Ballard Bridge Planning Study

Alternatives Comparison Report

Seattle Department of Transportation

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
Ave	Avenue
BBPS	Ballard Bridge Planning Study
BNSF	Burlington Northern Santa Fe
Ft	Foot, feet
High-Level	High-Level Fixed Bridge Alternative
KC	King County
Low-Level	Low-Level Bridge Rehabilitation Alternative
Mid-Level	Mid-Level Movable Bridge Alternative
MSPUI	Modified Single Point Urban Interchange
NB	Northbound
NW	Northwest
ROW	Right-of-Way
SB	Southbound
SDOT	Seattle Department of Transportation
St	Street
ST	Sound Transit
SUP	Shared Use Path
SPUI	Single Point Urban Interchange
W	West
WSBLE	West Seattle and Ballard Link Extensions

1. EXECUTIVE SUMMARY

The Ballard Bridge, located along the 15th Ave W-NW corridor, is a major north-south corridor in the City of Seattle, and one of just six vehicular and six pedestrian/cyclist connections across the Lake Washington Ship Canal. While the structure is still in good condition today, it is over 100 years old. And while SDOT continues to maintain its safety for daily travel, the likelihood that major maintenance or emergency repair work will be needed continues to increase with age. In addition, the structure is not up to current standards for providing space to people walking, biking, or traveling in a vehicle, hence it being categorized as "functionally obsolete". The purpose of the Ballard Bridge Planning Study (Project) is to explore bridge rehabilitation and replacement options, and to present the associated costs and trade-offs of each option. The overall goal is to develop cost-effective schemes that are embraced by the City of Seattle and the community, and which minimize the impacts associated with implementation.

This Ballard Bridge Planning Study identified three feasible alternatives for further consideration. These alternatives have been analyzed and compared using an evaluation process based on criteria developed for this study. The alternatives are:

- **Low-Level Bridge Rehabilitation Alternative**: Widening the existing sidewalk(s) along the approach spans and movable bridge. Includes rehabilitation and strengthening of the existing Ballard Bridge structures and construction of a Modified Single Point Urban Interchange at Emerson-Nickerson.

- **Mid-Level Movable Bridge Alternative**: Replacement of the existing low-level bridge with a mid-level movable bridge that has a profile approximately 30-ft higher than the existing bridge at the navigation channel, improving the vertical clearance by approximately 20-ft. Includes construction of new bascule bridge and approach structures for 15th Ave W-NW, ramp structures to NW Leary Way, a Modified Single Point Urban Interchange at Emerson-Nickerson. Requires temporary detour bridge to facilitate construction.

- **High-Level Fixed Bridge Alternative**: Replacement of the existing low-level bridge with a high-level fixed bridge that that has a profile approximately 110-ft higher than the existing bridge at the navigation channel, improving the vertical clearance by approximately 105-ft. Includes construction of new long-span bridge and approach structures for 15th Ave W-NW, ramp structures to NW Leary Way, and a Modified Single Point Urban Interchange at Emerson-Nickerson.

The multi-criteria evaluation processes focused on key attributes in five broad evaluation categories, including:

- **Mobility and Connectivity** including bascule opening delays, mobility of through traffic on 15th Ave W-NW, and connectivity & access for bike/pedestrian, freight, vehicle and transit;
- **Environmental Impacts & Permitting Conditions** including impacts to adjacent land uses, in-water work requirements, sensitive areas, visual impacts and urban design, and historic preservation;
- **Implementation Characteristics** including maintenance of traffic during construction, need for detour route(s), construction duration, and further Sound Transit coordination requirements;
- **Stakeholder Input** from the public, businesses/agencies; and

- **Cost Considerations** including planning-level cost estimates of construction, maintenance & operations, and right-of-way.

After considering the ratings for the alternatives amongst all evaluation criteria, the Low-Level Bridge Rehabilitation and Mid-Level Movable Bridge Alternatives consistently performed best.

2. INTRODUCTION

2.1. STUDY PURPOSE

The Ballard Bridge is a vital connection for both land and maritime traffic. It is the westernmost vehicular connection across the Lake Washington Ship Canal and is currently used by more than 57,000 vehicles per day (including about 1,500 trucks and over 300 bus trips per day) and as many as 139 bicyclists in a 6-hour period during peak riding months. The bascule bridge and its approach structures are approximately 3,500-feet long and connect 15th Ave NW to east-west arterial streets NW Leary Way and NW Ballard Way at the north end of the bridge. A separate structure connects 15th Ave W to east-west arterial streets W Nickerson St and W Emerson St at the south end of the bridge. The span over the navigation channel consists of bascules that open to allow passage of marine traffic from Puget Sound to areas further east along the Ship Canal, Lake Union and Lake Washington. Openings are restricted to off-peak vehicular traffic hours except for vessels in excess of 1,000 tons. For the peak boating month of May 2018, there was an average of 15.4 openings on weekdays and 16.4 openings on weekends. Nearly 57% of the bridge openings were for sailboats, with an average opening duration of 4.5 minutes each.

The City has planned for and is funding this study to carefully and methodically develop and evaluate rehabilitation and replacement options considering the constraints and opportunities presented by the project site. This planning study is intended to provide:

- Development of feasible rehabilitation and replacement options for the bridge.
- A comparison of these options that SDOT and elected officials can use as they pursue and prioritize future funding or consider when initiating future studies.
- Assessment of bike and pedestrian mobility and connectivity improvements that could be incorporated into the bridge and 15th Ave W/NW corridor.
- Assessment of construction options and their effect on all modes of transportation that use the 15th Ave W/NW corridor and/or the Ship Canal.

2.2. PROJECT BACKGROUND

The existing Ballard Bridge has four lanes of traffic (two lanes northbound and two lanes southbound) with substandard lane widths of 10.5-ft. There are narrow, substandard sidewalks (3.5-ft minimum) on both sides of the bridge that are shared by pedestrians and cyclists. The bridge has limited vertical clearance for underpassing marine traffic, and frequent openings cause delays for both marine and vehicular/pedestrian traffic. The bridge is showing signs of deterioration and is classified as functionally obsolete.

The Ballard Bridge Planning Study, funded by the *Levy to Move Seattle*, evaluates how to bring the bridge up to current transportation, operational, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. SDOT performs regular maintenance and frequent inspections on the bridge to ensure it remains operational and safe for road and marine traffic, but due to the age of the structure more significant rehabilitation will be needed to keep the bridge in service. The maintenance and operations costs will continue to increase to attain the same service life as a new structure, and the likelihood of needing to provide major maintenance along the structure will also increase over time.

Figure 1 was developed with input from other agencies to identify the opportunities, constraints and risks to consider when developing and evaluating each of the rehabilitation and replacement options.

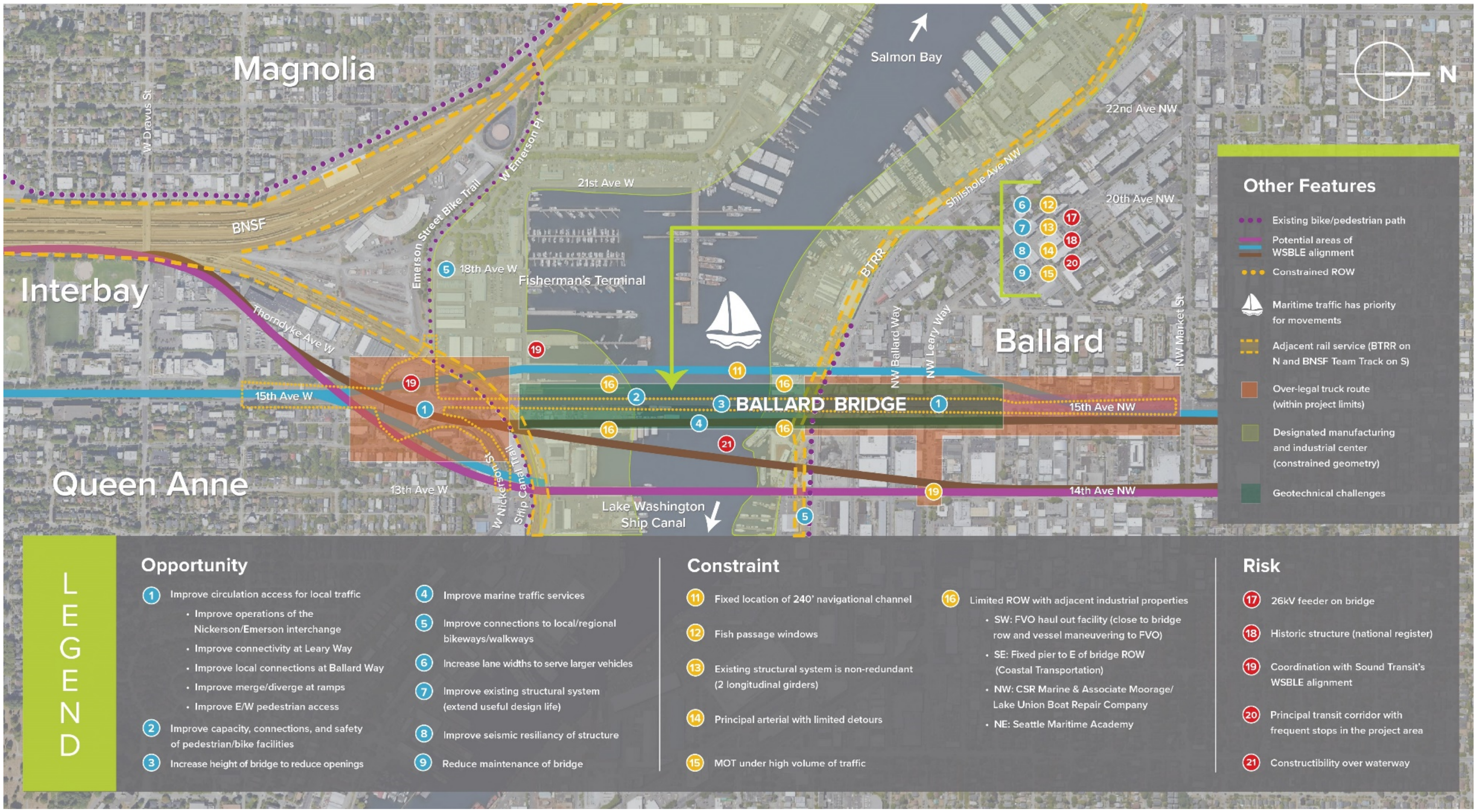

Figure 1. Constraints & Opportunities Map

2.3. Overview of Alternative Development and Evaluation Process

The project team used an evolving process to develop the alternatives for this project study and the evaluation process was conducted in three phases, the Initial Options Screening phase, Component Feasibility Analysis phase, and the Alternatives Analysis phase, as illustrated in Figure 2.

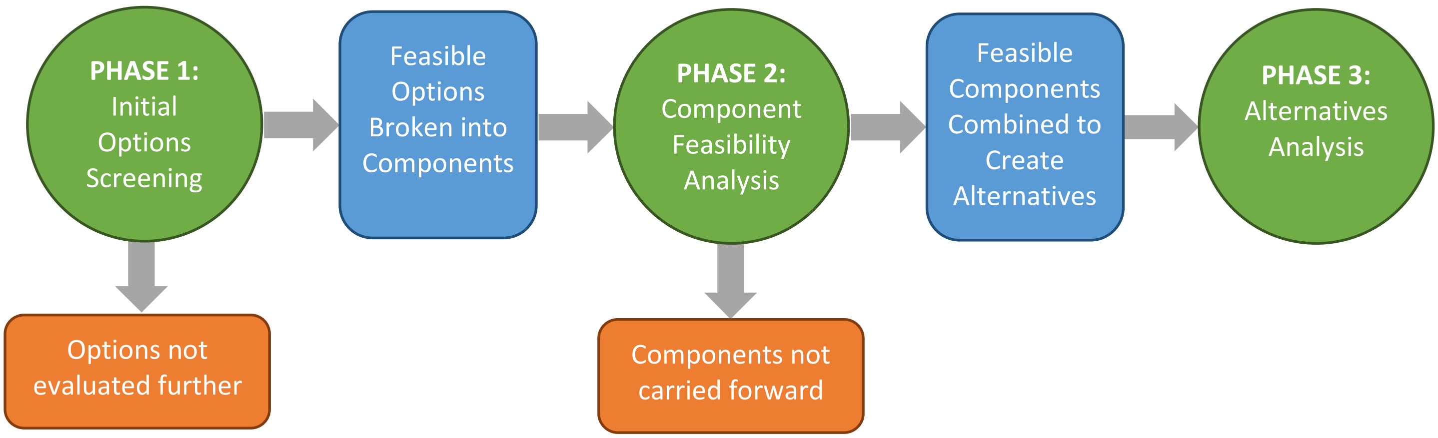

Figure 2. Ballard Bridge Evaluation Process

Screening of initial options was performed in Phase 1. Initial options included Low-Level Bridge Replacement, Low-Level Bridge Rehabilitation, Mid-Level Movable Bridge, High-Level Fixed Bridge, and Tunnel.

The low-level bridge replacement option has a similar profile to the existing bridge, which does not reduce the number of required bascule bridge openings to accommodate marine traffic and associated impacts to bridge and waterway traffic. The low-level bridge replacement option could increase lane widths and reset the structure service life compared to the low-level bridge rehabilitation option but would need a temporary detour bridge to facilitate construction. Although a viable option, the low-level bridge replacement option was not carried further through this study as outlined in Appendix C.

The low-level bridge rehabilitation consists of widening the existing bridge sidewalk(s) to create a SUP for bicycles and pedestrians on the west side of the bridge. In 2014, a Bridge Sidewalk Widening Study was conducted to evaluate alternatives to make travel across the Ballard Bridge more comfortable for pedestrians and bicyclists. That study was the reference point for the rehabilitation alternative in this study. This option improves bicycle and pedestrian safety and accessibility but does not provide any improvements for marine traffic in the ship canal or for vehicular traffic on the Ballard Bridge, with the exception of moving the cyclists using the traffic lanes today onto the SUP. The addition of the MSPUI at the Emerson-Nickerson Street intersection does improve vehicular and bicycle/pedestrian traffic at the south end of the project. The low-level bridge rehabilitation option was found to be a viable option and was carried into Phase 2.

The mid-level bridge option consists of the replacement of the existing low-level bridge with a mid-level bridge that has a profile at a higher elevation. The option still uses a movable bridge structure to span over the marine traffic channel. The mid-level option provides increased vertical clearance at the new movable bridge span in the down position, thereby reducing the number of required bridge openings and associated impacts to bridge traffic. The mid-level bridge option was found to be a viable option and was carried into Phase 2.

The high-level bridge option consists of the replacement of the existing low-level bridge with a high-level fixed bridge that would provide vertical clearance of about 150 feet over the navigation channel. This vertical clearance would allow for continuous, unimpeded flow of maritime and bridge traffic, similar in concept to the Aurora Bridge. The height selected is such that the existing bascule could fit inside the proposed clearance envelope during the majority of the construction of this option to facilitate phased construction. The high-level bridge option was found to be a viable option and was carried into Phase 2.

A tunnel option was considered at the screening level as part of this study. This option would require an alignment that extends through competent soils below the navigation channel, then rises up at 5% maximum longitudinal slope beyond the waterway until it reaches grade. The tunnel option was ruled out from further consideration for several reasons as outlined in Appendix C.

During Phase 2 - Component Analysis, a suite of components (or sub-options for discrete segments of the alignment) were identified for feasibility screening prior to combining feasible components into alternatives. These components were arranged into three groups based on location and function, including Ship Canal components, North End components, and South End components. In total, 14 potential components were identified as discussed in Appendices A, B and C.

The fourteen components were further evaluated through a technical screening process to determine which appeared viable before combining them into full-solution alternatives and advancing into this Alternatives Analysis. The Component Analysis included preparing very conceptual designs to determine the geometric and structural feasibility of each component while performing high-level traffic operations analyses to test the components' operational feasibility.

As part of Phase 3, viable components were then packaged together to create one rehabilitation and two replacement alternatives that would provide improved functionality compared to the existing Ballard Bridge. The following sections of this memo describe the three alternatives considered, document the alternatives analysis methodology, and discuss the analysis results.

Components that were considered not feasible include a Parallel Mid-Level Replacement Component, a couple High-Level North End Components, a Mid-Level North End Component, and a couple South End Components shared between the Mid-Level and High-Level Options. Discussion of all components and the details of their evaluation can be found in Appendices A,B, and C.

3. ALTERNATIVES CONSIDERED

Three alternatives for the rehabilitation or replacement of the Ballard Bridge were developed and evaluated for further consideration including Low-Level Bridge Rehabilitation Alternative (Low-Level), Mid-Level Movable Bridge Alternative (Mid-Level), and High-Level Fixed Bridge Alternative (High-Level). These alternatives are described below.

3.1. LOW-LEVEL BRIDGE REHABILITATION ALTERNATIVE

The low-level alternative would consist of widening the existing bridge sidewalk(s) along the approach spans and movable bridge to create a Shared Use Path (SUP). This alternative would improve bicycle and pedestrian safety and accessibility but would not have any improvements for marine or vehicular traffic on the Ballard Bridge in the final condition, except for moving cyclists using the traffic lanes today to the SUP. The addition of the Modified Single Point Urban Interchange (MSPUI) at the Emerson-Nickerson Street intersection does improve vehicular and bicycle/pedestrian traffic at the south end of the project. Figure 3 provides an overview of the Low-Level Bridge Rehabilitation Alternative.

Traffic: This alternative would maintain the existing bascule bridge with 44-ft vertical clearance above the ship canal, with no effect on the number of bridge openings or number of lanes of traffic. The SUP would accommodate an expected future increase of bike and pedestrian traffic. This option would retain the current vertical clearances of the bridges and the existing ramp configuration at NW Leary Way / NW Ballard Way. The SUP would connect to the street grid along the edge of the southbound on-ramp at Ballard Way. The MSPUI would provide substantial benefit to vehicular traffic operations and freight mobility, as well as bicycle and pedestrian connections to and from the Interbay neighborhood, the Ship Canal Trail, the Burke-Gilman Trail, and through routes on 15th Ave W/NW. For further traffic analysis see Appendix A.

Roadway/Geometry: This alternative would include widening the west sidewalk to create a 14-ft wide SUP on the west side of the existing bridge, extending from Ballard way at the north end to a new Emerson-Nickerson interchange at the south end. The east sidewalk on the approach structures would also be widened to 6-ft to match the existing bascule bridge. This alternative would maintain the existing horizontal and vertical alignments and lane widths. Right-Of-Way (ROW) property takes would be required along the west side of 15th Ave W/NW to construct the SUP. The Emerson-Nickerson interchange with 15th Ave W would be replaced with a MSPUI that realigns W Emerson St and W Nickerson St to provide one simple alignment over 15th Ave W and clearance for overheight vehicles, while maintaining maximum 5% grades. For further geometric analysis see Appendix B.

Structural: This alternative would replace the existing concrete sidewalk on the west side of the movable bridge structure with a 14-ft wide SUP using lightweight materials. Similar retrofits would be completed on the approach structures to widen the west sidewalk for a 14-ft wide SUP and widen the east sidewalk to 6-ft. The sidewalk widenings would continue down the ramps to Ballard Way at the north end by constructing new CIP retaining walls. The mechanical and electrical systems of the movable bascules should be replaced. The MSPUI constructed for the Emerson-Nickerson interchange would include new Southbound (SB) off-ramp and Northbound (NB) on-ramp structures connecting to the existing bridge, a new Emerson-Nickerson overpass bridge, and associated retaining walls. This alternative would also include rehabilitation and strengthening of the existing structures to account for existing conditions, load rating, and seismic deficiencies. For further structural analysis see Appendix C.

Figure 3. Low-Level Bridge Rehabilitation Overview

3.2. *Mid-Level Movable Bridge Alternative*

The mid-level alternative would consist of replacing the existing bridge with a mid-level bridge that would provide 60'-70' of vertical clearance under a new movable bridge at the marine traffic channel. It also would include a MSPUI at the Emerson-Nickerson Street intersection and new SB on-ramp and NB off-ramp connections to NW Leary Way. Figure 4 provides an overview of the Mid-Level Movable Bridge Alternative.

Traffic: This option would include a new bascule bridge with increased vertical clearance above the ship canal, reducing the frequency and duration of bridge openings; and also would have four vehicle lanes with standard widths for 15th Ave W/NW through traffic (two in each direction). The 14-ft wide SUP would accommodate an expected future increase of bike and pedestrian traffic. The connections to NW Leary Way would include a SB on-ramp that could connect at 17th Ave NW and a NB off-ramp that could connect at 14th Ave NW via NW 49th St. This alternative allows Shilshole Ave NW, NW 46th St, NW Ballard Way and NW Leary Way to connect under 15th Ave NW with clearance for overheight vehicles and would provide a new north-south surface access road on 15th Ave NW under the structure. The MSPUI would provide substantial benefit to vehicular traffic operations and freight mobility, as well as bicycle and pedestrian connections to and from the Interbay neighborhood, the Ship Canal Trail, the Burke-Gilman Trail, and through routes on 15th Ave W/NW. For further traffic analysis see Appendix A.

Roadway/Geometry: This alternative would provide a minimum of 60-ft vertical clearance above the ship canal while maintaining maximum grades of 5% on the roadways and ramps. Two lanes would be provided for each of the NB and SB directions along with an add/drop lane in the SB direction between NW Leary Way and Emerson-Nickerson. The 14-ft SUP along the west side of 15th Ave W/NW would provide connections to NW Leary Way and Emerson-Nickerson. This alternative would maintain the existing horizontal alignment, and ROW property takes would be required along the west side of 15th Ave W/NWand at each of the ramps. The Emerson-Nickerson interchange with 15th Ave W would be replaced with a MSPUI that realigns W Emerson St and W Nickerson St to provide one simple alignment over 15th Ave W and clearance for overheight vehicles. For further geometric analysis see Appendix B.

Structural: This alternative would include construction of a new bascule bridge and approach structures over water and land, new SB on-ramp and NB off-ramp bridges at NW Leary Way, a new Emerson-Nickerson overpass bridge, new SB off-ramp and NB on-ramp bridges for the MSPUI and associated retaining walls. This alternative would require a temporary detour with movable bridge to facilitate construction. For further structural analysis see Appendix C.

Figure 4. Mid-Level Movable Bridge Overview

3.3. *HIGH-LEVEL FIXED BRIDGE ALTERNATIVE*

The high-level alternative would consist of the replacing the existing bridge with a high-level bridge that would provide 140'-160' of vertical clearance under a new fixed bridge at the marine traffic channel. It also would include a MSPUI at the Emerson-Nickerson Street intersection and a new SB on-ramp / NB off-ramp connection to NW Leary Way. Figure 5 provides an overview of the High-Level Fixed Bridge Alternative.

Traffic: This option would include a new fixed bridge with much more clearance above the ship canal, eliminating the bridge openings; and also would have four vehicle lanes with standard widths for 15th Ave W/NW through traffic (two in each direction). The 14-ft wide SUP would accommodate an expected future increase of bike and pedestrian traffic. An elevated signalized intersection would provide connections to NW Leary Way via a SB on-ramp and NB off-ramp that could connect at 14th Ave via 52nd St. This alternative allows Shilshole Ave, 46th St, Ballard Way, NW Leary Way, 49th St, 50th St, and 51st St to connect under 15th Ave NW with clearance for overheight vehicles and would provide a new north-south surface access road on 15th Ave NW under the structure. The MSPUI would provide substantial benefit to vehicular traffic operations and freight mobility, as well as bicycle and pedestrian connections to and from the Interbay neighborhood, the Ship Canal Trail, and through routes on 15th Ave W/NW. For further traffic analysis see Appendix A.

Roadway/Geometry: This alternative would provide a minimum of 140-ft vertical clearance above the ship canal while maintaining maximum grades of 5%. Two lanes would be provided for each of the NB and SB directions. The 14-ft SUP along the west side of 15th Ave W/NW would provide connections to NW Market St and Emerson-Nickerson. This alternative would maintain the existing horizontal alignment, and ROW takes would be required along the west side of 15th Ave and at each of the ramps. The Emerson-Nickerson interchange with 15th Ave would be replaced with a MSPUI that realigns W Emerson St and W Nickerson St to provide one simple alignment over 15th Ave and clearance for overheight vehicles. For further geometric analysis see Appendix B.

Structural: This alternative would include construction of a new fixed main span bridge and approach structures over water and land, new SB on-ramp and NB off-ramp bridges at NW Leary Way, a new Emerson-Nickerson overpass bridge, new SB off-ramp and NB on-ramp bridges for the MSPUI, and associated retaining walls. The height selected is such that the existing bascule can fit inside the proposed clearance envelope during most of the construction of this alternative to facilitate construction phasing. For further structural analysis see Appendix C.

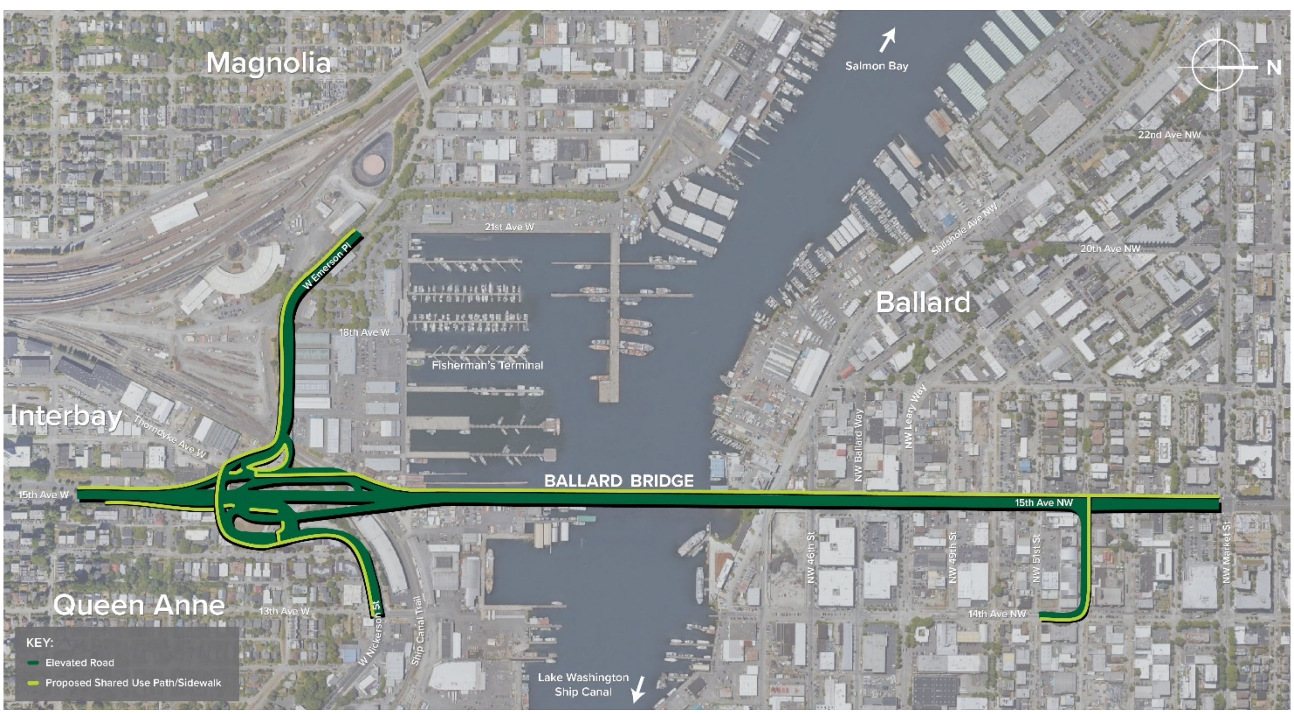

Figure 5. High-Level Fixed Bridge Overview

4. ALTERNATIVES ANALYSIS METHODOLOGY AND EVALUATION

The following section describes the analysis process and methodology used in this Alternatives Analysis to evaluate the three Ballard Bridge rehabilitation / replacement alternatives. An overview of the evaluation criteria and rating methods is provided and is followed by further details on each metric and the analysis results.

4.1. EVALUATION CATEGORIES AND CRITERIA

The Ballard Bridge Planning Study used a performance-based approach to the Alternatives Analysis. The project purpose and goals were used as a basis for establishing evaluation criteria that were used to compare the three alternatives. The evaluation criteria fall into the following five broad evaluation categories:

- Mobility & Connectivity
- Environmental & Permitting Considerations
- Implementation Characteristics
- Stakeholder Input
- Cost Considerations

Within each of the five main categories, project-specific criteria were identified to evaluate the project goals, measured either qualitatively or quantitatively. Figure 6 summarizes the evaluation categories and project-specific criteria.

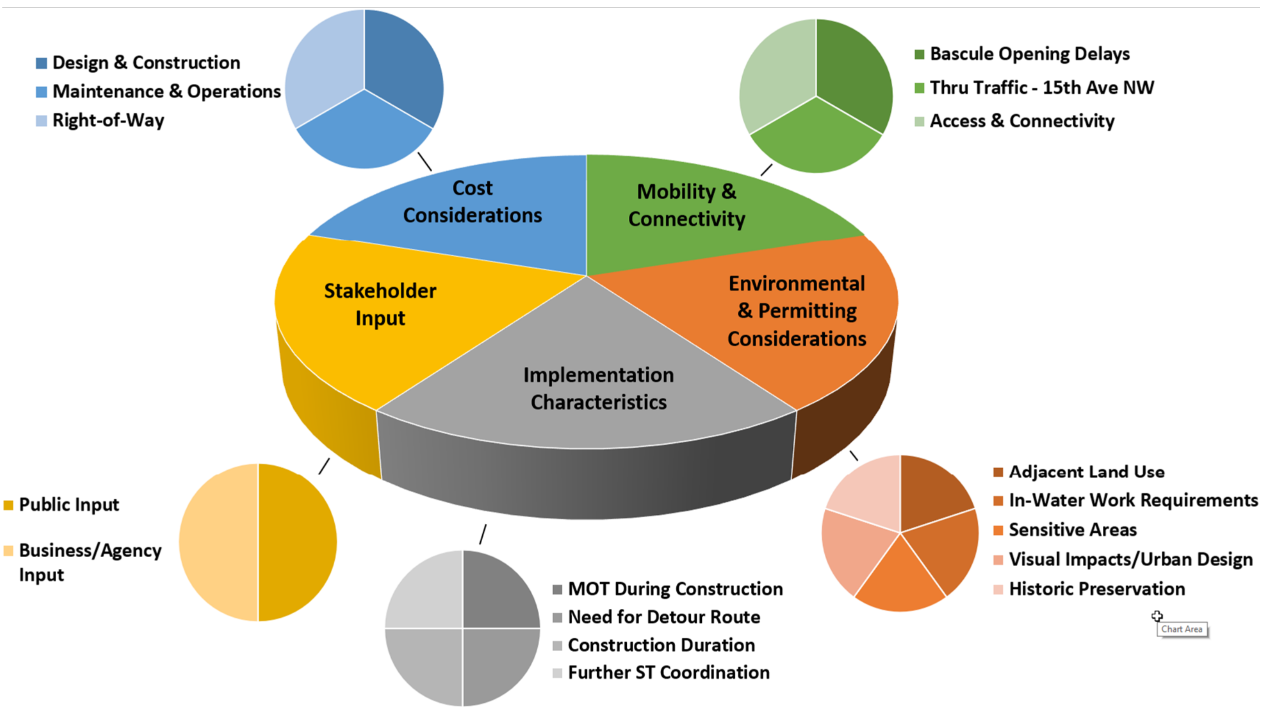

Figure 6. Evaluation Categories and Criteria

Rating of the alternatives for the Mobility & Connectivity category was done by comparing the proposed alternatives to the existing condition. Rating for most other categories was completed in a relative manner, comparing the alternatives against each other as opposed to the existing or "no-build" option. For each of the project-specific criteria, a rating scale was developed to represent the range of values observed or measured. The following sections provide details on each of the criteria including their analysis methods and metrics results.

4.2. Mobility & Connectivity

The Ballard Bridge provides access between the Ballard, Magnolia, Interbay and Queen Anne neighborhoods and impacts east-west mobility and connectivity within Ballard on the north end of the bridge. The ideal solution provides safer, improved, multimodal access to and from neighborhood destinations. A detailed traffic analysis was performed and is presented in Appendix A.

The transportation functions of the Ballard Bridge are captured by several criteria related to the mobility for each mode of travel, including marine navigation, as well as connectivity between different neighborhoods served by the bridge. The criteria used to evaluate the transportation functions are described below.

4.2.1. Bascule Opening Delays

This criterion compares the frequency and duration of bascule openings causing both vehicular and marine traffic delay. Table 1 shows the evaluation matrix.

Table 1. Bascule Opening Delays – Evaluation Matrix

	Rating	Rating Rationale Relative to the Existing Condition
●	Best	Elimination of bascule openings
◕	Better	Decrease in bascule opening frequency and/or duration
◑	No change	No change in bascule opening frequency or duration
◔	Worse	Increase in bascule opening frequency and/or duration
○	Worst	Increase in bascule opening frequency and duration

The rating assigned to each of the alternatives and an explanation of the evaluation are shown in Table 2.

Table 2. Bascule Opening Delays – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◑	Existing bascule bridge would remain. Frequency and duration of openings would be highest of all alternatives.
Mid-Level	◕	Raises bascule bridge, which would reduce both the frequency and duration of openings compared to the existing bridge.
High-Level	●	Fixed bridge would have no openings for marine traffic.

**- Rating scale relative to the existing condition*

4.2.2. Through Traffic on 15th Ave W/NW Corridor

This criterion compares the travel times of through traffic on the 15th Ave W/NW Corridor, as modeled for the PM Peak between W Dravus St and north of NW Market St. Table 3 shows the evaluation matrix.

Table 3. Travel Times for Through Traffic on 15th Ave W/NW – Evaluation Matrix

	Rating	Rating Rationale Relative to the Existing Condition
●	Best	<17 min (greatly reduced cumulative NB and SB travel times).
◕	Better	17 to <19 min (slightly reduced cumulative NB and SB travel times).
◑	No change	19 min (no change in cumulative NB and SB travel times).
◔	Worse	>19 to 21 min (slightly increased cumulative NB and SB travel times).
○	Worst	>21 min (greatly increased cumulative NB and SB travel times).

The existing travel time for this route is estimated at 14 min (northbound) + 5 min (southbound) = 19 min total. Generally, the Mid-Level Alternative performed best operationally because of the reduction of bridge openings coupled with the SPUI and geometric improvements for cars exiting and entering 15th Ave W/NW. The rating assigned to each of the alternatives and a discussion of the ratings assigned are shown in Table 4.

Table 4. Travel Times for Through Traffic on 15th Ave W/NW – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	18 min. Travel times are reduced slightly due to the operational efficiency of the SPUI at Emerson/Nickerson.
Mid-Level	◕	18 min. Travel times are reduced slightly due to the operational efficiency of the SPUI at Emerson/Nickerson and reduction in bridge openings.
High-Level	○	23 min. Travel time is increased because of the addition of a signal on 15th Ave NW just north of the bridge.

**- Rating scale relative to the existing condition*

4.2.3. Modal Access and Connectivity

These modal-specific criteria measure multimodal access and connectivity in the Ballard Bridge corridor by reviewing the quality of access and connections for each mode of transportation (vehicular/truck, bike and pedestrian, freight, and transit) compared to the existing condition using the evaluation matrix shown in Table 5. General discussions of the quality of access and connections for each mode follows with ratings for the modal evaluations shown in Table 6 (vehicular/truck), Table 7 (bike and pedestrian), Table 8 (freight), and Table 9 (transit) with explanations of the rating.

Table 5. Access and Connectivity – Evaluation Matrix

●	◕	◑	◔	○
Best	Better	OK or No Change	Worse	Worst

Vehicular/Truck Access and Connectivity

The alternatives have different ramp configurations at the north end of the bridge that could affect connections to industrial businesses along the Ship Canal and/or traffic served by NW Leary Way. The Low-Level Alternative retains the existing grid connections; the Mid-Level Alternative would have longer one-way ramps that connect to the grid further away from 15th Ave NW; the High-Level Bridge would have an elevated signalized intersection on 15th Ave NW with a two-way ramp that connects to NW Leary Way at 14th Ave NW. All alternatives propose the same reconfiguration of the W Emerson St/W Nickerson St/15th Ave W interchange on the south side of the bridge. The ratings in Table 6 measure the quality of each connection in terms of vehicular delay and travel time.

Table 6. Vehicular/Truck Access and Connectivity – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	No change in ramp configuration at the north end of bridge, but substantial improvement with the MSPUI at the south end of the bridge.
Mid-Level	●	Improvements in operation at north end of the bridge plus substantial improvement with the MSPUI at the south end of the bridge.
High-Level	◔	Introduces new signal on 15th Ave NW at north ramp junction and would increase congestion on 14th Ave NW. Substantial improvement with the MSPUI at the south end of the bridge.

**- Rating scale relative among the study alternatives*

Bike and Pedestrian Access and Connectivity

All alternatives would improve the non-motorized access across the bridge by providing a 14-foot shared-use path. The alternatives have different means of connecting to the Burke-Gilman Trail and Ship Canal Trail. The alternatives also have different profiles on the bridge deck that could affect expected energy expenditure by cyclists. The ratings in Table 7 measure the quality of the trail connections and effect of mainline grade.

Table 7. Bike and Pedestrian Access and Connectivity – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	Adds 14-ft wide SUP to west side of bridge and retains existing sidewalk on east side of bridge; improves connections at south end of bridge.
Mid-Level	◕	Adds 14-ft wide SUP to west side of bridge; improves connections at south end of bridge.
High-Level	◑	Adds 14-ft wide SUP to west side of bridge; improves connections at south end of bridge. Has steepest and longest uphill and downhill bridge segments that could affect climbing as well as the increase the differential in speed between bikes and peds on the bridge.

**- Rating scale relative among the study alternatives*

Freight Access and Connectivity

All the options are designed to a maximum 5% grade on the bridge mainline with turning radii to accommodate the largest semi-trailer truck expected (WB-67) in accordance with the AASHTO Policy on Geometric Design of Highways and Streets. All new structures on the mainline would also be designed to accommodate oversize vehicle loads (20-foot by 20-foot clearance). However, some of the alternatives may also increase over-dimension clearance for roads that pass under the 15th Ave W/NW mainline north and south of the bridge. The ratings in Table 8 reflect these additional freight attributes.

Table 8. Freight Access and Connectivity – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	No change in ramp configuration at the north end of bridge, but substantial improvement with the MSPUI at the south end of the bridge with ability to improve clearance for over-dimension freight.
Mid-Level	●	Improvements in operation at north end of the bridge plus substantial improvement with the MSPUI at the south end of the bridge. Ability to improve clearance for over-dimension freight north and south of the bridge.
High-Level	◕	Eliminates bascule openings of bridge during midday hours. Introduces new signal on 15th Ave NW at north ramp junction and would increase congestion on 14th Ave W. Substantial improvement with the MSPUI at the south end of the bridge. Ability to improve clearance for over-dimension freight north and south of the bridge.

**- Rating scale relative among the study alternatives*

<u>Transit Access and Connectivity</u>

The changes in the 15th Ave W/NW interchange configuration at both NW Leary Way and W Emerson St/W Nickerson St could affect transit routing and/or stop locations. The ratings in Table 9 reflect the potential impact to transit routing and stops.

Table 9. Transit Access and Connectivity – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	No change in ability to provide stops for through transit on 15th Ave W/NW corridor; MSPUI at the south end of the bridge could allow transit connections between Fremont and Magnolia.
Mid-Level	◔	Eliminates ability to provide stops for through transit on 15th Ave NW north of the bridge; could serve local routes on NW Leary Way; MSPUI at the south end of the bridge could allow transit connections between Fremont and Magnolia.
High-Level	○	Eliminates ability to provide stops for through transit on 15th Ave W north of the bridge and would be challenging for local transit service connecting between 15th Ave NW and NW Leary Way. MSPUI at the south end of the bridge could allow transit connections between Fremont and Magnolia.

**- Rating scale relative among the study alternatives*

4.3. Environmental & Permitting Considerations

Each alternative introduces a variety of environmental impacts and permitting conditions. The criteria in this category measure the relative impacts to existing adjacent land uses, in-water work requirements, sensitive areas, visual impacts, urban design and historic preservation as well as related permitting of the construction work for each alternative. The ideal solution avoids or mitigates impacts to the following areas. The evaluation of these criteria are relative to other alternatives considering the evaluation matrix in Table 10.

Table 10. Environmental & Permitting Considerations – Evaluation Matrix

●	◕	◑	◔	○
Best	Better	OK	Worse	Worst

4.3.1. Impacts to Adjacent Land Use

This criterion considers the relative impacts of the alternatives on adjacent land use both during and after construction. In general, land uses in the project area would not change as a result of the project. However, each Alternative has significant ROW impacts that affect land uses in the corridor. Table 11 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 11. Impacts to Adjacent Land Use - Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	Minimal right-of-way impacts or takes for the bridge structure and sidewalk widening. Biggest impacts are for the MSPUI, however, most are unused or underutilized parcels. The biggest impact is to the Essex parcel which is a condo complex that would likely be a total take requiring tenant relocation and buy out.
Mid-Level	◔	Similar MSPUI impacts as the Low-Level Alternative on the south end. Significant north end right-of-way takes including one historic parcel.
High-Level	◔	Similar MSPUI impacts as the other Alternatives on the south end. Significant north end right-of-way takes – avoids historic parcel.

**- Rating scale relative among the study alternatives*

4.3.2. In-Water Work Requirements

This criterion considers the in-water impacts and relative permitting difficulty of each alternative. The Mid-Level Alternative is anticipated to be hardest to permit because it will require a temporary detour structure across the Ship Canal as well as the permanent structure. The Mid-Level and High-Level Alternatives will require coordination with the Coast Guard to determine the actual navigational widths when bascules are open, bridge clearances, and navigational clearances – this will be relatively straightforward for the Mid-level Alternative, and will be more significant to set a clearance height for the High-Level Alternative based on the recent experience of BNSF and Sound Transit with similar Ship Canal crossings. Table 12 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 12. In-Water Work Requirements – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	Minimal coordination with the Coast Guard and relatively straightforward permitting of in-water work which would just be related to construction over water of the multi-use trail and sidewalk and bridge rehabilitation work.
Mid-Level	○	Moderate level of Coast Guard coordination to get approval for bascule replacement structure. Significant permitting and coordination of in-water structure for final Ship Canal crossing and temporary, movable detour bridge over the Ship Canal during construction.
High-Level	◔	Significant Coast Guard coordination to get approval for fixed height bridge over the Ship Canal. Permitting of a new in-water bridge structure and its construction.

**- Rating scale relative among the study alternatives*

4.3.3. Sensitive Areas

This criterion considers potential impacts to protected wildlife habitats, mapped wetland areas, and other mapped critical areas (i.e. steep slopes, liquefaction zones, etc.) which would require additional coordination, permitting, and mitigation measures. Table 13 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 13. Sensitive Areas – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	There is little change to the footprint of the existing bridge and very minimal impacts to fish habitats that could be caused in the shadow of the bridge.
Mid-Level	◔	Has the most significant impacts on habitats and critical areas of the three Alternatives as this Alternative requires a temporary detour bridge over the Ship Canal.
High-Level	◑	Moderate level of impacts to sensitive habitats and critical areas. Shadowing of habitats is likely not a significant issue because of the added height of the bridge structure.

**- Rating scale relative among the study alternatives*

4.3.4. Visual Impacts/Urban Character

This criterion considers the long-term impacts of visual character including retaining walls, noise walls, and structures proposed. Also considers the urban character of designed streets under approach structures, mostly on the north end of the project. The Low-Level Alternative is rated highest because it does not introduce a higher structure and maintains the same visual impacts as the existing bridge. The Mid-Level Alternative would raise the bridge and introduce new visual impacts in the project area; the High-Level will do the same, but to a much more significant level because of the extreme height. The High-Level bridge would provide an opportunity to create a signature bridge crossing. Table 14 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 14. Visual Impacts/Urban Design – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	No change from the existing; maintains location, character and aesthetics of current bridge.
Mid-Level	◔	Removes the existing bridge. New bridge will be designed with consideration of aesthetics and visual impacts. Structure is approximately 25-35’ higher than the existing bridge, which introduces more visual impacts than the Low-Level Alternative. Retaining and Noise walls would be designed to minimize impacts. Retaining and noise walls would be designed to minimize impacts – there is a significant amount of new retaining walls required for the raised structure and MSPUI. With the raised bridge, the streets under the bridge are more open than the existing bridge and will allow for the incorporation of urban character under the new bridge as well.
High-Level	○	Removes the existing bridge. New bridge will be designed with consideration of aesthetics and visual impacts. Structure is approximately 105-125’ higher than the existing bridge, which causes significantly more visual impacts than the Low-Level or Mid-Level Alternatives. Retaining and noise walls would be designed to minimize impacts – there is a significant amount of new retaining walls required for the heightened structure. With the significantly raised bridge, the streets under the bridge are much more open than the existing bridge and will allow for the incorporation of urban character under the new bridge as well.

**- Rating scale relative among the study alternatives*

4.3.5. Historic Preservation

This criterion considers the long-term impacts of the new construction on the historical elements of the existing bridge and buildings within the Area of Potential Effects (APE). Three historic buildings/structures were identified within the overall project corridor APE, including the Ballard Bridge, the FVO Winch House, and the Brekke Steel Co. building. In addition, each alternative APE identifies a number of potential historic properties (those that are currently older than 25 years and may be subject to historic designation when this Project is constructed).

Impacts to the Ballard bridge can likely be managed for the Low-Level Alternative so that they do not have adverse impacts on historic properties. However, the Mid-Level and High-Level Alternatives will remove the historic Ballard Bridge and construct a new bridge that will introduce significant visual intrusions into the project area (more significant as bridge height raises). Table 15 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 15. Historic Preservation – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	• If rehabilitation could be done with strict adherence to the Rehabilitation Standards of Secretary of the Interior’s Standards and Guidelines for the Treatment of Historic Properties and therefore not diminish the property’s integrity and if the Project had no other

Alternative	Rating*	Discussion
		effects on historic properties within the APE, the Project could potentially be determined to have no adverse effect on historic properties. • May have minor right-of-way take from FVO Winch House. • No effects on Brekke Steel Co. building. • No effects on 25+/- potential historic properties.
Mid-Level	◔	• Higher potential than the Low-Level Alternative of introducing a significant visual intrusion onto the landscape, which may have an adverse effect on historic properties within the recommended physical effects APE as well as any future recommended visual effects APE. • May have minor right-of-way take from FVO Winch House. • Total take of Brekke Steel Co. building. • Will have right-of-way takes from several of the 40+/- potential historic properties.
High-Level	○	• Highest potential of introducing a significant visual intrusion onto the landscape, which may have an adverse effect on historic properties within the recommended physical effects APE as well as any future recommended visual effects APE. • May have minor right-of-way take from FVO Winch House. • No effects on Brekke Steel Co. building. • Will have right-of-way takes from several of the 43+/- potential historic properties.

**- Rating scale relative among the study alternatives*

4.4. Implementation Characteristics

This category includes project-specific criteria that speak to aspects of the actual construction process, constructability, and how each alternative may impact or benefit the traveling public during construction. The ideal solution will be constructed with minimal impacts to traffic and can be constructed with limited detours and coordination with Sound Transit. The criteria used to evaluate the implementation characteristics are described below.

4.4.1. Maintenance of Traffic During Construction

Evaluates the impacts of construction on existing traffic in terms of length of construction and significance of impacts on traffic. Each alternative constructs the MSPUI for the Emerson-Nickerson interchange with 15th Ave at the south end of the project, so for comparative analysis, evaluation focuses on the bridge component and north end connections.

Table 16. Maintenance of Traffic During Construction – Evaluation Matrix

●	◕	◑	◔	○
Best	Better	OK	Worse	Worst

Table 17. Maintenance of Traffic During Construction – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	Single lane shutdowns as needed across the bridge. Least impacts to traffic.
Mid-Level	○	Longest duration to build a detour bridge and then the mid-level bascule bridge. Most significant impacts to traffic even with lanes maintained by the detour.
High-Level	◔	Longer duration to construct the highest structure. Minimizes impacts to existing traffic by constructing bridge over existing structure. Likely maintain 2 lanes in peak flow direction throughout construction.

**- Rating scale relative among the study alternatives*

4.4.2. Need for Detour Route

Evaluates the impacts of detour routes needed in terms of months of detour anticipated multiplied by the number of travel lanes affected. Table 18 shows the evaluation matrix and Table 19 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 18. Need for Detour Route – Evaluation Matrix

Rating	Rating Rationale Relative to the Existing Condition
● No	Detour Route over the Ship Canal is needed during construction.
○ Yes	Detour Route over the Ship Canal is not needed during construction.

Table 19. Need for Detour Route – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	Rehabilitates existing structure without requiring a detour during construction to maintain vehicular, bike and pedestrian traffic.
Mid-Level	○	Requires a detour to maintain vehicular, bike and pedestrian traffic in order to construct a new movable bridge on the existing alignment.
High-Level	●	Constructs a new fixed bridge structure over the existing structure without requiring a detour during construction to maintain vehicular, bike and pedestrian traffic.

4.4.3. Construction Duration

Evaluates the construction duration in terms of months of construction anticipated for each alternative based on a conceptual level schedule. Table 20 shows the evaluation matrix and Table 21 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 20. Construction Duration – Evaluation Matrix

●	◕	◑	◔	○
Best	Better	OK	Worse	Worst

Table 21. Construction Duration – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	●	Shortest duration to rehabilitate existing bridge.
Mid-Level	○	Longest duration to build a detour bridge and then the mid-level bascule bridge with the north end connections.
High-Level	◔	Longer duration to construct the highest structure and make the north end connections.

**- Rating scale relative among the study alternatives*

4.4.4. Further Sound Transit Coordination Requirements

Considers the level of coordination needed with Sound Transit based on the potential West Seattle and Ballard Link Extensions (WSBLE) alignments (as defined during the period of this study) and construction characteristics. Table 22 shows the evaluation matrix and Table 23 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 22. Further Sound Transit Coordination Requirements – Evaluation Matrix

Rating		Rating Rationale Relative to the Existing Condition
●	Highest	No further coordination required with Sound Transit.
◕	High	Further Coordination required with Sound Transit for one component of SDOT's Alternative.
◑	Medium	Further Coordination required with Sound Transit for two components of SDOT's Alternative.
◔	Low	Further Coordination required with Sound Transit for three components of SDOT's Alternative.
○	Lowest	Further Coordination required with Sound Transit for more than three components of SDOT's Alternative.

Table 23. Further Sound Transit Coordination Requirements – Evaluation Results

Alternative	Rating*	Requires further coordination with Sound Transit regarding…
Low-Level	◕	• The location and construction of potential WSBLE alignments near the SE corner of the MSPUI.
Mid-Level	◑	• The location and construction of potential WSBLE alignments near the SE corner of the MSPUI. • The location and construction of potential WSBLE alignments near the replacement bascule bridge.
High-Level	◔	• The location and construction of potential WSBLE alignments near the SE corner of the MSPUI. • The location and construction of potential WSBLE alignments and stations near the replacement fixed bridge. • The location and construction of potential WSBLE alignments and stations near the North End Ramp proposed along and terminating on 14th Ave NW.

**- Rating scale relative among the study alternatives*

4.5. STAKEHOLDER INPUT

This category includes project-specific criteria related to the level of community support expressed by the public, businesses, and agencies for each alternative during the Ballard Bridge Planning Study outreach efforts.

4.5.1. Public Input

Outreach concluded with drop-in sessions and an online survey that presented the three alternatives and asked respondents to select the “most preferred” and “least preferred” alternatives. A report summarizing the extent and results of the stakeholder outreach performed for this study is provided in Appendix H. The ideal solution should be broadly supported by the general public. Table 24 provides an evaluation matrix used to evaluate community input based on the percentage of respondents selecting each alternative as the “most preferred” alternative.

Table 24. Public Input – Evaluation Matrix

Rating	Rating Rationale based on Percentage of “Most Preferred” Votes Received
● Highest	81% - 100% of votes for “most preferred” alternative
◕ High	61% - 80% of votes for “most preferred” alternative
◑ Medium	41% 60% of votes for “most preferred” alternative
◔ Low	21% - 40% of votes for “most preferred” alternative
○ Lowest	0% - 20% of votes for “most preferred” alternative

This criterion considers the level of relative support for each alternative by the public at large and was determined through public outreach activities and surveys, specifically public selection of the “most preferred” alternative collected at the drop-in sessions and online open house. Table 25 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 25. Public Input – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	Received 67% of votes for “most preferred” alternative. (Received 10% of votes for "least preferred" alternative.)
Mid-Level	◔	Received 25% of votes for “most preferred” alternative. (Received 10% of votes for "least preferred" alternative.)
High-Level	○	Received 8% of votes for “most preferred” alternative. (Received 80% of votes for "least preferred" alternative.)

**- Rating scale relative among the study alternatives*

4.5.2. Business/Agency Input

This criterion considers the level of relative support for each alternative based on feedback received from key businesses and Sound Transit, KC Metro, the Port of Seattle, BNSF, and SDOT that was collected during the outreach for this project. Ratings were assigned using a relative assessment of potential impact for each alternative using the ratings shown in Table 26. Table 27 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 26. Business/Agency Input – Evaluation Matrix

●	◕	◑	◔	○
Best	Better	OK	Worse	Worst

Table 27. Business/Agency Input – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	• Potential impacts to BNSF properties. • Potential impacts to Port of Seattle properties. • Few business impacts, especially on the north end. • Operational improvements at Emerson/Nickerson but doesn't reduce the number of bridge openings.
Mid-Level	◔	• Potential impacts to BNSF properties. • Potential impacts to Port of Seattle properties. • Significant business impacts, especially on the north end. • Operational improvements at Emerson/Nickerson and significantly reduces the number of bridge openings. • Potential for minor transit re-routing due to new ramp locations.
High-Level	◔	• Potential impacts to BNSF properties. • Potential impacts to Port of Seattle properties. • Significant business impacts, especially on the north end. • Operational improvements at Emerson/Nickerson and eliminates bridge openings. • Potential for major transit re-routing due to new ramp locations.

**- Rating scale relative among the study alternatives*

4.6. COST CONSIDERATIONS

This category includes project-specific criteria that speaks to the expected cost of each alternative in terms of construction, maintenance & operations, and right-of-way costs. The ideal solution is financially feasible and provides the most benefit to the traveling public for the most economical cost.

4.6.1. Design & Construction Cost

This criterion measures the relative construction cost based on preliminary order-of-magnitude cost estimates (in 2019 dollars) based on conceptual design before ranges were applied. It is important to note that the ranges are significant to the cost estimates and should be included at all times, but are not suitable for scoring on a scale. In no way, should using these pre-range scores be an indicator of a higher level of accuracy than the ranges provide. Table 28 shows the evaluation matrix and Table 29 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 28. Design & Construction Cost – Evaluation Matrix

Rating	Rating Rationale Relative to Other Alternatives
● Lowest	< $200 M
◕ Lower	$200 M to $400 M
◑ Medium	$401 M to $600 M
◔ Higher	$601 M to $800 M
○ Highest	> $800 M

Table 29. Design & Construction Cost – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◑	$390 M
Mid-Level	○	$857 M
High-Level	○	$851 M

**- Rating scale relative among the study alternatives*

4.6.2. Maintenance & Operations Cost

This criterion measures the relative maintenance & operations cost based on preliminary order-of-magnitude cost estimates (in 2019 dollars) based on conceptual design. Table 30 shows the evaluation matrix and Table 31 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 30. Maintenance & Operation Cost – Evaluation Matrix

●	◕	◑	◔	○
Lowest	Lower	OK or No Change	Higher	Highest

Table 31. Maintenance & Operation Cost – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◑	Same structure as existing with rehabilitated bascule section. Will require ongoing operations staff and movable bridge maintenance. Older structure requires more ongoing maintenance.
Mid-Level	◕	Slightly longer structure requires ongoing operations staff and movable bridge maintenance (less than existing because number of openings is reduced. New structure will require less ongoing maintenance than rehabilitated structure.
High-Level	●	Much longer structure requires more maintenance. Fixed structure doesn't require operations staff or movable bridge maintenance. New structure will require less ongoing maintenance than rehabilitated structure.

**- Rating scale relative among the study alternatives*

4.6.3. Right-of-Way Cost

This criterion measures the relative construction cost based on preliminary order-of-magnitude cost estimates (in 2019 dollars) based on conceptual design. Table 32 shows the evaluation matrix and Table 33 shows the rating of each Alternative and provides a brief discussion to support the ratings.

Table 32. Right-of-Way Cost – Evaluation Matrix

Rating	Rating Rationale Relative to Other Alternatives
● Lowest	< $60 M
◕ Lower	$60 M to $90 M
◑ Medium	$91 M to $120 M
◔ Higher	$121 M to $150 M
○ Highest	> $150 M

Table 33. Right-of-Way Cost – Evaluation Results

Alternative	Rating*	Discussion
Low-Level	◕	$81 M
Mid-Level	◑	$114 M
High-Level	◔	$130 M

**- Rating scale relative among the study alternatives*

5. ALTERNATIVES ANALYSIS

The following section provides a summary of the project-specific criteria scores and the application of the assigned category evaluation matrices, as discussed in Section 4.

Table 34 summarizes the results of the analysis methodology described in Section 3, compiling all the criteria scores in the five main categories for each of the alternatives.

Table 34. Evaluation Results Summary

	Evaluation Rating		
Criterion	**Low-Level Bridge Rehabilitation Alternative**	**Mid-Level Movable Bridge Alternative**	**High-Level Fixed Bridge Alternative**
Mobility & Connectivity	↓ *Scale Relative to the Existing Condition* ↓		
Bascule Opening Delays	◑	◕	●
Through Traffic on 15th Ave NW Corridor	◕	◕	○
Modal Access and Connectivity			
Vehicular/Truck	◕	●	◔
Bike and Pedestrian	●	◕	◑
Freight	◕	●	◕
Transit	◕	◔	○
Environmental & Permitting Considerations	↓ *Scale Relative Among Alternatives* ↓		
Impacts to Adjacent Land Use	◕	◔	◔
In-Water Work Requirements	●	○	◔
Sensitive Areas	●	◔	◑
Visual Impacts/Urban Design	●	◔	○
Historic Preservation	●	◔	○
Implementation Characteristics	↓ *Scale Relative Among Alternatives* ↓		
Maintenance of Traffic During Construction	●	○	◔
Need for Detour Route	No	Yes	No
Construction Duration	●	○	◔
Further ST Coordination	◕	◑	◔
Stakeholder Input	↓ *Scale Relative Among Alternatives* ↓		
Public Input	◕	◔	○
Business/Agency Input	◕	◔	◔
Cost Considerations	↓ *Scale Relative Among Alternatives* ↓		
Design & Construction	◑	○	○
Maintenance & Operations	◑	◕	●
Right-of-Way	◕	◑	◔

For definition of ratings, refer to section 4 of this report. In general, ratings follow the rationale below

●	◕	◑	◔	○
Best	Better	OK	Worse	Worst

6. RECOMMENDATIONS FOR FUTURE WORK

The analyses performed for the Ballard Bridge Planning Study was based on high-level, conceptual designs. The study team, with assistance from external stakeholders and our internal SDOT Roadway Structures (RS) staff[1], identified several recommendations for future enhancements, design refinements, or additional analyses that should be considered as this body of work is advanced. This list is not all-inclusive, and future work will need to be completed to vet these items and identify other applicable considerations.

6.1. ALL ALTERNATIVES

- Operational Considerations – A summary of the comments received from SDOT RS staff
    - Move the Operator Tower to the North side of any movable bridge alternative to provide better line of sight to the Ballard Locks and Fremont Bridge.
    - Increase the size of the Operator Tower, design access to the lower levels of the structure from within the tower, and separate the bathroom, galley, and lockers from the operation console.
    - Connect the Operator Tower to City's sewer, water, and electrical systems (this may be easier if the tower is moved to the North).
    - Cover and protect mechanical systems and operator's paths from roadway debris and pedestrian and bicycle interference (i.e. provide an entrance that doesn't open into the sidewalk and include a catwalk for bascule and centerlock access).
    - Improve pedestrian access to the Operator Tower and provide a 3-car-length parking cut out next to the tower for staff, electricians, and mechanics.
    - Ensure a new bridge doesn't have lips or over-hangs for birds to perch or roost on.
- Marine Traffic – Future studies should include formal marine traffic surveys to establish vessel types and frequencies. This information can be used to establish the estimated number of openings for each bridge height, as well as the minimum height required to eliminate openings.
- Geotechnical Investigation – this study only included geotechnical and foundation investigation for the portion of the Ballard Bridge over water. Future studies tasked with developing an alternative beyond the conceptual level should include a geotechnical investigation to cover all segments of the structures.
- Historic Preservation – The alternatives presented in this study will need further review in future phases of project development to confirm that they will meet the requirements outlined in the Analysis of Potential Effects to Cultural Resources and/or Historic Properties Memo and subsequent historic preservation reviews.
- Tribal Coordination – The City recognizes area tribes, such as the Muckleshoot and Duwamish, as important and vital stakeholders and voices in the decision-making process. Subsequent project analysis and stakeholder engagement shall include coordination with Tribes.
- Maintenance of Traffic during construction of MSPUI – Further analysis would be needed to determine how the MSPUI could be constructed while retaining through traffic on 15th Ave W as well as all connections to W Nickerson St and W Emerson St.

[1] SDOT Roadway Structures Staff provided comments on the Ballard Bridge Rehabilitation and Replacement Concepts in October 2019. Staff that reviewed the information and provided feedback include Barb Abelhauser, Mary Brown, Fred Ericsen, Rich Hovde and Constantinos Smith. Their complete comments are included in Appendix H.

- Continued Coordination with Sound Transit – As Sound Transit develops their West Seattle and Ballard Link Extensions (WSBLE) project, identifies preferred alternatives, sites stations, and starts design, further coordination with all alternatives will be needed. Each alternative includes a MSPUI at the W Emerson St – W Nickerson St interchange with 15th Ave W, which is in close proximity to the future WSBLE alternative alignments. Future studies may consider shared-use-path connections to the proposed Ballard Link Extension Interbay station. In addition, Mid-Level and High-Level Alternatives have connections to NW Leary Way that tie in along 14th Ave NW, which are also in close proximity to the future WSBLE alternative alignments.
- Funding Options – Future studies will need to evaluate funding options for each of the alternatives.
- Interbay Study – Future studies will need to coordinate with current adjacent and future SDOT projects, such as the Ballard-Interbay Regional Transportation System (BIRT) study.
- Impacts to the Public – Future studies will need to further evaluate the public impacts of each alternative, including short-term and long-term commercial effects.
- Right-of-Way Estimates – Future work should develop ROW estimates using a ROW specialist and estimating actual costs to acquire, costs to cure, relocation, and condemnation by parcel. The estimate in this study is percentage based and is suitable for providing ranges to include in a conceptual level study only.

6.2. Low-Level Bridge Rehabilitation Alternative

- NW Leary Way/15th Ave NW ramps intersection – This study assumed no changes to the existing configuration or traffic control at the NW Leary Way/15th Ave NW ramps intersection. However, operations at this intersection could be improved by providing a left turn lane on NW Leary Way to the southbound on-ramp. There appears to be adequate space available to provide this lane within the existing curb-to-curb width. Further design analysis (including assessment of the overhead clearance) would be needed to determine if this is possible. SDOT may also consider investigating improvements to the NW Leary Way bridge and approach retaining walls as part of future phases of this project or as part of a separate project.
- Shared-Use Path Connection to NW Ballard Way – The existing sidewalk connection to and across Ballard Way could be improved by eliminating the ability to drive southbound from the 15th Ave NW southbound ramp to the southbound frontage road across the pedestrian and bicycle route. Access to the frontage road could be relocated further west and allow only right-turn access from NW Ballard Way. This would likely require additional property acquisition. Further design analysis would be needed to determine the optimal configuration.
- Rehabilitation and retrofit of existing bridge – future investigations into the condition and capacity of the existing bridge to validate the rehabilitation and retrofit assumptions made in this study.
- A low-level replacement option may warrant evaluation in future studies, but would require a detour route during construction. If evaluated in the future, a detailed life-cycle cost analysis should be performed to compare this alternative to the low-level bridge rehabilitation alternative.

6.3. Mid-Level Movable Bridge Alternative

- Maintenance of Traffic during construction of replacement bridge – The existing Ballard Bridge cannot continue to operate while this alternative is being constructed, and alternative crossings at the Fremont and Aurora Bridge do not have enough capacity to accommodate diverted traffic. Therefore, a temporary bridge and detour route would be needed to serve traffic that crosses the Ship Canal. Extensive traffic and design analysis would be needed to determine the optimal configuration and location of a temporary crossing, including the number of lanes and traffic control where the detour route meets the existing arterial network. Right-of-way requirements and would also need addressed. Future studies could consider raising the profile by another ~10-ft to allow the new approach spans over water and land to be built above the existing bridge while it remains in service. The concept for this scheme is similar to the high-level fixed bridge alternative. Raising the profile would have impacts to the tie-ins, particularly to the ramps at NW Leary Way, which may significantly detract from the constructability benefits.

- 17th Ave NW/NW Leary Way/Southbound On-Ramp – The Component Analysis for this intersection noted that 17th Ave NW may not be wide enough to accommodate two-way vehicular traffic (including the large-radius turns for trucks from northbound onto the bridge ramp) as well as a shared bike path. If needed, 17th Ave NW could be converted to a one-way northbound street to provide access to the mid-level on-ramp. The companion southbound movements could be relocated under the bridge along 15th Ave NW where the added bridge height would allow a new road to be located under the bridge. Further design would be needed to assess geometric needs.

6.4. High-Level Fixed Bridge Alternative

- Maintenance of Traffic during construction of replacement bridge – Most of the High-Level Bridge could be constructed above the existing Ballard Bridge, while maintaining clearance to open the bridge for marine traffic. However, construction of portions of the bridge approaches would require closure of lanes on the 15th Ave W mainline. In addition, construction of the MSPUI could affect connections to W Nickerson St and W Emerson St. Further work related to construction phasing and maintenance of traffic would be needed for this alternative to ensure that three lanes of traffic can be maintained at all times without requiring a temporary detour bridge.
- 14th Ave NW improvements at NW Leary Way, NW Ballard Way and NW 46th St – This alternative would concentrate traffic onto the 14th Ave NW corridor, and would also allow NW Ballard Way to be connected under the bridge. These changes are expected to increase vehicle traffic on 14th Ave NW through these intersections and require changes to the lane geometry as well as traffic control. The current configuration of 14th Ave NW, with angled parking in the center of the street, should be evaluated.

Appendix A

Transportation Discipline Report

SDOT

Seattle Department of Transportation

COWI

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Seattle Department of Transportation

Ballard Bridge Planning Study
Transportation Discipline Report

August 7, 2020

COWI

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I. EXECUTIVE SUMMARY

This Transportation Discipline Report presents technical analysis and information used to support the Ballard Bridge Planning Study. It includes information about the existing and planned future transportation conditions on the Ballard Bridge and near-bridge vicinity; assesses many options that were considered for the junctions at the north and south ends of the bridge, assesses non-motorized improvements on the bridge and connections to near-bridge trails and routes, and evaluates how the three finalist alternatives would operate for all modes of transportation.

A. Alternatives Evaluated

Three Ballard Bridge alternatives were evaluated, and were created based on findings from the Component Analyses that evaluated various junction options at the north and south ends of the bridge as well as non-motorized facility analysis. The transportation elements included in each alternative are described below; illustrations of these alternatives are provided in Section 4.1:

High-Level Fixed Bridge (High-Level)

- Fixed bridge with approximately 150-foot clearance above the Ship Canal. Bridge would have four vehicle lanes (two lanes in each direction).
- Elevated signalized ramp intersection connecting from bridge deck at NW 52nd St to 14th Ave NW. The ramp would have two westbound-to-southbound left turn lanes, and a northbound-to-eastbound right turn/deceleration lane. No turns would be allowed to or from the north due to space limitations.
- Modified Single-Point Urban Interchange (SPUI) at the W Nickerson St/W Emerson St/15th Ave W intersection.
- A 14-foot wide shared-use path on west side of the bridge. This would connect to grade at the north end at approximately NW 54th St. A pedestrian/bicycle crossing would be provided at the elevated intersection above NW 52nd St with a connection to 14th Ave NW via the ramp. At the south end, connections to the Ship Canal and Interbay Trails would be made through the SPUI and W Emerson St.

Mid-Level Movable Bridge (Mid-Level)

- Bascule bridge with 60 to 70-foot clearance above the Ship Canal. Bridge would have five vehicle lanes (two in each direction plus a southbound auxiliary lane between the NW Leary Way on-ramp and the Emerson-Nickerson Street off-ramp).
- Northbound off-ramp that would exit the bridge north of NW Leary Way and connect to 14th Ave NW at a T-intersection.
- Southbound on-ramp that would begin near the intersection of NW Leary Way and 17th Ave NW and connect to the bridge south of Shilshole Ave NW.
- Modified SPUI at the W Nickerson St/W Emerson St/15th Ave W intersection.
- A 14-foot wide shared-use path on west side of the bridge. At the north end, this would connect to the street grid along the edge of the southbound on-ramp. At the south end, connections to the Ship Canal and Interbay Trails would be made through the SPUI and W Emerson St.

Low-Level Bridge Rehabilitation (Low-Level)

- Existing bascule bridge with 44-foot clearance above the Ship Canal. Bridge would have four vehicle lanes (two in each direction).
- Existing on and off-ramps at the north end of the bridge would be retained in their current configuration with connections to NW Ballard Way and NW Leary Wy.
- Modified SPUI would replace existing interchange at the W Nickerson St/W Emerson St/15th Ave W intersection.
- A 14-foot wide shared-use path on west side of the bridge. At the north end, this would connect to the street grid along the edge of the NW Ballard Way on-ramp. At the south end, connections between the shared-use path and the Ship Canal and Interbay Trails would be made through the SPUI and W Emerson St.
- Retain existing sidewalk on the east side of the bridge.

B. Summary of Findings

The transportation analysis determined that all three of the alternatives would improve transportation conditions compared to the No Build (No Improvement) condition. The Low-Level Bridge retrofit options would substantially improve non-motorized access across the bridge. The Modified SPUI at the 15th Ave W/W Emerson St/W Nickerson St intersection would substantially improve vehicular traffic operations, freight mobility, as well as bicycle and pedestrian connection to and from the Interbay and Ship Canal Trails and for those who cross 15th Ave W.

Both the Mid and High-Level Bridge would offer the same benefits with a new shared-use path on the west side of the bridge and improved transportation functions at the Modified SPUI. The Mid-Level Bridge would reduce the frequency of bridge openings and the High-Level Bridge would eliminate bridge openings. At the north end of the bridge, the ramp junctions paired with the Mid-Level Bridge would provide the best operations for vehicular traffic and bicycle/pedestrian connections. The High-Level Bridge would introduce a new elevated intersection to the 15th Ave NW corridor, and its single-ramp system would concentrate traffic at the NW Leary Way/14th Ave NW intersection, increasing congestion near that junction compared to the other alternatives. Both the Mid-Level and High-Level Bridge alternatives would allow for new roadway connections under the north end of the bridge, some of which would accommodate over-dimension freight.

This study did **not** evaluate traffic conditions during construction. However, the project team's civil and structural experts did consider how each alternative could be constructed. The most severe construction impacts would occur for the Mid-Level Bridge Alternative, which would require complete closure of the existing Ballard Bridge during construction. Existing Ship Canal crossings at the Fremont and Aurora Bridges do not have enough capacity to accommodate diverted traffic. Therefore, a temporary bridge and detour route would be needed to serve traffic that crosses the Ship Canal. If this alternative is advanced, extensive traffic and design analysis would be needed to determine the optimal configuration and location of a temporary crossing, including the number of lanes and traffic control where the detour route meets the existing arterial network. Most of the High-Level Bridge could be constructed above the existing Ballard Bridge, while maintaining clearance to open the bridge for marine traffic. However, construction of portions of the bridge approaches would require closure of lanes on the 15th Ave W mainline to connect the existing roadway to the new bridge. For all alternatives, detailed construction planning for the Modified SPUI would be needed to maintain through and local access during construction.

1. Introduction

1.1 Project Purpose

The Ballard Bridge, on the 15th Ave W/NW corridor, is a major north-south corridor in Seattle, and one of six connections across the Lake Washington Ship Canal. While the structure is still in good condition today, it is over 100 years old. And while SDOT continues to maintain its safety for daily travel, the likelihood that major maintenance or emergency repair work will be needed continues to increase with age. In addition, the structure is not up to current standards for providing space to people walking, biking, or traveling in a vehicle, hence it being categorized as "functionally obsolete." The purpose of the Ballard Bridge Planning Study is to explore bridge rehabilitation and replacement options including the associated costs and trade-offs of each option. The goal is to develop cost-effective options that meet the multi-modal transportation needs of the corridor, and are embraced by the City and the community, and which minimize the impacts associated with implementation.

This report presents detailed information and analysis to support the planning study. It includes information about the existing and planned future transportation conditions on the Ballard Bridge and near-bridge vicinity; assesses many options that were considered for the junctions at the north and south ends of the bridge, and evaluates how the three finalist alternatives would operate for all modes of transportation.

1.2 Study Area

Transportation analysis to support the Ballard Bridge Planning Study focuses on the 15th Ave W/NW corridor from north of W Dravus St to north of NW Market St. It includes intersections east and west of this corridor that could be affected by new ramp connections. North of the bridge, the study area extends along NW Leary Way and NW Ballard Way from about 14th Ave NW to 17th Ave NW. South of the bridge, the study evaluates W Nickerson St and W Emerson St between 13th Ave NW and 19th Ave NW.

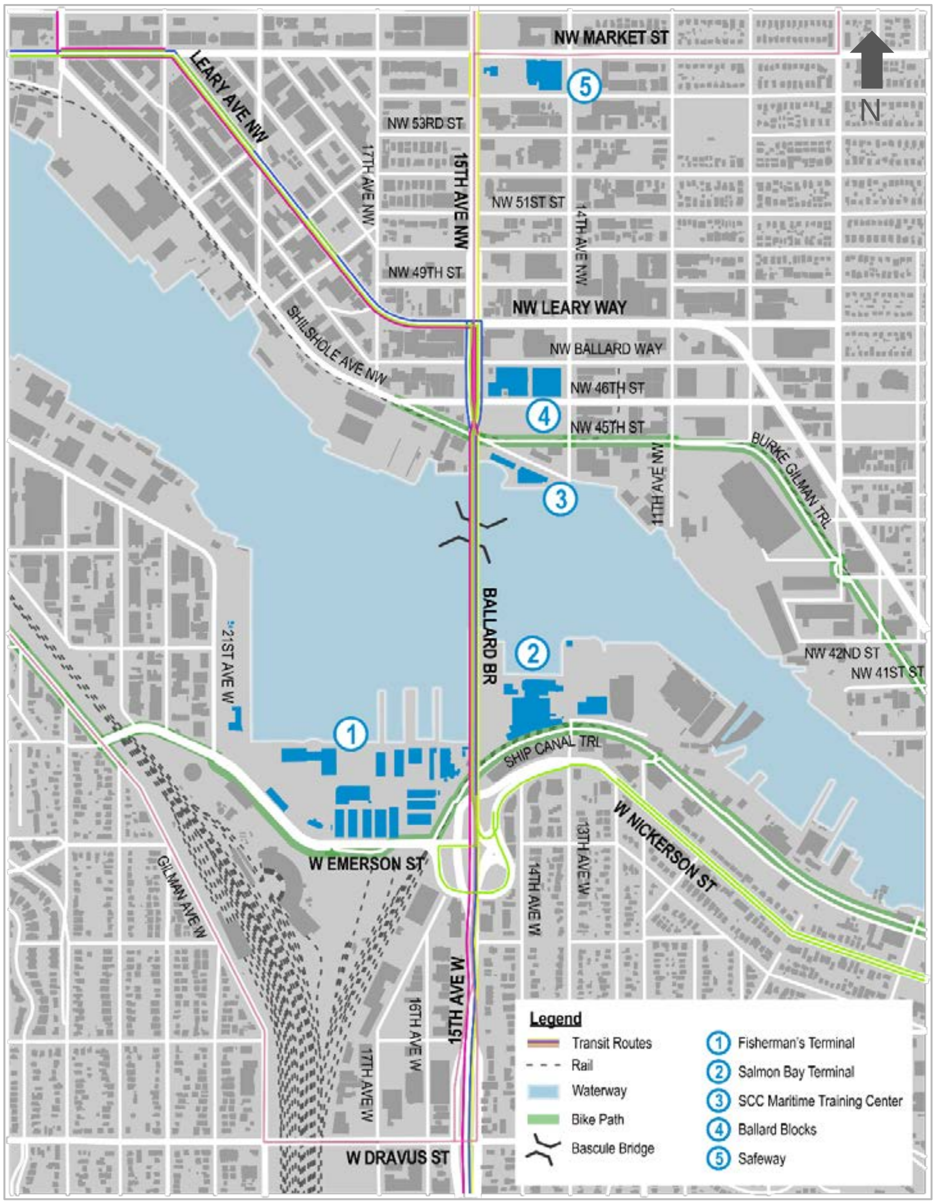
2. Background Conditions

2.1 Street Network

2.1.1. Existing Conditions

The 15th Ave W/NW corridor crosses the Lake Washington Ship Canal on the Ballard Bridge. Streets and avenues in the study area have a "W" directional designation south of the bridge and a "NW" designation north of the bridge. Figure 1 shows the roadway network and some landmarks near the bridge.

Figure 1. Ballard Bridge Corridor Map



Source: OpenStreetMap, May 2019. City of Seattle GIS Database, May 2019.

North of the Ship Canal, 15th Ave NW crosses over NW 45th St and NW 46th St and then connects to NW Leary Wy via a ramp system, which also provides access to NW Ballard Wy, NW 49th St, and NW 50th St. Further north, four local east-west streets—NW 51st, 52nd, 53rd and 54th Streets—connect to 15th Ave NW at unsignalized intersections (stop-sign control on the east and west legs); all side-street movements at these intersections are limited to right turns only. At NW 53rd St, a half signal facilitates pedestrian and bicycle traffic crossing 15th Ave NW. Between NW 51st St and NW Market St there is a curbside Business Access and Transit (BAT) lane in the northbound direction and a center median that prevents left turn movements. NW Market St is a major signalized intersection with a southbound BAT lane.

South of the Ship Canal, a series of ramps and intersections connect to W Nickerson St (east of 15th) and W Emerson St (west of 15th). Further south, the corridor connects to W Dravus St at a grade-separated interchange that is in a tight-diamond configuration, with on and off-ramps connecting to a bridge over 15th Ave W. There is a center median between W Emerson St and W Dravus St that prevents left turn movements. Two local streets connect to 15th Ave W in that segment—W Ruffner St on the east and W Bertona St on the west—for which access is limited to right turns only.

Modal designations for the Ballard Bridge are summarized in Table 1.

Table 1. Modal Designations for Ballard Bridge

Modal Classification	Description
Arterial Classification [a]	Principal Arterial
Transit Classification [a]	Frequent Transit Network.
Freight Classification [a]	Major Freight Street / Industrial Access Over-legal Route
Bicycle Designation	Existing signed bike route[b]; Recommended for Off-Street facility [c]
Pedestrian Designation [a]	Priority Investment Network

a. *SDOT, Seattle Streets Illustrated; https://streetsillustrated.seattle.gov/map/, Accessed June 2019.*

b. *SDOT, SDOT Bike Web Map, Accessed June 2019*

c. *SDOT, Bicycle Master Plan, April 2014.*

2.1.2. Future Transportation System

Past studies of the transportation system in the vicinity of the Ballard Bridge were summarized in the *Ballard Bridge Summary of Previous Plans and Studies*[1]. Many of these studies recommended future system improvements. The largest planned improvement is the extension of Sound Transit's Link Light Rail system between downtown Seattle and Ballard, with stations planned in Interbay (near W Dravus St) and Ballard (near NW Market St). Several alignments are now under study by Sound Transit and include aerial and tunnel crossings of the Ship Canal. Preliminary concept plans for the Ballard Bridge were coordinated with Sound Transit's alternatives to avoid potential alignment conflicts and identify areas for further coordination.

1 SDOT, February 7, 2019.

The *Ballard Urban Design and Transportation Framework*[2] and the companion *Move Ballard*[3] were prepared to address land use and transportation needs in advance of the Sound Transit project. These plans distilled over 100 transportation recommendations from earlier studies into the final 10 prioritized projects. Several of the top ten recommendations are along corridors near or that feed into the Ballard Bridge. These projects include:

- Shilshole Ave NW & 17th Ave NW Truck Access Improvements – Improve freight access to the Ballard Bridge by adding an eastbound left turn lane.
- 17th Ave NW Greenway Connection – Connect 17th Ave Greenway to Ballard Bridge and existing Burke-Gilman Trail (BGT).
- Leary Ave NW Corridor Study – Study the Leary Ave NW corridor (from 17th Ave NW to NW Market St) to determine how to accommodate freight, transit, and bicycle travel.
- 15th Ave NW & Market St Intersection Study – Improve pedestrian safety and crossings. Enhance transit accessibility in conjunction with final Sound Transit alignment decision.

Improvements are also planned to complete the Missing Link of the Burke-Gilman Trail, an approximately 1.4-mile segment through Ballard. An Environmental Impact Study was completed, and design for the segment along Shilshole Ave NW was finalized in 2018 with phased construction slated to begin in 2020. A new traffic signal planned for the intersection at the 17th Ave NW/Shilshole Ave NW intersection as part of this project was included in the future conditions analyses.

The *City of Seattle Freight Master Plan (FMP)*[4] identified several improvements in the study area. First among the list of "Catalyst Projects" in the plan was "Ballard Bridge Replacement - Replace structure to increase capacity and improve access." Catalyst Project Number 7 recommended "15th Ave W Spot Improvements at W Dravus St and W Emerson St. This project was defined as, "*addresses turn radii issues for trucks and enhanced multimodal operations through small-scale geometric and intersection operations improvements along 15th Ave W. Trucks of all sizes experience challenges traveling on the elevated structures at W Emerson St…15th Ave W, W Emerson St, and W Dravus St are vital connections for freight traveling to and from the Ballard-Interbay-Northend Manufacturing/Industrial Center (BINMIC)."* One of this project's components seeks to improve the bridge over 15th Ave W to serve trucks traveling between W Emerson St and W Nickerson St.

2.2 Traffic Volumes

2.2.1. Historic Traffic Volumes on Ballard Bridge

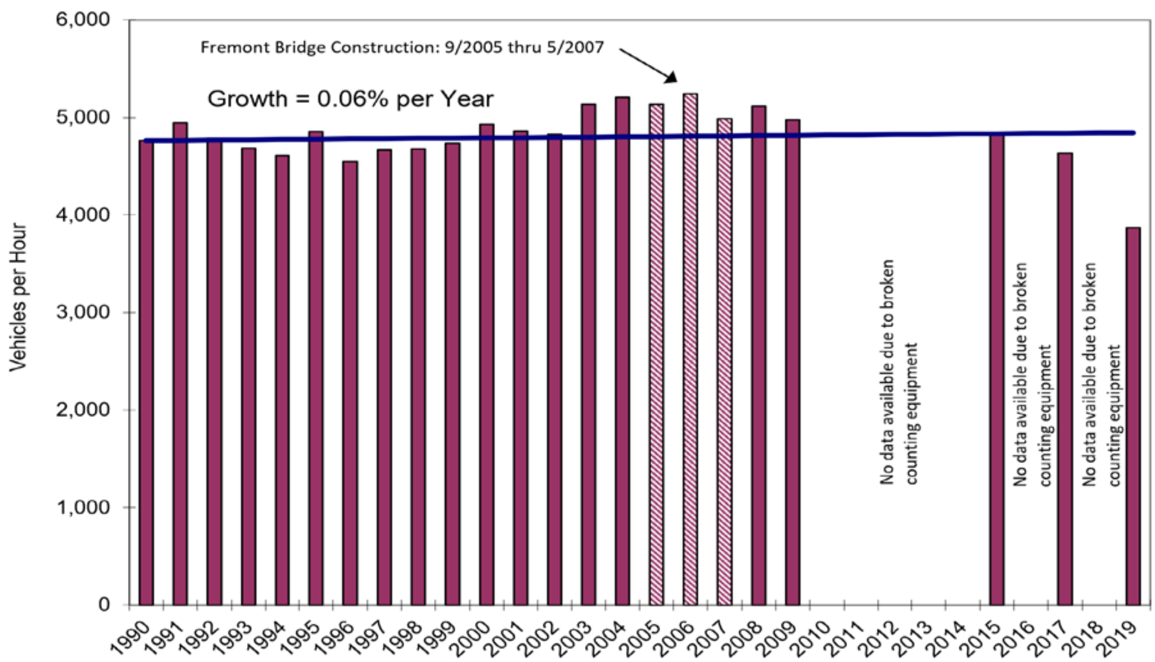
SDOT has a permanent traffic counting device (an imbedded induction loop) on the Ballard Bridge for which one weeks' worth of data are compiled every month of every year. That device was damaged in early 2010, and was only recently replaced. The available data from 1990 through 2019 were compiled to show how traffic volumes have changed over time. The volumes reflect counts performed between August and October of each year, except in 2008 and 2019, when counts were only available for March through May. Past analysis had shown that there is little variation in the bridge volumes by season. The highest volumes typically occur in the spring and fall when volumes are 3% to 4% higher than an average month. Lowest volumes typically occur in January and February. Figure 2 shows the PM peak hour volumes on the Ballard Bridge and Figure 3 shows the daily volumes.

2 Seattle Department of Planning and Development, July 2016.
3 Seattle Department of Transportation, 2016.
4 Seattle Department of Transportation, September 2016.

Overall, the PM peak hour volumes have changed very little from 1990 to 2017, reflecting a compound growth rate less than 0.1% per year. There was little difference in the growth by direction of travel, with northbound volumes decreasing slightly (-0.3% per year) and southbound increasing by 0.1% per year. It is recognized that growth on the Ballard Bridge could be constrained by the peak hour capacity; therefore, growth in daily traffic volumes were also evaluated. Daily traffic grew by about 0.4% per year over the same period with no difference in the growth by direction.

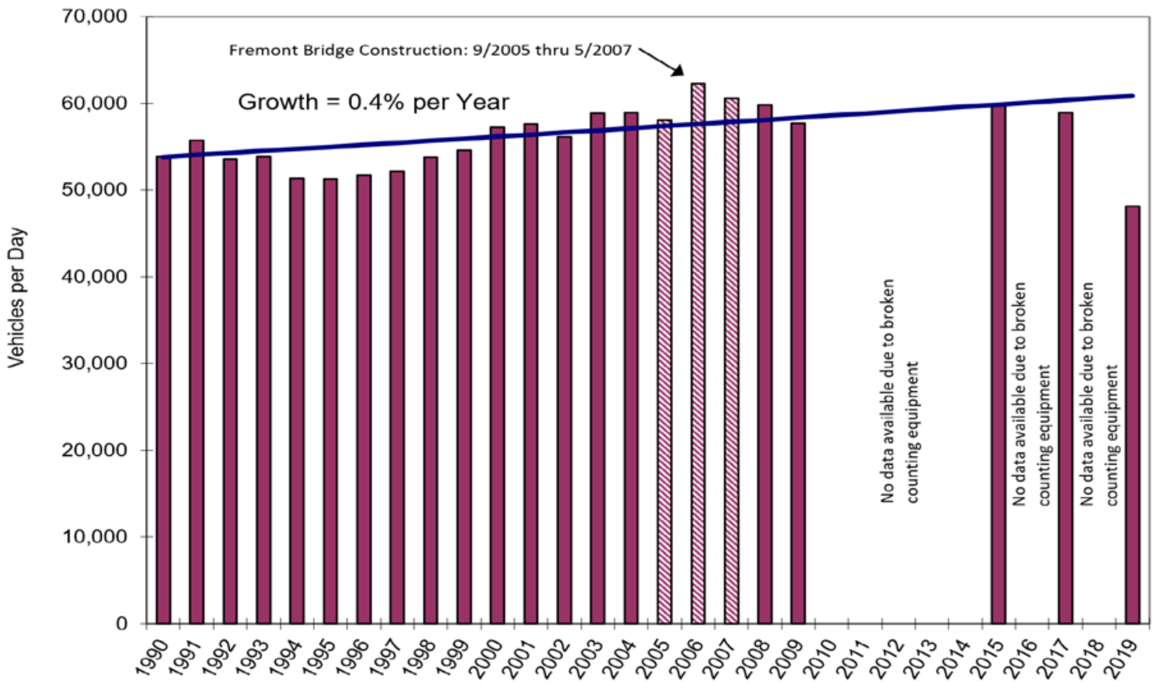
Peak volumes occurred in 2006 when capacity of the Fremont Bridge was constrained during reconstruction of that bridge's approaches. The volumes from 2019 show a substantial decrease compared to prior years, which is likely a result of Alaskan Way Viaduct demolition and ongoing construction along the central waterfront that has forced more traffic to use the new SR 99 tunnel and SR 99 across the Aurora Bridge to reach northwest Seattle. **Because SR 99 and Viaduct construction may have temporarily affected traffic on the Ballard Bridge, existing traffic volumes on the bridge and nearby intersections were set to reflect year 2017 conditions.**

Figure 2. PM Peak Hour Volumes by Year on Ballard Bridge



Source: Counts from Seattle Department of Transportation (SDOT) Traffic count database. Counts for permanent traffic recording station at "Ballard Bridge south of Point A."

Figure 3. Average Weekday Traffic (AWDT) Volumes by Year on Ballard Bridge

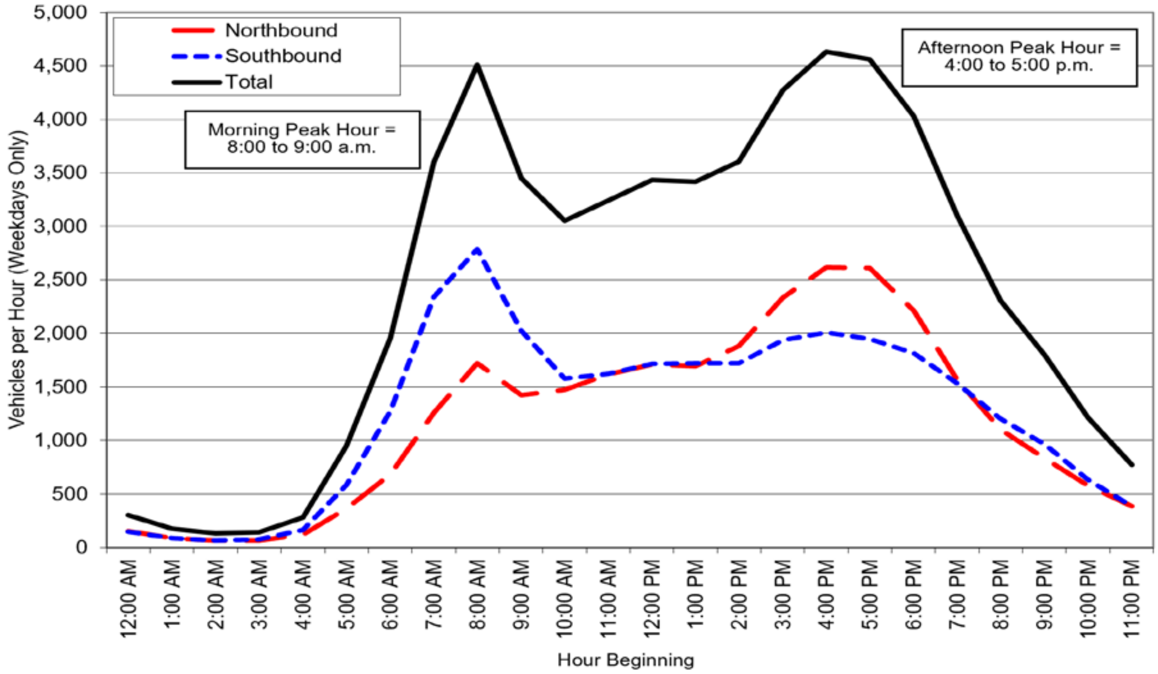


Source: Counts from Seattle Department of Transportation (SDOT) Traffic count database. Counts for permanent traffic recording station at "Ballard Bridge south of Point A."

2.2.2. Traffic Volumes by Time of Day

Figure 4 shows the weekday traffic flows on the Ballard Bridge by hour. Traffic follows a typical Seattle commuting pattern with peak volumes southbound towards downtown in the morning between 7:00 and 9:00 A.M. and northbound away from downtown in the afternoon between 4:00 and 6:00 P.M. Total volumes are highest in the afternoon.

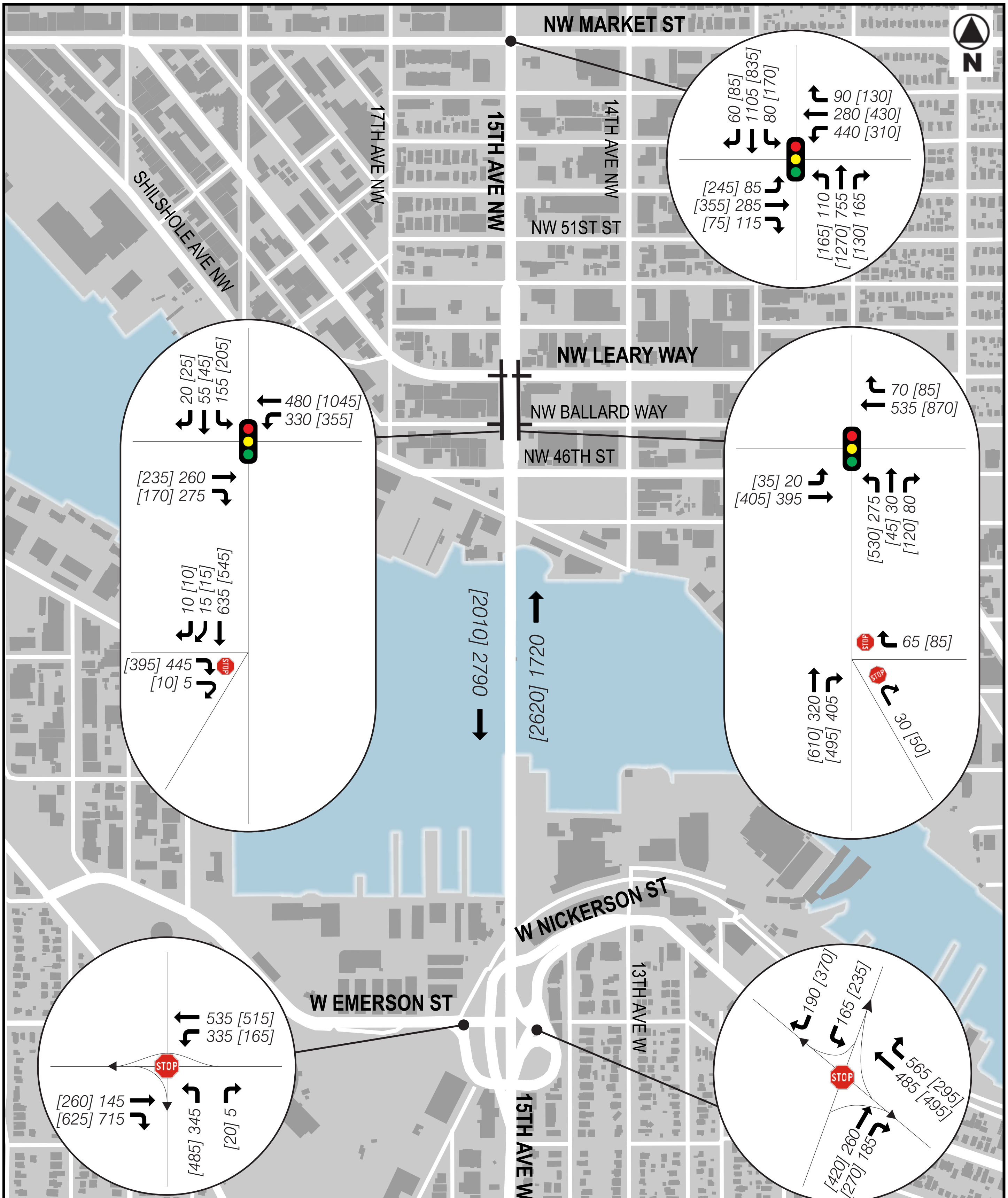
Figure 4. Traffic Volumes by Time of Day, October 2017 – Ballard Bridge



Source: Counts from Seattle Department of Transportation (SDOT) Traffic count database. Counts for permanent traffic recording station at "Ballard Bridge south of Point A.".

Intersection turning movement counts were compiled from a variety of sources, and include counts performed in 2017, 2018 and 2019. As noted above, all traffic volumes were adjusted to reflect the year 2017 peak hour traffic across the Ballard Bridge before corridor traffic was affected by Alaskan Way Viaduct construction. Existing intersection volumes for the AM and PM peak hours are shown on Figure 5.

