Day Cruiser	Ship	150	32	428	360	15.0	830.0	0.000183159	0.163956682	0.000000000	1.0	->	0.000000000	4269
Pleasure Craft - Powerboat	Ship	49	13	16.5	16.5	20.0	232.0	0.000183159	0.008261090	0.000000000	1.0	->	0.000000000	1118
Pleasure Craft - Sailing	Ship	49	12	13	13	20.0	66.0	0.000183159	0.008021267	0.000000000	1.0	->	0.000000000	992
Pleasure Craft - Large Powerboat	Ship	79	18	50	50	15.0	33.2	0.000183159	0.067898068	0.000000000	1.0	->	0.000000000	1459
Tug & Tow - Single Barge	Barge	200	40	-	1712	4.5	123.0	0.000366319	0.169836169	0.000000000	1.0	->	0.000000000	N/A
Tug & Tow - Double Barge	Barge	200	80	-	3424	4.5	123.0	0.000366319	0.225570748	0.000000000	1.0	->	0.000000000	N/A
Government	Ship	87	20	92	92	12.0	184.0	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1583
Alert	Ship	210	34	1000	759	14.4	1.0	0.000183159	0.158591717	0.022501333	1.0	->	0.000000654	6265
Henry Blake	Ship	175	36	1126	855	12.0	1.0	0.000183159	0.169616162	0.010941081	1.0	->	0.000000340	5541
Bluebell	Ship	100	25	130	168	7.0	26.0	0.000183159	0.116353458	0.000000000	1.0	->	0.000000000	1098
Blackfin	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Edmonton	Ship	181	37	1304	990	12.0	0.4	0.000183159	0.170094004	0.018013207	1.0	->	0.000000224	5962
Whitehorse	Ship	181	37	1304	990	12.0	0.3	0.000183159	0.170094004	0.018013207	1.0	->	0.000000168	5962
Hawiian Chieftain	Ship	103	22	85	64	5.0	20.0	0.000183159	0.117034660	0.000000000	1.0	->	0.000000000	634
Lady Washington	Ship	112	22	99	210	5.0	20.0	0.000183159	0.128265697	0.000000000	1.0	->	0.000000000	684
Fir	Ship	225	46	2635	2000	12.0	0.8	0.000183159	0.169973109	0.045577992	1.0	->	0.000001135	8474
Tern	Ship	87	20	85	92	20.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	2537
Blue Shark	Ship	87	20	85	92	20.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	2537
Redlinger	Ship	59	24	40	30.4	28.8	0.6	0.000183159	0.027877655	0.000000000	1.0	->	0.000000000	2507
Active	Ship	210	34	1000	759	14.0	0.2	0.000183159	0.158591717	0.019972799	1.0	->	0.000000116	6091
Saskatoon	Ship	181	37	1278	970	12.0	0.4	0.000183159	0.170094004	0.017059472	1.0	->	0.000000213	5902
Adelie	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Oriole	Ship	102	19	92	0	10.0	0.8	0.000183159	0.111825087	0.000000000	1.0	->	0.000000000	1320
Cuttyhunk	Ship	110	21	221	168	15.0	0.2	0.000183159	0.124697892	0.000000000	1.0	->	0.000000000	3070
Waesche	Ship	418	54	5673	4306	22.4	0.2	0.000183159	0.117933881	0.087114459	1.0	->	0.000000376	23211
Wahoo	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Swordfish	Ship	87	20	85	92	12.0	0.2	0.000183159	0.087230811	0.000000000	1.0	->	0.000000000	1522