As noted above, there has been a decrease in traffic across the Ballard Bridge in recent years. To assess if traffic may be using other routes to reach Ballard (e.g., NW Market St), total volumes through the intersection at NW Market St/15th Ave NW were compared to an historic intersection count. An intersection count taken in 1998 showed a total entering volume of 4,370 vehicles during the PM peak hour, which is nearly identical to the current traffic volume of 4,305 vehicles during the PM peak hour. In that 20-year period, northbound traffic has decreased but southbound traffic has increased. Eastbound and westbound traffic on NW Market St is virtually unchanged.



BALLARD BRIDGE PLANNING STUDY

Figure 5
AM and PM Peak Hour Traffic Volumes
Existing Conditions

2.2.3. Future (Year 2040) Traffic Volumes

Improvement options for the Ballard Bridge were compared for future year 2040 conditions. Year 2040 traffic volumes for the No Build (No Improvement) condition were estimated based on the capacity of the Ballard Bridge, which is estimated to be 2,800 vehicles per direction at the posted travel speed.[5] Future volumes could exceed the capacity with crunch flow at a volume-to-capacity (v/c) ratio of about 1.2, which is a peak-direction volume of about 3,360 per hour. For the PM peak hour, the growth in northbound traffic from the existing 2,620 vehicles per hour to 3,360 vehicles per hour would reflect a compound growth rate of 1.2% per year, higher than the historic growth rate described previously, which has been less than 0.1% per year. Reverse direction traffic was also assumed to increase by 1.2% per year, which would reflect a traffic volume of 2,580 in the PM peak hour's southbound direction.

The forecast growth rate and resulting volumes were compared to the forecasts for the Ballard Bridge in the City's *2035 Comprehensive Plan* (adopted October 17, 2016). Year 2035 traffic forecasts provided in the transportation appendix of the *Mayor's Recommended Plan*[6] were derived from projected PM peak hour v/c ratios of vehicular traffic on arterials crossing screenlines defined throughout the City.[7] The *Comprehensive Plan* estimated the future traffic on the Ballard Bridge at 5,300 vehicles per hour in the PM peak hour (3,300 northbound, 2,000 southbound). The forecasts used for the No Build conditions are similar in the peak direction (northbound) and higher in the off-peak direction (southbound).

The future No Build volumes are also very similar to what the Ballard Bridge was able to accommodate during reconstruction of the Fremont Bridge. During that period (in 2006 and 2007), the Ballard Bridge accommodated approximately 3,300 northbound vehicles during the PM peak hour, which is near the assumed force-flow capacity of the bridge. Southbound traffic (2,000 vehicles per hour) did not reach capacity during the Fremont Bridge construction, and those volumes could continue to increase in the future due to growth. Potential southbound growth is reflected in the 2040 forecasts used for this analysis.

Intersection turning movement counts for the AM and PM peak hour traffic volumes for the 2040 No Build conditions are shown on Figure 6.

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[5] City of Seattle DPD Director's Rule 5-2009, Attachment C, which presents capacities at the various screenlines used to assess Transportation Concurrency.

[6] *Seattle 2035 Comprehensive Plan, Mayor's Recommended Plan,* May 2016.

[7] Volume-to-capacity values listed for the screenlines were used to estimate future volumes. This assumes that the corridors selected would have no major changes proposed that would change capacity.

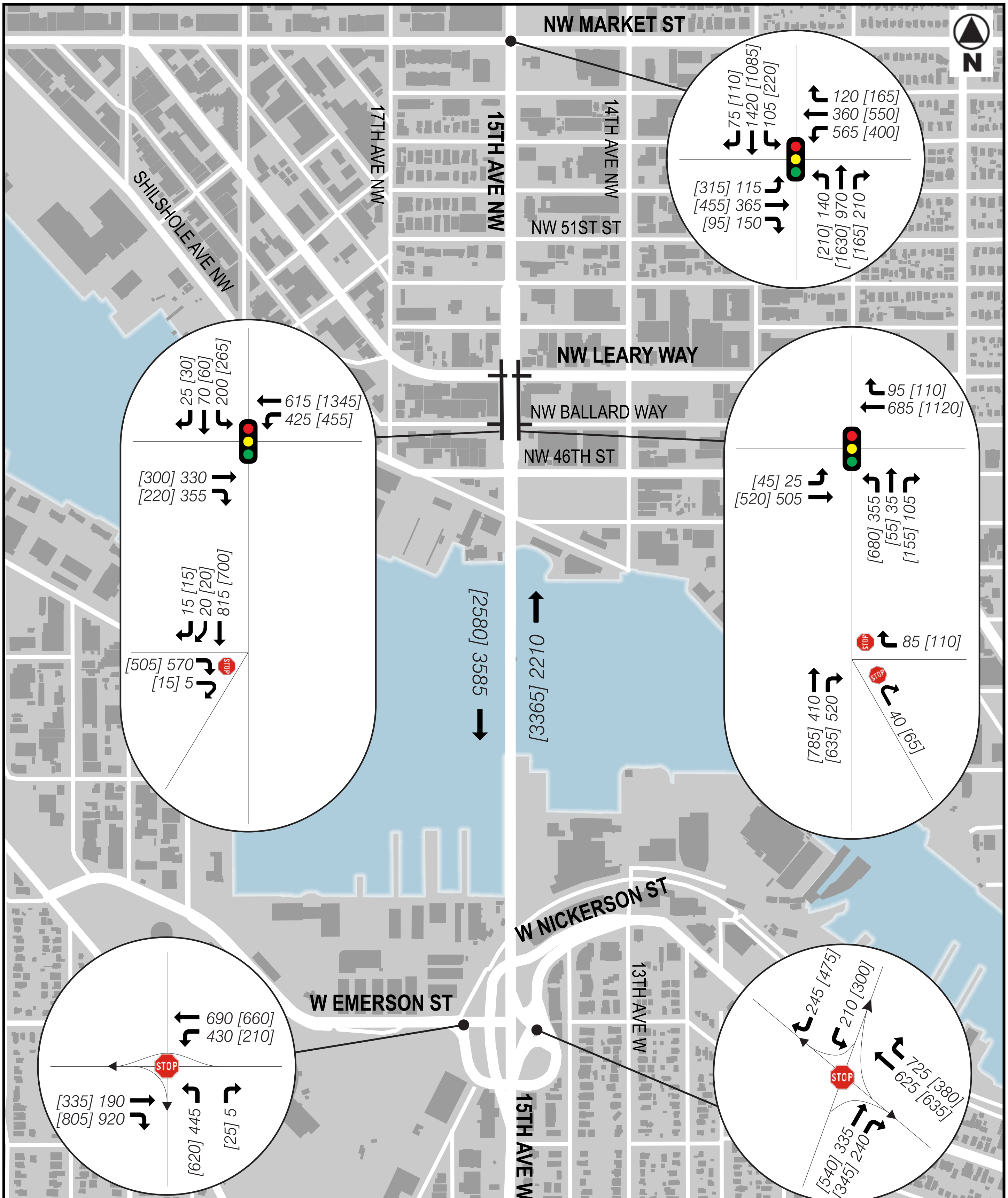


Figure 6
AM and PM Peak Hour Traffic Volumes
Year 2040 No Build Conditions

BALLARD BRIDGE PLANNING STUDY

2.3 Land-Side Freight

2.3.1. Existing Truck Network

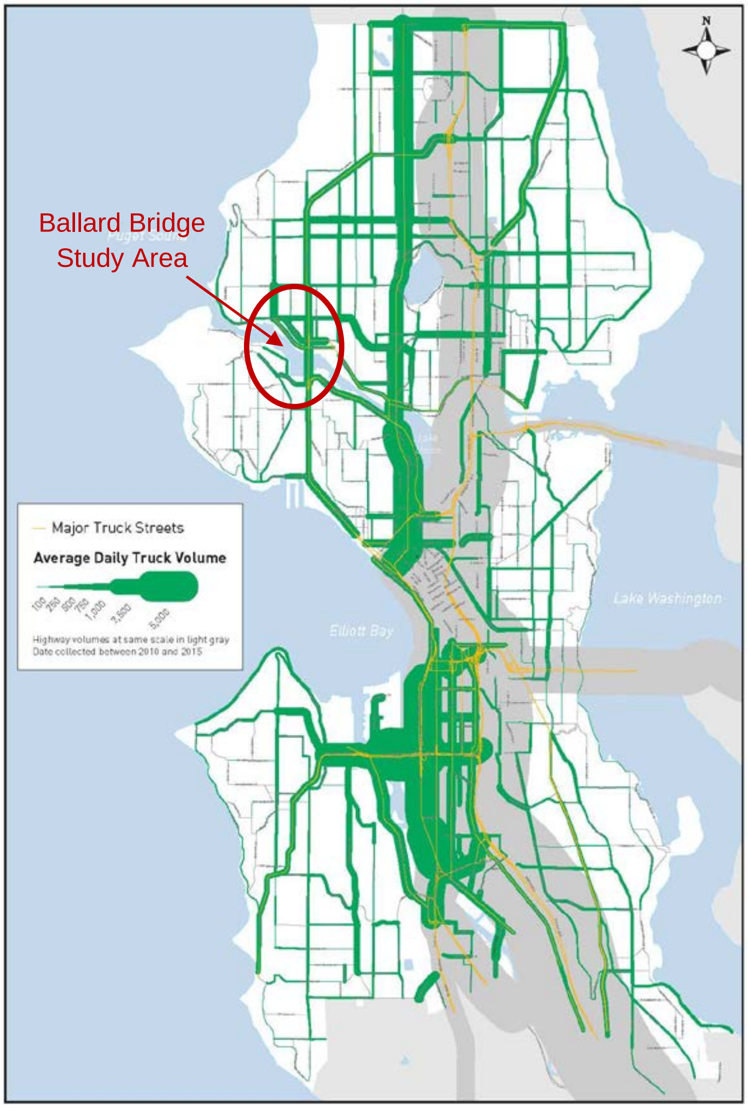
The Ballard Bridge is designated as a Major Freight Street in the *City of Seattle Freight Master Plan (FMP)*[8]. General truck travel patterns throughout Seattle were also documented in the *FMP*. The 15th Ave W/NW corridor is the primary access route to and through the Ballard Interbay Manufacturing and Industrial Center (BINMIC), which is one of two designated MICs in the City. It includes industrial lands on both sides of the Ship Canal. In addition to general industrial uses, the area is one of the largest hubs supporting maritime industries in the Pacific Northwest and Alaska.

Industries along the Ship Canal rely on the Ballard Bridge and the interchanges located just north and south of the bridge. The NW Leary Way/Ballard Way ramps at the north end of the bridge provide access to Shilshole Ave NW and NW 45th St, which serve local access to water-dependent uses on the north side of the Ship Canal. Likewise, the W Emerson St/Nickerson St ramps and intersections at the south end of the bridge provide access to Fishermen's Terminal and Commodore Way west of the bridge and to 13th Ave W and local access streets east of the bridge. NW Leary Way, Shilshole Ave NW, NW Market St and W Nickerson St are designated as Major Freight Streets; W Emerson St is designated as a Minor Freight Street.

The Freight Master Plan shows that the Ballard Bridge is one of the few corridors in the City with truck volumes in excess of 1,500 trucks per day. The City-wide truck volumes and local patterns in Ballard/Interbay are shown on Figure 7.

8 Seattle Department of Transportation, September 2016.

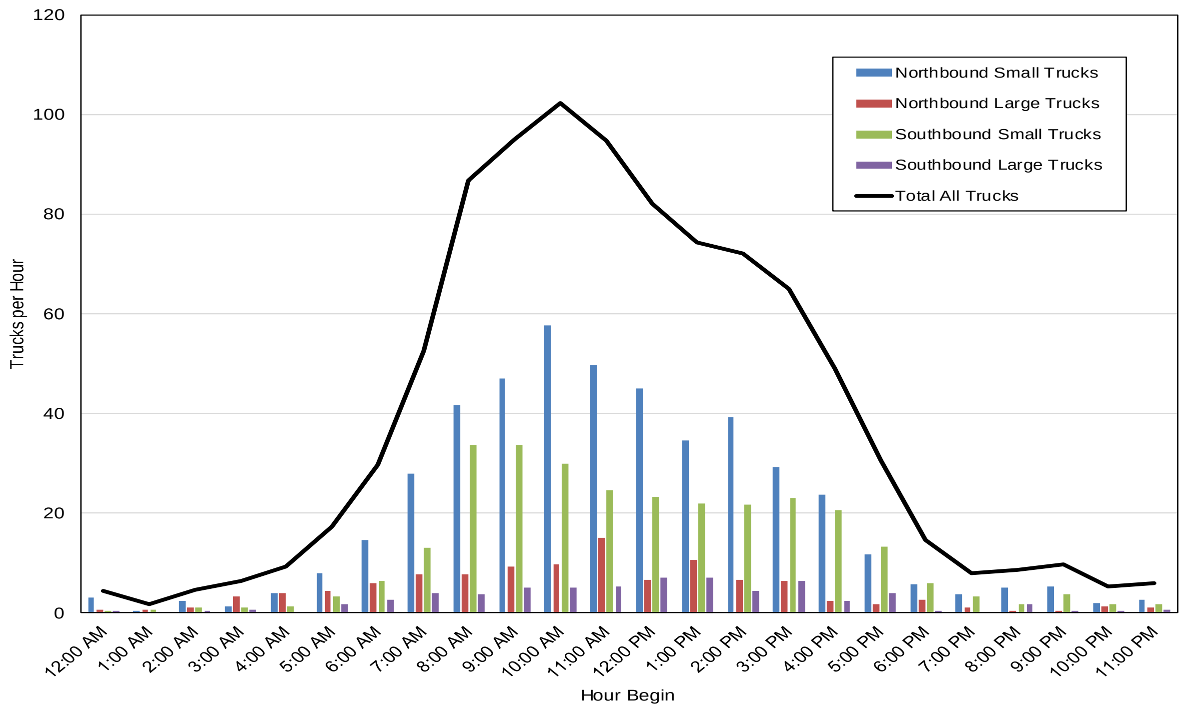
Figure 7. City-Wide Truck Volumes – 2015



Source: City of Seattle Freight Master Plan, October 2016.

Vehicle classification counts on 15th Ave W just south of the Ballard Bridge were performed by SDOT in September 2019 to determine truck volumes by time of day. Figure 8 shows that truck volumes across the bridge peak during the midday hours with over 100 trucks per hour (68 northbound and 35 southbound). The majority of these are small trucks (two to three axles) representing about 86% of all trucks during the midday peak hour and 81% of the daily trucks across the bridge. Trucks represent about 2.6% of the total traffic during the AM peak hour and 1.3% of the total traffic during the PM peak hour. It is noted that these counts were performed in September 2019 during a period when the Alaskan Way Viaduct was being demolished along the Waterfront. As previously noted, overall traffic volumes on the Ballard Bridge had decreased in 2019 compared to prior years, perhaps because of construction on the Waterfront. While the volume of trucks may be lower than normal, the time of day travel patterns and truck percentage of total traffic are not likely affected by Waterfront construction.

Figure 8. Existing (2019) Truck Volumes by Time of Day



Source: Data collected by Seattle Department of Transportation on September 11, 12, and 13, 2019. Data above reflects the average of the three days.

The 15th Ave W corridor is also a designated Over-Legal route intended to accommodate loads that require a 20-foot wide by 20-foot high envelope. Every vehicle that meets the over-legal specifications, which includes an exceedance of the maximum weight, height, width, and/or length (as specified by state and city laws), is required to obtain a permit to transport goods using the city's street network. Very large freight is usually moved at night with police escort when it can use streets or ramps in unintended ways. For example, large yachts at Seattle's Boat Show are often hauled out of the Ship Canal north of the Ballard Bridge and transported on very long low-boy trailers (to minimize overhead clearance). Under escort, these trailers may access the Ballard Bridge by going the reverse direction on the NW Leary Way ramps. They may also travel in the reverse direction through other intersections to avoid overhead conflicts with signal poles, light poles or overhead power lines. Large construction equipment, such as cranes and industrial equipment also use the Ballard Bridge and/or the access ramps at each end of the bridge.

2.3.2. Rail Network

15th Ave W crosses two freight-rail facilities, one on each side of the Ship Canal. North of the Ship Canal is the Ballard Terminal Railroad (BTRR) and south of the Ship Canal is a BNSF Railway Company (BNSF) Spur track that connects to its Interbay Yard.

Ballard Terminal Railroad (BTRR)

BTRR, a Class III common-carrier railroad in Seattle, was formed in 1997 to serve freight customers located on three miles of track on the north side of Salmon Bay. In 1997, the City of Seattle (the City) granted BTRR a 30-year Franchise Agreement to operate within the City-owned right-of-way subject to specific terms and conditions. BTRR runs from NW 40th St and 6th Ave NW northwest to a connection with the BNSF mainline near the Shilshole Marina at a location known as Ballard Junction.[9]

Balmer Yard Spur and Ship Canal Team Track

BNSF owns a rail spur that extends north from its main Balmer Yard in Interbay towards Fremont. A double-track segment extends under the Ballard Bridge and along the north side of the Ship Canal Trail to just east of 13th Ave W. The northernmost track is used as a "Team Track" for industrial shipping, primarily for Coastal Transportation, which uses the track to ship seafood that has arrived from Alaska by ship or to receive supplies that will be exported to Alaska. Coastal Transportation stores a small engine on this track to move cars delivered by the BNSF.

The BNSF and Coastal Transportation are planning to extend the double track segment further east of 13th Ave W and connect the two tracks to increase the capacity of the team track and provide an escape for BNSF engines so that they can pull longer strings of cars into this yard (rather than push them, which is the current operation without the track connection).

9 Washington State 2010-2030 Freight Rail Plan, December 2009

2.4 Maritime Freight and Bridge Openings

2.4.1. Federal Navigation Requirements

The Ballard Bridge provides 44-feet of vertical clearance above the ordinary high-water mark.[10] It is subject to Coast Guard and Code of Federal Regulations (CFR 117.1051). Marine traffic on the Lake Washington Ship Canal has priority over vehicle traffic with a few exceptions. The CFR states:

> *d) The draws of the Ballard Bridge, mile 1.1, Fremont Bridge, mile 2.6, and University Bridge, mile 4.3, shall open on signal, except that:*
>
> > *(1) The draws need not be opened for a period of up to 10 minutes after receiving an opening request, if needed to pass accumulated vehicular traffic. However, the draws shall open without delay, when requested by vessels engaged in towing operations.*
> >
> > *(2) The draws need not open from 7 a.m. to 9 a.m. and from 4 p.m. to 6 p.m. Monday through Friday, except all Federal holidays but Columbus Day for any vessel of less than 1000 tons, unless the vessel has in tow a vessel of 1000 gross tons or over.*
> >
> > *(3) Between the hours of 11 p.m. and 7 a.m. the draws shall open if at least one hour notice is given by telephone, radio, telephone, or otherwise to the drawtender at the Fremont Avenue Bridge.*

As noted, vessels over 1,000-gross tons can request that the Ballard Bridge open even during the commuter peak hours for street traffic.

2.4.2. Bridge Openings – Seasonal Variation, Duration and Vessel Types

Detailed analysis of Ballard Bridge openings was performed for all of 2018, using records maintained by the bridge tenders. In that year, there were 3,985 openings of the bridge. The number of openings varies substantially by month, with the peak season occurring from May through August, as shown on Figure 9.

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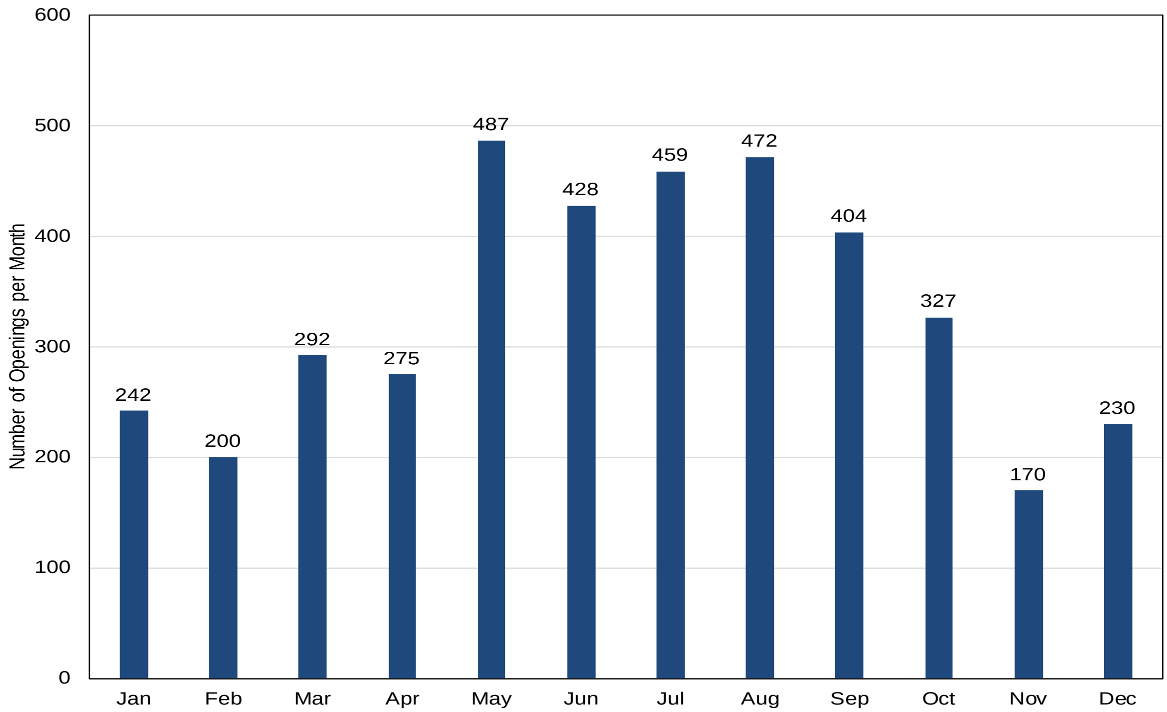
[10] Per SDOT Bridge website, http://www.seattle.gov/transportation/projects-and-programs/programs/bridges-stairs-and-other-structures/bridges, accessed June 25, 2019.

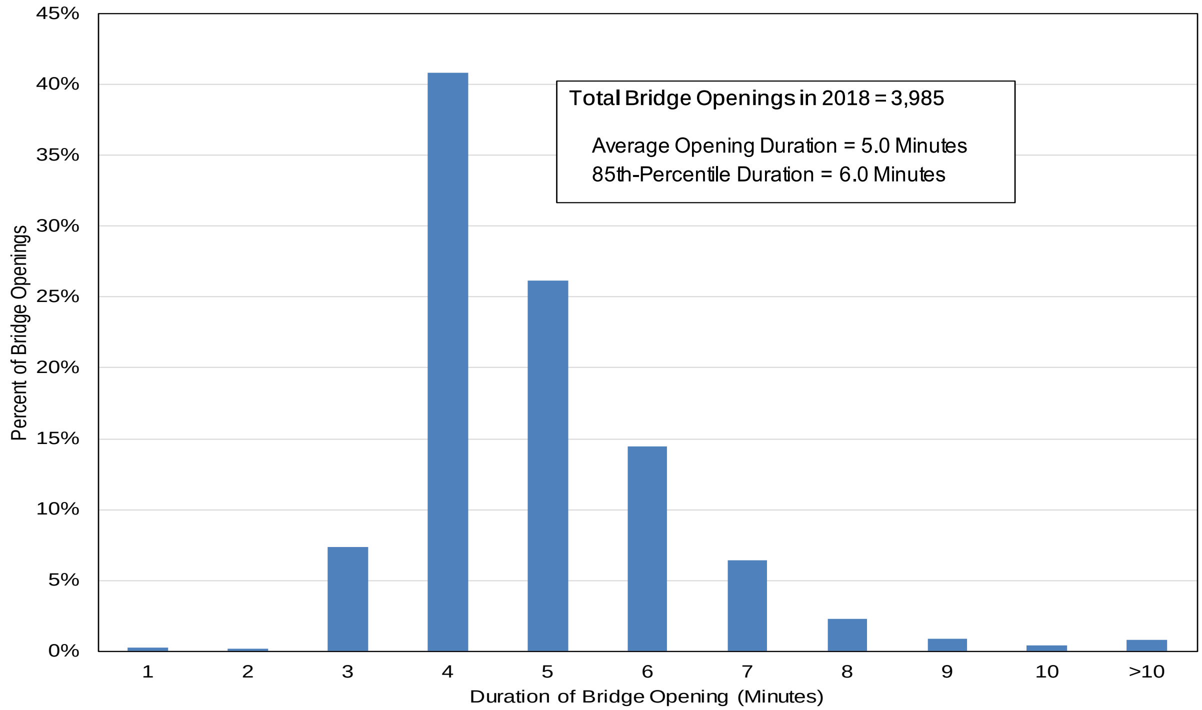
Figure 9. Bridge Openings – 2018



Source: SDOT, data compiled by Heffron Transportation, Inc.

The average bridge opening in 2018 had a duration of 5 minutes. Most of the openings that exceeded 10 minutes were related to maintenance and cleaning; however, there were three openings that lasted for longer than one hour (77 minutes, 96 minutes, and 109 minutes). The longest of those related to a malfunction that prevented the bridge from closing. Figure 10 shows the distribution of bridge openings by duration.

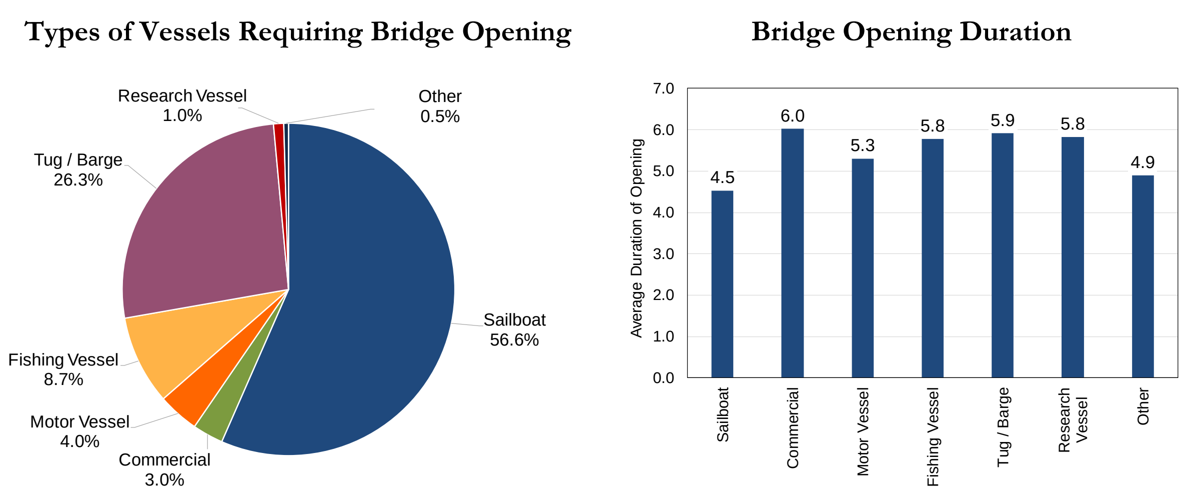
Figure 10. Duration of Bridge Openings - 2018



Source: SDOT, data compiled by Heffron Transportation, Inc.

The types of vessels and average bridge opening durations for each type of vessel were also compiled. These are shown on Figure 11. Nearly 57% of the bridge openings in 2018 were for sailboats, with an average opening duration of 4.5 minutes each.

Figure 11. Bridge Openings by Type of Vessel

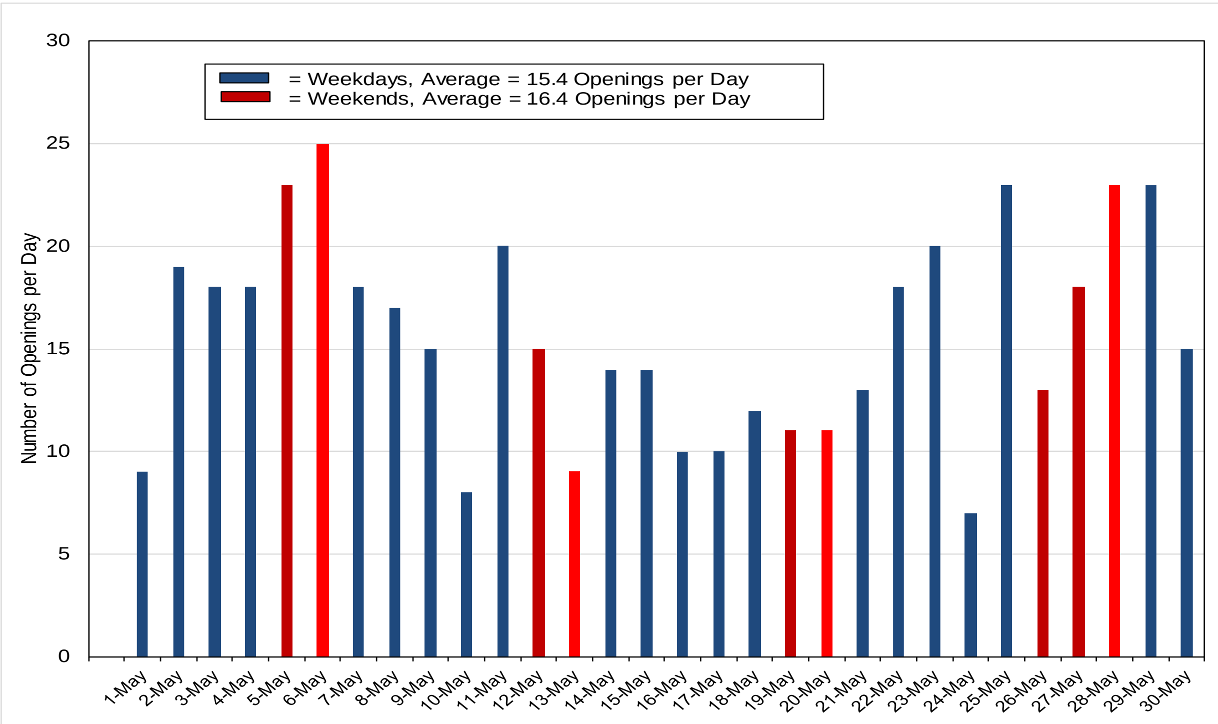


Source: SDOT, data compiled by Heffron Transportation, Inc.

2.4.3. Openings by Hour of Day – Weekdays in May 2018

More detailed analysis was performed for the peak month of the year (May). The number of openings by day in May are shown in Figure 12. The weekdays are shown in blue and the weekends are shown in red. The highest number of openings occurred in the first weekend in May, which coincides with the Opening Day of Boating Season on the Montlake Cut. There was an average of 15.4 bridge openings per weekday in May.

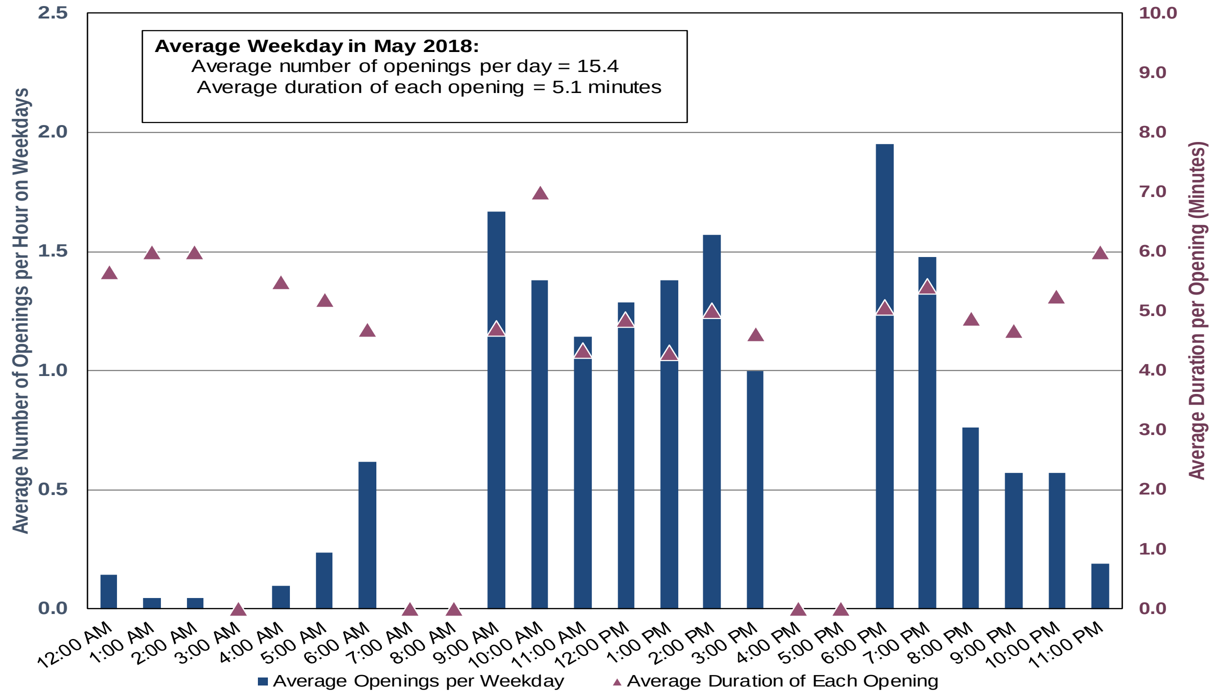
Figure 12. Ballard Bridge Openings by Day – May 2018



Source: SDOT, data compiled by Heffron Transportation, Inc.
Red bars are weekends and holidays.

The effect of bridge openings on vehicle traffic is worst on weekdays when the number of vehicles on the 15th Ave W/NW corridor is highest. The average number of openings on the average weekday in May, along with the duration for each opening, is shown on Figure 13. As noted previously, Federal regulations restrict bridge openings on weekdays between 7:00 and 9:00 A.M. and between 4:00 and 6:00 P.M. to vessels in excess of 1,000 tons. In May 2018, there were no openings during the commuter black-out periods. However, the bridge was opened during the commuter peak hours in other months of the year. For all of 2018, there were 129 bridge openings that occurred during the commuter peak hour periods, equivalent to one peak period opening every other weekday.

Figure 13. Ballard Bridge Openings by Time of Day – Average Weekday in May 2018



Source: SDOT, data compiled by Heffron Transportation, Inc.

2.4.4. Vessel Mast Heights

The bridge opening records do not include any information about the height of the vessel. A mast height survey was performed by the bridge tender during a 20-day period in July 2016 using references of known heights.[11] During this survey, the heights of 158 vessels were recorded. Figure 14 summarizes the percentage of vessels by mast height. It is noted that the bridge may be opened for vessels that are shorter than the 44-foot clearance to assure that masts do not strike the structure.

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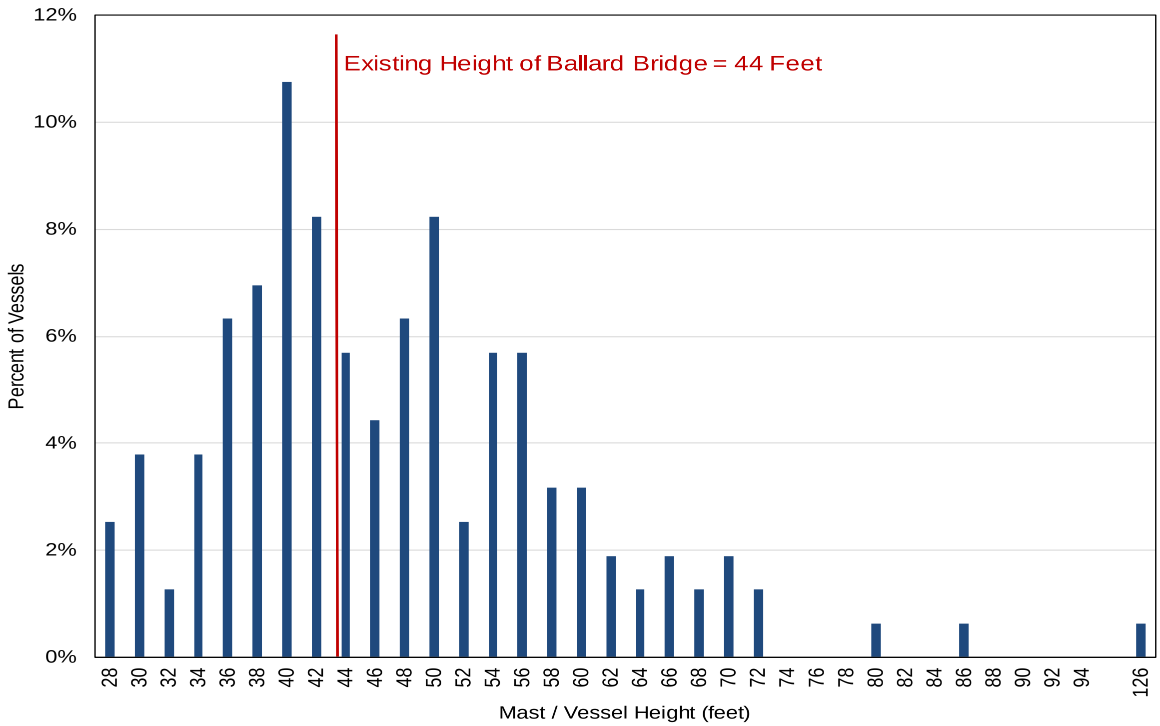
11 SDOT, Fred Ericsen, *Twenty Day Mast Height Study,* July 2016.

Figure 14. Mast Height Study Results



Source: SDOT, Mast Height Survey; data reflect vessels observed on 20 days in 2016 (July 7-11, July 14-18, July 21-15, and July 29-August 1) between 3:00 P.M. and 11:00 P.M. While the existing clearance within the navigable channel is 44-ft, the bridge does open for vessels below this clearance height as requested.

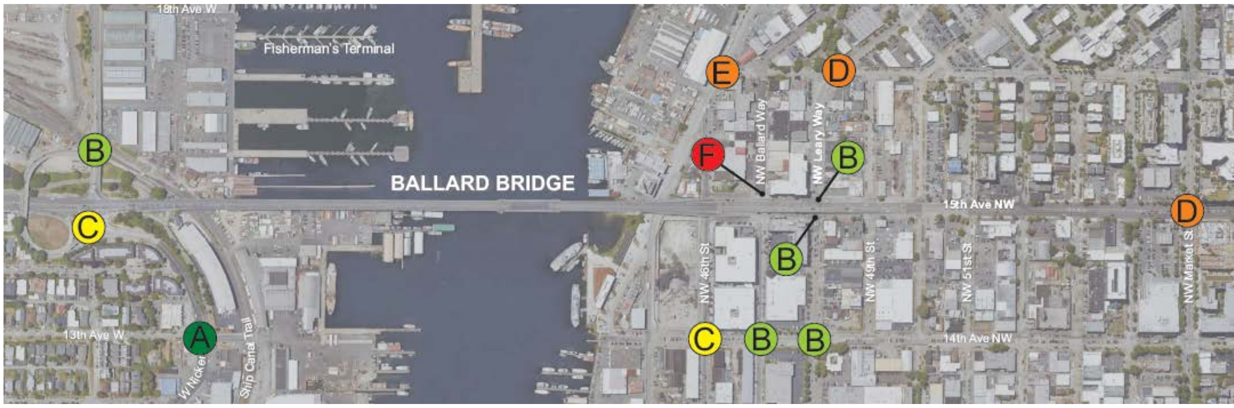
2.5 Traffic Operations

2.5.1. Intersection Operations

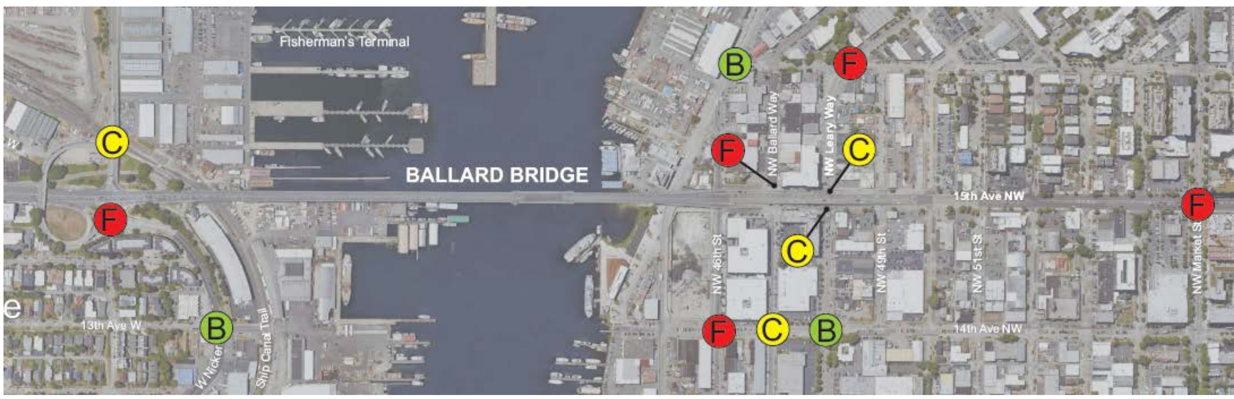
Intersection operations are evaluated using level of service (LOS) with six letter designations, "A" through "F." LOS A is the best and represents good traffic operations with little or no delay to motorists. LOS F is the worst and indicates poor traffic operations with long delays. Levels of service for area intersections were determined using the Synchro 10.3 traffic operations analysis software. Intersection geometric characteristics were obtained from various City sources, and signal timing and phasing cards were provided by SDOT. Results for signalized intersections are reported using the Synchro module; and results for unsignalized intersections are reported using the Highway Capacity Manual (HCM) module unless the intersection had an unusual lane configuration or stop-sign location, and then the Synchro module was used. The existing and 2040 No Build condition levels of service are shown on Figures 15 and 16 for the AM and PM peak hours, respectively. Detailed results are provided in Attachment 1.

Figure 15. Existing and 2040 No Build Intersection Level of Service – AM Peak Hour

Existing (2018) Conditions

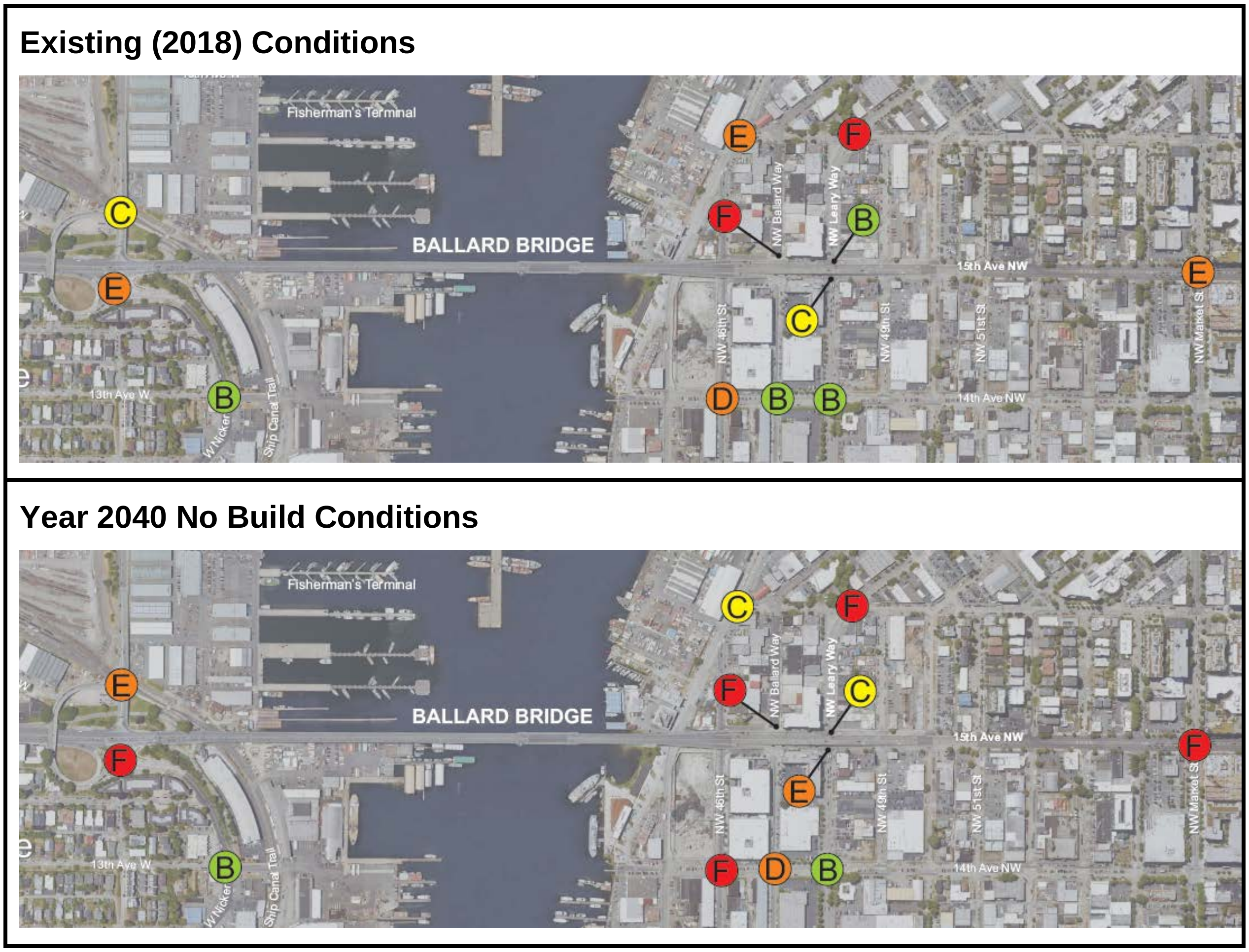


Year 2040 No Build Conditions



Source: Heffron Transportation, Inc., November 2019.

Figure 16. Existing and 2040 No Build Intersection Level of Service – PM Peak Hour



Source: Heffron Transportation, Inc., November 2019.

Most of the study area's signalized intersections currently operate at LOS D or better during the peak hours. The exception is the signalized intersection at 15th Ave NW/NW Market St, which operates at LOS E during the PM peak hour. Several unsignalized intersections currently operate at LOS E or F, including the two intersections on 17th Avenue NW where side-street traffic is controlled by a stop sign. Turns from NW Ballard Way to the 15th Ave NW southbound on-ramp operate at LOS F during both the AM and PM peak hours. The on-ramp from W Nickerson Street to northbound 15th Avenue W also operates at LOS E during the PM peak hour. With growth to 2040, many of the study area intersections would operate at LOS E or F during the AM and PM peak hours. The intersection at 17th Avenue NW/Shilshole Avenue NW is planned to be signalized in the future, which would improve its operation.

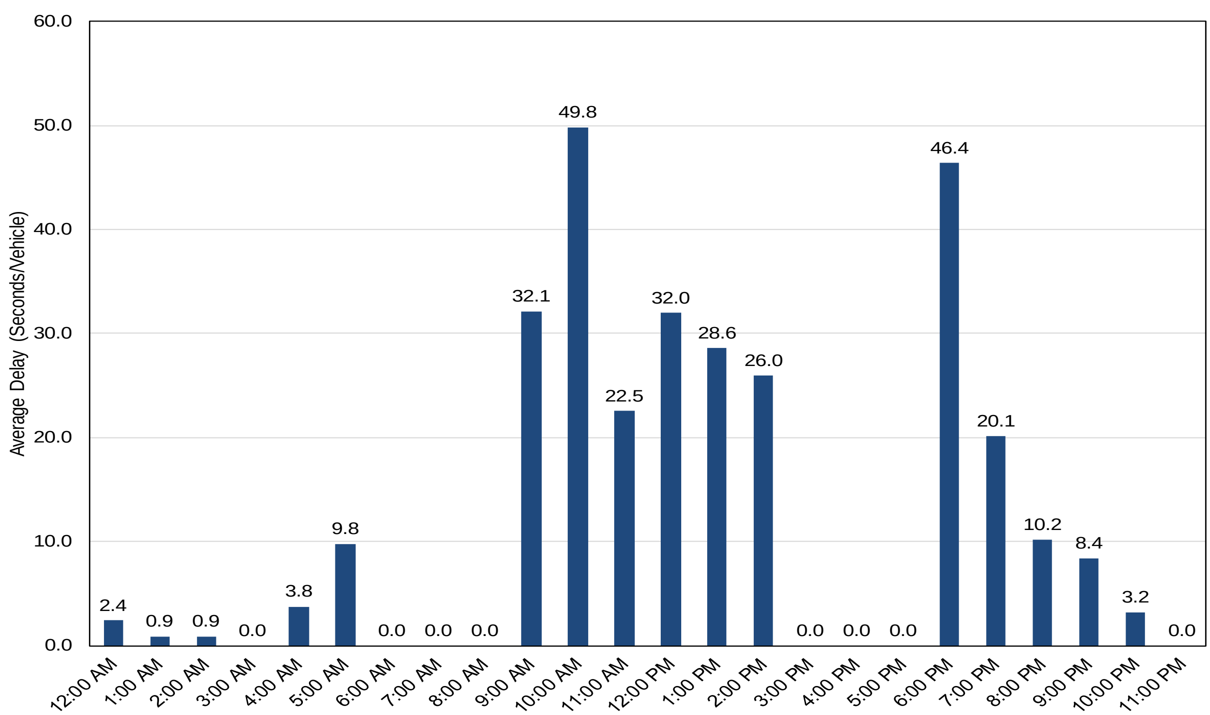
2.5.2. Effect of Bridge Openings

As previously discussed, the Ballard Bridge seldom opens during the AM and PM peak hours for traffic. However, bridge openings can substantially delay traffic during other hours of the day. The total vehicle delay incurred when the Ballard Bridge opens for marine traffic was determined for each hour of the day using the theory of traffic flow. This methodology assumes that the bridge opening affects traffic similar to a signalized intersection with two phases—one phase with the bridge open and red to all auto traffic and a second phase with the bridge down and green to all auto traffic. Since the typical bridge opening is usually much longer than typical "red time" at a signalized intersection, it is important to calculate the total delay, which accounts for stopped delay as well as traffic queue-dissipation delay. To calculate the total delay for all vehicles resulting from a bridge opening, the Webster equation developed for signalized intersections was used.[12]

Delay was derived using information previously presented about traffic volumes, number of bridge openings, and average opening duration for each hour of the day. The assumed number of bridge openings was based on an average weekday from May 2018, which is the peak month of the year for marine traffic.

As shown on Figure 17, vehicles are most affected by bridge openings during the midday hours and in the 6:00 P.M. hour immediately following the period when bridge openings are not allowed for most vessels. During these periods, the average delay per vehicle is estimated at approximately 50 seconds per vehicle and accounts for the delay experienced by vehicles at the front of the queue (having arrived just as the bridge closes and stopping the longest) as well as those at the end of the queue arriving just as it begins moving again. For comparison, that delay would reflect LOS D conditions at a signalized intersection. The cumulative delay for the entire day totaled approximately 261 vehicle-hours, equivalent to an average of about 16 seconds per vehicle for the 59,000 vehicles that cross the bridge each weekday.

Figure 17. Vehicle Delay Associated with Bridge Openings (Existing Weekday in May)



Source: Heffron Transportation, Inc., November 2019. Delay estimated using Webster Equation.

[12] May, Adolf D; *Traffic Flow Fundamentals;* 1990, pg. 144.

By 2040, vehicle delay is estimated to increase to a cumulative of over 650 hours per day assuming that both traffic volumes across the bridge and marine traffic requiring a bridge opening increase at 1.2% per year. The average delay per vehicle over the full day is estimated at about 31 seconds, with average delays that exceed 85 seconds per vehicle during the peak midday period. This delay is equivalent to LOS F conditions for vehicular traffic at signalized intersections.

2.6 Non-motorized Facilities

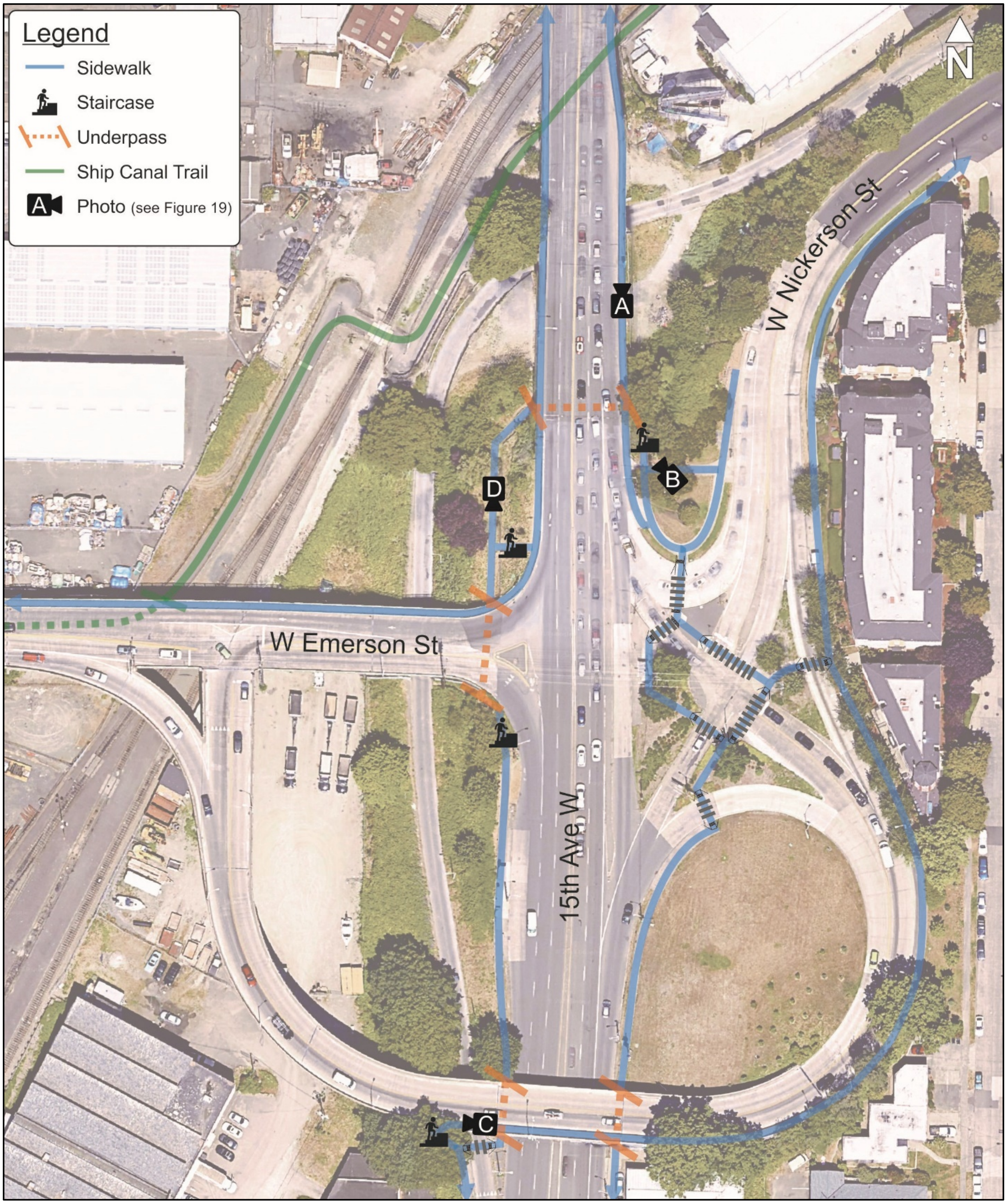
2.6.1. Existing Pedestrian and Bicycle Facilities

Currently, there are narrow sidewalks on both sides of the Ballard Bridge that are shared by pedestrians and cyclists. For most of the length of the bridge's half-mile-long approaches, the sidewalks are 4-feet wide, narrowing to 3.5 feet at the current and former street light pilasters, which are located every 20 feet. On the bascule portion of the bridge, the sidewalks are 6-feet wide except at each quadrant of the bascule, where the sidewalk narrows to 3.5 feet because of mechanical units that open the bridge. A 6-inch high concrete divider separates the sidewalk from the vehicle lanes along the bridge approaches; there is a metal railing approaching the bascule segment (within 200 to 250 feet on each approach). On the north end of the bridge, both sidewalks depart/enter the bridge approach structure at the NW Leary Way ramps. There are no sidewalks in the structured segment of the 15th Ave NW mainline over NW Leary Way (between NW 46th St and NW 50th St). Camera counts performed on those ramps found that most cyclists ride in the travel lanes on the segment between NW Leary Wy and NW Ballard Wy and then use the sidewalk south of NW Ballard Wy.

There are two pairs of stairwells on each end of the bridge that descend from bridge level to ground. On the north approach, the stairs connect to Shilshole Ave NW and on the south approach, the stairs connect near Fishermen's Terminal (W Thurman St). The south end stairs are barricaded. Further south near W Emerson St, there is a system of under-structure paths and stairways that connect the east and west sidewalks along 15th Ave W and allow pedestrians and cyclists to pass under the W Emerson St structure. Metal guardrail-type barriers prevent both pedestrians and cyclists from crossing W Emerson St at its intersection with 15th Ave W. Non-motorized users can use the underpass below the structure or use the sidewalk on the north side of W Emerson St to the west, from which cyclists can access the Interbay and Ship Canal Trails near the intersection with 19th Ave W. Some cyclists have reported that they ride in the travel lanes south of the bridge to avoid the circuitous routing along the sidewalk.

The existing overpass of 15th Ave W that connects W Nickerson St to W Emerson St can be used by cyclists if they ride in the vehicle lanes; however, it has limited pedestrian facilities. There is a sidewalk only on the south side of that structure that connects from the all-way stop on the east side of 15th Ave W to a stairway that connects to the west side of 15th Ave W. From there, pedestrians must use the system of underpasses and stairs to reach W Emerson St. Figure 18 shows the existing non-motorized facilities on the south end of the Ballard Bridge. Photos of some of the existing facilities are shown on Figure 19.

Figure 18. Non-Motorized Facilities on South End of Ballard Bridge



Source: Heffron Transportation, Inc., November 2019. Aerial photo from GoogleEarth.

Figure 19. Existing Pedestrian Facilities

Photo A: *East sidewalk looking north*

Photo B: *Stair on south end of bridge, east side*

Photo C: *Pedestrian stair from W Nickerson St overpass to west side of 15th Ave W*

Photo D: *Underpass of W Emerson St just west of 15th Ave W*

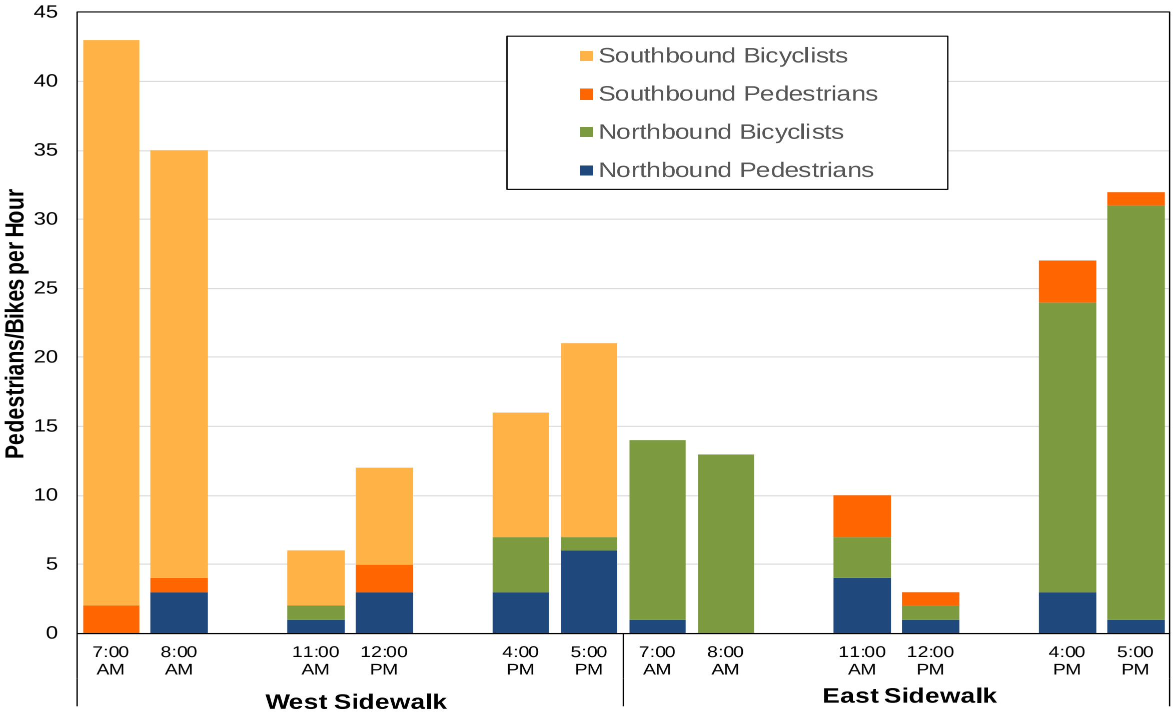
Source: Heffron Transportation, Inc., July 2019. Photo locations are shown on Figure 18.

2.6.2. Existing Pedestrian and Bicycle Use of Ballard Bridge

Almost all pedestrians and cyclists that use the Ballard Bridge enter and exit the bridge via the ramps to NW Leary Way/NW Ballard Way.[13] Camera counts performed at that ramp junction in May 2019 were used to determine the number of pedestrians and cyclists who cross the Ballard Bridge during each of the six hours counted. The volumes by hour and side of bridge are shown on Figure 20. The count occurred during bike-to-work month on a sunny day.

13 The exception is the few pedestrians who may use the stairs on the north end of the bridge to reach Shilshole Ave NW.

Figure 20. Pedestrian and Bicycle Traffic on Ballard Bridge – May 2019



Source: IDAX camera count, performed May 21, 2019.

For the six hours counted, a total of 193 cyclist and 39 pedestrians travelled across the Ballard Bridge. The peak occurred during the 7:00 to 8:00 A.M. hour when there were 54 cyclists (41 southbound on the west sidewalk and 13 northbound on the east sidewalk) and 3 pedestrians (2 southbound on the west sidewalk and 1 northbound on the east sidewalk). During this peak hour, both pedestrians and cyclists flowed in the same direction as traffic. In fact, southbound cyclists used the west sidewalk only during all count periods. However, during other periods, northbound pedestrians and cyclists also used the west sidewalk.

2.7 Transit Service and Facilities

2.7.1. Existing Bus Service

King County Metro currently provides bus service across the Ballard Bridge. One all-day bus route, Rapid Ride D Line, provides 230 daily bus trips through the 15th Ave W/NW corridor. Four peak-period bus routes, 15X, 17X, 18X, and 29, utilize the bridge before diverging off of the 15th Ave W/NW corridor at various points north and south of the bridge. Route 994, a school service route, also operates when Lakeside School and University Prep are in session. Table 2 summarizes the peak hour bus service using the Ballard Bridge.

Currently the Rapid Ride D Line has a northbound stop tucked into the W Emerson St/W Nickerson St ramp configuration. Buses are required to merged back into traffic with the northbound on-ramp traffic, which is a very heavy movement in the PM peak hours. All routes, outside of Route 15 and 994, use stops on the north side of the bridge that are located on the ramp system at NW Leary Way. Northbound, the Rapid Ride D Line then reenters 15th Ave NW by utilizing the northbound on-ramp at NW Leary Way. Routes 17X, 18X, and 29 continue their routes on NW Leary Way.

Table 2. Bus Service on Ballard Bridge – Existing Conditions

Route	AM Peak Hour Buses (8-9AM)		PM Peak Hour Buses (4-5PM)	
	Northbound	Southbound	Northbound	Southbound
Rapid Ride D Line	7	10	8	10
15X	-	6	2	-
17X	-	3	2	-
18X	-	3	2	-
29	-	3	2	-
994	1	-	-	1
Total	8	25	16	11

Source: One Bus Away, June 2019.

2.7.2. Future Transit Improvements

King County Metro has several major investments planned for Ballard, as detailed in the *Metro Connects, 2016 Long-Range Plan*[14]. Two transit enhancements from this plan are proposed to be led by SDOT as part of a Transit Plus Multimodal Corridor project and include transit improvements from University District to Ballard through Wallingford (scheduled for 2023), and the route from Northgate to downtown through Ballard (scheduled for 2024).

Sound Transit plans to complete its Downtown-to-Ballard Link Light Rail extension in 2035. It is currently evaluating several alignment options including the route and method for crossing the Ship Canal (whether on a fixed bridge or in a tunnel) along with the location of stations in Interbay and Ballard. Once complete, King County Metro would likely revise existing transit services to and through Ballard to connect to the Link Light Rail system. Changes will not be known for many years. However, it is likely that fewer transit routes would cross the Ballard Bridge in the future as routes that connect to downtown Seattle are redeployed to connect to light rail.

2.8 Collision History and Emergency Response

2.8.1. Collision History

Five years of collision data were compiled for the Ballard Bridge and the ramp junctions north and south of the bridge. These are summarized in Table 3. The main segment of the Ballard Bridge between the ramp junctions (about NW 46th St to W Emerson St) experienced 58 collisions during this period, which included 6 head-on and 9 sideswipe collisions to which the existing design of the bridge could be contributing factors. Twenty-five (25) of the 58 collisions on the bridge were rear-end collisions that could be related to congestion emanating from the ramps at each end of the bridge. During the five-year period on the Ballard Bridge section, there were no collisions that resulted in a fatality, but one that resulted in a serious injury. Of the others, 21 collisions resulted in an injury, and the rest had property damage only.

[14] King County Metro, Adopted January 2017.

Table 3. Collision Summary (June 1, 2014 through June 1 2019)

Intersection	Rear-End	Side-Swipe	Right Turn	Left Turn	Angle	Ped / Cycle	Head On	Other [a]	Total for 5.0 Years	Average/ Year
15th Ave NW / NW Leary Way Interchange	7	8	0	16	1	1	4	17	54	10.8
15th Ave W / W Emerson St / W Nickerson St Interchange	9	11	0	1	7	1	6	11	46	9.2
Roadway Segment	**Rear-End**	**Side-Swipe**	**Right Turn**	**Left Turn**	**Angle**	**Ped / Cycle**	**Head On**	**Other [a]**	**Total for 5.0 Years**	**Average/ Year**
Ballard Bridge (ramp to ramp)	25	9	0	0	0	0	6	18	58	11.6

Source: Seattle GeoData, May 2019.

a. 'Other' collision types included insufficient information, driver inattention, parked car and improper movement.

2.9 Local Business Access

There are many driveways along 15th Ave W/NW that serve adjacent businesses, these are shown on Figures 21 and 22, for the south and north segments adjoining the Ballard Bridge, respectively. Most of the businesses have alternate access on an adjoining east-west street. The businesses with sole access onto 15th Ave W/NW include:

- Pelican Press (5201 15th Ave NW), on a site that was under construction at time of study in May 2019.
- Brown Bear Car Wash (5111 15th Ave NW), which was not operating in May 2019, and the site occupied by coffee stand and food truck.
- Point S Tire & Auto Service (3620 15th Ave NW)

BALLARD BRIDGE PLANNING STUDY

Figure 21
Existing Businesses Along the Ballard Bridge Corridor - South

heffron transportation inc

BALLARD BRIDGE PLANNING STUDY

Figure 22
Existing Businesses Along the Ballard Bridge Corridor - North

heffron transportation inc

3. Component Feasibility Analysis

3.1 Purpose of Component Feasibility Analysis

This study evaluates rehabilitation and replacement options for the Ballard Bridge that would be located in the same alignment as the existing bridge. Different vertical-clearance options—ranging from the current low-level bridge height (44-feet clearance above the ordinary high-water mark), a mid-level bridge height (60 to 70 feet), and high-level bridge height (approximately 140 to 160 feet)—were evaluated. The low- and mid-level options would continue to have a bascule segment that would open to allow passage of marine traffic; the high-level option would be a fixed bridge.

To help inform development of the three feasible options, various geometric configurations and/or traffic control configurations for intersection connections at the north and south ends of the bridge were developed and analyzed. Because it is not feasible within the study budget or schedule to evaluate all of the potential combinations of bridge height and interchange configurations, this analysis focused on stand-alone "components" to first determine if each is physically feasible, and if so, to determine the optimal configuration needed to provide acceptable traffic operations and pedestrian/bicycle connectivity. The most promising components were then combined as part of a larger alternative for further analysis and refinement, including assessment of transit connectivity and travel times along various routes, which is later presented in Section 4 (Alternatives Analysis).

Three sub-areas of the bridge corridor were evaluated to assess various components.

A. **North side connections** – North of the Ship Canal, the existing bridge has ramps that connect to NW Ballard Way and NW Leary Way in both the northbound and southbound directions, which serve a high proportion of the corridor traffic volume. Parallel to each side of the north bridge approach are surface frontage roads that connect to east-west streets between NW 46th St and NW 50th St. The component analysis focused on the primary connections to NW Leary Way and NW Ballard Way. Different configurations were evaluated for these junctions and ranged from eliminating the ramps altogether (and forcing traffic further north on the corridor) to creating different configurations of ramps and interchanges. These are described further in Section 3.3.

B. South side connections – South of the Ship Canal, the existing bridge has a series of ramps and intersections that connect to W Nickerson St (east of 15th Ave W) and W Emerson St (west of 15th Ave W). This interchange connects the 15th Ave W corridor to the Magnolia, Interbay, and Fremont neighborhoods of Seattle. These are necessary connections to retain due to the limited grid of streets on the south side of the bridge in this area. The various options considered for this component are described in Section 3.4.

C. **Bridge segment** – As noted above, three different vertical-clearance options were evaluated: low-level, mid-level, and high-level. Each option would have a minimum of four lanes (two lanes in each direction) across the bridge, but depending on the intersection configurations at each end of the bridge, auxiliary lanes to facilitate merging and diverging traffic may be required or desired. Those needs are evaluated as part of the North Side connections. In addition, different configurations for pedestrian and bicycle facilities could be constructed and range from providing separate one-way facilities on both sides of the bridge to providing a two-way facility on one side of the bridge. The non-motorized facility options are evaluated in Section 4.3.

3.2 Component Analysis Process

Each potential component was tested using year 2040 forecast traffic volumes. These forecasts were described in Section 2.2.3. It is assumed that PM peak hour traffic on the bridge would increase to 3,360 vehicles per hour in the northbound direction and 2,580 vehicles per hour in the southbound direction. Year 2040 No Build condition volumes for study area intersections were adjusted to reflect changes in access associated with the various components.

Traffic operations analysis was then performed to test various components and determine the optimal lane configuration and traffic control needed to attain acceptable levels of service (LOS). A target operation of LOS E or better, which reflects capacity conditions, was used to determine the needed lane configuration and traffic control. However, it is recognized that the configuration should be reasonable within the urban context of Ballard and recommendations were targeted to limit the size of intersections to no more than three approach lanes in each direction. For components that would operate below LOS E even with the upper limit in number of intersection lanes, sensitivity analysis was then performed to determine how traffic operations would change with growth over time to determine the resiliency of the options. Those options that would only exceed capacity near the end of the analysis horizon period (20-plus years) are considered more resilient to growth than those that would reach capacity in near-term years. Components that would result in very poor levels of service with high delays or that would require unreasonable lane configurations (e.g., more than three approach lanes in one or more directions) to achieve acceptable operations were eliminated from consideration.

3.3 North Side Connections

The existing bridge has ramps that connect to NW Ballard Way and NW Leary Way in both the northbound and southbound directions. Existing traffic counts determined that nearly 40% of the peak hour traffic crossing the bridge uses these ramps with about half of that turning to/from NW Ballard Way and the other half turning to/from NW Leary Way. These existing connections can be retained for the low-level bridge option, but become more challenging for bridge options with higher vertical clearance. The ramp configuration for the high-level bridge, with a 150-foot clearance for vessels on the Ship Canal, would be the most challenging since the aerial structure is estimated to be about 90-feet above NW Leary Way as it descends from its maximum height. Therefore, components were first tested for the high-level bridge option, and then used to inform potential design for the mid-level option.

3.3.1. High-Level Bridge Components

The components evaluated below focus on the needs of the high-level bridge, and included:

1. Eliminating the NW Leary Way / NW Ballard Way ramps altogether and forcing the ramp traffic to connect to the street grid further north on the corridor, mostly through the NW Market St intersection;
2. Providing two lengthened on- and off-ramps at or near NW Leary Way; or
3. Creating an elevated signalized intersection to provide a consolidated single ramp connection for on and off access at or near NW Leary Way. It is noted that a signalized intersection at this location is not desirable for either the low-level or mid-level bridge options due to its proximity to the bascule opening, and the desire to avoid near-bridge congestion or queuing that could delay opening the bridge.

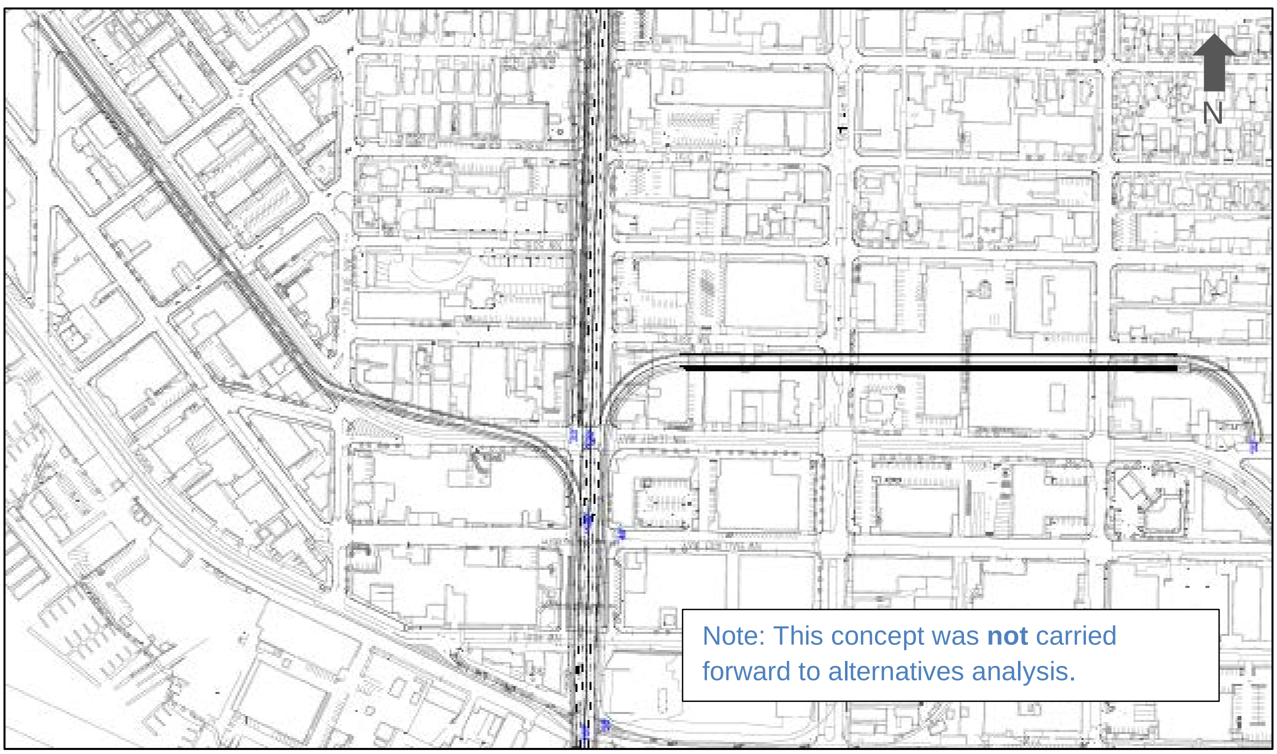
Eliminate NW Leary Way Ramps

This option would force all of the traffic that now exits or enters the 15th Ave NW corridor from NW Leary Way and NW Ballard Way to use an alternative route north of NW Leary Way. However, it was determined that diverting that traffic further north would substantially increase congestion through the NW Market St / 15th Ave NW intersection. During the PM peak hour in the year 2040, average vehicle delays for all movements at that intersection could exceed six minutes per vehicle if there were no ramps to NW Leary Way. The delay to northbound traffic would be even higher. Thus, eliminating the ramps would negate the benefit of eliminating the bridge's bascule openings, which during the PM peak hour, occurred every other day and lasted an average of 5 minutes each. If the NW Leary Way ramps are eliminated, all traffic that crosses the bridge would experience increased delay as opposed to the portion of traffic that is affected by bridge openings. For these reasons, **eliminating the NW Leary Way ramps should not be considered.**

Lengthen NW Leary Way Ramps

As noted above, the high-level bridge option would have an elevation that is about 90 feet above the grade of NW Leary Way. Therefore, much longer ramps (than currently exist) would be needed to connect the bridge to grade. Traditional on- and off-ramps would also require space for deceleration and acceleration from and to the mainline of the bridge. Figure 23 below shows a conceptual plan of these ramps assuming a maximum 5% grade.

Figure 23. Concept of High-Level Bridge Ramps to NW Leary Way



Source: SCJ Alliance, June 2019.

Even though most of the ramps could be built within City-owned right-of-way, they would still likely have substantial property impacts, including acquisition and/or access accommodations. Acceptable levels of service at the ramp junctions with the local street system can be achieved; however, the long ramps would require out-of-direction travel for many bridge users. For example, trips from areas east of the bridge would need to travel far to the west to access the on-ramp. The length and grade of these ramps would also challenge freight access as well as non-motorized travel. The advantages and disadvantages of this option are summarized in Table 4.

Table 4. Advantages and Disadvantages of Lengthened Ramps

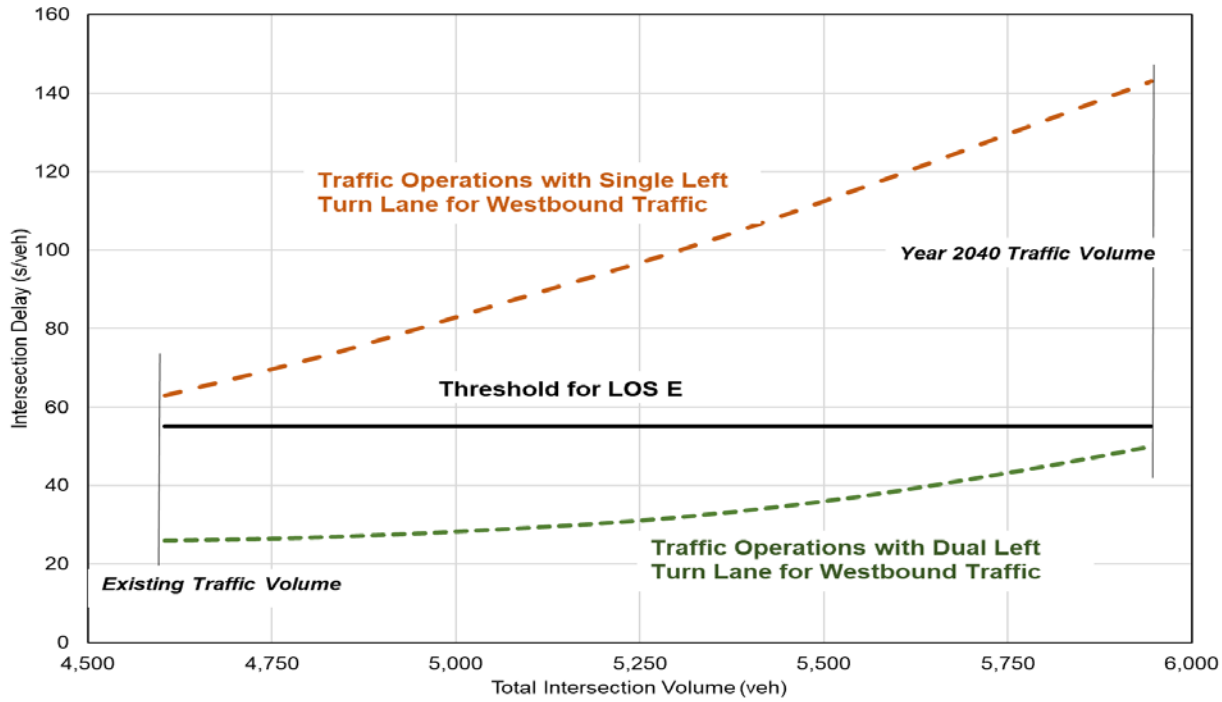
Advantages	Disadvantages
• Has less disruption to mainline traffic on 15th Ave NW than elevated intersection (see Elevated Intersection component analysis in section below)	• Has substantial property impacts • May require changes to provide local access to properties near ramp structure • Requires out-of-direction travel for some users to reach on- or off-ramps • Length and grade of ramps challenging for trucks • Length of ramps and conflicts at ramp junctions challenging for pedestrians and cyclists • Likely requires two new signalized intersections at ramp junctions with surface street system

Elevated Intersection

The high-level bridge option could allow for a new signalized intersection on the corridor, since there would be no bridge openings with which it could interfere. To determine if it would be feasible to serve the north side connections with an elevated intersection, several configurations were evaluated. The findings from that initial analysis determined that the connection should be configured as a "T" intersection extending to the east of the bridge to eliminate the need to serve left turns with one or more left-turn lanes on the bridge deck.

Sensitivity analysis was performed to determine how a signalized intersection would function with growth in traffic volumes between the existing and future 2040 conditions. The analysis assumed that the mainline of 15th Ave NW would have four lanes (two lanes in each direction) but tested conditions with one and two left-turn lanes for traffic turning onto the bridge. The results are summarized in Figure 24.

Figure 24. Sensitivity Analysis for Elevated, Signalized Ramp Intersection

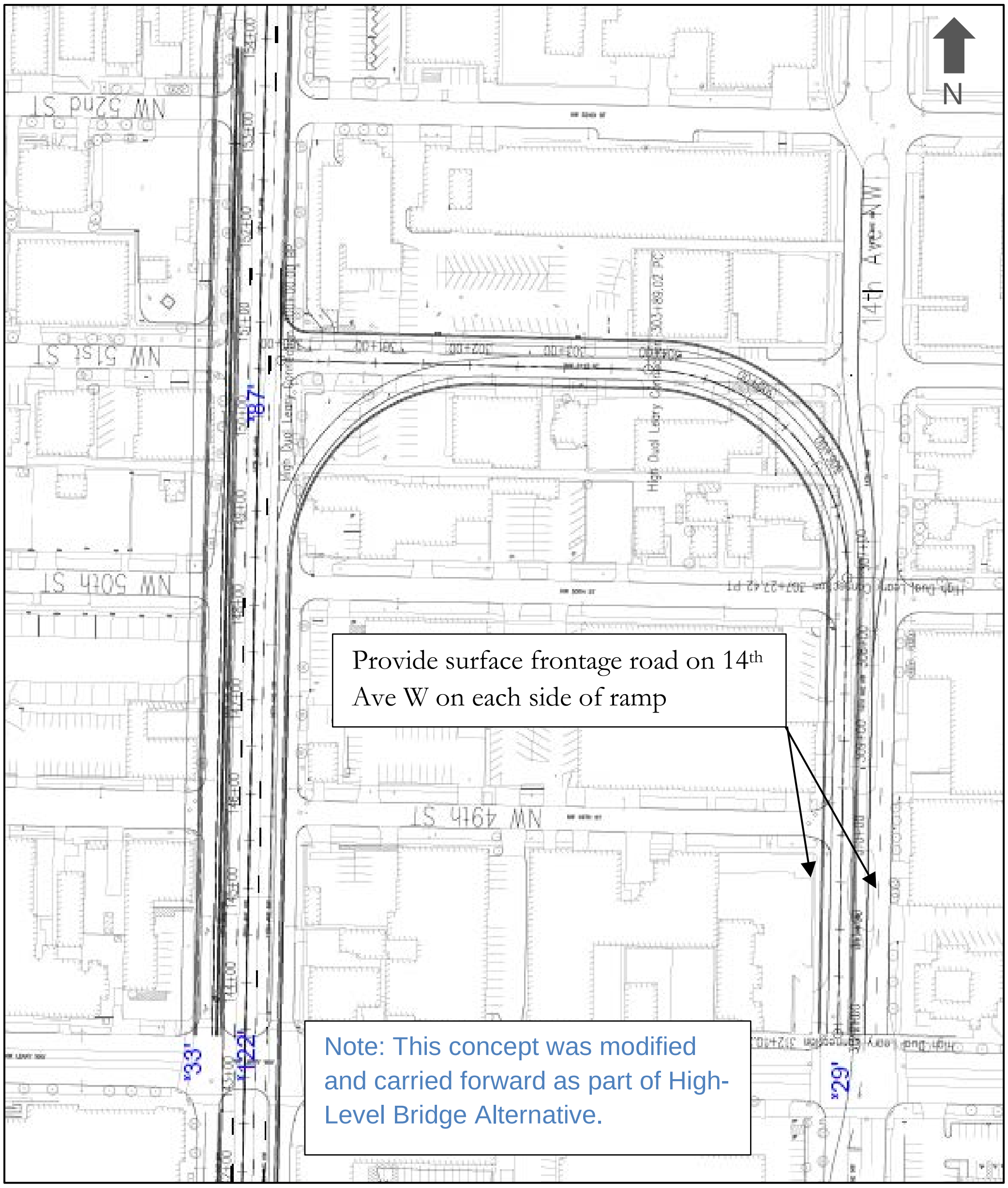


Source: Heffron Transportation, Inc., July 2019.

The analysis shows that the signal would operate at an acceptable level of service with a dual left turn lane for traffic turning onto the bridge from the NW Leary Way Ramp. A conceptual plan for the feasible configuration, assuming a maximum grade of 5%, is shown in Figure 25. Separate analysis of the geometric feasibility of this intersection determined that the elevated intersection should **not** accommodate westbound-to-northbound traffic at the elevated intersection. That movement would require a very large radius intersection, increasing the property acquisition needs for a relatively small amount of traffic. To better serve local traffic, a north-south surface roadway could be located under the bridge and connected to east-west streets (NW 49th, 50th and 51st St). North of NW 52nd St, frontage roads on each side of 15th Ave NW could be retained to connect to the mainline.

The preliminary concept tested for the Component Analysis would connect to the high-level bridge at NW 51st St and would have required a long ramp descending to grade on 14th Ave NW. Frontage roads would have been required on each side of the 14th Ave NW ramp to provide local access. Refinements to this design were incorporated into the High-Level Bridge Alternative, which is presented in Section 4. The refinement pushed the ramp junction north to NE 52nd St which reduced the elevation and length of the ramp, and would provide better local connections and reduce the length of local frontage roads on each side of the elevated ramp structure along 14th Ave NW.

Figure 25. Preliminary Concept of Elevated, Signalized Ramp (High-Level Bridge Only)



Source: SCJ Alliance, July 2019. Note that the configuration included in the High Bridge Alternative would locate the ramp junction further north on 15th Ave NW at NW 52nd St and reduce length of 14th Ave NW frontage roads.

The elevated signalized intersection configuration can consolidate the southbound on and northbound off movements onto a single ramp structure, reducing the potential property impacts compared to the two-ramp option described above. Non-motorized travel on the bridge could be consolidated on the west side where it could flow freely without stopping for or conflicting with vehicle movements at the signal. Since the ramp would allow no westbound-to-northbound right turn movements, a signalized pedestrian/bicycle crossing could be provided across the north leg of the elevated ramp intersection. However, even with that connection to the ramp, the non-motorized connection to the local street system would be located north of NW Leary Way, requiring additional out-of-direction travel for those destined to and from the Burke-Gilman Trail.

The ramp to the high-level bridge would consolidate bridge access traffic onto 14th Ave NW. Some additional improvements may be needed along 14th Ave NW, particularly at NW Leary Way, NW Ballard Way, and NW 46th St. This could include reconfiguring the roadway to move center median parking to the edges and/or changing traffic control to accommodate increased north-south traffic on 14th Ave NW. If Sound Transit located an elevated light rail line in the 14th Ave NW corridor, further design coordination would be required in the segment with the new ramp.

The advantages and disadvantages of this component are summarized in Table 5.

Table 5. Advantages and Disadvantages of Elevated Signal Intersection

Advantages	Disadvantages
• Would have shorter, consolidated ramp compared to two-ramp option, reducing property- and local-access impacts • Would require fewer lanes on 15th Ave NW at ramp junction compared to two-ramp option (5 lanes instead of 6 lanes) • Avoids vehicle conflicts with non-motorized path that could be located on west side of bridge with a crossing of the elevated intersections north leg.	• Adds signal and delay to through traffic on 15th Ave NW • Has some property impacts • May require changes to provide local access to properties near ramp structure • Increased congestion on 14th Ave NW at NW Leary Way, NW Ballard Way, and NW 46th St. • Requires most out-of-direction travel for bikes destined to and from the Burke-Gilman Trail. • Eliminates the ability for north-south transit routes on 15th Ave NW to serve riders near NW Leary Way.

All of the north side access components associated with the high-level bridge would have some challenges due to the length of the ramps, the effect on local circulation, and where they could intersect the existing grid system. Substantial improvements at the touchdown intersections and local circulation would be required. However, based on the Component Analysis, the single ramp with an elevated signalized intersection was carried forward as part of the High-Level Bridge Alternative.

3.3.2. Mid-Level Bridge Components

The mid-level bridge option would require longer ramps than currently exist to reach NW Leary Way from the anticipated bridge elevation. The higher elevation would eliminate the ability for either the on or the off-ramp to connect to NW Ballard Way, and the longer ramps would need to be pushed away from 15th Ave NW to be long enough to achieve the target maximum grade of 5%. Several options were tested. Based on the geometric analysis for the high-level bridge, it was determined that the northbound off-ramp should diverge from the structure north of NW Leary Way in order to provide a deceleration lane from mainline traffic that does not encumber the bascule section of the bridge. The ramp could bend east to connect to 14th Ave NW at a T-intersection, allowing vehicles to connect to northbound or southbound 14th Ave NW.

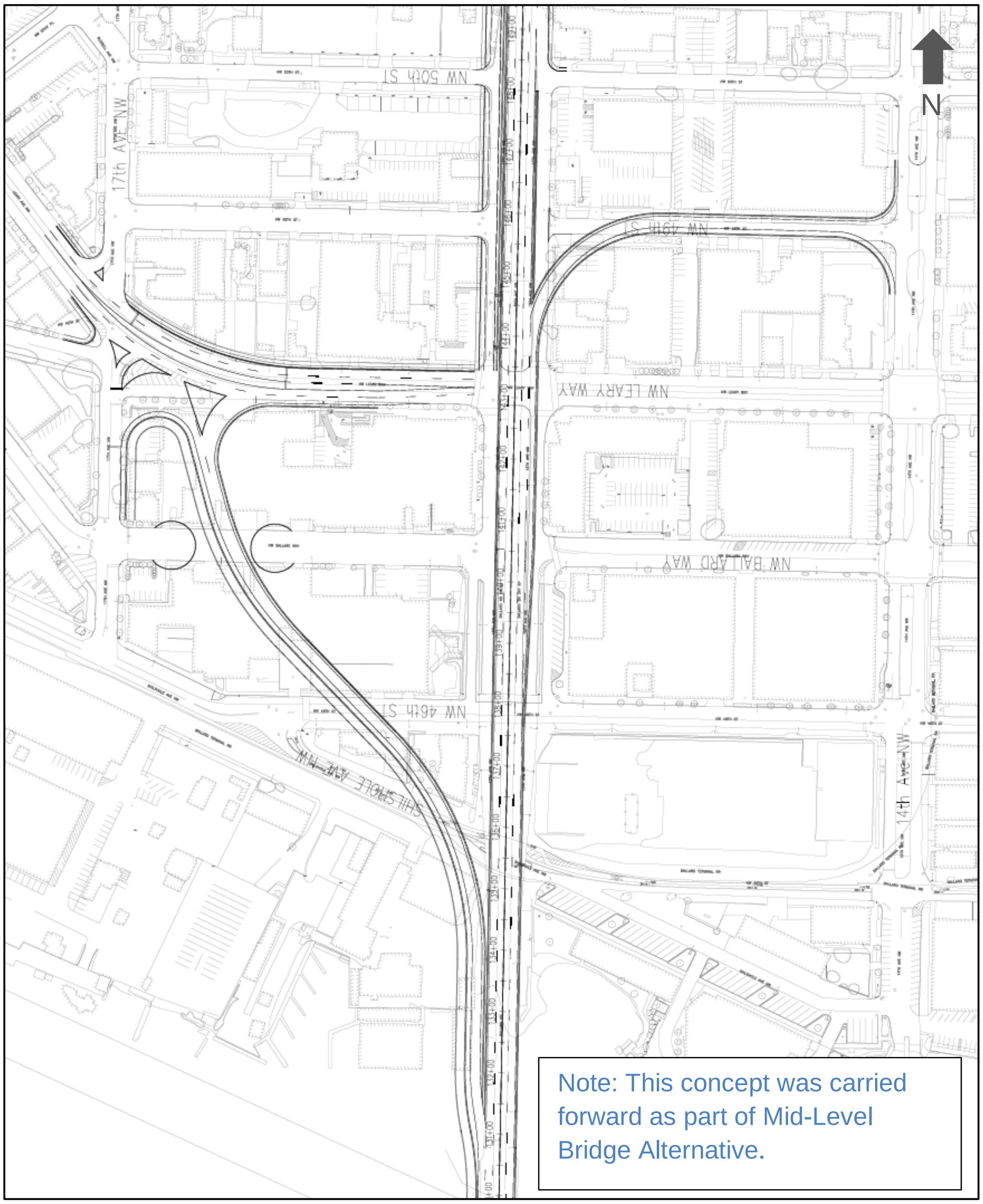
The southbound on-ramp entrance would need to move west to near the NW Leary Way/17th Ave NW intersection. Several traffic operation and geometric conditions were evaluated. The largest geometric constraint is accommodating a large truck turning from northbound 17th Ave NW onto the ramp. This would require additional maneuvering area on the south side of the intersection. While these two closely-spaced intersections may be able to operate with stop-sign control on the minor legs (as it operates today), the intersections were tested with two closely-spaced traffic signals to make sure that control option would work in the future, if needed or desired. The signals would operate at acceptable levels of service with the following parameters.

- Convert NW 48th St west of 17th Ave NW to one-way westbound. This would eliminate the need to serve this local street with the signal.
- Consolidate a shared-use bike/pedestrian path on the east side of 17th Ave NW south of the ramp so that bikes can flow unimpeded onto the bridge without being crossed by vehicles.
- Prohibit right-turn on red (RTOR) from northbound 17th Ave NW onto the on-ramp since this movement would conflict with traffic turning to the ramp from both directions of NW Leary Way.
- Locate bike/pedestrian crossings of NW Leary Way where it would have the shortest crossing distance (and shortest length of crossing signal phase).

It is noted that 17th Ave NW may not be wide enough to accommodate two-way vehicular traffic (including the large-radius turns for trucks from northbound onto the bridge ramp) as well as a two-way bike path. If needed, 17th Ave NW could be converted to a one-way northbound street to provide access to the mid-level on-ramp. The companion southbound movements could be relocated under the bridge along 15th Ave NW where the added bridge height would allow a new road to be located under the bridge. Further design would be needed to assess geometric requirements.

The potential concept evaluated for the mid-level bridge is shown on Figure 26.

Figure 26. Concept Plan for Mid-Level Bridge Ramps to NW Leary Way



Source: SCJ Alliance, November 2019.

3.3.3. Low-Level Bridge Components

This option would retain the current vertical clearance of the bridge and the existing ramp configuration at NW Leary Way / NW Ballard Way. Improvements to integrate new pedestrian and bicycle facilities on the bridge would be needed. No other modifications are considered.

3.4 South Side Connections

South of the Ship Canal, 15th Ave W currently connects to W Nickerson St (east of 15th Ave W) and W Emerson St (west of 15th Ave W) with a complex system of at-grade ramps plus an overpass that connects the east and west sides of the corridor. All of the ramp intersections are controlled with stop signs. Further south, the corridor connects to W Dravus St at a grade-separated interchange that is in a tight-diamond configuration, with on- and off-ramps connecting to a bridge over 15th Ave W. There is a center median between W Emerson St and W Dravus St that prevents left-turn movements. Two local streets connect to 15th Ave W in that segment: W Ruffner St on the east and W Bertona St on the west.

The mid- and high-level Ballard Bridge replacement options would require rebuilding the interchange at W Nickerson / Emerson Streets since the existing at-grade ramps would not meet the elevated road grade. This provides an opportunity to improve traffic flow and non-motorized access at this interchange. Physical constraints dictate where ramps can be located. To the west, W Emerson St must clear the BNSF railroad tracks by a minimum of 23.5 feet. The overpass connecting the east and west sides of 15th Ave W must provide a minimum of 20 feet of clearance over 15th Ave W to provide for over-dimensioned freight. Any new ramps should allow for merge and diverge movements between W Dravus St and W Emerson St.

3.4.1. Components for All Bridge Options

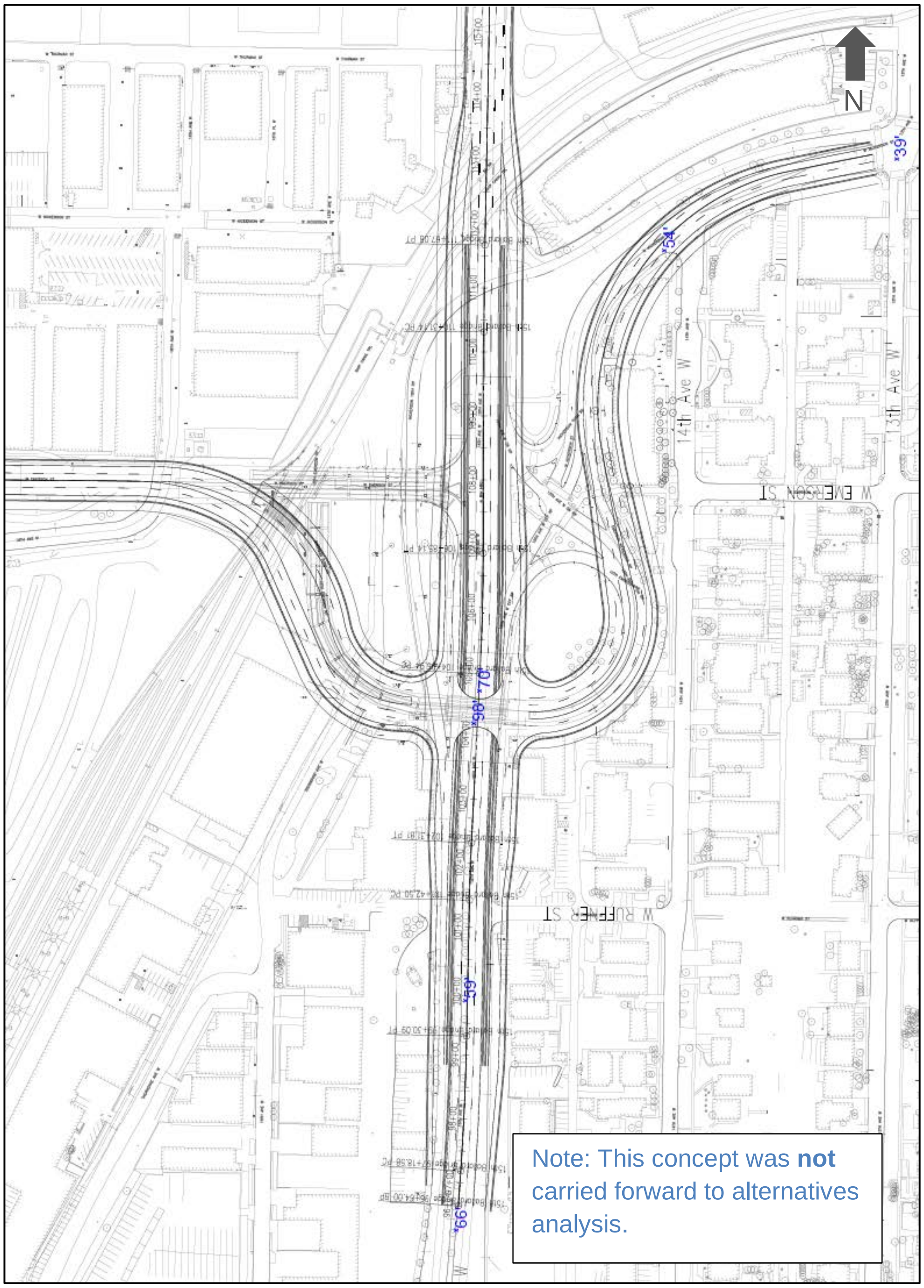
The components evaluated below focus on the south side components needed for the low-, mid-, and high-level bridge options. They include the following:

1. Construct a traditional single-point urban interchange (SPUI) at the W Nickerson / W Emerson Streets interchange;
2. Construct a modified single-point urban interchange (Modified SPUI) at the W Nickerson / W Emerson Streets interchange; or
3. Create an at-grade signalized intersection at W Nickerson / W Emerson Streets.

Traditional SPUI

A traditional SPUI was tested at this location, and is shown on Figure 27. In a traditional configuration, the northbound off-ramp and southbound on-ramp would extend south of the overpass and connect to the 15th Ave W mainline within 200 feet of W Dravus St. This distance would not provide enough space for merge and diverge maneuvers between the two interchanges. For this reason, the traditional SPUI was eliminated from future consideration for all bridge replacement options. A modified configuration, described below, would provide good operations with increased merge/diverge space.

Figure 27. Concept of Traditional SPUI Interchange



Source: SCJ Alliance, July 2019.

Modified SPUI

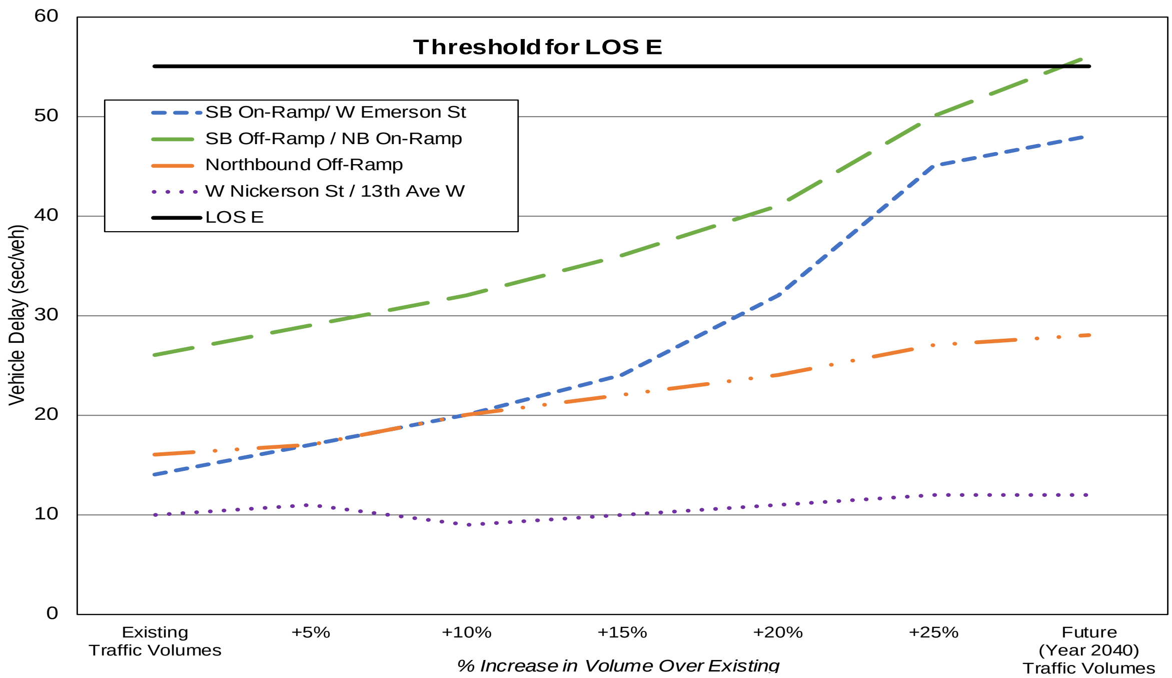
A modified SPUI configuration is shown on Figure 28. It would have a northbound on-ramp and a southbound off-ramp (traffic to and from the Ballard Bridge) that connect to a new overpass in approximately the same location as the existing overpass. The northbound off-ramp would tuck under that bridge and connect to W Nickerson St at a "T" intersection. The existing southbound on-ramp that connects W Nickerson St at 13th Ave W would remain and continue to pass under the 15th Ave W bridge approach. A new southbound on-ramp from W Emerson St would connect to that same ramp. It is noted that this configuration would allow a continuous two-way pedestrian/bicycle facility to be provided on the south side of the overpass that would have no vehicle conflicts. Transit stops could be provided either in the space near the loop ramps or a speed ramp north of the interchange.

Figure 28. Concept of W Nickerson / W Emerson Streets Modified SPUI

Source: SCJ Alliance, November 2019.

The initial concept tested for the Modified SPUI assumed a four-lane overpass connecting from W Nickerson St to W Emerson St, was found to operate at a very good level of service (LOS C or better at all intersections). Therefore, reduced-lane configurations were tested that have three or fewer lanes at the key intersections. Sensitivity analysis for the recommended configuration, showing vehicle delays for each intersection with projected growth through 2040, are presented on Figure 29. This shows that all four intersections in the interchange area would operate better than the LOS E threshold through the year 2039. Only near at the last horizon year of this sensitivity analysis would the central intersection (where the northbound on-ramp and southbound off-ramp converge) reach the LOS E threshold. Therefore, the configuration with a three-lane overpass is recommended.

Figure 29. Sensitivity Analysis for Modified SPUI
Recommended Lane Configuration

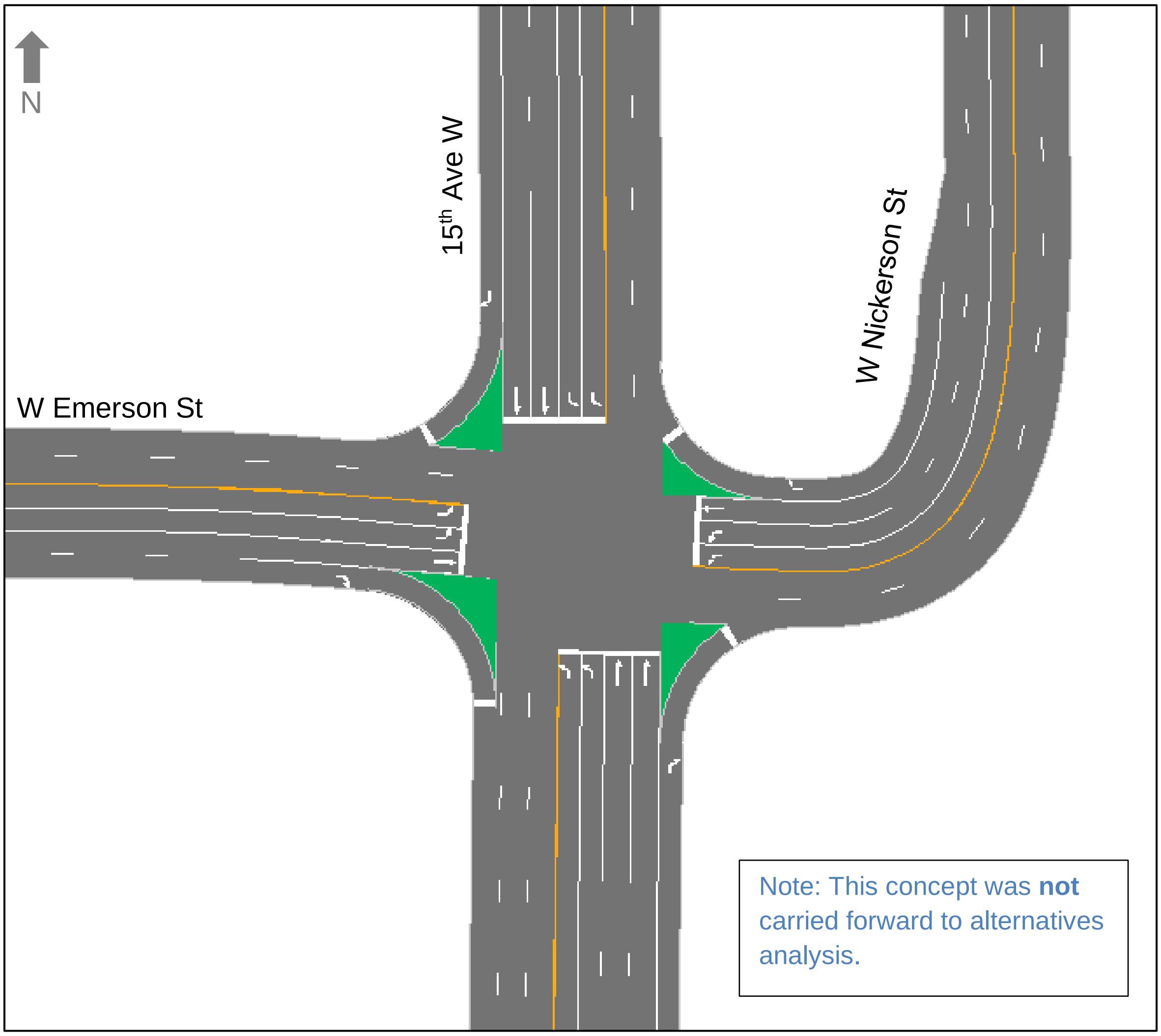


Source: Heffron Transportation, Inc., July 2019.

At-Grade Signalized Intersection

With a high-level bridge, a signalized intersection on the 15th Ave W mainline could be considered since there would be no interference with bridge openings. Such a configuration was tested at this location, and even with dual left-turn lanes and right turn lanes on all approaches and multiple through lanes, the intersection would operate at a very poor level of service (average vehicles delay in excess of 160 seconds, and a northbound queue that could exceed 1,700 feet on average). The pedestrian and bicycle operations would also be poor due to the need for a very long cycle length to separate all of the vehicular conflicts. The configuration tested is in shown on Figure 30. **Because of its size and poor performance, an in-line signalized intersection on 15th Ave W at W Emerson/Nickerson St is not recommended for further analysis for any of the bridge replacement options.**

Figure 30. W Nickerson / W Emerson Streets At-Grade Signalized Intersection Evaluated Lane Configuration



Source: Heffron Transportation, Inc., November 2019. Image of Synchro model lane configuration assumptions.

The Component Analysis determined that the Modified SPUI with a three-lane overpass bridge should be advanced to the Alternatives Analysis stage. Since the Modified SPUI would provide substantial benefit to vehicle and non-motorized operations compared to the current configuration, it was carried forward in all alternatives, including the low-level bridge alternative.

3.5 Pedestrian and Bicycle Facilities on the Bridge

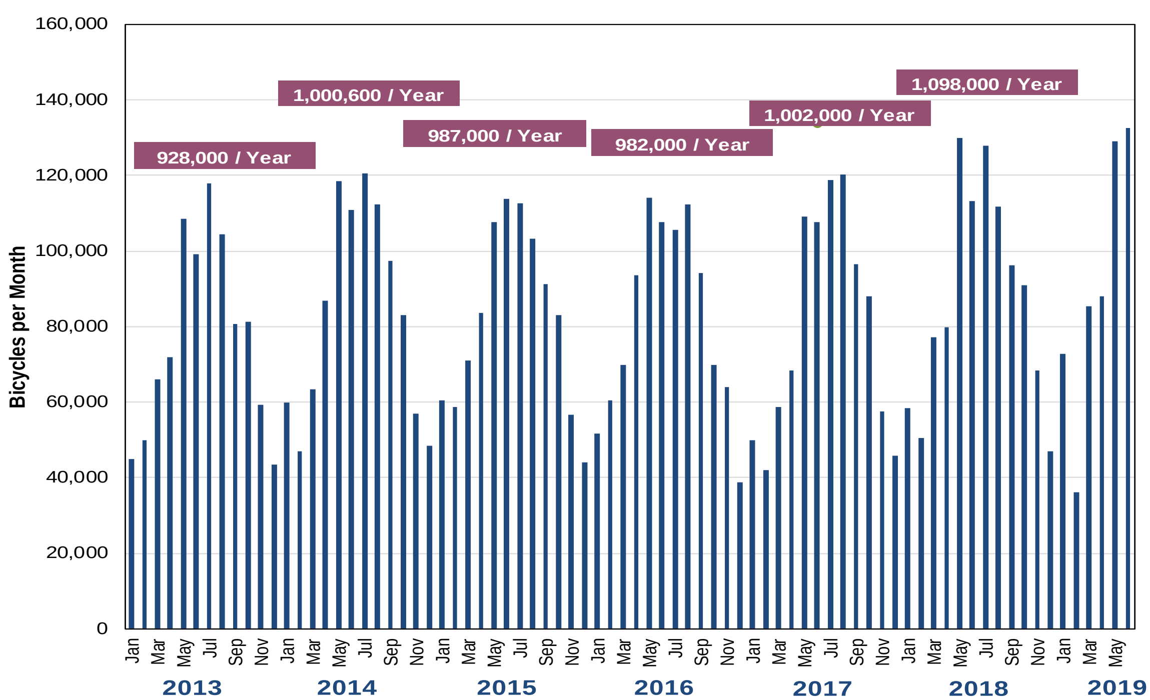
One of the primary functional needs of a new or reconstructed Ballard Bridge is improved pedestrian and bicycle facilities. Several options were evaluated including wider sidewalks on each side of the bridge or providing a wide shared-use path on only one side of the bridge.

Bicycle and pedestrian volumes on the existing Ballard Bridge are constrained by its narrow width and compromised connections on the south end of the bridge. Historic volumes should not be used to predict future use of upgraded facilities. Therefore, data from the Fremont Bridge, which is the most highly-used bicycle crossing of the Ship Canal, were compiled to assess the desired non-motorized facilities on the Ballard Bridge.

3.5.1. Comparative Use of Fremont Bridge

The Fremont Bridge has a permanent bike count station for which the number of cyclists is counted on both the east and west sides of the bridge by time of day. Counts have been performed since fall 2012. These data were compiled to show the seasonal changes in bike traffic as well as the growth over time, as shown on Figure 31. In the last full year counted (2018), approximately 1.1 million cyclists crossed the Fremont Bridge.

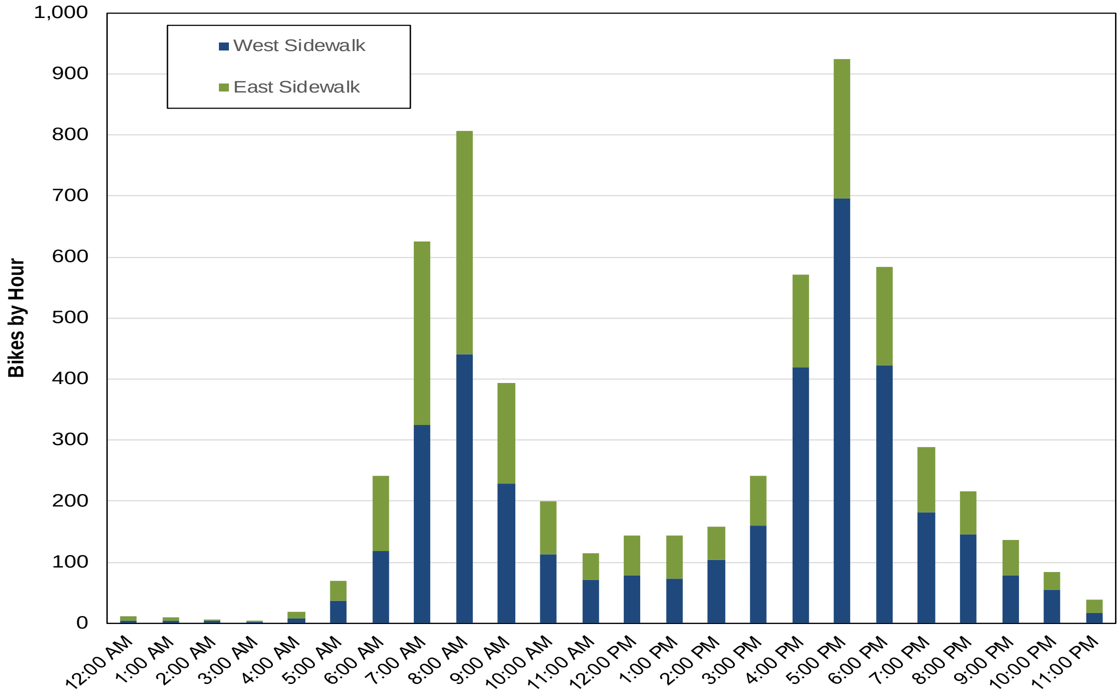
Figure 31. Fremont Bridge Bike Volumes by Month



Source: Source: Seattle Department of Transportation, Daily Bike Traffic Counts, accessed from https://data.seattle.gov/Transportation/daily-bike-traffic/d4dx-u56x, July 21, 2019. Data compiled by Heffron Transportation.

June 2019 was the highest month so far for bicycle use on the Fremont Bridge. Data for a typical weekday in that month were compiled to show bike use by time of day. It is noted that there is no information about the direction of travel. As shown on Figure 32, bicycle use of the bridge has similar peaking characteristics to that of vehicle traffic with peaks during the morning and afternoon commute periods. The peak use of the bridge occurred during the 5:00 to 6:00 P.M. hour when 924 cyclists crossed the bridge.

Figure 32. Fremont Bridge – Peak Day Bike Volumes by Hour



Source: Seattle Department of Transportation, Daily Bike Traffic Counts, accessed from https://data.seattle.gov/Transportation/daily-bike-traffic/d4dx-u56x, July 21, 2019. Data compiled by Heffron Transportation.

3.5.2. Non-Motorized Facility Operations

For planning purposes, potential non-motorized shared-use path improvements on the Ballard Bridge were evaluated for up to 1,000 bicycles per hour. This reflects a condition where bicycle traffic over the Fremont and Ballard Bridges combined would double by the year 2040. Based on existing counts on the Ballard Bridge, an estimated 75% of the bike trips would be in the peak direction (southbound in the morning and northbound in the afternoon). A peak of 50 pedestrians per hour in both directions was also assumed. These estimates are very conservative, and were used to determine the desired width of a shared-use path on the bridge.

Non-motorized facilities on the Ballard Bridge were assessed using the Federal Highway Administration's (FHWA) *Shared-Use Path Level of Service Calculator (SUPLOS).*[15] This tool was designed specifically to assess shared-use facilities from a cyclist's perspective based on potential conflicts with other cyclists and pedestrians. The level of service is based on path width, number of active passes (overtaking other users going the same direction), and number of opposing users. Two level-of-service measures are reported. The User's Perception LOS is based on surveys of other trails and calibrated to the features such as volume and width. The Trail LOS factors in the ability for a cyclist to pass other trail users moving the same direction.

Table 6 summarizes the level of service on the Ballard Bridge during the peak hour condition. The existing width as well as two improvement options were considered:

- A 14-foot wide shared-use path on the west side of the bridge only; and
- A 7-foot wide shared-use path on each side of the bridge

15 US Department of Transportation, July 2006.

The width of the shared-use path was established based on design guidance in the *Seattle Right-of-Way Improvement Manual*. This guidance states, "In areas that serve a high percentage of pedestrians (30% or more of total pathway volume) and higher user volumes (more than 300 total users in the peak hour) pathway widths of 12 to 14 feet should be provided. Where grades over 5% are necessary due to topography, the minimum width shall be increased to allow for passing and weaving." Although the number of pedestrians is relatively small compared to the number of cyclists, the grade of the bridge could be at 5%. Therefore, all of the alternatives assumed a 14-foot width.

As shown, the existing narrow sidewalk has a "user perception" rating of LOS F even though that width is sufficient to accommodate the very low bicycle and pedestrian volumes. A 14-foot shared use path would accommodate future increases in bicycle traffic (conservatively estimated at 1,000 bikes per hour and 50 pedestrians per hour) and operate with a user perception of LOS B and a Trail LOS of D. That same volume on two 7-foot wide shared paths would operate at LOS D for the user perception and Trail LOS of F. While it is possible that the volume could split to two different paths, existing use of the bridge suggests that most cyclists use the west sidewalk in the peak direction. Even with half of the volume (275 bicycles per hour), a 7-foot wide shared path would operate at LOS E.

Table 6. Ballard Bridge Sidewalk / Shared Use Path Level of Service

Condition	Bicycles/Hr in Peak Direction	Pedestrians/Hr in Peak Direction	User Perception LOS [a]	Trail LOS [b]
Existing – 3.5-foot sidewalk on both sides	43	2	F	A
Future – Peak Season Day with 14-foot shared-use path on west side of bridge	750 [c]	38	B	D
Future – Peak Season Day with 7-foot wide shared paths on both sides of bridge	750 [d]	38	D	F

a. *SUPLOS = Shared Use Path Level of Service. Derived using the FHWA SUPLOS Calculator. The User-Perception LOS is based on surveys of other shared use facilities.*

b. *The Trail LOS accounts for the ability of a cyclist to pass users moving in the same direction.*

c. *Evaluated for two-way bike volume of 1,000 per hour, which is higher than currently accommodated by the Fremont Bridge on the peak day in 2019. Assumes that 75% of the trips would be in the peak direction.*

This analysis shows that a 14-foot wide path would provide the best operation, and could accommodate substantial future increases in bike and pedestrian trips that would exceed what now crosses the Ship Canal on the Fremont Bridge. It was incorporated into all three of the bridge alternatives.

4. Alternatives Analysis

4.1 Alternatives

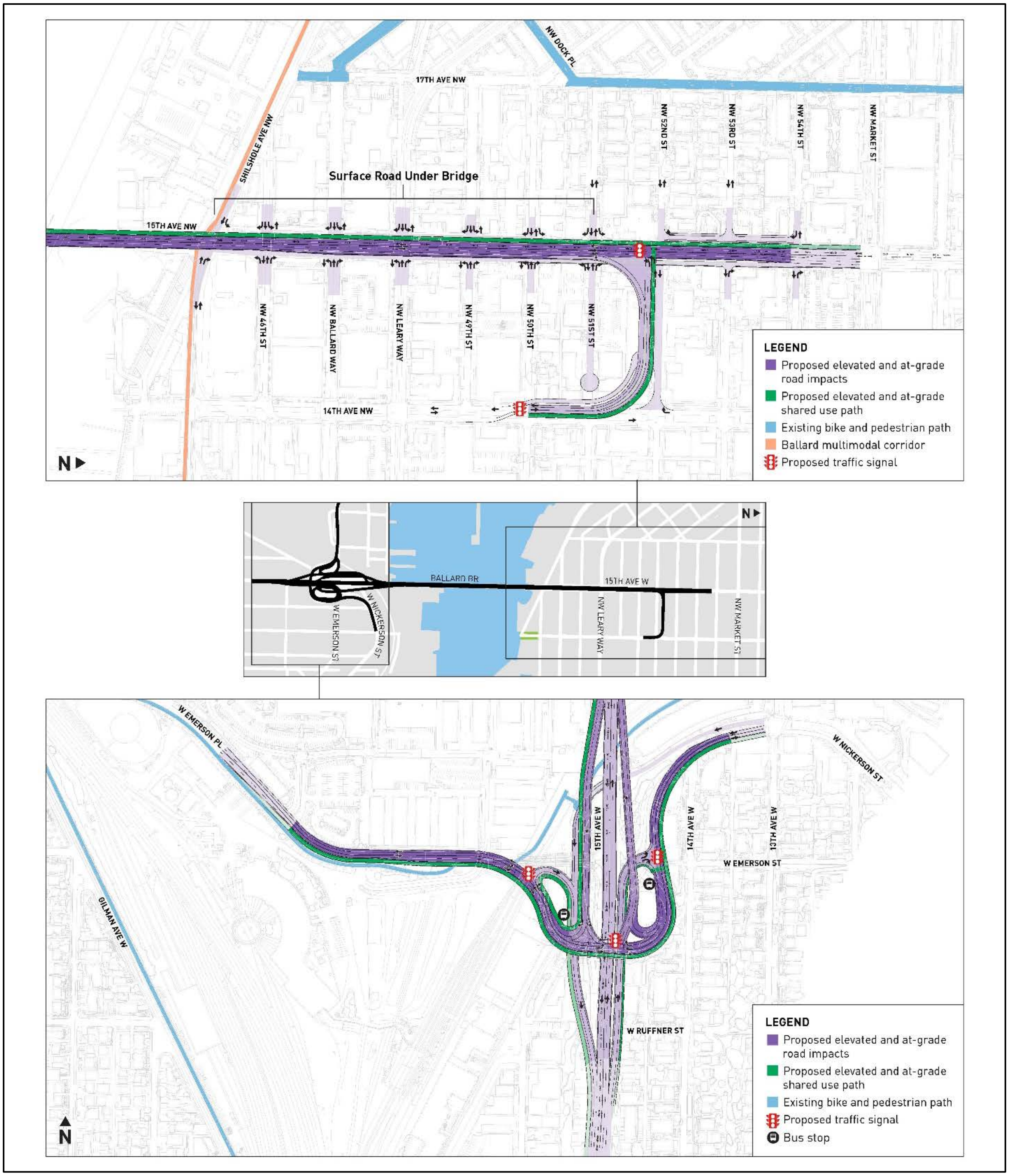
Three Ballard Bridge alternatives were evaluated, and were created based on findings from both the traffic operations and geometric Component Analyses. The transportation elements included in each alternative are described below.

4.1.1. High-Level Fixed Bridge (High-Level)

The High-Level Bridge Alternative is shown on Figure 33, and would have the following features.

- Fixed bridge with approximately 150-foot clearance above the Ship Canal. Bridge would have four vehicle lanes (two lanes in each direction).
- Elevated signalized ramp intersection connecting from bridge deck at NW 52nd St to 14th Ave NW. The ramp would have two westbound-to-southbound left turn lanes, and a northbound-to-eastbound right turn/deceleration lane. No turns would be allowed to or from the north due to space limitations.
- Modified Single-Point Urban Interchange (SPUI) at the W Nickerson St/W Emerson St/15th Ave W intersection.
- A 14-foot wide shared-use path on west side of the bridge. This would connect to grade at the north end at approximately NW 54th St. A pedestrian/bicycle crossing would be provided at the elevated intersection above NW 52nd St with a connection to 14th Ave NW via the ramp. At the south end, connections to the Ship Canal and Interbay Trails would be made through the SPUI and W Emerson St.

Figure 33. High-Level Fixed Bridge Alternative



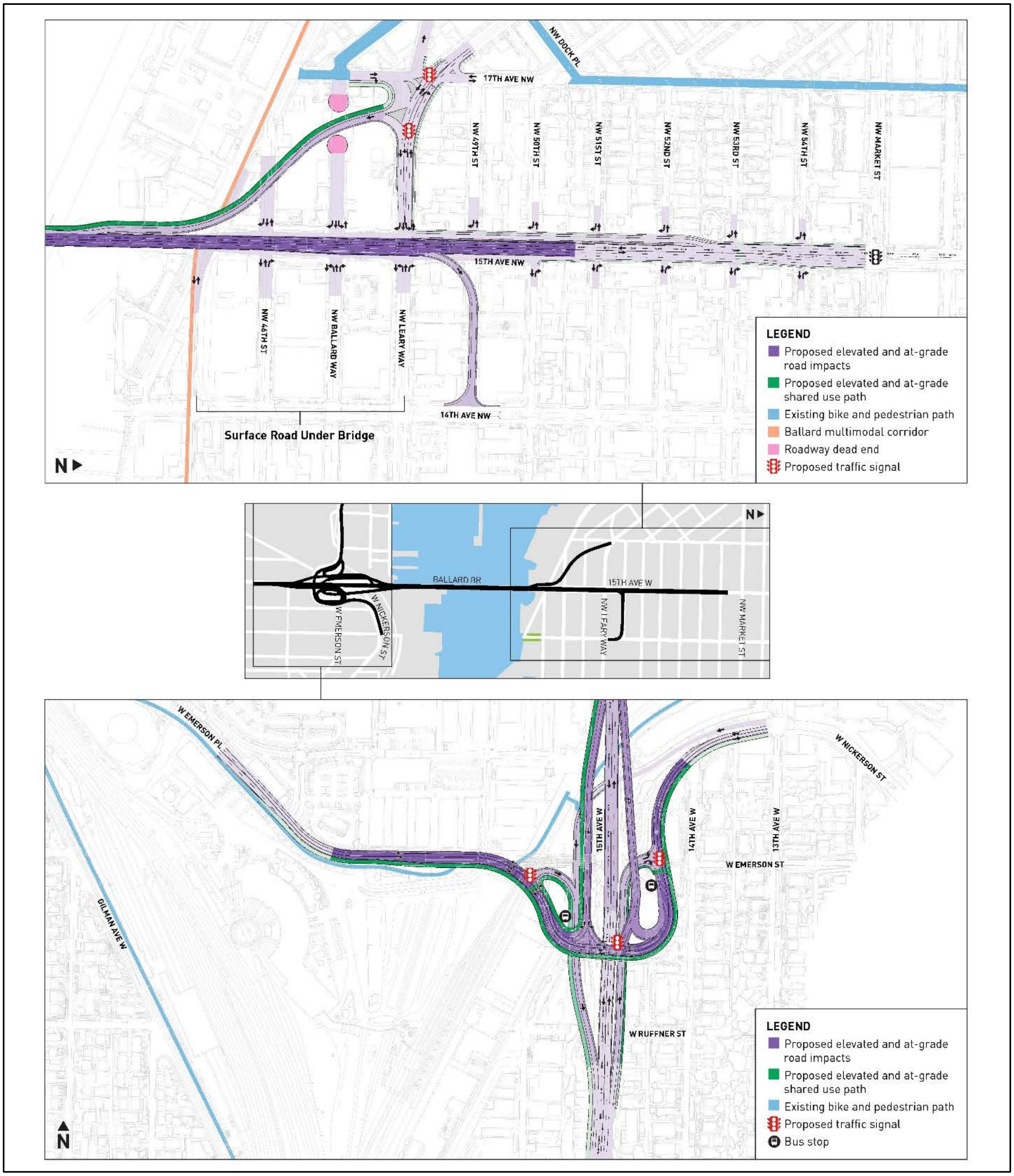
Source: SDOT, October 2019.

4.1.2. Mid-Level Moveable Bridge (Mid-Level)

The Mid-Level Bridge Alternative is shown on Figure 34, and would have the following features.

- Bascule bridge with 60 to 70-foot clearance above the Ship Canal. Bridge would have five vehicle lanes (two in each direction plus a southbound auxiliary lane between the NW Leary Way on-ramp and the Emerson-Nickerson Street off-ramp).
- Northbound off-ramp that would exit the bridge north of NW Leary Way and connect to 14th Ave NW at NW 49th St with a T-intersection.
- Southbound on-ramp that would begin near the intersection of NW Leary Way and 17th Ave NW and connect to the bridge south of Shilshole Ave NW.
- Modified SPUI at the W Nickerson St/W Emerson St/15th Ave W intersection.
- A 14-foot wide shared-use path on west side of the bridge. At the north end, this would connect to the street grid along the edge of the southbound on-ramp. At the south end, connections to the Ship Canal and Interbay Trails would be made through the SPUI and W Emerson St.

Figure 34. Mid-Level Moveable Bridge Alternative



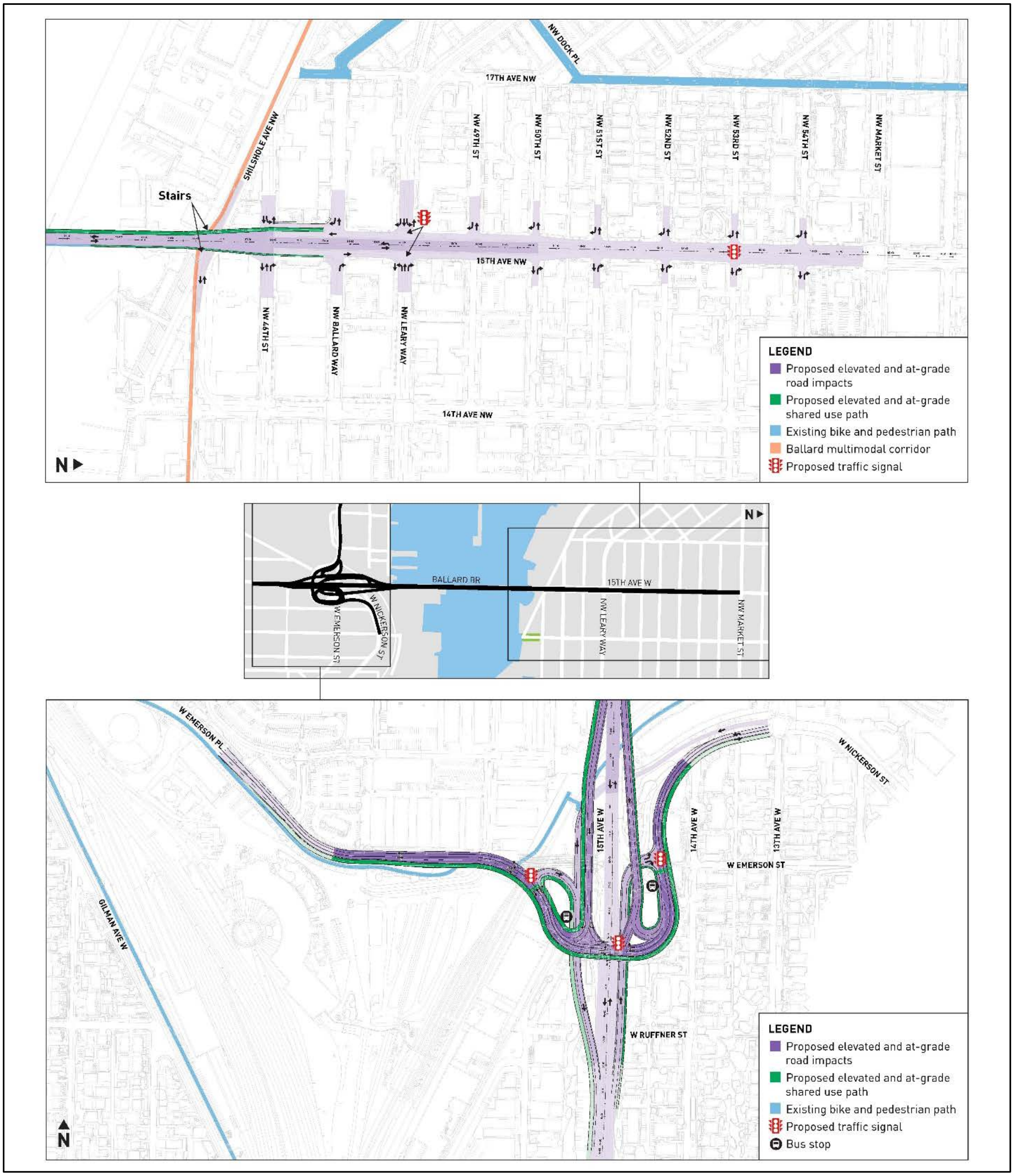
Source: SDOT, October 2019.

4.1.3. Low-Level Bridge Rehabilitation (Low-Level)

The Low-Level Bridge Alternative is shown on Figure 34, and would retrofit and rehabilitate the existing bascule bridge and approach structures with the following features.

- Retain existing bascule bridge with 44-foot clearance above the Ship Canal. Bridge would have four vehicle lanes (two in each direction).
- Retain existing on and off-ramps at the north end of the bridge in their current configuration with connections to NW Ballard Way and NW Leary Way.
- Replace existing interchange at the W Nickerson St/W Emerson St/15th Ave W intersection with a Modified SPUI.
- Add a 14-foot wide shared-use path on the west side of the bridge. At the north end, the path would connect to the NW Ballard Way along the west side of the on-ramp. At the south end, connections to the Ship Canal and Interbay Trails would be made through the SPUI and W Emerson St.
- Widen the existing sidewalk on the east side of the bridge's approach spans to match the existing bascule span width of 6-ft.

Figure 35. Low-Level Bridge Rehabilitation Alternative



Source: SDOT, October 2019.

4.2 Traffic Operations Analysis

4.2.1. Intersection Level of Service

Level of service analysis for all three alternatives was conducted for PM peak hour conditions in year 2040. All analyses were performed using the Synchro 10.3 traffic operations analysis software. The level of service for the key junctions are shown on Figures 37. Levels of service for the existing and Year 2040 No Build conditions were previously shown on Figure 16. Detailed results are provided in Attachment 1.

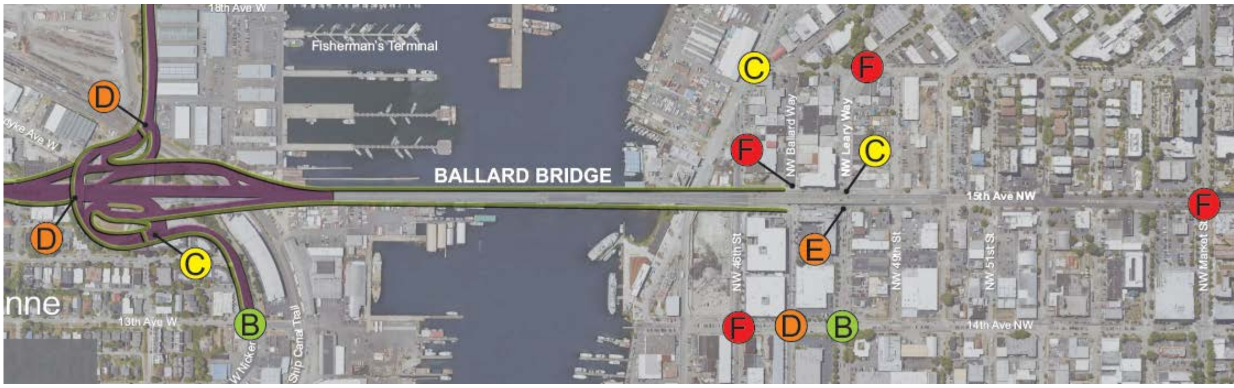
The Low-Level Bridge Alternative would have the same traffic operations at its north side intersections as the No Build Condition; however, operations of the Modified SPUI would be substantially improved from LOS E/F to LOS D or better at the three interchange intersections.

The Mid-Level Bridge Alternative would have the same operations at the Modified SPUI as the Low-Level Bridge but improved operations at the NW Leary Way ramp intersection north of the bridge. Some congestion could remain along 14th Ave NW at the intersections with NW Leary Way, NW Ballard Way and NW 46th St.

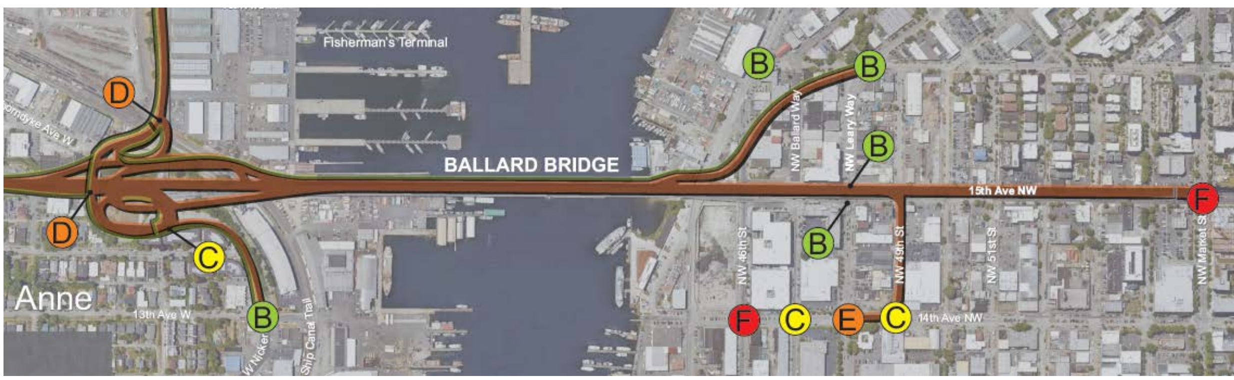
The High-Level Bridge Alternative would have the same operations at the Modified SPUI as the Low-Level Bridge. The elevated ramp intersection at 15th Ave NW is expected to operate at LOS E. Some congestion could remain along 14th Ave NW at the intersections with NW Leary Way, NW Ballard Way, and NW 46th St. It is noted that for all alternatives, including the No Build Alternative, the intersection at NW Market St/15th Ave NW is expected to operate at LOS F.

Figure 36. Existing and 2040 No Build Intersection Level of Service – PM Peak Hour

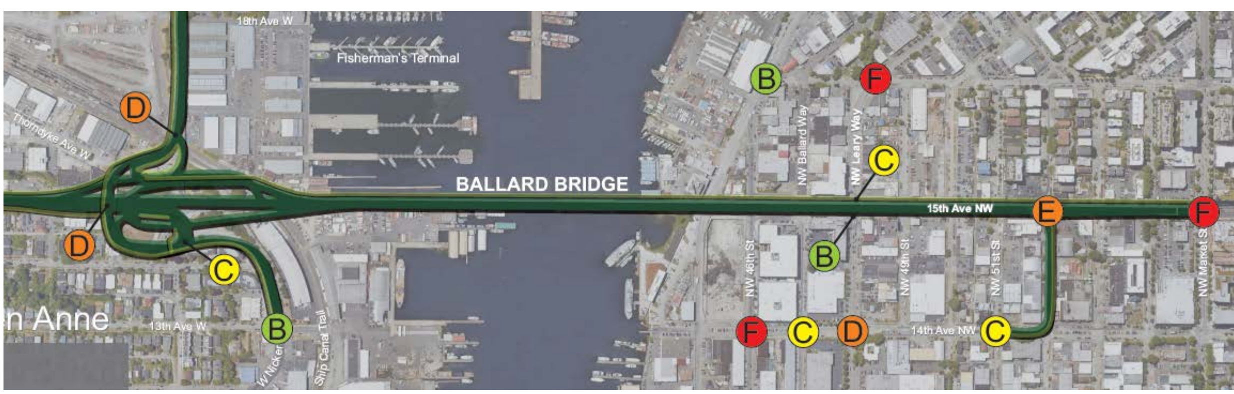
Year 2040 with Low-Level Bridge Alternative



Year 2040 with Mid-Level Bridge Alternative



Year 2040 with High-Level Bridge Alternative



Source: Heffron Transportation, Inc., November 2019.

4.2.2. Travel Times

The level of service analysis for individual intersections, presented in the section above, shows how the Ballard Bridge ramp connections would operate with each of the alternatives. However, it does not convey how much extra time it may take to travel through the corridor given that some of the alternatives would change the location of the ramps and the distance traveled to reach them.

Travel time analysis was performed using SimTraffic, a micro-simulation program. Six major travel routes that cross the Ballard Bridge or through the Nickerson/Emerson St interchange, listed below, were evaluated during the PM peak hour, which reflects the worst-case condition for travel in the corridor.

Route A: Through Traffic on 15th Ave W/NW – Measured between W Dravus St and north of NW Market St

Route B: Fremont to NW Market St – Measured from W Nickerson St/13th Ave W to north of 15th Ave NW/NW Market St

Route C: Fishermen's Terminal to NW Market St – Measured from W Emerson St/19th Ave W to north of 15th Ave NW/NW Market St

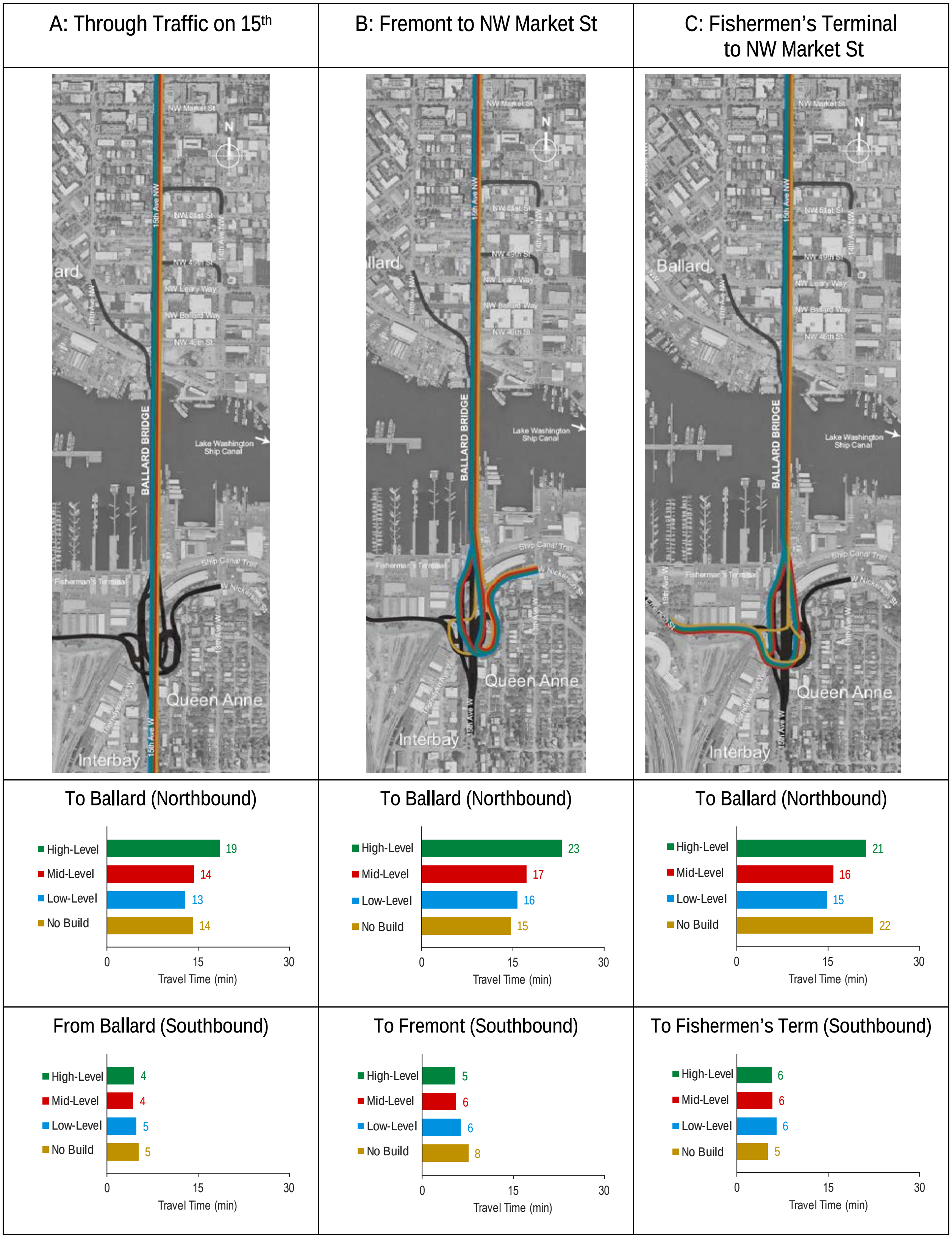
Route D: W Dravus St to Shilshole Ave NW – Measured between 15th Ave W/W Dravus St and NW Leary Way/14th Ave NW

Route E: W Dravus St to NW Leary Way – Measured between 15th Ave W/W Dravus St to east of NW Leary Way/14th Ave NW

Route F: Fremont to Fishermen's Terminal – Measured between W Nickerson St/13th Ave W and W Emerson St/19th Ave W

The results are shown on Figure 37. This shows that for the travel routes headed through to the NW Market St/15th Ave NW intersection, the Mid-Level Bridge would result in the best travel times. The High-Level Bridge would introduce a new signal on 15th Ave NW, and would require longer distance to reach those ramps.

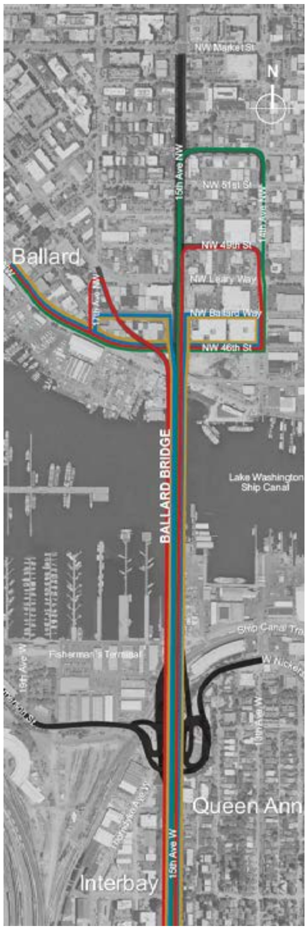
Figure 37. PM Peak Hour Travel Times for Various Routes - Year 2040 Conditions

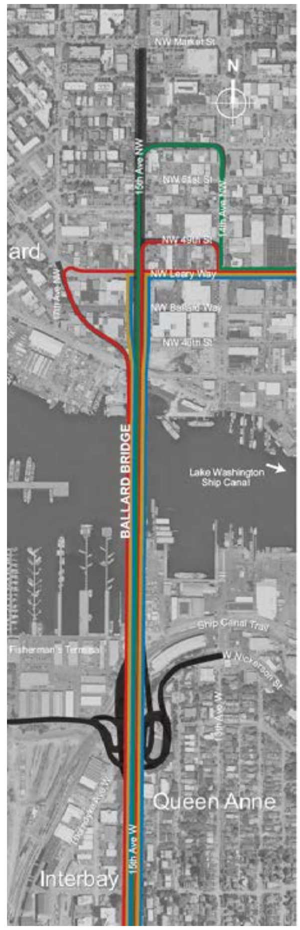


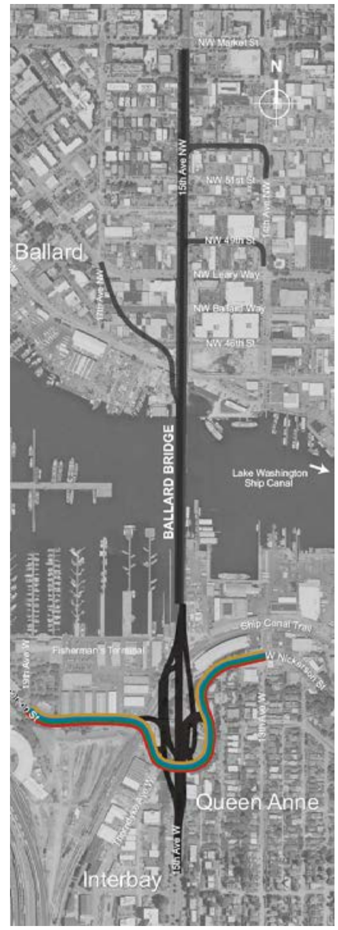
Source: Heffron Transportation, Inc., November 2019.

Figure 39 (Continued). PM Peak Hour Travel Times for Various Routes – Year 2040 Conditions

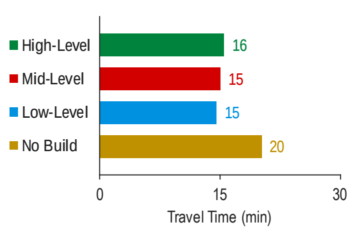
D: W Dravus St to Shilshole Ave NW	E: W Dravus St to NW Leary Way	F: Fremont to Fishermen's Terminal



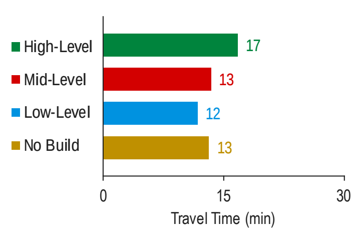




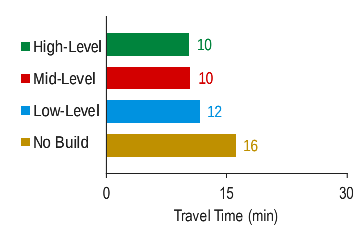
To Ballard (Northbound)



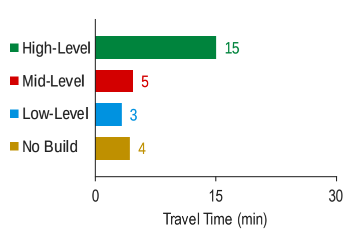
To Ballard (Northbound)



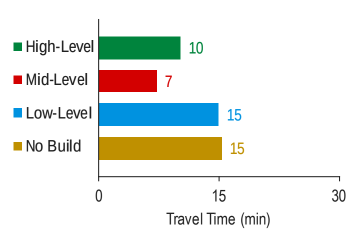
Westbound



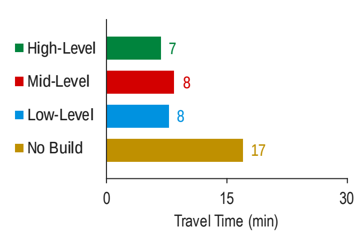
From Ballard (Southbound)



From Ballard (Southbound)



Eastbound



Source: Heffron Transportation, Inc., November 2019.

4.2.3. Bridge Opening Delay

The travel times described above reflect PM peak commute times when there are few, if any, openings of the Ballard Bridge for marine traffic. The cumulative daily delay caused by bridge openings was determined using the same methodology described in Section 2.5.2. The Mid-Level Bridge, with a clearance of at least 60 feet, is estimated to eliminate about 70% of the bridge openings. The cumulative vehicle delay for the Mid-Level Bridge would decrease from about 650 hours per day to below 200 hours per day during an average weekday in May, which is when bridge openings are most frequent. The average delay per vehicle would decrease from about 31 seconds per vehicle to 9 seconds per vehicle. The High-Level Bridge would eliminate bridge openings altogether.

Table 7. Vehicle Delay from Bridge Openings

Ballard Bridge Condition	# of Openings / Day	Cumulative Duration of Openings (Minutes/Day)	Daily Vehicles	Total Delay per Day (veh-hrs)	Ave Delay (sec/vehicle)
Existing	16	96.9	58,965	261	16.0
2040 with Low-Level Bridge	21 [a]	125.9	76,700 [b]	653	30.7
2040 with Mid-Level Bridge	6	37.8	76,700	196	9.2
2040 with High-Level Bridge	0	0.0	76,700	0	0.0

Source: Heffron Transportation, Inc., November 2019.

a. No data are available related to historic growth of vessels using the Ship Canal. To reflect a worst-case condition, vessel openings assumed to grow at 1.2% per year.

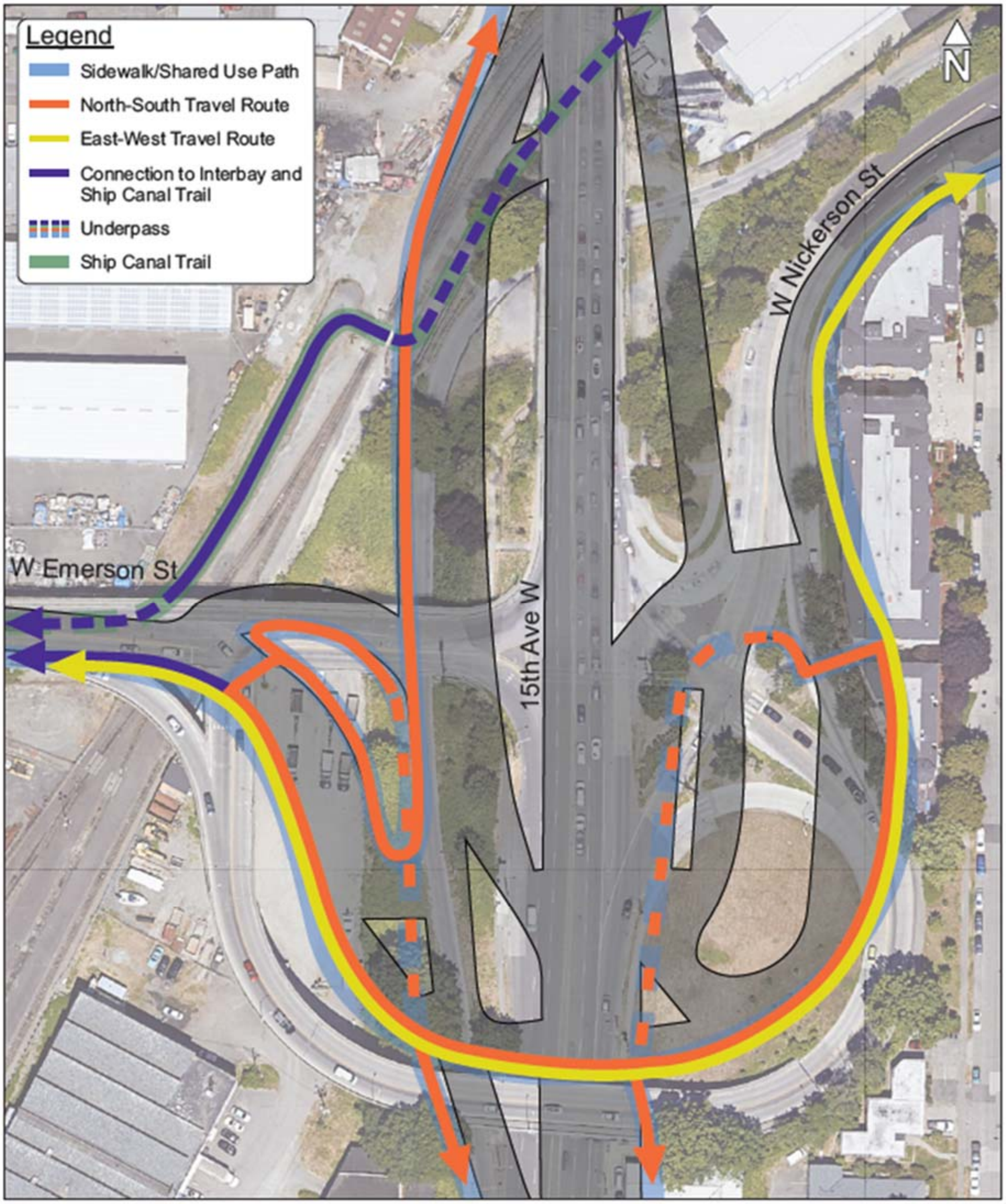
b. Future traffic volumes expected to increase by 1.2% per year (see Section 2.2.3)

4.3 Non-Motorized Facility Analysis

All of the alternatives would provide a 14-foot shared-use path on the west side of the bridge. Analysis performed as part of the Component Analysis determined that facility would operate at an acceptable level of service even if bicycle traffic increased to over 1,000 bike trips per day.

All three alternatives would have similar connections through the Modified SPUI at the south end of the bridge. The primary travel routes are shown on Figure 38. North-south travel on 15th Ave W would follow the west side of the ramp to W Nickerson St. Cyclists or pedestrians wanting to continue south could follow the on-ramp to rejoin 15th Ave W south of the SPUI. This movement would cross no vehicular movements and could be made without stopping. Connections to either the Interbay or Ship Canal Trail could be made by crossing W Emerson St at the proposed signalized ramp intersection. East-west travel from W Nickerson St to W Emerson St would be provided along the south side of the proposed Modified SPUI, a route that would cross no vehicular traffic. The Low-Level Bridge Alternative would retain the sidewalk on the east side of the bridge.

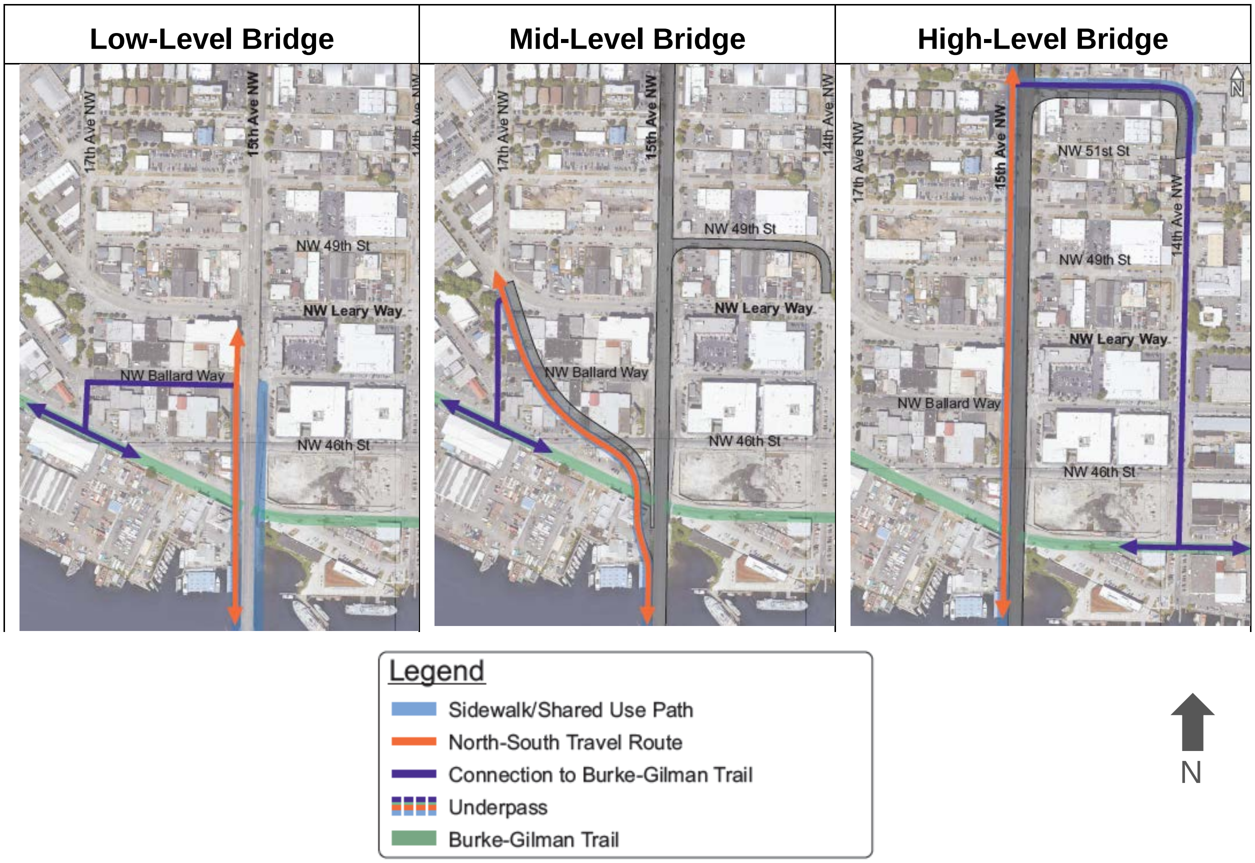
Figure 38. Bicycle and Pedestrian Travel Routes through Modified SPUI



Source: Heffron Transportation, November 2019. Note: Low-Level Bridge Alternative would retain sidewalk on east side of the Ballard Bridge.

Bike and pedestrian routes at the north end of the bridge would differ substantially depending on the alternative. The various routes to and from the bridge are shown on Figure 39. The Low-Level Bridge would have the same access routes that currently exist; the Mid-Level Bridge's access routes would be very similar to existing, but moved west towards 17th Ave NW. The High-Level Bridge, however, would require substantial out-of-direction travel for users destined south of NW Leary Way, including the Burke-Gilman Trail, and would have to cross 15th Ave NW as well as NW Leary Way and 14th Ave NW along that route.

Figure 39. Bicycle and Pedestrian Travel Routes on North End of Bridge



Source: Heffron Transportation, November 2019.

4.4 Transit Operations

King County Metro currently operates several bus routes on the 15th Ave W/NW corridor with stops at the W Emerson St/W Nickerson St intersection as well as on the NW Leary Way on- and off-ramps. In the future when Link Light Rail reaches Ballard, Metro is likely to revise its route structure to eliminate routes that duplicate the light rail service, and redeploy or truncate local routes so that they connect to the light rail station. The potential changes are not yet known, and would not likely be programmed until closer to light rail completion (currently planned for 2035). A preliminary assessment of transit operations for each of the bridge alternatives was performed in coordination with King County Metro. It evaluates the potential for each alternative to accommodate both local and through service. The findings are summarized below.

- Low-Level Bridge – This alternative would retain existing transit service and stops. It is conducive to serving through routes on 15th Ave W/NW with in-line stops south and north of the bridge. East-west transit on NW Leary Way would retain stops in close proximity to 15th Ave W to facilitate transfers. The Modified SPUI on the south end of the bridge would create improved operations for east-west transit between Fremont and Magnolia.

- Mid-Level Bridge – This alternative could accommodate in-line stops south of the bridge near the Modified SPUI, but the stops on the ramps north of the bridge would no longer serve routes that need to continue further north on 15th Ave NW. Routes that exit the bridge and use NW Leary Way could be served. The ramp configuration would allow routes to connect between the bridge and the potential light rail stations proposed near 14th Ave NW. The Modified SPUI on the south end of the bridge would create improved operations for east-west transit between Fremont and Magnolia.

- High-Level Bridge – This alternative could retain in-line stops south of the bridge near the Modified SPUI, but would eliminate the ability to provide in-line stops north of the bridge due to the elevation difference to the bridge deck. The single ramp that serves on- and off- traffic could be used by routes on NW Leary Way, but would likely increase travel times, particularly for southbound buses. The Modified SPUI on the south end of the bridge would create improved operations for east-west transit between Fremont and Magnolia.

4.5 Freight Analysis

All of the options are designed to a maximum 5% grade on the bridge mainline and access ramps with turning radii to accommodate WB-67 trucks. The mainline of 15th Ave W/NW, which is a designated over-dimension freight route, would also be designed to accommodate oversize vehicle loads (20-foot by 20-foot clearance). The Modified SPUI at the south end of the bridge, which would be a part of all alternatives, would substantially improve truck movements by reducing congestion compared to the existing intersection configurations. The Modified SPUI could also be designed to better accommodate large truck turning radii as well as over-dimension freight as desired by the Freight Master Plan. However, there are some differences in how each of the alternatives would serve freight on the corridor, which are described below.

- Low-Level Bridge – This alternative would retain the 44-foot clearance for the bascule bridge. This alternative would have the highest number of bridge openings. No changes in the overhead or lateral clearances would be made north of the bridge.

- Mid-Level Bridge – This alternative would raise the bascule bridge height to 60 to 70 feet, reducing the number of openings for marine traffic. The higher bridge deck would allow increased vertical clearances above several east-west roadways north of the bridge. The configuration of the new southbound on-ramp/NW Leary Way/17th Ave NW intersection may require that 17th Ave NW be converted to one-way northbound with the companion southbound roadway located under the bridge deck in the 15th Ave NW right-of-way. The northbound off-ramp would connect to 14th Ave NW, and that street would need to be designated and upgraded to a truck street between the off-ramp and NW 46th St.

- High-Level Bridge – This alternative would eliminate marine openings of the bridge. However, the longer grades may slow trucks on their ascent over the bridge. The elevated signalized intersection would also increase travel time and delay for trucks, particularly those destined southbound. The new ramp would connect to 14th Ave NW, and that street would need to be designated and upgraded to a truck street between the off-ramp and NW 46th St. The higher bridge deck would allow increased vertical clearances above several east-west roadways north of the bridge.

4.6 Evaluation Criteria and Ratings

The transportation functions of the Ballard Bridge are captured by several criteria related to the mobility for each mode of travel, including marine navigation, as well as connectivity between different neighborhoods served by the bridge. The three alternatives were rated against these criteria relative to the No Build condition using the following rating nomenclature:

●	◕	◑	◔	○
Best	Better	OK or No Change	Worse	Worst

Bascule Opening Delays – The frequency and duration of bridge openings affects all modes of transportation that travel over the bridge, as well as vessels on the Ship Canal that require a bridge opening. Bridge openings would be most frequent and of longest duration for the low-level bridge, and would decrease with increased bridge deck clearance. The high-level option would have no bridge openings.

Alternative	Rating*	Notes
Low Level	◑	Existing bascule bridge would remain. Frequency and duration of openings would be highest of all alternatives.
Mid Level	◕	Raises bascule bridge, which would reduce frequency and duration of openings compared to existing bridge.
High Level	●	Fixed bridge would have no openings for marine traffic.

**- Rating scale relative to No Build conditions*

Vehicular/Truck Access – The alternatives have different ramp configurations at the north end of the bridge that could affect connections to industrial businesses along the Ship Canal and/or traffic served by NW Leary Way. The low-level option retains the existing grid connections; the mid-level option would have longer one-way ramps that connect to the grid further away from 15th Ave NW; the high-level bridge would have an elevated signalized intersection on 15th Ave NW with a two-way ramp that connects to NW Leary Way at 14th Ave NW. All alternatives propose the same reconfiguration of the W Emerson St/W Nickerson St/15th Ave W interchange on the south side of the bridge. The rating measures the quality of each connection in terms of vehicular delay and travel time.

Alternative	Rating	Notes
Low Level	◕	No change in ramp configuration at the north end of bridge, but substantial improvement with the Modified SPUI at the south end of the bridge.
Mid Level	●	Improvements in operation at north end of the bridge plus substantial improvement with the Modified SPUI at the south end of the bridge.
High Level	◔	Introduces new signal on 15th Ave NW at north ramp junction and would increase congestion on 14th Ave NW. Substantial improvement with the Modified SPUI at the south end of the bridge.

*- *Rating scale relative to No Build conditions*

Bike and Pedestrian Connections – All alternatives would improve the non-motorized access across the bridge by providing a 14-foot shared-use path. The alternatives have different means of connecting to the Burke-Gilman Trail and Ship Canal Trail. The alternatives also have different profiles on the bridge deck that could affect expected energy expenditure by a cyclist. The rating measures the quality of the trail connections and effect of mainline grade.

Alternative	Rating	Notes
Low Level	●	Adds 14-foot path to west side of bridge and retains existing sidewalk on east side of bridge; improves connections at south end of bridge.
Mid Level	◕	Adds 14-foot path to west side of bridge; improves connections at south end of bridge.
High Level	◑	Adds 14-foot path to west side of bridge; improves connections at south end of bridge. Has steepest and longest uphill and downhill bridge segments that could affect climbing as well as the increase the differential in speed between bikes and peds on the bridge.

*- *Rating scale relative to No Build conditions.*

Freight – All of the options are designed to a maximum 5% grade on the bridge mainline with turning radii to accommodate WB-67 trucks. All new structures on the mainline would also be designed to accommodate oversize vehicle loads (20-foot by 20-foot clearance). However, some of the alternatives may also increase over-dimension clearance for roads that pass under the 15th Ave W/NW mainline north and south of the bridge. The rating reflects these additional freight attributes.

Alternative	Rating	Notes
Low Level	◕	No change in ramp configuration at the north end of bridge, but substantial improvement with the Modified SPUI at the south end of the bridge with ability to improve clearance for over-dimension freight.
Mid Level	●	Improvements in operation at north end of the bridge plus substantial improvement with the Modified SPUI at the south end of the bridge. Ability to improve clearance for over-dimension freight north and south of the bridge.
High Level	◕	Eliminates bascule openings of bridge during midday hours. Introduces new signal on 15th Ave NW at north ramp junction and would increase congestion on 14th Ave W. Substantial improvement with the Modified SPUI at the south end of the bridge. Ability to improve clearance for over-dimension freight north and south of the bridge.

**- Rating scale relative to No Build conditions*

Transit – The changes in the 15th Ave W/NW interchange configuration at both NW Leary Way and W Emerson St/W Nickerson St could affect transit routing and/or stop locations. The rating reflects the potential impact to transit routing and stops.

Alternative	Rating	Notes
Low Level	◕	No change in ability to provide stops for through transit on 15th Ave W/NW corridor; Modified SPUI at the south end of the bridge could allow transit connections between Fremont and Magnolia.
Mid Level	◔	Eliminates ability to provide stops for through transit on 15th Ave NW north of the bridge; could serve local routes on NW Leary Way; Modified SPUI at the south end of the bridge could allow transit connections between Fremont and Magnolia.
High Level	○	Eliminates ability to provide stops for through transit on 15th Ave W north of the bridge, and would be challenging for local transit service connecting between 15th Ave NW and NW Leary Way. Modified SPUI at the south end of the bridge could allow transit connections between Fremont and Magnolia.

**- Rating scale relative to No Build conditions*

5. Summary

The transportation analysis determined that all three bridge alternatives would improve transportation conditions compared to no improvement of the bridge. The Low-Level Bridge retrofit options would substantially improve non-motorized access across the bridge. The Modified SPUI at the 15th Ave W/W Emerson St/W Nickerson St intersection would substantially improve vehicular traffic operations, freight mobility, as well as bicycle and pedestrian connections to and from the Interbay and Ship Canal Trails and for those who cross 15th Ave W.

Both the Mid and High-Level Bridge would offer the same benefits with a new shared-use path on the west side of the bridge and improve transportation functions at the Modified SPUI. The Mid-Level Bridge would reduce the frequency of bridge openings and the High-Level Bridge would eliminate bridge openings. At the north end of the bridge, the ramp junctions paired with the Mid-Level Bridge would provide the best operations for vehicular traffic and bicycle/pedestrian connections. The High-Level Bridge would introduce a new elevated intersection to the 15th Ave W/NW corridor, and its single-ramp system would concentrate traffic at the NW Leary Way/14th Ave NW intersection, increasing congestion near that junction compared to the other alternatives.

5.1 Future Design Considerations

The transportation analysis performed for the Ballard Bridge Planning Study was based on conceptual designs. The study identified several elements where future enhancements, design refinements, or additional analysis should be considered in future studies. These are summarized below.

Low-Level Bridge Alternative

- **NW Leary Way/15th Ave NW ramps intersection** – This study assumed no changes to the existing configuration or traffic control at the NW Leary Way/15th Ave NW ramps intersection. However, operations at this intersection could be improved by providing a left turn lane on NW Leary Way to the southbound on-ramp. There appears to be space to provide this lane within the existing curb-to-curb width. Further design analysis (including assessment of the overhead clearance) would be needed to determine if this is possible.
- **Shared-Use Path Connection to NW Ballard Way –** The existing sidewalk connection to and across Ballard Way could be improved by eliminating the ability to drive southbound from the 15th Ave NW southbound ramp to the southbound frontage road across the pedestrian and bicycle route. Access to the frontage road could be relocated further west and allow only right-turn access from NW Ballard Way. This would likely require additional property acquisition. Further design analysis would be needed to determine the optimal configuration.
- **Maintenance of Traffic during construction of Modified SPUI –** Further analysis would be needed to determine how the Modified SPUI could be constructed while retaining through traffic on 15th Ave W as well as all connections to W Nickerson St and W Emerson St.

Mid-Level Bridge Alternative

- **Maintenance of Traffic during construction of replacement bridge –** The existing Ballard Bridge cannot continue to operate while this alternative is being constructed, and alternative crossings at the Fremont and Aurora Bridge do not have enough capacity to accommodate diverted traffic. Therefore, a temporary bridge and detour route would be needed to serve traffic that crosses the Ship Canal. Extensive traffic and design analysis would be needed to determine the optimal configuration and location of a temporary crossing, including the number of lanes and traffic control where the detour route meets the existing arterial network.

- **17th Ave NW/NW Leary Way/Southbound On-Ramp** – The Component Analysis for this intersection noted that 17th Ave NW may not be wide enough to accommodate two-way vehicular traffic (including the large-radius turns for trucks from northbound onto the bridge ramp) as well as a shared-use path. If needed, 17th Ave NW could be converted to a one-way northbound street to provide access to the mid-level on-ramp. The companion southbound movements could be relocated under the bridge along 15th Ave NW where the added bridge height would allow a new road to be located under the bridge. Further design would be needed to assess geometric needs.

High-Level Bridge Alternative

- **Maintenance of Traffic during construction of replacement bridge –** Most of the High-Level Bridge could be constructed above the existing Ballard Bridge, while maintaining clearance to open the bridge for marine traffic. However, construction of portions of the bridge approaches would require closure of lanes on the 15th Ave W mainline. In addition, construction of the Modified SPUI could affect connections to W Nickerson St and W Emerson St. Further work related to construction phasing and maintenance of traffic would be needed for this alternative.

- **14th Ave NW improvements at NW Leary Way, NW Ballard Way and NW 46th St –** This alternative would concentrate traffic onto the 14th Ave NW corridor, and would also allow NW Ballard Way to be connected under the bridge. These changes are expected to increase vehicle traffic on 14th Ave NW through these intersections, and require changes to the lane geometry as well as traffic control. The current configuration of 14th Ave NW, with angled parking in the center of the street, should be evaluated.

ATTACHMENT 1
INTERSECTION LEVEL OF SERVICE

Levels of service (LOS) are qualitative descriptions of traffic operating conditions. These levels of service are designated with letters ranging from LOS A, which is indicative of good operating conditions with little or no delay, to LOS F, which is indicative of stop-and-go conditions with frequent and lengthy delays. Levels of service for this analysis were developed using procedures presented in the *Highway Capacity Manual, Sixth Edition* (Transportation Research Board, 2016).

Levels of service for the study area intersections were determined using the *Synchro 10.3* analysis software and reported using the *Synchro* module for signalized intersections and the *HCM 6* module for unsignalized intersections, unless otherwise noted.

Level of Service Summary Table

Intersections	PM Peak Hour										AM Peak Hour			
	Existing (2019)		2040 No Build		Low Level Build		Mid Level Build		High Level Build		Existing (2019)		2040 No Build	
Signalized	LOS [1]	Delay [2]	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS [1]	Delay [2]	LOS	Delay
15th Ave NW / NW Market St	E	65.3	F	104.4	F	104.4	F	104.4	F	111.4	D	50.2	F	97.1
15th Ave NW (NB Ramps) / NW Leary Way	C	29.8	E	62.0	E	62.0	B	17.7	B	13.8	B	19.6	C	25.2
15th Ave NW (SB Ramps) / NW Leary Way	B	13.9	C	23.6	C	23.6	B	14.9	C	22.6	B	13.8	C	30.1
14th Ave NW / NW Leary Way	B	10.5	B	14.6	B	14.6	E	59.0	D	36.3	B	13.0	B	14.5
13th Ave W / W Nickerson St	B	10.4	B	14.0	B	13.2	B	13.1	B	13.3	A	8.9	B	12.5
17th Ave NW / Shilshole Ave NW	*TWSC*		C	25.5	C	25.5	B	19.1	B	18.9	*TWSC*		B	11.0
W Nickerson St / 15th Ave W NB Off Ramp	*AWSC*		*AWSC*		C	25.8	C	26.3	C	26.5	*AWSC*		*AWSC*	
Modified SPUI Centerpoint Intersection	*No Intersection*		*No Intersection*		D	54.3	D	54.3	D	54.5	*No Intersection*		*No Intersection*	
W Emerson St / 15th Ave W SB On Ramp	*AWSC*		*AWSC*		D	49.6	D	49.5	D	49.6	*AWSC*		*AWSC*	
15th Ave NW SB On Ramp / NW Leary Way	*No Intersection*		*No Intersection*		*No Intersection*		B	12.4	*No Intersection*		*No Intersection*		*No Intersection*	
14th Ave NW / 15th Ave NW NB Off Ramp	*No Intersection*		*No Intersection*		*No Intersection*		C	28.5	*No Intersection*		*No Intersection*		*No Intersection*	
15th Ave NW (Elevated Intersection)	*No Intersection*		*No Intersection*		*No Intersection*		*No Intersection*		E	70.3	*No Intersection*		*No Intersection*	
14th Ave NW / 15th Ave NW Ramps	*No Intersection*		*No Intersection*		*No Intersection*		*No Intersection*		C	28.0	*No Intersection*		*No Intersection*	
14th Ave NW / NW Ballard Way	*AWSC*		*AWSC*		*AWSC*		*AWSC*		C	21.7	*AWSC*		*AWSC*	
All-Way-Stop Controlled (AWSC)	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
14th Ave NW / NW Ballard Way	B	14.2	D	26.2	D	26.2	C	15.3	*Signalized*		B	11.6	C	16.8
14th Ave NW / NW 46th St	D	29.2	F	101.9	F	101.9	F	101.9	F	85.2	C	18.6	F	57.6
W Nickerson St / W Emerson St [3]	C	15.1	E	37.1	Reconfigured and signalized (See Above)						B	12.6	C	18.9
15th Ave W / W Nickerson St	E	43.1	F	108.5	Reconfigured and signalized (See Above)						C	23.3	F	72.6
Two-Way-Stop Controlled (TWSC)	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
17th Ave NW / NW Leary Way [3]	A	3.4	A	9.4	A	9.4	A	2.9	C	20.3	A	2.6	A	4.9
Northbound Movements	C	19.8	D	29.2	D	29.2	C	23.1	E	41.1	E	38.5	F	91.4
Eastbound Left-Turn	A	0.1	A	0.1	A	0.1	A	0.1	A	0.1	A	0.1	A	0.1
Westbound Left Turn	A	1.3	A	2.2	A	2.2	-		A	1.9	A	1.4	A	2.5
Southbound Movements	F	55.6	F	215.1	F	215.1	F	56.0	F	79.2	D	28.9	F	71.5
15th Ave NW (SB Ramps) / NW Ballard Way	C	21.3	F	102.7	F	102.7	*Reconfigured*		*Reconfigured*		F	53.1	F	194.5
Northbound Left Turn	-		-		-		Not Reported		Not Reported		-		-	
Eastbound Movements	F	50.5	F	245.0	F	245.0					F	129.3	F	474.6
Westbound Movements	-		-		-						-		-	
Southbound Left Turn	-		-		-						-		-	
17th Ave NW / Shilshole Ave NW	A	2.8	*See Above*		*See Above*		*See Above*		*See Above*		A	3.1	*See Above*	
Northbound Movements	-		Signalized		Signalized		Signalized		Signalized		-		Signalized	
Eastbound Left-Turn	B	10.8									A	8.8		
Westbound Left Turn	-										-			
Southbound Movements	E	36.5									E	35.4		

Levels of service were determined using methodologies established in the *Highway Capacity Manual (HCM), 6th Edition*. Levels of service for the study area intersections were determined using the *Synchro 10.3* analysis software and reported using the *Synchro* module for signalized intersections and the *HCM 6* module for unsignalized intersections, unless otherwise noted. Only PM peak hour analysis was performed for the Build Alternatives since it reflected the worst-case condition.

Source: Heffron Transportation, Inc., March 2020.

1. *LOS = Level of service.*
2. *Delay = Average seconds of delay per vehicle.*
3. *Determined using the Synchro module due to intersection geometry and channelization incompatibility with HCM 6th Edition calculations*

Appendix B

Geometric Analysis of Components

Seattle Department of Transportation

COWI

SCJ Alliance
Consulting Services

Technical Memorandum

To	Wes Ducey, SDOT Project Manager Paul Guenther, COWI Project Manager
From	Lisa Reid, PE, PMP/SCJ Alliance Susann Babaei, PE/ SCJ Alliance
Date	August 07, 2020
Project	Ballard Bridge Planning Study
Subject	Task 5.3 Geometric Analysis of Components

The Ballard Bridge, on the 15th Ave W/NW corridor, is a major north-south corridor in the City of Seattle (the City), and one of six vehicular connections across the Lake Washington Ship Canal. The purpose of the Ballard Bridge Planning Study is to explore bridge rehabilitation and replacement options, the associated costs and trade-offs of each option. The goal is to develop cost-effective schemes that are embraced by the City and the community, and minimize the impacts associated with implementation.

Many potential alternatives and their connection configurations are being considered to replace or rehabilitate the existing Ballard Bridge crossing over the Ship Canal. Because it is not feasible within the study budget or schedule to evaluate all of these potential combinations of bridge height and connection configurations, the project team has performed a “Component Analysis” to first determine if each is feasible, and, if so, to determine the optimal configuration needed to provide acceptable traffic operations and pedestrian/bicycle connectivity. The most promising components were then packaged into larger alternatives and carried forward into further mobility, connectivity, and structural analysis.

Preliminary analysis of the Ship Canal crossing determined that a bridge would be required. A tunnel, like the one proposed by Sound Transit for the Ballard to West Seattle Link Light Rail Extension, was also considered to transport vehicles under the Canal. A tunnel component for this project would have many challenges that differentiate it from the Sound Transit tunnel, which is not confined to any roadway alignment as they are still siting their station facilities. However, a 15th Ave NW tunnel would have to be aligned with the roadway at both ends and would have to “daylight” on both ends with adequate room to tie into NW Market St and W Nickerson St/W Emerson St. This is very challenging in profile design and space is not available, especially on the north side to launch a tunnel boring machine (TBM).

The profile would be limited to maximum grades of 5% and could not physically connect to NW Ballard Way and NW Leary Ave. The lack of a connection at NW Ballard Way and NW Leary Way is not acceptable from a traffic operations perspective and would significantly limit freight connections in the corridor.

Finally, a long tunnel component would not provide safe pedestrian and bicycle connections and would not be designed to accommodate either. An alternate route over the Ship Canal would be required for bicycles and pedestrians.

Therefore, because of construction constraints (no place to launch a TBM), connectivity disconnects (Ballard and Leary), and the lack of bicycle and pedestrian facilities, the tunnel component was considered not feasible. The bridge option was advanced into the component analysis.

1. Introduction to Component Analysis

A suite of components (or sub-options for discrete segments of the crossing options) were identified for feasibility analysis prior to combining feasible components into alternatives. These components were arranged into three groups based on location and function, including:

A. **Ship Canal Components.** Three different components were evaluated for the bridge crossing over the Ship Canal. These include a low-level component, which would rehabilitate the existing bridge without requiring modification to the north side or south side connections; a mid-level component, which would construct a new, higher bascule bridge that would reduce the frequency of openings for marine traffic; and a high-level component, which would construct an even higher fixed bridge that would eliminate openings for marine traffic. Section 2 describes and discusses the three bridge span components and two associated pedestrian and bicycle (ped/bike) components.
B. **North End Connection Components.** The northern end of the project currently has a ramp that provides essential freight, transit, and passenger vehicle connections to NW Leary Way and NW Ballard Way. The north end also provides essential bike and pedestrian connections. Section 3 describes and discusses components evaluated to replace these connections.
C. **South End Connection Components.** The southern end of the project currently has multiple ramps that provide vital connections to neighborhoods such as Fremont, Magnolia, and Interbay. Section 4 describes and discusses the components evaluated to replace these connections.

The following sections summarize the geometric feasibility analysis and findings by component group, making recommendations about which components and configurations would be viable for packaging into alternatives and moving forward in the next phase of analysis. For each component, a high-level graphic is provided, with a larger plan and relevant profiles included in the attachments. Components were tested for geometric feasibility looking at roadway horizontal layouts, including cross-section widths, turning radii, right-of-way impacts, freight and transit mobility, and ped/bike accessibility; and vertical profiles, including grades, sight distance, and required clearances. All components assume that the Ship Canal will remain in its existing location. A parallel memo summarizes the evaluation of the multi-modal operations feasibility of these same components. In some cases, preliminary results of the traffic operations analysis informed the design requirements, especially at intersection locations. If a component was found to be both operationally and geometrically feasible, it would be a viable component to include in alternatives for the following phase of analysis.

1.1. Design Parameters

The following parameters were used in the conceptual-level design of each component:

- Reference Codes
  - City of Seattle, *Streets Illustrated*
  - City of Seattle, *SDOT Design Standards for In-Street Bike Facilities*

- AASHTO, *A Policy on Geometric Design of Highways and Streets (7th Edition 2018)*
- FHWA, *Manual on Uniform Traffic Control Devices (MUTCD) (2009 with Revisions 1 and 2, May 2012)*

- SDOT Street Classifications
  - 15th Avenue W (Ballard Bridge) – Principal Arterial – Industrial Access
  - W Emerson Street – Principal Arterial – Industrial Access
  - W Nickerson Street – Principal Arterial – Urban Center Connector
  - NW Leary Way – Principal Arterial – Urban Village Main (West of 15th) and Industrial Access (East of 15th)
- Existing Posted Speeds
  - 15th Avenue W (Ballard Bridge) – 30 MPH
  - W Emerson Street – Unposted 30 MPH (per City code) with one 15 MPH advisory speed for a curve
  - W Nickerson Street – 30 MPH with 25 MPH advisory speeds for curves
  - NW Leary Way – 30 MPH
- Proposed Design Speeds
  - Ballard Bridge – 30 MPH
  - W Emerson Street – 30 MPH with 20 MPH advisory curve
  - W Nickerson Street – 30 MPH with 20 MPH advisory curve
  - NW Leary Way – 30 MPH
- Design Vehicles
  - WB67 truck
  - Bus 40 with 5’ front bike rack
- Stopping Sight Distance
  - Ballard Bridge – min 200’ on level terrain, and 215’ upgrade
  - W Emerson Street – min 200’ level terrain, and 215’ upgrade
  - W Nickerson Street – min 200’ level terrain, and 215’ upgrade
  - NW Leary Way – min 200’ level terrain, and 215’ upgrade
- Grades
  - Min 1%
  - Max 5% on arterials
  - Max 7% on ramps
- Marine Clearance over Waterway
  - Low-level – maintain existing
  - Mid-level – min 60’-70’ over navigational channel
  - High-level – min 140’-160’ over navigational channel
- Bridge Clearance over Roadways
  - Low-level – maintain existing
  - Mid-level and high-level – min 20’ between all roadways
- Bridge Clearance over Railway
  - 23.5’ over BNSF tracks
- Cross Slope
  - 2% normal crown (Urban Low Speed), max 4% super
- Travel Lane Widths

    - Inner Lane – 11’
    - Outer Lane – 12’
    - Turn Lane – 11’
    - Single-Lane Ramps – 16’
    - Double-Lane Ramps – 12’
- Shoulder Widths
    - Outside (multi-lane) – 2’
    - Ramp (outside) – 8’
    - Ramp (inside) – 4’
- Shared-Use Path Widths
    - Shared-Use Path – 10’ minimum, 14’ in areas of high pedestrian and bicycle volumes

1.2. Pedestrian and Bicycle Access

Improving ped/bike access is one of the primary goals of this project. The 15th Ave NW corridor at the Ballard Bridge is identified as part of the Citywide Bicycle Network in the City of Seattle’s *2014 Bicycle Master Plan*. This could connect the Ship Canal Trail to the Burke Gilman Trail; however, the road does not currently provide this connection. In addition, the existing infrastructure does not meet current City or ADA standards. There are no dedicated bicycle facilities on 15th Ave NW between NW Market St and the W Emerson St/W Nickerson St interchange. Rather, bicyclists must use the sidewalks or ride in the traffic lanes to cross the Ballard Bridge, often choosing to walk their bikes along narrow sections of sidewalk for safety.

Existing sidewalks extend along both sides of 15th Ave NW from NW Market St to NW Ballard Way, coming up the on- and off-ramps at NW Ballard Way and continuing south across the Ballard Bridge to the W Emerson St/W Nickerson St interchange. The sidewalks on the bascule portion of the bridge are 6’ wide, and narrow to approximately 3.5’ wide at the external quadrants. For approximately 650’ of the bascule span, there is a handrail separating the sidewalk and the road. In all other locations, there is a concrete barrier separating the sidewalk from traffic. For most of the approach span, the sidewalks are 4’ wide, and narrow to 3.5’ at the current and former streetlight pilasters.

A previous study prepared for the City, the 2014 *Ballard Bridge Sidewalk Alternative Study,* evaluated improving pedestrian and bicyclist connections across the Ballard Bridge. This study evaluated 3 alternatives: increasing the sidewalk by 1’, increasing the sidewalk to 6’-10’ on either a single side or both sides, and installing a railing between the travel lanes and the existing sidewalks; none of the alternatives considered widening the sidewalk at the bascule section. The study also analyzed the feasibility of a connection from the Ballard Bridge to the Ship Canal Trail. All alternatives were deemed feasible, but a preferred alternative recommendation was not selected.

Considering the goals of this study, and noting the results of the 2014 study, two options were considered to improve ped/bike safety across the Ballard Bridge. The first would construct a shared-use path on the west side of 15th Ave NW, and the second would construct separate bike lanes and sidewalks on both sides. While the prior study’s options have been deemed not feasible, from the operational standpoint of providing a high-capacity facility and improving connections, this study focused on providing a single 14’ shared-use path. The shared-use path on the west side was selected for all evaluated components because it provides opportunities for better connectivity to the existing ped/bike network than the east side. The west side path provides for better connections to the Burke-Gilman Trail north of the bridge and the Ship Canal/Interbay Trail south of the bridge. Per SDOT design standards, the width of the shared-use path is 14’ for new construction and would be dependent on structural feasibility in the rehabilitation option evaluated in the *Structural and Constructability Feasibility Analysis of Components Memo*. If the 14’ path is viable, it would also provide higher capacity for bicyclists and pedestrians, with room for passing and two-way traffic, than narrower paths on each side of the bridge.

2. Ship Canal Components

Three bridge span components and a tunnel were considered for the 15th Ave NW bridge over the Ship Canal. The bridge components include:

- A low-level component, which would structurally rehabilitate the existing bridge and add shared-use ped/bike facilities;
- A mid-level component, which would replace the existing bridge with a new bascule that would provide 60’-70’ of clearance over the navigational marine channel, reducing the frequency of bridge openings; and
- A high-level component, which would replace the existing bridge with a fixed bridge that would provide 140’-160’ of clearance over the navigational marine channel, eliminating all bridge openings. For comparison, the existing bascule bridge provides approximately 44’ of clearance over the navigational marine channel.

2.1. Low-Level Rehabilitation

Description

The low-level rehabilitation component, shown in Figure 1 (and Attachments 1 and 2), would maintain the existing horizontal alignment, vertical alignment, and lane widths. It would also maintain the 44’ of clearance over the navigational marine channel and, therefore, would open at the same frequency it does today. As described in Section 1.2, it would include the addition of a shared-use path on the west side of the existing bridge, extending north to NW Ballard Way and south to the W Emerson St/W Nickerson St interchange, including a connection to the Ship Canal Trail. The north end would terminate at Ballard Way and the south end would terminate at the Ship Canal Trail. The existing bridge was evaluated to determine if a new shared-use path could be 14’ wide or if it would need to be reduced to 10’. The 14’ width was determined to be structurally feasible (with significant structural rehabilitation), therefore a 14’ path is included in the layouts. Unlike in the previous study, widening the sidewalk over the bascule is also included as part of this component.

This component would also bring the existing east side sidewalk on the approaches to the same width as the bascule span, providing more consistent widths for maneuverability, passing, and comfort.

The widening will also require the southbound 15th Ave NW frontage road to be widened, as the shared-use path will encroach into the existing road.