Orcas	Ship	110	20	221	168	12.0	0.4	0.000183159	0.123370812	0.000000000	1.0	->	0.000000000	2456
Ironwood	Ship	180	37	1232	935	10.8	0.4	0.000183159	0.170274581	0.004685977	1.0	->	0.000000058	5215
Brandon	Ship	181	37	1304	990	12.0	0.2	0.000183159	0.170094004	0.018013207	1.0	->	0.000000112	5962
Steadfast	Ship	211	34	1000	759	14.0	0.2	0.000183159	0.158443545	0.019972799	1.0	->	0.000000116	6091
Nanaimo	Ship	181	37	1304	990	12.0	0.2	0.000183159	0.170094004	0.018013207	1.0	->	0.000000112	5962
Regina	Ship	440	54	6219	4720	24.0	0.2	0.000183159	0.112919448	0.089706950	1.0	->	0.000000371	26037
SS Legacy	Ship	192	40	1084	912	11.0	10.0	0.000183159	0.171980292	0.000000000	1.0	->	0.000000000	4982
American Empress	Ship	360	82	10201	6756	13.0	10.0	0.000183159	0.160653542	0.080307342	1.0	->	0.000023631	18063
American Pride	Ship	257	55	2998	2269	13.0	10.0	0.000183159	0.169590062	0.054383886	1.0	->	0.000016893	9792
American Song	Ship	328	56	4693	3379	13.0	10.0	0.000183159	0.145055524	0.065748749	1.0	->	0.000017468	12252
Queen of the West	Ship	232	50	2157	1689	13.0	10.0	0.000183159	0.172728783	0.044253146	1.0	->	0.000014000	8306
American Harmony	Ship	301	56	4086	2981	13.0	10.0	0.000183159	0.154326222	0.062503914	1.0	->	0.000017668	11432
Portland Spirit	Ship	150	32	428	360	13.0	475.0	0.000183159	0.163956682	0.000000000	1.0	->	0.000000000	3700
Willamate Star	Ship	93	20	174	146	13.0	475.0	0.000183159	0.098584547	0.000000000	1.0	->	0.000000000	2359
Crystal Dolphin	Ship	84	24	91	77	13.0	475.0	0.000183159	0.085261230	0.000000000	1.0	->	0.000000000	1706
Sea Lion/Sea Bird/Sea Quest	Ship	164	30	500	421	13.0	20.0	0.000183159	0.161787350	0.000000000	1.0	->	0.000000000	3999
LCI 713	Barge	160	23	238	200	4.5	50.0	0.000366319	0.151950164	0.000000000	1.0	->	0.000000000	N/A
Millenium Derrick Barge	Barge	282	78	-	2408	4.5	4.0	0.000366319	0.186933836	0.004809880	1.0	->	0.000001317	N/A
DB125 Derrick Barge	Barge	117	52	-	424	4.5	4.0	0.000366319	0.175513180	0.000000000	1.0	->	0.000000000	N/A
DB4100	Barge	120	60	-	350	4.5	4.0	0.000366319	0.190153859	0.000000000	1.0	->	0.000000000	N/A
DB4000	Barge	105	60	-	316.4	4.5	4.0	0.000366319	0.171296640	0.000000000	1.0	->	0.000000000	N/A
DB4041	Barge	100	50	-	254	4.5	4.0	0.000366319	0.149001570	0.000000000	1.0	->	0.000000000	N/A
Crane Barge Lucy	Barge	120	36	-	240	4.5	60.0	0.000366319	0.155547223	0.000000000	1.0	->	0.000000000	N/A
Ross Island Dredge	Barge	177	30	-	270.4	4.5	6.0	0.000366319	0.159898145	0.000000000	1.0	->	0.000000000	N/A