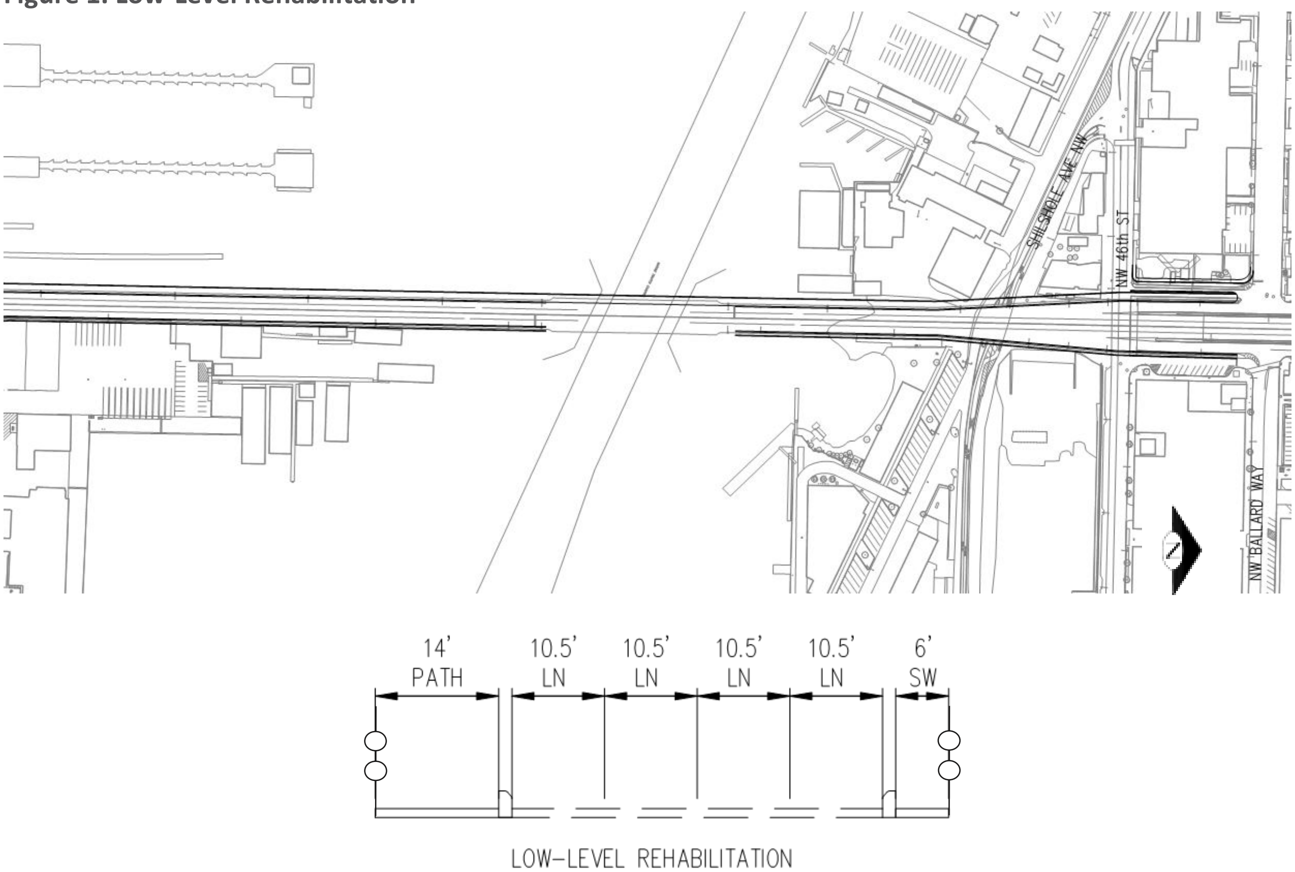
Evaluation

This component would improve the existing ped/bike crossing of the Ballard Bridge and would have no grade-related impacts on the crossing time. It would also improve regional ped/bike connectivity by including a connection to the Ship Canal Trail.

The existing City right-of-way aligns with the back of railing on the existing Ballard Bridge in the bascule section and approximately 0'-6' off of the railing in the rest of the bridge section, therefore, additional right-of-way would be required from the properties along the west side of 15th Ave NW to construct the shared-use path. Impacts to existing properties and roadways would be minimal.

This component is geometrically feasible.

Figure 1. Low-Level Rehabilitation

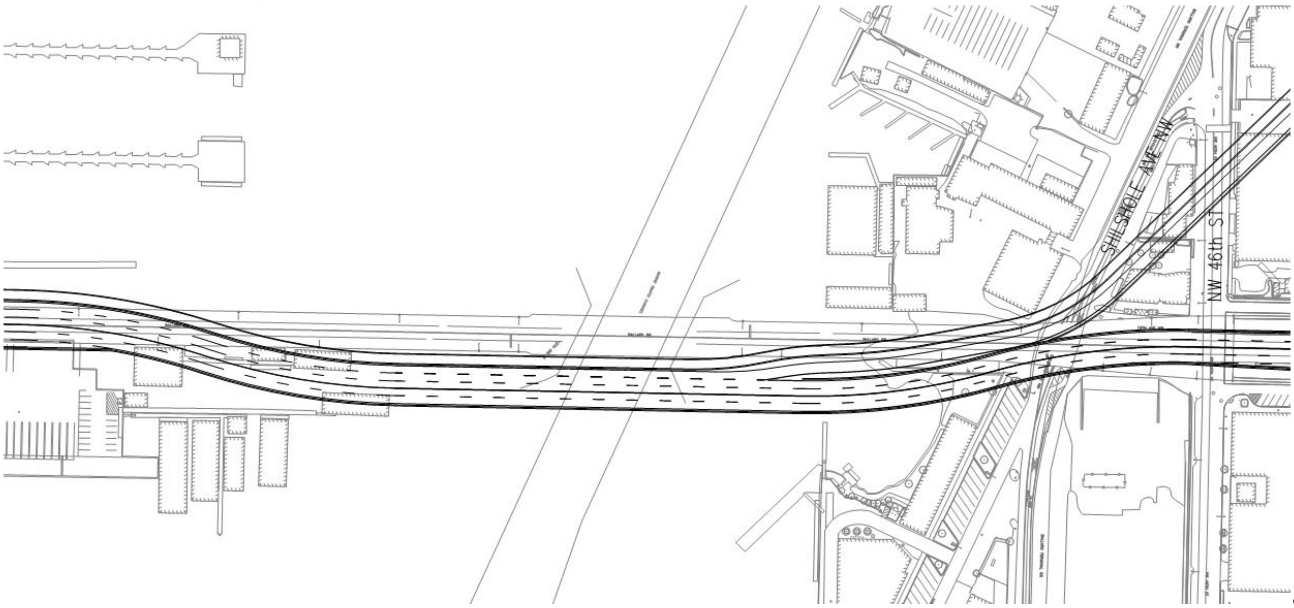


2.2. Mid-Level Replacement

Description

The mid-level bridge component would increase the height of the bascule bridge to provide a 60'-70' clearance under the bridge for marine traffic at the navigational channel, which would significantly reduce openings of the bascule section. It was determined that a 60' clearance was the minimum for this component, but that as much clearance as possible would be provided while maintaining a maximum grade of 5% on 15th Ave NW and the ramp connections to NW Leary Way at the north and to W Emerson St and W Nickerson St at the south end.

Two lanes would be provided northbound (NB) and southbound (SB) across the bridge, matching the existing. An add/drop lane in the SB direction would provide room for acceleration from the W Nickerson St on-ramp and deceleration to the NW Leary Way off-ramp (the lane was carried across the bridge because the required acceleration and deceleration tapers nearly overlap). A 14’ shared-use path would be provided along the west side of 15th Ave NW, which would allow connections to the Ship Canal Trail and NW Leary Way. Lane widths would match the design parameters specified in Section 1.1 and the component layout is shown in Figure 2a. Parallel Mid-Level Replacement



and

Figure 2b. Mid-Level Replacement along Existing Alignment (and Attachments 3-5).

A conceptual-level profile was designed to maximize the height of the bridge while maintaining a maximum 5% grade from the ramps at NW Leary Way. On the north side, the profile would tie into 15th Ave NW at approximately NW 50th St, with a maximum grade of 5% on the bridge and ramps to NW Leary Way. On the south side, the profile would tie into the existing bridge abutment approximately 200’ north of the existing W Emerson St/W Nickerson St interchange, with a maximum grade of 5%. In addition, a minimum 20’ of clearance would be provided under 15th Ave NW at NW Ballard Way, NW Leary Way, NW 45th St, NW 46th St, and Shilshole Ave NW to allow over-legal trucks to pass under the bridges. The W Emerson St/W Nickerson St interchange was also designed to allow over-legal trucks to pass under the bridges.

This component would be compatible with the preliminary alignments for Sound Transit’s West Seattle to Ballard Light Rail Extension. This component was evaluated against the tunnel and the elevated rail design files that were provided from Sound Transit in July 2019. The analysis of the mid-level design file with the provided Sound Transit files showed that the mid-level option geometry fits alongside both the elevated rail and the tunnel.

The existing Ballard Bridge main bascule span and approach spans over water have a structure type consisting of two longitudinal girders (or trusses) and floor beams, which deems partial demolition infeasible (per the *Structural Feasibility and Constructability Analysis of Components Memo*). In addition, due to the limited detour routes, some traffic capacity on 15th Ave NW traffic must be maintained during construction and the bascule must be operational, without exception, to allow marine traffic to pass. With these constraints, two sub-components were evaluated.

Evaluation

This mid-level bridge component would improve the existing ped/bike crossing of the Ballard Bridge, but would introduce 5% grades and 36’ of elevation gains for both NB and SB traffic, which would increase the crossing time for bicyclists and pedestrians as compared to existing. It would also improve regional ped/bike connectivity by including a connection to the Ship Canal Trail.

While the connection to NW Leary Way would be maintained, the diamond ramp configuration, including a connection to NW Ballard Way, could not be maintained due to the increased height of the bridge.

This component is geometrically feasible; however, constructability concerns were evaluated for each subcomponent.

2.2.1. Parallel Mid-Level Bascule

Description

In order to maintain traffic on the current mid-level bridge, this component would be constructed on a parallel horizontal alignment and then tie back in on the north and south ends. Horizontal alignment shifts to the east and west of the existing bridge were both examined. While both would require additional right-of-way and have significant impacts to existing properties, it was decided to shift the mid-level alignment to the east because it would avoid significant impacts to the Fishing Vessel Owners’ haul out facility and to the CSR Marine & Associate Moorage property (these properties are essential to the Fishermen’s Terminal and boating commerce, and are likely irreplaceable given today’s permitting requirements). To minimize right-of-way impacts and permanent alignment shifts along 15th Ave NW, the mid-level horizontal alignment shift to the east is minimized to provide only the separation necessary to construct a new bascule bridge adjacent to the existing bridge per discussions with the bridge design team.

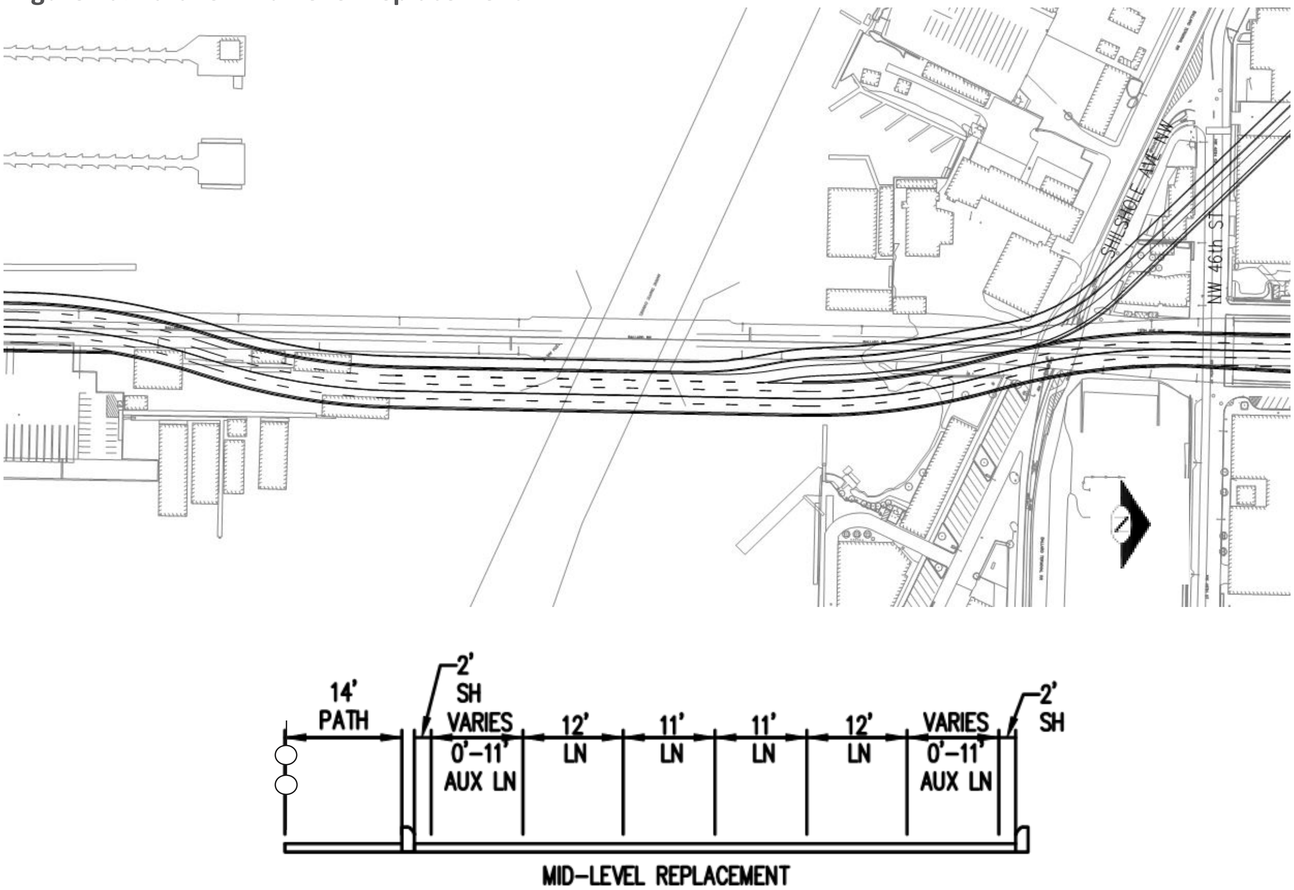
Evaluation

This component would require significant right-of-way acquisition related to approximately 1,500’ of new bridge construction adjacent to the existing structure. Significant property impacts would affect the Seattle Maritime Academy as a result, and could potentially impact the newly constructed Ballard Blocks.

As discussed in the *Structural and Constructability Feasibility Analysis Memo,* the tie-ins for this component cannot be constructed while maintaining traffic on existing 15th Ave NW. The existing bridge is not wide enough to facilitate a staged sequence that maintains at least 2 lanes of traffic. For this concept to work, the profile would need to be raised, which would make the northern connections discussed in Section 3 infeasible.

This component is not geometrically feasible because of constructability considerations.

Figure 2a. Parallel Mid-Level Replacement



2.2.2. Mid-Level Replacement along Existing Alignment

Description

This replacement option would be constructed on the existing alignment of 15th Ave NW. In order for this to be constructible, a temporary detour bridge would be built to cross the Canal. This bridge would be used to divert traffic from the existing bridge, which would be demolished and replaced by the mid-level replacement. The detour bridge is discussed in more detail in the *Structural Feasibility and Constructability Analysis of Components Memo.*

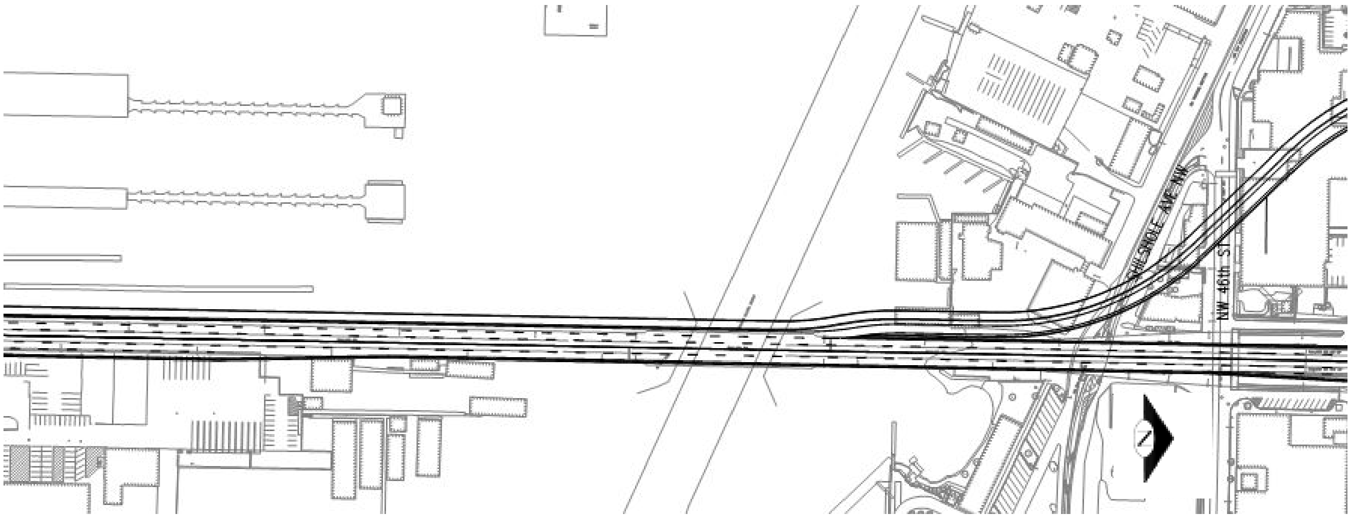
Evaluation

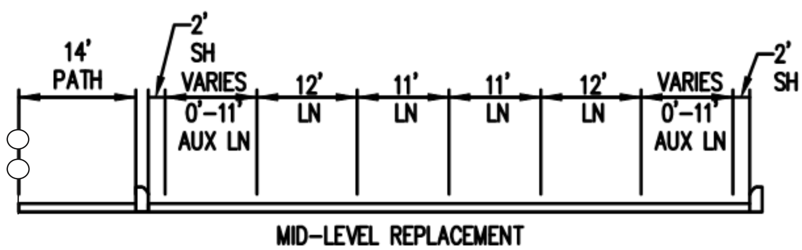
This component would require significant temporary construction easements related to approximately 1,500' of new bridge construction adjacent to the existing structure. Significant impacts to property would affect the Seattle Maritime Academy. However, the mid-level replacement would require minimal right-of-way over the Ship Canal.

The detour bridge allows the mid-level bridge to be constructed in full along its current alignment.

This component is geometrically feasible and constructible.

Figure 2b. Mid-Level Replacement along Existing Alignment





2.3. High-Level Replacement

Description

The high-level bridge component was designed to include a new, fixed (i.e. not movable) bridge providing 150' of navigational marine clearance, eliminating all bridge openings for marine traffic. Based on the April 2019 study, *Existing 99 George Washington Bridge Vertical Clearance*, the State Route 99 bridge, a similar fixed structure, provides 136.54'-140.14' of clearance at high water for the same marine channel. This is based on the NAVD88 datum which shows the Lake Washington High Water at 18.75'. The 150' span would allow the same marine traffic to pass under the Ballard Bridge as currently pass under the George Washington Bridge. The 150' height would also allow the new bridge to be constructed along its current alignment above the existing bridge by straddling the existing structure. The construction could be performed such that the existing bridge would remain in service, as there would be enough clearance for the existing bascule to fully open.

Two lanes would be provided NB and SB across the bridge, matching the existing. Acceleration and deceleration lanes would also be provided in the NB direction to facilitate merging from the W Nickerson St on-ramp and exiting to the NW Leary Way off-ramp. However, these lanes would not need to be carried across the bridge as there would be adequate acceleration/deceleration distance between the ramps and the bridge. A 14' shared-use path would be provided along the west side of 15th Ave NW, which would allow connections to the Ship

Canal Trail on the south and avoid vehicular conflicts at the NW Leary Way ramp intersection. Lane widths would match the design parameters specified in Section 1.1 and the component layout is shown in Figure 3 (and Attachments 6 and 7).

A conceptual-level profile was designed at 150’ of vertical clearance across the Ship Canal. The profile would maintain a 5% grade on each side to tie back to existing. On the north side, the profile would tie into 15th Ave NW at approximately NW 54th St. On the south end, the profile would tie back to existing approximately 400’ south of W Emerson St. In addition, a minimum 20’ of clearance would be provided under 15th Ave NW at Shilshole Ave NW, NW 45th St, NW 46th St, NW Ballard Way, NW Leary Way, NW 49th St, 50th St NW, and 51st St NW to allow over-legal trucks to pass under the bridge. The clearance under the bridge at NW Ballard Way would allow more east-west crossings under the bridge than currently exist today. The W Emerson St/W Nickerson St interchange was also designed to allow over-legal trucks to pass under the bridges.

This component would be compatible with the final alignments for Sound Transit’s West Seattle to Ballard Light Rail Extension. This component was evaluated against the tunnel and the elevated rail options, and the geometry fits alongside both. This component was evaluated against the tunnel and the elevated rail design files that were provided from Sound Transit in July 2019. The elevated rail option presents a challenge to the northern connections, but appears feasible with close coordination with Sound Transit. This connection is discussed further in Section 3.2.3.

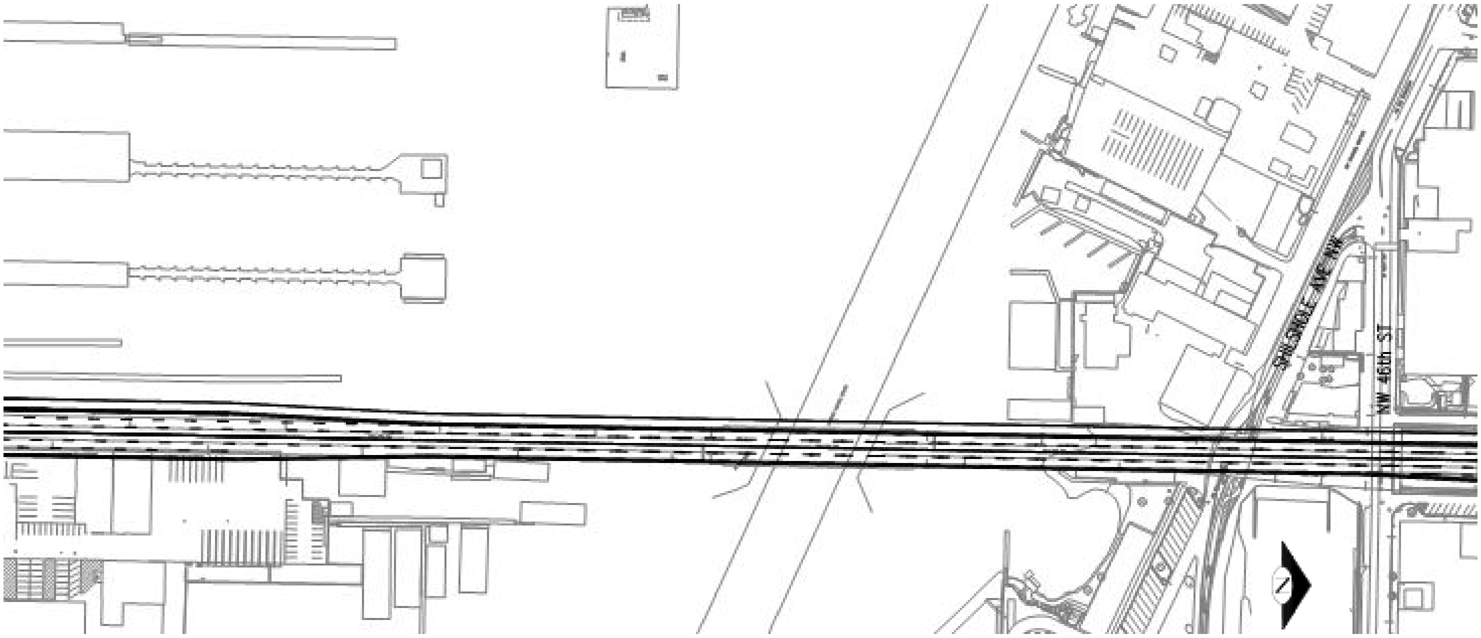
Evaluation

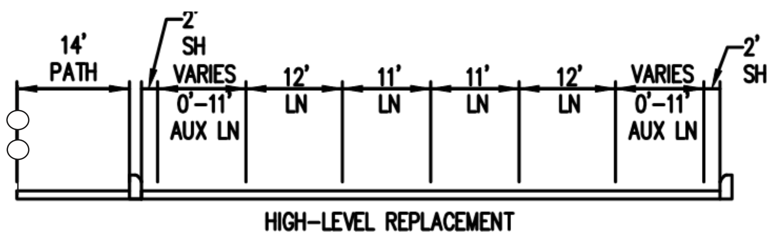
This component would improve the existing ped/bike crossing of the Ballard Bridge, but would introduce extended 5% grades and 111’ of elevation gains for both NB and SB traffic, which would significantly increase the crossing time for bicyclists and pedestrians as compared to the existing. It would also improve regional ped/bike connectivity by including a connection to the Ship Canal Trail. However, north of the bridge, the path would not reach grade until about NW 54th St, which would increase the connection distance to the Burke-Gilman Trail.

While the connection to NW Leary Way would be maintained, the diamond ramp configuration including a connection to NW Ballard Way could not be maintained due to the increased height of the bridge. The height of the bridge limits the connections that could be provided at the north end as discussed in Section 3.2. This component would require right-of-way acquisition along both sides of the existing bridge for the piers, which straddle the existing structure, and to accommodate the wider cross-section. This would result in moderate impacts to properties on both sides of the existing right-of-way.

This component is geometrically feasible.

Figure 3. High-Level Replacement





2.4. Summary of Key Findings for Ship Canal Components

The Component Analysis for the bridge components are summarized in Table 1**.**

Table 1. Bridge Component Geometric Feasibility

Bridge Component	**Geometrically Feasible?**
Low-Level Rehabilitation	Yes
Parallel Mid-Level Replacement	No
Mid-Level Replacement along Existing Alignment	Yes
High-Level Replacement	Yes

3. North End Components

3.1. Existing Configuration

The existing roadway configuration north of Ballard Bridge is a tight half-diamond interchange to and from the south as shown in Figure 4. It provides a direct off-ramp connection from NB 15th Ave NW to eastbound (EB) NW Ballard Way and to EB and westbound (WB) NW Leary Way via a signal at the intersection. This signal also controls a SB on-ramp from NW Leary Way (both directions) to SB 15th Ave NW. The on-ramp provides access from EB NW Ballard Way via a T-intersection located mid-way up the ramp.

Figure 4. Existing North Side Connections to NW Leary Way and NW Ballard Way

The following sections describe and discuss the north side components and their geometric feasibility. Different ramp configurations were evaluated with the goal of maintaining similar interchange connections as the existing. The low-level rehabilitation option would not change the existing north side connections; however, design of the north side components for the mid-level and high-level alternatives would require removal of the connections to and from NW Ballard Way and reconfiguration of the ramps at NW Leary Way. The elevations for these connections would vary significantly based on the bridge component; therefore, the components are divided into Section 3.32 for the mid-level components and Section 3.3 for the high-level components.

3.2. North End Components for the Mid-Level Bridge Component

The mid-level bridge component would include a new bascule bridge providing 60’-70’ of navigational marine clearance that would minimize the frequency of openings for marine traffic. Preliminary traffic analysis showed that the connections to and from NW Leary Way must be provided for the mid-level bridge to be operationally feasible at the north end, since nearly 40% of the bridge traffic uses those existing ramps. Eliminating the ramps is infeasible as it would create substantial congestion at the NW Market St intersection. Two north end components were designed and evaluated to maintain these connections and are discussed below. It is noted that a maximum grade of 5% on 15th Ave NW would eliminate the possibility of connecting a 60’ mid-level bridge to NW Ballard Way with on- or off-ramps. Some of the components would provide for circulation to segments of NW Ballard Way and some would not, as described below.

3.2.1. Modified Diamond Interchange Ramps at NW Leary Way

Description

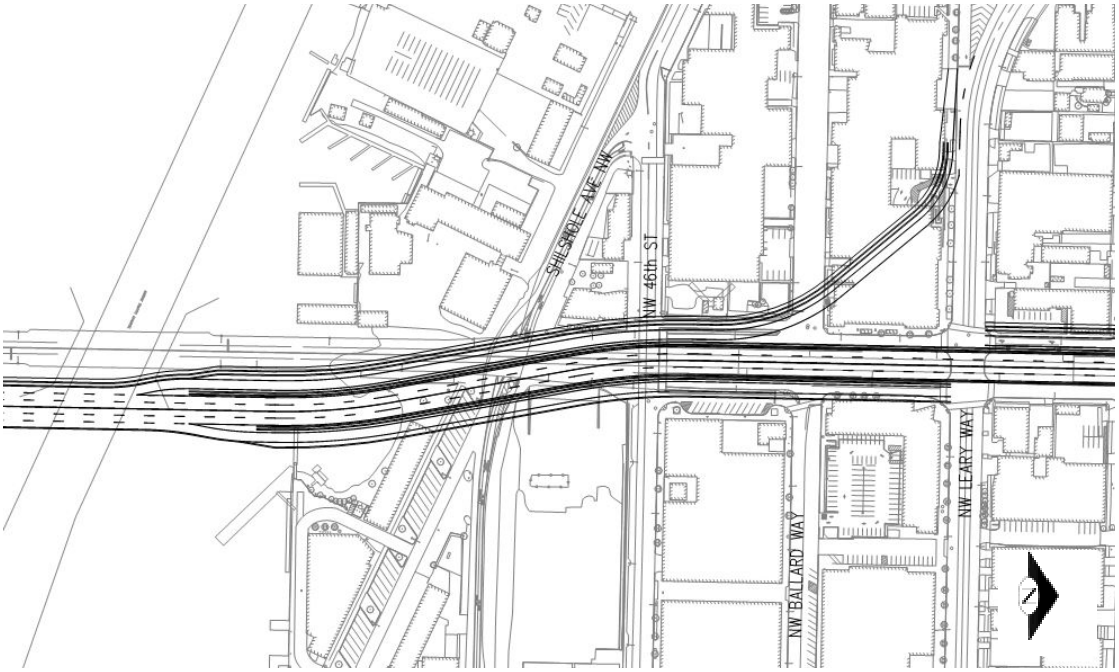
This component was designed as a modified diamond interchange. The off-ramp was designed to function similar to the existing ramp configuration, with parallel off-ramps connecting to a signal at NW Leary Way. Traffic could then turn EB or WB as shown in Figure 5 (and Attachment 8). As noted above, the T-intersection connections to NW Ballard Way from that ramp would be eliminated due to the increased ramp elevation. Two different sub-components for the off-ramp were considered as part of this component design. The first would maintain the off-ramp slope at 5%, and the second would increase the off-ramp grade to maximum of 7%. Both ramp components would reach grade at NW Leary Way. The grades on the off-ramp would control the clearance of 15th Ave NW over the navigational channel; the 5% ramp would provide only 55’ of clearance for marine vessels at the navigational channel, while the 7% ramp would provide 70’ of clearance. After further discussion with freight stakeholders, it was decided that the maximum downgrade of 5% should be maintained on the off-ramp to NW Leary Way because of the heavy freight volumes. Therefore, it is infeasible to achieve this grade with a parallel off-ramp.

To provide a maximum 5% grade on the SB on-ramp, it would need to begin near the NW Leary Way/17th Ave NW intersection, and would serve only EB traffic. This would severely affect traffic access to the bridge by requiring vehicles from areas east of the bridge to circulate on other streets to reach this EB ramp. As noted below, this alignment was deemed infeasible due to its compromised access function.

Evaluation

This component could not be designed using a maximum 5% grade on 15th Ave NW or the off-ramp to NW Leary Way to provide a minimum clearance of 60’ over the navigational marine channel. In addition, the on-ramp, which would only serve traffic from EB NW Leary Way, would require vehicles from the east side of the bridge to circulate on other local roads to reach the ramp. Therefore, this component is not geometrically feasible and was not carried forward for further analysis.

Figure 5. Modified Diamond Interchange Ramps at Leary Way



3.2.2. Maximum 5% Ramps at NW Leary Way

Description

This component was designed to maintain a minimum clearance of 60’ over the marine navigational channel and maintain maximum grades of 5% on 15th Ave NW and the ramps to NW Leary Way. The ramp lengths and alignments were extended as needed to maintain the maximum grades as shown in Figure 6 (and Attachments 9 and 10). Both the on-ramp and the off-ramp would tee into NW Leary Way at new signals, and both are designed as single lane ramps per the parameters specified in Section 1.1.

The NB off-ramp would follow a similar alignment as the high-level elevated intersection described in Section 3.3.3, as it would use the existing right-of-way of NW 49th St to ramp down to 14th Ave NW and would continue parallel to 14th Ave NW. This ramp would preserve connectivity to NW Ballard Way as vehicles could continue straight through the light at NW Leary Way to NW Ballard Way. The off-ramp requires minimal design coordination with Sound Transit’s elevated rail design, as it would tee into 14th Ave NW and would have minimal impacts to existing 14th Ave NW.

The on-ramp would begin at a reconfigured intersection with 17th Ave NW. It would then cross over NW Ballard Way, NW 46th St, and Shilshole Ave NW before it would meet the Ballard Bridge. East-west access along NW Ballard Way would be impeded by this design but would be maintained at NW 46th St and Shilshole Ave NW. Unlike the component above, the on-ramp would provide access from both EB and WB NW Leary Way.

Bicyclists and pedestrians on the western shared-use path would exit via the on-ramp to the intersection of NW Leary Way and 17th Ave NW where they could follow 17th Ave NW to the existing network.

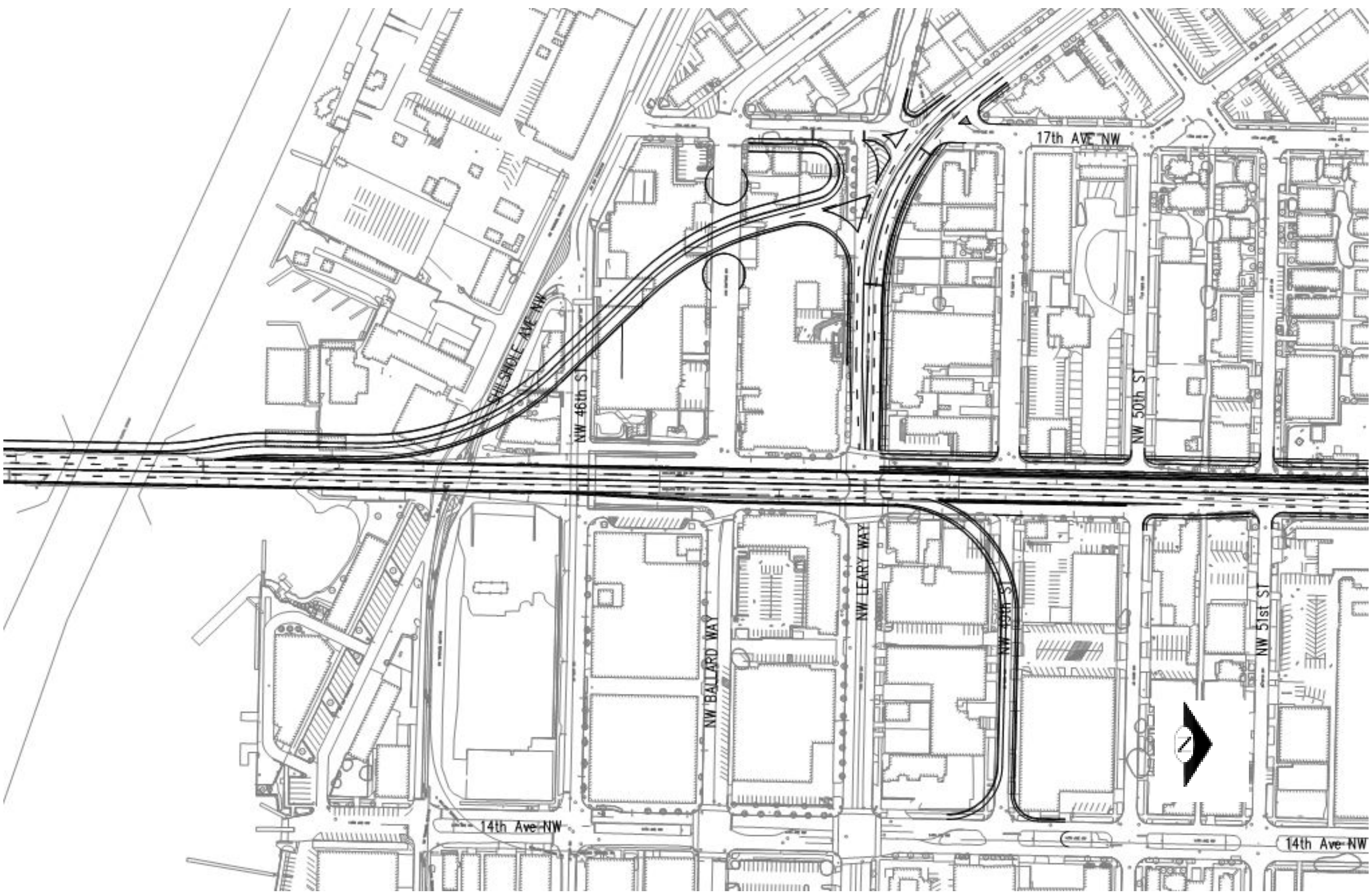
Evaluation

This component would provide both EB and WB on- and off-ramp connections from 15th Ave NW to NW Leary Way, while maintaining the preferred maximum grade of 5%. It would also provide off-ramp connectivity to NW Ballard Way through the signal at NW Leary Way and 14th Ave NW. Both ramps would impede current through movements. The on-ramp would block the through movement of NW Ballard Way and the on-ramp would close NW 49th St east of the bridge. The ramps would provide a connection for pedestrians and bicyclists to the existing network. Because the on-ramp connects at 17th Ave NW and Leary Way, pedestrians and bicyclists following the shared-use path along the ramp would have access to the 17th Ave Greenway. This connection would also put them closer to the Burke-Gilman Trail once the missing link is complete. The ramps are compatible with Sound Transit's elevated rail design.

Both the on- and off-ramp alignments would require significant right-of-way acquisition, impacts to properties, and impacts to existing east-west streets. The off-ramp would block NW 49th St and the on-ramp would block NW Ballard Way between 15th Ave NW and 17th Ave NW.

This component is geometrically feasible.

Figure 6. Maximum 5% Ramps at NW Leary Way



3.3. North End Components for the High-Level Bridge Component

The high-level bridge component would include a new, fixed bridge providing 150’ of vertical navigational marine clearance that would eliminate openings for marine traffic. With the high-level bridge elevation set to provide 150’ of clearance and using maximum grades of 5% on 15th Ave NW, it would not be physically possible to connect a high-level bridge to NW Ballard Way. However, preliminary traffic analysis showed that the connections to and from NW Leary Way must be provided for the high-level bridge to be operationally feasible at the north end. Three north end connection components were designed and evaluated to maintain these connections and are discussed below.

3.3.1. Modified Diamond Ramps at NW Leary Way

Description

This component was designed to connect the high-level bridge component to NW Leary Way with a maximum grade of 5% on 15th Ave NW and the ramps. The configuration of this component would include extensive ramps along NW Leary Way and would restrict the on-ramp to WB traffic only.

This component would include one single-lane on-ramp and one single-lane off-ramp designed to the parameters specified in Section 1.1. At the centerline intersection, 15th Ave NW would be approximately 90’ higher than NW Leary Way, which would eliminate a typical diamond ramp configuration. Instead, the ramps would be extended east and west as needed to match existing grades. The on-ramp would be changed from its current configuration to an EB-only on-ramp, which would match existing grade at 20th Ave NW. Pedestrians and bicyclists would follow the on-ramp to the intersection of NW Leary Way and 20th Ave NW. Restricting the off-ramp to WB NW Leary Way traffic would not be operationally feasible, so the off-ramp would be shifted to the NW 46th St alignment, curve 90-degrees to the south, and connect to NW Leary Way at a new signal, allowing traffic to turn EB or WB onto NW Leary Way. This component layout is shown in Figure 7 (and Attachment 11). This design is preliminary and was not refined due to the significant impacts to right-of-way.

This component is not compatible with the elevated rail alignments for Sound Transit’s West Seattle to Ballard Light Rail Extension, as any ramp crossing 14th Ave NW would conflict with the Sound Transit alignment.

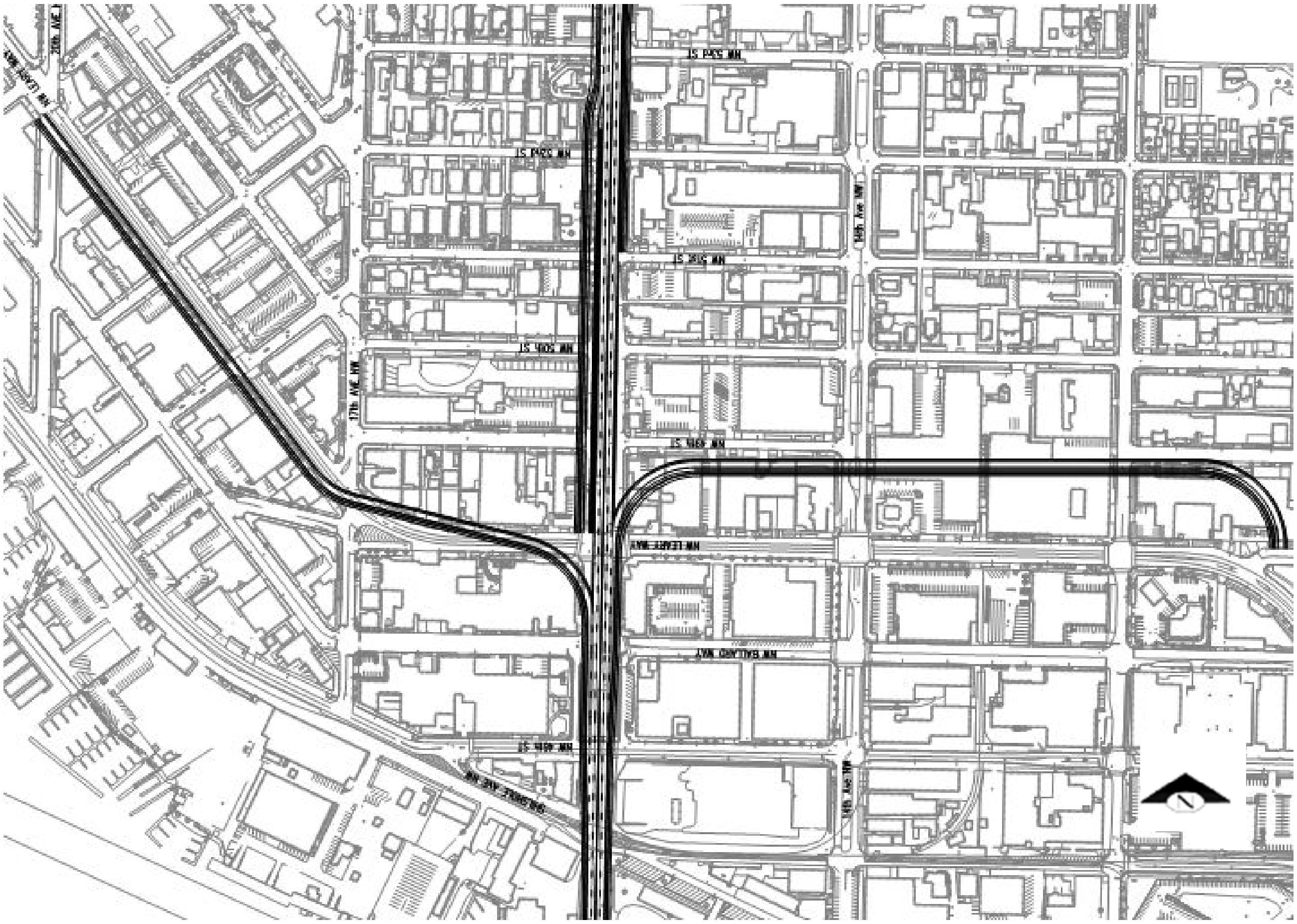
Evaluation

This component would improve existing ped/bike facilities along 15th Ave NW and connect to the existing facilities at NW Leary Way. However, bicyclists and pedestrians would be required follow the on-ramp off the bridge to the ramp terminus connection at 20th Ave NW, resulting in a long and circuitous path for pedestrians and bicyclists that does not directly connect into the existing network. Both ramps would result in significant impacts to existing properties and significant right-of-way acquisition along NW Leary Way.

While the connection to NW Leary Way is maintained, the diamond ramp configuration, including a connection to NW Ballard Way, could not be maintained due to the increased height of the bridge. The configuration of this component would include extensive ramps along NW Leary Way and restrict the on-ramp to WB traffic only.

This component is not geometrically feasible without requiring significant impacts to properties and operational changes to the existing north end connections.

Figure 7. High-Level Modified Diamond Ramps at NW Leary Way



3.3.2. Loop Ramp to NW Leary Way

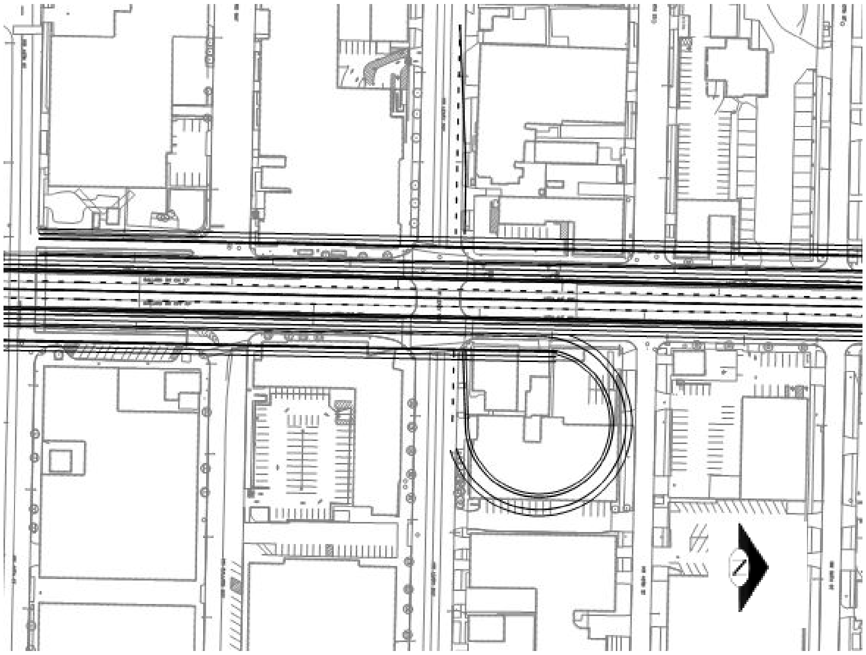
Description

This component was designed to revise the off-ramp described in Section 3.3.1 with a loop ramp from the high-level bridge component to NW Leary Way as shown in Figure 8 (and Attachment 12)**.** The ramp was designed to avoid the potential elevated rail at 14th Ave NW and tie back into EB NW Leary Way, but could not be designed to provide access to WB NW Leary Way. The off-ramp would tie into the 15th Ave NW profile, which has a maximum grade of 5%, resulting in a vertical difference of 90’ between the high-level option and the existing NW Leary Way. This would result in a ramp profile with an 8.5% downgrade, which does not meet the design parameters described in Section 1.1.

Evaluation

This option would not meet the design parameter for maximum grade; therefore, it is not geometrically feasible and was not carried forward for further analysis. Note that Figure 8 (Attachment 12) is a preliminary layout that was not refined once this component was deemed geometrically infeasible.

Figure 8. High-Level Loop Ramp



3.3.3. Elevated Intersection

Description

This component provides a connection between NB and SB 15th Ave NW and both EB and WB NW Leary Way at an elevated traffic signal as shown in Figure 9 (and Attachments 13 and 14). Maximum grades of 5% on 15th Ave NW and the ramps are maintained. Note that this option would not be operationally feasible for the mid-level bridge because it could not be combined with bridge openings.

The ramps would begin at a signal on the high-level bridge profile at 15th Ave NW and slope down to existing grade at another traffic signal at the intersection of 14th Ave NW and NW Leary Way. The alignment would follow existing NW 50th St until it would turn to meet 14th Ave NW. Sound Transit proposed an alternative: an elevated rail with columns in the existing 14th Ave NW median. The ramp alignment must stay west of the median in order to avoid a conflict. The grade of the ramp would stay at 5% because the terminus of the Ballard Bridge is north of NW Leary Way, which would result in a 60’ elevation difference at the centerline intersection. This component would provide connectivity to NW Ballard Way through the new signal at NW Leary Way (by continuing straight). The intersection on the Ballard Bridge would include one off-ramp lane that would turn right onto the ramp to NW Leary Way and two on-ramp lanes that would turn left to the SB Ballard Bridge. The lane configuration and geometry for these ramps were designed to the parameters specified in Section 1.1 and based on a preliminary traffic analysis.

This component also provides connectivity for pedestrians and bicyclists to Leary Way as a shared-use path is included as part of the ramp. Additionally, those using the shared-use path along the west side of 15th Ave NW would be able to continue to NW Market St unimpeded by vehicles entering and exiting the ramp at the elevated signal. Local access improvements to 14th Ave NW would be required with possible frontage roads on each side of the elevated ramp. The frontage roads, NW Leary Way, and the ramp would all meet at a signal.

The ramp could be configured for compatibility with Sound Transit's elevated rail on the 14th Ave NW alignment; however, close coordination would be required between the two projects.

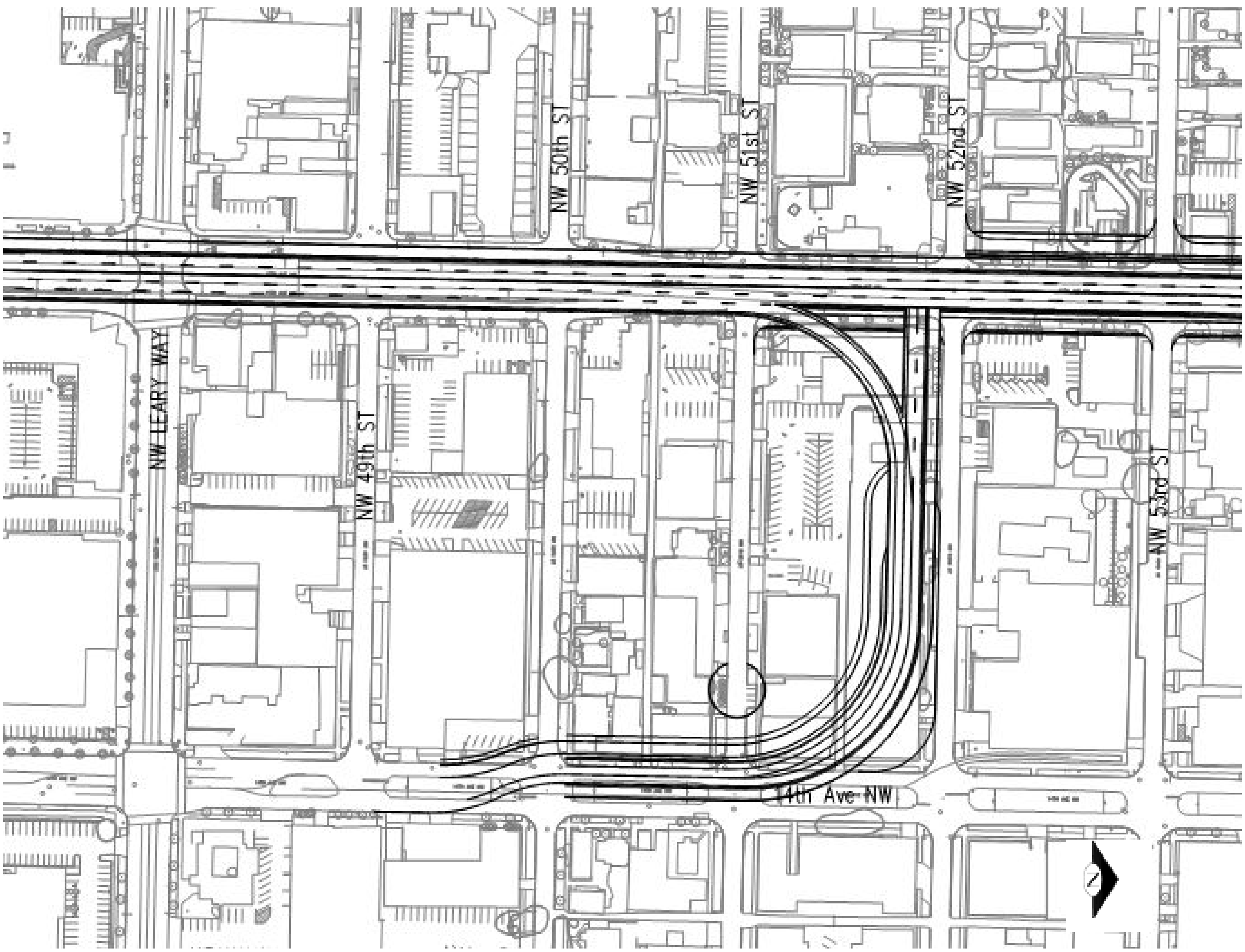
Evaluation

This component provides both EB and WB on and off connections to 15th Ave NW. This option would consolidate both the on-ramp and the off-ramp into one structure, thereby reducing impacts to properties and the acceleration/deceleration lanes required across the Ballard Bridge as compared to a dual structure option.

The combined single ramp for the elevated intersection would require right-of-way acquisitions, but fewer than most other components because of the combined structure, and because the alignments utilize existing City rights-of-way. Having one ramp on the east side would remove the conflict point between vehicular and ped/bike traffic, and allow the shared-use path to continue unimpeded to NW Market St.

This component is geometrically feasible.

Figure 9. Elevated Intersection



3.4. Summary of Key Findings for North End Components

Three components were considered for the high-level bridge component. The height of the high-level bridge component would push the connection to existing grade along 15th Ave NW to NW 54th St to the north and make it challenging to achieve the necessary grade and length for ramps. Only the **Elevated Intersection** component was deemed geometrically feasible for the high-level bridge component. However, this component is not operationally feasible for the mid-level bridge component because it cannot be combined with bridge openings. Two different components were reviewed for the mid-level bridge component. Only the **Maximum 5% Ramps** at NW Leary Way component was deemed geometrically feasible for the mid-level bridge component. These results are summarized in Table 2**.**

Table 2. North End Component Geometric Feasibility

Bridge Component	North End Component	Geometrically Feasible?
High-Level Replacement	3.3.1 Modified Diamond Ramps at NW Leary Way	No
	3.3.2 Loop Ramp to NW Leary Way	No
	3.3.3 Elevated Intersection	Yes
Mid-Level Replacement	3.2.1 Modified Diamond Ramps at NW Leary Way	No
	3.2.2 Maximum 5% Ramps at NW Leary Way	Yes

4. South End Components

4.1. Existing Configuration

The South End interchange shown in Figure 10 would connect the Ballard Bridge to Fremont, Magnolia, and Interbay via ramps to and from W Emerson St and W Nickerson St. These inter-neighborhood connections are vitally important and must be maintained. The stop-controlled ramps would provide full access to NB and SB 15th Ave NW and to EB and WB W Emerson St and W Nickerson St. A diamond interchange farther south connects 15th Ave NW to W Dravus St. Additionally, north of the interchange is the BNSF railroad. The design must clear the railroad tracks with a minimum of 23.5’. The overpass over 15th Ave NW must provide a minimum 20’ of clearance to provide for over-dimension freight. The proposed components could be applied to the high-level, mid-level, and low-level bridge alternatives.

Figure 10. Existing Southern Ramps

4.2. Traditional Single Point Urban Interchange (SPUI)

Description

This component is a single point urban interchange (SPUI), which would provide ramps for each leg of the interchange that would be controlled by one signal at their intersection.

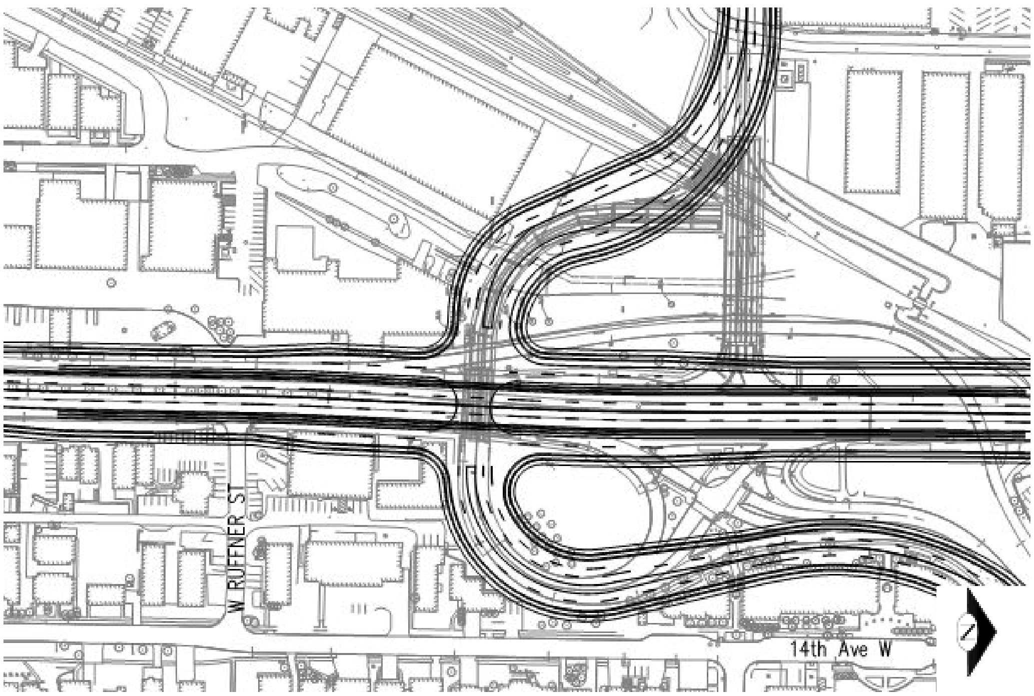
This component would connect W Emerson St to W Nickerson St via an elevated intersection with ramps connecting them to 15th Ave NW. W Emerson St and W Nickerson St have a maximum grade of 5% for both the mid-level and high-level bridges. Ramps to and from both SB and NB 15th Ave NW would meet W Emerson St and W Nickerson St at the same elevated intersection as shown in Figure 11 (and Attachment 15). The bridge over 15th Ave NW would provide a 20’ clearance to allow for over-legal trucks. The ramps, layouts, and geometry were designed to match the parameters described in Section 1.1.

Pedestrians and bicyclists would follow a shared-use path down the south side of W Emerson St to the Ship Canal Trail. Additional stairs or a switch-back ramp could be provided for immediate access from the interchange to the Ship Canal trail below. This design would not be in conflict with the Sound Transit elevated rail either vertically or horizontally; however, close coordination would be required between the two projects.

Evaluation

This component would realign W Emerson St and W Nickerson St, provide one simplified alignment over 15th Ave NW, and maintain maximum grades of 5%. The ramps to and from the north would provide adequate acceleration and deceleration distances prior to the bridge. However, 5% grade ramps to and from the south would result in ramp tie-ins to 15th Ave NW that would be within 200’ of W Dravus St, which is not operationally feasible. The ramps could not be designed to provide adequate interchange spacing without exceeding the maximum 5% grade for both the mid-level and high-level bridge alternatives. Therefore, this component is not geometrically feasible.

Figure 11. Traditional Single Point Urban Interchange (SPUI)



4.3. Modified Single Point Urban Interchange (SPUI)

Description

This component modifies the SPUI described in Section 4.2 by changing the ramps to and from the south to loop ramps as shown in Figure 12 (and Attachments 16-18). The NB off-ramp would pass under the NB on-ramp, which would connect to W Nickerson St at a T-intersection. The SB on-ramp would originate at a T-intersection and go under W Emerson St to meet 15th Ave NW. The existing underpass connection from W Nickerson St would connect to the SB on-ramp, which would provide a connection between W Nickerson St and SB 15th Ave NW. This design would provide adequate interchange spacing between W Emerson St/W Nickerson St and W

Dravus St, and maintain the maximum 5% grades for both the high-level and mid-level alternatives. The W Emerson St/W Nickerson St bridge alignment would be the same as the traditional SPUI component.

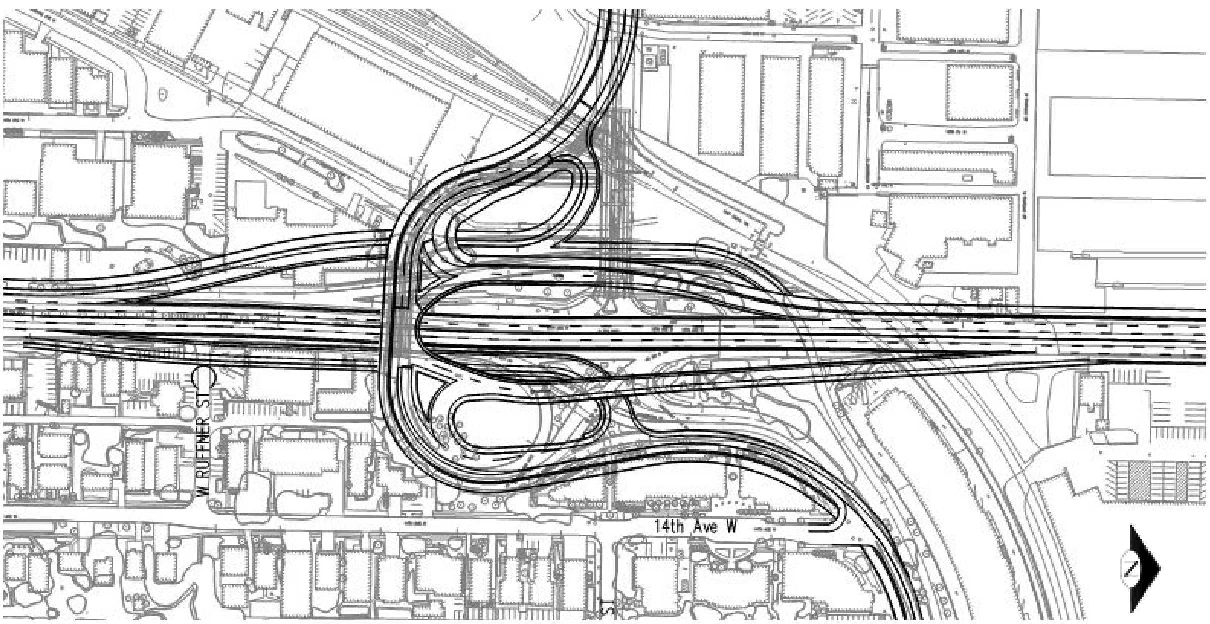
Bicycles and pedestrians would follow a similar path as the traditional SPUI along the SB off-ramp and cross W Emerson St at a signalized intersection. This design would not be in conflict with the Sound Transit elevated rail either vertically or horizontally; however, close coordination would be required between the two projects.

Evaluation

This component would realign W Emerson St and W Nickerson St, provide one simplified alignment over 15th Ave NW, and maintain maximum grades of 5% for the low-level, mid-level, and high-level alternatives. The ramps to and from the north would provide adequate acceleration and deceleration distances prior to the bridge main span. Adequate interchange spacing would be provided between W Emerson St, W Nickerson St, and W Dravus St.

This component is geometrically feasible and was advanced for further consideration.

Figure 12. Modified Single Point Urban Interchange (SPUI)



4.4. At-Grade Signalized Intersection

Description

A smooth alignment connecting W Emerson St and W Nickerson St was considered first as an overpass above 15th Ave NW, then as an at-grade intersection as shown in Attachment 19. The overpass did not have enough space to connect back to the existing alignment without exceeding the maximum 5% grade because the existing road is already sloping downward (away from 15th Ave NW). Therefore, this component would require a signal at the intersection with 15th Ave NW, as it would be an at-grade intersection. However, the intersection could not be designed to accommodate sufficient through lanes or left-turn lanes on all approaches to operate at an acceptable level of service, which is the main reason it was not carried forward. Additionally, a signalized intersection is not operationally feasible in conjunction with bridge openings, making it infeasible for the mid-level option. Accordingly, this component was not carried forward for the mid-level or high-level alternatives.

Evaluation

This component was abandoned as it was not operationally feasible. It could not be redesigned with sufficient lanes at the signalized intersection to overcome the operational conflict, therefore, it was also deemed geometrically infeasible.

Figure 13. At-Grade Signalized Intersection

4.5. Summary of Key Findings for South End Components

The geometric feasibility analysis for the south end components are summarized in the Table 3**.**

Table 3. South End Component Geometric Feasibility

Bridge Component	South End Component	Geometrically Feasible?
High-Level Replacement and Mid-Level Replacement and Low-Level Rehabilitation	Traditional SPUI	No
	Modified SPUI	Yes
	Smooth Alignment Overpass	No
High-Level Replacement and Mid-Level Replacement	At Grade-Signalized Intersection	No

5. Conclusions

Only one north end and one south end component were found to be geometrically feasible for each of the bridge components as shown in Table 4. These components will be packaged into alternatives for the next phase of the evaluation.

Table 4. Geometrically Feasible Components to Advance

Bridge Component	North End Component	Main Span	South End Component
Low-Level Rehabilitation	No Change	• Maintain Existing Clearance • Maintain Existing Lane Configuration • 14’ Shared-Use Path • 6’ Sidewalk	Modified SPUI
Mid-Level Replacement	Northern Ramps to NW Leary Way	• 60’-70’ Clearance • 2 12’ Outside Lanes • 2 11’ Inside Lanes • 14’ Shared-Use Path	Modified SPUI
High-Level Replacement	Elevated Intersection	• 140’-160’ Clearance • 2 12’ Outside Lanes • 2 11’ Inside Lanes • 14’ Shared-Use Path	Modified SPUI

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ATTACHMENT 1
LOW-LEVEL PLAN

DRAWING No.:

SHEET No.:

OF

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LOW-LEVEL REHABILITATION PROFILE

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LOW-LEVEL
PROFILE

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ATTACHMENT 3
MID-LEVEL PLAN

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MID-LEVEL REPLACEMENT PROFILE

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ATTACHMENT 4
MID-LEVEL
PROFILE

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ATTACHMENT 5
MID-LEVEL PLAN
PARALLEL ALIGNMENT

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ATTACHMENT 6
HIGH-LEVEL PLAN

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HIGH-LEVEL REPLACEMENT PROFILE

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ATTACHMENT 7
HIGH-LEVEL
PROFILE

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ATTACHMENT 8
MODIFIED DIAMOND
RAMPS AT LEARY

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ATTACHMENT 9
MAXIMUM 5%
RAMPS AT LEARY

DRAWING No.:

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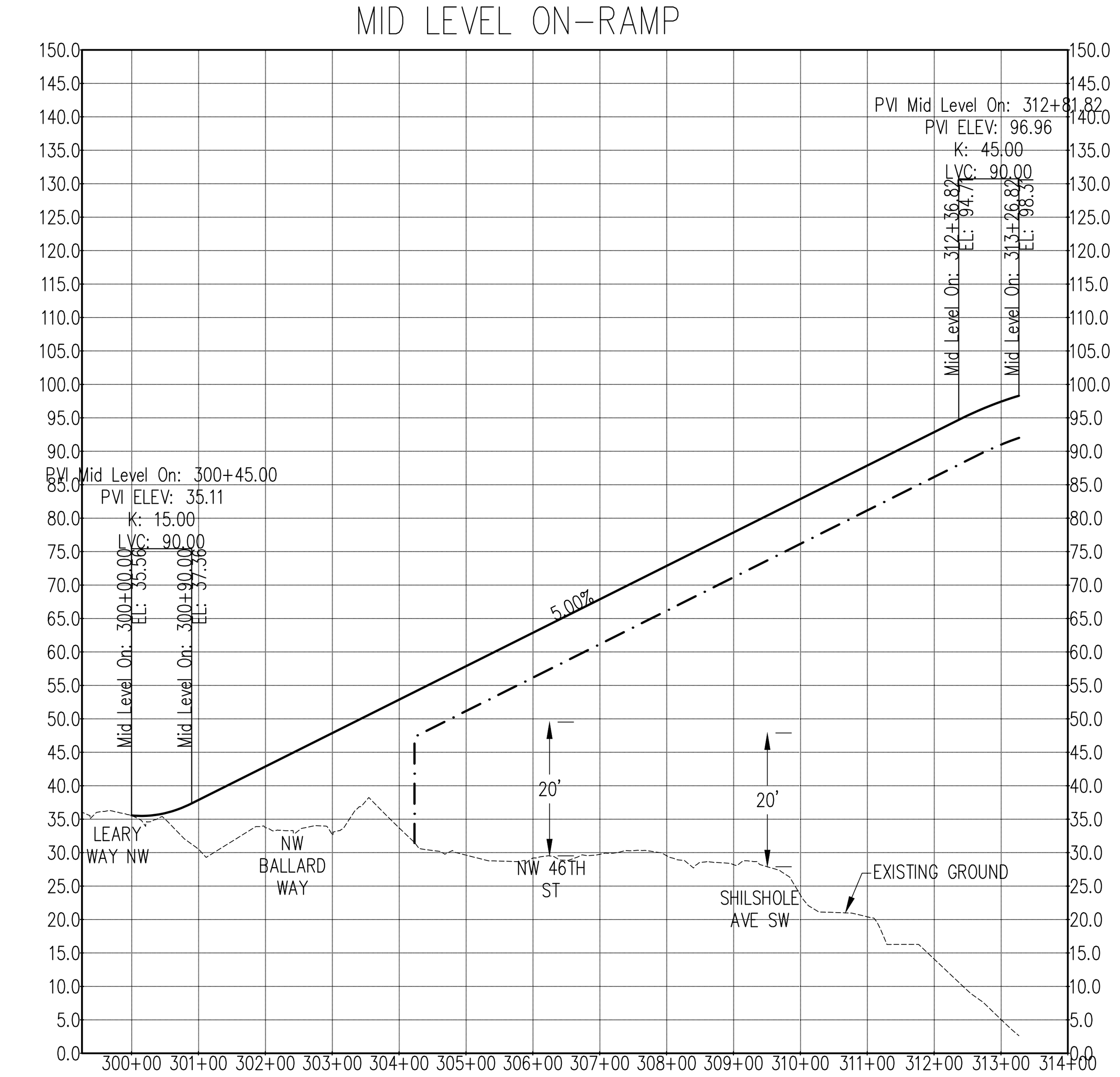
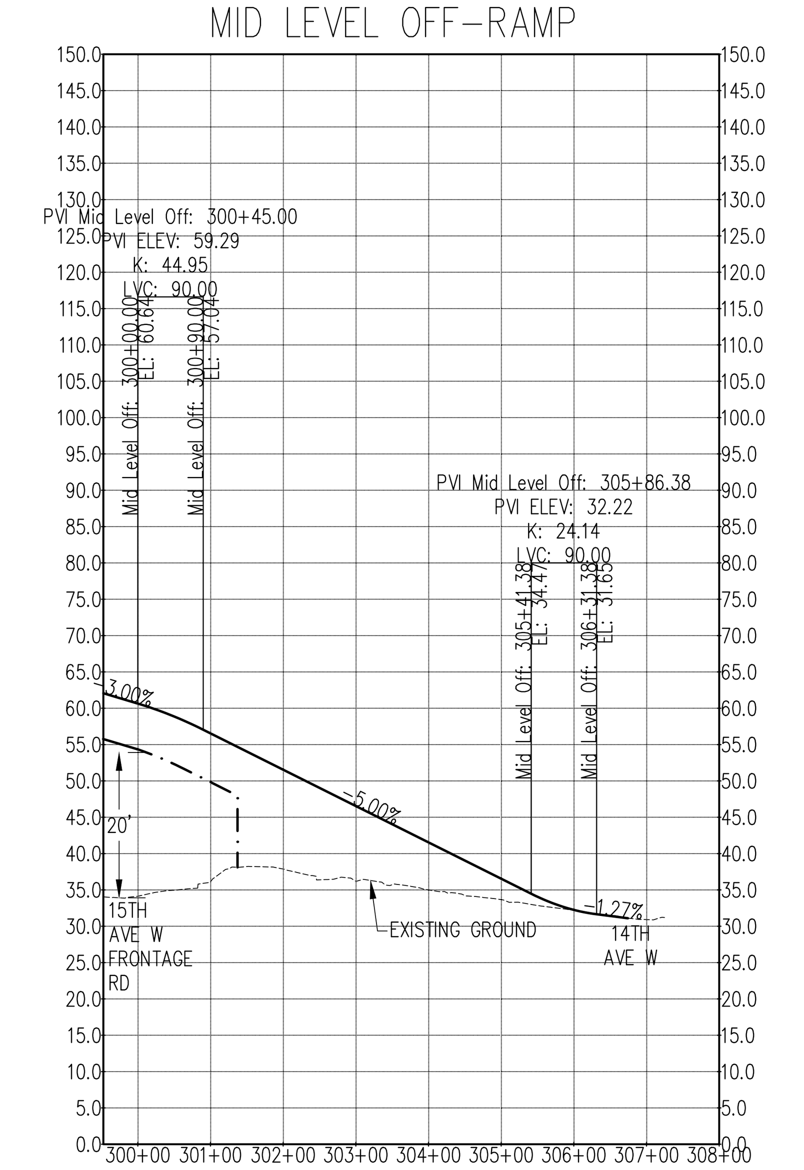
MID LEVEL ON-RAMP



MID LEVEL OFF-RAMP



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ATTACHMENT 10
MID-LEVEL NORTH
PROFILES

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ATTACHMENT 11
MODIFIED DIAMOND
RAMPS AT LEARY

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ATTACHMENT 12
LOOP RAMP TO
LEARY

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ATTACHMENT 13
ELEVATED INTERSECTION

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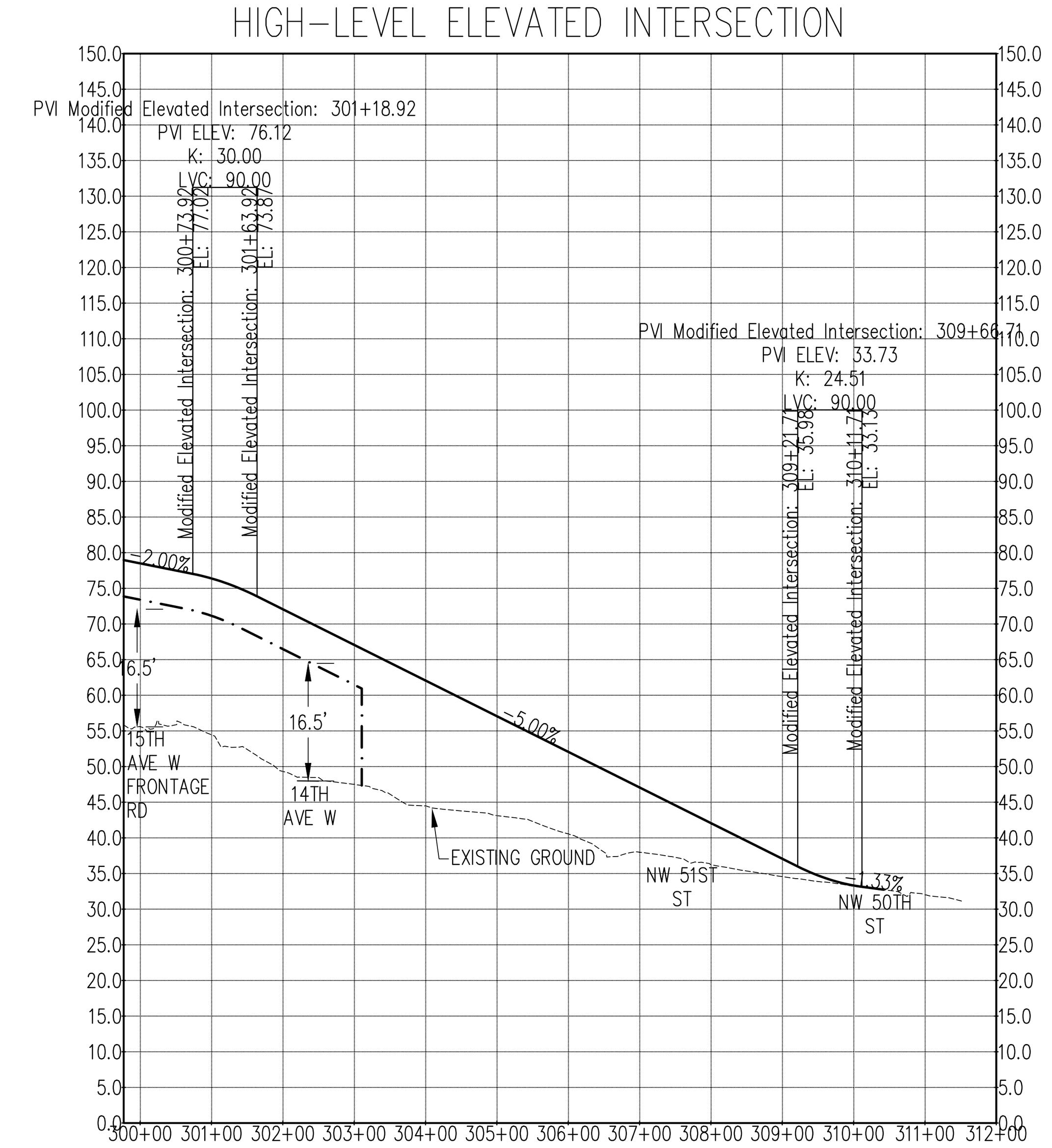
HIGH-LEVEL ELEVATED INTERSECTION



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ATTACHMENT 14
HIGH-LEVEL NORTH
PROFILE

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ATTACHMENT 15
TRADITIONAL SPUI

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ATTACHMENT 16
MODIFIED SPUI

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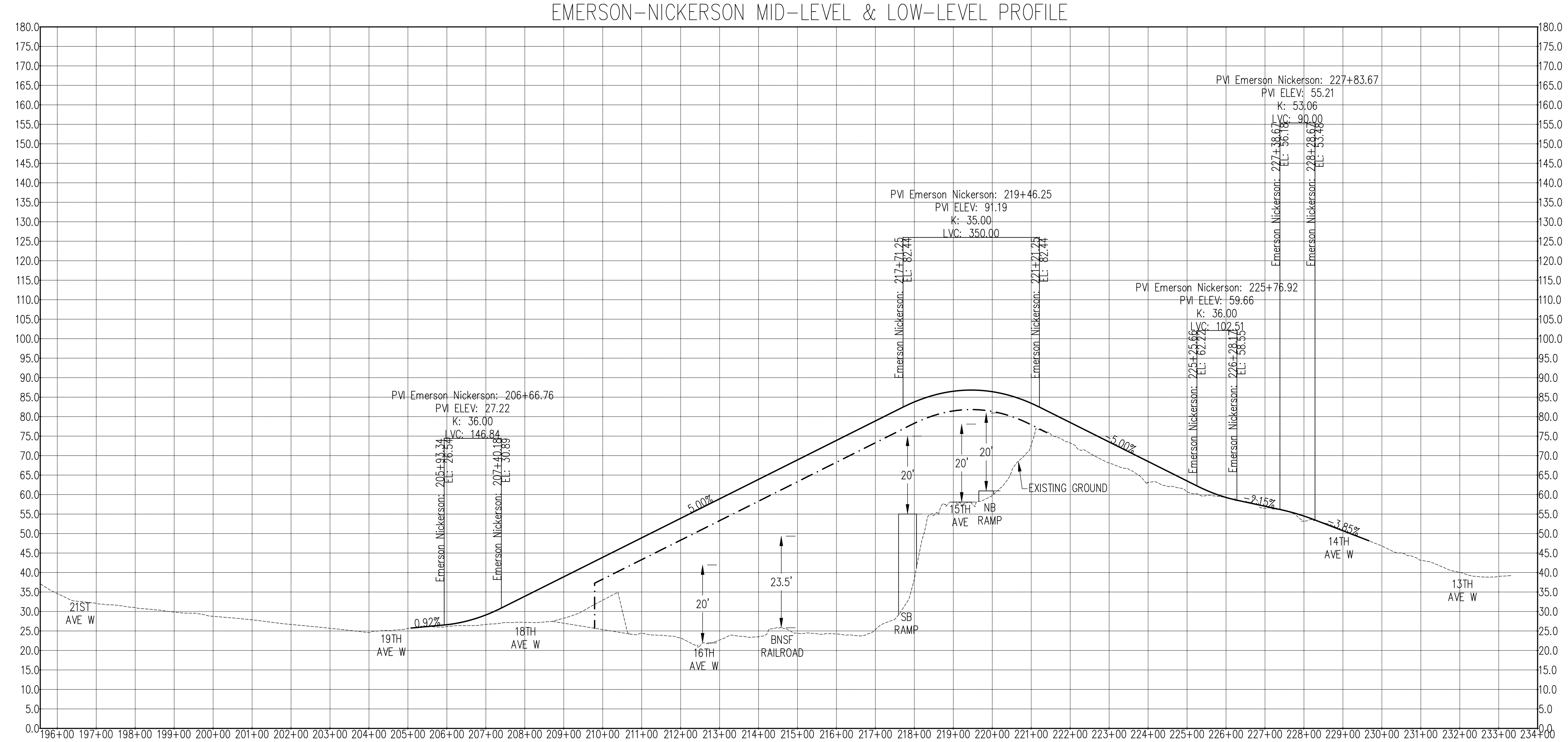
EMERSON-NICKERSON MID-LEVEL & LOW-LEVEL PROFILE



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ATTACHMENT 17
MID & LOW-LEVEL MODIFIED SPUI
PROFILE

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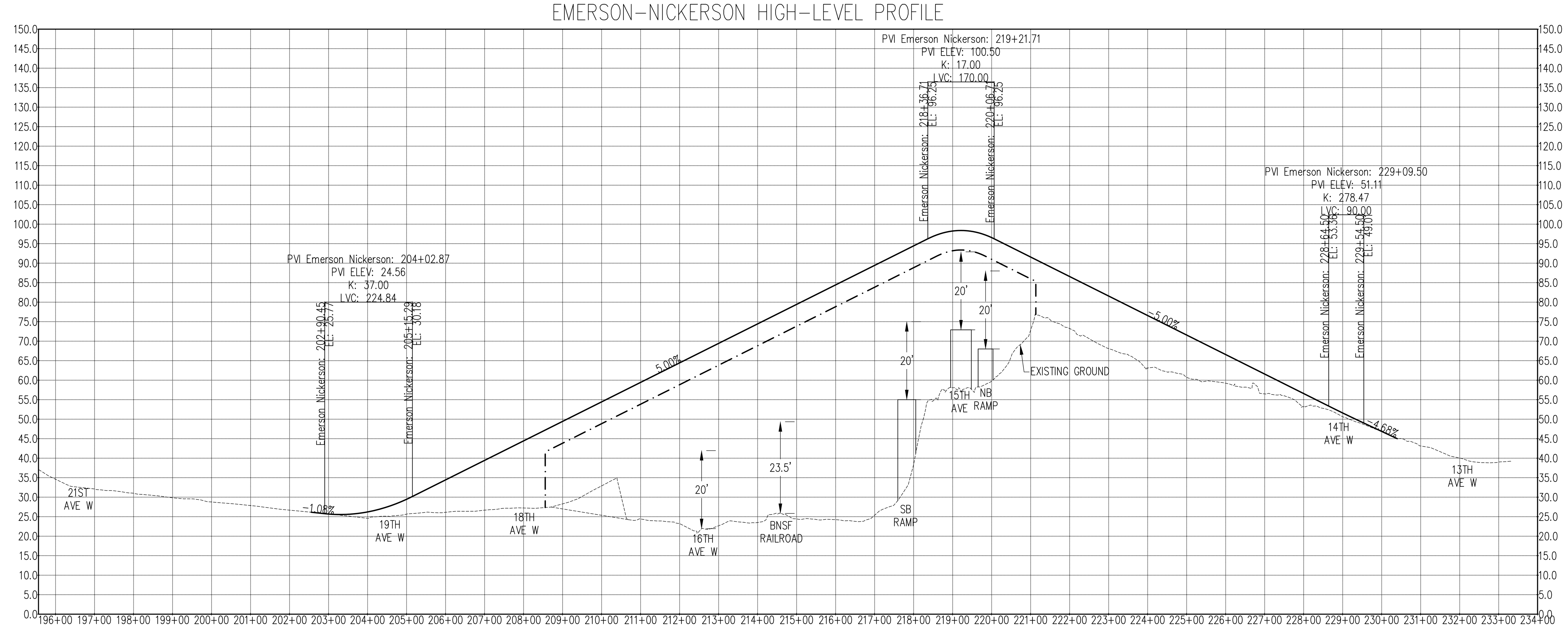
EMERSON–NICKERSON HIGH-LEVEL PROFILE



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ATTACHMENT 18
HIGH-LEVEL MODIFIED SPUI
PROFILE

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ATTACHMENT 19
AT GRADE
SIGNALIZED
INTERSECTION

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Appendix C

Structural Feasibility and Constructability

Seattle Department of Transportation

TECHNICAL MEMORANDUM

PROJECT	Ballard Bridge Planning Study
TITLE	Task 5.5 – Structural Feasibility and Constructability Analysis of Components
DATE	7 August 2020
TO	Seattle Department of Transportation (SDOT)
FROM	COWI
PROJECT NO.	A115271

ADDRESS COWI North America Inc.
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Suite 1110
Seattle, WA 98101
USA

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Executive Summary

The Ballard Bridge, located on the 15th Ave W/NW corridor, is a major north-south corridor in the City of Seattle, and one of just six vehicular and six pedestrian/cyclist connections across the Lake Washington Ship Canal. While the structure is still in good condition today, it is over 100 years old. And while SDOT continues to maintain its safety for daily travel, the likelihood that major maintenance or emergency repair work will be needed continues to increase with age. In addition, the structure is not up to current standards for providing space to people walking, biking, or traveling in a vehicle, hence it being categorized as "functionally obsolete".

The purpose of the Ballard Bridge Planning Study (Project) is to develop and evaluate initial bridge rehabilitation and replacement options, including implementation considerations, comparison of expected order-of-magnitude costs, and functional trade-offs for each option. The overall goal is to develop alternatives and key considerations that take into account representative input for each of the comparison metrics.

This technical memorandum supports Task 5 – Component Feasibility Analysis, addressing structural considerations for the Ballard Bridge. The following options have been considered as part of this study:

- Low-Level Bridge Crossing with Movable Span over Navigation Channel:
  - Rehabilitate and Widen Existing Bridge
  - In-Kind Replacement Bridge (considered at a broad concept level, but not fully evaluated as part of this study)
- Mid-Level Replacement Bridge with Movable Span over Navigation Channel
- High-Level Replacement Bridge with Fixed Span over Navigation Channel
- Tunnel Crossing (considered at a broad concept level, but not fully evaluated as part of this study)

This memorandum addresses structural and constructability analyses for the above options. The following information is provided for each option:

- Narrative description with emphasis on structural design
- Constructability considerations

Contents

1 Introduction

This technical memorandum supports Task 5 Component Feasibility Analysis of the Ballard Bridge Planning Study (Project).

The purpose of this memorandum is to:

- Present and evaluate several structural options identified for the Project
  - Rehabilitate the Existing Low-Level Bridge with bascule span, providing no change in navigational clearance.
  - Mid-Level Replacement Bridge with Movable Span, providing approximately 20-ft more navigational clearance below the bascule span than existing conditions.
  - High-Level Replacement Bridge with Fixed Span, providing approximately 150-ft of navigational clearance.
- Discuss constructability considerations

This memo was produced in coordination with other related project documents contained within the overall study report, including in particular:

- Geometric Analysis of Components Technical Memo, in Appendix B
- Preliminary Geotechnical Engineering Letter Report, in Appendix D
- Analysis of Potential Effects to Cultural Resources and/or Historic Properties Memo, in Appendix E
- Ballard Bridge Planning Study Preliminary Design Criteria, in Appendix G

The geotechnical letter report only addresses structures in this Project which are over the existing waterway. Future studies should include a geotechnical and foundation investigation to cover all segments of the structures.

Refer to Figure 1.1 for the existing site layout indicating the structure limits per the available record plans. Figure 1.2 shows the typical section for the existing Ballard Bridge approach spans over water, on both sides of the existing bascule bridge, per the available record plans.

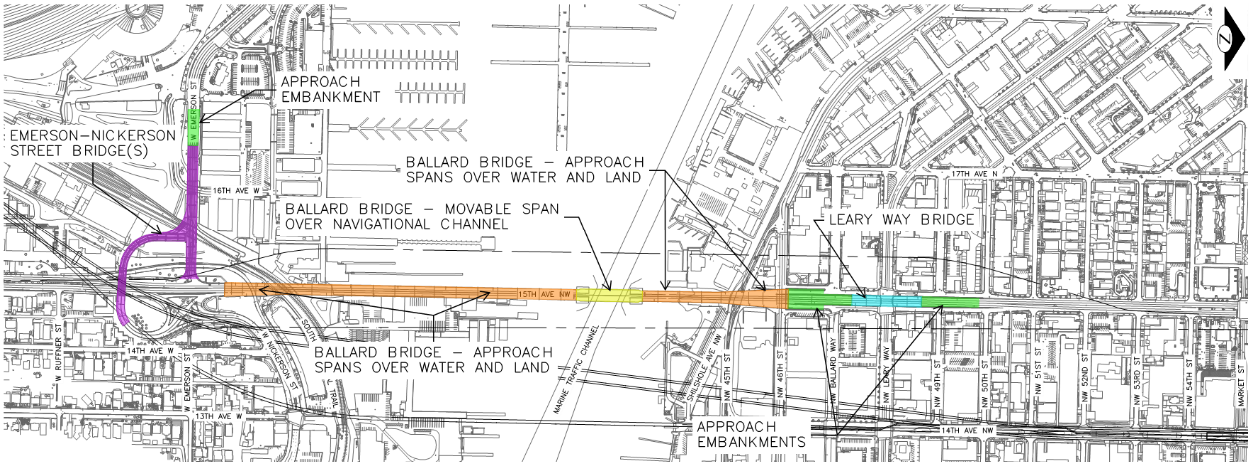


Figure 1.1 Existing Bridge: Site Map

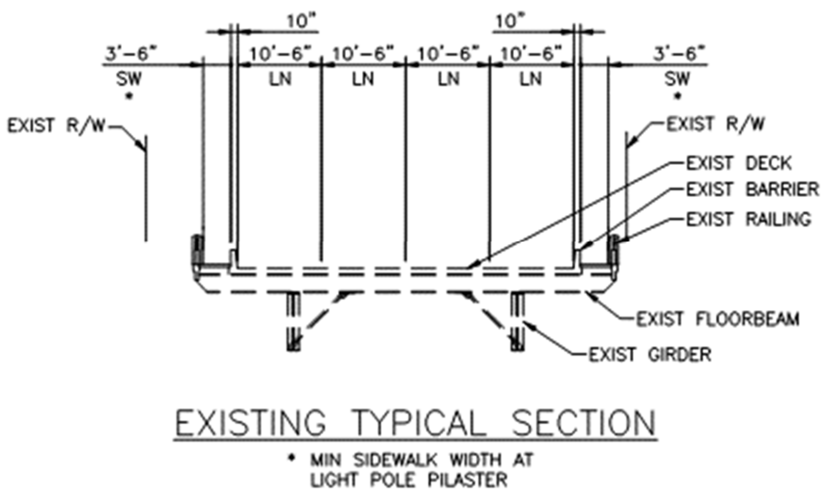


Figure 1.2 Existing Ballard Bridge: Approach Spans Over Water

The documents provided by SDOT for this study indicate the following history for the structures within the scope of this study, and were used when evaluating each of the options:

Ballard Bridge:

- 1917: Construction of the double-leaf bascule bridge
- 1939: Rehabilitation and Re-Decking of bascule bridge
  Construction of permanent approaches
- 1957: Construction of north approach to Ballard Bridge
  Includes ramps at NW Ballard Way and bridge over NW Leary Way
  1964: Bridge Tower Reconstruction
  Removal of four original towers and construction of one current tower
- 1964: Removal and reconstruction of pier protection system
- 1975: Rehabilitation of expansion joints
- 1994: Rehabilitation and seismic retrofits
  Pier cap beam and diaphragm retrofits, installation of catcher blocks and restrainers
  Modifications to bascule span
- 2014: Seismic retrofit of approaches
  Girder strengthening and restrainers in segment 2, deck joint retrofit, longitudinal blocking, diaphragms, seat extensions and column jackets in segments 3, 5, 6, 7.

Emerson + Nickerson Street Bridge(s):

- 1949: Construction of Emerson Street Viaduct
  Construction of the nine span Emerson street bridge
- 1949: W Emerson St Viaduct Extension
  Addition of three 60ft steel spans with three new piers, modifications to existing piers
- 1959: 15th Ave W, grade separation and widening
- 1968: W Emerson St Viaduct West Approach Slab
- 1995: W Emerson St Viaduct Seismic Retrofit Program
  Seismic retrofit of shafts, strengthening of diaphragms and crossbeam. Addition of catcher blocks, girder joint splices, support brackets for longitudinal restrainers
- 1988: W Emerson St Rail Replacement
- 2014: 15th Ave W & W Nickerson St Interchange Bridge rehabilitation
  Removing and replacing north exterior prestressed concrete girders, concrete deck, curb parapet, metal railing between bents B-10, B11. Modifications to deck, joints, drains.

Leary Way Bridge:

- 1957: Construction of bridge, including north approach to Ballard Bridge (see above)
- 1976: Railing retrofits
- 1993: Seismic retrofits (restrainers)

2 Structural Options

2.1 Low-Level Bridge Structural Options

The low-level options consist of replacing the existing bridge with a new bridge with a similar profile and tie-in points or rehabilitating and widening the existing bridge.

2.1.1 Low-Level Bridge Replacement

The low-level replacement bridge option was considered at the option screening level, but not fully evaluated as part of this study. This option has a similar profile to the existing bridge, which does not reduce the number of required bascule bridge openings to accommodate marine traffic and associated impacts to bridge and waterway traffic. The structural solution and constructability for this option would be similar to the mid-level bridge, with the exception of the ramps at NW Leary Way. The low-level bridge replacement option could increase lane widths and reset the structure service life compared to the low-level bridge rehabilitation option but would need a temporary detour bridge to facilitate construction. There may be value to SDOT in evaluating this alternative further as part of future project development.

2.1.2 Low-Level Bridge Rehabilitation

The low-level rehabilitation consists of widening the existing bridge sidewalk(s) to create a Shared Use Path (SUP) for bicycles and pedestrians on the west side of the bridge. This option improves bicycle and pedestrian safety and accessibility but does not provide any improvements for marine traffic in the ship canal or for vehicular traffic on the Ballard Bridge, with the exception of moving the small number of cyclists using the traffic lanes today onto the SUP. The addition of the Modified Single Point Urban Interchange (MSPUI) at the Emerson-Nickerson Street intersection does improve vehicular and bicycle/pedestrian traffic at the south end of the project.

The low-level rehabilitation option includes four basic segments as shown in Figure 2.1.1:

- Movable Bridge Over Navigational Channel
- Approach Bridges Over Water and Land
- Ballard Way Ramps
- Emerson-Nickerson Modified Single Point Urban Interchange (MSPUI) Bridge
- Approach Embankments

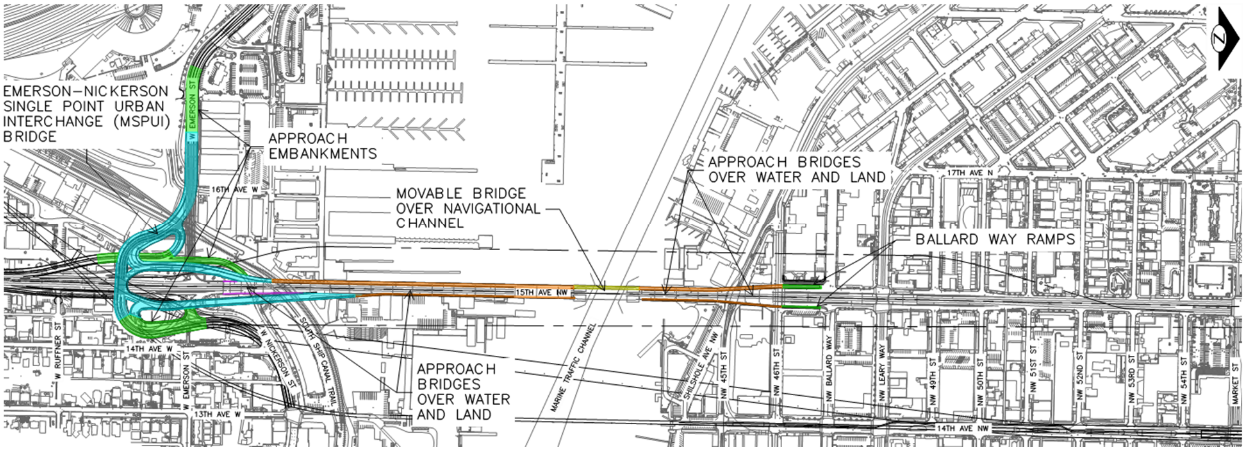


Figure 2.1.1 Low-Level Bridge Rehabilitation: Segment Map

This study also considers rehabilitation and/or strengthening of the existing structures to account for condition, load rating, and seismic deficiencies identified in the latest bridge inspection reports (dated October 9th,2019 from SDOT), bridge rating summaries (dated April 5th, 2013) and bascule bridge seismic retrofit concept design report (dated September 27th, 2019). Below is a brief summary of the repair and strengthening options that are assumed to be required based on the SDOT reports. These options will need to be evaluated in greater detail using the latest information if this option is selected.

<u>Strengthening Options</u>

- For the steel and concrete approaches, the typical members identified as deficient include the steel floor beams in segments 3, 5 and 6, concrete girders in segments 2 and 7, and concrete crossbeams in segment 2.
- The strengthening could be done by attaching reinforcing plates to the steel members and by providing Fibre-Reinforced Polymer (FRP)wraps for concrete members.

<u>Repair Options</u>

The elements identified as significantly deficient are listed below. Each could be repaired with typical procedures following a detailed inspection.

- Steel floorbeams at expansion joints in segments 3 and 5 are corroded.
- Concrete beams at expansion joints in segments 2 and 7 are corroded.
- Various other steel members exhibiting some corrosion.
- Structural steel in segments 3, 5 and 6 needs repainted.
- Many expansion joints in all segments are open or closed too far, with seal issues.
- Concrete box girder in Segment 1 has cracking and vehicular impact spalls
- Deck overlay is worn and is due for replacement.

There are also other minor deficiencies like scaling, deck soffit cracks, minor edge deformation of stiffener plates, damaged barrier and railing, spalled, cracked and delaminated concrete members, rusting of bearings, broken conduits with exposed cable and others.

This option assumes that the work on the approach bridges would include a deck rehabilitation to prolong their service life. This consists of milling and overlaying the existing concrete bridge decks along with spot repairs as required based on a detailed condition assessment. The open grid deck on the bascule bridge is not included in this assumption, as the latest inspection report indicates that it is in good condition with only minor deficiencies.

This scope of this study did not include evaluation of any strengthening or repairs to the NW Leary Way bridge as part of this alternative. This differs from the Mid-Level and High-Level alternatives, which replace this structure. SDOT may consider investigating improvements to the NW Leary Way bridge and approach retaining walls as part of future phases of this project if this alternative is selected, or as part of a separate project.

The widening and retrofit options presented in this study will need further review in future phases of project development to confirm that they are consistent with the requirements outlined in the Analysis of Potential Effects to Cultural Resources and/or Historic Properties Memo and subsequent historic preservation reviews.

Refer to Figure 3 in Attachment A for a preliminary site layout indicating the approximate structure limits. The existing Ballard Bridge crossing is comprised of eight distinct segments described north to south as follows:

- Segment 1 is north of NW 46th St and consists of Cast-In-Place (CIP) retaining walls for the mainline shown in 1935 record plans. This segment also includes CIP retaining walls for the adjacent ramps shown in 1957 record plans.
- Segment 2 is from the north side of NW 46th St to the south side of Shilshole Ave NW and consists of haunched CIP T-beams on 3-column piers for the mainline shown in 1935 record plans. This structure was widened with CIP box beams on single column piers for the adjacent ramps shown in 1957 record plans. The mainline pier between Shilshole Ave NW and NW 45th St is a single, skewed hammerhead column, with single columns for each ramp also placed along the skew.
- Segment 3 is from the south side of Shilshole Ave NW to the north side of the navigation channel and consists of a steel edge girder and floor beam system supported on 2-column piers as shown in 1935 record plans.
- Segment 4 is the bascule bridge over the navigation channel as shown in 1915 record plans.
- Segment 5 is from the south side of the navigation channel to the north side of the BNSF Railroad tracks along the south side of the ship canal and consists of a steel edge girder and floorbeam system on 2-column piers as shown in 1935 record plans.
- Segment 6 spans the railroad tracks and consists of steel edge girders with diagonal floor beams supported on wall piers as shown in 1935 record plans. The wall piers are skewed to follow the railroad Right-Of-Way (ROW).
- Segment 7 is from the south side of the railroad tracks to the north side of W Emerson St and consists of haunched CIP T-beams supported on 3-column piers as shown in 1935 record plans.
- Segment 8 is south of the bridge and consists of roadway supported on earth fill.

<u>Widening Options</u>

- Movable Bridge Widening Option:
  - The widening of the existing movable bridge is anticipated to consist of replacing the existing concrete sidewalk on the west side of the structure with a 14-ft wide, shared

use path. The new sidewalk structure could use lightweight material, such as FRP, to minimize the total weight change and impact to the transverse balance of the structure weight.

- For additional information and details on widening the sidewalk along the existing movable bridge span, see the Movable Bridge Alternatives technical memo in Attachment B.

- Approach Spans Widening Option:
  - Widening the existing sidewalks to either 10-ft on both sides or 14-ft on one side have been considered. The 14-ft wide SUP on the west side has been selected as the preferred option as it provides better connectivity to bike paths on both ends of the bridge and functions better as a two-way path than dual paths that are narrower. The sidewalk on the east side would also be widened to 6-ft to match the existing sidewalk width on the bascule span.
  - The sidewalk widening options have been developed to support pedestrian/bike loading only, and thus would require a new traffic barrier to separate the sidewalk from adjacent vehicular traffic.
  - Both the 10-ft and 14-ft sidewalk widening options would require a strengthening of the existing bridge. The use of lightweight materials, such as FRP decking, are anticipated for the sidewalk widening to minimize new structural demands on the existing bridge and minimize or eliminate the need for new foundations.
  - Figure 2.1.2 shows the sidewalk widening options for the approach spans over water. By keeping the additional superstructure as light as possible, it is feasible to get the additional sidewalk width without adding new columns and foundations, but instead supporting the new structural components off the existing piers. This study assumes that by keeping the mass increase below 10% of the original structure mass and not adding columns, this can be deemed a “Minor Widening” project as defined by typical WSDOT practice and would thus avoid triggering a seismic evaluation and retrofit of the entire structure. This assumption will need to be validated if this option moves forward for implementation.
  - Approach spans over land could use similar options for the superstructure, though the option for widening without the addition of new foundations does not appear feasible for the structure types in these segments. Simple columns (approximately 3-ft diameter) on single drilled shafts (approximately 5-ft diameter) may be sufficient to support the lightweight deck widening option, though detailed foundation analysis outside the channel was beyond the scope of this study.
  - The widenings could be achieved without any changes to current vertical clearances.
  - Figures 4, 4a and 4b in Attachment A show the widening options for other segments of the approach spans.
  - The ROW lines shown are assumed based on available data, as survey and detailed ROW investigation was not included as part of this study.

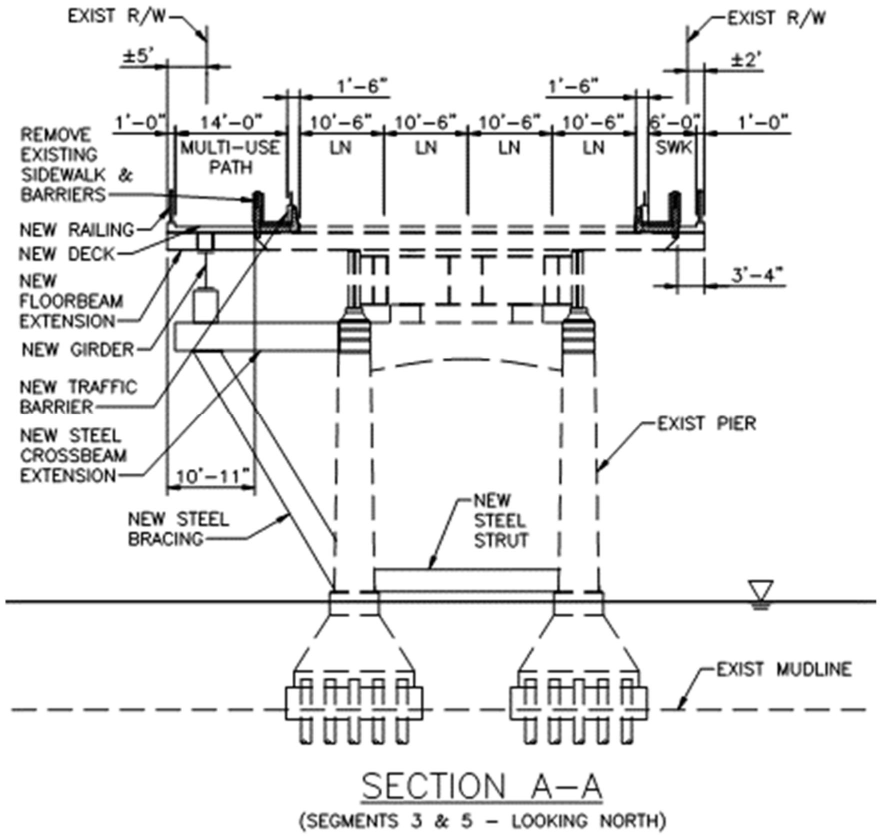


Figure 2.1.2 Low-Level Bridge Rehabilitation: Widening Option for Approach Spans Over Water

- Ballard Way Ramps Widening Option:
  - At the north end of the bridge, widening the existing sidewalks down the ramps to Ballard Way would require new CIP retaining walls to be built adjacent to the existing walls. The walls could be connected at the footing and with fin walls to create a bin style wall to reduce demands on the new wall, assuming the existing walls are in good condition as they visually appear to be. This option is an efficient and feasible structural solution.
  - Figure 4a in Attachment A shows the widening option for the Ballard Way ramps.

2.1.3 Low-Level Emerson-Nickerson Modified Single Point Urban Interchange (MSPUI) Bridge

The Emerson-Nickerson MSPUI consists of multiple structures as follows:

- Emerson-Nickerson: Most of the bridge alignment is curved, with radii that are tight enough to complicate a structure type with chorded concrete girders. Therefore, curved steel plate and/or post-tensioned concrete box girder bridges are the conventional type selection. Due to vertical and horizontal clearance constraints and the likelihood of needing staged construction, curved steel plate girders are assumed in this study. Piers would be located to accommodate spans over the South Ship Canal Trail, BNSF RR tracks, 15th Ave W, and the interchange ramps. With span lengths up to about 110-ft, a structure depth of 5-ft is anticipated to be sufficient.

- SB offramp: Most of this alignment is straight and is suitable for precast concrete girders with an integral cap on two column bents. With span lengths up to about 120-ft, a structure depth of approximately 6-ft is anticipated to be sufficient. The connection to the existing bridge is feasible as an option, but the details will need to be evaluated further in future studies.
- SB onramp: Due to the curved alignment, this bridge type is expected to be similar to the Emerson-Nickerson bridge until the roadway is closer to grade. The remaining portion of the ramp could be supported on retaining walls and at grade.
- NB onramp: This bridge is expected to be similar to the SB offramp structure.
- NB offramp: This ramp would be at grade and supported by retaining walls.

2.2 Mid-Level Bridge Structural Options

The mid-level option consists of the replacement of the existing low-level bridge with a mid-level bridge that has a profile at a higher elevation. The option still uses a movable bridge structure to span over the marine traffic channel. The mid-level option provides increased vertical clearance at the new movable bridge span in the down position, thereby reducing the number of required bridge openings and associated impacts to bridge traffic.

The mid-level replacement bridge includes five basic segments as shown in Figure 2.2.1:

- Movable Bridge Over Navigational Channel
- Approach Bridges Over Water and Land
- Emerson-Nickerson Modified Single Point Urban Interchange (MSPUI) Bridge
- Ramp Bridges to and from NW Leary Way
- Approach Embankments

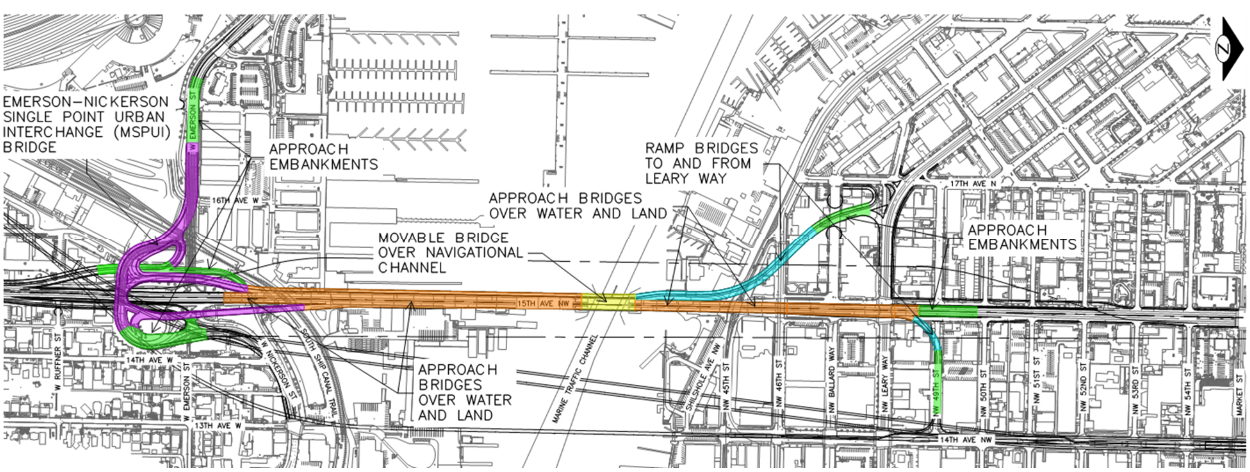


Figure 2.2.1 Mid-Level Bridge Replacement: Segment Map

Refer to Figure 5 in Attachment A for a preliminary site layout indicating the assumed structure limits. This alternative requires a detour route with temporary bridge, which is discussed further in Section 3.2. See Figure 2.2.2 for a representative cross-section of the mid-level bridge option, which is shown for the approach bridges over water.

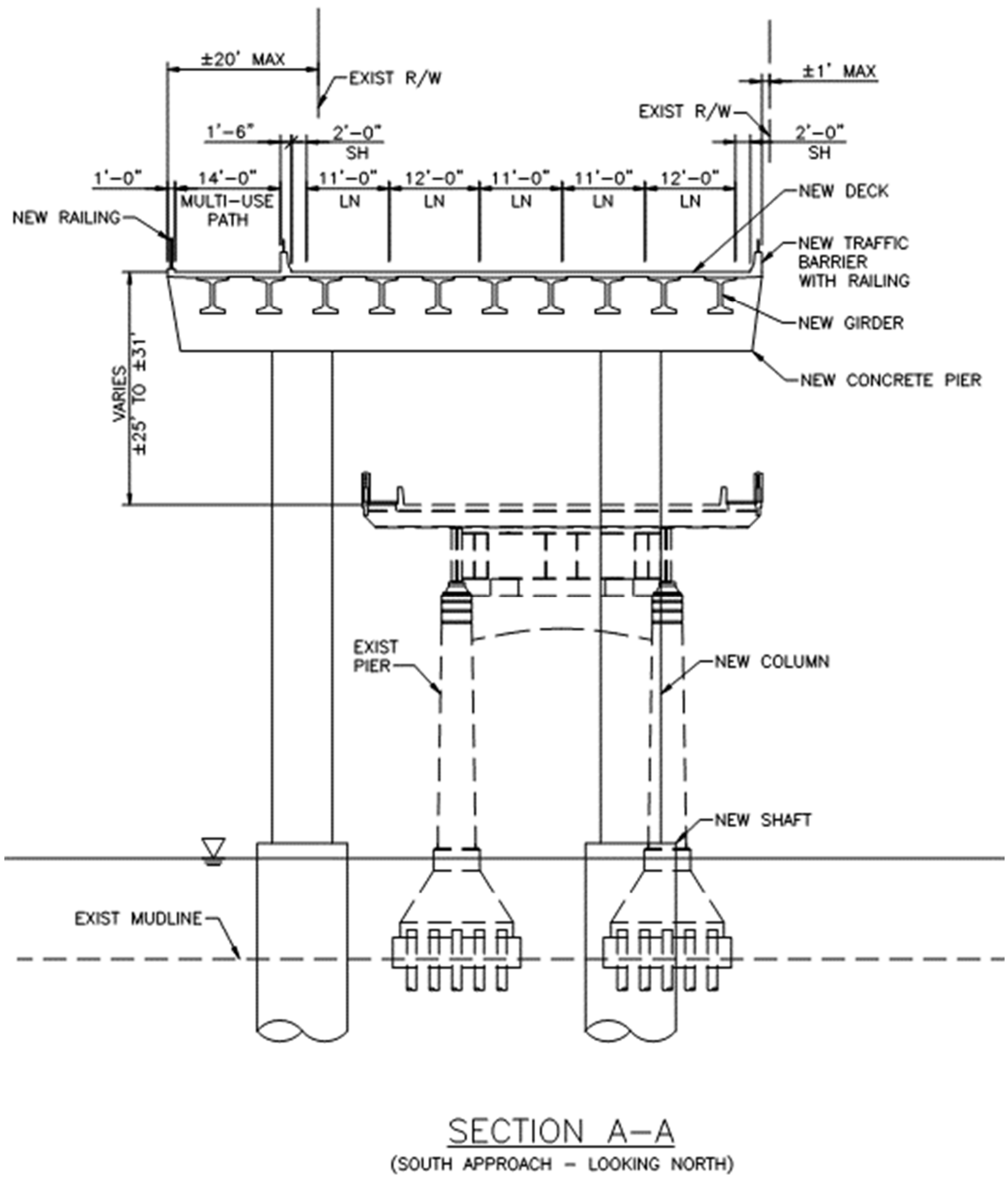


Figure 2.2.2 Mid-Level Bridge Structural Option: Approach Spans over Water

2.2.1 Mid-Level Movable Bridge

Both bascule and vertical movable bridge types were considered as part of this study. The vertical movable bridge type was discarded due to the limited vertical clearance that it could provide in its open position. A bascule bridge, providing a vertical clearance of about 65 feet when closed and sized to maintain the current horizontal limits of the navigational channel, has been included as the preferred option.

See the Movable Bridge Alternatives technical memo in Attachment B for additional information and details on the new movable bridge of the mid-level option.

2.2.2 Mid-Level Approach Bridges Over Water

The approach bridges over water to the immediate south and north of the movable bridge for the mid-level option are anticipated to be girder-type bridges, with typical spans of approximately 150-ft with a structure depth of approximately 7-ft. This bridge would likely consist of multiple units of typical prestressed concrete girders with concrete deck on integral concrete crossbeams. Three-span units with expansion joints at each end are assumed in this study, with spans adjusted to fit site constraints. Future studies should look to minimize bearings and joints when determining pier locations and bridge units. The superstructure could be supported by large diameter concrete columns (approximately 8-ft diameter) supported on large diameter drilled shafts (approximately 10 to 12-ft diameter). Per the geotechnical engineering letter report performed for this study, this bridge type is anticipated to require shafts that extend approximately 120-ft below the water surface level for much of the south approach and approximately 90-ft below the water surface level for the north approach. Figures 6a and 6c in Attachment A show the options for other segments of the approach spans.

2.2.3 Mid-Level Approach Bridges Over Land

The approach bridges over land for the mid-level option are anticipated to be girder-type bridges, with typical spans of approximately 120-ft on the north and south shores of the channel. Piers would be located to not interfere with grade-level undercrossing streets, railroads and trails. Piers for the north approach would also have columns spaced to facilitate a lower-level 15th Ave NW roadway from Shilshole Ave NW to NW Leary Way. Utility investigation was not included as part of this study but will need to be completed to determine preferred pier locations and/or required utility relocations. This bridge would be similar in structure type to the approach bridges over water, but with shorter unit lengths and a structure depth of approximately 6-ft. Multiple columns on single drilled shafts are assumed for each pier, with smaller diameter and shallower depth than the spans over water. Figures 6b and 6d in Attachment A show the options for other segments of the approach spans.

2.2.4 Mid-Level Emerson-Nickerson Modified Single Point Urban Interchange (MSPUI) Bridge

The basic concept for these bridge structures would be the same as the low-level rehabilitation (see Section 2.1.3). The Emerson-Nickerson bridge and 15th Ave W roadways are at a similar elevation for the mid-level option as the low-level option, but the SB offramp and NB offramp have different tie-in points where they connect to the mainline north of the intersection.

2.2.5 Mid-Level Ramp Bridges to NW Leary Way

The ramp bridges to NW Leary Way consist of multiple structures as follows:

- SB offramp: This ramp would be at grade with some retaining walls.
- SB onramp: Most of this alignment is straight and is suitable for precast concrete girders with an integral cap on a single column. Piers would be located to accommodate spans over Shilshole Ave NW and NW 46th St. With span lengths up to about 120-ft, a structure depth of approximately 6-ft is sufficient.

- NB onramp: This ramp/entrance would be at grade.
- NB offramp: The elevated portion of this ramp is curved with radii that are too tight to allow chorded precast concrete girders to be efficient. Therefore, curved steel plate and/or post-tensioned concrete box girders would be the conventional type selection. With fewer vertical and horizontal clearance constraints at this site, a cast-in-place post-tensioned concrete box girder is assumed in this study. With span lengths up to about 110-ft, a structure depth of 5-ft is sufficient.

2.2.6 Mid-Level Approach Embankments

There are six distinct locations of retained embankment at the end of bridges:

- South end of mainline bridge (including Emerson-Nickerson ramps)
- North end of mainline bridge (including NW Leary Way ramps)
- West end of Emerson-Nickerson bridge
- East end of Emerson-Nickerson bridge
- North end of SB ramp from NW Leary Way
- East end of NB ramp to NW Leary Way

Structural earth wall or Geofoam embankments have been considered for each of these locations, with the preferred embankment type dependent on soil settlement and underground infrastructure protection. Settlement and utility investigation were beyond the scope of this study and will need considered if this option advances. Figure 6b in Attachment A shows the concept for north end of the mainline bridge.

2.3 High-Level Bridge Structural Options

The high-level bridge option consists of the replacement of the existing low-level bridge with a high-level fixed bridge that would provide vertical clearance of about 150 feet over the navigation channel. This vertical clearance would allow for continuous, unimpeded flow of maritime and bridge traffic, similar in concept to the Aurora Bridge. The height selected is such that the existing bascule could fit inside the proposed clearance envelope during the majority of the construction of this option to facilitate phased construction.

The high-level replacement bridge includes five basic segments as shown in Figure 2.3.1:

- Fixed Bridge Over Navigational Channel
- Approach Bridges Over Water and Land
- Emerson-Nickerson Modified Single Point Urban Interchange (MSPUI) Bridge
- Ramp Bridge to NW Leary Way
- Approach Embankments

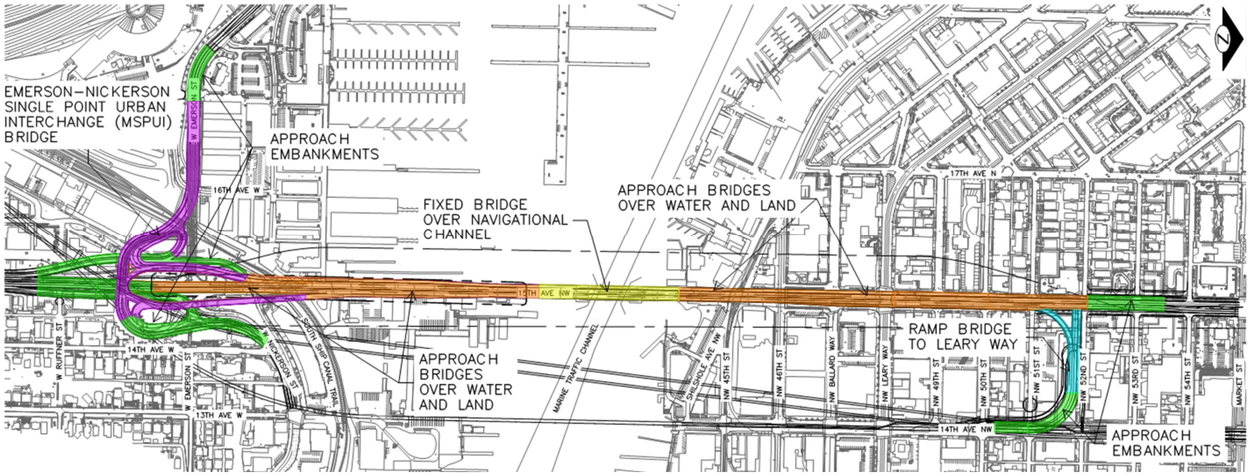


Figure 2.3.1 High-Level Bridge Replacement: Segment Map

Refer to Figure 7 in Attachment A for a preliminary site layout indicating the assumed structure limits. See Figure 2.3.2 for a representative cross-section of the high-level bridge option, which is shown for the approach bridges over water.

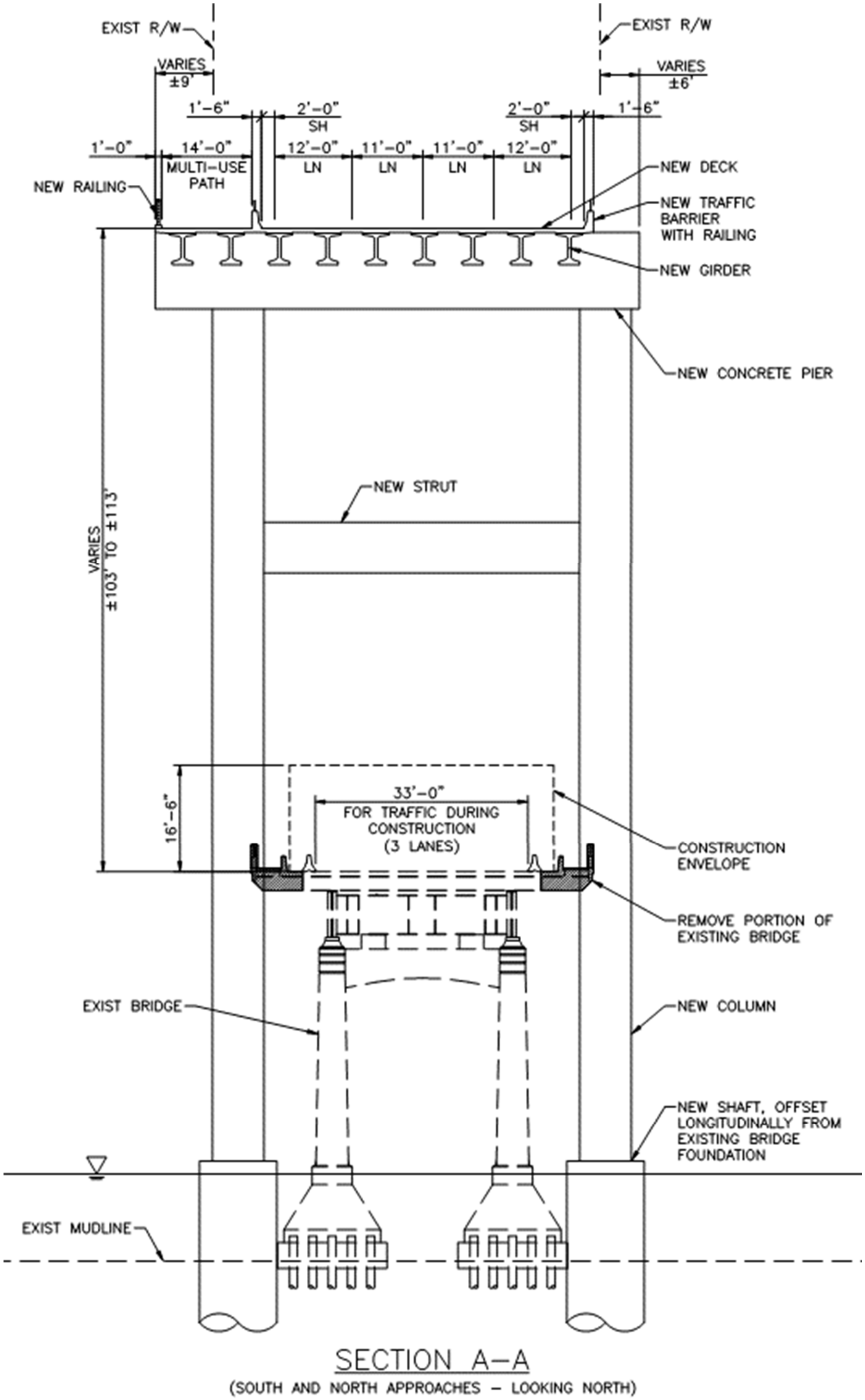


Figure 2.3.2 High-Level Bridge Structural Option: Approach Spans over Water

2.3.1 High-Level Main Span Bridge Over Navigational Channel

The main span over the navigation channel would be a long-span fixed bridge. Several bridge type options have been considered including:

- Steel Arch
- Cable-Stayed
- Concrete Segmental

Figures 2.3.3 and 2.3.4 show representative elevations and sections for these main span options. Each option has positives and negatives that will need evaluated in further studies before determining which structure type to progress. Each is constructible with a group of large diameter drilled shafts at each pier. With each of these options, a structure depth of approximately 10-ft over the main channel is sufficient.

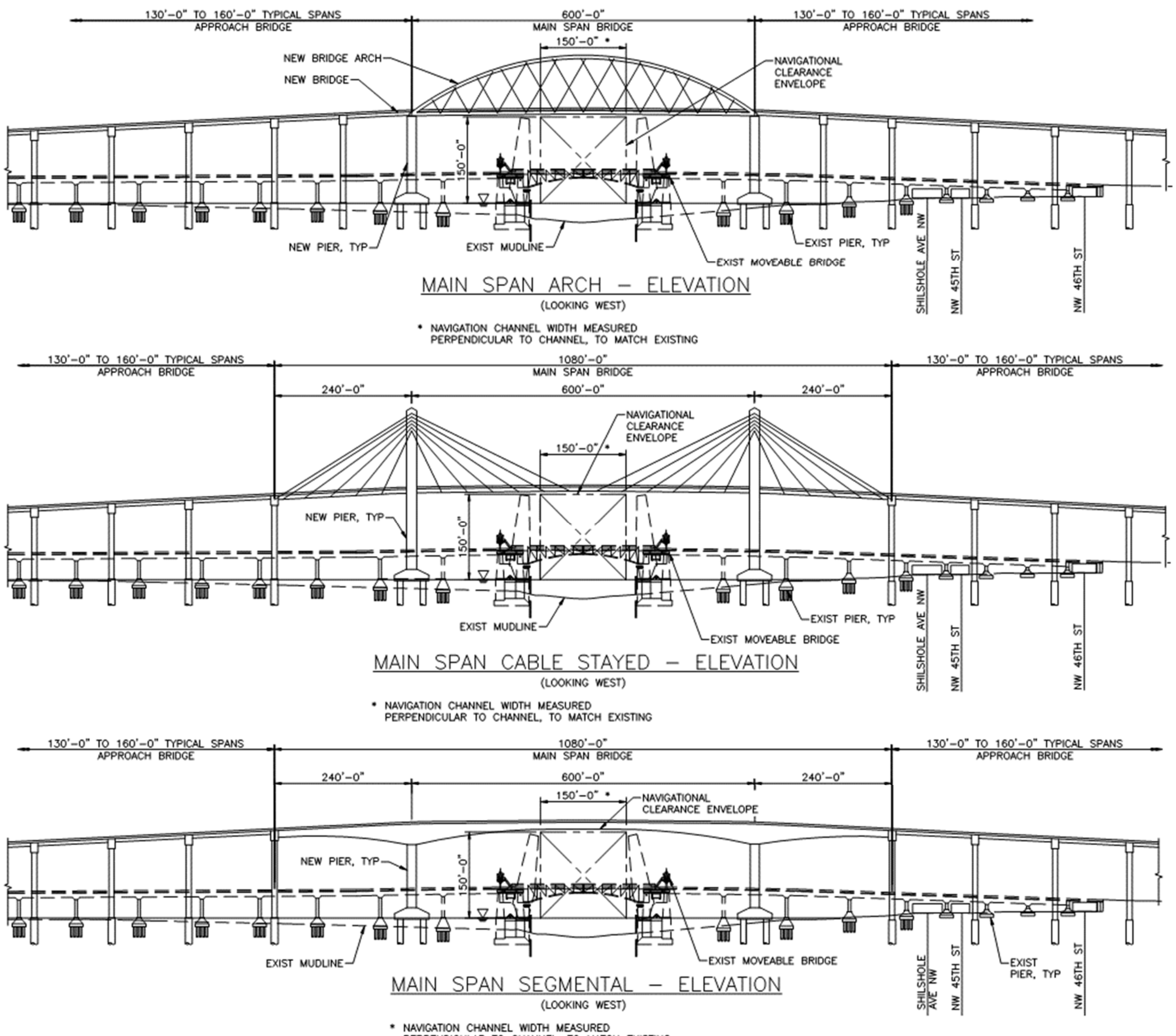


Figure 2.3.3 High-Level Bridge Structural Option: Main Span Elevations

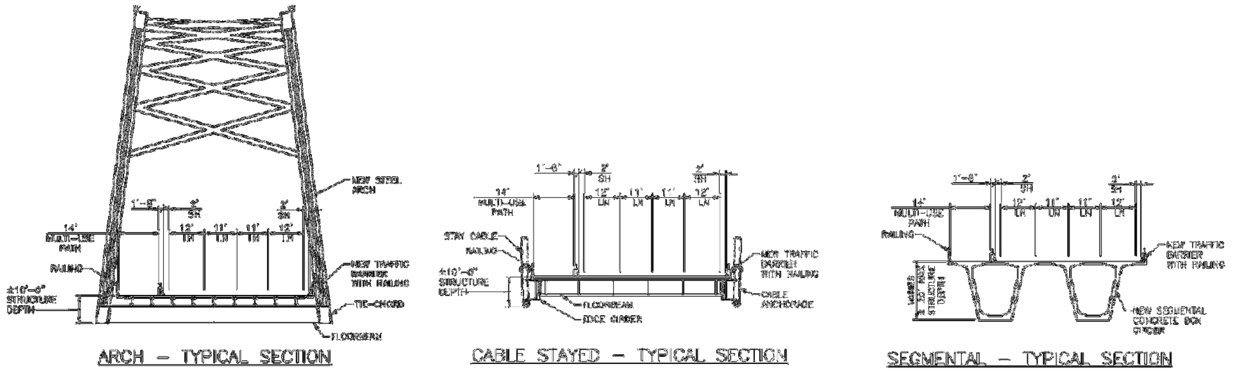


Figure 2.3.4 High-Level Bridge Structural Option: Main Span Cross-Sections

2.3.2 High-Level Approach Bridges Over Water

These bridge structures would be similar to those for the mid-level replacement option (see Section 2.2.2). However, they would have longer spans and larger columns near the main span due to the increased height. A steel girder superstructure should be considered in future studies as a means to lengthen units and potentially reduce foundation requirements. The columns would be spaced transversely to fit outside the existing bridge, with the sidewalk overhangs removed. The wide column spacing may lead to a post-tensioned cap beam being attractive to reduce depth and thus weight. Figure 9c in Attachment A shows the concept for other segments of the approach spans.

The horizontal alignment of a new high-level bridge crossing is anticipated to match the alignment of the existing crossing. These structure types would allow the proposed bridge to constructed over the top of the existing bridge while it remains in service.

2.3.3 High-Level Approach Bridges Over Land

These bridge structures would be similar to that for the mid-level replacement option (see Section 2.2.3), though with more spans, taller columns, and a longer total length. Piers for the north approach would also have columns spaced to facilitate a lower-level 15th Ave NW roadway from Shilshole Ave NW to NW 51st St. Utility investigation was not included as part of this study but will need to be completed if this option advances to determine utility relocation or pier location requirements. A structure depth of approximately 6-ft is sufficient. Figures 9a, 9b, and 9d in Attachment A show the concepts for other segments of the approach spans.

Two-column piers, similar to the approach spans over water, would be used for the majority of the bridge length until the vertical clearance is no longer sufficient to build the new structure over existing. At this point and beyond, multiple columns on single drilled shafts are assumed for each pier, with smaller diameter and shallower depth than the spans over water.

2.3.4 High-Level Emerson-Nickerson Modified Single Point Urban Interchange (MSPUI) Bridge

The basic concept for these bridge structures would be the same as the mid-level replacement (see Section 2.2.4). Longer structures with taller columns would be required due to the increased height of the intersection.

2.3.5 High-Level Ramp Bridge to NW Leary Way

The ramp bridge to NW Leary Way would consist of a single structure as follows:

- A single structure would carry the NB offramp and SB onramp. The elevated portion of this ramp is curved with radii that are too tight to allow chorded prestressed concrete girders to be efficient. Therefore, curved steel plate and/or post-tensioned concrete box girders would be the conventional type selection. With fewer vertical and horizontal clearance constraints at this site, a cast-in-place post-tensioned concrete box girder is assumed in this study. Pier columns would be spaced to accommodate a lower-level NW 51st St underneath the structure. With span lengths up to about 110-ft, a structure depth of 5-ft is sufficient.
- SB offramp: This ramp would be at grade, with some retaining walls.
- NB onramp: This ramp/entrance would be at grade.

2.3.6 High-Level Approach Embankments

There are five distinct locations of embankment at the end of bridges:

- South end of mainline bridge (including Emerson-Nickerson ramps)
- North end of mainline bridge (including NW Leary Way ramp)
- West end of Emerson-Nickerson bridge
- East end of Emerson-Nickerson bridge
- South/East end of ramp at NW Leary Way

Structural earth wall or Geofoam embankments have been considered for each of these, with the preferred embankment type dependent on soil settlement and underground infrastructure protection. Settlement and utility investigation were beyond the scope of this study and will need considered if this option advances. Figures 9b and 9e in Attachment A show the concepts for the north and south ends of the mainline bridge, respectively.

2.4 Tunnel Structural Options

A tunnel option was considered at the screening level as part of this study. This option would require an alignment that extends through competent soils below the navigation channel, then rises up at 5% maximum longitudinal slope beyond the waterway until it reaches grade. As a viable option, a tunnel was ruled out from further consideration for a number of reasons, including:

- It cannot accommodate pedestrians and cyclists, nor freight with hazardous materials (considered a fatal flaw on this corridor).
- The connection points back to grade are in the vicinity of W Dravus St at the south end and NW Market Street at the north end, omitting critical connections at Emerson-Nickerson and NW Leary Way.
- The connections and launch pits for tunneling equipment must be located on the existing alignment to tie into 15th Ave W/NW, which cannot be built while maintaining traffic on 15th Ave W/NW.
- The tunnel must be large enough to accommodate four lanes of traffic, plus shoulders.

Potential conflicts with utilities and other underground structures has not been studied and could also prove to present project challenges.

3 Constructability

Several constructability challenges have been identified for the Ballard Bridge Planning Study, including:

- Maintaining maritime traffic during construction.
- Maintaining 15th Ave W/NW bridge traffic during construction.
- Maintaining Emerson-Nickerson bridge traffic during construction.
- Maintaining traffic connections to 15th Ave W/NW at each end of the project (specifically W Emerson St, W Nickerson St, and NW Leary Way).
- Maintaining existing undercrossing facilities (specifically NW 46th St and Shilshole Ave NW at north end and BNSF RR, SB Onramp and Ship Canal Trail at south end).
- Heavy civil construction in a dense urban environment as well as construction on water.
- Limited ability to obtain construction easements.

This list is not all-inclusive, and future work will need to be completed to vet these challenges and identify other constructability issues. The following section discusses some of the unique construction details of the considered structural options.

3.1 Low-Level Bridge Rehabilitation Constructability

- Movable Bridge
  - The west sidewalk would need to be closed during construction.
  - Mechanical and electrical upgrades may require keeping the bridge in its closed position for several days.
  - See the Movable Bridge Alternatives technical memo in Attachment B for additional constructability information and details regarding the movable bridge.
- Approach Spans over Water
  - Sidewalk widening on the west side would require closing the west sidewalk, and temporary closure of the westernmost traffic lane. In this condition, bridge traffic would be limited to the following:
    - Pedestrians and cyclists would be restricted to the east sidewalk only.
    - Vehicular traffic would have 3 lanes available. The center lane could be made to be reversible to accommodate peak am and pm flow directions.
  - Sidewalk widening on the east side would require similar staging after construction on the west side is substantially completed.
  - Temporary concrete barrier is expected to be used to protect the work zone on the approach bridges, with barrels or other lighter types on the bascule span. The work on the bascule span would need to be tightly scheduled around any required openings. Further temporary lane closures would likely be required for the delivery of materials (ie. nightly girder placement).
  - In addition to the permanent property takes or air rights agreements, a construction easement of approximately 20 feet on each side of the existing bridge would be

required. It is anticipated that the construction for the bridge spans over water would be performed from the deck as well as from the water below.

- Approach Spans over Land
  - Traffic restrictions and protections on the bridge would be similar to the approach spans over water.
  - Construction easements would also be similar to the approach spans over water. Much of the approach spans over land could be built from the ground below, particularly the piers and their foundations. Some spans, such as the BNSF RR crossing, may require more work from the deck level, which would likely necessitate nightly lane closures. Traffic on Shilshole Ave NW and NW 46th St at the north end and the SB onramp and Ship Canal Trail at the south end would likely require lane restrictions or relocations during pier construction.
- The frontage road on the west side of 15th Ave NW between NW 46th St and NW Ballard Way may need to be closed temporarily to construct the new retaining wall and frontage road with standard construction methods. There appears to be adequate space within the ROW for a single lane to be maintained throughout construction with adequate staging and temporary roadway work.
- The Emerson-Nickerson bridge is only one lane in each direction where it crosses over 15th Ave W. It is a multi-girder structure type that would allow staged construction, but due to site constraints, it is only possible to maintain just a single lane with a flagger at each end alternating traffic in each direction. This would require the south half of the new bridge to be constructed first, prior to switching traffic. Traffic studies have shown that a full shutdown of this structure has significant impacts and detour routes that rely on local connections with inadequate capacity. Future studies could consider additional ROW takes to allow the proposed structure to be built offline in order to maintain traffic on the existing bridge.
- It is feasible to build the ramps for the Emerson-Nickerson MSPUI offline while maintaining traffic on undercrossing roads. The SB offramp has adequate clearance to span over the existing W Nickerson St connection to 15th Ave W. Work would have to be staged to allow equipment access and material deliveries.

3.2 Mid-Level Movable Bridge Constructability

With the conceptual alignment and profile for the mid-level movable bridge replacement alternative, traffic cannot be maintained on the existing bridge during construction. The existing bridge is not wide enough and does not have a structure type that would facilitate a staged sequence to build half structure at a time in order to maintain at least 2 lanes of traffic (1 each direction).

- This alternative would require the construction of a new, temporary bridge structure to cross the canal. This detour bridge would conceptually consist of low-level approach structures and a movable bridge span over the navigation channel. A conceptual layout is shown in Figure 3.2 for reference.

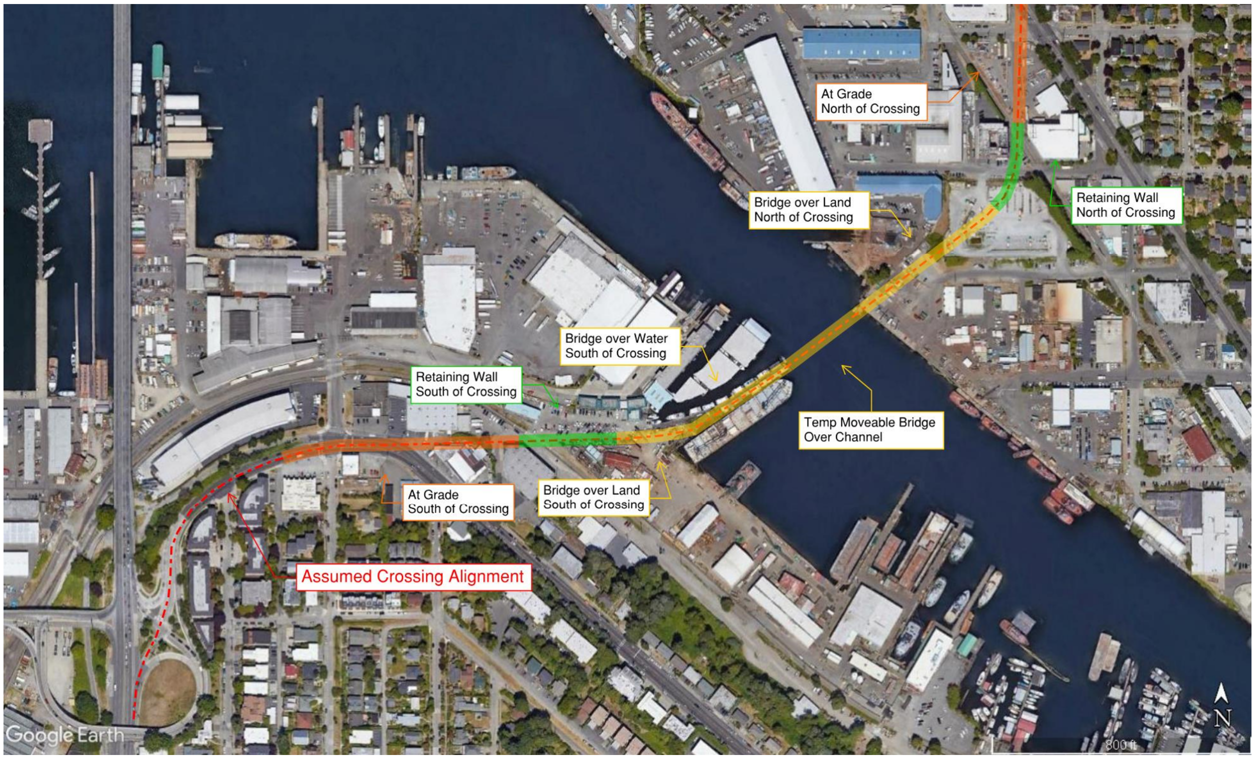


Figure 3.2 Temporary Detour Bridge Concept

- This temporary detour crossing would be used to divert traffic from the existing bridge, which would be demolished and replaced by the new mid-level bridge on the same alignment.
  - See the Movable Bridge Alternatives technical memo in Attachment B for additional constructability information and details regarding the movable bridge.
  - A temporary movable bridge for the length of span required at this site is likely restricted to a vertical lift type. The vertical clearance under the bridge in the open position may be restricted to approximately 100-ft at this structure, based on prior projects with similar structures and current temporary bridge industry capabilities. Future studies must evaluate the feasibility of this solution.
  - An alternative was considered which would shift the alignment at the navigation span to allow the movable bridge to be built offline, while minimizing ROW impacts. This option would allow traffic to be kept on the existing bridge during the construction of the new movable bridge, shortening the duration of the detour for closure of 15th Ave W/NW. This also simplifies construction of the new movable bridge by avoiding conflicts with existing foundations, effectively removing this complicated structure from the critical path for construction schedule. This solution does not eliminate the need for the detour bridge and was not deemed to have enough benefits to outweigh the additional property takes that would be required.
  - A shifted alignment for the full length of the Ballard Bridge (from W Emerson St to NW 46th Ave) was not considered as part of this study. It would allow the full bridge to be

built offline while maintaining traffic on the existing structure but would have significant property impacts.

- Demolition of the existing bridge could be done from the water with limited impacts on adjacent facilities in this option.
- The approach bridges over land and water would be built after demolishing the existing bridge in this scenario. With an open site, the Contractor would have the flexibility to use the most efficient means and methods to construct the new bridge for any structure type selected.
- The Emerson-Nickerson MSPUI structures have similar Maintenance Of Traffic (MOT) issues as the low-level option.
- Close NW 49th St between 14th Ave NW and 15th Ave NW for construction of the new NB off-ramp with standard construction methods. If required, limited local access could be maintained by constructing temporary pavement and using intermittent closures within the limits of ROW acquisition.
- Close Ballard way between 15th Ave NW and 17th Ave NW for construction of the new SB on-ramp with standard construction methods. The SB onramp bridge over NW 46th St and Shilshole Ave NW could be built with standard methods, assuming night closures for girder placement.
- Future studies could consider raising the profile by another ~10-ft to allow the new approach spans over water and land to be built above the existing bridge while it remains in service. The concept for this scheme is similar to the high-level option discussed in section 3.3. Raising the profile would have impacts to the tie-ins, particularly to the ramps at NW Leary Way, which may significantly detract from the constructability benefits.

3.3 High-Level Fixed Bridge Constructability

The horizontal alignment for the new high-level fixed bridge would be the same as the existing bridge.

- The new profile is high enough for the mainline to be built over the existing bridge for the full length, with the tie-ins at both north and south ends being over existing roadway at grade. Between the tie-ins, it would be possible to build approximately 4,100-ft of the new bridge structures while traffic is maintained on the existing bridge. Other projects have used similar techniques to maintain traffic during construction, such as the recent Bayonne Bridge project in New York. Special measures would be required to protect traffic from overhead construction activities on the new structures. Girder erection and other critical steps would be performed at night with temporary closures.
- The main span structure could be built over the existing bascule bridge while it remains in service. For example, the segmental and cable-stayed options could be completed using balanced cantilever construction by lifting segments from the water adjacent to the bridge, leaving the space directly below the bridge open.

- Staged construction could be used for the tie-ins at each end. The south tie-in would be about 900-ft long, starting at the south end of the existing bridge. The north tie-in would be about 700-ft long, starting just north of 51st St. The concept involves shifting existing traffic to the east half of the existing road, while the bridge and walls are built on the west half. Once complete, traffic is moved to the west half, where it would then go across the newly built bridge while the east half is constructed. There appears to be sufficient space at each tie-in to maintain 2 lanes of traffic (one in each direction) at all times. Further studies should investigate if 3 lanes of traffic (one lane each direction, plus one reversible lane for peak traffic volume direction) could be accommodated.
- The Emerson-Nickerson MSPUI structures have similar MOT issues as the mid-level option, with the added complexity of all roads being raised in elevation at the interchange.
- Close 52nd St between 14th Ave NW and 15th Ave NW for construction of the new ramp bridge with standard construction methods. If required, limited local access could be maintained by constructing temporary pavement and using intermittent closures within the limits of ROW acquisition.
- Partial closure of 14th Ave NW between NW Leary Way and NW 51st St for construction of new ramp walls with standard construction methods. Roadway work including temporary paving and removal of existing parking could be staged to maintain 2 lanes (1 each direction) at all times. Future studies should coordinate with Sound Transit in this vicinity if light rail facilities are planned to be constructed in this corridor.

As an alternative to this scheme, a temporary detour bridge could be constructed to allow much of the mainline to be built without any traffic underneath it. The basic concept of this option is the same as for the mid-level replacement; see Section 3.2.

Attachment A – Conceptual Figures

Figure 1 = Existing Layout

Figure 2 = Existing Bridge Approach Spans

Figure 3 = Low-Level Rehabilitation Layout

Figures 4, 4a, 4b = Low-Level Rehabilitation Approach Spans

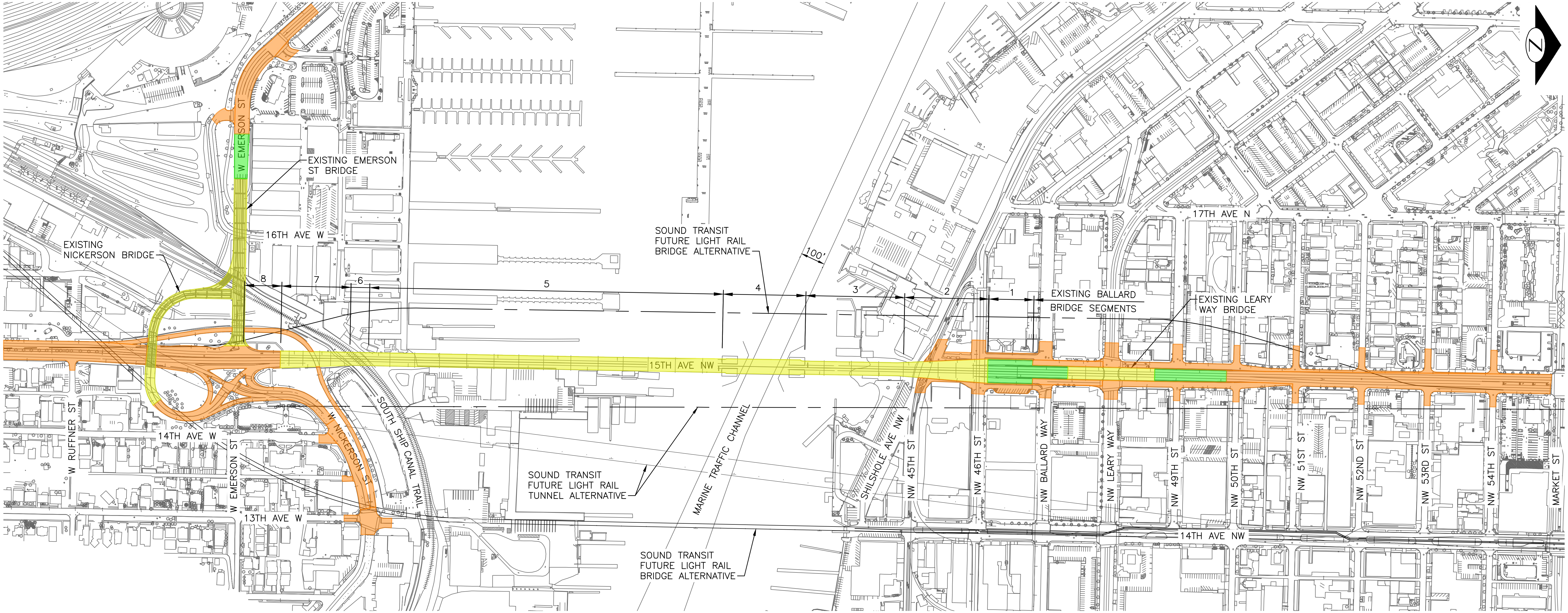
Figure 5 = Mid-Level Replacement Layout

Figures 6, 6a, 6b, 6c, 6d = Mid-Level Replacement Approach Spans

Figure 7 = High-Level Replacement Layout

Figure 8 = High-Level Replacement Main Span Bridge Concepts

Figures 9, 9a, 9b, 9c, 9d, 9e = High-Level Replacement Approach Spans



EXISTING LAYOUT

LEGEND:

- AT GRADE
- BRIDGE
- RETAINING WALL

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE PLANNING STUDY
SEATTLE, WA

EXISTING LAYOUT

FIGURE 1

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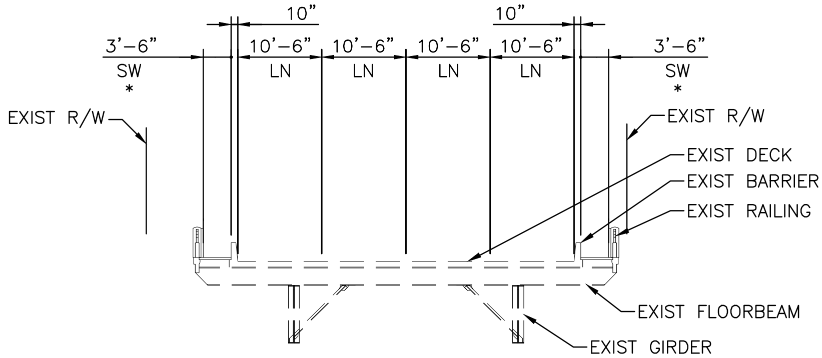
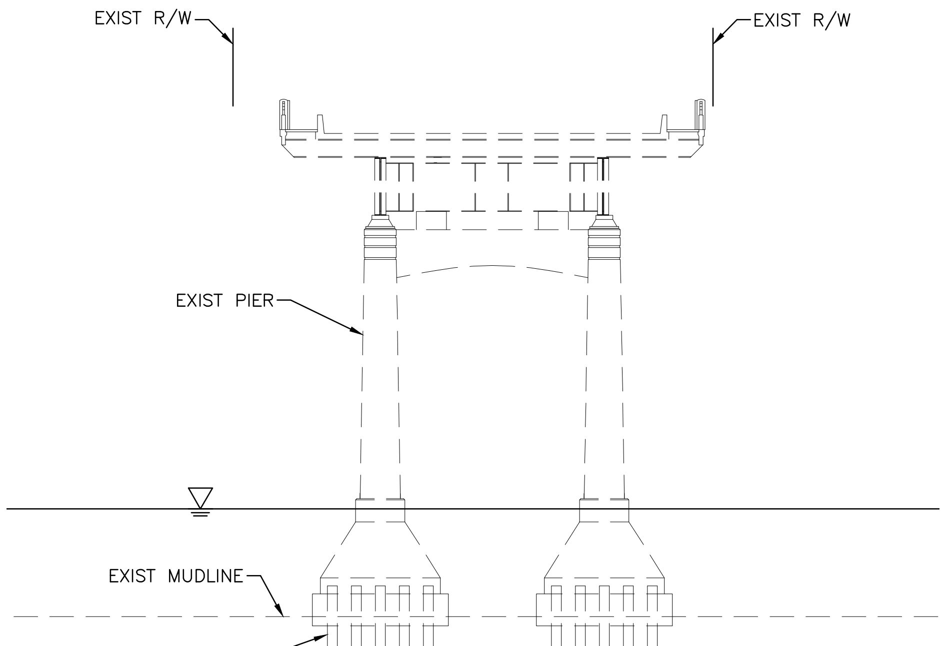


EXISTING TYPICAL SECTION

* MIN SIDEWALK WIDTH AT
LIGHT POLE PILASTER



EXISTING TYPICAL PIER

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SEATTLE, WA

EXISTING BRIDGE
APPROACH SPANS

FIGURE
2

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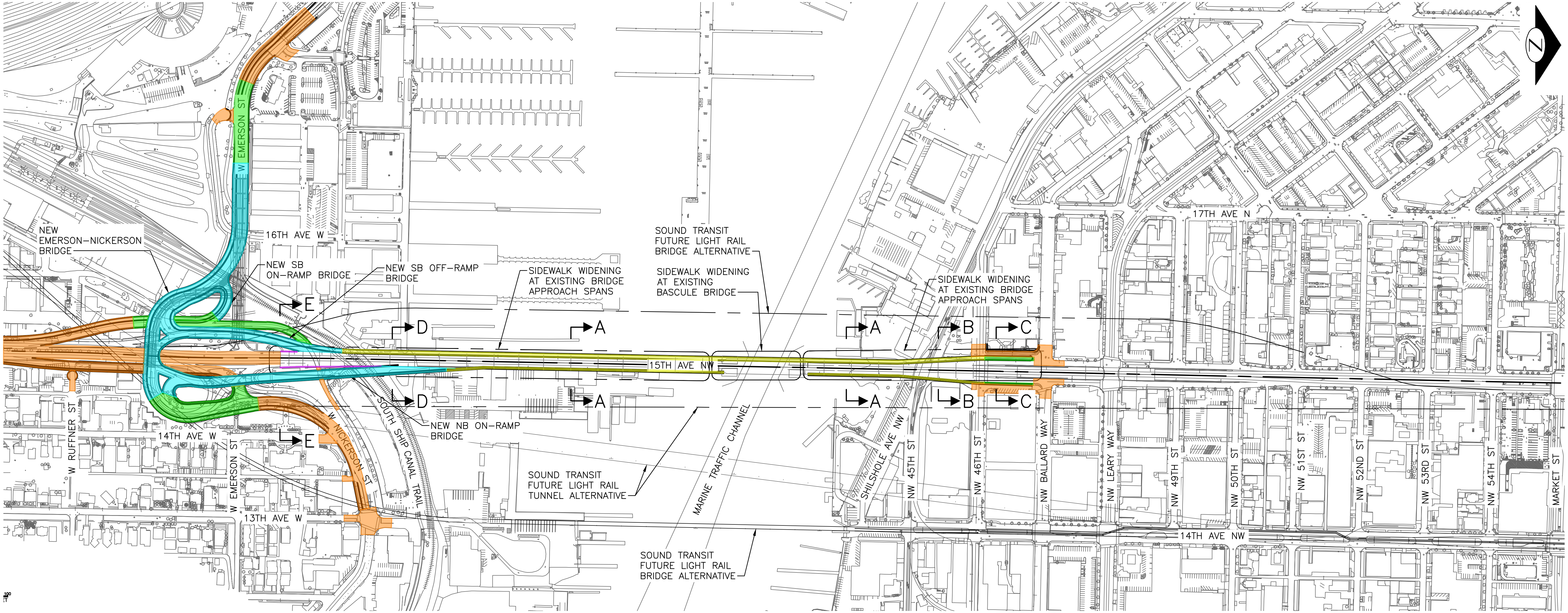
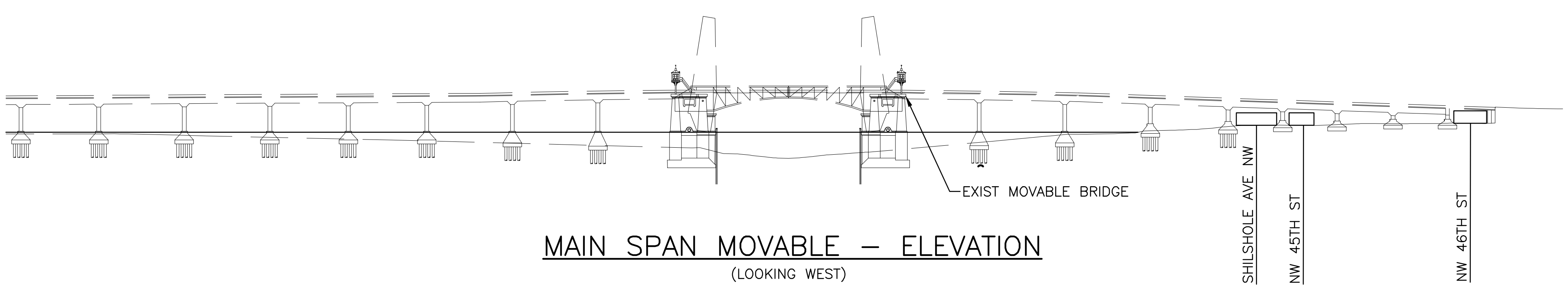


LOW LEVEL REHABILITATION LAYOUT



MAIN SPAN MOVABLE – ELEVATION

(LOOKING WEST)

LEGEND:

- AT GRADE
- BRIDGE WIDENING
- NEW BRIDGE
- RETAINING WALL
- BRIDGE OVERHANG REMOVAL

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Nov-15-19 3:02pm

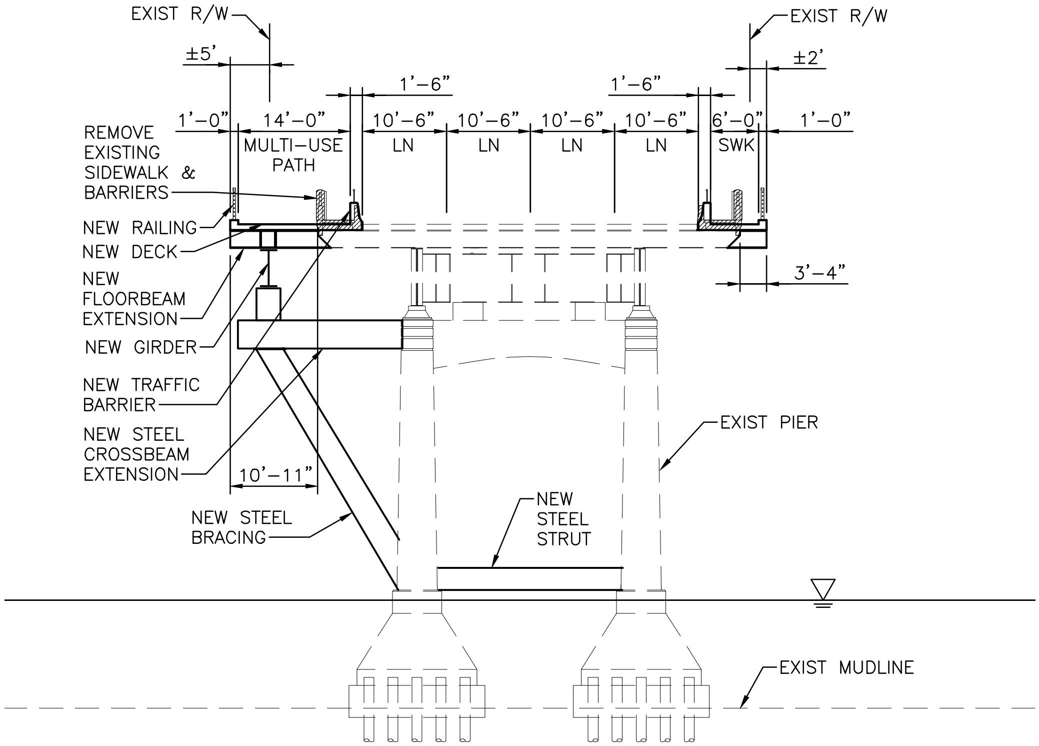
COWI

City of Seattle
Seattle Department of Transportation
ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE PLANNING STUDY
SEATTLE, WA

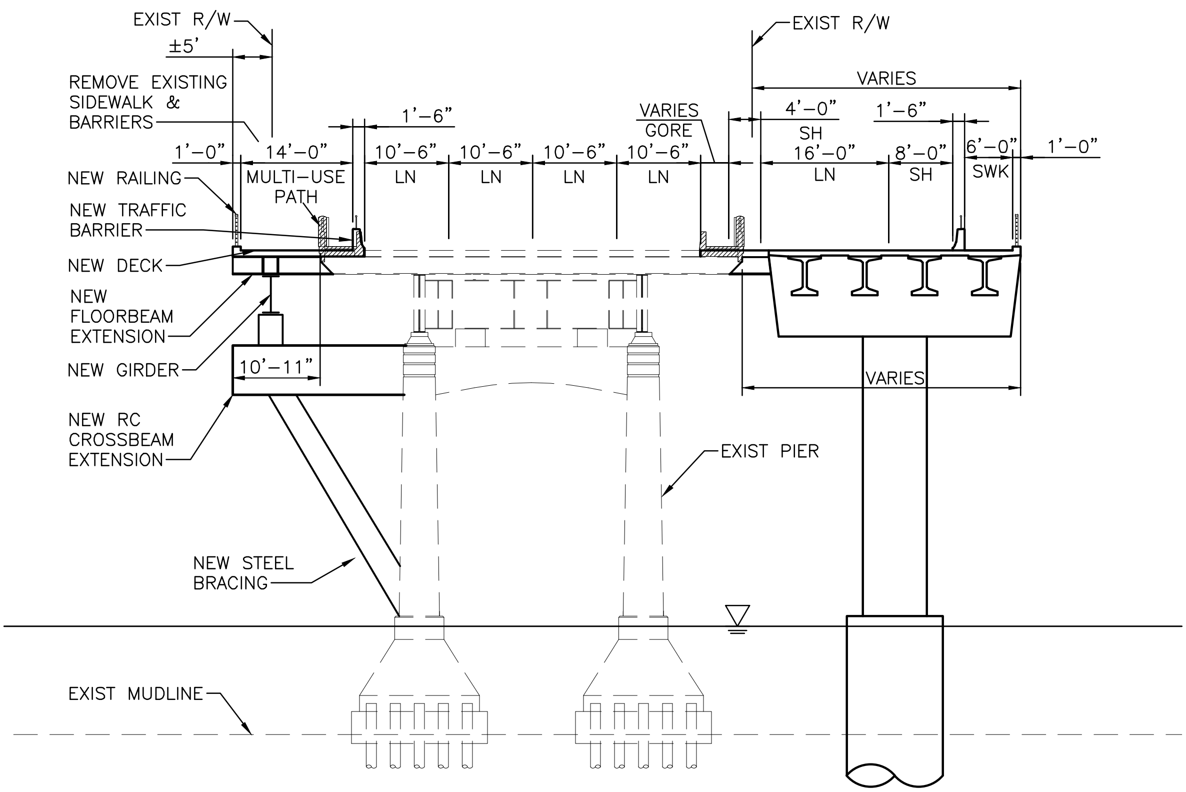
LOW–LEVEL REHABILITATION LAYOUT

FIGURE 3



SECTION A–A

(SEGMENTS 3 & 5 – LOOKING NORTH)



SECTION D–D

(SEGMENT 5 AT PIER 21 – LOOKING NORTH)

COWI

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FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

LOW–LEVEL REHABILITATION
APPROACH SPANS
14 FT MUP WEST SIDE, 6' SIDEWALK EAST SIDE

FIGURE
4

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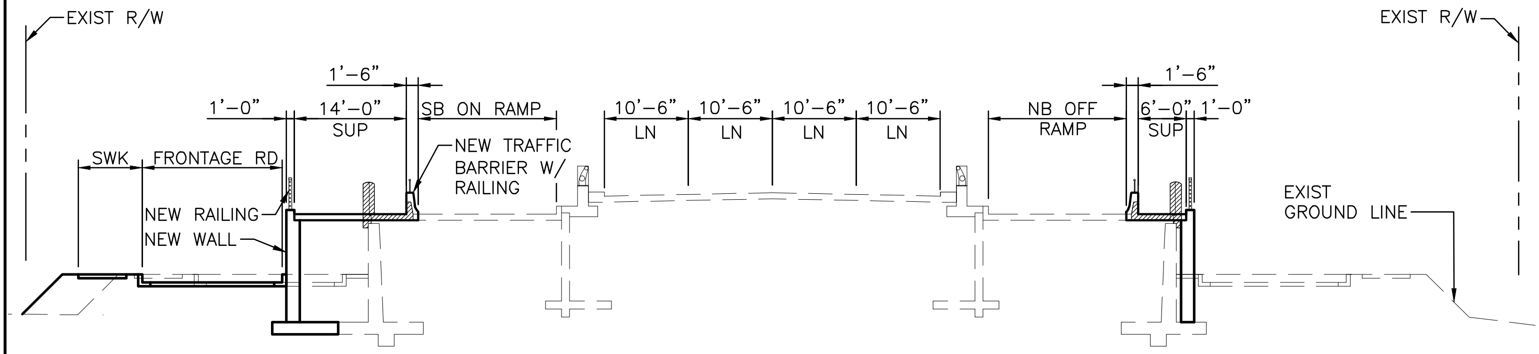
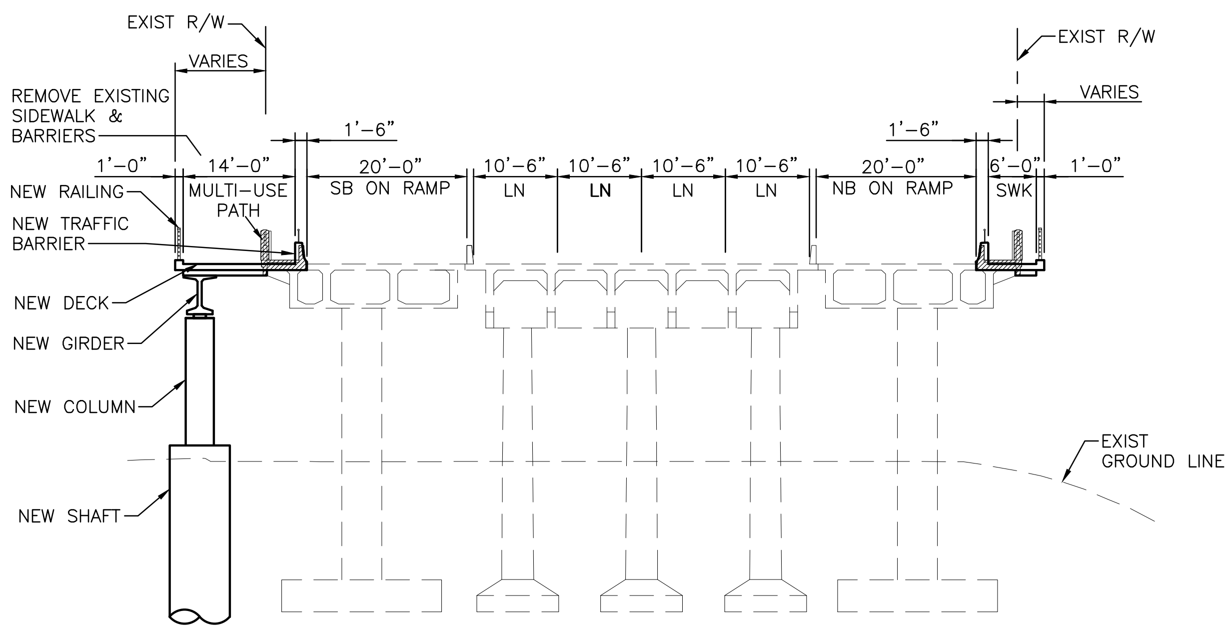


SECTION C–C

(SEGMENT 1 – LOOKING NORTH)



SECTION B–B

(SEGMENT 2 AT PIER 3 – LOOKING NORTH)

COWI

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Seattle Department of Transportation

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FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

LOW–LEVEL REHABILITATION
APPROACH SPANS
14 FT MUP WEST SIDE, 6' SIDEWALK EAST SIDE

FIGURE 4a

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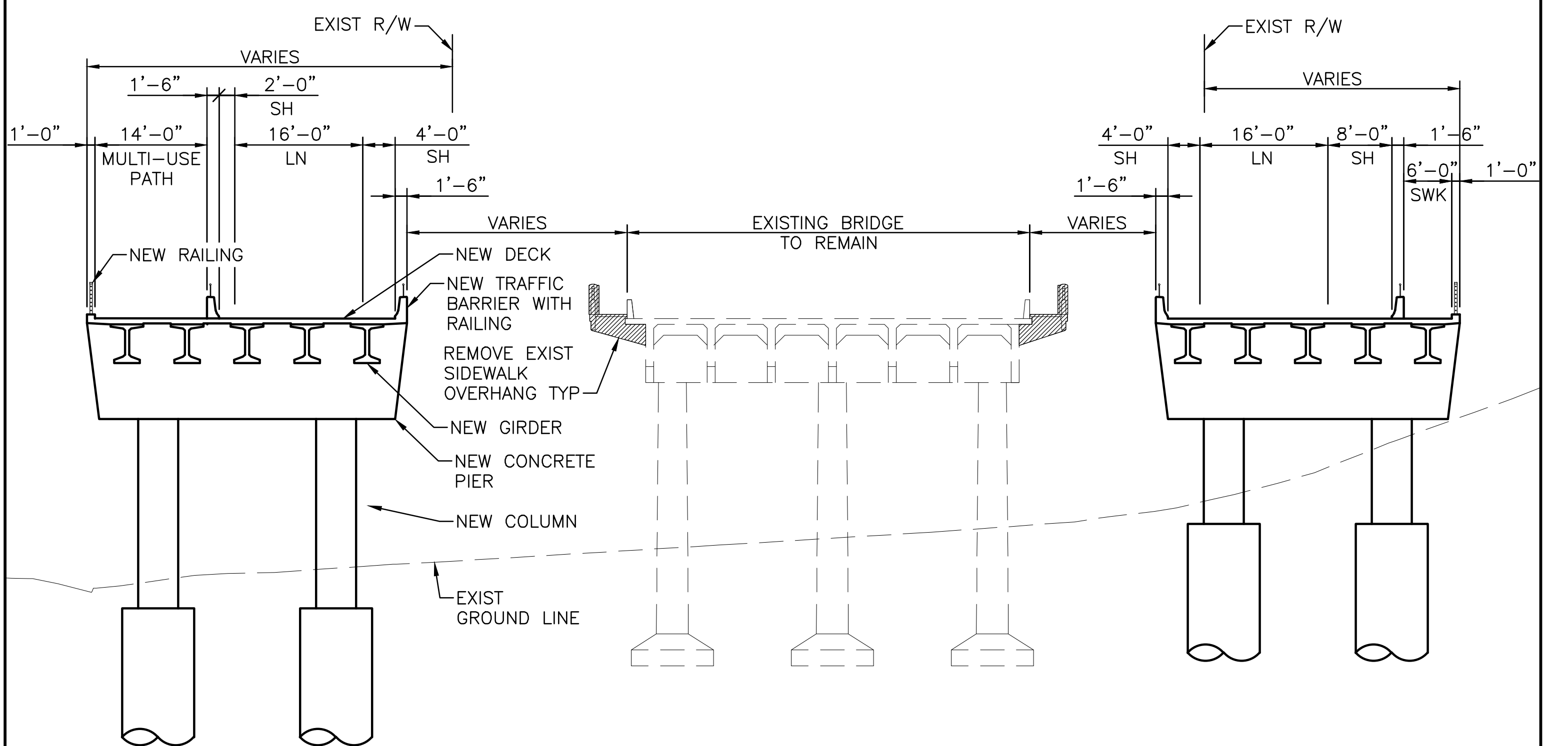

SECTION E–E

(SEGMENT 7 AT PIER 27 – LOOKING NORTH)

COWI

City of Seattle
Seattle Department of Transportation

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FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

LOW–LEVEL REHABILITATION
APPROACH SPANS
14 FT MUP WEST SIDE, 6' SIDEWALK EAST SIDE

FIGURE 4b

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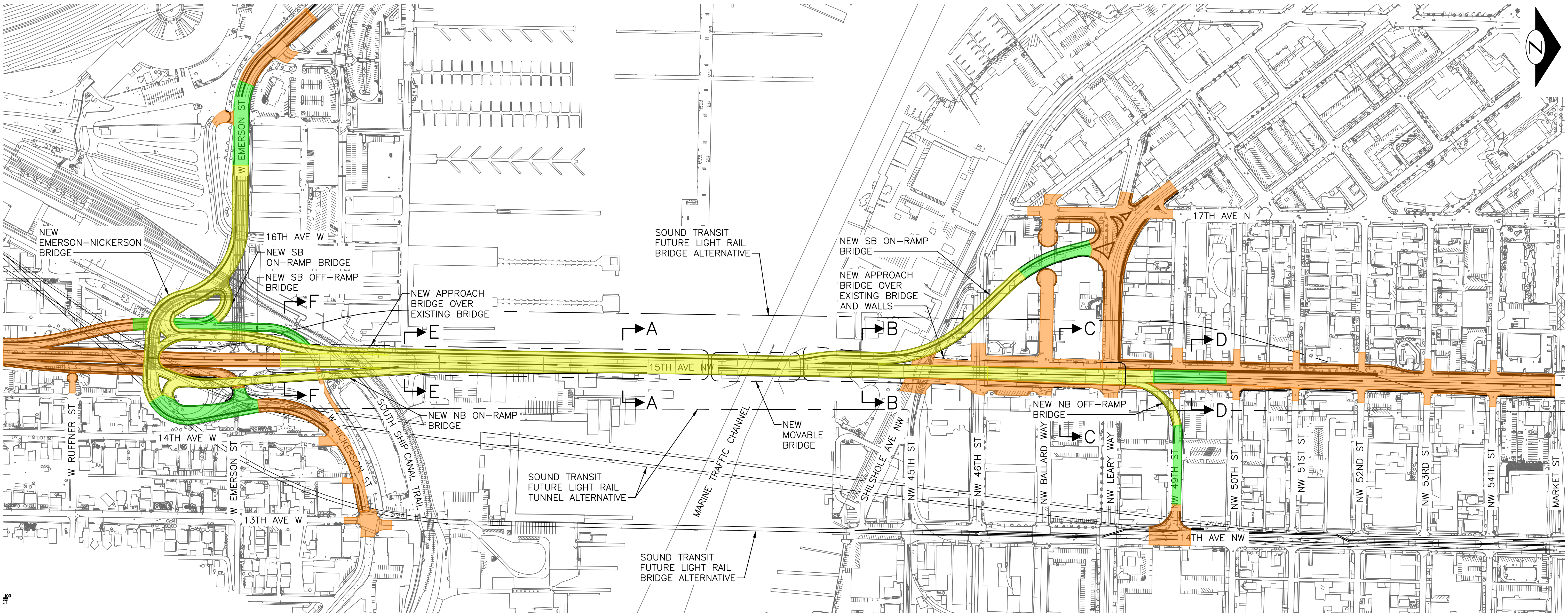
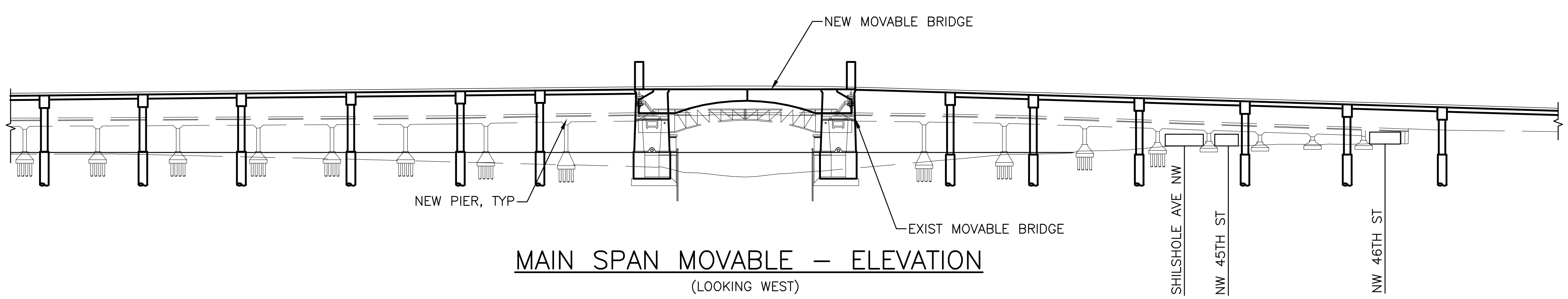


MID LEVEL REPLACEMENT LAYOUT



MAIN SPAN MOVABLE – ELEVATION

(LOOKING WEST)

LEGEND:

- AT GRADE
- BRIDGE
- RETAINING WALL

COWI

City of Seattle
Seattle Department of Transportation

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FUND:
SCALE:

BALLARD BRIDGE PLANNING STUDY
SEATTLE, WA

MID–LEVEL REPLACEMENT LAYOUT

FIGURE
5

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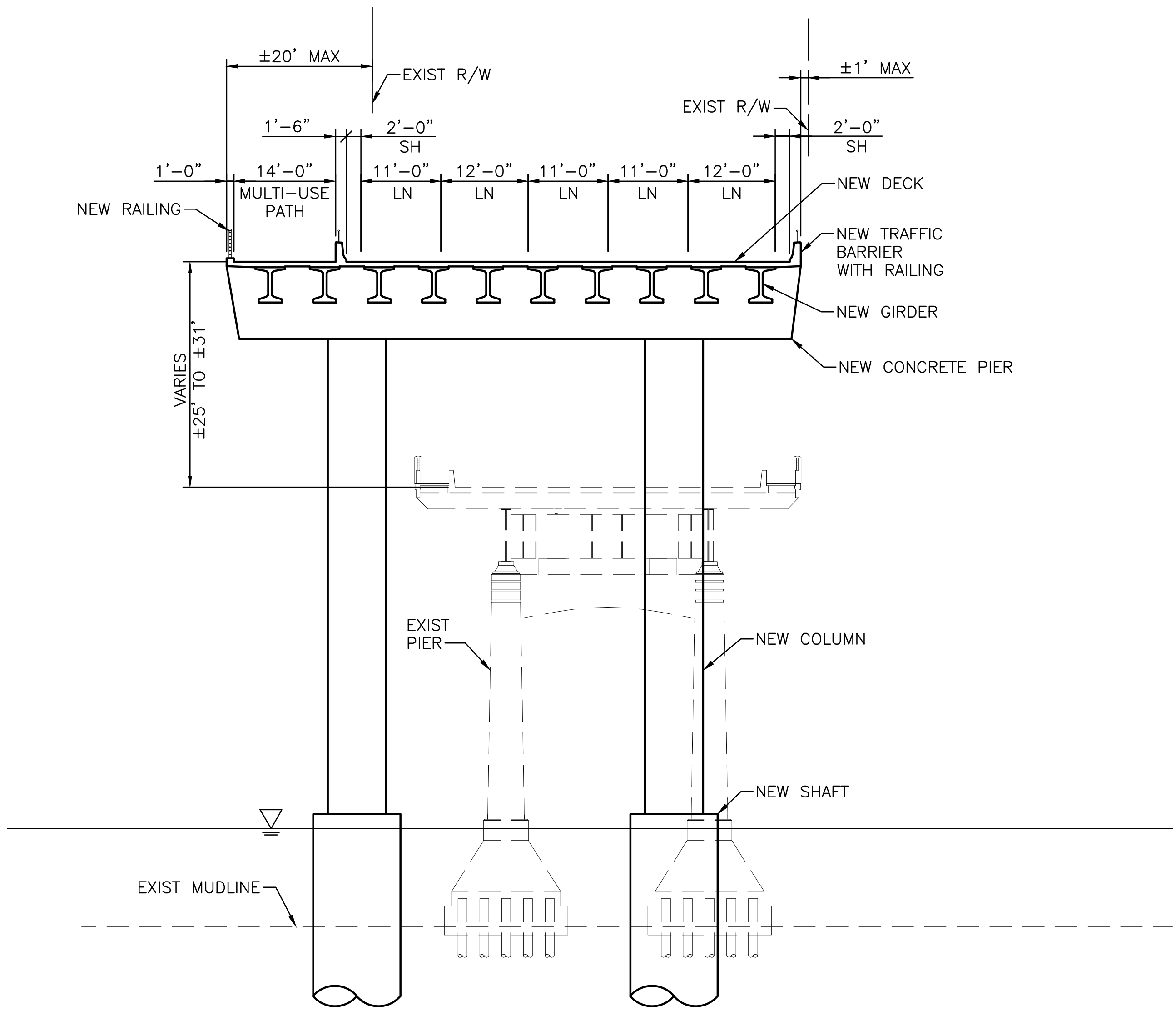

SECTION A–A

(SOUTH APPROACH – LOOKING NORTH)

COWI

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FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

MID-LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER
EXISTING BRIDGE

FIGURE
6

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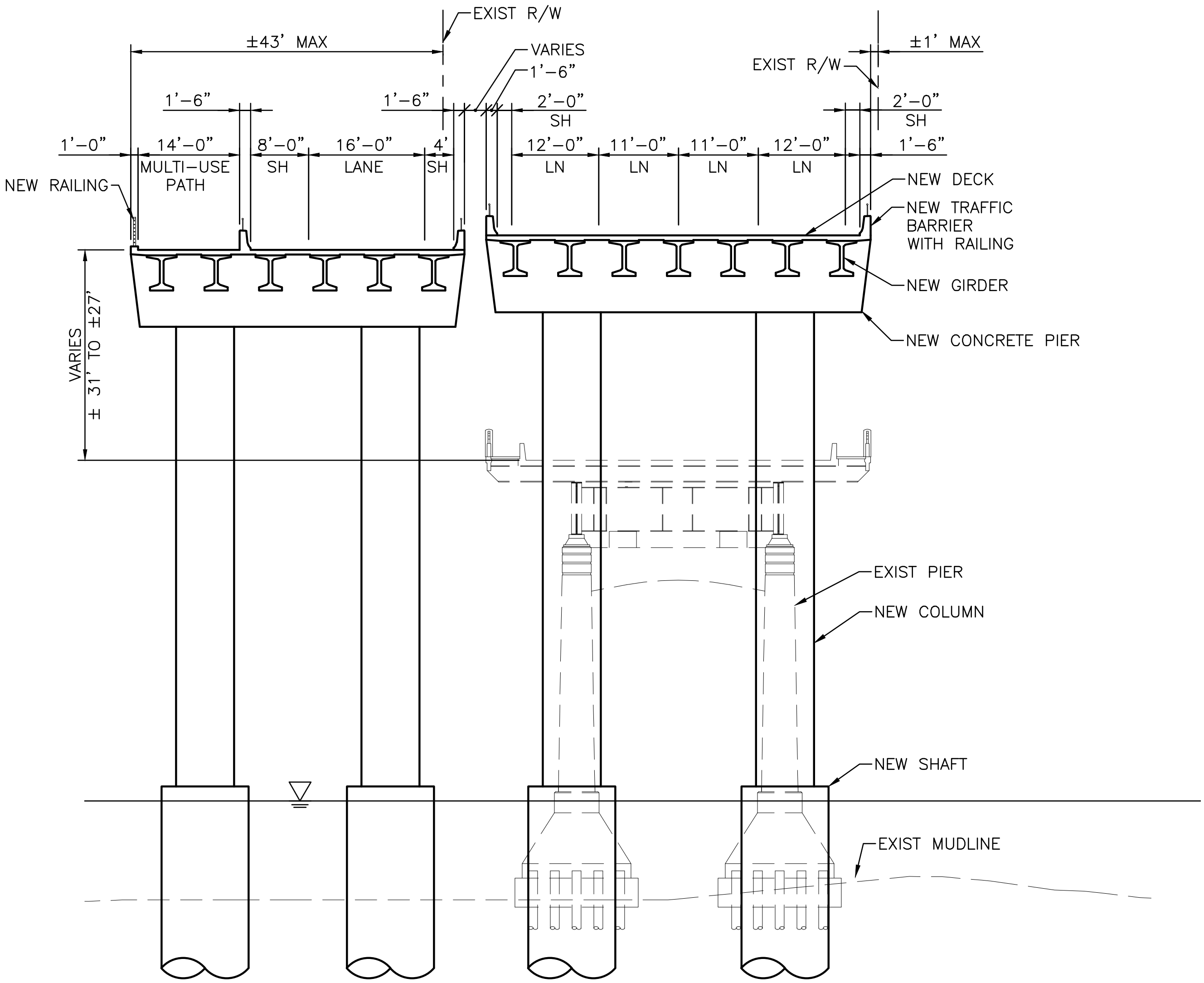

SECTION B–B

(NORTH APPROACH – LOOKING NORTH)

COWI

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Seattle Department of Transportation

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FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

MID–LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER
EXISTING BRIDGE

FIGURE
6a

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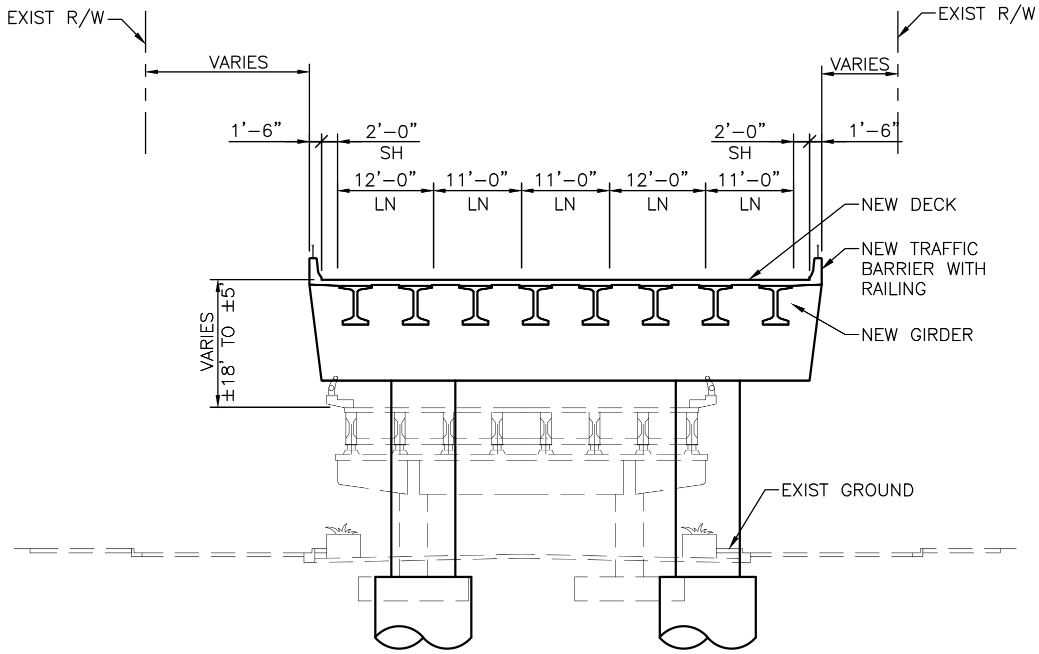
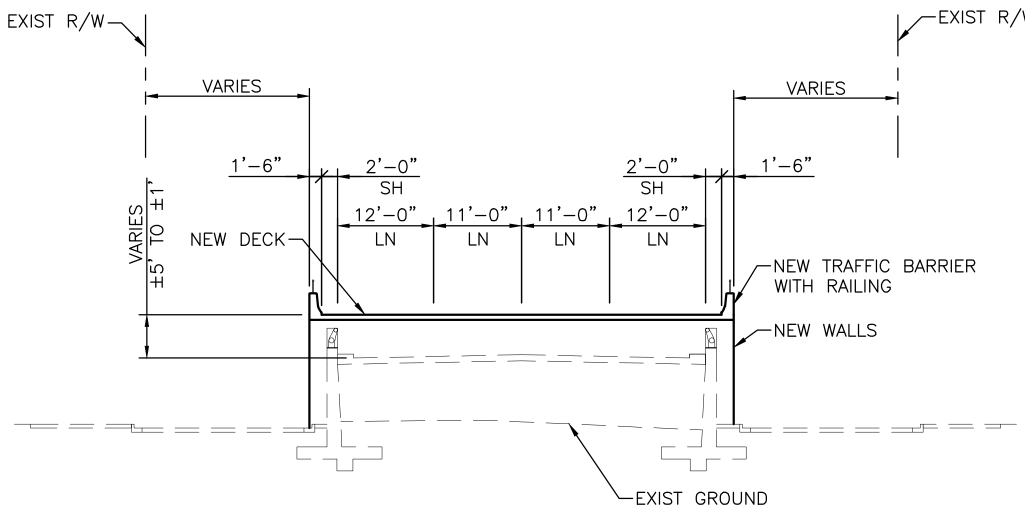


SECTION C–C

(SHOWN BETWEEN BALLARD AND LEARY – LOOKING NORTH)



SECTION D–D

(SHOWN BETWEEN NW 49TH AND NW 50TH – LOOKING NORTH)

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO.
PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

MID–LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER
EXISTING BRIDGE

FIGURE

6b

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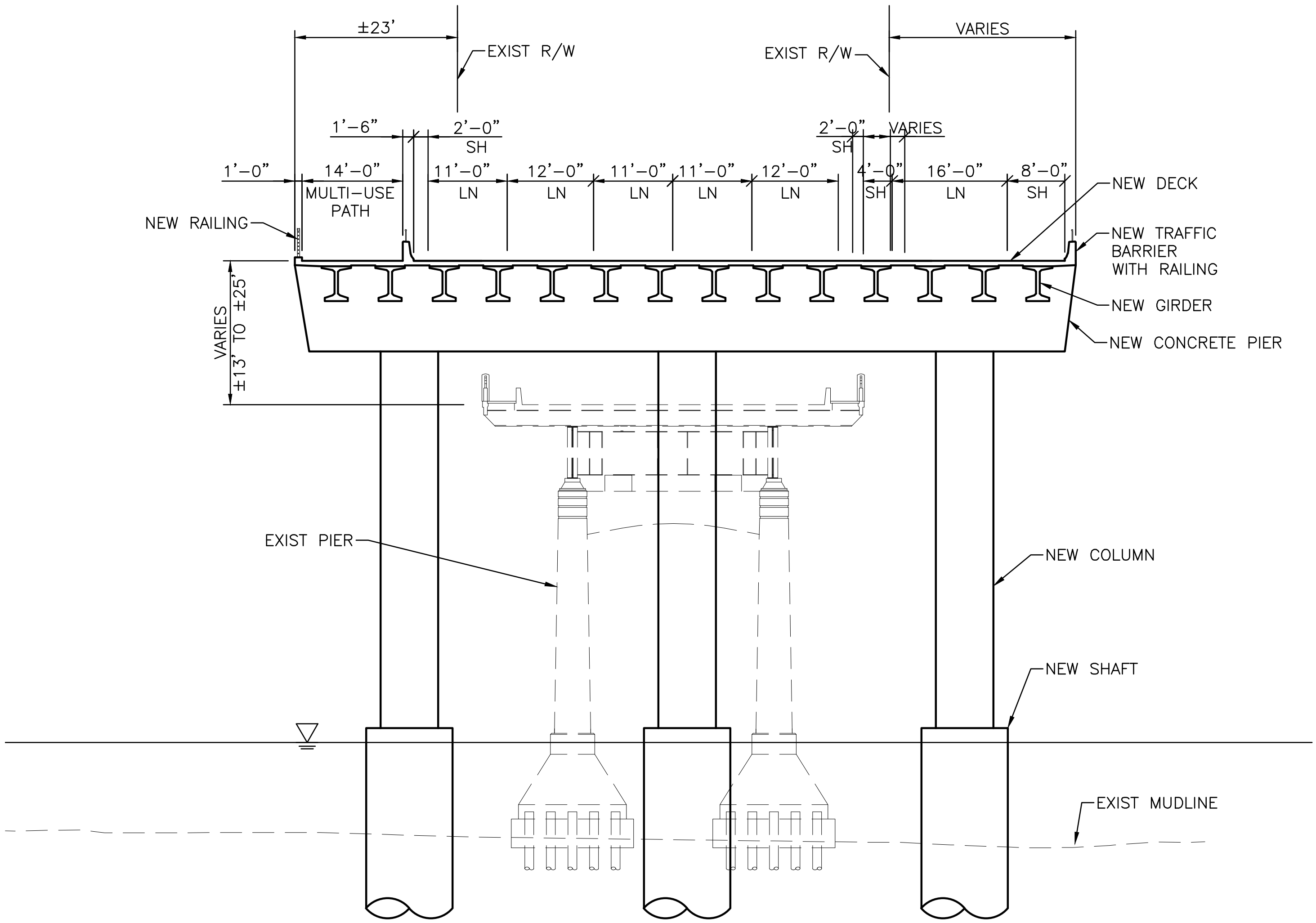