Appendix C AIS Vessel Counts

Year	Type	Count (CL Cell)	Count (Adj. Cells)	Total (N)	Scaled Total	Note
2015	Cargo	0	0	0	**0**	2015 Seems incomplete, disregard statistics.
2015	Fishing	0	0	0	**0**	
2015	Passenger	105	10	115	**138**	
2015	Pleasure/Sailing	127	30	157	**189**	
2015	Tanker	0	0	0	**0**	Tanker traffic stops at Swan Island industrial park.
2015	Tug & Tow	417	23	440	**530**	
			2015 Total	**712**		
			'All Vessels' Count→	922	65	Assume Govt and Other @ 7%
					857	
2016	Cargo	27	0	27	**27**	
2016	Fishing	23	8	31	**31**	
2016	Passenger	1522	359	1881	**1,878**	
2016	Pleasure/Sailing	127	18	145	**145**	
2016	Tanker	0	0	0	**0**	
2016	Tug & Tow	532	25	557	**556**	
			2016 Total	**2641**		
			'All Vessels' Count→	2836	199	Assume Govt and Other @ 7%
2017-2019 AIS Counts used in analysis					2637	
2017	Cargo	3	1	4	**5**	
2017	Fishing	8	3	11	**13**	
2017	Passenger	1625	394	2019	**2,315**	
2017	Pleasure/Sailing	106	17	123	**141**	
2017	Tanker	0	0	0	**0**	
2017	Tug & Tow	400	23	423	**485**	
			2017 Total	**2580**		
			'All Vessels' Count→	3181	223	Assume Govt and Other @ 7%
					2958	
2018	Cargo			3	**4**	*Averages from 2017 & 2019*
2018	Fishing			6	**7**	*Averages from 2017 & 2019*
2018	Passenger			1993	**2375**	*Averages from 2017 & 2019*
2018	Pleasure/Sailing			213	**254**	*Averages from 2017 & 2019*
2018	Tanker			0	**0**	*Averages from 2017 & 2019*
2018	Tug & Tow			332	**396**	*Averages from 2017 & 2019*
			2018 Total	**2546**		
			'All Vessels' Count→	3263	228	Assume Govt and Other @ 7%
					3035	
2019	Cargo	2	0	2	**2**	
2019	Fishing	0	0	0	**0**	All fishing appears to only be on Columbia now.
2019	Passenger	1730	236	1966	**2,154**	
2019	Pleasure/Sailing	259	44	303	**332**	
2019	Tanker	0	0	0	**0**	
2019	Tug & Tow	204	37	241	**264**	
			2019 Total	**2512**		
			'All Vessels' Count→	2959	207	Assume Govt and Other @ 7%
					2752	

Appendix E. Potential Right-of-Way Impacts Maps



EARTHQUAKE READY BURNSIDE BRIDGE

Source:
City of Portland, Oregon
HDR, Parametrix

0 25 50 100 Feet

Temporary Construction Easement Limits

Aquisition Status

Full

Partial

Easement

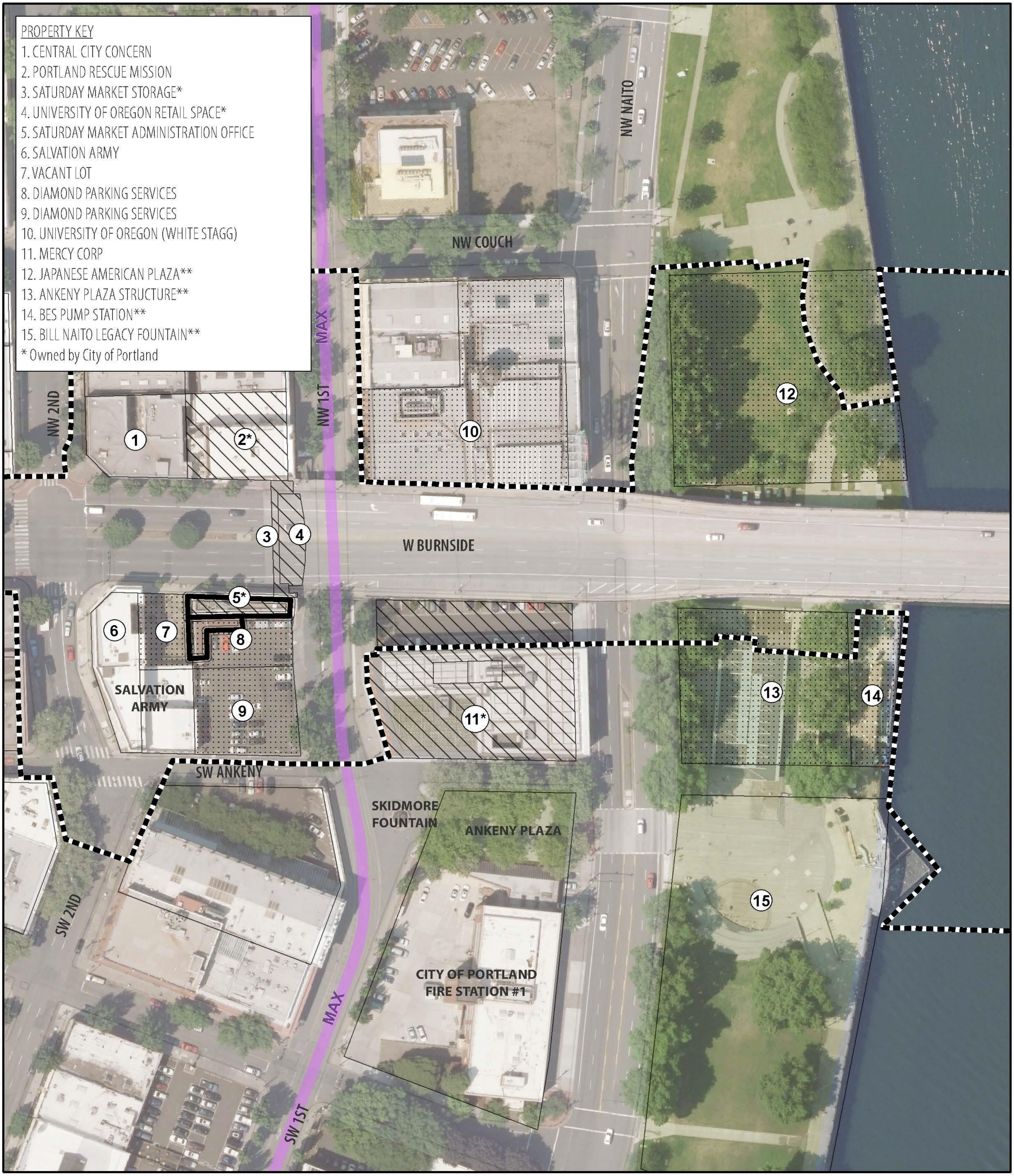
TCE

Building Impact

^ Map IDs 17, 18, 21, and 26 would also require TCEs.

Property Impacts
East Bridgehead
Refined Long-span

Earthquake Ready Burnside



Temporary Construction Easement Limits

Aquisition Status

- Full
- Partial
- Easement
- TCE
- Building Impact

*Map IDs 2, 5, and 11 would also require TCEs.

EARTHQUAKE READY BURNSIDE BRIDGE

Source:
City of Portland, Oregon
HDR, Parametrix

0 25 50 100 Feet

Property Impacts
West Bridgehead
Refined Long-span

Earthquake Ready Burnside

Date: 1/27/2020 Author: ahmanjos Path: U:\Port\Projects\Clients\3767-MultnomahCounty\273-3767-810 Burnside Bridge NEPA\99Svcs\GIS\Mapdocs\Tech_Memos\Displacements\Fig_9_Offsite_Staging_Areas.mxd

EARTHQUAKE READY BURNSIDE BRIDGE

Source:
City of Portland, Oregon
HDR, Parametrix

0 0.25 0.5 1 Miles

Potential Off-site Staging Areas

A. Willamette Staging Option off Front Ave.
B. USACE Portland Terminal 2
C. Willamette Staging Option off Interstate Ave.

Figure 9
Potential Off-site Staging Areas

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