SECTION E–E

(SHOWN NEAR EXIST PIER 21 – LOOKING NORTH)

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

MID-LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER
EXISTING BRIDGE

FIGURE
6c

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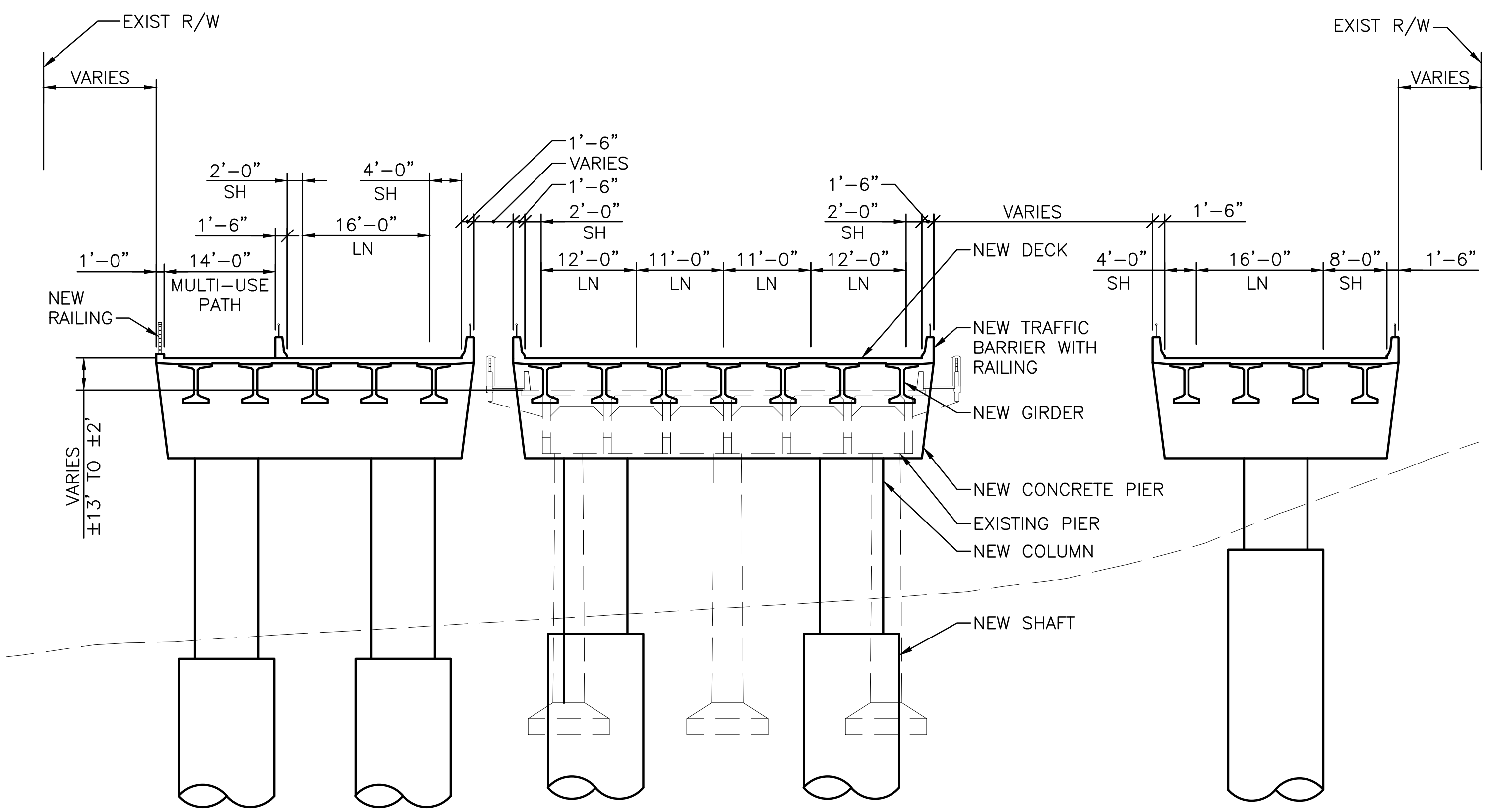

SECTION F–F

(SHOWN NEAR EXIST PIER 27 – LOOKING NORTH)

COWI	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE:	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA MID-LEVEL REPLACEMENT NEW APPROACH BRIDGE OVER EXISTING BRIDGE	FIGURE 6d

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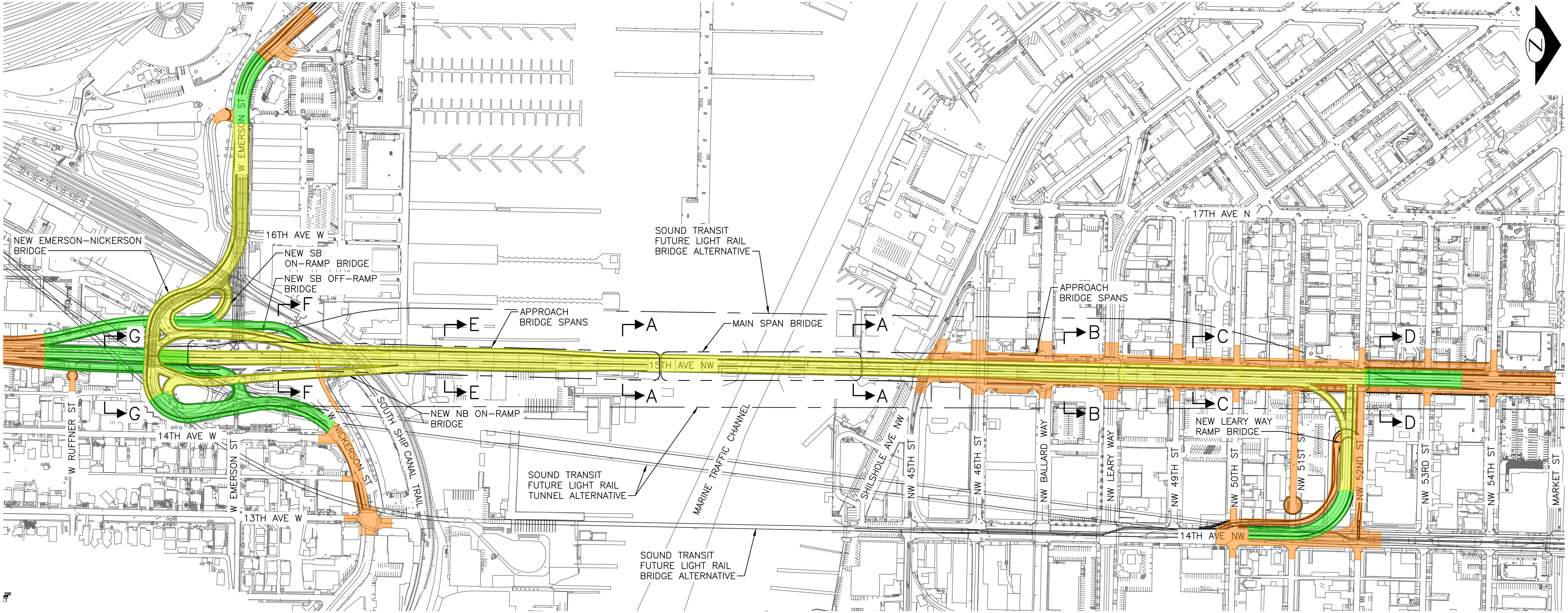

HIGH LEVEL REPLACEMENT LAYOUT

LEGEND:

(orange)	AT GRADE
(yellow)	BRIDGE
(green)	RETAINING WALL

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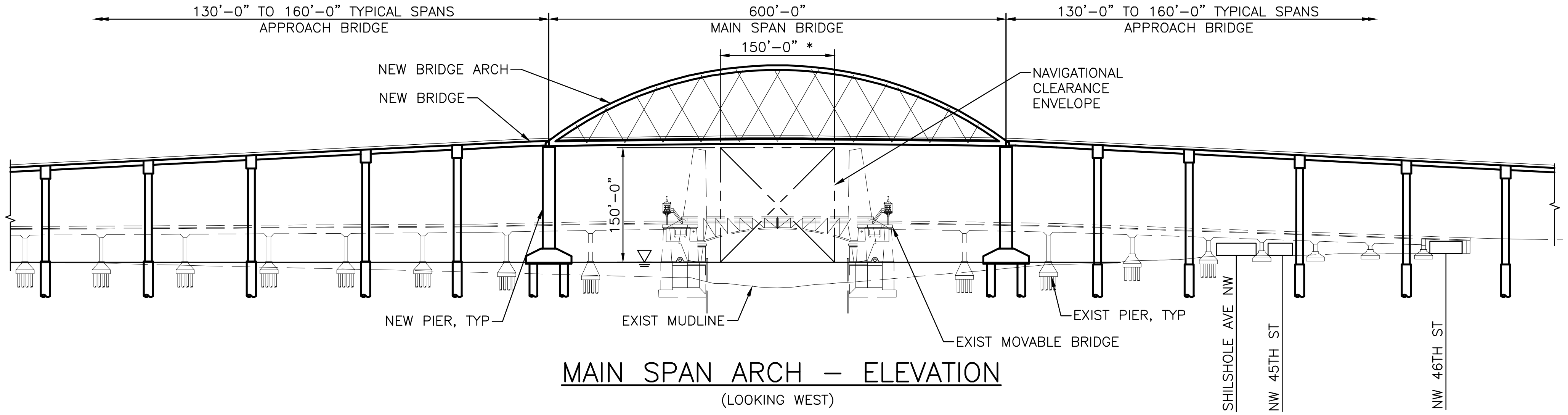
COWI

City of Seattle
Seattle Department of Transportation
ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

HIGH–LEVEL REPLACEMENT LAYOUT

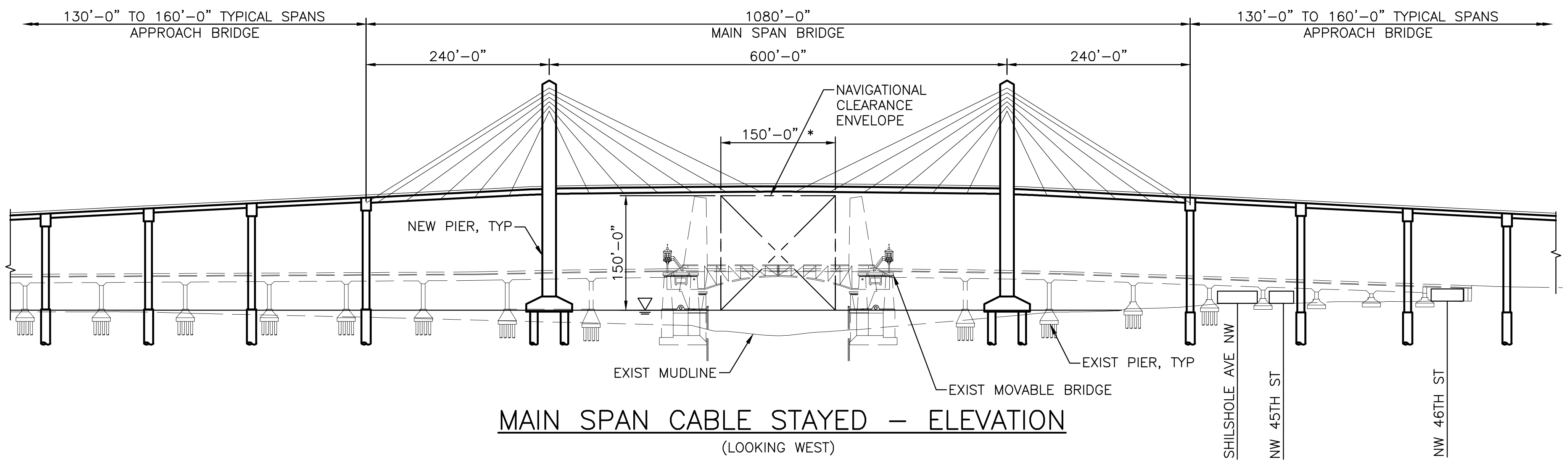
FIGURE
7



MAIN SPAN ARCH — ELEVATION

(LOOKING WEST)

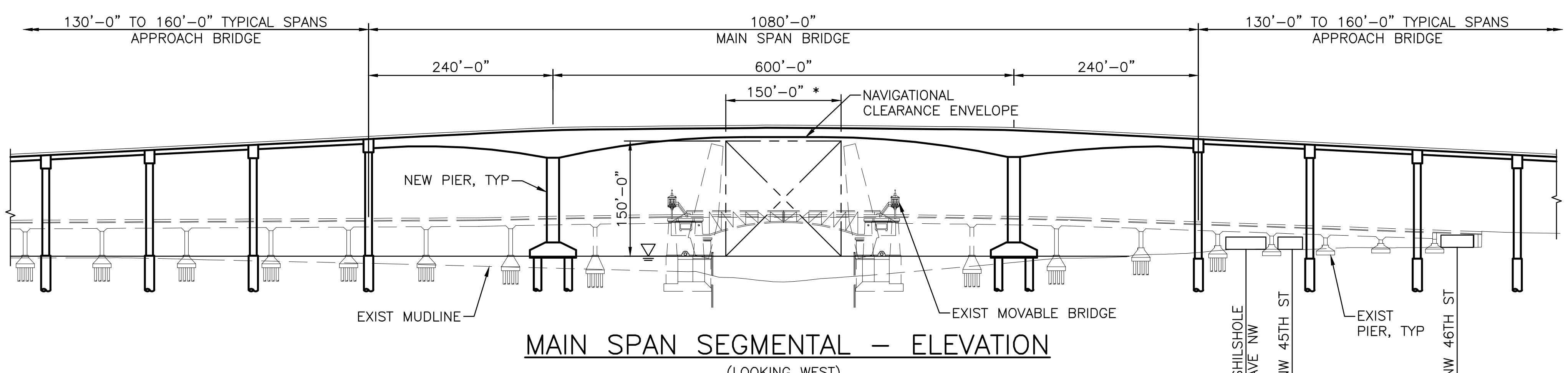
* NAVIGATION CHANNEL WIDTH MEASURED PERPENDICULAR TO CHANNEL, TO MATCH EXISTING



MAIN SPAN CABLE STAYED — ELEVATION

(LOOKING WEST)

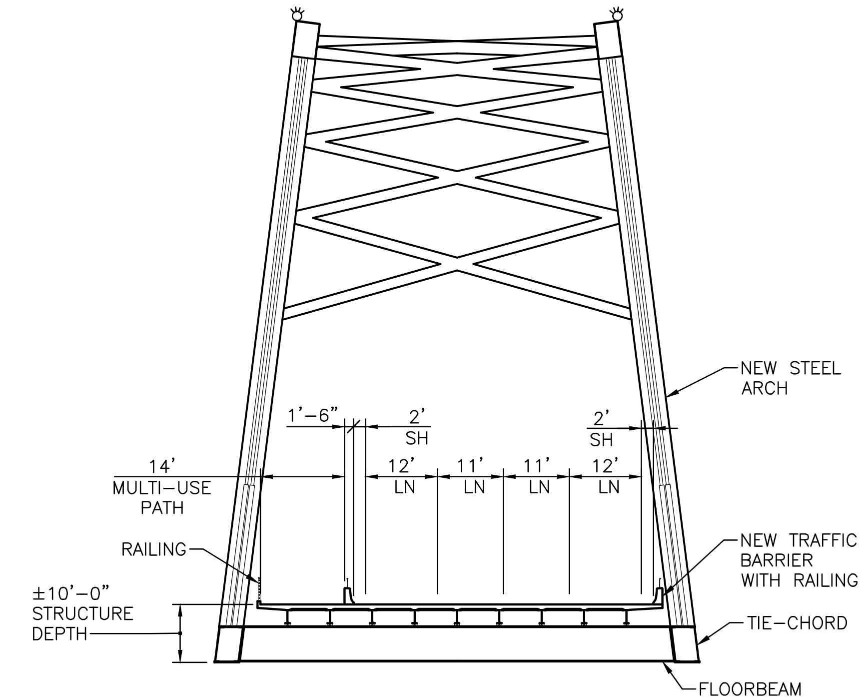
* NAVIGATION CHANNEL WIDTH MEASURED PERPENDICULAR TO CHANNEL, TO MATCH EXISTING



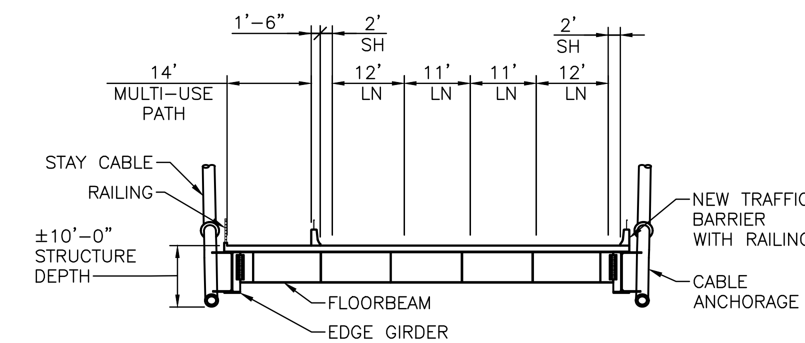
MAIN SPAN SEGMENTAL — ELEVATION

(LOOKING WEST)

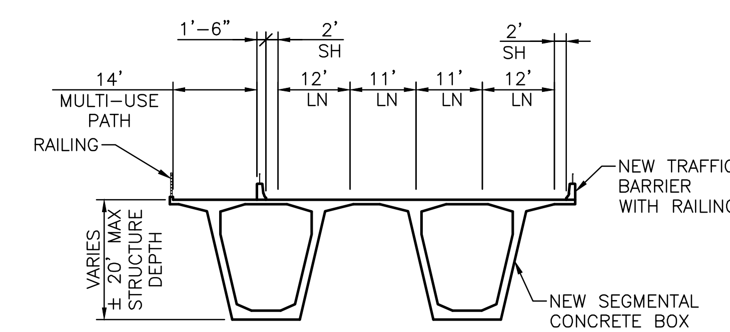
* NAVIGATION CHANNEL WIDTH MEASURED PERPENDICULAR TO CHANNEL, TO MATCH EXISTING



ARCH — TYPICAL SECTION



CABLE STAYED — TYPICAL SECTION



SEGMENTAL — TYPICAL SECTION

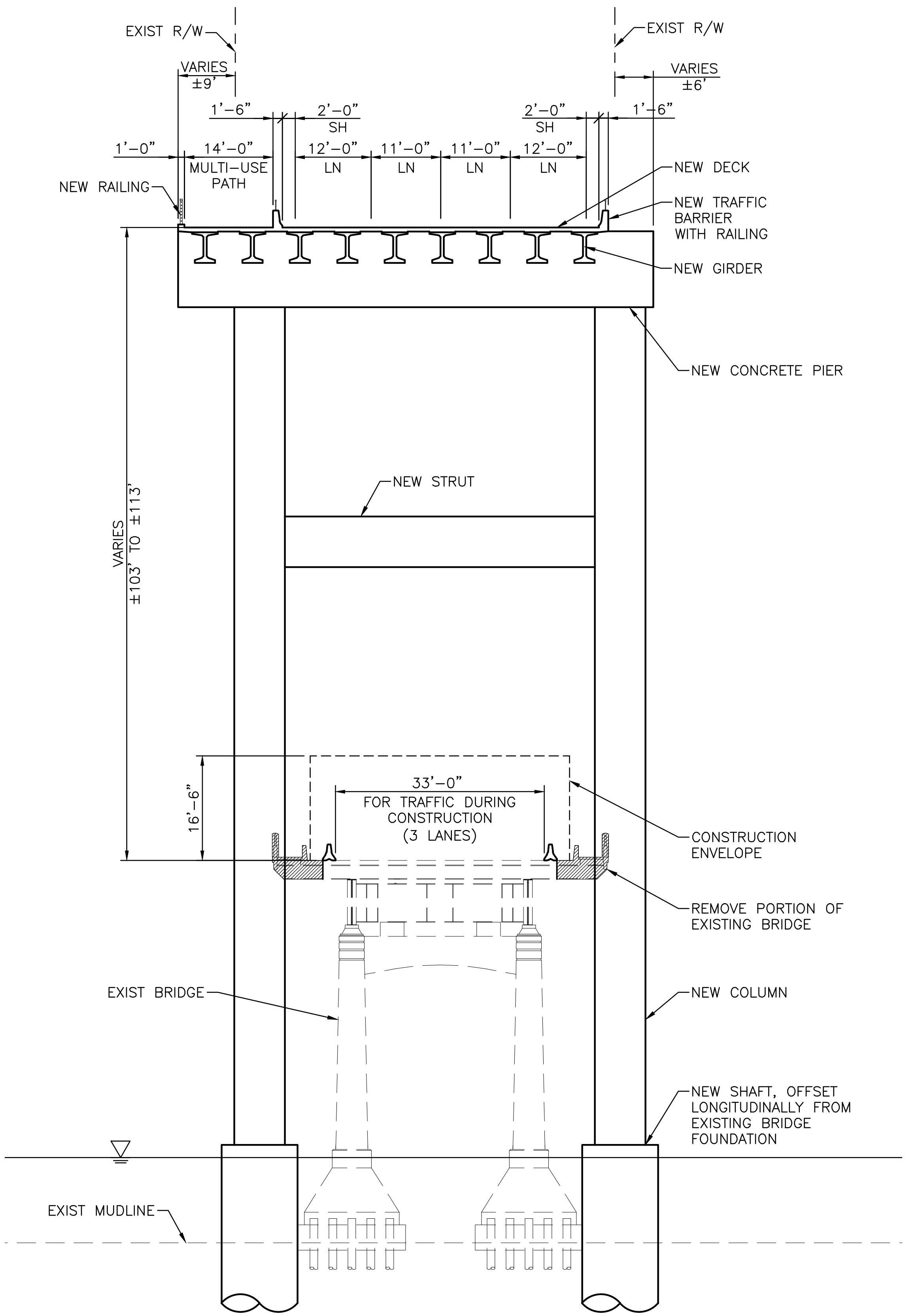
COWI

City of Seattle
Seattle Department of Transportation
ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE PLANNING STUDY
SEATTLE, WA

HIGH–LEVEL REPLACEMENT MAIN SPAN BRIDGE CONCEPTS

FIGURE 8



SECTION A-A

(SOUTH AND NORTH APPROACHES – LOOKING NORTH)

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City of Seattle
Seattle Department of Transportation

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FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

HIGH-LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER EXISTING BRIDGE

FIGURE 9

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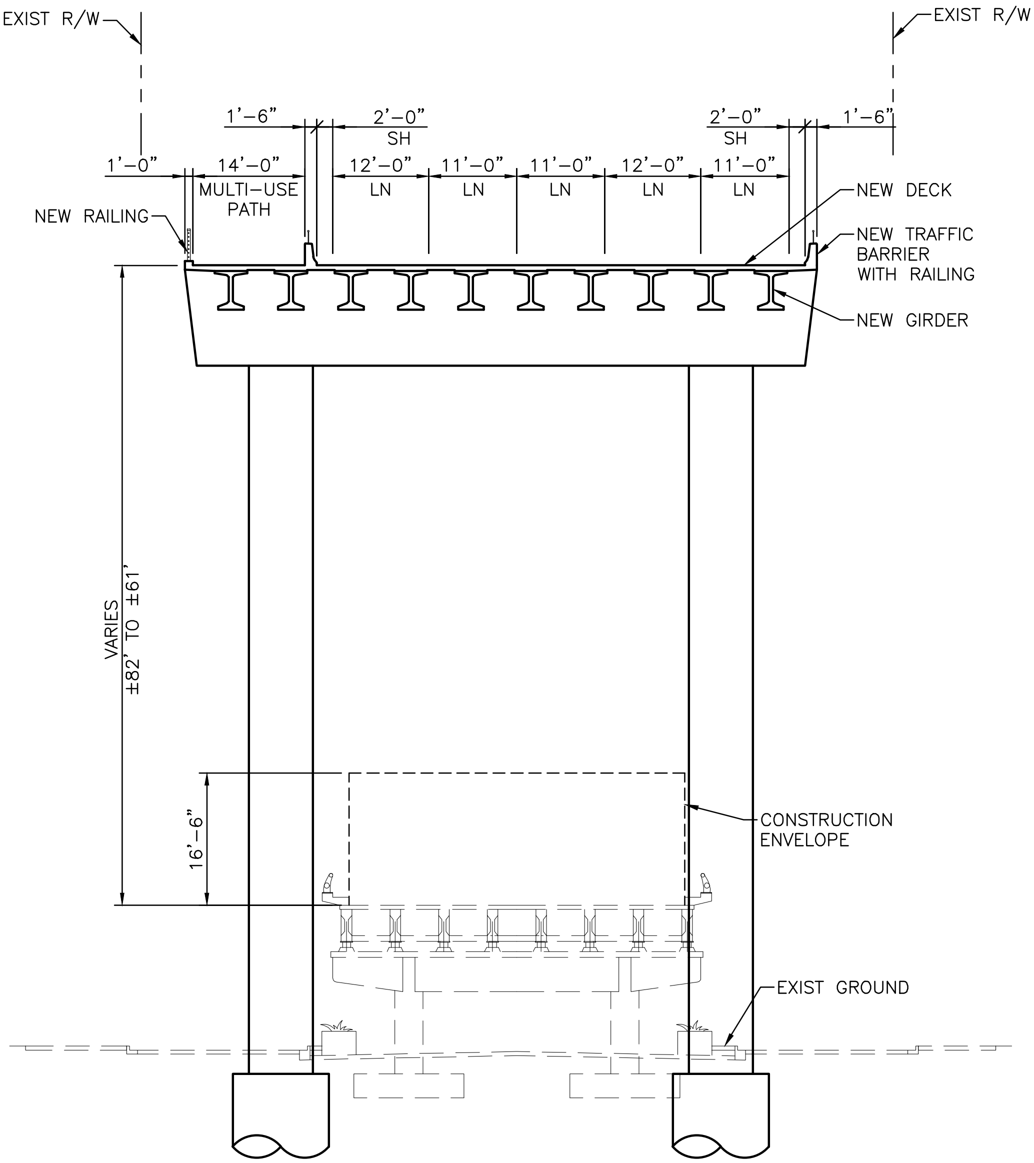

SECTION B–B

(SHOWN BETWEEN BALLARD AND LEARY – LOOKING NORTH)

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

HIGH–LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER EXISTING BRIDGE

FIGURE
9a

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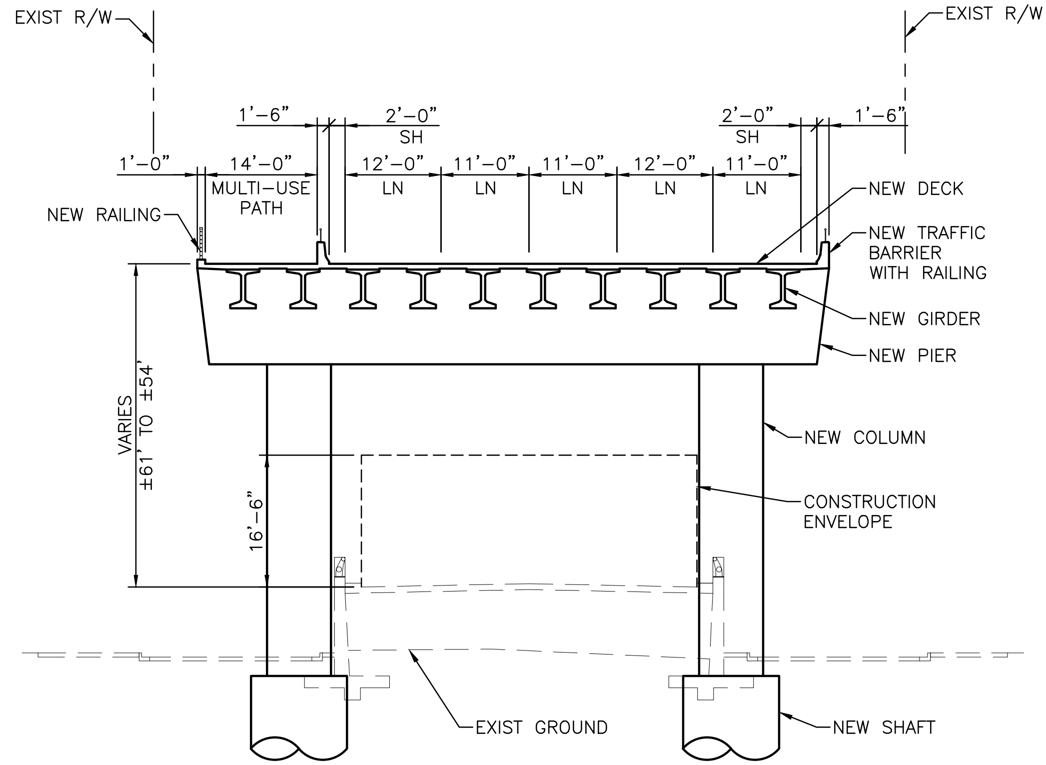

SECTION C–C

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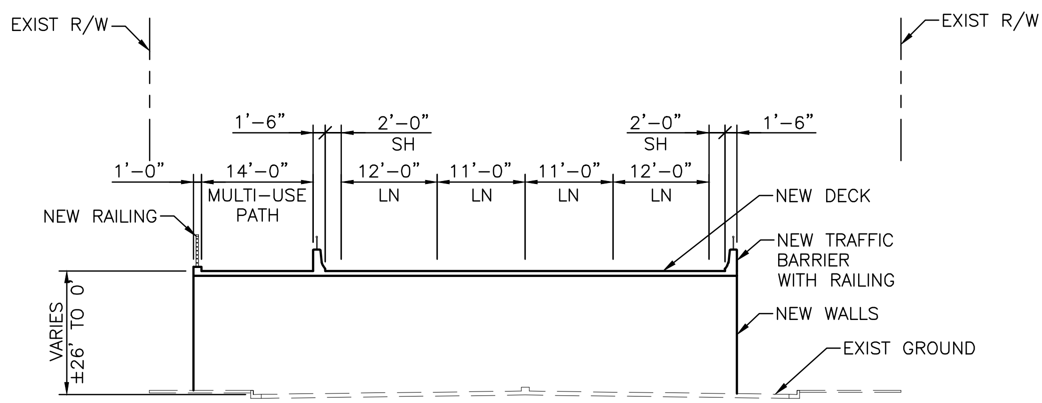

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COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

HIGH–LEVEL REPLACEMENT
NEW APPROACH BRIDGE OVER EXISTING BRIDGE

FIGURE
9b

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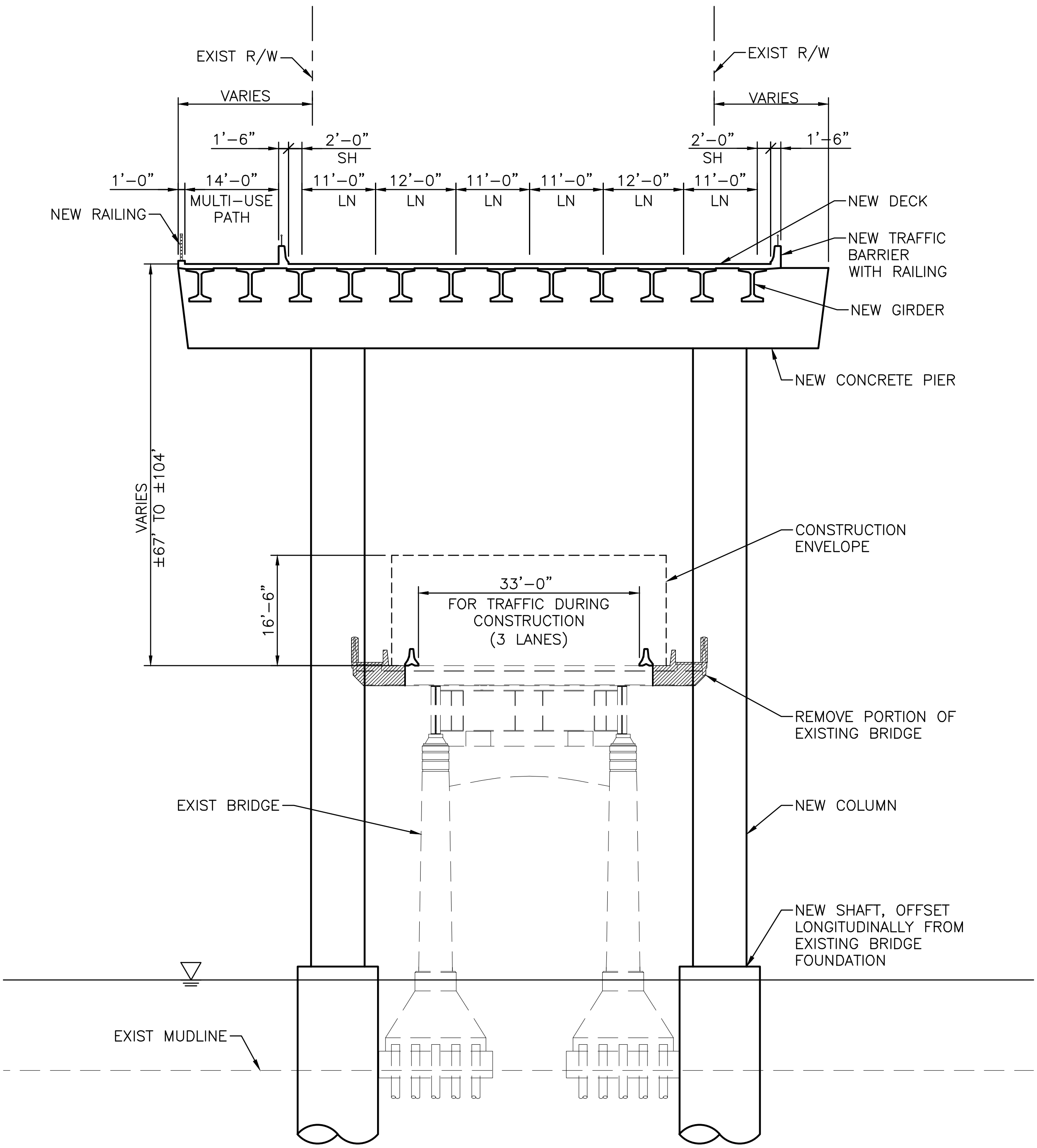

SECTION E–E

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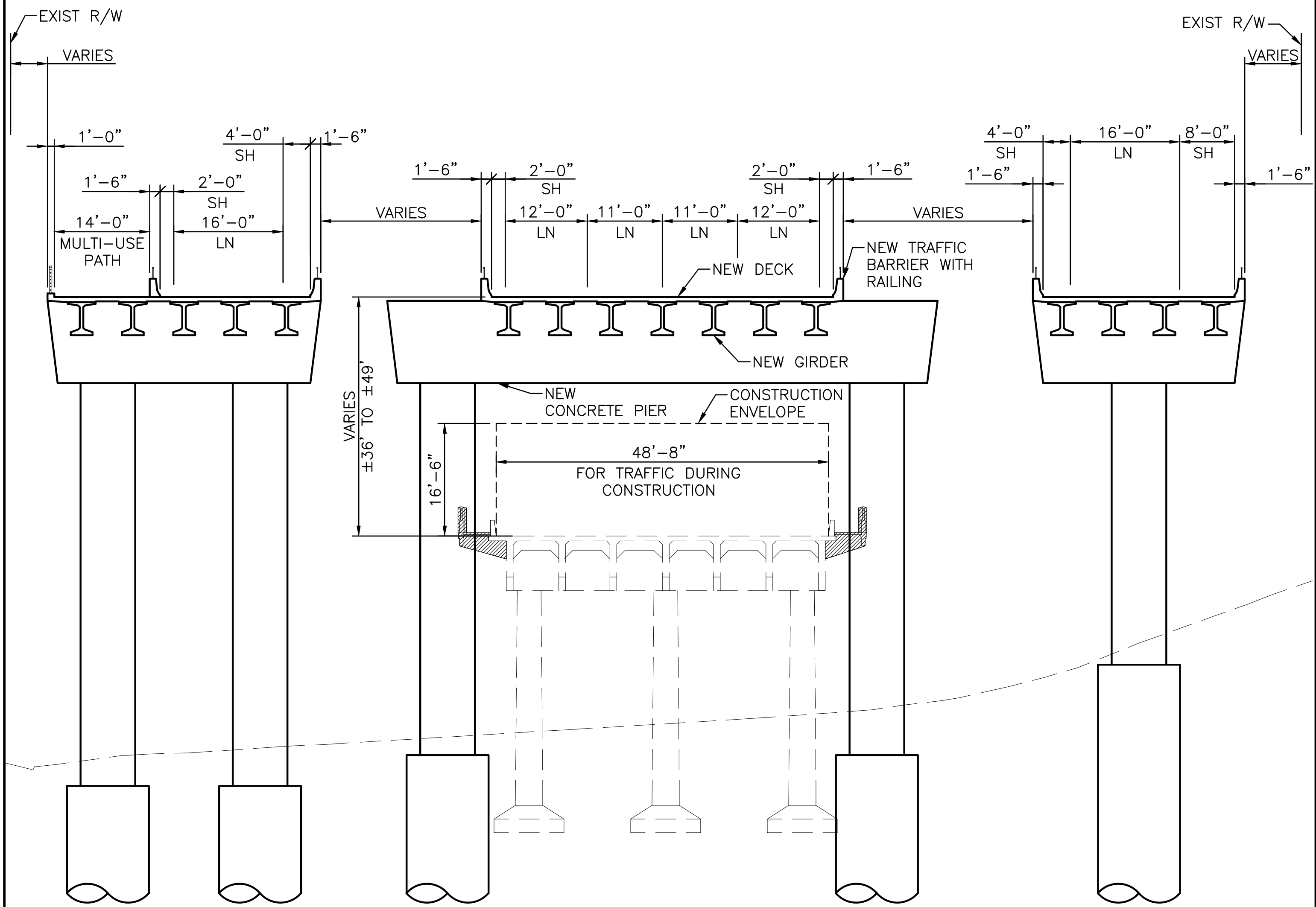

SECTION F–F

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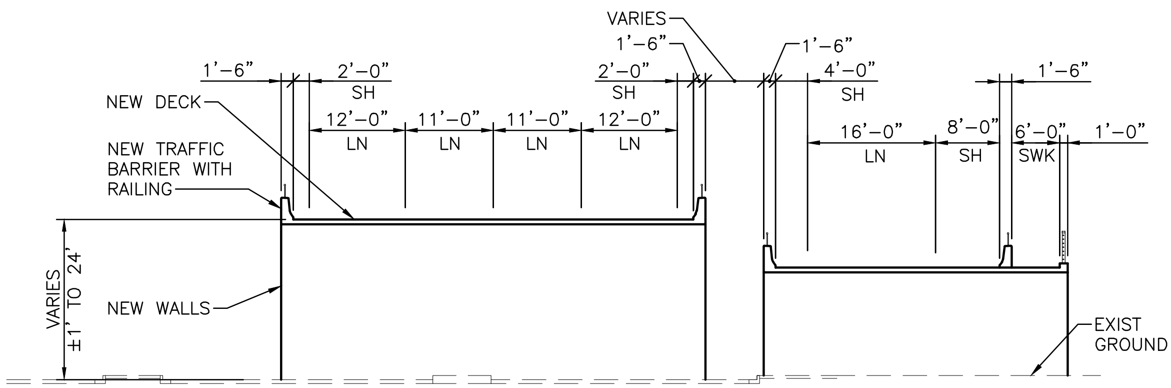

SECTION G-G

(SHOWN BETWEEN RUFFNER AND EMERSON – LOOKING NORTH)

COWI	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE:	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA HIGH-LEVEL REPLACEMENT NEW APPROACH BRIDGE OVER EXISTING BRIDGE	FIGURE 9e

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Attachment B – Movable Bridge Alternatives

Technical Memo

Date:	Wednesday, November 20, 2019
Project:	Ballard Bridge Planning Study
To:	Matt Baughman (COWI)
From:	Greg Harrell, Matt McGuire, Rob Moses (HDR)
Subject:	Movable Bridge Alternatives

Executive Summary

The following movable span alternatives were conceptually developed and preliminarily evaluated based on feasibility and user impacts, and order-of-magnitude construction costs were developed to support the Ballard Bridge Planning Study:

- Low-level rehabilitation/widening of the existing bascule span
- Mid-level replacement with a movable span for the purpose of improving all modes of transportation and upgrading the facility for seismic performance and resiliency

The rehabilitation/widening alternative is feasible for improving safety and connectivity for pedestrians and cyclists crossing the existing bridge by widening the sidewalk to 14 feet on one side to serve as a shared-use path. The roadway portion of the deck cannot be widened because the roadway width is limited by the main trusses projecting above the deck along the edges of the travel lanes. Therefore, this alternative does not include improvements for vehicular traffic. Widening the existing bridge will also not improve navigation clearance to reduce the number of openings and associated disruptions to vehicular traffic. Upgrades to enhance seismic performance of the existing bridge are being evaluated in a parallel study. Recommendations and cost estimates from that study are referenced herein for a comprehensive summary of the rehabilitation/widening alternative. Seismic response deficiencies identified in the seismic retrofit study notwithstanding, preliminary evaluation of the geometry and capacity of the existing truss demonstrate potential to accommodate the widening by removing the existing sidewalk overhangs and replacing them with longer, deeper brackets. The existing trunnion shafts can support an increase in the dead load reaction of 12 to 13 percent, exceeding the increase anticipated due to the additional weight and transverse imbalance. Widening at the pier is feasible by extending the deck onto new concrete brackets projecting off the side of the pier and incorporating a flush floor door in the shared-use path for access to the machinery level. Additional deck area and weight on the bascule span are expected to warrant drive machinery and electrical system replacement, including motors, brakes, gears and controls, and limited space available for growth of these systems will likely require significant rehabilitation, or complete replacement of the existing control house. Incremental performance of the work to minimize impacts to navigation and vehicular traffic will require frequent re-balancing of the span. Travel lane reductions and sidewalk closures will be required throughout the duration of the widening work. Navigation restrictions are anticipated but can be minimized. This work can be coordinated to take place in conjunction with partial and full closures anticipated for seismic retrofit implementation. The estimated cost of work on the existing bascule span, including seismic retrofit recommendations, as a component of the overall low-level widening alternative for the entire bridge is $43M.

The mid-level replacement alternative offers an opportunity to increase the number and width of travel lanes, improve navigation clearance to reduce the number of bridge openings, and build a safer bridge that would be designed and built to current seismic performance and resiliency standards, in addition to accommodating the shared-used path. To minimize the span length of the replacement bridge, the existing bascule pier foundations on spread footings would either need to be completely removed or left in place and drilled through to install deep foundation elements. Vertical and horizontal navigation restrictions, as well as multiple short-term channel outages, will be necessary for various elements of the work. The estimated cost to build a replacement bascule along the existing alignment with an elevated profile as a component of an overall mid-level bridge replacement project is $68M.

The estimates in this study represent costs to construct each alternative as a component of the overall project and do not reflect project-wide factors for right of way, mobilization, staging, design and construction contingencies, inflation, risk premiums, etc.

1. Introduction

This memo was prepared in conjunction with, and supplementary to, the Ballard Bridge Planning Study technical memo prepared by COWI for the Seattle Department of Transportation to assess feasible alternatives for improving all modes of transportation along 15th Ave W/NW across the Lake Washington Ship Canal. The overall study evaluates the following options:

- Extending the sidewalk overhang on the existing bridge (low-level)
- Replacing the existing structure with another movable bridge with improved vertical clearance for navigation in the closed position (mid-level)
- Replacing the existing structure with a fixed span with a sufficient increase in vertical clearance for navigation to accommodate current and future vessel traffic in the canal (high-level)

The next section (Section 2) list the design provisions, guidelines, and other supporting documents that were considered for this evaluation. Sections 3 and 4 of this memo focus on the main span features of the low-level and mid-level movable bridge options (first two bullets above), respectively, and the information presented is to be used in conjunction with separate evaluations of the approach spans for a complete assessment of these two alternatives. For each of these alternatives, a preliminary description of the movable span concept is provided (including structural, mechanical and electrical attributes), followed by constructability considerations and an order-of-magnitude cost estimate for the movable span component of the overall bridge. Section 5 includes a summary of both options.

2. Assumptions and References

The evaluation documented in this technical memo was conducted within a framework of assumptions established by governing design provisions and previous related work performed outside the scope of this assignment.

The following design provisions and guidelines were referenced:

- AASHTO LRFD Bridge Design Specifications (8th Edition)
- AASHTO LRFD Movable Highway Bridge Design Specifications (2nd Edition)
- AASHO Standard Specifications for Movable Highway Bridges (1938 and 1953)
- AASHTO Standard Specifications for Movable Highway Bridges (1981 and 1988)
- AASHTO LRFD Guide Specification for the Design of Pedestrian Bridges (2009)
- AASHTO Guide Specification for LRFD Seismic Bridge Design (2nd Edition)
- WSDOT Bridge Design Manual (2019)

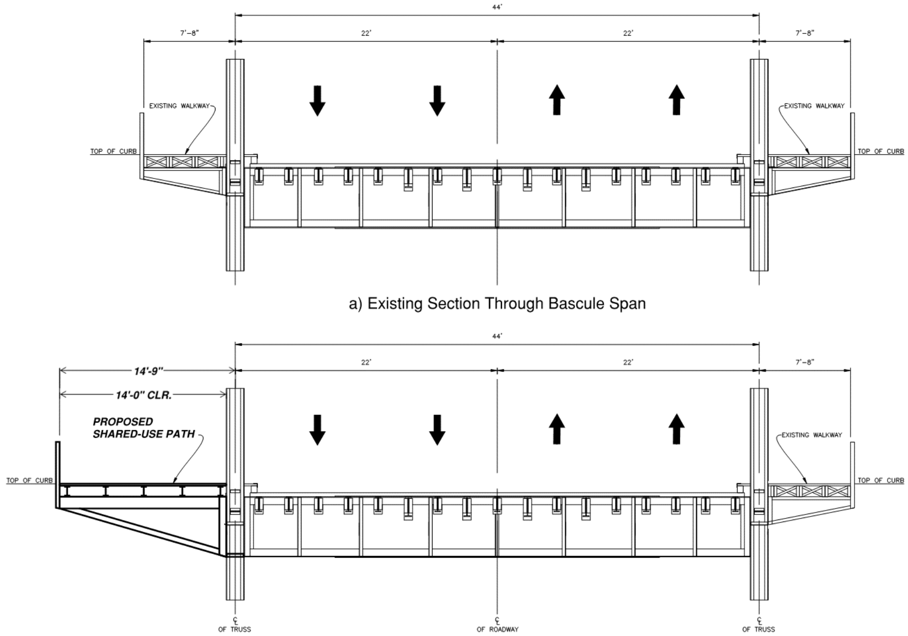
In addition to the companion technical memoranda and design criteria prepared specifically for this evaluation, documents and studies referenced throughout the course of this work include the following:

- SDOT Bridge Seismic Retrofit Philosophy, Policies, and Criteria (2015)
- Ballard Bridge Sidewalk Widening Concept Study (September 2014)
- Bridge Seismic Retrofit Ballard Bridge BRG20 Bascule Piers and Movable Spans Concept Design Report (September 2019)
- Ballard Bridge Bascule Span Load Rating Summary (May 2012)
- BRG-020B Ballard Bridge Inspection Report (July 2019)
- Existing Bridge Plans, Original (1915)
- Existing Bridge Plans, Seismic Retrofit (1996)
- Existing Bridge Plans, Electrical and Span Drive Rehabilitation (2000)

The rehabilitation/widening alternative discussed in the next section does not address features intended to improve seismic performance. A seismic rehabilitation evaluation is documented in the Bridge Seismic Retrofit report noted above, and recommendations and costs from that study are referenced herein for a comprehensive summary of rehabilitation/widening alternative.

3. Low-Level Rehabilitation/Widening Alternative

Widening the bridge to accommodate the SUP has geometric, structural, mechanical, and electrical implications. The concept requires increasing the width of the deck available to be designated for pedestrian and bicycle use to 14 feet. The configuration of the superstructure precludes shifting of traffic because the roadway is confined to the space between the trusses projecting above the deck (see Figure 1). Increasing the available width of the existing bridge is, therefore, only achievable by extending the length of the deck overhang on the west side of the bridge, as depicted in Figure 1b.



a) Existing Section Through Bascule Span

b) Proposed Section Through Bascule Span

Figure 1. Typical Sections through the Existing Bascule Span

3.1. Superstructure

Because the existing overhang would more than double in length to accommodate the SUP, the existing support brackets would need to be replaced with deeper, stiffer brackets to satisfy the strength and deflection requirements of AASHTO. The existing brackets are attached to the main truss verticals opposite the floorbeams (see Figure 2). Brackets as deep as the floorbeams are feasible without significant strengthening of the vertical truss members.

The existing concrete plank sidewalk is supported on W8 stringers and weighs an estimated 45 psf. Increasing the width of the sidewalk to more than double its current width suggests a weight-neutral solution for the deck would need to weigh approximately 20 psf. A lightweight

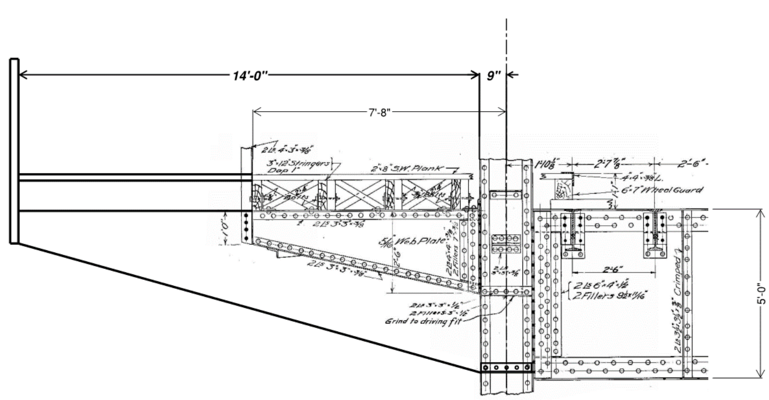


Figure 2. Typical Overhang Geometry

concrete, partially filled grid deck is feasible but is not likely to be truly weight-neutral with the larger deck area. A deck system composed entirely of FRP elements would be effective in minimizing the increase in weight at the sidewalk overhang. Net weight gain for the overall bascule span may be further limited by removing the existing east sidewalk upon completion of the SUP. While technically feasible, removal of the east sidewalk is not recommended as a primary design strategy because it introduces disadvantages related to schedule, staging, navigation impacts, maintenance and operator access impacts, user safety impacts, and historic/aesthetic concerns. Therefore, the primary design approach should be based on supporting the SUP and balancing additional weight without removing the east sidewalk. Since initial indications suggest that the machinery and electrical systems will need to be replaced whether the east sidewalk is removed or remains (see Section 3.3), this evaluation assumes that it will remain.

The most recent load rating summary from 2012 identifies select chord members and gusset plates with substandard load ratings. The most recent inspection report (2019) notes evidence of minor high load hits on both leaves, along with signs of corrosion throughout. The seismic retrofit recommendations already include strengthening or replacing several elements on the bridge, including most of the chord members and gusset plates that are damaged and/or do not rate. No additional strengthening beyond what is included in the retrofit recommendations is considered in this evaluation.

3.2. Substructure

The sidewalk from the approach spans is continuous across the bascule pier and is partially obstructed by barrier gates, main span trusses, and pier access stairs (see Figure 3). Maintaining the increased width of the SUP across the pier will provide a consistent transition

Figure 3. Existing Sidewalk at the Bascule Pier

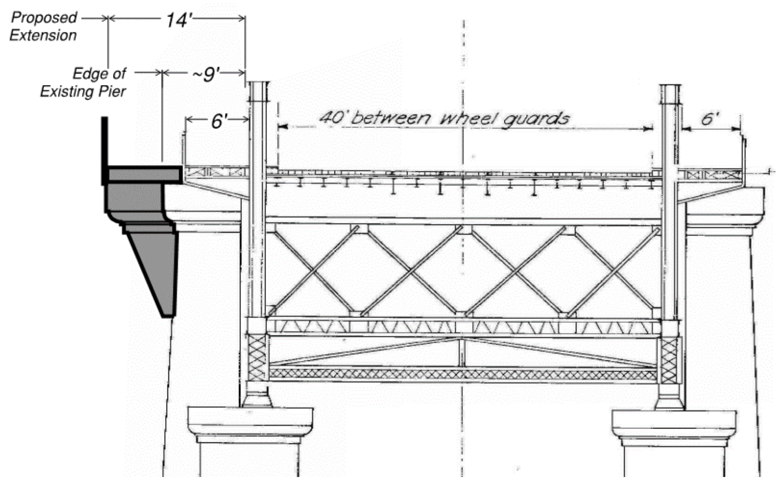


Figure 4. Proposed SUP at the Bascule Pier

from the widened path on the approach spans (separate evaluation) to the widened bascule span.

The exterior fascia of the existing sidewalk is aligned with the outside edge of the pier structure below, so the deck level of the pier requires an extension. Expanding the entire footprint of the pier structure to support the expanded sidewalk is not warranted. Concrete brackets detailed within the architectural style of the existing pier would be an effective means of economically providing the necessary support without detracting from the historic character of the bridge. Figure 4 schematically illustrates this concept. Along with extending the sidewalk, the deck joints at both the channel and approach span edges would need to be extended with the deck using details similar to the existing. The additional weight of the extension should be minimal and should not negatively impact the capacity and seismic performance of the existing pier.

Upon widening the deck, the stairs currently on the outside edge of the sidewalk that provide access to the machinery level within the pier will need to be reconfigured. Referring to the existing conditions in Figure 3, the access opening in the deck for the stairs on the left side of the picture will be in the middle of the SUP in the widened condition. A floor hatch or door could be installed within the SUP, simplifying the physical alterations required to retain west side pier access and limiting aesthetic impacts to physical changes associated with the addition of concrete brackets to support the deck extension.

3.3. Machinery and Electrical Systems

Building upon the preliminary findings presented in the Bridge Seismic Retrofit Ballard Bridge BRG20 Bascule Piers and Movable Spans Concept Design Report (CDR), the existing trunnion shafts were evaluated in more detail to identify available capacity to support additional dead load that may be introduced as a result of widening the span. In addition, impacts on the drive system and span balance were also considered, as discussed below.

3.3.1. Trunnions

The trunnion assemblies on each leaf are original construction and support the dead load of the leaf (see Figure 5). The trunnion analysis revealed that each shaft has an additional capacity of roughly 13 percent, or approximately 130 kips per trunnion, when evaluated according to provisions in various editions of the Standard Specifications for Movable Highway Bridges (the “Specifications”) published by AASHO and AASHTO between 1938 and 1988. The additional capacity assumes the transverse center of mass of the bridge remains unchanged. By adding a cantilevered sidewalk on the west side of the span, the center of mass will shift toward the trunnion on the same side, generating additional load on the west trunnion, with corresponding relief at the east trunnion, due to the eccentricity of the additional weight. Transverse counter-balancing (subsequently discussed) can be effective in achieving similar reactions at both trunnions by adding additional weight to the side of the span opposite the sidewalk extension.

In addition to verifying the trunnion shear capacity under seismic loading for 100-yr and 1000-yr return period events, HDR also recommends checking the trunnions using a bending stress analysis. Based on the 1000-yr return period event loads (CDR, page 29), the capacity-to-demand ratio calculated for bending as part of this evaluation is 1.13. HDR maintained the allowable 90 percent of yield strength criterion stated in the CDR. HDR also recommends checking shear and bending under dead load to represent normal operating conditions. HDR assumed material properties for forged steel similar to ASTM A235 Class C, with an allowable stress of 16 ksi, and found the capacity-to-demand ratio to be 1.20 for dead load. References to ASTM A235 Class C material was found in both the 1938 and 1953 Specifications and is assumed to be the closest reference material to the forged steel called out on the original plans. The allowable stress used was based on these Specifications. If the same analysis were performed using a more recent Specification with modern material requirements (e.g., ASTM A668 Class D or G), allowable stress would be 15 ksi to 16 ksi, depending on material class assumed, with a corresponding potential reduction in the capacity-to-demand ratio to 1.12,

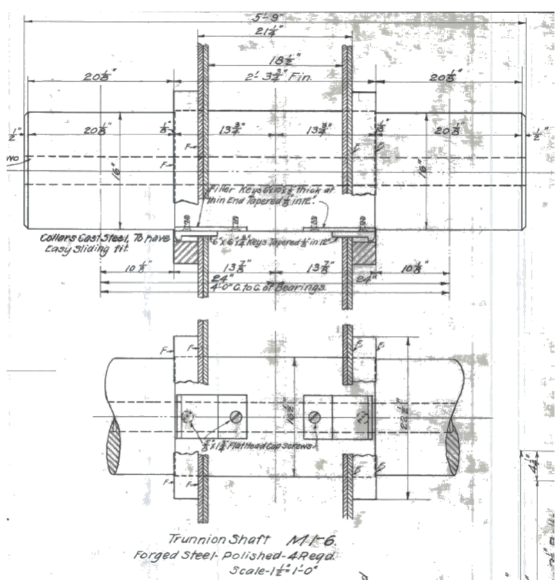


Figure 5. Existing Trunnion Shaft

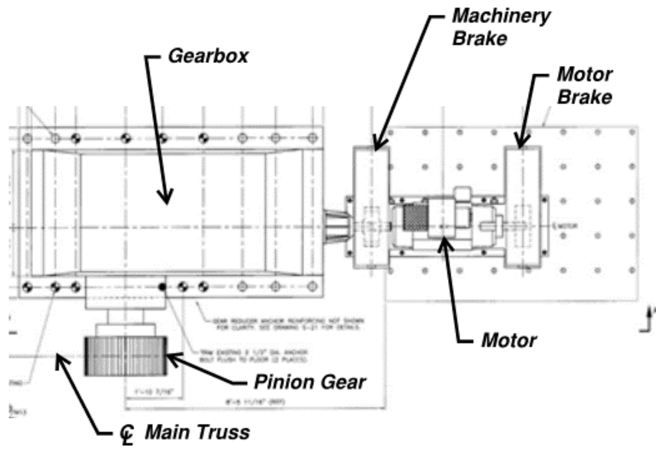


Figure 6. Existing Operating Machinery (1 at each main truss, 2 per leaf)

slightly more conservative than the upper-level seismic case. Based on the three analyses, using the existing information available for the original bridge and conventional design and construction methods at the time it was built, this initial review considers the 1000-yr seismic event as the governing case that provides 13 percent reserve capacity available for the deck extension.

Uniform loading on the trunnions of a single leaf is favorable to promote uniform wear and longevity. Uneven loading is feasible to the extent that the net increase on a single trunnion does not exceed the capacity of the trunnion shaft, including weight added to the span for the sidewalk extension as well as ballast to maintain longitudinal balance, which is subsequently discussed. However, balancing for transverse loads is the recommended approach.

3.3.2. Operating Machinery and Motors

The operating machinery on the bridge was replaced approximately 20 years ago, including new motors, brakes, and gearing. Each leaf is driven by two sets of independent machinery, one set at each main truss, that share the load of driving the leaf and are balanced by the motor drives (see Figure 6). Equal distribution of load to drive the span evenly at both trusses is assumed.

A power calculation was developed to determine the capacity available in the existing machinery motor. In order to meet the requirements of AASHTO LRFD Movable Highway Bridge Design Specifications (LRFD), the motor must be sized for the following for a bascule bridge:

- 100% Full Load Torque (FLT) of the motor must be greater than the wind, imbalance, and friction constant velocity forces as specified in LRFD Section 5.4
- 150% FLT of the motor must be greater than the wind, ice, imbalance, and friction starting and accelerating forces as specified in LRFD Section 5.4

With these criteria, it was determined that the constant-velocity torque when compared with the FLT of the existing motors (60 HP, 860 RPM) has an additional capacity of approximately

11 percent when the adverse condition loads are applied. However, comparing the starting torque with the criteria suggests the existing motors run at 204 percent FLT, exceeding the 150 percent allowable, representing the governing case. Current LRFD loads for new designs are generally conservative and measured loads are typically less. Performance is highly dependent upon adequacy of lubrication and condition of the existing machinery. The calculation for starting torque for this evaluation did not take into account operational protocols that SDOT may have for limiting operation of the span under high-wind conditions that are less than the LRFD requirements.

The rest of the machinery, including gearboxes, rack-and-pinion gears, brakes, and couplings, were assumed to be sized appropriately for the current motor loads. If the motor has to be replaced to meet additional demand, it is likely that the drive train will also need to be upgraded to satisfy AASHTO requirements.

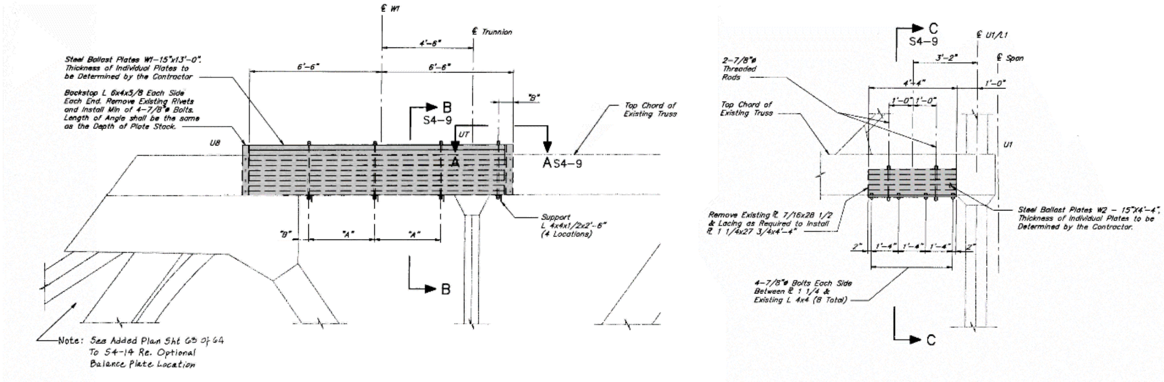
As with the trunnions, adding the cantilevered sidewalk on one side of the bascule span will put a greater demand on the machinery on the same side as the sidewalk expansion. The recommended design approach is to balance the span transversely for load changes. However, if the span remains in a transversely imbalanced condition, control system changes would be needed to account for uneven loading of the two machinery sets per leaf. With the motors already overloaded at starting torque, it would require the complete replacement of the motors and operating machinery with larger sized machinery and motors to account for the additional loads imparted by the modified leaf. Such changes to the sizing of the machinery and motors would also carry over to sizing of the motor drives and electrical feeders for the motors, which will likely require replacement of a significant portion of the electrical power and controls for the bridge.

In addition to the needs for replacing the operating machinery, motors, and associated electrical equipment, there are further challenges with the staging of the replacement equipment to be considered. Both the location of the operating machinery and the lack of space for new electrical equipment will have to be considered in the final design. Additional space requirements for temporary and permanent controls is expected to drive the need for a significant operator's house rehabilitation or replacement. The placement of the operating machinery with limited access from above the deck and the possible need for barge cranes will also increase the time it will take to replace the mechanical equipment and the outages required to perform the work.

3.3.3. Span Balance

The current balance condition of the existing bridge is not known. However, for this preliminary assessment, ensuring a viable means of either restoring the existing condition or establishing another desirable state during, and upon completion of, the work is critical. A common approach for rehabilitation projects is to produce no net change in the balance as a result of changes to the leaf. Therefore, the goal would be to offset the impacts of additional, removed, and/or redistributed weight in both the longitudinal and transverse directions.

The location of each leaf's center of gravity can be finely adjusted in three dimensions (longitudinal, transverse, and vertical) by strategically adding or removing weight ahead of or



a) b)

Figure 7. Existing Ballast Plates at the a) Trunnion and b) Toe of Leaf

behind the centerline of the trunnions for longitudinal adjustment, left or right of the bridge's center-of-gravity longitudinal axis (typically near the midpoint between trunnion bearings) for transverse adjustment, and above or below the trunnion elevation for vertical adjustment. For the asymmetry associated with the SUP addition, transverse adjustment would be necessary to achieve uniform bearing and wear at the trunnion bearings. To offset additional weight above the trunnion axis, vertical balance may also need to be adjusted to ensure the center of gravity remains within the desired range of imbalance with respect to the trunnions for all positions of the span.

Phase 1 plans for this bridge from the Bridge Seismic Retrofit Program offer some insight into the distribution of ballast weight throughout the bridge for span balance after modifications were made to the span. Balance plates were added directly above the trunnion and at the toe (see Figure 7). Approximately 40,000 lbs. was added above the trunnion of each leaf to raise the center of gravity without significantly affecting balance about the trunnion axis, and 300 lbs. and 2,600 lbs. was added to the north leaf and south leaf, respectively, to counterbalance a net weight gain behind the trunnions. The weight of the SUP addition will tend to raise the span's center of gravity, while shifting it toward the toe of the span and to the west, the effects of which can be partially offset by relocating previously installed balance plates from the west truss to the east truss. The rehabilitation design would also need to consider adding material to the counterweight if the net effect of the SUP addition is more span-heavy than desired. Materials with higher density than steel (e.g., lead) can be used if space is limited for additional balance ballast.

Span balance details should be strategically developed to facilitate frequent installation and removal of material for use during construction to minimize the effort required to rebalance the span for operation at intermediate stages of completion.

3.4. Constructability

The paragraphs that follow identify constructability considerations for the work described for the rehabilitation/widening option, specifically with respect to impacts on pedestrian, vehicular, and navigation traffic. Traffic staging for work on the bascule span can generally be coordinated with work on the approach spans since sidewalk and lane closures can be extended across the bascule span. Staging the work for maintenance of marine traffic requires extensive coordination with the USCG to balance the needs of navigation and construction efficiency, which ultimately translates into cost and downtime for motorists, pedestrians, and cyclists.

3.4.1. Roadway and Sidewalk Considerations

Bascule span superstructure work can be performed from the deck, from work platforms in the water, and from platforms suspended from the superstructure. The general sequence of work will be as follows: erect containment, remove sidewalk planks, remove existing brackets, install new brackets, install new sidewalk deck, and remove containment. The sidewalk on the west side of the bridge will be out of commission throughout the performance of this work. Similar to work being performed on the approach spans, all pedestrian and bicycle traffic will be constrained to the sidewalk along the east side of the bridge. To provide room for a construction buffer, vehicular access, and worker safety, one full lane closure across the bridge adjacent to the west truss is anticipated for the duration of the work. In the event three lanes remain open to traffic (or two lanes to traffic and one lane to bicyclists), periodic closure of an additional lane on the west side of the bridge is anticipated for material and equipment access.

3.4.2. Navigation Considerations

Any work that is expected to encroach upon the navigation envelope requires coordination, requiring some form of restriction or channel outage of a specified duration. In the interest of minimizing impacts to navigation and associated schedule inefficiencies, work adjacent to, in, or above the navigation channel should be minimized to a practical extent.

Structural work at the bascule piers to install brackets and extend the deck can be performed from the deck, as well as from barges and work platforms outside the limits of the federal navigation channel. Work on the superstructure, however, requires work directly over the channel. A long-term full channel outage for all work would be ideal for construction but would not be viewed favorably by the USCG due to the navigation needs of the ship canal. A

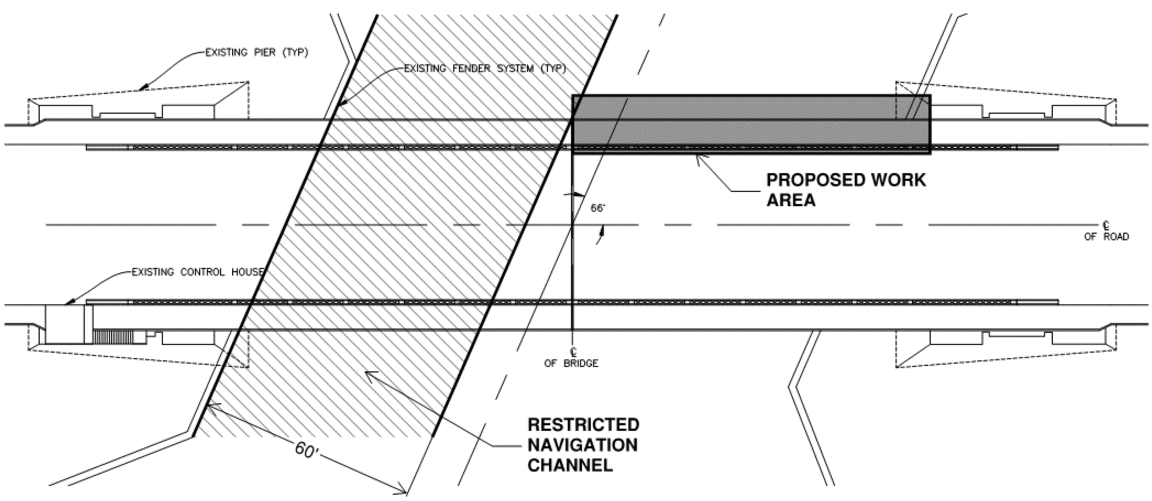


Figure 8. Channel Restriction for Work on North Bascule Leaf Superstructure

horizontal restriction limiting the width of the channel to approximately 60’ would be sufficient to allow nearly all of superstructure work on one leaf to proceed uninhibited by the need to operate the span. Once the work on one leaf is complete, the restriction could be shifted to the opposite side of the channel. Figure 8 provides a plan view illustrating the interaction between the work zone on the superstructure and the navigation channel. Restricting navigation to the hatched side of the channel allows all work (except the outside edge of the new deck at the toe) to be performed without encroaching on the channel. The restricted width proposed here is for illustration purposes only. If a long-duration horizontal restriction is permissible with a channel wider than 60 feet, it could be coupled with short-duration restrictions to accomplish work at the toe or otherwise encroaching on the prevailing temporary channel. Figure 8 shows work on the north leaf with navigation restricted to the south side of the channel. Note that the skew of the bridge relative to the channel allows for a temporary channel approximately 20 to 30 feet wider on the north side when work is being performed on the south leaf. Environmental containment enclosures and work platforms suspended from the bridge are not expected to violate the existing vertical clearance of the bridge.

Channel restrictions discussed in the previous paragraph are purely hypothetical and do not reflect any previous or on-going coordination efforts with the USCG. Detailed coordination of the anticipated work is encouraged to begin as early as possible in planning the work to establish expectations that will significantly influence design and schedule development. If the span must remain operational during the performance of the superstructure work to accommodate passage of large vessels, all of the removal and replacement activities will have to be performed in short-duration increments between span openings, and the span will need to be temporarily balanced for its condition at the time of each operation. Containment enclosures required during steel removal will need to either be modularized and designed for easy set-up and removal, or they will need to be robust enough to operate with the span (which will also contribute to the temporary balance requirements).

Navigation impacts associated with the seismic retrofit work are expected to exceed those anticipated for the widening work in both extents and duration. It may be possible to coordinate the superstructure widening with the member strengthening to minimize impacts to the channel for this alternative.

Conditions of the channel bottom and existing fender system were not addressed as part of this constructability assessment. Bathymetric survey and evaluation of the existing fender based on a detailed condition assessment are recommended to determine if channel dredging or fender strengthening/replacement would be necessary.

3.5. Cost Estimate

The rehabilitation/widening alternative described in this study is focused solely on providing a comprehensive structural and operational solution for widening the existing bascule span to accommodate the needs of pedestrians and bicyclists. Based on the concept presented in this memo, widening the bascule span is anticipated to satisfy the conditions for a “minor widening” per Section 4.3 of the WSDOT Bridge Design Manual. However, the seismic vulnerability of this bridge has been well documented and seismic retrofit strategies are being developed in a separate evaluation. Costs associated with recommendations made in that evaluation are included in the order-of-magnitude estimate of probable cost in Table 1. This estimate covers all modifications to the bascule span and piers required to increase the width of the sidewalk on the west side of the bridge to 14 feet. This estimate also includes seismic retrofit work, per the recommendations in the CDR and as noted in Table 1, which covers strengthening and/or replacement of deficient members identified in the load rating summary and inspection report. The estimate includes geometric and structural modifications to the bascule leaves and piers, superstructure blasting and painting, mechanical and electrical rehabilitation for reliable long-term operation, intermediate and final span balancing, and operator house rehabilitation/replacement due to anticipated additional space needs with larger controls and equipment. Mechanical and electrical estimates consider access difficulty and temporary operation systems for the replacement of the drive machinery, motors, and controls, and this work is expected to be developed in a manner that effectively incorporates the mechanical and electrical recommendations made in the seismic retrofit study. Channel dredging and fender system improvements are not included.

Estimated values in Table 1 represent labor and material costs to complete the work and do not reflect project-wide factors for right of way, mobilization, staging, design and construction contingencies, inflation, risk premiums, etc.

Structural	$	3.6 M
Mechanical	$	5.3 M
Electrical	$	2.8 M
Architectural	$	1.0 M
Seismic Retrofit*	$	30.6 M
Cleaning and Coating**	$	30.6 M
Total	$	43.3 M

* Superstructure and Substructure Option 2 retrofit, upper end of probable cost range (see SDOT Bridge Seismic Retrofit Ballard Bridge BRG20 Bascule Piers and Movable Spans)

Table 1. Order-of-Magnitude Cost Estimate: Low-Level Rehabilitation/Widening Alternative

4. Mid-Level Replacement Alternative

Building a new bridge to replace the existing structure offers an opportunity to incorporate mobility improvements for all modes of transportation (as opposed to just sidewalk users) while building an inherently safer structure that will be designed and constructed in accordance with modern seismic performance and resiliency standards. The long-term safety and mobility benefits of building a new bridge relative to rehabilitating the existing one need to be considered along with the near-term cost and constructability disadvantages when determining the most effective path forward.

A replacement bridge would provide enough roadway for an acceleration/deceleration lane, wider through lanes, shoulders, and a barrier-separated shared-used path. The proposed mid-level solution would not be high enough to accommodate all vessel traffic, but an increase of approximately 20 feet relative to the existing clearance of 45 feet is anticipated to allow a

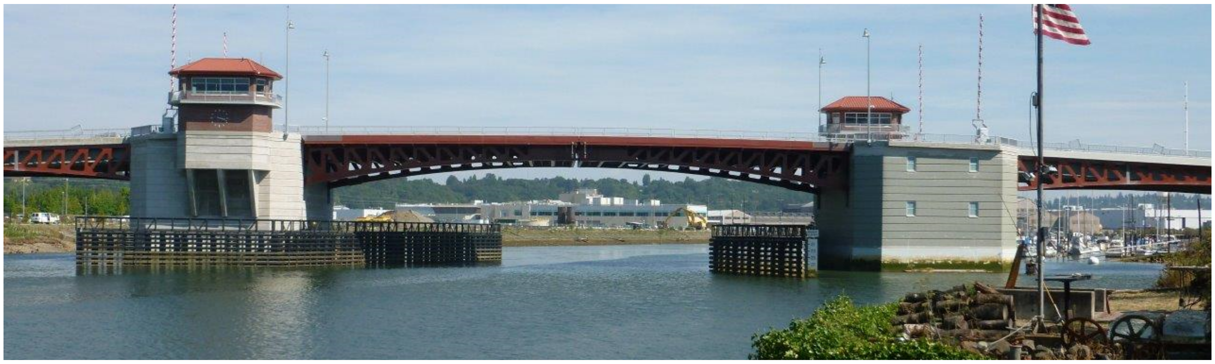


Figure 9. South Park Bridge in Seattle, WA

significantly larger percentage of boats passing under the bridge without requiring an opening. If a mid-level bascule span replacement advances to planning and preliminary design, a study is recommended to establish a cost-effective navigation clearance. A detailed vessel study across multiple navigation seasons can be useful in establishing trends for predicting current and future operation needs for the bridge. Including vessel height measurements in the gathered data can be used to identify a vertical clearance that will accommodate a significant portion of the total vessel inventory, beyond which the benefits of additional clearance would affect only a small percentage of vessels, i.e., the point of diminishing returns.

4.1. Superstructure

For this study, a double-leaf bascule span (similar to the general configuration of the existing bridge) was the only type of movable span considered in detail. A deck-type structure with a solid deck would be recommended for durability of the underlying superstructure and environmental benefits. The lack of structural elements projecting above the deck also allows more flexibility for shifting traffic lanes throughout the life of the bridge relative to a through-type structure. A drawback of this configuration relative to through-type structure is that a higher profile is necessary for the same under-clearance. Hybrid deck systems comprised of lightweight concrete and an orthotropic steel grid are effective for strength and durability while minimizing weight.

The primary load path would consist of transverse floorbeams supporting the deck and spanning between the main girders near the outer edges of the bridge, with the deck projecting out beyond the main girders on cantilever brackets at each floorbeam location. The concept presented in Figures ML-1 and ML-2 (attachments) was developed assuming the main load-carrying members would be girders. Trusses are also feasible if desired or necessary to satisfy historic mitigation requirements or other stakeholder commitments. The South Park Bridge over the Duwamish Waterway offers another potential solution, where the main girder webs were perforated to emulate the look of the existing historic truss that previously occupied the site while realizing some of the benefits of plate girder construction relative to conventional trusses (Figure 9).

4.2. Substructure

Bascule piers are typically sized to enclose the operating machinery and other sensitive equipment for protection from the environment. As a result, the footprint of a typical bascule pier is wider than the leaf in the transverse direction, and longer than the distance between the counterweight at the back and the live shoes at the front. The typical roadway section will require a bridge that is approximately 80 feet wide, so a rectangular footprint 100’ wide x 50’ long is assumed for this evaluation. The additional 10 feet of width outside of the roadway and path on both sides of the pier provide space for the access features into the pier and control house, as well as a place for SUP users to safely congregate while the span is operating.

On-alignment and parallel offset alignments were considered for the overall bridge replacement, and both options are viable for the movable span. The on-alignment strategy was favored for this study due to design and staging factors at the approach spans. The potential benefits of using an offset alignment should not be ignored, however, and should be evaluated in greater detail in future studies. In order to replace the bascule span on the same alignment as the existing bridge, a temporary movable span will be required adjacent to the bridge to maintain traffic during demolition of the existing bridge and construction of its replacement. The temporary alignment must allow for the temporary span to be built a sufficient distance from the existing and proposed bridges to accommodate demolition and construction activities without physical conflicts or settlement concerns (Figure 10).

The control house will be incorporated into one of the bascule piers. The location and elevation of the house is generally based on optimizing operator sight lines of the roadway and navigation channel, as well as safe access for operation and maintenance personnel. Channel skew favors the NW and SE corners, offering the operator full views of the channel without having to look around the far side of the bridge to see the channel when the span is open. The SE corner

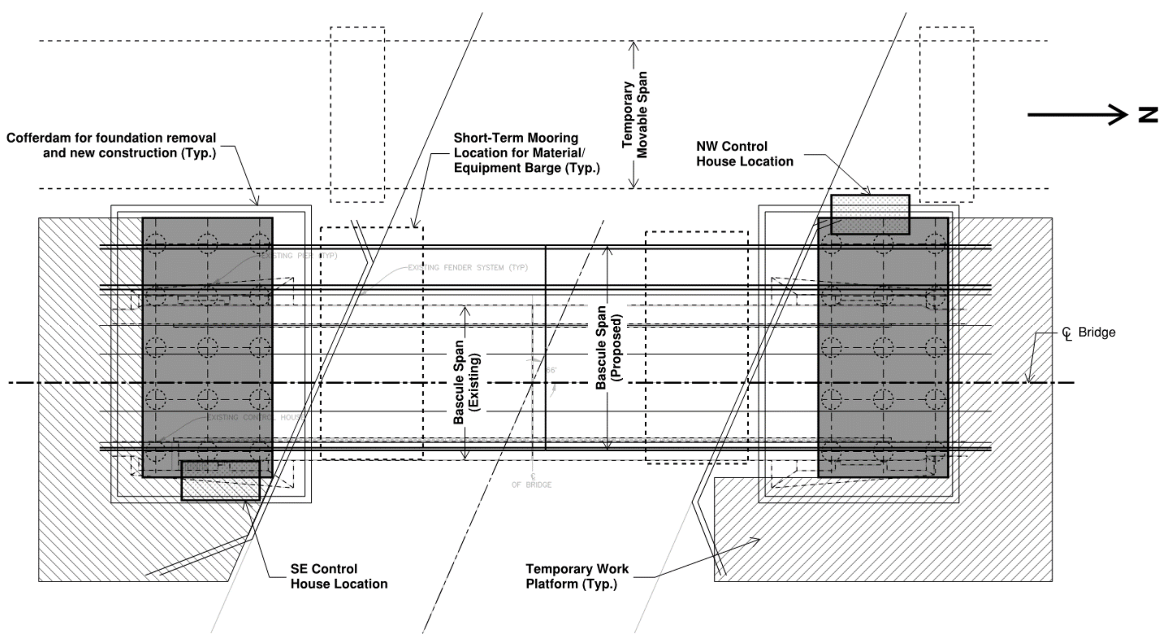


Figure 10. Conceptual Layout for Mid-Level Replacement Alternative

initially appears more favorable than the NW corner because the SE vantage point offers a wider field of view of the SUP for the operator. However, access to/from the house along the SUP favors the NW quadrant. Operator parking, aesthetics, security, and other factors will also weigh into determining which corner is optimal at a more advanced stage of planning and design.

The assumed foundation type for the replacement structure is a group of large-diameter drilled shafts. Using existing soil boring data, strength and extreme event limit state capacity curves for 8-ft, 10-ft and 12-ft diameter drilled shafts were developed by HWA for this evaluation (see Preliminary Geotechnical Engineering Letter Report prepared for this study). Lateral seismic loading is expected to govern the size of the foundation. Using the short-period spectral acceleration for Site Class C, lateral and overturning effects acting on the foundation were computed using estimated weights for the bascule span and pier. A group of fifteen 8 ft-diameter shafts spaced at 20 feet (2.5 x shaft diameter) demonstrates potential to satisfy strength and stiffness needs within the pier footprint required to house the bascule leaf. This arrangement is used as a reasonable approximation for preliminarily evaluating space requirements for construction of the new bridge. Additional geotechnical data gathering and foundation design is recommended in later phases of development. Based on preliminary geotechnical analyses, the length of drilled shafts for these foundations are expected to exceed 100 feet.

Preliminary geotechnical analyses using existing data indicates that liquefaction potential in the vicinity of the main span is low. While not anticipated to be a factor at this stage, a final determination on liquefaction potential should be made during later stages of design using subsurface data acquired specific to the bascule pier locations.

4.3. Machinery and Electrical Systems

The mechanical and electrical systems for a replacement bridge would be designed to meet the requirements of the most recent version of the AASHTO LRFD Movable Highway Bridge Design Specifications, along with design, maintainability, and performance features as required by the Seattle DOT.

Seismic design would adhere to the bi-level performance requirements in Chapter 4 of the WSDOT Bridge Design Manual (BDM). Because reliable operation of movable bridges is sensitive to small displacements between mating parts of the drive machinery, alignment features and locking devices, a holistic approach that considers the interaction between the structural and mechanical systems is recommended to ensure that permanent deformations that could compromise safe operation of the span are either completely prevented or limited to elements that can be safely bypassed or easily replaced. For this reason, each bascule leaf and its interfaces with the operating machinery will likely be designed to exceed the minimum performance requirements in the BDM, regardless of the bridge's designation as "essential" or "critical."

To expedite returning the bridge to an operable condition in a post-earthquake environment, maintaining alignment of the drive machinery relative to itself and relative to its mating components on the bascule leaf are critical. A common machinery support for all motors, brakes, gearboxes and bearings that is designed to remain elastic, even during the Safety Evaluation Event (1000-yr return period), would minimize the effort required to re-align the drive system with the bridge. If the bascule span and bearing supports are also designed to respond elastically, even if the machinery assembly experiences permanent displacement relative to the span, it could be repositioned without having to realign components internal to the drive train. Span locks, centering devices, joints, and other features likely to come into contact during an earthquake should be designed elastically where it makes sense to do so without compromising other features of the bridge, or a fusing mechanism should be incorporated that allows the element to fail in a compartmentalized manner so that it can be bypassed or repaired with little effort. Conduit runs between components expected to experience significant relative displacement should be as flexible as possible.

4.4. Constructability

4.4.1. Roadway and Sidewalk Considerations

For the on-alignment replacement concept, a temporary movable span would be used to maintain traffic for vehicles, cyclists, pedestrians and boats during demolition of the existing bridge and construction of the replacement structure. The temporary span would be built a sufficient distance from the existing and proposed bridges to minimize potential impacts to surface transportation. Temporary disruptions at key phases of construction may be experienced to shift traffic from existing to temporary, and temporary to proposed, but long-term disruptions would be limited.

4.4.2. Navigation Considerations

Removal of the existing bridge and temporary bridge superstructures will each require an additional short-term channel outage, while removal of the substructure can be performed with channel restrictions one side at a time.

Temporary work platforms installed behind the temporary and proposed piers can accommodate most of the activities required to build the movable span support structures. For the proposed piers, addition platforms on the east side (away from the temporary span) can be added for additional access. If roadway geometry and other factors can accommodate enough separation between the temporary and proposed bridges, addition platform may also be feasible between them. Occasional channel blockages for material and equipment barges are anticipated, but these blockages can be limited to one side of the channel at a time (Figure 10).

Bascule leaf installation will require as little as one to as many as four two- to three-day channel outages, depending on how the leaf installation and deck work is staged. Once installed, the leaves can be raised and locked in the open position for the remainder of construction, if desired, to avoid imposing a vertical restriction. Anticipating the temporary movable span will provide similar under-clearance as the existing bridge, the leaves of the new bridge could also be lowered without imposing a vertical restriction because the clearance provided by the new span will be significantly higher than the temporary bridge.

4.5. Cost Estimate

Unlike the rehabilitation/widening alternative discussed in the previous section, the mid-level replacement alternative described in this study is focused on a complete solution that address the safety and mobility goals of the corridor and meets seismic performance and resiliency expectations.

Construction of a replacement bascule span built along the existing alignment is estimated to cost $68M for all elements of work related to the bascule span, including the foundations, bascule piers, fender systems, control house (and associated mechanical and electrical systems), bascules leaves, bridge mechanical systems, and bridge electrical systems and controls. It does not include costs associated with construction, operation, and removal of a temporary movable span. This estimate represents labor and material costs to complete the work and does not reflect project-wide factors for right of way, mobilization, staging, design and construction contingencies, inflation, risk premiums, etc.

5. Summary

In support of the Ballard Bridge Planning Study, the following movable span alternatives were developed and preliminarily evaluated (based on constructability and user impacts), and order-of-magnitude construction costs were developed:

- Low-level rehabilitation/widening of the existing bridge for the purpose of improving safety and connectivity for pedestrians and cyclists crossing the bridge
- Mid-level replacement with a movable span for the purpose of improving all modes of transportation and upgrading the facility for seismic performance and resiliency

Each concept was described to identify critical issues relevant to constructability, and costs estimates were developed. Construction cost estimates in Table 2 do not reflect project-wide factors for right of way, mobilization, staging, temporary structures, design and construction

Alternative	Cost Estimate	Description
Low-level Rehabilitation/ Widening	$43M	• Removal of existing 6’ sidewalk overhang on west side • New overhang for 14’ shared-use path • Extended deck level at bascule piers • New mechanical and electrical systems • Enlarged/new operator house • Seismic retrofit of superstructure and substructure • No roadway improvements • No maintenance or operator access improvements • No improvement to navigation clearance
Mid-level Replacement*	$68M	• Acceleration/deceleration lane • Wider traffic lanes • 14’ shared-use path • Additional navigation clearance • Enhanced seismic performance

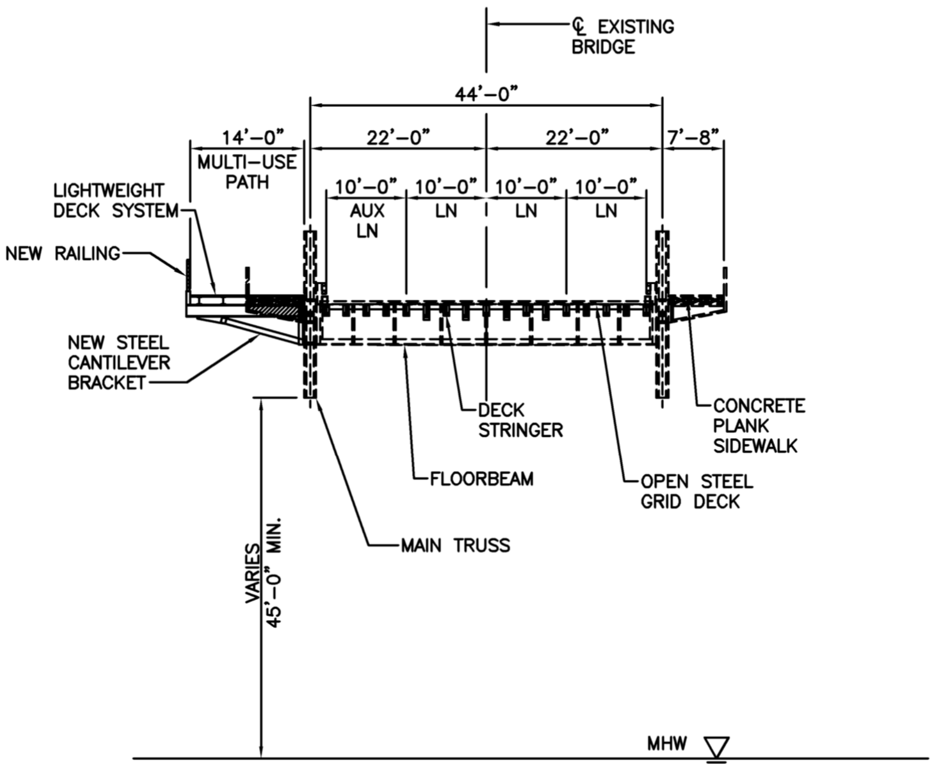
* Estimate does not include costs associated with construction and operation of a temporary bridge.

Table 2. Movable Span Alternative Summary Table

contingencies, inflation, risk premiums, etc. and are to be included as component costs in project-wide cost estimates.

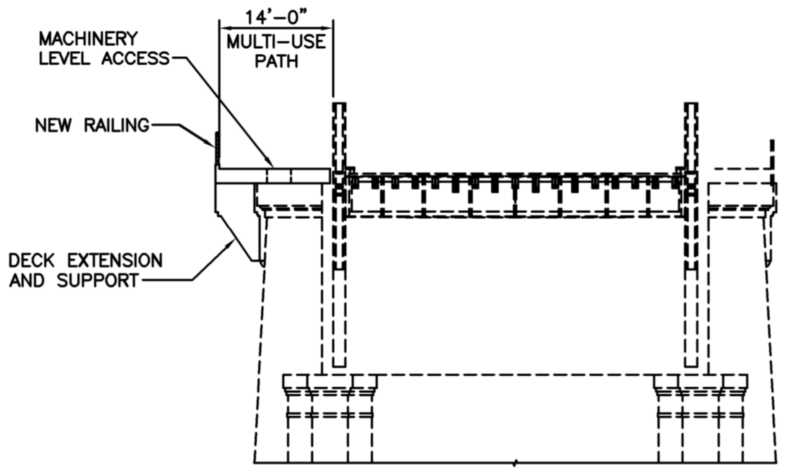
For details of the seismic retrofit strategies for the low-level rehabilitation/widening alternative, refer to the study titled Bridge Seismic Retrofit Ballard Bridge BRG20 Bascule Piers and Movable Spans Concept Design Report (September 2019).

Refer to Figures LL-1 and LL-2 attached to this memo for concept sketches showing the bascule span and bascule pier, respectively, for the low-level rehabilitation/ widening alternative. Similarly, for the mid-level replacement alternative, see Figures ML-1 and ML-2.

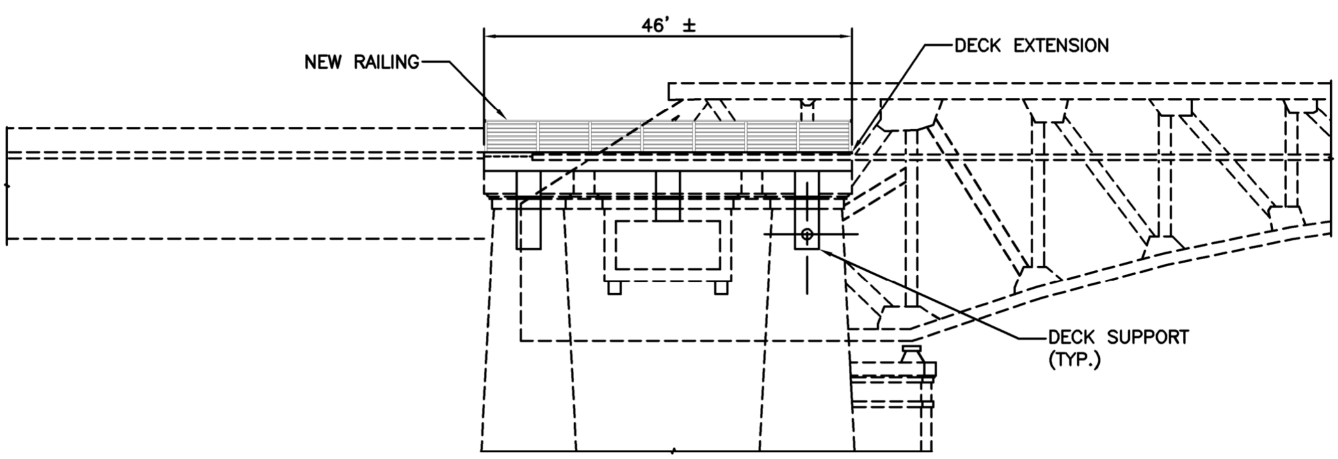


LOW–LEVEL REHABILITATION/WIDENING EXISTING BASCULE SPAN
(LOOKING NORTH)

HDR	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE: 1/2" = 1'–0"	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA LOW–LEVEL REHAB/WIDENING BASCULE SPAN	FIGURE LL–1

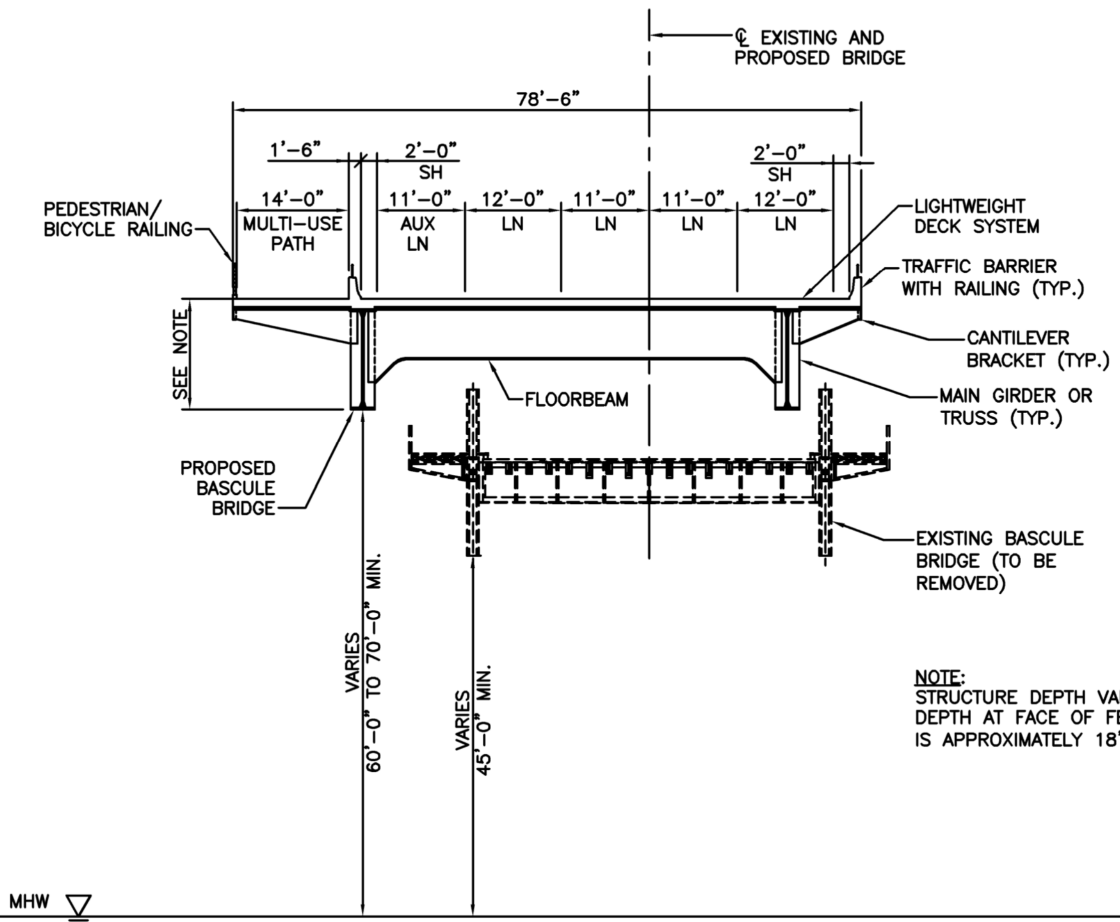


LOW–LEVEL REHABILITATION/WIDENING EXISTING PIER
(CHANNEL ELEVATION NORTH PIER, SOUTH PIER SIMILAR)



LOW–LEVEL REHABILITATION/WIDENING EXISTING PIER
(WEST ELEVATION NORTH PIER, SOUTH PIER OPP. HAND)

HDR	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE: 1/2" = 1'–0"	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA LOW–LEVEL REHAB/WIDENING BASCULE PIER	FIGURE LL–2

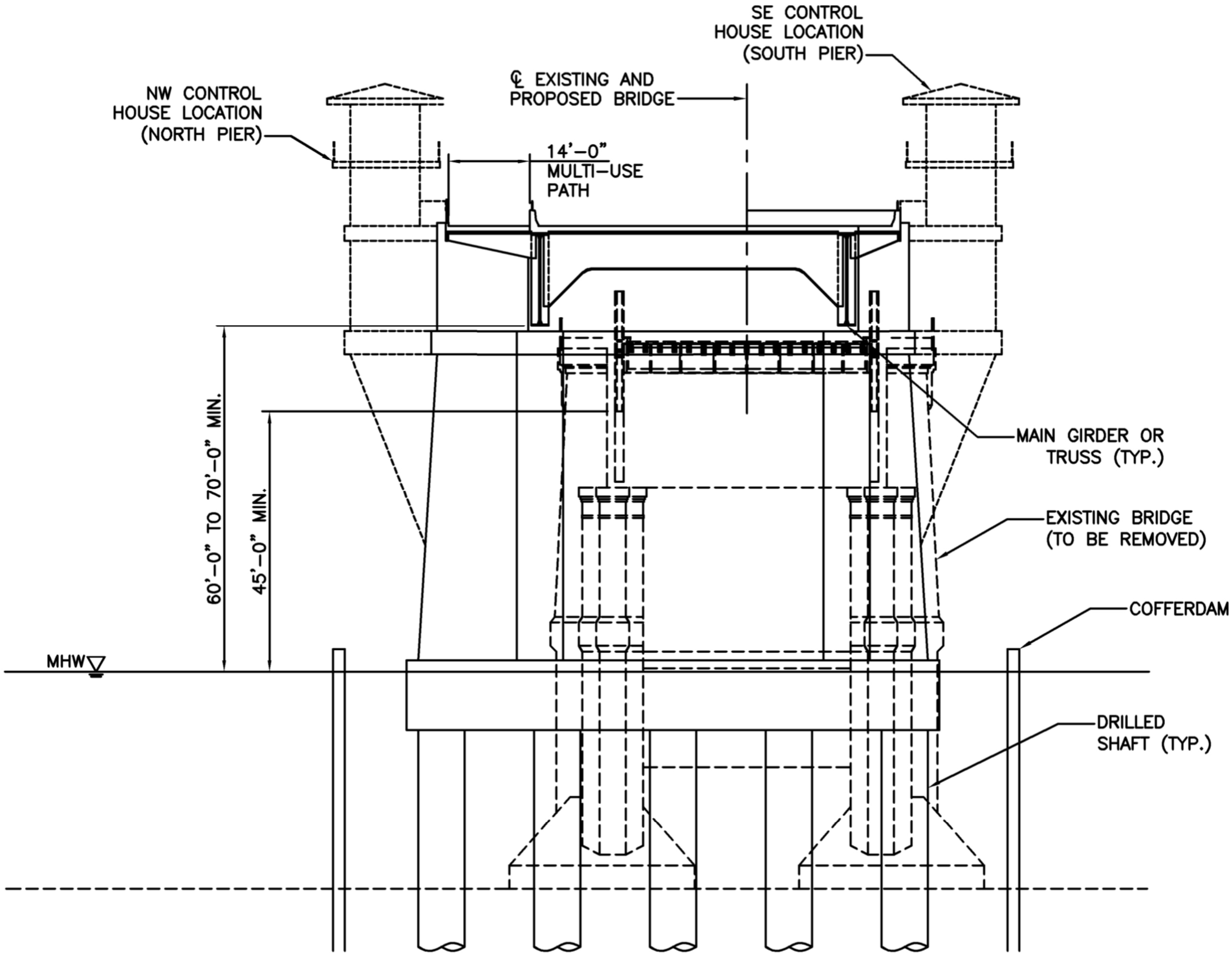


NOTE:
STRUCTURE DEPTH VARIES. MAXIMUM DEPTH AT FACE OF FENDER SYSTEM IS APPROXIMATELY 18'-0"

MID-LEVEL REPLACEMENT BASCULE SPAN

(LOOKING NORTH)

HDR	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE: 1/2" = 1'-0"	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA MID-LEVEL REPLACEMENT BASCULE SPAN	FIGURE ML-1



MID-LEVEL REPLACEMENT BASCULE PIER

(CHANNEL ELEVATION NORTH PIER, SOUTH PIER OPP. HAND EXCEPT AS NOTED)

HDR

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE: 3/8" = 1'-0"

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

MID-LEVEL REPLACEMENT
BASCULE PIER

FIGURE
ML-2

Appendix D

Preliminary Geotechnical Engineering Report

SDOT

Seattle Department of Transportation

COWI

HWA GeoSciences Inc.

DBE/MWBE

PRELIMINARY GEOTECHNICAL ENGINEERING REPORT
BALLARD BRIDGE STUDY
SEATTLE, WASHINGTON

HWA Project No. 2019-085-21

August 7, 2020

Prepared for:

COWI North America, Inc.

HWA GEOSCIENCES INC.

August 7, 2020
HWA Project No. 2019-085-21

COWI North America, Inc.
1191 2nd Avenue, Suite 1110
Seattle, WA 98101

Attention: Matt Baughman P.Eng., P.E., S.E.

Subject: **PRELIMINARY GEOTECHNICAL ENGINEERING REPORT**
Ballard Bridge Study
Seattle, Washington

Dear Mr. Baughman:

Attached is our preliminary geotechnical engineering report for the proposed Ballard Bridge Study in Seattle, Washington. This preliminary report includes the results of our field explorations, and our engineering analyses for design and construction of the proposed improvements along the Ballard Bridge.

We appreciate the opportunity to provide geotechnical services on this project. Should you have any questions or comments, or if we may be of further service, please do not hesitate to call.

Sincerely,

HWA GEOSCIENCES INC.

Donald Huling, P.E.
Geotechnical Engineer, Principal

Sean Schlitt, P.E.
Geotechnical Engineer

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August 7, 2020
HWA Project No. 2019-085-21

PRELIMINARY GEOTECHNICAL ENGIENERING REPORT
BALLARD BRIDGE STUDY
SEATTLE, WASHINGTON

1. INTRODUCTION

We are pleased to submit this preliminary geotechnical letter report for the geotechnical engineering services associated with the Ballard Bridge Study in Seattle, Washington. The project location is indicated on the Vicinity Map, Figure 1, and Site and Exploration Plan Figures 2A through 2H. Our role in the project was to review and interpret existing geotechnical subsurface investigation data and develop preliminary recommendations for the alternative evaluation study of the Ballard Bridge project. The scope of this study includes consideration of construction of a new bascule (movable) bridge and associated approach piers, within the approximate area between station markers STA 113+00 to 132+00.

2. PROJECT DESCRIPTION

The Ballard Bridge carries more than 57,000 vehicles per day across the Salmon Bay Waterway. While the structure is still in good condition today, it is over 100 years old. And while SDOT continues to maintain its safety for daily travel, the likelihood that major maintenance or emergency repair work will be needed continues to increase with age. In addition, the structure is not up to current standards for providing space to people walking, biking, or traveling in a vehicle, hence it being categorized as "functionally obsolete". Knowing that the replacement of the bridge structure could potentially be a significant cost to the City, as part of the Levy to Move Seattle, funding was provided to conduct a planning study that would explore rehabilitation and replacement options and identify the associated costs and trade-offs.

We understand that the design team is investigating rehabilitation and replacement options for the existing Ballard Bridge structure extending across the Salmon Bay Waterway, including a movable bridge section designated to allow passage along the Lake Washington Ship Canal. The location of the proposed improvements to the existing Ballard Bridge are shown on the Proposed Ballard Bridge Improvements Plan View, Figure 3. This figure shows the mid-level bridge replacement concept and stationing. Several proposed bridge rehabilitation options have similar stationing, which has been used for dividing the bridge alignment into specific segments used for referencing each segment's applicable recommendations.

The options to be considered are: (1) a low-level rehabilitation that will reinforce the existing bridge with a variety of support structure options; (2) a mid-level replacement option with a new approach bridge connecting to a new bascule bridge structure slightly above and along the same alignment as the existing bridge; and (3) a high-level replacement option consisting of a new bridge approach and main span bridge entirely above the existing bridge.

If the high-level option is utilized, the existing low-clearance bascule bridge system will be replaced by a high-clearance main span bridge, thus eliminating the necessity for a movable bridge section. The remainder of the bridge approach is assumed to be founded on a pier system with an average span length of about 150 feet. The location of each pier and type of structure for the navigation span has not been determined at the time of this study. We anticipate that the pier systems for the mid- and high-level options will be founded on drilled shafts. Our recommendations are based on the proposed bridge plan as provided by COWI, entitled "2019-08-02_A115271 Progress Set," dated August 2, 2019.

3. EXPLORATIONS BY OTHERS

3.1 FIELD EXPLORATIONS BY OTHERS

A review of the historic subsurface investigation data revealed fifty-eight studies within the broad vicinity of the Ballard Bridge Corridor study area, extending from the north edge of NW Market Street to just south of the W Emerson Street interchange at the south end of the project. Of the studies reviewed, only one was determined to be suitable for analyzing the subsurface profile anticipated at the locations of the proposed approach piers and movable bridge bascule pier system. The remainder of the studies were found to be located outside of the proximity of the bridge study area or were found to have insufficient resolution of data to be used for analysis.

The exploration program used for our analysis was conducted by Shannon & Wilson (S&W) in 2003 in support of the proposed Monorail system to be located within this corridor. The findings of this study can be found in the geotechnical engineering report entitled "Report Addendum No. 095-1, Geotechnical Data Report (GDR), Seattle Monorail Project (SMP), Seattle, Washington" dated April 1, 2004. This exploration program included the advancement of multiple subsurface explorations across the ship canal. The boreholes used in this study (designated BX-101 through BX-108) were extended to depths ranging from 61.9 to 218.5 feet below ground surface (bgs). It should be noted that for all borings conducted within the ship canal, the ground surface was designated as the mudline elevation; water surface elevations varied in height above this level.

The approximate locations of the S&W borings specific to the current area of study are shown on the Site and Exploration Plan, Figures 2C though 2E. Summary logs of the boreholes are presented in Appendix A.

3.2 Laboratory Testing By Others

Geotechnical laboratory tests were conducted, by S&W, on selected samples retrieved from their explorations to characterize relevant engineering and index properties of the soils encountered at the site. The tests included visual classifications, determining natural moisture contents, Atterberg limits, and grain size distributions. The test results are presented in Appendix B.

4. SITE CONDITIONS

4.1 General Geologic Conditions

The project site is located within the Puget Lowland, a topographic sediment basin between the Cascade and Olympic mountain ranges. This basin has been repeatedly scoured and infilled by continental glaciation during the most recent ice ages of the Quaternary geologic time period. For at least seven cycles of glaciation within the last 20,000 years, portions of the North American continental ice sheet advanced southwards from British Columbia into the lowlands of Western Washington as the Cordilleran Lobe, as far south as Olympia, Washington. Each major advance included multiple interstitial periods of minor advance and retreat, resulting in overlapping, repeated sequences of erosion and deposition. In-between this, local sediments infilled the Puget basin from the bordering Cascade and Olympic ranges. The final retreat of the Cordilleran glacial lobe subsequently revealed an irregular landscape of elongated, north-south trending hills and valleys, composed of a complex sequence of glacial and interglacial deposits. Glacial materials encountered within the Puget Lowland vary widely in location and extent, from glaciolacustrine materials, glaciofluvial outwash, bordering and end moraine till, and transitional drift.

General geologic information for the site was obtained from the publication *The Geologic Map of Seattle – A Progress Report* (Troost et al., 2005). The project site is underlain by the ship canal; as such, general geologic information does not provide a geologic unit for this heavily-modified project alignment. Based on our experience, we anticipate the site is underlain by relatively modern lacustrine deposits (Ql). These deposits consist of silt and clay with local sand layers, peat, and other organic sediments, deposited in slow flowing water. Beneath this, we anticipate very dense, glacially-consolidated soils discussed in detail in the following section.

4.2 Site Soil Conditions

The explorations completed by others typically encountered fill at the mudline, with a highly variable subsurface stratigraphy across the alignment. Brief descriptions of the soil units observed in the explorations are presented below in order of deposition, beginning with the most recently deposited.

Fill – A fill layer was observed in borings BX-101, BX-105, BX-106, BX-107, BX-108 at the surface of each exploration. This deposit consists of very soft to soft, clayey, sandy silt and very loose to medium dense clayey, silty sand. BX-101 showed significantly denser soils with a higher percentage of gravel soils; this soil may be undocumented structural fill. We believe that fill soils placed outside of the ship canal may contain similar material to those encountered in BX-101. Fill soils vary in constituency and material and were likely placed in support of construction.

Peat – Holocene-aged peat was encountered in borings BX-101 and BX-102 near surface or beneath the fill soils. This deposit consists of very soft, peat soils with a very high organic content. The presence of peat is easily distinguished by very high moisture contents observed in samples. The peat soils appear to range greatly in thickness and are anticipated to be located sporadically across the site. Modern peat soils in this vicinity can be generally attributed to Lake Washington wetland deposits prior to major anthropogenic influence.

Lacustrine – Quaternary-aged lacustrine soils were encountered in borings BX-102, BX-103, BX-104, and BX-107 near surface or encountered beneath the peat and fill soils. This deposit consisted of very soft to soft, silty, lean to fat clay with a wide range of organic contents. Modern lacustrine material in this vicinity can be generally attributed to Lake Washington deposits prior to major anthropogenic influence.

Recessional Outwash – Vashon-age recessional outwash was observed in borings BX-101, BX-103, BX-104, BX-105, and BX-106 beneath the quaternary aged deposits. The outwash consisted of medium dense to very dense silty sands with varying silt contents and gravel. These soils generally increased in density with depth. The unit exhibited blow counts greater than those anticipated for recessional outwash; this may be the result of overstated blows due to gravel obstructions. This unit was deposited in the meltwaters of the receding glacier and therefore, is not as dense as glacially overridden layers. Where encountered below the ground water these soils are usually susceptible to liquefaction during a seismic event.

Glacially Consolidated Soils – A variety of glacially consolidated soils were encountered in all borings at depth, extending to the termination depth of each exploration. These units included glaciomarine deposits, glaciolacustrine deposits, and glacially consolidated fluvial deposits. Each unit generally consisted of very dense silty to clayey sands and very stiff sandy, silts and clays. These units were observed to be interbedded with each other, with their constituent contents locally variable along the alignment. Given the nature of these deposits at depth, we have determined for the purposes of this report that these glacially-consolidated soil materials along the alignment can be considered as one engineering unit characterized by the material parameters of very high density and stiffness.

4.3 Soil Contamination

Contaminated soils were encountered along the bridge alignment and within the vicinity of the project corridor. As a result, environmental sampling and laboratory testing was performed in areas where potential contamination was suspected based on observations made during previously completed field explorations. The type, extent and location of soil contamination has been evaluated by S&W. For specific information associated with soil contamination across the site, please refer to the geotechnical engineering report (Shannon & Wilson, 2003).

4.4 Ground Water Conditions

For all borings within the ship canal, water was encountered above the mud line; these borings were assumed to be saturated at the bathymetric surface with saturated conditions at all depths. Groundwater was observed in borings BX-101 and BX-108 which were situated outside of the ship canal. The depth to groundwater in both these borings, which approximately reflects the water elevation of the ship canal, was observed to be approximately 5 feet bgs. We expect that the groundwater level varies seasonally with the highest level occurring in the wet winter months and the lowest level in the dry summer months. Given the depth of groundwater and the placement of pier systems within the ship canal, the impacts of high groundwater conditions should be considered during construction.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 General

The soil conditions and site topography in the vicinity of the Ballard Bridge are such that the evaluated alternatives for replacement and/or rehabilitation are feasible. However, some geotechnical constraints will need to be addressed during design.

It is our understanding that this initial study has been requested to determine the feasibility of each of the options under consideration. As a result, the provided seismic considerations have been divided into two sections; the rehabilitation options (low-level) and the replacement options (mid- and high-level).

For the rehabilitation and replacement option conditions, drilled shaft capacity charts have been included for drilled shafts of 8-, 10- and 12-feet diameters. Also, L-PILE parameters are provided for each designated bridge segment. Given the variability in soil conditions encountered, recommendations have been designated based on the locations of the existing borings rather than the locations of the pier systems. As a result, we recommend additional subsurface investigations be completed once the preferred alternative has been selected, to verify the anticipated soil conditions beneath the location of each foundation system. Table 1 presents the boring(s) used to analyze and provide recommendations for each defined segment. It should be noted that the scope of this preliminary study includes recommendation for structures on water, and not the approach and interchange bridges on land.

Our analyses suggest that the coarse-grained fill and recessional outwash soils in borings BX-101 and BX-103, respectively, could liquefy during the 1,000-year return period event (i.e. high-level event). This could result in liquefaction induced settlement and lateral spreading. Pier foundations within these deposits should be designed to resist down drag loading associated with the liquefaction-induced settlement. Design will also need to consider the potential for large lateral loads to be exerted on the foundations due to lateral movement of the crust of non-liquefiable soils.

Table 1: Corresponding Boring Number and Stationing for Each Geotechnical Design Segment of Proposed Bridge

Stationing		Corresponding Boring
Start	End	
113+00	116+00	BX-101
116+00	118+00	BX-102
118+00	121+00	BX-103
121+00	124+00	BX-104
124+00	129+00	BX-105, BX-106
129+00	132+00	BX-107, BX-108

5.2 SEISMIC CONSIDERATIONS

5.2.1 Design Parameters

Earthquake loading for the Ballard Bridge structure was developed in accordance with the General Procedure provided in Section 3.4 of the *AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2011* (AASHTO, 2011 with 2012, 2014 and 2015 Interim Revisions), SDOT *Bridge Seismic Retrofit Program – Phase III, Bridge Seismic Philosophy, Policies, and Criteria (BSRPPC)*, Revision 1, December 2015 (SDOT, 2015) and WSDOT *Bridge Design Manual* (LRFD) *(BDM*, June 2018).

For seismic analysis, the associated seismic Site Class for the soil conditions to be analyzed is determined based on the average soil properties in the upper 100 feet below the ground surface. Based upon an evaluation of the existing borings for our proposed study area, the underlaying soils along the north approach and the bridge structure are consistent with the characteristics of "Very Dense Soil," corresponding to a Site Class C. The existing data suggests that the underlaying soils along the bridge south approach starting from about 1,000 feet north of the Emerson Street Intersection to the southern end of the south approach alignment is consistent with soils that exhibit characteristics of "Stiff Soil" Site Class D sites. Additionally, a few of the existing geotechnical borings along the south approach of the bridge exhibit soil properties that could be classified as "Soft Clay Soils" characteristic of Site Class E and/or soils requiring site response analysis designated as Site Class F.

HWA assumes that all the bridge foundation elements are founded on competent soils below very loose and/or very soft soil layers indicted in some of the existing borings; input seismic design parameters are thus controlled by the underlying very dense and stiff soils associated with Site Class C and Site Class D rather than the softer soils associated with Site Class E and F. For preliminary seismic analyses, we recommend assuming Site Class C for the northern bridge approach to about 1,000 feet north of the intersection of 15th Avenue West and Emerson Street and Site Class D for the southern approach and areas south of about 1,000 feet north of the intersection of 15th Avenue West and Emerson Street.

Design response spectra were determined for the two options (rehabilitation and replacement) with two levels of seismic events for each option, for a total of four levels of seismic events. The rehabilitation option conforms to the SDOT *BSRPPC* and the WSDOT *BDM* Section 4.3 which requires the 1,000-year (Upper Level Earthquake, ULE) event and the 100-year (Lower Level Earthquake, LLE). The replacement option must conform to the WSDOT *BDM* Section 4.1 and 4.2 which requires the 975-year (Safety Evaluation Earthquake Level, SEE) and the 210-year (Functional Evaluation Earthquake, FEE).

Given the similarity in seismic conditions, the ULE and SEE events have been grouped together for the purpose of our analysis. Parameters for the 1,000-year event were obtained using BridgeLink, a program developed by WSDOT to incorporate the probabilistic seismic hazard parameters from the *2014 Updates to the National Hazard Maps* (Peterson, et al., 2014), and the site coefficients for peak ground acceleration (F_{pga}), 0.2 seconds (F_a), and 1 second (F_v) provided in *ASCE 7-16*. Table 2 presents the recommended seismic coefficients based on a design event with a 7 percent probability of exceedance in 75 years (equal to a return period of approximately 1,000 years).

The design parameters for the 100-year and 210-year events were obtained using the Uniform Hazard Tool provided on the U.S. Geologic Survey (USGS) website, using the Dynamic Conterminous U.S. 2014 (v4.1.1) model and incorporated the site coefficient tables referenced above to compute the site coefficients for the 100-year and 210-year event. Table 3 presents recommended seismic coefficients based on a design event with a 30 percent probability of exceedance in 75 years (equal to a return period of approximately 210-year). Table 4 presents recommended seismic coefficients based on a design event with a 50 percent probability of exceedance in 75 years (equal to a return period of approximately 100-year).

Table 2: Design Seismic Coefficients for Evaluation Using AASHTO 2011 with Modifications per SDOT 2015 and WSDOT 2017 (Return period of 1,000-year)

Site Class	USGS Model	Peak Horizontal Bedrock Acceleration PBA (g)	Spectral Bedrock Acceleration at 0.2 sec S_s (g)	Spectral Bedrock Acceleration at 1.0 sec S_1 (g)	Site Coefficients			Peak Horizontal Acceleration PGA_M (g)
					F_{pga}	F_a	F_v	
C	2014	0.417	0.950	0.277	1.200	1.200	1.500	0.500
D	2014	0.417	0.950	0.277	1.183	1.120	2.046	0.493

HWA has reviewed the AASHTO Table 3.5-1 and based on the determined values in the table above for the 1,000-year event, Seismic Design Category C applies Site Class C and Seismic Design Category C applies to Site Class D conditions.

Table 3: Design Seismic Coefficients for Evaluation Using AASHTO 2011 with Modifications per SDOT 2015 and WSDOT 2017 (Return period of 210-year)

Site Class	USGS Model	Peak Horizontal Bedrock Acceleration PBA (g)	Spectral Bedrock Acceleration at 0.2 sec S_s (g)	Spectral Bedrock Acceleration at 1.0 sec S_1 (g)	Site Coefficients			Peak Horizontal Acceleration PGA_M (g)
					F_{pga}	F_a	F_v	
C	2014	0.192	0.4401	0.1146	1.208	1.130	1.208	0.232
D	2014	0.192	0.4401	0.1146	1.416	1.448	2.371	0.272

HWA has reviewed the AASHTO Table 3.5-1 and based on the determined values in the table above for the 210-year event Seismic Design Categories of A and B apply to Site Class C and D conditions, respectively.

Table 4: Design Seismic Coefficients for Evaluation Using AASHTO 2011 with Modifications per SDOT 2015 and WSDOT 2017 (Return period of 100-year)

Site Class	USGS Model	Peak Horizontal Bedrock Acceleration PBA (g)	Spectral Bedrock Acceleration at 0.2 sec S_s (g)	Spectral Bedrock Acceleration at 1.0 sec S_1 (g)	Site Coefficients			Peak Horizontal Acceleration PGA_M (g)
					F_{pga}	F_a	F_v	
C	2014	0.128	0.292	0.0715	1.272	1.300	1.500	0.163
D	2014	0.128	0.292	0.0715	1.543	1.566	2.400	0.198

HWA has reviewed the AASHTO Table 3.5-1 and based on the determined values in the table above for the 100-year event Seismic Design Categories of A and B apply to Site Class C and D conditions, respectively.

HWA recommends the bridge be designed using the most conservative Seismic Design Category noted on the bridge for the specified seismic events and Seismic Site Class conditions, as a result the use of Seismic Design Category D is recommended for preliminary design purposes.

5.2.2 Near Fault Ground Motion Considerations

As required by the AASHTO *Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition* (AASHTO, 2011), near-fault effects must be considered for bridges that are within 6 miles of a known fault. The Ballard Bridge site is located about 4 to 6 miles north of the Seattle Fault Zone and near-fault effects must be considered for the bridge site. The effects considered for this bridge include: (1) the large amplitude of the ground motions given the proximity to the fault, (2) potential for ground rupture, and (3) forward directivity. The first impact of large amplitude ground motions that could occur due to rupture of the Seattle Fault is accounted for in the seismic design coefficients provided, which are based on the national hazard maps where the influence of the Seattle Fault Zone is already included. The impacts of ground rupture and forward directivity are described in the sections below.

5.2.3 Ground Rupture

The site is located between the Seattle Fault Zone and the Whidbey Island Fault Zone but there is no evidence that inferred fault traces may intersect the project site. Based on this information, we anticipate the likelihood of surface rupture at our project site to be low.

5.2.4 Forward Directivity

Near-fault systems undergo the effect of forward directivity in which a short duration, high magnitude pulse-like motion is produced normal to the fault surface. Guidance from Chapter 6 of the WSDOT *Geotechnical Design Manual (GDM),* 2019, indicates that directivity should be considered when the site is within 6 miles of a fault that is capable of producing a magnitude 5 earthquake or greater and directivity has not been incorporated into the probabilistic hazard maps that have been used. As the 2014 *National Seismic Hazard Maps* (Peterson, et al., 2014) do not include directivity effects, it is recommended to incorporate forward directivity into the design response spectrum. For bridge design we recommend using the methods provided in the SDOT *BSRPPC*, which provides a 20 percent increase to the spectra obtained by the General Procedure for all periods greater than 1 second and tapers to 0 percent increase at 0.5 second for the LLE, FEE, ULE, and SEE events.

5.2.5 Basin Effects

Sedimentary basins are topographically low regions of underlying volcanic bedrock infilled with sediments that then became weak sedimentary rock. The geometry of these basins is often complex, and the formation of these structures can often be traced to a variety of sources. These basins have been shown to have varying effects on seismic waves and are known to significantly amplify ground motions during earthquakes, referred to as the Basin Effect. The amplification of seismic waves occurs as ground motions from a source project into a basin and reflect within the topographic bowl producing regions of constructive and destructive interference. These waves will often produce amplified surface ground shaking, generally increasing long-period motions above about 2 seconds. Seattle is underlain by the Seattle Basin; research has shown that the Seattle Basin could significantly impact the ground motions within the City. This phenomenon has been addressed by the Seattle Department of Construction Inspection (SDCI) in their *Director's Rule 20-2018*. This rule stipulates that all tall buildings utilizing site-specific ground motion procedures must incorporate basin amplification effects into the site-specific analyses.

We understand that Seattle Department of Transportation (SDOT) is reviewing the potential to include basin amplification effects into bridge design given that many bridges have resonant periods within the range of periods for which basin amplification factors could significantly increase ground motions. However, consensus has not yet been reached on this topic to date. Due to this fact, it is our understanding that SDOT has chosen to not consider basin effects at this stage of the project.

5.2.6 Liquefaction Susceptibility

Liquefaction is a temporary loss of soil shear strength due to earthquake shaking. Loose, saturated cohesionless soils are the most susceptible to earthquake-induced liquefaction; however, recent experience and research has shown that certain silts and low-plasticity clays are also susceptible. Primary factors controlling the development of liquefaction include the intensity and duration of strong ground motions, the characteristics of subsurface soils, in-situ stress conditions and the depth to ground water. Based on the *GDM*, the liquefaction susceptibility of the soils along the project alignment was determined utilizing the simplified procedure originally developed by Seed and Idriss (1971) and updated by Youd et al (2001) and Idriss and Boulanger (2004, 2006).

The simplified procedure is a semi-empirical approach which compares the cyclic resistance ratio (CRR) required to initiate liquefaction of the material to the cyclic shear stress ratio (CSR) induced by the design earthquake. The factor of safety relative to liquefaction is the ratio of the CRR to the CSR; where this ratio is computed to be less than one, the analysis would indicate that liquefaction is likely to occur during the design earthquake. The CRR is primarily dependent on soil density, with the current practice being to base it on the Standard Penetration Test (SPT) N-value, corrected for energy consideration, fines content and earthquake magnitude. CSR is generally determined by the formulation developed by Seed and Idriss (1971) and relates equivalent shear stress caused in the soil at any depth to the effective stress at that depth and the peak ground acceleration at the surface.

Our analyses indicate that the saturated, very loose to medium dense, fill soils along with the medium dense recessional outwash sand soils are both potentially liquefiable during the maximum considered earthquake events for each option (1,000-year event). Both of these liquefaction susceptible soils are observed to be present along the southern approach starting from about 1,000 feet north of the Emerson Street Intersection to the southern end of the south approach alignment. These soils were observed in Borings BX-101 and BX-103; BX-102 was located within this region, but this boring did not exhibit soils susceptible to liquefaction. The extent of liquefaction susceptible soils may extend further north; however, these conditions should be evaluated using new explorations to limit unknowns and to properly assess the site susceptibility to liquefaction.

Upon the initiation of liquefaction, we expect that liquefiable soils will lose shear strength, undergo liquefaction induced settlement, and potentially result in liquefaction induced lateral movement. Details associated with each are provided below.

5.2.7 Liquefaction Settlement Analysis

For liquefaction susceptible soil deposits, excess pore water pressure builds up during the earthquake excitation, leading to loss of strength, termed as liquefaction. After the shaking stops, excess pore water pressures dissipate toward a zone where water pressure is relatively lower, usually the ground surface. The dissipation is accompanied by a reconsolidation of the loose sand (Ishihara and Yoshimine, 1992 & Tokimatsu and Seed, 1987). The reconsolidation is manifested at the ground surface as vertical settlement, usually termed as liquefaction-induced settlement or seismic settlement. The potential for liquefaction-induced settlement was evaluated for the each of the borings along the proposed bridge alignment. The methodologies used were developed by Idriss and Boulanger (2008) and are generally based on the relationship between cyclic stress ratio, corrected SPT blow counts, and volumetric strain. Using these methods, liquefaction-induced settlement was estimated for each area corresponding to an existing boring and are provided in Table 5, which also provides the anticipated depths of liquefaction. When subsurface soil properties were not available due to missing information in existing boring logs, conservative assumptions were made for the determination of liquefaction.

Table 5: Anticipated Liquefaction-Induced Settlement for Each Boring

Corresponding Boring	Depth of Potentially Liquefiable Soils	Potential Liquefaction Induced Settlement
BX-101	5 to 17 feet	4-8 inches
BX-102	No Liquefaction	-
BX-103	15 to 20 feet	0-1 inch
BX-104	No Liquefaction	-
BX-105, BX-106	No Liquefaction	-
BX-107, BX-108	No Liquefaction	-

The liquefaction induced settlements anticipated may vary greatly across the site given the high variability in subsurface conditions anticipated. Liquefaction induced settlement could be differential in nature and will likely result in damage to structural elements founded above or within potentially liquefiable materials. Therefore, deep foundations should be designed to resist the loads and deformations that could occur as a result of liquefaction-induced settlements. Additional subsurface investigation beneath finalized pier locations should be completed to verify the presence of liquefaction susceptible soils at each location.

5.2.8 Post-Liquefaction Residual Shear Strength

To perform analyses for foundations impacted by liquefaction, residual shear strengths for the liquefiable soils were developed. Residual strengths were developed using a weighted average of the results of the Idriss (1999), Olson and Stark (2002), Idriss and Boulanger (2007) and Kramer and Wang (2007) relationships. The residual shear strengths assigned are a function of the equivalent clean sand SPT value, $(N_1)_{60cs}$, the potential for void redistribution, and the initial effective overburden stress. The residual strengths computed for soils at the location of the Ballard Bridge alignment was incorporated into design for their respective analyses.

5.2.9 Slope Instability Due to Liquefaction

Initiation of liquefaction is triggered by the generation of increased pore water pressures within the liquefiable soils. As the pore water pressures increase, the soils lose shear strength. When the soil is fully liquefied the soil shear strength is at its lowest level, this is termed “residual shear strength". This reduction in shear strength can result in liquefaction-induced slope instability. Liquefaction-induced slope failures can either occur as a lateral spreading event or as a flow failure.

Liquefaction-induced lateral spreading occurs as the shear strength of liquefiable soils decrease during seismic shaking but do not decrease to the point that a complete flow failure would occur. Lateral spreading occurs cyclically when the horizontal ground accelerations combine with gravity to create driving forces which temporarily exceed the available strength of the soil mass. This is a type of failure known as cyclic mobility. The result of a lateral spreading failure is horizontal movement of the partially liquefied soils and any overlying crust of non-liquefied soils. Displacements associated with lateral spreading are generally quantifiable and on the order of several inches to several feet. The actual magnitude of displacement depends on the site geometry, soil characteristics and earthquake loading.

Given the localized zones of anticipated liquefaction, the degree and effect of liquefaction induced lateral spreading is difficult to quantify with the limited amount of subsurface data available for this study. Additional subsurface investigations should be conducted after pier locations have been determined, to better understand the magnitude of lateral spreading that should be anticipate on the proposed structure. For the purpose of this study, the design team should consider that between Stations 113+00 to 116+00 and 118+00 to 121+00 there is a potential of undergoing lateral spreading. Budget estimates for the evaluation of the proposed alternatives should have a contingency in case some piers within the mentioned stationing have to be designed to resist passive pressure loading acting on the shaft within non-liquefied crustal and liquefied soils due to a lateral spreading event.

5.3 BRIDGE FOUNDATIONS

We recommend that new pier foundations be founded on drilled shaft foundations that bear in the very dense glacially consolidated soils encountered in each boring location beneath the soft sediments and fill soils. We understand that these foundations may consist of 8-, 10-, or 12-foot diameter drilled shafts. The location, elevation, number, and orientation of the drilled shafts have not been determined at this time.

5.3.1 Drilled Shaft Axial Capacity

Axial shaft capacities were evaluated using LRFD methods in general conformance with the procedures referenced in the recently updated FHWA Drilled Shafts Manual (Brown, et al., 2018). Axial shaft capacities will be derived from both shaft friction and end bearing. Based on variable soil conditions, axial shaft capacities have been developed based on adjacency to existing subsurface borings. It should be noted that if soil profiles encountered in multiple borings were determined to be similar, the bridge segments where the soil profiles were located were grouped for the purpose of our analysis. These segments have been designated based on the provided stationing and correspond to the existing subsurface boring explorations, as shown above in Table 6.

Table 6: Corresponding Boring Number used on Each Geotechnical Design Segment to Develop Shaft Capacities

Stationing		Corresponding Boring	Drilled Shaft Capacity Figure Number
Start	End		
113+00	116+00	BX-101	Figure C-1A – C-1C
116+00	118+00	BX-102	Figure C-2A – C-2C
118+00	121+00	BX-103	Figure C-3A – C-3C
121+00	124+00	BX-104	Figure C-4A – C-4C
124+00	129+00	BX-105, BX-106	Figure C-5A – C-5C
129+00	132+00	BX-107, BX-108	Figure C-6A – C-6C

Nominal axial shaft capacities versus embedment depths for each of the piers are presented in Appendix C, Figures C-1A through C-6C, for 8-, 10-, and 12-foot diameter shafts. As indicated on these figures, a resistance factor (ϕ) of 0.55 and 0.45 should be applied to the nominal ultimate side, or friction, capacities for Strength I Limit State design for cohesionless and cohesive soils, respectively. A resistance factor of 0.5 and 0.4 should be applied to ultimate base resistance for Strength I Limit State design for cohesionless and cohesive soils, respectively. For the Extreme I and the Service I Limit States, the resistance factor ϕ should be 1.0 for both shaft resistance and end bearing.

For the Extreme Event I Limit State, shaft resistance is neglected to the bottom of the potentially liquefiable soils where identified. It should be noted that for the purpose of this preliminary study, drilled shaft capacities have been provided based on evaluations for the largest design seismic acceleration coefficient computed for the study corridor (i.e. for an earthquake event with a 1,000-year return period and a Site Class D). Downdrag loads for the LLE or the FEE events may be lower than those provided for the larger design event.

For the Service I Limit State, total shaft resistance (i.e., friction plus end bearing) is provided for an allowable settlement of 1 inch. If a Service I Limit State capacity for a different settlement value (e.g. 2 inches or ½ inch) is needed, we should be contacted to revise our calculations. Additionally, we recommend that the shafts be placed with no closer than 2.5 shaft diameter center-to-center spacing to avoid excessive reductions in vertical capacity due to group affects.

5.3.2 Group Reduction Factors

A group reduction factor (η) for drilled shaft capacities should be applied in accordance with Table 7.8.1-1 of WSDOT *BDM* to the capacities presented for all Limit States for single and/or multiple row configurations. This factor will be determined as additional design information is provided.

5.3.3 Downdrag Loading Parameters

Downdrag loading on shafts occurs when the surrounding soil settles or otherwise moves downward relative to the shaft. Downward movements on the order of ¼ inch are sufficient to fully mobilize negative shaft resistance or downdrag. The application of downdrag loads could be imposed on the shaft due to liquefaction-induced settlement of the liquefied and non-liquefied crust soils above. This downdrag incorporates the residual strength mobilization of the liquefiable soils and the full-strength mobilization of the non-liquefiable crust. The unfactored seismic down drag force for each shaft are provided on their respective figures for each of the proposed shaft diameters where downdrag occurs. Similar to drilled shaft capacities, downdrag loads have been determined based on the most conservative seismic design condition (1,000-year return period event) and may differ for the LLE and FEE events.

5.3.4 Drilled Shaft Lateral Design Parameters

The proposed drilled shafts will extend into the very dense, glacially-consolidated soils. We understand that the design team desires to use conventional p-y method of lateral analysis (i.e., L-PILE) to estimate shears, moments and deflections of the shafts. Soil parameters for use in L-PILE analyses are provided in Appendix D. The soil parameters provided in Appendix D may be used with L-PILE for lateral structural analysis and design of the abutments. Parameters are provided for static, and liquefied analyses.

For post-liquefaction, analyses should be performed by applying the recommended P-multipliers provided in Appendix D to the liquefiable layers. This method proposed by Brandenberg (2007) and referenced in Chapter 6 of the *GDM* (WSDOT, 2019) reduces the lateral resistance provided by the materials to represent the post-liquefaction residual strengths of the soils. The lateral spreading/flow sliding loads should also be applied to the shafts while using the reduced soil strength for the post-liquefaction case.

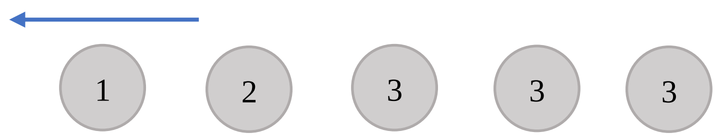
The p-y curves generated by the lateral parameters provided in Appendix D must be modified by the applicable p multipliers to account for the group reduction effects. The p multipliers for shafts spacing of 2, 3, and 5 shaft diameters are provided in Table 7. When additional design information is provided and shaft spacings are verified, a p-multiplier should be determined as a linear interpolation between the factors provided below.

Table 7: P-Multipliers for Center-to-Center Spacing of 2, 3, and 5 Shaft Diameters

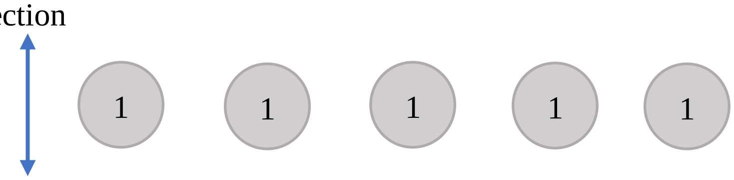
Pile Center-To-Center Spacing	P-Multiplier		
	Row 1	Row 2	Row 3 or Higher
2D	0.45	0.33	0.25
3D	0.8	0.4	0.3
5D	1	0.85	0.7

The same p multiplier factor should be applied parallel and perpendicular to the group shaft alignment. The following diagram shows how the p multipliers should be assigned with respect to the load direction and shaft orientation.

Parallel Direction



Perpendicular Direction



5.4 Known Uncertainty and Possible Additional Geotechnical Analysis

The geotechnical recommendations and design parameters provided in this letter report are based on existing geotechnical data, that is widely spaced and incomplete in some areas. The location and quality of existing subsurface data along the alignment affects the certainty of our assumed subsurface geometry of each pier and material properties. Specific areas of known geotechnical uncertainty are discussed below as well as possible additional geotechnical effort that could be completed to reduce these uncertainties.

5.4.1 Subsurface Soil Geometry

The existing geotechnical explorations available along the bridge alignment assist us in identifying the general soil conditions along the bridge alignment. However, high variability along the bridge alignment is anticipated. Soil geometry and material properties in the immediate vicinity of the bridge piers are based on widely spaced subsurface explorations. This lack of data beneath each of the pier locations results in a relatively high level of uncertainty with respect to soil geometry and material properties along the bridge alignment. These uncertainties could affect the results of the seismic analysis and drilled shaft capacities.

To reduce these identified uncertainties, supplementary subsurface explorations would need to be completed at the locations of the proposed piers to better define the geometry and strength properties of the subsurface soils, once the preferred alternative is selected. If completed, we would recommend that supplementary explorations consist of machine drilled borings. Completion of supplementary explorations would reduce the uncertainty in the recommended geotechnical design parameters.

5.4.2 Inconsistencies in Laboratory Testing of Existing Borings

Analysis of the existing laboratory results for the subsurface borings reveal several inconsistencies in classification and characterization of soil types. These include, but are not limited to, incorrect USCS classification of soil types based on grain size distributions and Atterberg Limits, incorrect classification of geologic units, and a complete lack of test results for multiple units. As indicated in Section 4.4.1 above, reduction of uncertainties would require completion of supplementary explorations.

6. CONDITIONS AND LIMITATIONS

We have prepared this letter report for COWI, Inc. for use in the concept design of a portion of this project. Additional geotechnical studies will be necessary for final design. Experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA should be notified for review of the recommendations of this report, and revision of such if necessary.

We recommend that HWA be retained to review the plans and specifications and to monitor the geotechnical aspects of construction, particularly construction dewatering, excavation, subgrade preparation, bedding and backfill placement and compaction.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, express or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site.

HWA does not practice or consult in the field of safety engineering. We do not direct the contractor's operations, and we cannot be responsible for the safety of personnel other than our own on the site; the safety of others is the responsibility of the contractor. However, the contractor should notify the owner if he considers any of the recommended actions presented herein unsafe.

We appreciate the opportunity to provide geotechnical services on this project. Should you have any questions or comments, or if we may be of further service, please do not hesitate to call.

Sincerely,
HWA GEOSCIENCES INC.

Sean Schlitt, P.E.
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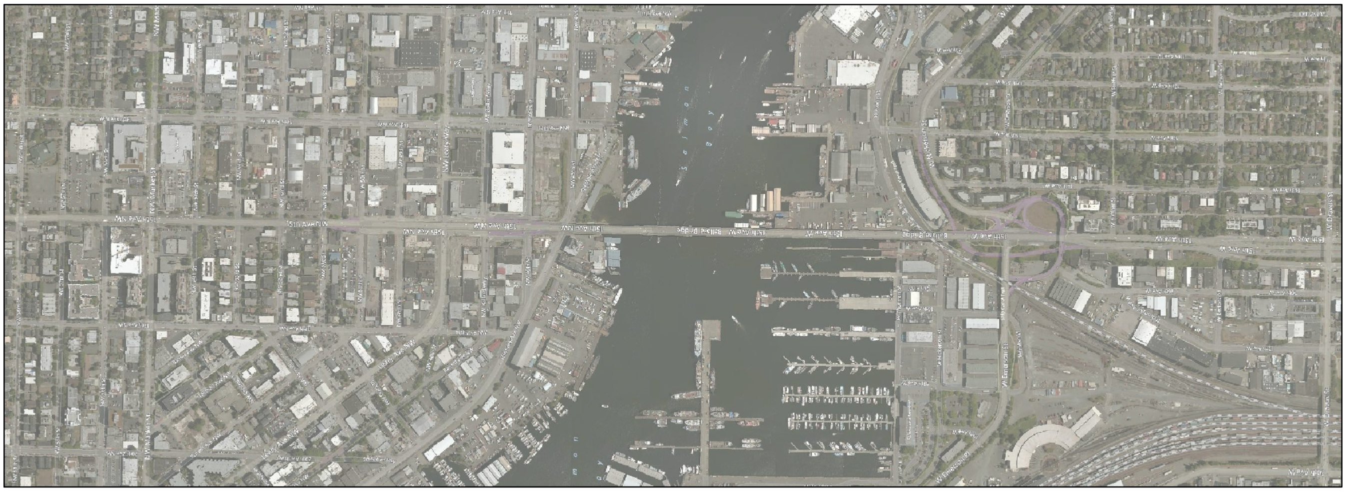
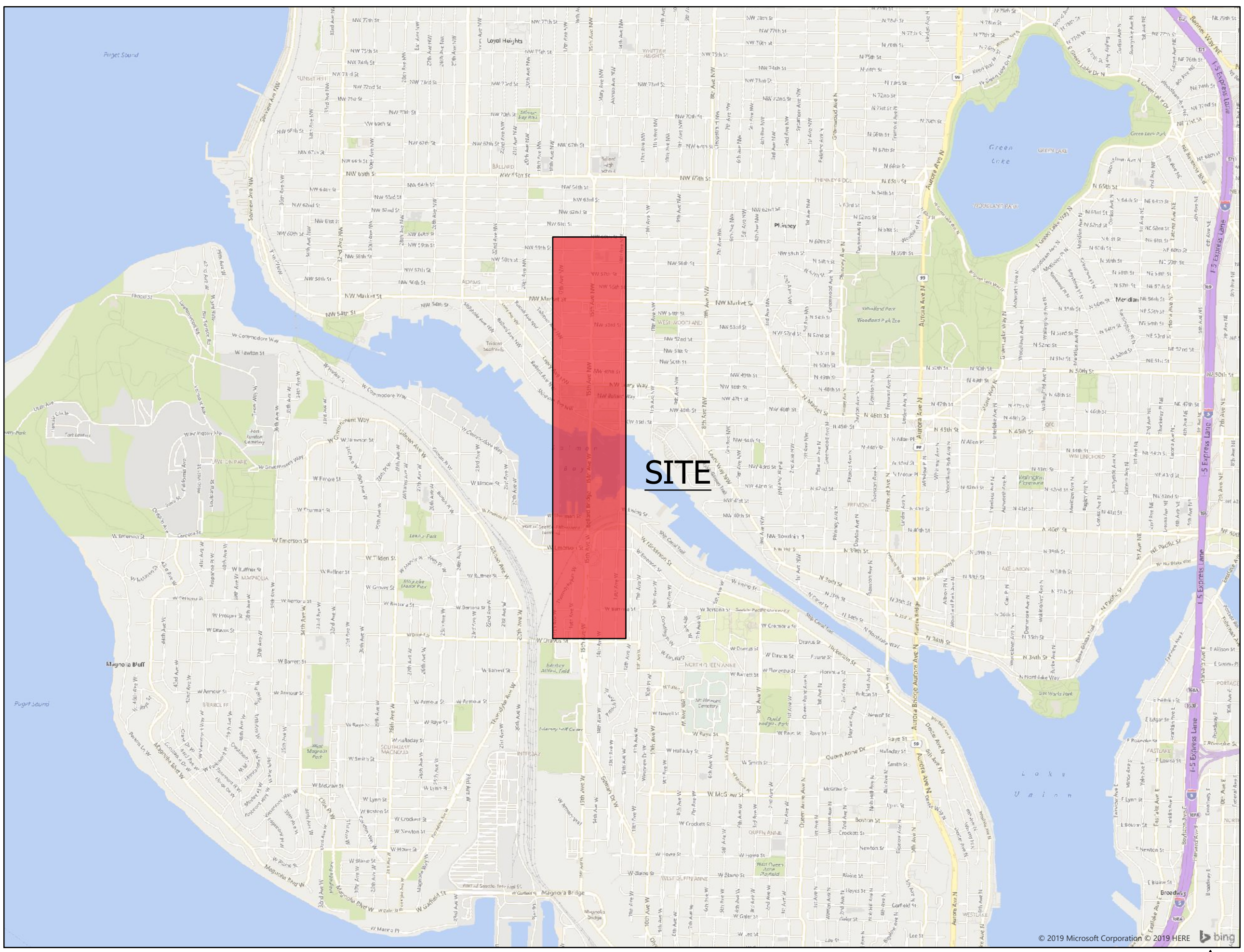


SITE MAP

0 600' 1200' 1800' 2400'

SCALE: 1" = 1200'

N



VICINITY MAP

0 2000' 4000' 6000' 8000'

SCALE: 1" = 4000'

N

HWA GEOSCIENCES INC.

VICINITY MAP

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

FIGURE NO.: 1

DRAWN BY: BFM

CHECK BY: AO / DH

PROJECT # 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 1> Plotted: 8/15/2019 6:35 PM

EXPLORATION LEGEND

103710
- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
- CITY OF SEATTLE - DEPT. OF ENGINEERING [1939, 1957, FEB. 1970, JUNE 1970, 1973, 1980, 1984, 1990]
- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003]
APPROXIMATE BORE LOCATION
YEAR REPORT
BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER
APPROACH BRIDGE PIER

MATCHLINE SEE 2B

0 50 100 150 200
SCALE: 1" = 100'

				2G	
2A	2B	2C	2D	2E	2F
				2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
BFM	2A
CHECK BY: AO / DH	PROJECT NO.: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2A> Plotted: 11/6/2019 9:51 AM

EXPLORATION LEGEND

103710

- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
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- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003]

APPROXIMATE BORE LOCATION

YEAR REPORT

BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER

APPROACH BRIDGE PIER

MATCHLINE SEE 2A

MATCHLINE SEE 2C

0 50 100 150 200

SCALE: 1" = 100'

			2G	
2A	2B	2C	2D	2E	2F
				2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY: BFM

CHECK BY: AO / DH

FIGURE NO.: 2B

PROJECT NO.: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2B> Plotted: 11/6/2019 9:53 AM

EXPLORATION LEGEND

103710

- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
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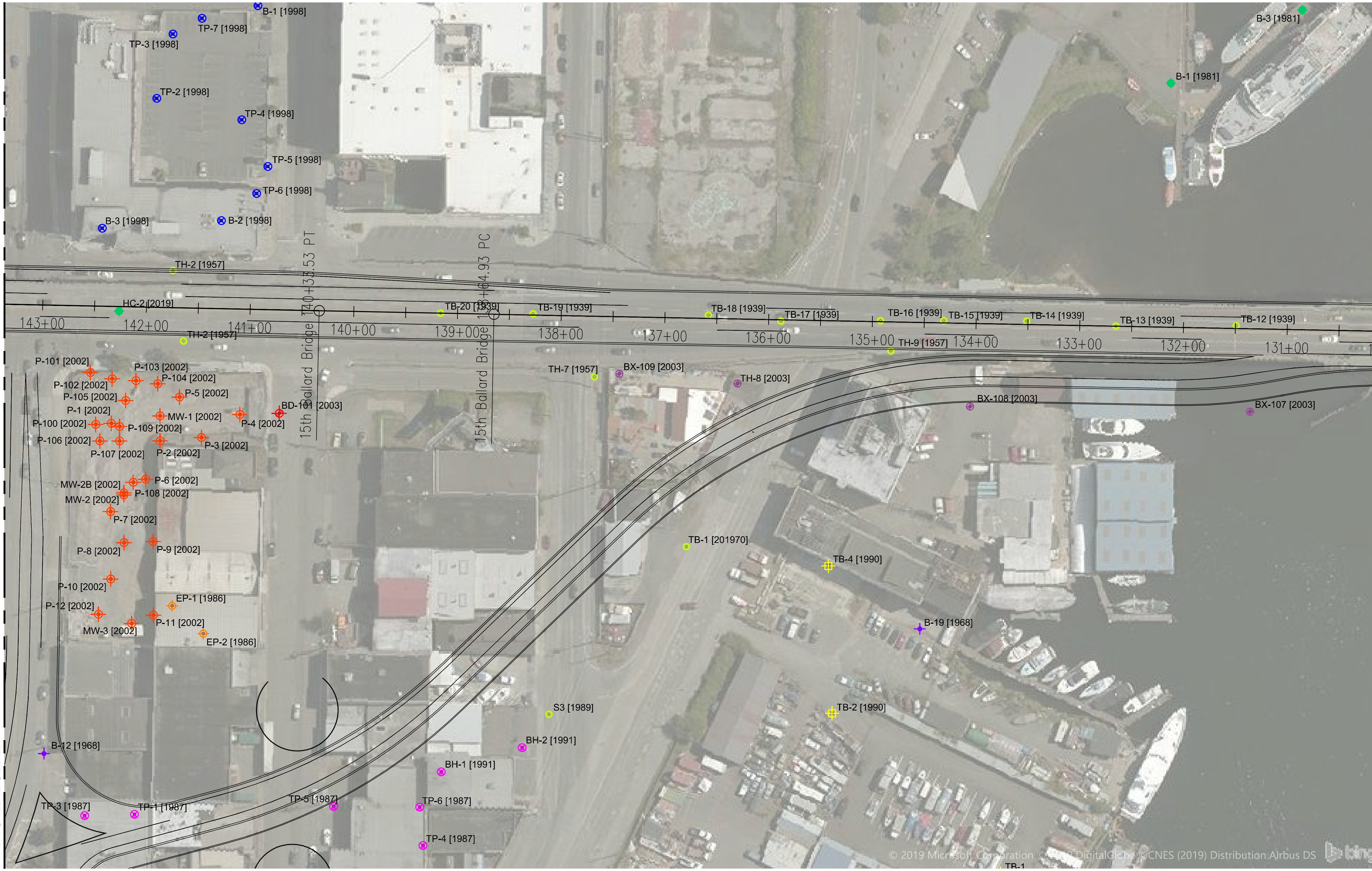
- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003]
APPROXIMATE BORE LOCATION
YEAR REPORT
BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER
APPROACH BRIDGE PIER



0 50 100 150 200

SCALE: 1" = 100'

	2G	
2A 2B **2C** 2D	2E	2F
	2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
BFM	2C
CHECK BY: AO / DH	PROJECT NO.: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2C> Plotted: 11/6/2019 10:48 AM

EXPLORATION LEGEND

103710

- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
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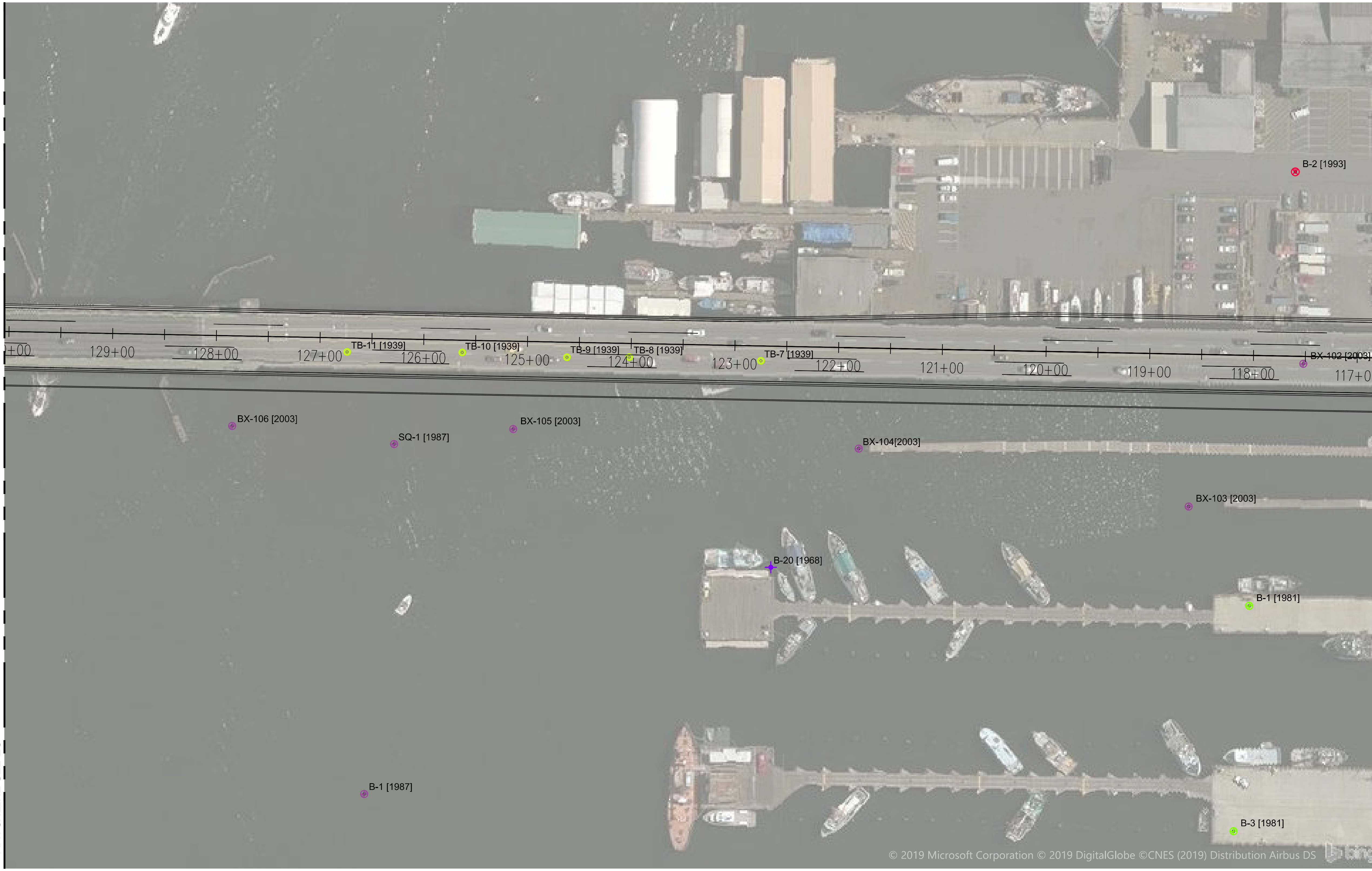
- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003]
APPROXIMATE BORE LOCATION
YEAR REPORT
BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER
APPROACH BRIDGE PIER

MATCHLINE SEE 2C



MATCHLINE SEE 2E

0 50 100 150 200
SCALE: 1" = 100'

				2G	
2A	2B	2C	2D	2E	2F
				2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY: BFM
CHECK BY: AO / DH
FIGURE NO.: 2D
PROJECT NO.: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2D> Plotted: 11/6/2019 10:48 AM

EXPLORATION LEGEND

103710
- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
- CITY OF SEATTLE - DEPT. OF ENGINEERING [1939, 1957, FEB. 1970, JUNE 1970, 1973, 1980, 1984, 1990]
- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

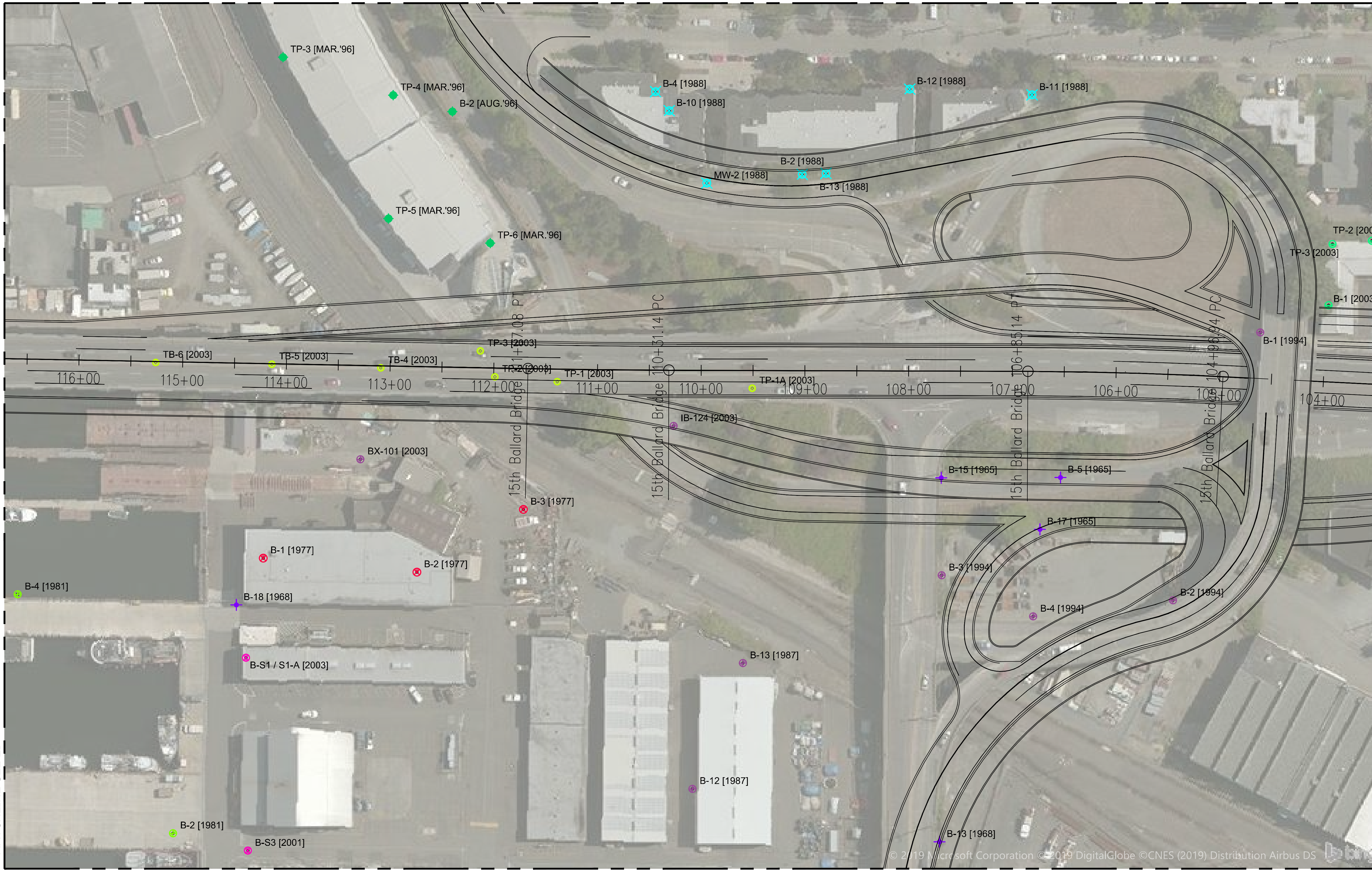
EXPLORATION EXAMPLE

BH-12 [2003]
APPROXIMATE BORE LOCATION
YEAR REPORT
BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER

APPROACH BRIDGE PIER

MATCHLINE SEE 2G



MATCHLINE SEE 2D

MATCHLINE SEE 2F

MATCHLINE SEE 2H

0 50 100 150 200

SCALE: 1" = 100'

	2G	
2A	2B	2C	2D	2E	2F
	2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
BFM	2E
CHECK BY:	PROJECT NO.:
AO / DH	2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2E> Plotted: 11/6/2019 10:49 AM

EXPLORATION LEGEND

103710

- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
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- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003] — APPROXIMATE BORE LOCATION; YEAR REPORT; BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER

APPROACH BRIDGE PIER

MATCHLINE SEE 2E

0 50 100 150 200

SCALE: 1" = 100'

				2G	
2A	2B	2C	2D	2E	2F
				2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
BFM	2F
CHECK BY: AO / DH	PROJECT NO.: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2F> Plotted: 11/6/2019 10:50 AM

EXPLORATION LEGEND

103710

- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
- CITY OF SEATTLE - DEPT. OF ENGINEERING [1939, 1957, FEB. 1970, JUNE 1970, 1973, 1980, 1984, 1990]
- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003]
APPROXIMATE BORE LOCATION
YEAR REPORT
BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER
APPROACH BRIDGE PIER

MATCHLINE SEE 2E

0 50 100 150 200

SCALE: 1" = 100'

				2G	
2A	2B	2C	2D	2E	2F
				2H	

SHEET KEY

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
BFM	2G
CHECK BY:	PROJECT NO.:
AO / DH	2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2G> Plotted: 11/6/2019 10:50 AM

MATCHLINE SEE 2E

EXPLORATION LEGEND

103710

- ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
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- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
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- GROVER C WAY, P.E. [1987, 1991]
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- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
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- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003]

APPROXIMATE BORE LOCATION

YEAR REPORT

BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER

APPROACH BRIDGE PIER

				2G	
2A	2B	2C	2D	2E	2F
				2H	

SHEET KEY

N

0 50 100 150 200

SCALE: 1" = 100'

BASE MAP PROVIDED BY: BING AND SURVEYOR

HWA GEOSCIENCES INC.

BALLARD BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE & EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
BFM	2H
CHECK BY: AO / DH	PROJECT NO.: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 2H> Plotted: 11/6/2019 10:51 AM

15TH AVE NW BALLARD BRIDGE REPLACEMENT
Scale: 1" = 50'-0"

EXPLORATION LEGEND

- 103710 ADAPT ENGINEERING, INC. [2000]
- ASPECT CONSULTING, INC. [2002]
- ASSOCIATED EARTH SCIENCES, INC. [1986, 1999]
- BRUCE A. LIESCH - CHARLES E. PRICE KENNETH L. WALTERS [1933]
- CASCADE GEOTECHNICAL, INC. [1989, 1990]
- CASCADE TESTING LABORATORY, INC [1981]
- CITY OF SEATTLE - DEPT. OF ENGINEERING [1939, 1957, FEB. 1970, JUNE 1970, 1973, 1980, 1984, 1990]
- CONVERSE WARD DAVIS DIXON [1981]
- DAMES AND MOORE, INC. [1963]
- DODDS GEOSCIENCES, INC. [2002]
- EARTH CONSULTANTS, INC. [1999]
- GEO GROUP NORTHWEST, INC. [2003]
- GEOTECH CONSULTANTS, INC. [MAR.1987, NOV.1987, 1988, 1989, 1997, 2001, 2004]
- GOLDER AND ASSOCIATES, INC. [1988, 1999, 2001]
- GROVER C WAY, P.E. [1987, 1991]
- HART CROWSER AND ASSOCIATES, INC. [1975, 1981, MAR. 1996, AUG. 1996, 2019]
- ICICLE CREEK ENGINEERS, INC. [1998]
- KLEINFELDER, INC. [1998]
- LIU AND ASSOCIATES, INC. [1998]
- METROPOLITAN ENGINEERS [APRIL 1965, JUNE 1965, 1968]
- NEIL H TWELKER AND ASSOCIATES, INC. [1965]
- PACIFIC TESTING LABORATORIES [1986, 1987, 1990, 1991]
- PAN GEO, INC. [2001]
- PROFESSIONAL SERVICE INDUSTRIES, INC. [2001]
- RITTENHOUSE-ZEMAN AND ASSOCIATES, INC. [MAY 1977, DEC. 1 1977, DEC. 5 1977, 1986, 1988, 1993]
- ROGER LOWE ASSOCIATES [1978]
- SHANNON AND WILSON, INC. [1987, 1990, MAY 1994, JULY 1994, 2003]
- TERRA ASSOCIATES, INC. [2004]

EXPLORATION EXAMPLE

BH-12 [2003] — APPROXIMATE BORE LOCATION; YEAR REPORT; BORE NUMBER DESIGNATION

MOVABLE BRIDGE PIER

APPROACH BRIDGE PIER

HWA GEOSCIENCES INC.	BALLARD BRIDGE REPLACEMENT SEATTLE, WASHINGTON	PROPOSED BALLARD BRIDGE IMPROVEMENTS PLAN VIEW	DRAWN BY: BFM; CHECK BY: AO / DH; DATE: 05.31.2019; FIGURE #: 3; PROJECT #: 2019-085-21

S:\2019 PROJECTS\2019-085-21 BALLARD BRIDGE STUDY\CAD\2019-085-21 BALLARD BRIDGE REPLACEMENT.DWG <Fig 3> Plotted: 11/6/2019 10:55 AM

APPENDIX A

FIELD INVESTIGATIONS BY SHANNON & WILSON

SOIL DESCRIPTION

Coordinates: N: 242,910 E: 1,260,104

Surface Elevation: 22.6 Ft. (NAVD-88)

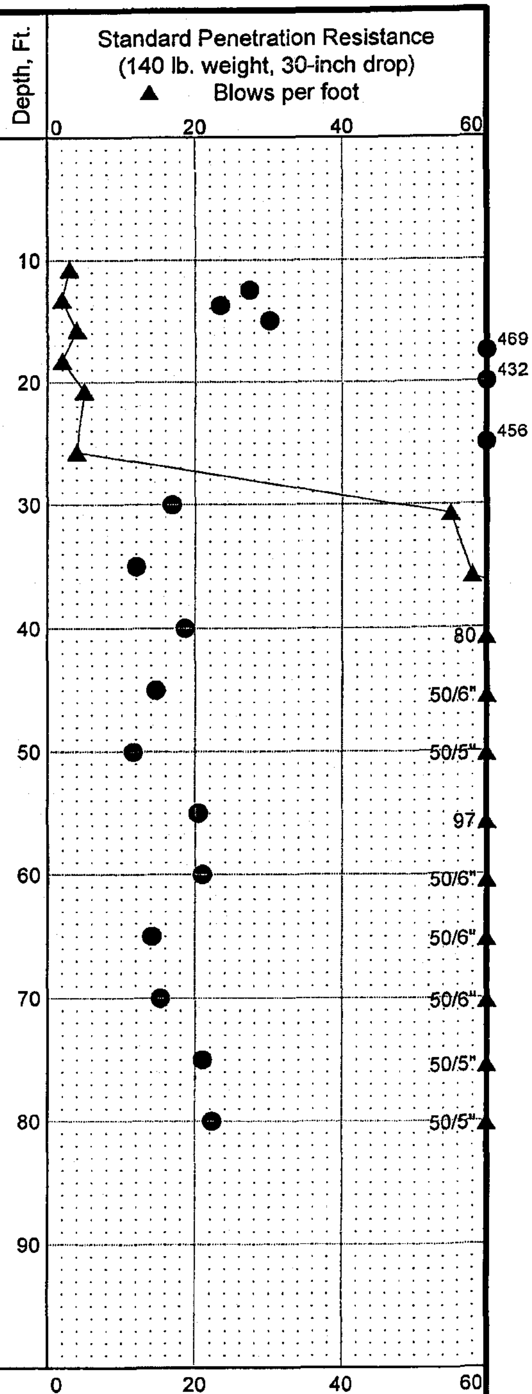
Soil Description	Depth, Ft.
ASPHALT	0.3
Dense, gray, silty, gravelly SAND; moist; (Hf) SM.	2.5
Soft, dark brown, slightly clayey, sandy SILT; wet; layers of silty, fine sand; (Hf) ML/SM.	6.0
Soft, gray, slightly sandy, silty CLAY; wet; with abundant sand-filled fractures and pockets of SAND; wet; (Hf) CL/SM.	17.0
Dark brown PEAT; wet; grading finer and less fibrous with depth; (Hp) PT.	27.0
Very dense, gray, slightly silty, fine to medium to silty, gravelly SAND; wet to moist; locally sandy silt; (Qvro) SP-SM/SM.	43.0
Very dense, gray, slightly silty to silty, fine to medium SAND, trace of gravel; wet; scattered gravelly layers; (Qpnf) SM/SP-SM.	80.4

PID, ppm	Samples
0.7	1 E
0.3	2
0.1	3
0.1	4
0.2	5
0.1	6
0.1	7
0	8
0.1	9
0.1	10
0.1	11
0.2	12
0.2	13
0.1	14
0	15
0	16
	17

Ground Water: During Drilling ⊻

BOTTOM OF BORING
COMPLETED 10/16/2003

Note: Soil descriptions and PID readings above 7.3 feet are based on observations and measurements made during vacuum excavation.



LEGEND

* Sample Not Recovered

E Environmental Sample Obtained

⌶ Standard Penetration Test

⊻ Ground Water Level ATD

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-101

December 2003 21-1-09910-091

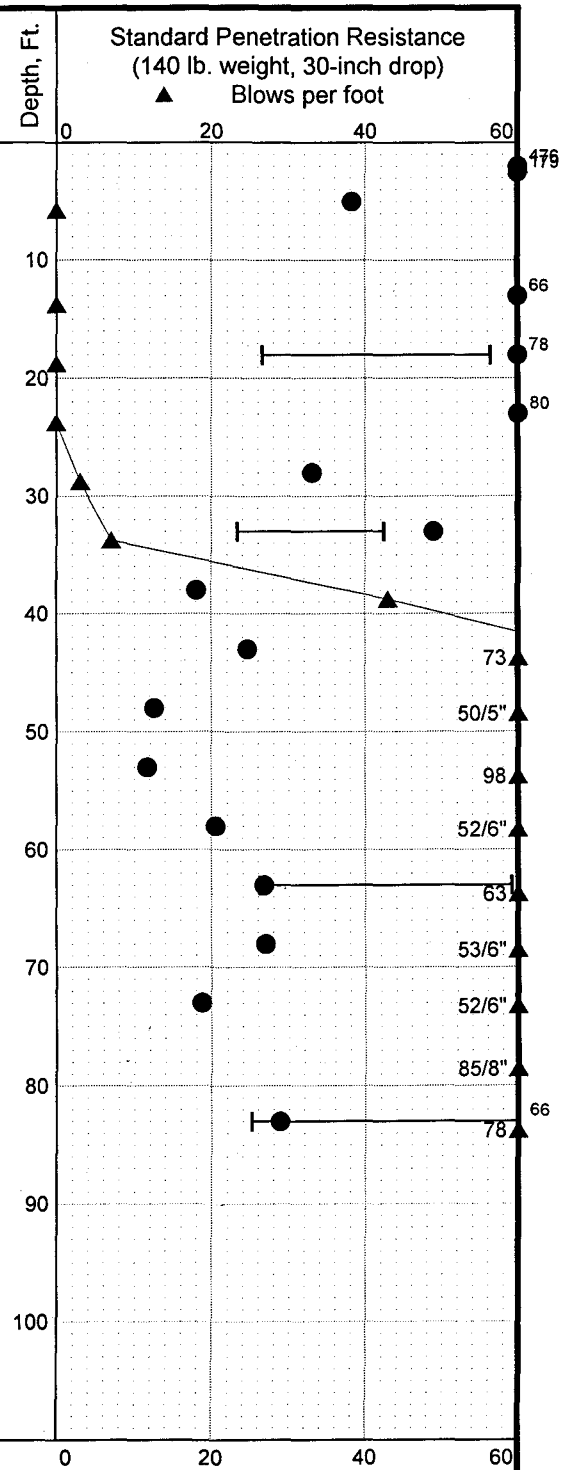
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.6-1

REV 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03 Log: JJ Rev: TWH Typ: LKD

SOIL DESCRIPTION Coordinates: N: 243,333 E: 1,260,195 Surface Elevation: 9.6 Ft. (NAVD-88)	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water
Very soft, dark brown PEAT; wet; amorphous, abundant twigs; (Hp) PT.	2.5		8	1	
Interbedded, very soft, gray, silty CLAY and very loose, silty SAND with laminations of organic silt; (Hl) CL/SM.	6.5		0	2	
Very soft, gray, silty CLAY; wet; (Hl) CH/CL.	26.0		0 0 0	3 4 5	
Soft to medium stiff, gray, silty CLAY; moist to wet; massive; trace of sand locally; (Hl) CL.	36.0			6 7	
Dense to very dense, gray, silty, fine SAND; wet; massive; (Qpnf) SM.	45.0			8 9	
Very dense, gray, slightly gravelly to gravelly, silty SAND grading to silty, fine SAND; wet; (Qpnf) SM.	61.0			10 11 12	
Hard, gray, silty CLAY, trace of sand; moist; abundant fractures, scattered discontinuous slickensides; (Qpgl) CH.	68.5			13 14	
Very dense, gray, silty, fine SAND; wet; massive; (Qpgl) SM.	75.0			15	
Hard, gray, silty CLAY; moist; highly fractured, scattered discontinuous slickensides; (Qpgl) CH.	84.5			16 17	



BOTTOM OF BORING
COMPLETED 10/7 2003

Notes:
(1) Downhole seismic testing performed in this boring.
(2) Boring was drilled over water. Surface elevation refers to mudline, which is 7 feet below water surface.

LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- Grab Sample
- 3.0" O.D. Osterberg Sample
- Standard Penetration Test

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-102

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.6-2

REVISED FOR ADDENDUM NO. 095-1

REV 3

Log: XHL Rev: WDN Typ: EET

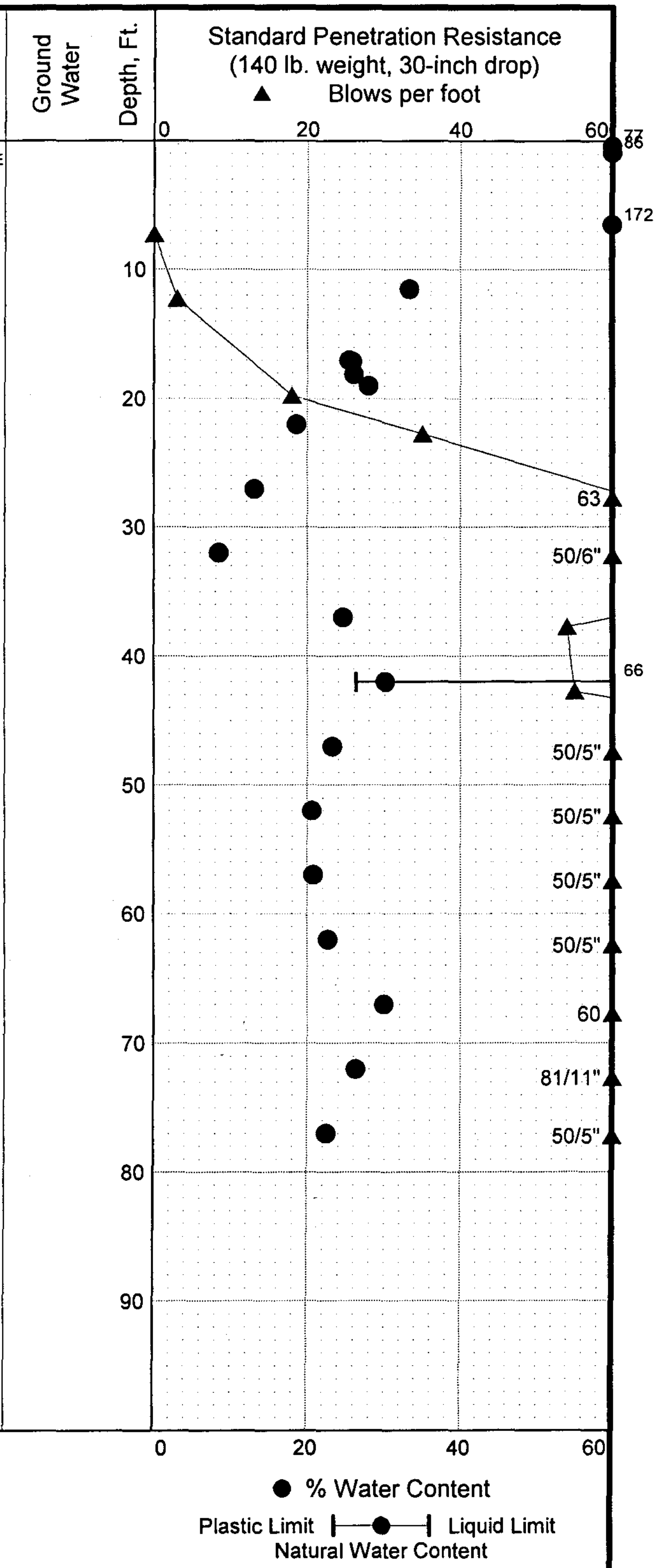
MASTER LOG2 21-09910.GPJ TEMP.GDT 4/1/04

SOIL DESCRIPTION

Coordinates: N: 243,443 E: 1,260,058
Surface Elevation: -6.6 Ft. (NAVD-88)

Soil Description	Depth, Ft.	PID, ppm	Samples
Interbedded, very soft, gray, silty CLAY, trace of sand, and silty, fine SAND, trace of clay; wet; abundant seams of organic silt; (HI) CL/SM/OL.		0, 0, 0	1 E, 2, 3
Medium dense to dense, gray, fine sandy SILT, and silty, fine SAND; wet; scattered organics and clayey at top; (Qvro) SM.	15.0	0, 0, 0	4, 5, 6
Very dense, gray, silty, fine to medium SAND; wet; (Qpnf) SM.	25.0		7
Very dense, gray, silty, gravelly SAND, to silty, sandy GRAVEL; wet; (Qpnf) GM/SM.	30.5		8
Hard, gray, silty CLAY; moist; highly fractured, scattered discontinuous slickensides; (Qpgl) CH.	36.5		9, 10
Very dense, gray, fine sandy SILT to silty, fine SAND; wet; massive; (Qpgl) ML/SM.	46.0		11, 12, 13, 14
Hard, gray, silty CLAY; moist; abundant fractures, scattered to abundant high-angle slickensides; (Qpgl) CH.	65.0		15, 16
Very dense, gray, silty, fine SAND; wet; massive; (Qpgl) SM.	75.0		17
BOTTOM OF BORING COMPLETED 10/8/2003	77.4		

Note: Boring was drilled over water. Surface elevation refers to mudline, which is 23 feet below water surface.



LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- 3.0" O.D. Osterberg Sample
- Standard Penetration Test

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-103

March 2004 21-1-09910-091

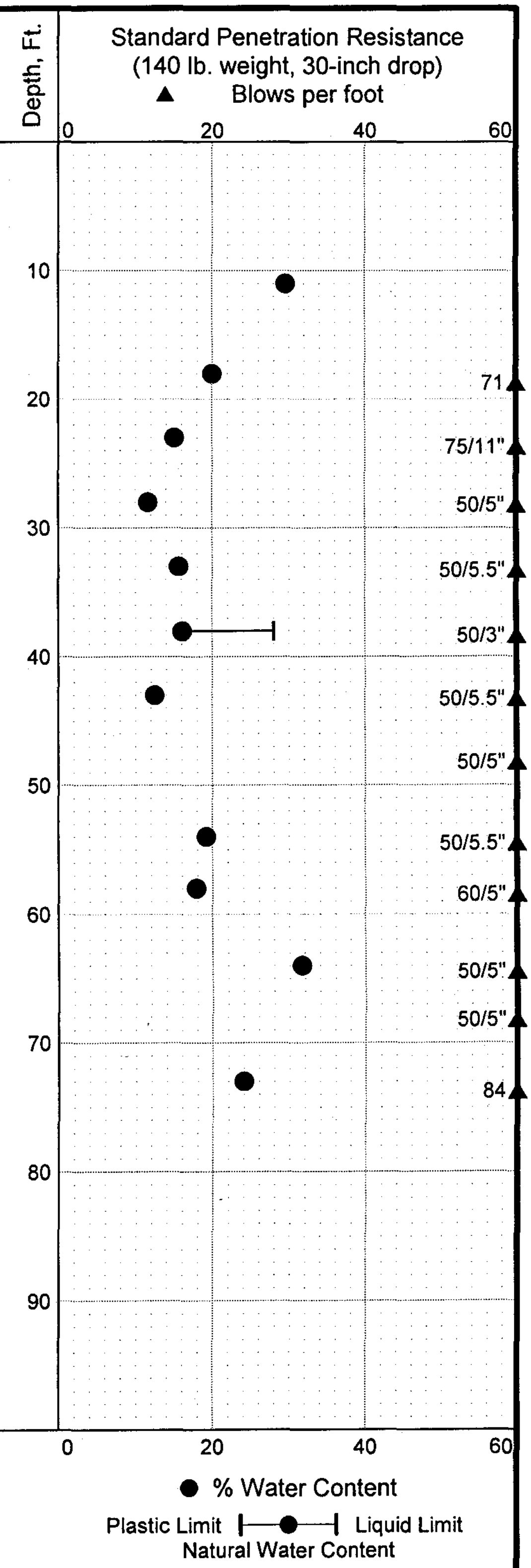
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.6-3

REVISED FOR ADDENDUM NO. 095-1

REV 3

SOIL DESCRIPTION Coordinates: N: 243,762 E: 1,260,114 Surface Elevation: -5.4 Ft. (NAVD-88)	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water
Interbedded, very soft, gray, silty CLAY and very loose, gray, silty, fine SAND; wet; scattered shells, wood debris, and organic seams; (Hl) CL/SM.			0	G E 1	
Very dense, gray, slightly silty, fine to coarse SAND; wet; (Qvro) SP-SM.	13.0		0	2	
Hard, gray, sandy, silty CLAY, trace of gravel; moist; (Qpgm) CL.	20.0		0	3 4 M57 f 5 6 7 M58 f 8 *	
Very dense, gray, slightly silty, fine to coarse SAND, trace of gravel; wet; scattered gravelly, locally silty; (Qpgo/Qpnf) SP-SM.	52.0			9 M59 f 10 M60 11 12	
Hard, gray, silty CLAY; moist; scattered slickensides; (Qpgl) CL.	69.5			13	
BOTTOM OF BORING COMPLETED 10/14/2003 Note: Boring was drilled over water. Surface elevation refers to mudline, which is 22 feet below water surface.	74.5				



LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- G Grab Sample
- 3.0" O.D. Osterberg Sample
- Standard Penetration Test
- M Pressuremeter Test (f=failed)

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-104

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
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FIG. A.6-4

REVISED FOR ADDENDUM NO. 095-1 REV 3

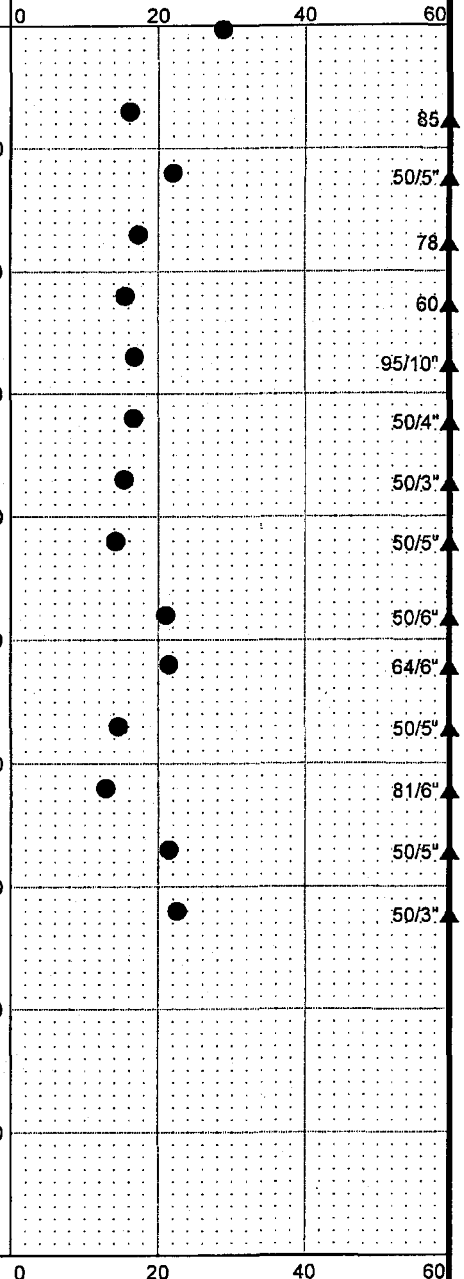
MASTER LOG2 21-09910.GPJ TEMP.GDT 4/1/04 Log: XHL Rev: TWH Typ: LKD

SOIL DESCRIPTION	Depth, Ft.	PID, ppm	Samples	Ground Water
Coordinates: N: 244,095 E: 1,260,133 Surface Elevation: -6.0 Ft. (NAVD-88)				
Loose, gray, clayey, silty SAND; wet; scattered gravel, wood chips, organics, and till clasts; (Hf) SM.	5.0	0 0	1, 2	None Observed During Drilling
Very dense, gray, silty, gravelly, fine to coarse SAND; wet; (Qvro) SM.	10.0			
Very dense, gray, silty, clayey SAND, trace of gravel; moist; massive, gravelly layer at 30 feet; (Qpgm) SC.	40.0		3, 4, M61, 5, 6, 7, 8	
Very dense, gray, slightly silty to silty, fine to medium SAND; wet; massive; (Qpgo/Qpnf) SM/SP-SM.	54.0		9, M62, 10, 11	
Very dense, gray, slightly silty, fine to coarse SAND, trace of gravel; wet; increasing gravel with depth; (Qpgo/Qpnf) SP-SM/SW-SM.	65.0		12, 13	
Very dense, gray, slightly silty to silty, fine to medium SAND; wet; massive; (Qpgo/Qpnf) SP-SM/SM.	72.7		14, 15	

BOTTOM OF BORING
COMPLETED 10/15/2003

Note: Boring was drilled over water. Surface elevation refers to mudline, which is 13 feet below water surface.

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND
* Sample Not Recovered
3.0" O.D. Osterberg Sample
Standard Penetration Test
Pressuremeter Test (f=failed)

● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-105

December 2003 21-1-09910-091

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FIG. A.6-5

REV 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03 Log: XHL Rev: TWH Typ: LKD

SOIL DESCRIPTION

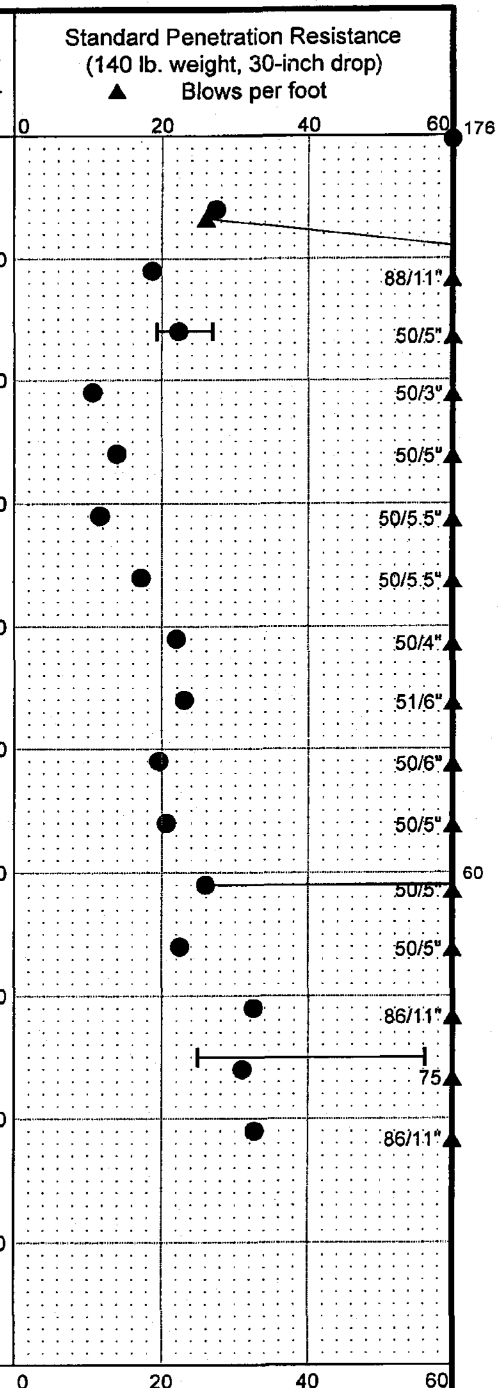
Coordinates: N: 244,366 E: 1,260,136
Surface Elevation: 6.4 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.	PID, ppm	Samples
Very soft, dark brown, organic fragments; wet; abundant wood debris; (Hf/Hp) PT.	0.8	0	1
Interbedded, medium dense, gray, silty, fine to medium SAND, and very soft, silty CLAY; wet; scattered organics; (Qvro/Hl) SM/CL.	9.0	0, 0	2, 3
Very dense, gray, silty, clayey SAND, trace of gravel; moist; with seams of silty clay in upper 10 feet; (Qpgm) SC.	32.0		4, M63, 5, 6, 7
Very dense, gray, slightly silty and silty, fine to medium SAND; wet; locally trace of gravel, slightly gravelly at top; (Qpgo/Qpnf) SP-SM/SM.	61.0		8, M64, 9, 10, 11, 12, M65 f
Hard, gray, silty CLAY; moist; massive to fractured layer of silty, fine sand from 64 to 68 feet; abundant sheared zones and slickensides below 80 feet; (Qpgl) CH.	82.4		13, 14, 15, M66, 16, 17

Ground Water: None Observed During Drilling

BOTTOM OF BORING
COMPLETED 10/17/2003

Note: Boring was drilled over water. Surface elevation refers to mudline, which is 13 feet below water surface.



● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- 3.0" O.D. Osterberg Sample
- Standard Penetration Test
- Pressuremeter Test (f=failed)

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-106

December 2003 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

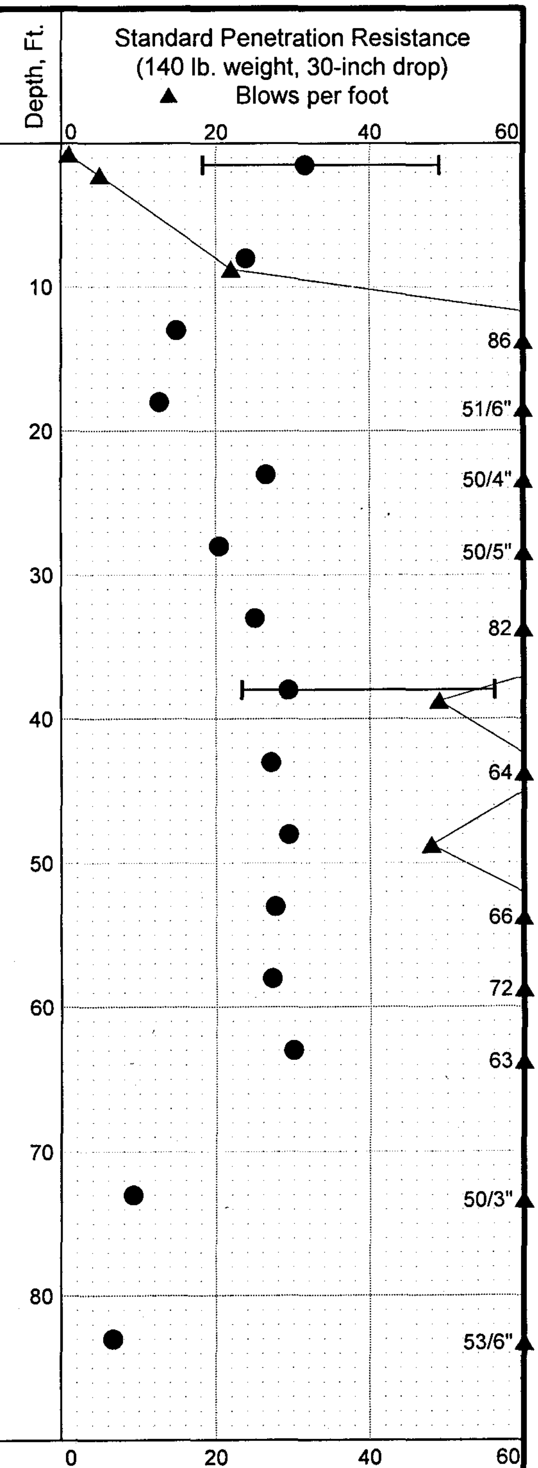
FIG. A.6-6

REV 3

MASTER LOG2 21-09910.GPJ SHAN WIL.GDT 12/19/03 Log: XHL Rev: WDN Typ: LKD

SOIL DESCRIPTION Coordinates: N: 244,717 E: 1,260,149 Surface Elevation: 4.6 Ft. (NAVD-88)	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water
Very soft, dark brown, organic fragments; wet; abundant wood debris; (Hf/Hp) PT.			0 0	1 E 2 E	
Very stiff, gray, interbedded, silty CLAY and sandy, silty CLAY, trace of gravel; moist; scattered sand seams; (Qvrl) CL.	5.0		0	3	
Very dense, gray, silty, clayey SAND, trace of gravel; moist; massive; (Qpgm) SC.	12.0		0	4 5	
Very dense, gray, fine sandy SILT, trace of clay; wet; massive; (Qpgl) ML.	23.5			6 7	
Hard, gray, silty CLAY; moist; massive, bedded and with scattered sand seams above 40 feet, sheared seams at 53 feet; (Qpgl) CH/CL.	32.0			8 9 10 11 12 13 14	
Very dense, gray, silty, clayey, gravelly SAND to silty, sandy GRAVEL, trace of clay; moist to wet; (Qpgo/Qpnf) GM/SC.	71.0			15 16	

CONTINUED NEXT SHEET



LEGEND

* Sample Not Recovered

E Environmental Sample Obtained

Ⅰ Standard Penetration Test

● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-107

March 2004 21-1-09910-091

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FIG. A.6-7
Sheet 1 of 3

REVISED FOR ADDENDUM NO. 095-1 *REV 3*

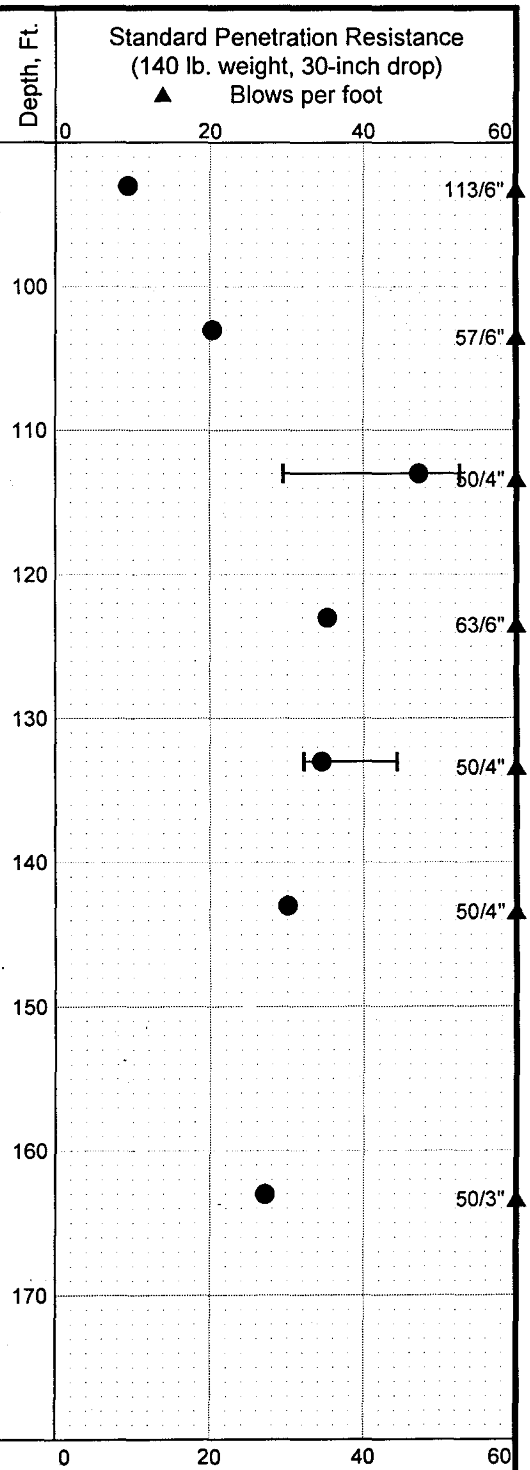
SOIL DESCRIPTION

Coordinates: N: 244,717 E: 1,260,149

Surface Elevation: 4.6 Ft. (NAVD-88)

SOIL DESCRIPTION	Depth, Ft.	Samples
Very dense, gravelly SAND to silty, sandy GRAVEL; (Qpgo/Qpnf) GM/SC (cont.)		17
Very dense, blue-gray, silty, fine to medium SAND; wet; massive; (Qpgo/Qpnf) SM.	102.0	18
Hard, gray, silty CLAY to clayey SILT, trace of sand; moist; scattered to abundant layers and seams of organic silt to peat, abundant organic fragments; (Qpnl) CH/CH/PT.	112.0	19, 20
Hard, gray, clayey SILT, trace of sand, to slightly fine sandy SILT; moist; massive; scattered organic seams; micaceous; silty, fine sand at bottom; (Qpnl) ML.	130.0	21, 22, 23
Very dense, gray, silty, fine SAND, trace of clay; moist to wet; micaceous, scattered organic fragments; (Qpnl) SM.	165.0	

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- Ɪ Standard Penetration Test

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-107

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

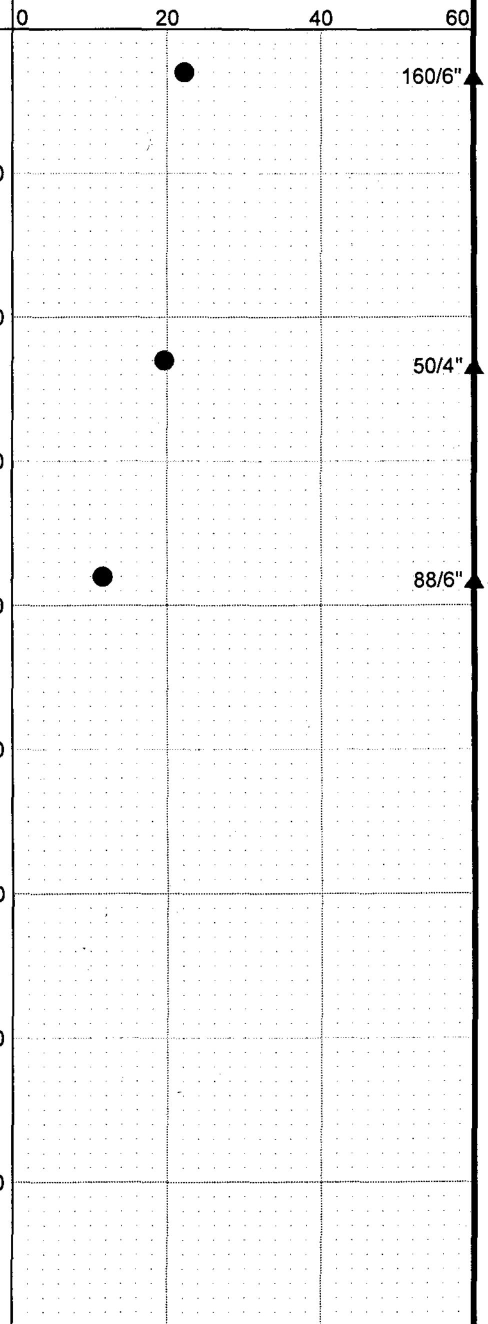
FIG. A.6-7
Sheet 2 of 3

REVISED FOR ADDENDUM NO. 095-1

REV 3

SOIL DESCRIPTION Coordinates: N: 244,717 E: 1,260,149 Surface Elevation: 4.6 Ft. (NAVD-88)	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.
Very dense, gray, silty, fine SAND; moist to wet; (Qpnl) SM (cont.) - Gravelly layer inferred from drill action at 192 feet.				24		190
Very dense, interbedded, green-gray, slightly silty, fine to medium SAND and slightly silty, sandy GRAVEL; moist to wet; trace of clay locally; (Qpnf) SP-SM/GP-GM.	195.0			25		200 210
BOTTOM OF BORING COMPLETED 10/10/2003 Note: Boring was drilled over water. Surface elevation refers to mudline, which is 12 feet below water surface.	218.5			26		220 230 240 250 260

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



0 20 40 60

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered

E Environmental Sample Obtained

Ⅰ Standard Penetration Test

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-107

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.6-7
Sheet 3 of 3

REVISED FOR ADDENDUM NO. 095-1 *REV 3*

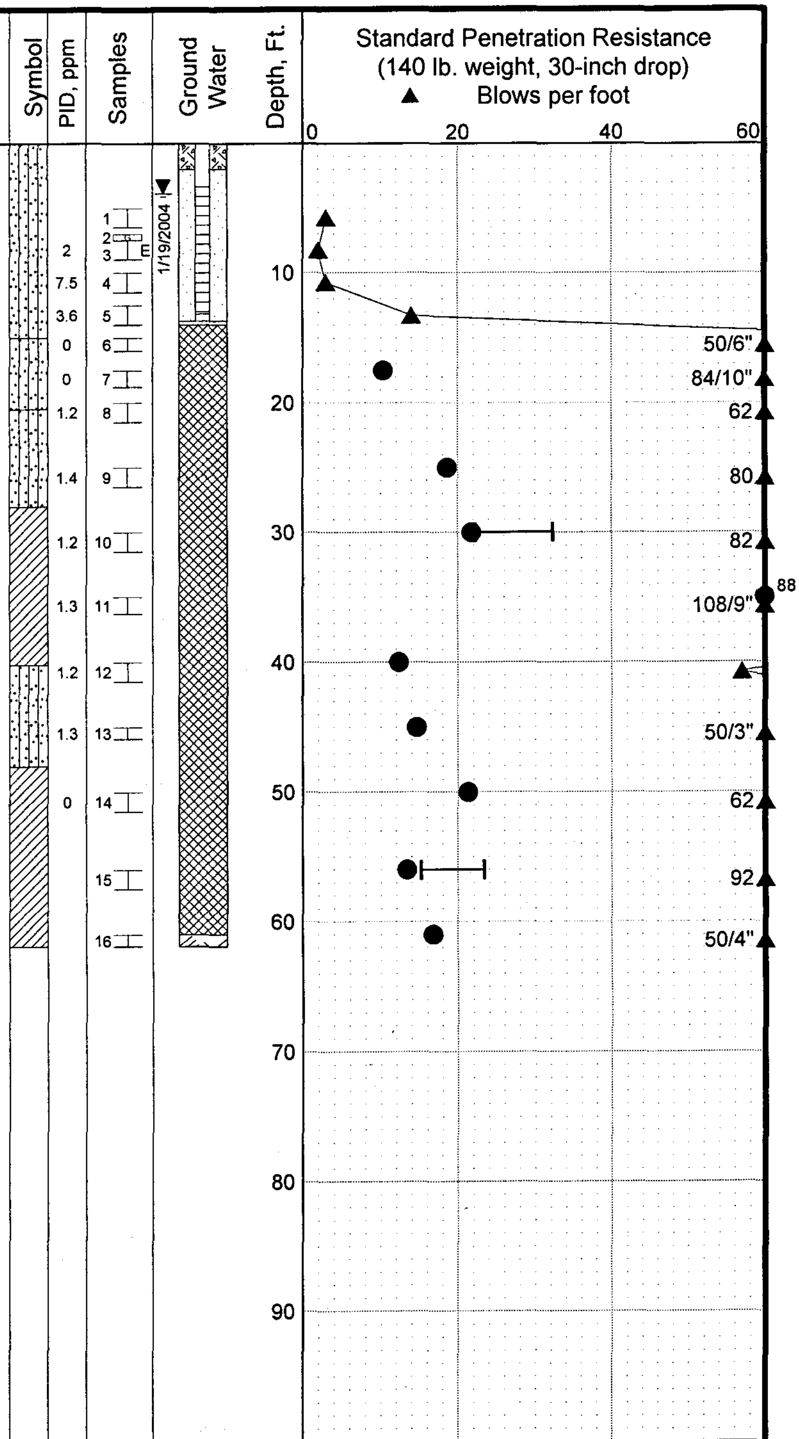
Log: XHL Rev: WDN Typ: LKD

MASTER_LOG2 21-09910.GPJ TEMP.GDT 4/1/04

SOIL DESCRIPTION Coordinates: N: 244,987 E: 1,260,154 Surface Elevation: 20.9 Ft. (NAVD-88)	Depth, Ft.
Very loose to medium dense, brown to gray, silty SAND; moist to wet; abundant brick and wood debris, gravel, and clay layers and pockets; strong petroleum odor; (Hf) SM.	15.0
Very dense, gravelly, silty SAND, trace of clay; moist; massive; (Qvt) SM.	20.5
Very dense, gray, silty, fine to medium SAND; wet; massive (Qva) SM.	28.0
Hard, gray, silty CLAY to sandy, silty CLAY and silty, clayey SAND; moist; bedded, scattered sand seams; (Qpgl) CL/SC.	40.2
Very dense, silty, fine to medium SAND, trace of gravel; moist to wet; (Qpgo) SM.	48.0
Hard, gray, slightly sandy to sandy, silty CLAY, trace of gravel; moist; scattered fractures; (Qpgm) CL.	61.9

BOTTOM OF BORING
COMPLETED 10/17/2003

Note: Soil descriptions and PID readings above 3.7 feet are based on observations and measurements made during vacuum excavation.



LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- Standard Penetration Test
- Grab Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Seattle Monorail Project
Seattle, Washington

LOG OF BORING BX-108

March 2004 21-1-09910-091

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A.6-8

REVISED FOR ADDENDUM NO. 095-1 *REV 3*

MASTER_LOG2 21-09910.GPJ TEMP.GDT 4/1/04 Log: PVH Rev: WDN Typ: LKD

APPENDIX B

LABORATORY RESULTS BY SHANNON & WILSON

TABLE D-6
SUMMARY OF LABORATORY TESTING - BALLARD CROSSING

									Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
Boring No.	Test Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
BX-101	7.2	-	GRAB	-	CL	HF													X
BX-101	12.5	2	SPT	2	CL	HF	27.4												
BX-101	13.8	2	SPT	2	CL	HF	23.4												
BX-101	15.0	3	SPT	4	CL	HF	30.1												
BX-101	17.5	4	SPT	2	PT	HP	469.0												
BX-101	20.0	5	SPT	5	PT	HP	432.2												
BX-101	25.0	6	SPT	4	PT	HP	456.0												
BX-101	30.0	7	SPT	55	SP-SM	QVRO	16.9				56.9								
BX-101	35.0	8	SPT	58	SP-SM	QVRO	12.1												
BX-101	40.0	9	SPT	80	SP-SM	QVRO	18.7												
BX-101	45.0	10	SPT	50/6"	SM	QPNF	14.7												
BX-101	50.0	11	SPT	50/5"	SM	QPNF	11.7												
BX-101	55.0	12	SPT	97	SM	QPNF	20.4		0.1	91.0	8.9	1.2							
BX-101	60.0	13	SPT	50/6"	SM	QPNF	21.0												
BX-101	65.0	14	SPT	50/6"	SM	QPNF	14.2												
BX-101	70.0	15	SPT	50/6"	SM	QPNF	15.3												
BX-101	75.0	16	SPT	50/5"	SM	QPNF	21.0												
BX-101	80.0	17	SPT	50/5"	SM	QPNF	22.3												
BX-102	2.0	1	OSTER	-	PT	HP	475.7												
BX-102	2.5	1	OSTER	-	CL	HL	179.1												
BX-102	5.0	2	SPT	0	CL	HL	38.3												
BX-102	13.0	3	SPT	0	CH	HL	66.2												
BX-102	18.0	4	SPT	0	CH	HL	78.2						56	27					
BX-102	23.0	5	SPT	0	CH	HL	80.5												
BX-102	28.0	6	SPT	3	CL	HL	33.0												
BX-102	33.0	7	SPT	7	CL	HL	48.9						42	23					
BX-102	38.0	8	SPT	43	SM	QPNF	18.1												
BX-102	43.0	9	SPT	73	SM	QPNF	24.6												
BX-102	48.0	10	SPT	50/5"	SM	QPNF	12.6												
BX-102	53.0	11	SPT	98	SM	QPNF	11.7		15.4	60.5	24.1								

(see page 6 for notes)

TABLE D-6
SUMMARY OF LABORATORY TESTING - BALLARD CROSSING

Boring No.	Test Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
BX-102	58.0	12	SPT	52/6"	SM	QPNF	20.5												
BX-102	63.0	13	SPT	63	CH	QPGL	26.8						59	26					
BX-102	68.0	14	SPT	53/6"	CH	QPGL	27.0												
BX-102	73.0	15	SPT	52/6"	SM	QPGL	18.8												
BX-102	83.0	17	SPT	78	CH	QPGL	28.9						66	25					
BX-103	0.4	1	OSTER	-	CL	HL	76.8												
BX-103	0.9	1	OSTER	-	CL	HL	86.0												
BX-103	6.5	2	SPT	0	CL	HL	171.6												
BX-103	11.5	3	SPT	3	CL	HL	33.2												
BX-103	17.0	4	OSTER	-	SM	QVRO	25.4												
BX-103	17.1	4	OSTER	-	SM	QVRO	25.8	125											
BX-103	18.1	4	OSTER	-	SM	QVRO	26.0												
BX-103	19.0	5	SPT	18	SM	QVRO	27.9												
BX-103	22.0	6	SPT	35	SM	QVRO	18.6												
BX-103	27.0	7	SPT	63	SM	QPNF	13.1		0.0	85.8	14.2								X
BX-103	32.0	8	SPT	50/6"	GM	QPNF	8.4												
BX-103	37.0	9	SPT	54	CH	QPGL	24.6												
BX-103	42.0	10	SPT	55	CH	QPGL	30.1						66	26					
BX-103	47.0	11	SPT	50/5"	ML	QPGL	23.2				83.8								
BX-103	52.0	12	SPT	50/5"	ML	QPGL	20.6												
BX-103	57.0	13	SPT	50/5"	ML	QPGL	20.8												
BX-103	62.0	14	SPT	50/5"	ML	QPGL	22.7												
BX-103	67.0	15	SPT	60	CH	QPGL	29.9												
BX-103	72.0	16	SPT	81/11"	CH	QPGL	26.3												
BX-103	77.0	17	SPT	50/5"	SM	QPGL	22.5												
BX-104	11.0	1	OSTER	-	CL	HL	29.6												
BX-104	18.0	2	SPT	71	SP-SM	QVRO	20.0				4.1								
BX-104	23.0	3	SPT	75/11"	CL	QPGM	15.1												
BX-104	28.0	4	SPT	50/5"	CL	QPGM	11.7												
BX-104	33.0	5	SPT	50/5.5"	CL	QPGM	15.6												

TABLE D-6
SUMMARY OF LABORATORY TESTING - BALLARD CROSSING

Boring No.	Test Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2µm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
BX-104	38.0	6	SPT	50/3"	CL	QPGM	16.1		3.5	25.9	70.6	22.5	28	16					
BX-104	43.0	7	SPT	50/5.5"	CL	QPGM	12.6												
BX-104	54.0	9	SPT	50/5.5"	SP-SM	QPGO	19.2												
BX-104	58.0	10	SPT	60/5"	SP-SM	QPGO	17.9												
BX-104	64.0	11	SPT	50/5"	SP-SM	QPGO	31.7		1.5	93.6	4.9								
BX-104	73.0	13	SPT	84	CL	QPGL	24.0												
BX-105	0.3	1	OSTER	-	SM	HF	28.8												X
BX-105	7.0	2	SPT	85	SM	QVRO	16.1												
BX-105	12.0	3	SPT	50/5"	SC	QPGM	22.0												
BX-105	17.0	4	SPT	78	SC	QPGM	17.3		1.3	21.4	77.3	21.9							
BX-105	22.0	5	SPT	60	SC	QPGM	15.5												
BX-105	27.0	6	SPT	95/10"	SC	QPGM	16.8												
BX-105	32.0	7	SPT	50/4"	SC	QPGM	16.6				63.5								
BX-105	37.0	8	SPT	50/3"	SC	QPGM	15.3												
BX-105	42.0	9	SPT	50/5"	SM	QPGO	14.2												
BX-105	48.0	10	SPT	50/6"	SM	QPGO	21.0												
BX-105	52.0	11	SPT	64/6"	SM	QPGO	21.5												
BX-105	57.0	12	SPT	50/5"	SP-SM	QPGO	14.6												
BX-105	62.0	13	SPT	81/6"	SP-SM	QPGO	12.9												
BX-105	67.0	14	SPT	50/5"	SP-SM	QPGO	21.5												
BX-105	72.0	15	SPT	50/3"	SP-SM	QPGO	22.6												
BX-106	0.3	1	OSTER	-	PT	HF	176.0												
BX-106	6.0	2	SPT	26	SM	QVRO	27.4												
BX-106	11.0	3	SPT	88/11"	SC	QPGM	18.7												X
BX-106	16.0	4	SPT	50/5"	SC	QPGM	22.3						27	19					
BX-106	21.0	5	SPT	50/3"	SC	QPGM	10.6												
BX-106	26.0	6	SPT	50/5"	SC	QPGM	13.9												
BX-106	31.0	7	SPT	50/5.5"	SC	QPGM	11.6												
BX-106	36.0	8	SPT	50/5.5"	SP-SM	QPGO	17.2												
BX-106	41.0	9	SPT	50/4"	SP-SM	QPGO	22.0		0.6	87.2	12.3								

(see page 6 for notes)

TABLE D-6
SUMMARY OF LABORATORY TESTING - BALLARD CROSSING

Boring No.	Test Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4]				Plasticity[5]			Other Tests Performed[6]			
									Gravel (%)	Sand (%)	Fines (%)	<2μm (%)	Liquid Limit	Plastic Limit	Non-Plastic	Triaxial Test	Consol-idation	Cyclic Shear	Corrosion Tests
BX-106	46.0	10	SPT	51/6"	SP-SM	QPGO	23.0												
BX-106	51.0	11	SPT	50/6"	SP-SM	QPGO	19.6												
BX-106	56.0	12	SPT	50/5"	SP-SM	QPGO	20.6												
BX-106	61.0	13	SPT	50/5"	CH	QPGL	26.0						60	26					
BX-106	66.0	14	SPT	50/5"	CH	QPGL	22.5												
BX-106	71.0	15	SPT	86/11"	CH	QPGL	32.5												
BX-106	76.0	16	SPT	75	CH	QPGL	31.0						56	25					
BX-106	81.0	17	SPT	86/11"	CH	QPGL	32.6												
BX-107	1.5	2	SPT	5	CH	HF	31.6						49	18					
BX-107	8.0	3	SPT	22	CL	QVRL	23.8												
BX-107	13.0	4	SPT	86	SC	QPGM	14.9												
BX-107	18.0	5	SPT	51/6"	SC	QPGM	12.7												
BX-107	23.0	6	SPT	50/4"	SC	QPGM	26.5												
BX-107	28.0	7	SPT	50/5"	ML	QPGL	20.4												
BX-107	33.0	8	SPT	82	CH	QPGL	25.0												
BX-107	38.0	9	SPT	49	CH	QPGL	29.3						56	23					
BX-107	43.0	10	SPT	64	CH	QPGL	27.1												
BX-107	48.0	11	SPT	48	CH	QPGL	29.4												
BX-107	53.0	12	SPT	66	CH	QPGL	27.6												
BX-107	58.0	13	SPT	72	CH	QPGL	27.2												
BX-107	63.0	14	SPT	63	CH	QPGL	30.0												
BX-107	73.0	15	SPT	50/3"	GM	QPGO	9.2												
BX-107	83.0	16	SPT	53/6"	GM	QPGO	6.6												
BX-107	93.0	17	SPT	113/6"	GM	QPGO	9.4												
BX-107	103.0	18	SPT	57/6"	SM	QPGO	20.3												
BX-107	113.0	19	SPT	50/4"	CH	QPNL	47.2						53	29					
BX-107	123.0	20	SPT	63/6"	CH	QPNL	35.3												
BX-107	133.0	21	SPT	50/4"	ML	QPNL	34.5						44	32					
BX-107	143.0	22	SPT	50/4"	ML	QPNL	30.0				94.1	4.6							
BX-107	163.0	23	SPT	50/3"	ML	QPNL	27.1												

(see page 6 for notes)

TABLE D-6
SUMMARY OF LABORATORY TESTING - BALLARD CROSSING

Boring No.	Test Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4] Gravel (%)	Grain-Size Analyses[4] Sand (%)	Grain-Size Analyses[4] Fines (%)	Grain-Size Analyses[4] <2µm (%)	Plasticity[5] Liquid Limit	Plasticity[5] Plastic Limit	Plasticity[5] Non-Plastic	Other Tests Performed[6] Triaxial Test	Other Tests Performed[6] Consol-idation	Other Tests Performed[6] Cyclic Shear	Other Tests Performed[6] Corrosion Tests
BX-107	183.0	24	SPT	160/6"	SM	QPNL	22.2				16.5								
BX-107	203.0	25	SPT	50/4"	SP-SM	QPNF	19.6												
BX-107	218.0	26	SPT	88/6"	SP-SM	QPNF	11.6												
BX-108	17.5	7	SPT	84/10"	SM	QVT	10.4		8.4	56.1	35.6								
BX-108	25.0	9	SPT	80	SM	QVA	18.6												
BX-108	30.0	10	SPT	82	CL	QPGL	21.8						32	22					
BX-108	35.0	11	SPT	108/9"	CL	QPGL	88.0												
BX-108	40.0	12	SPT	57	CL	QPGL	12.4												
BX-108	45.0	13	SPT	50/3"	SM	QPGO	14.7												
BX-108	50.0	14	SPT	62	CL	QPGM	21.3												
BX-108	56.0	15	SPT	92	CL	QPGM	13.4						23	15					
BX-108	61.0	16	SPT	50/4"	CL	QPGM	16.8		1.3	29.7	69.0	21.3							
BX-109	6.5	1	SPT	21	SM	QVRO	16.6												
BX-109	10.0	2	SPT	85/11"	SM	QVD	10.7												
BX-109	12.5	3	SPT	50/5"	SM	QVD	10.5												
BX-109	15.0	4	SPT	75/11"	SM	QVD	9.6												
BX-109	17.5	5	SPT	45	SM	QVD	13.8												
BX-109	20.0	6	SPT	57	SM	QVD	14.5		6.5	70.5	22.9								
BX-109	27.5	8	SPT	54/6"	CL	QPGM	23.1												
BX-109	32.5	9	SPT	50	CL	QPGM	36.9						60	32					X
BX-109	37.5	10	SPT	51	SM	QPGM	14.0												
BX-109	42.5	11	SPT	90/11"	SM	QPGM	12.5												
BX-109	47.5	12	SPT	50/5"	SM	QPGM	10.0												
BX-109	52.5	13	SPT	91	SP-SM	QPGO	18.9		2.8	82.3	14.9								
BX-109	57.5	14	SPT	48	CH	QPGL	27.3												
BX-109	62.5	15	SPT	86	CH	QPGL	18.8												
BX-109	67.5	16	SPT	55/6"	SM	QPGO	20.4												
BX-109	72.5	17	SPT	83	CH	QPGL	24.4												
BX-109	77.5	18	SPT	75	SM	QPLS	22.9												
BX-109	82.5	19	SPT	72	SM	QPLS	34.8												

(see page 6 for notes)

TABLE D-6
SUMMARY OF LABORATORY TESTING - BALLARD CROSSING

Boring No.	Test Depth (feet)	Sample No.	Sample Type[1]	Blow Count (blows/foot)	USCS[2]	Geologic Unit[3]	Water Content (%)	Wet Unit Weight (pcf)	Grain-Size Analyses[4] Gravel (%)	Grain-Size Analyses[4] Sand (%)	Grain-Size Analyses[4] Fines (%)	Grain-Size Analyses[4] <2µm (%)	Plasticity[5] Liquid Limit	Plasticity[5] Plastic Limit	Plasticity[5] Non-Plastic	Other Tests Performed[6] Triaxial Test	Other Tests Performed[6] Consol-idation	Other Tests Performed[6] Cyclic Shear	Other Tests Performed[6] Corrosion Tests
BX-109	87.5	20	SPT	96	SM	QPGO	20.2												
BX-109	92.5	21	SPT	50/5"	SM	QPGO	17.8												
BX-109	97.5	22	SPT	50/5"	SM	QPGO	17.7		1.4	84.6	14.0								
BX-109	102.5	23	SPT	50/5"	SM	QPGO	17.4												
TOTAL NUMBER OF TESTS:							153	1	12		18	5	16			0	0	0	5

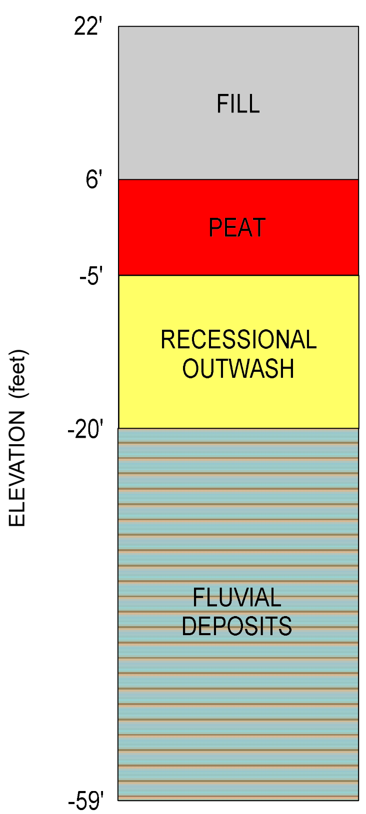
NOTES:

1. SPT = Standard Penetration Test (split-spoon) sample. PT = Pitcher Tube sample. OSTER = Osterberg tube sample. GRAB = Grab Sample.
2. USCS = Unified Soil Classification System. See Figure A-1 in Appendix A for explanation of classifications.
3. See Table A-1 for a description of the geologic units.
4. See Appendix D.1 for plots of the grain-size curves. Gravel = percent larger than 3/4 inch. Sand = percent of soil between 3/4 inch and 0.08 mm. Fines = percent passing the No. 200 sieve (0.08 mm). 2 mm = micrometers = clay fraction
5. See Appendix D.2 for plasticity (Atterberg Limits) plots.
6. See Appendix D.3 through D.6 for triaxial test, consolidation test, cyclic shear test, and corrosion test results.

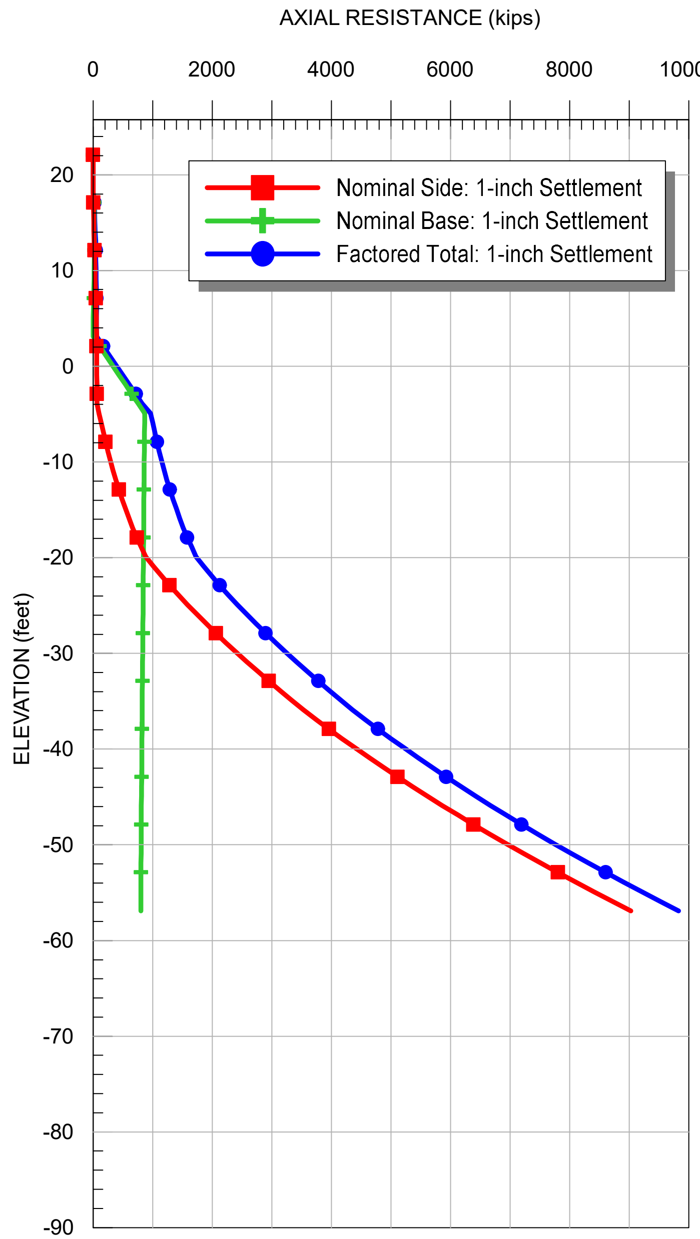
APPENDIX C

DRILLED SHAFT CAPACITIES

ASSUMED SUBSURFACE PROFILE



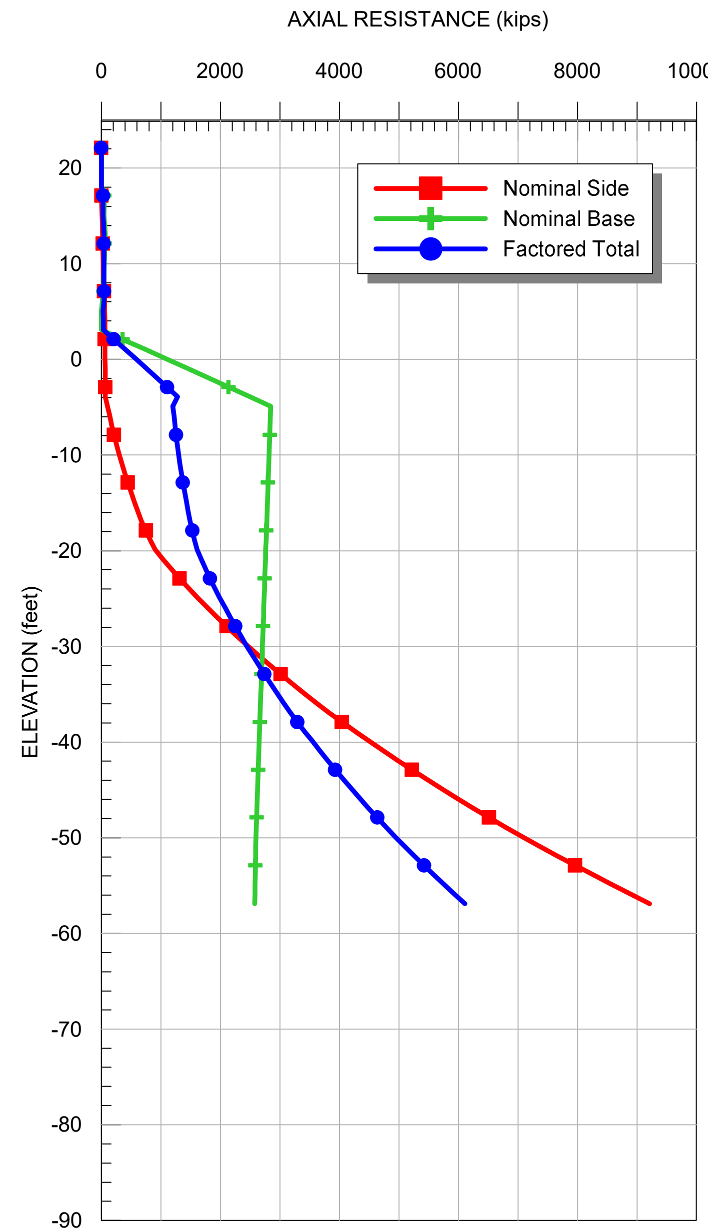
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

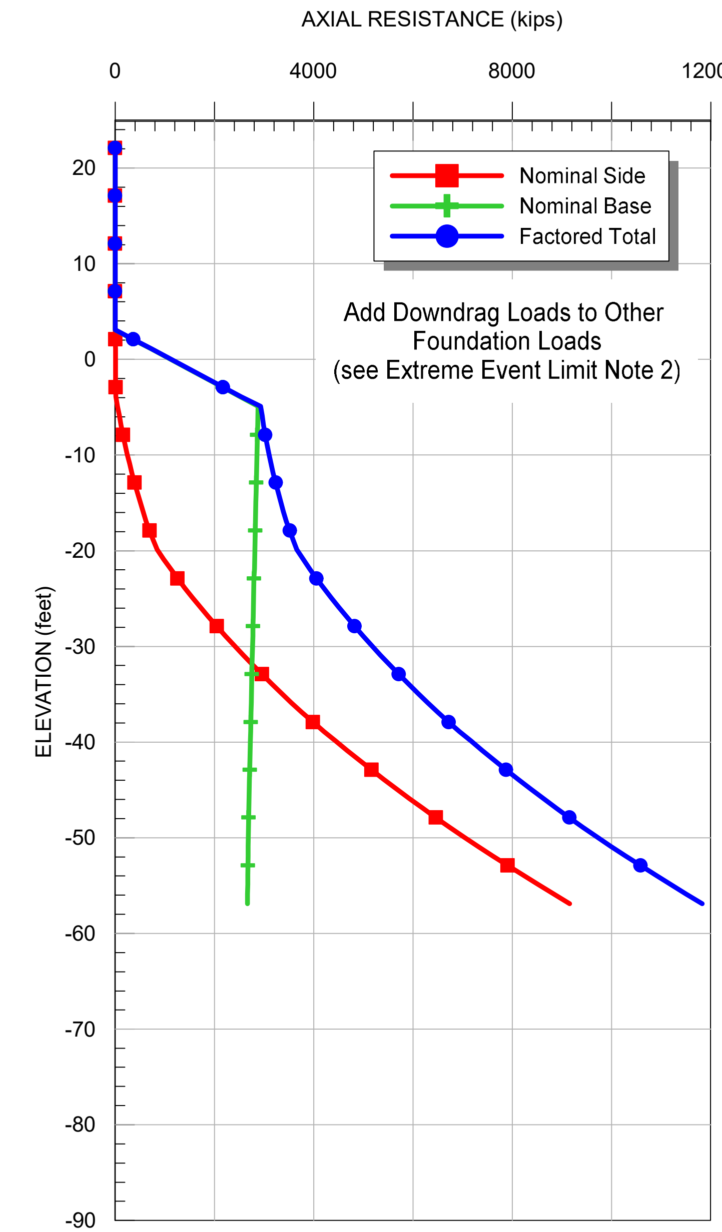
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

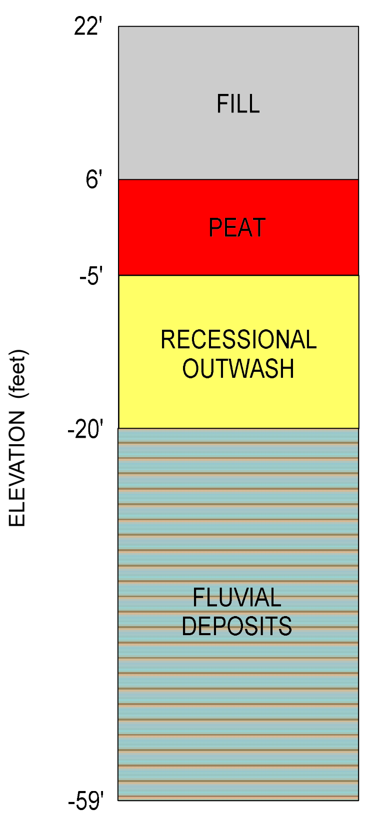
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Unfactored static downdrag force, due to liquefaction-induced settlement, for each shaft is estimated to be **13 kips**.
   A load factor of 1.05 should be applied to all downdrag loads (Allen, 2005) to determine factored downdrag force.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

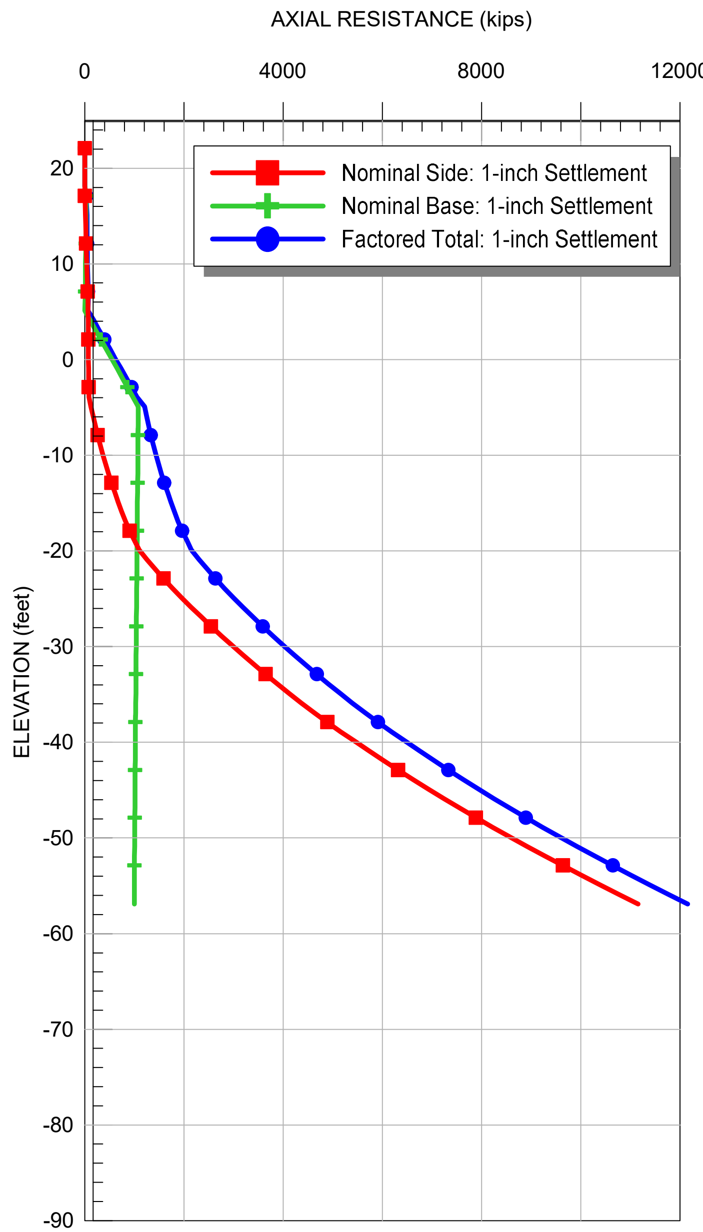
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 113+00 TO 116+00 (Boring BX-101) NOMINAL AXIAL SHAFT CAPACITIES 8-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 1A PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



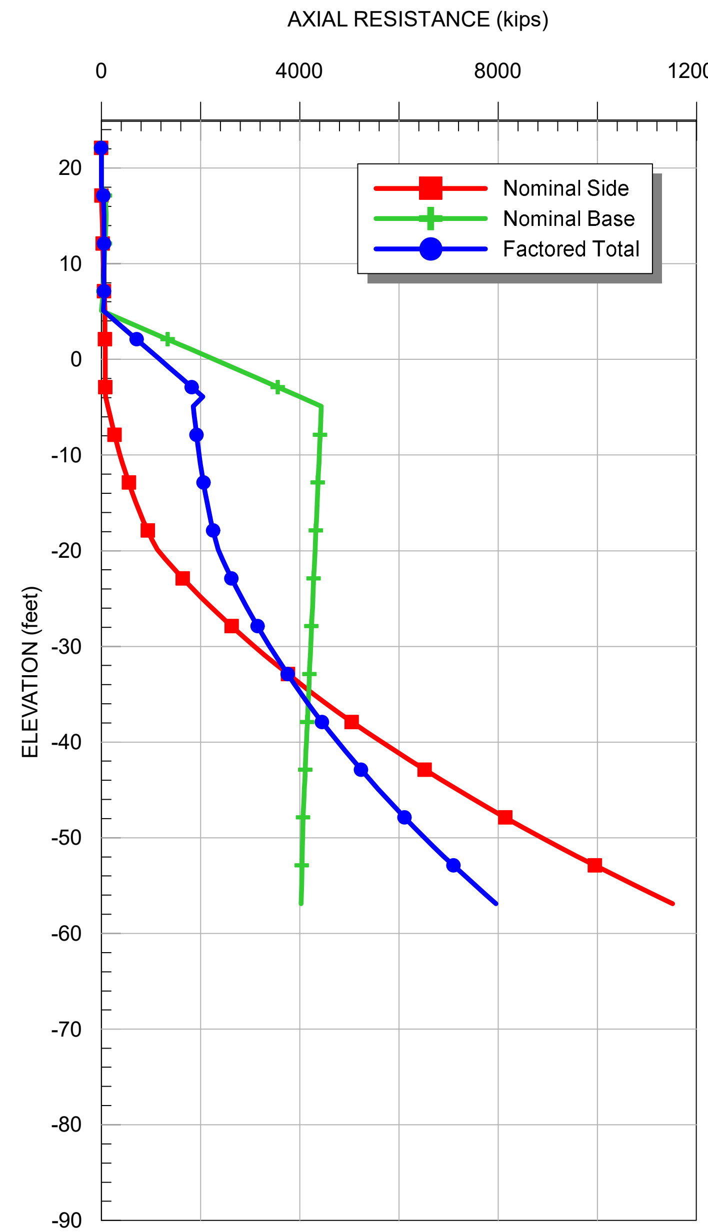
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

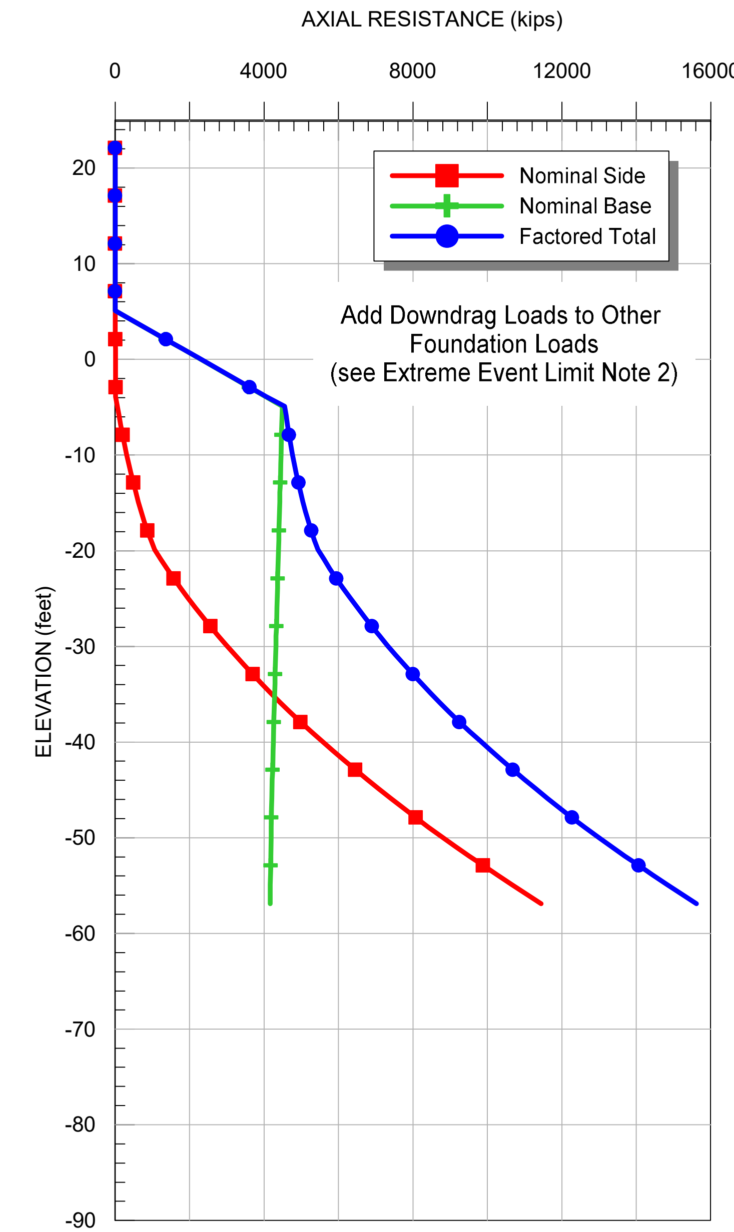
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

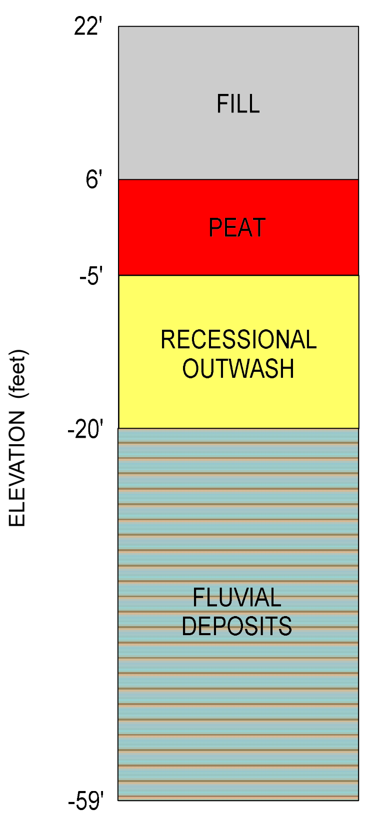
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Unfactored static downdrag force, due to liquefaction-induced settlement, for each shaft is estimated to be **16 kips**.
   A load factor of 1.05 should be applied to all downdrag loads (Allen, 2005) to determine factored downdrag force.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

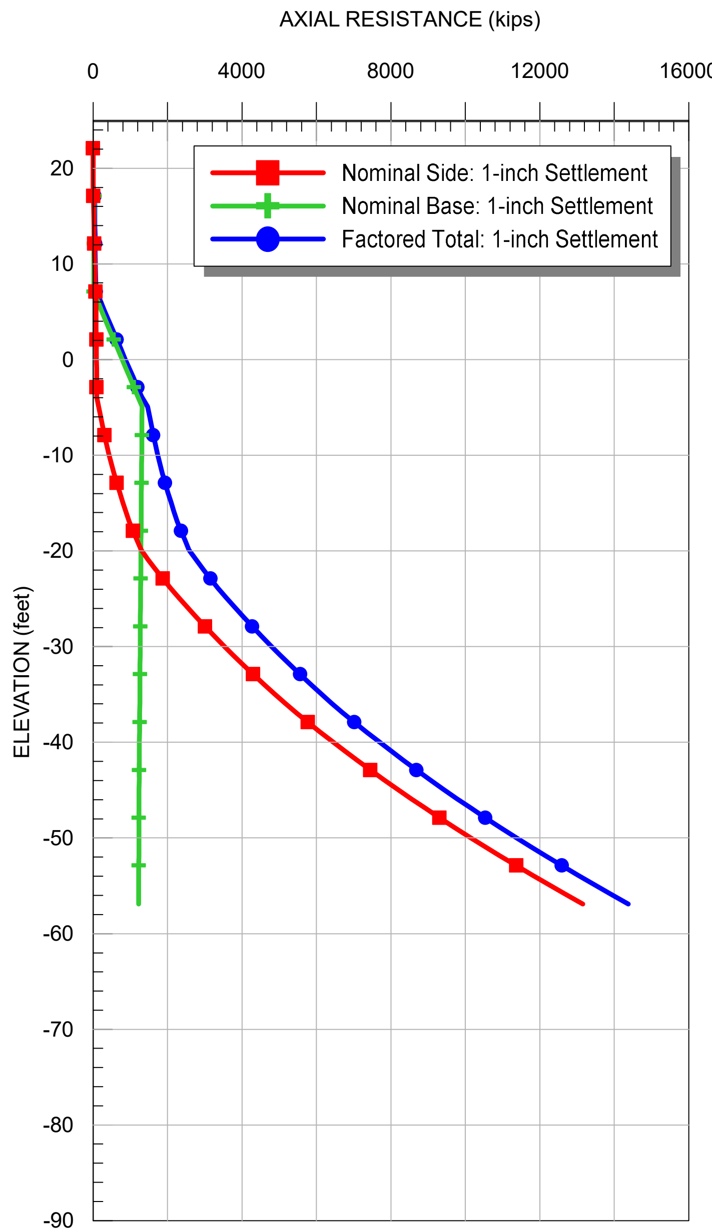
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appopriate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appopriate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 113+00 TO 116+00 (Boring BX-101) NOMINAL AXIAL SHAFT CAPACITIES 10-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 1B PROJECT NO. 2019-085-21

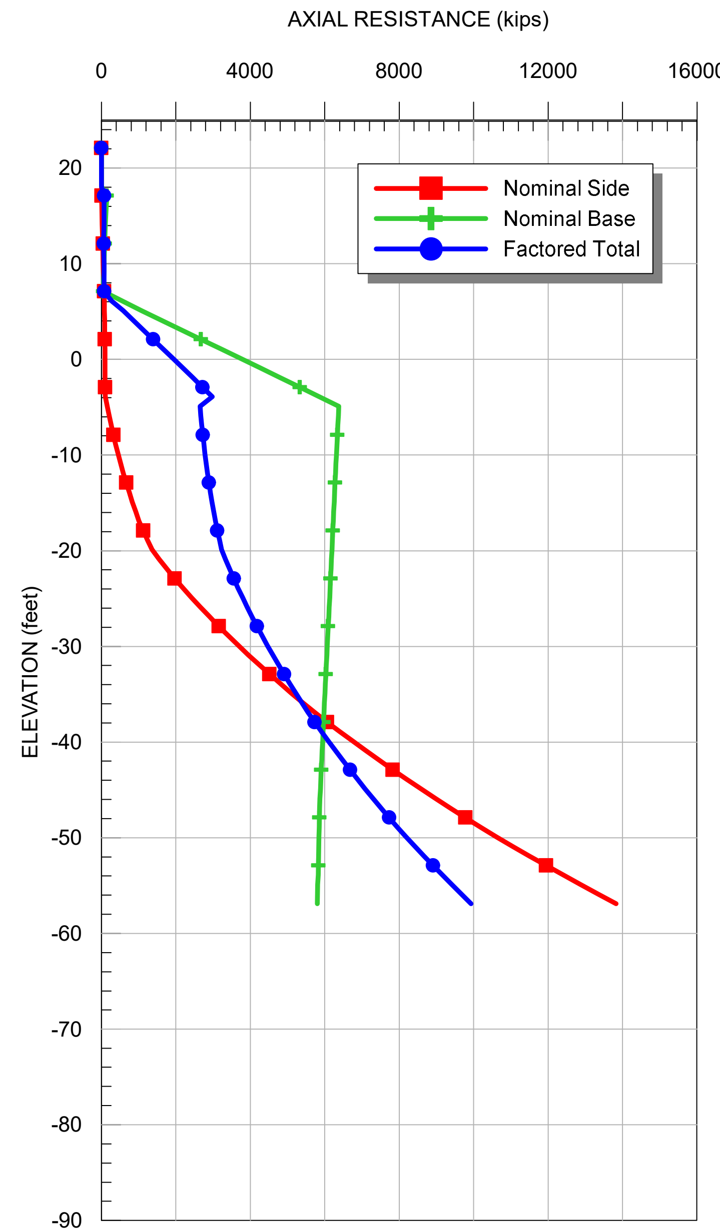
ASSUMED SUBSURFACE PROFILE



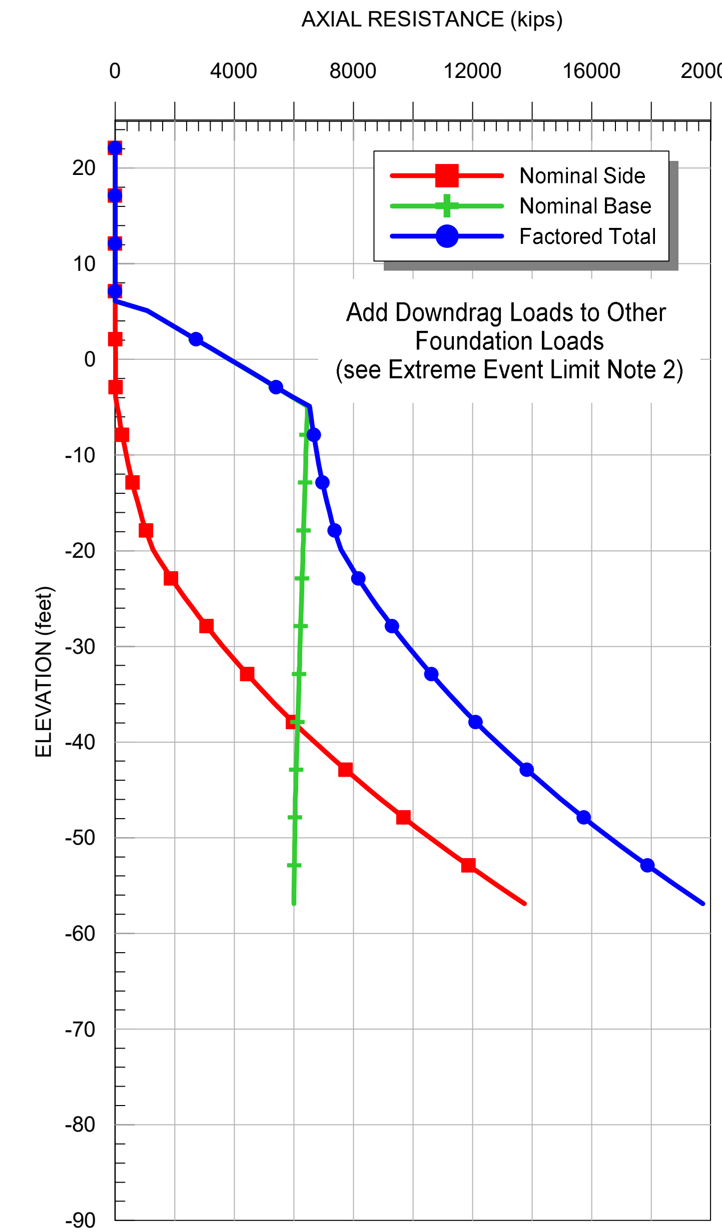
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT NOTES:

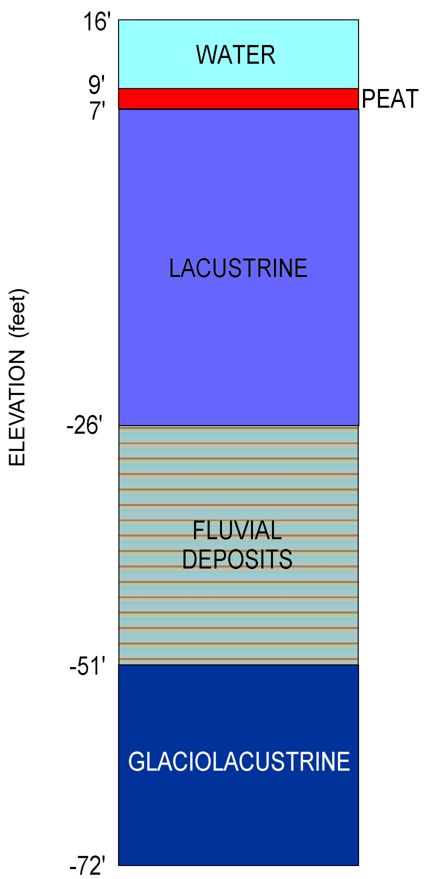
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Unfactored static downdrag force, due to liquefaction-induced settlement, for each shaft is estimated to be **19 kips**. A load factor of 1.05 should be applied to all downdrag loads (Allen, 2005) to determine factored downdrag force.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

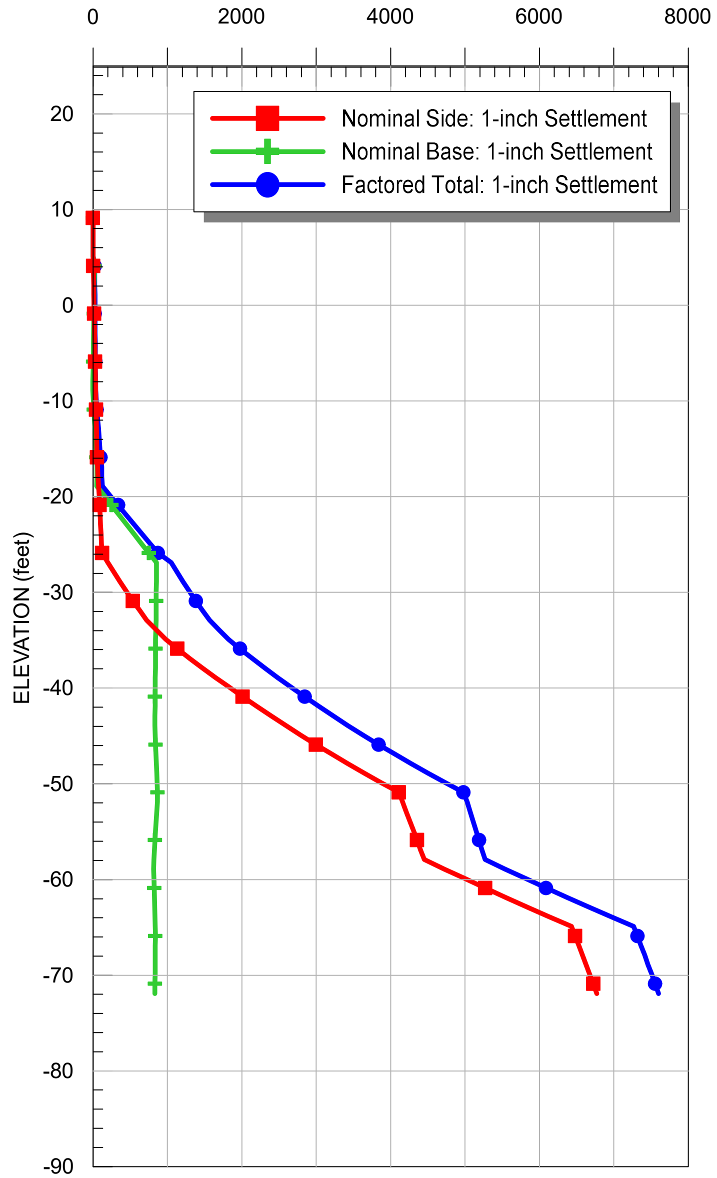
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 113+00 TO 116+00 (Boring BX-101) NOMINAL AXIAL SHAFT CAPACITIES 12-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 1C PROJECT NO. 2019-085-21

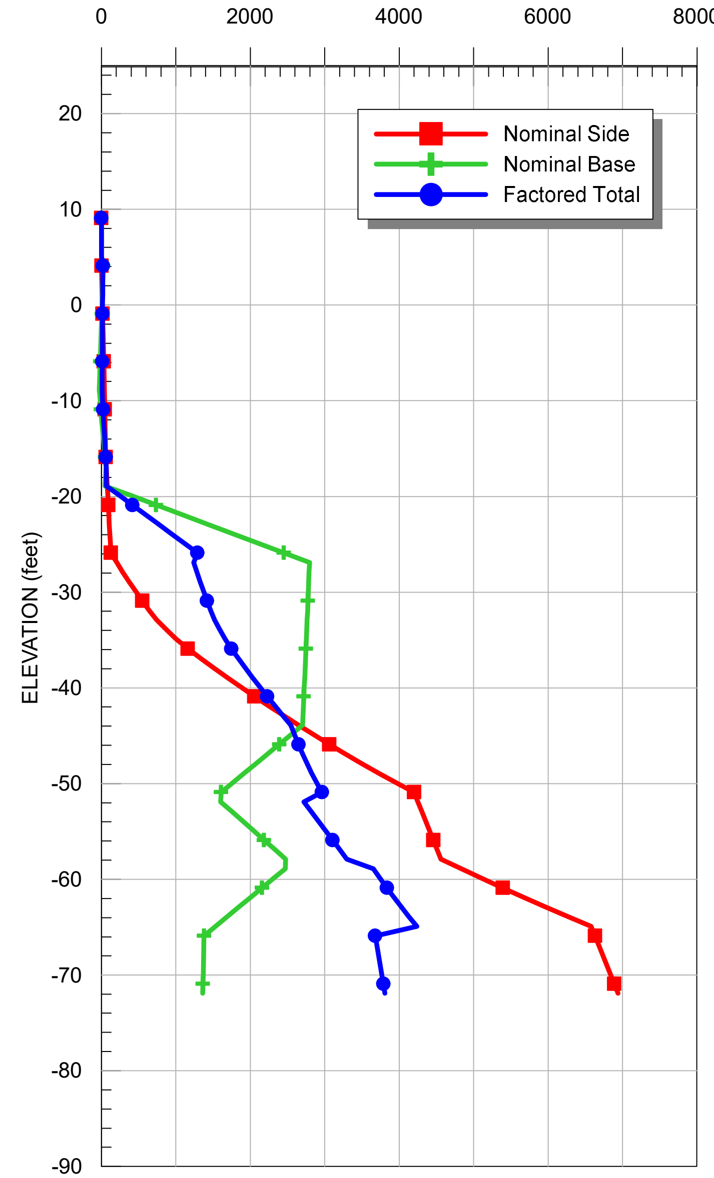
ASSUMED SUBSURFACE PROFILE



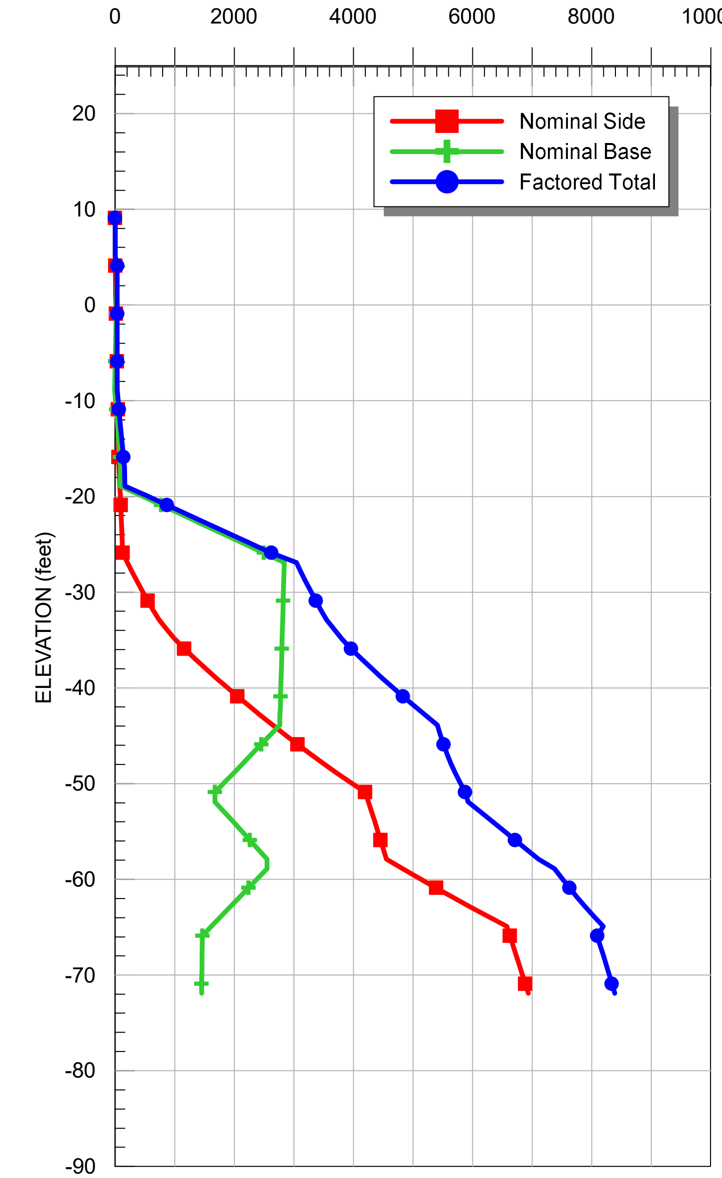
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT NOTES:

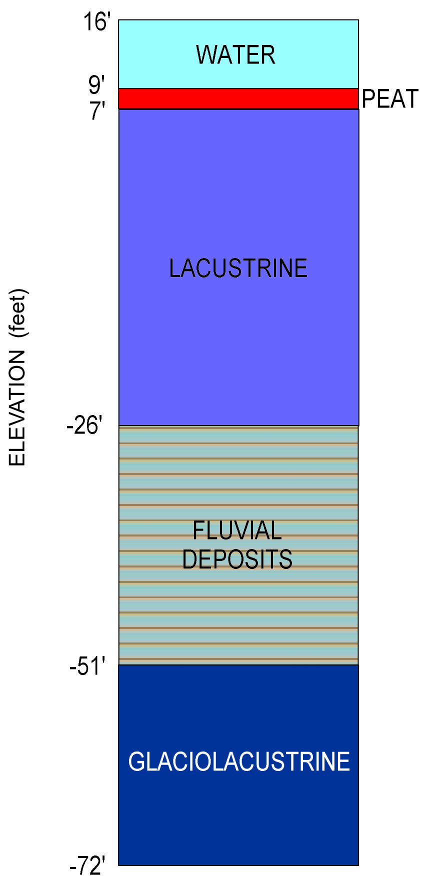
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

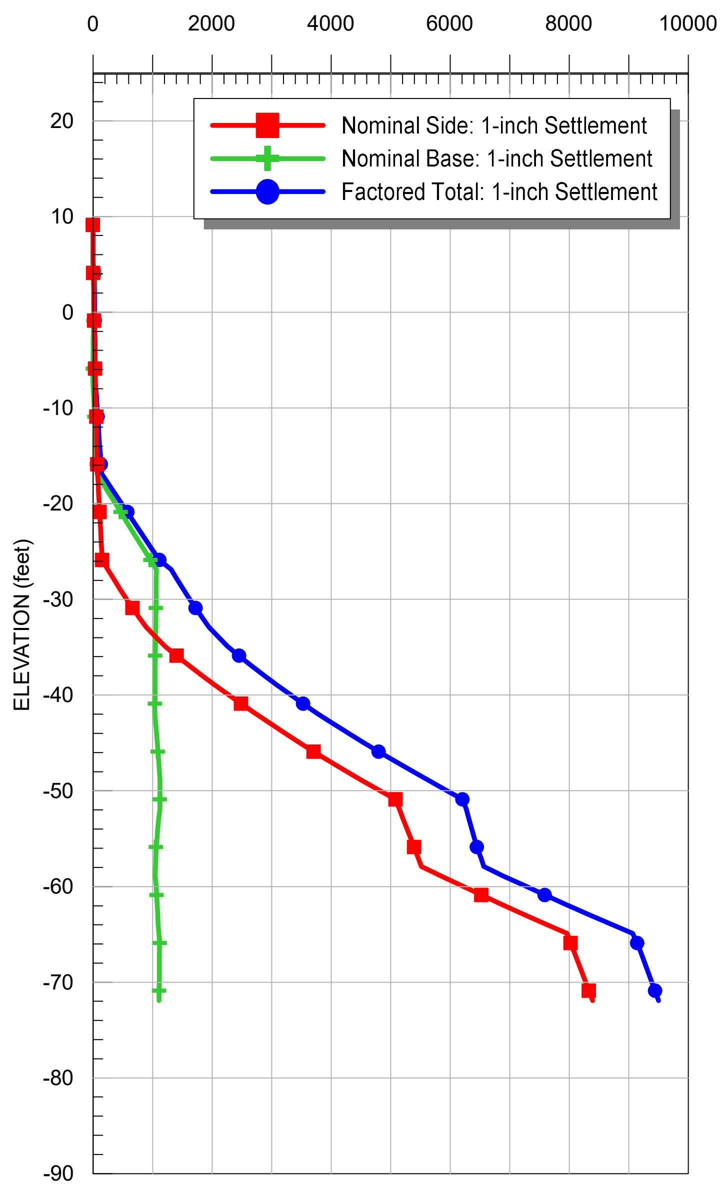
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 116+00 TO 118+00 (Boring BX-102) NOMINAL AXIAL SHAFT CAPACITIES 8-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 2A PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



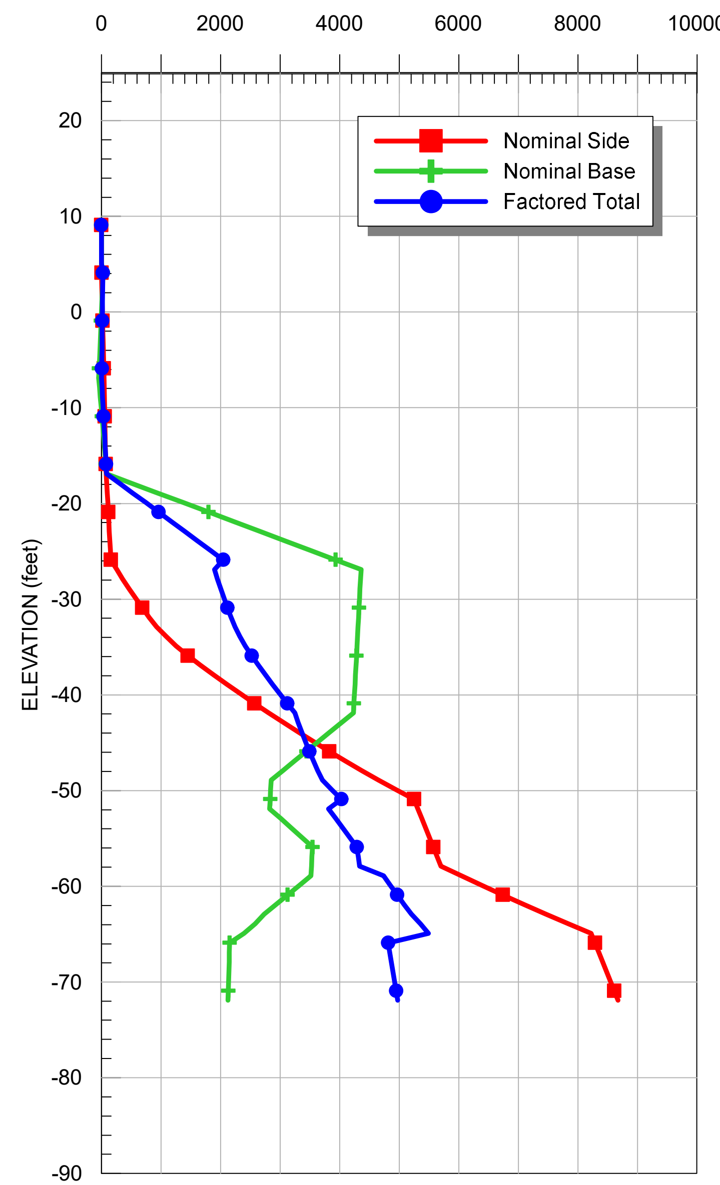
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

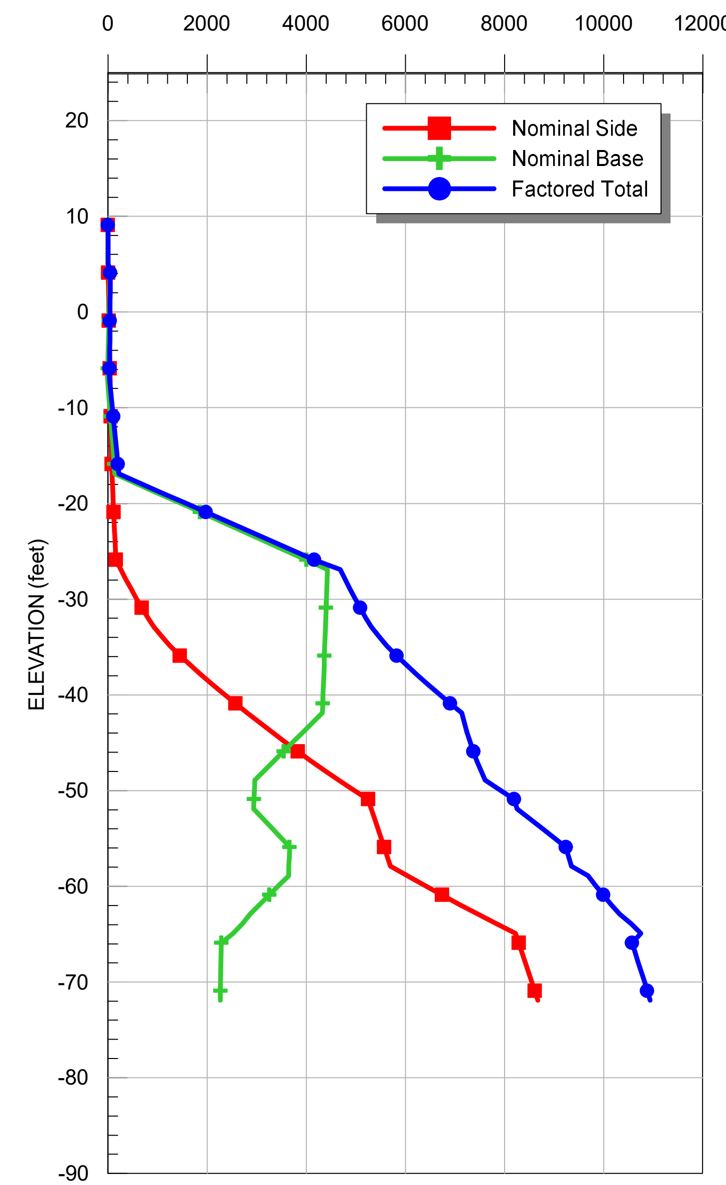
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

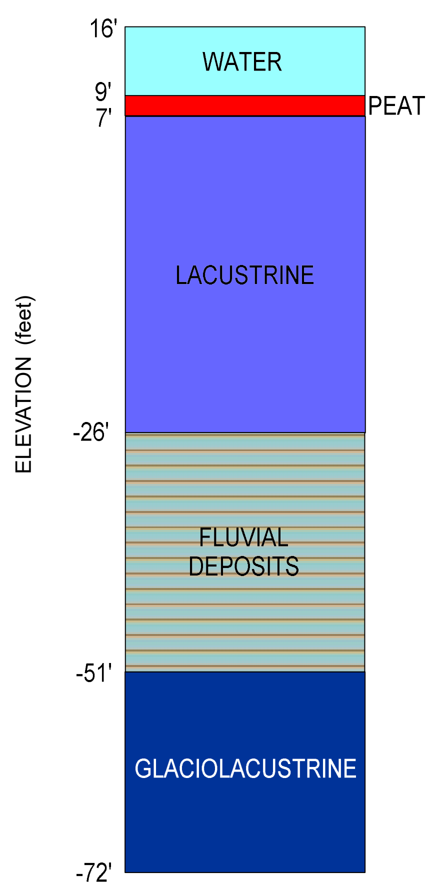
HWA GEOSCIENCES INC.

BALLARD BRIDGE
BRIDGE REHAB
SEATTLE, WASHINGTON

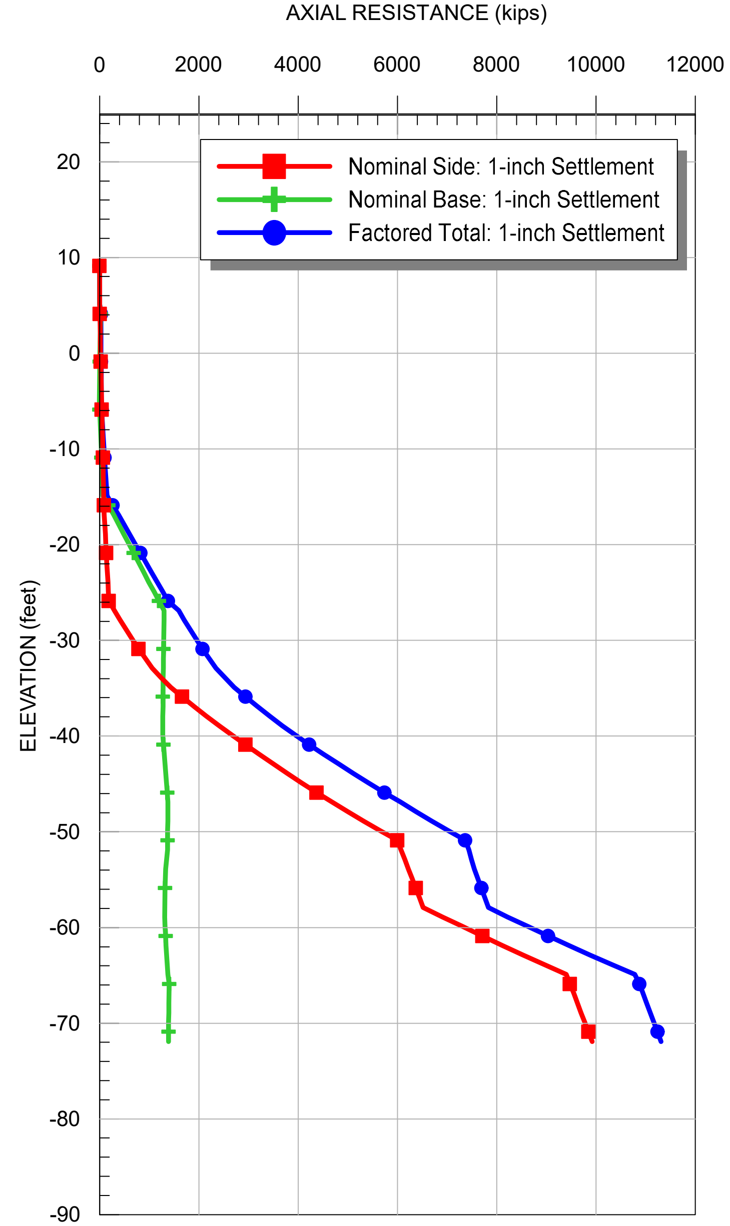
STATION 116+00 TO 118+00
(Boring BX-102)
NOMINAL AXIAL
SHAFT CAPACITIES
10-FOOT DIAMETER SHAFT

DRAWN BY SKS	FIGURE NO. 2B
CHECKED BY DJH	PROJECT NO. 2019-085-21
DATE 07.19.19	

ASSUMED SUBSURFACE PROFILE



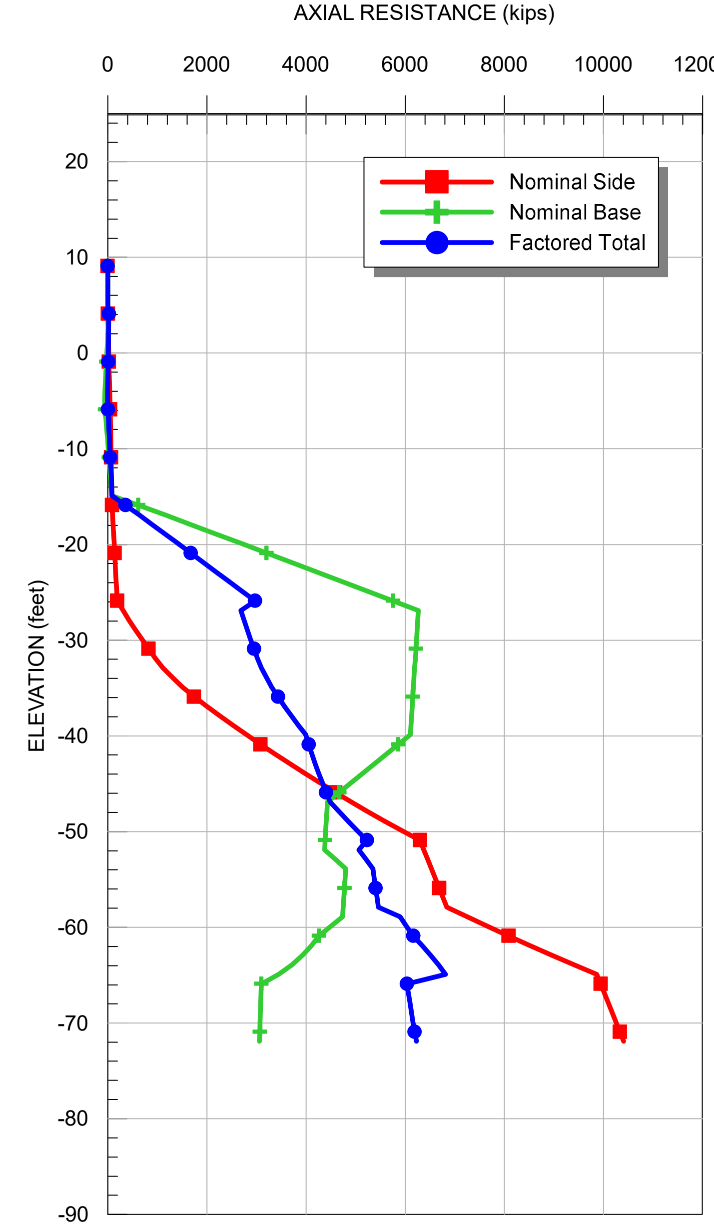
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

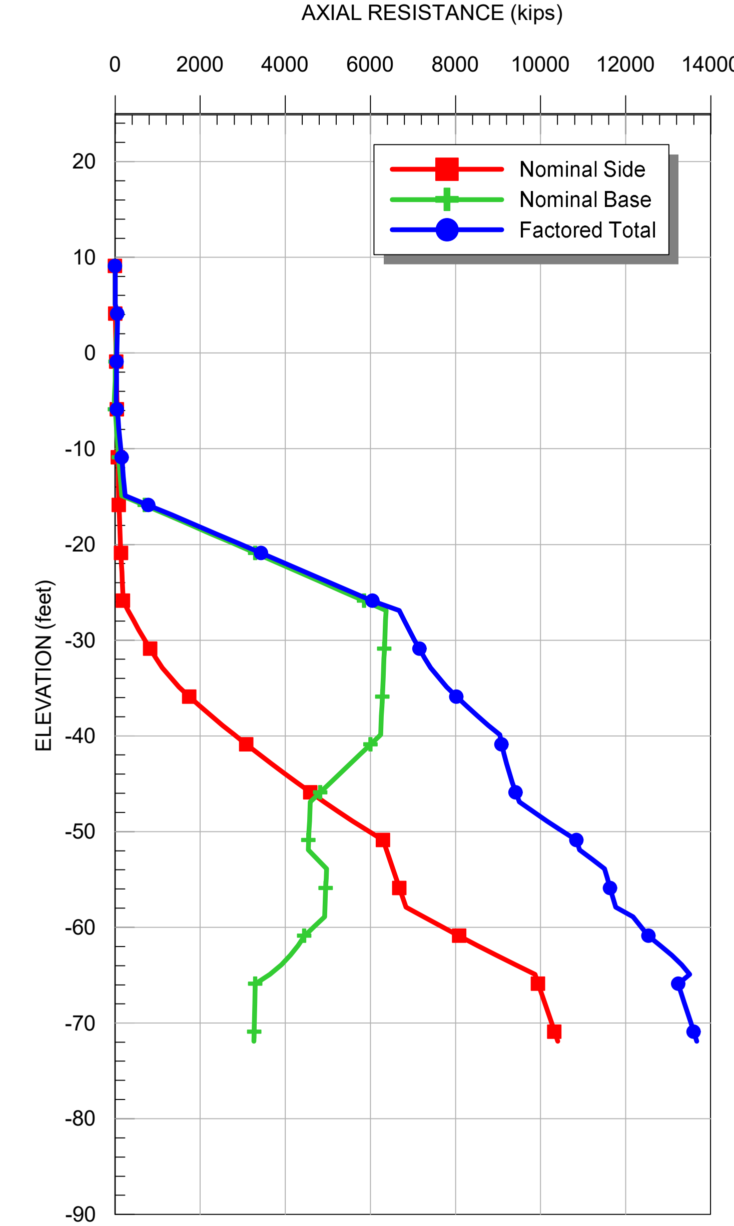
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

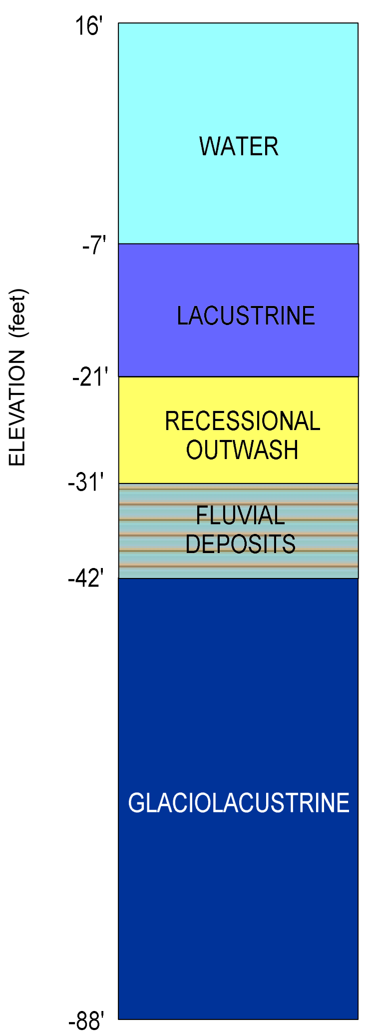
HWA GEOSCIENCES INC.

BALLARD BRIDGE
BRIDGE REHAB
SEATTLE, WASHINGTON

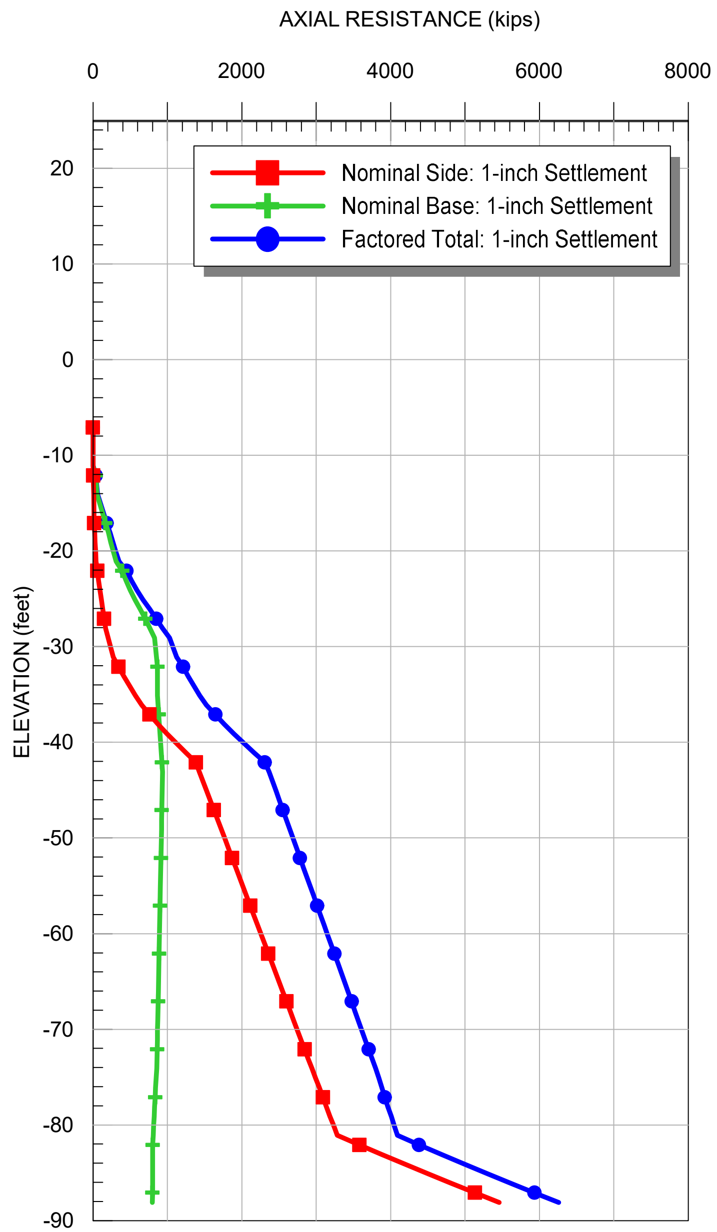
STATION 116+00 TO 118+00
(Boring BX-102)
NOMINAL AXIAL
SHAFT CAPACITIES
12-FOOT DIAMETER SHAFT

DRAWN BY SKS	FIGURE NO. 2C
CHECKED BY DJH	
DATE 07.19.19	PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



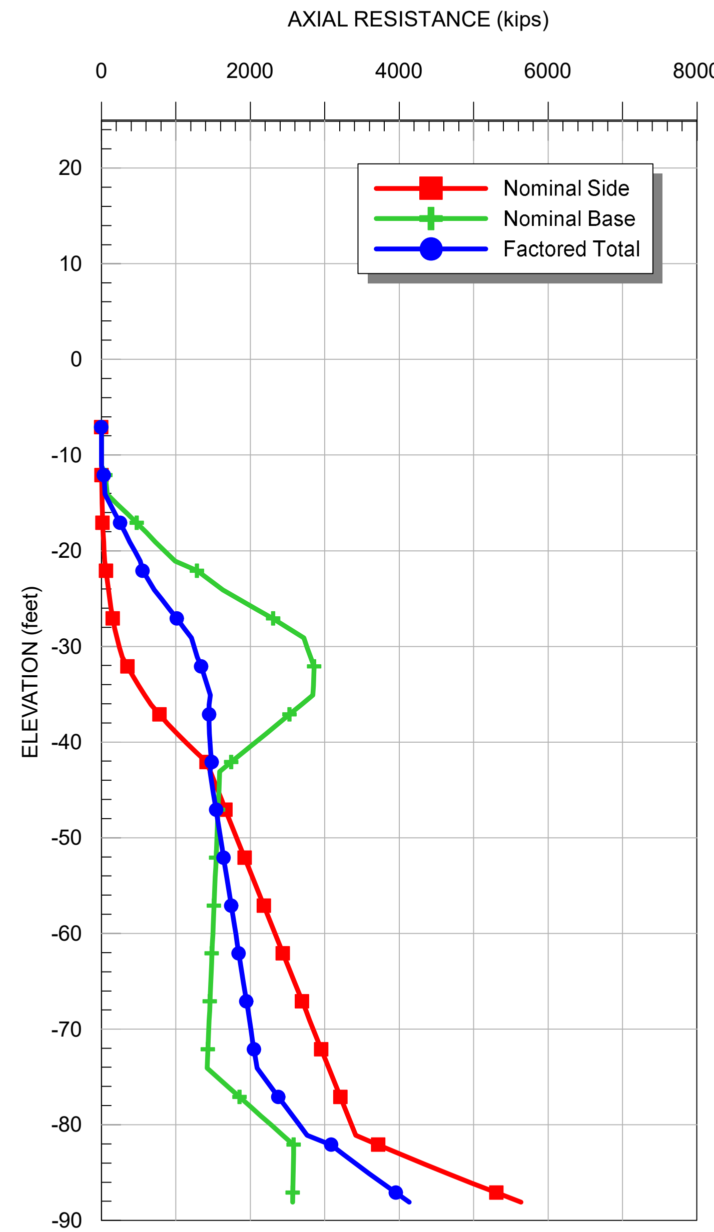
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

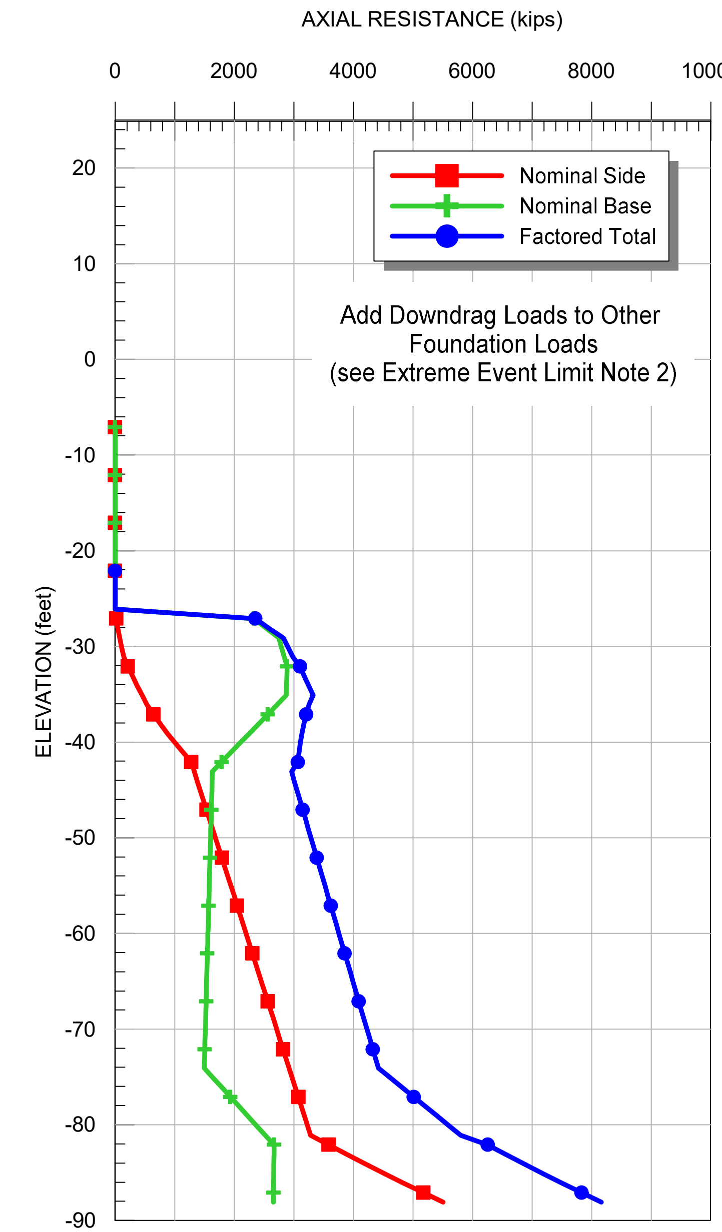
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

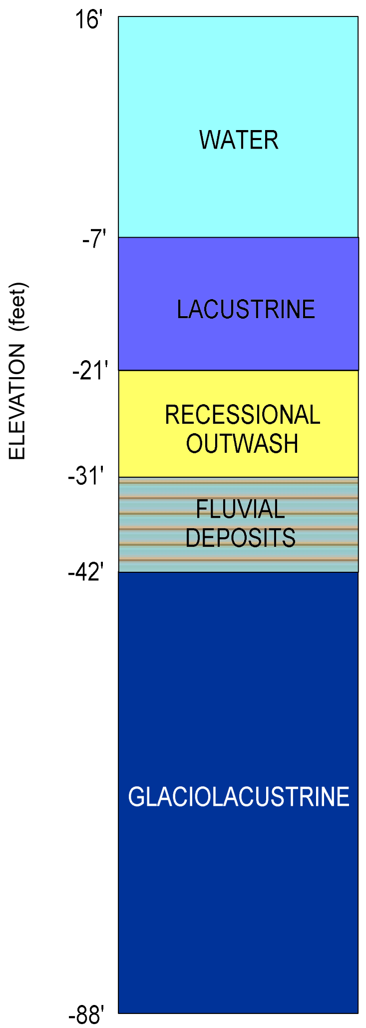
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Unfactored static downdrag force, due to liquefaction-induced settlement, for each shaft is estimated to be **110 kips.** A load factor of 1.05 should be applied to all downdrag loads (Allen, 2005) to determine factored downdrag force.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

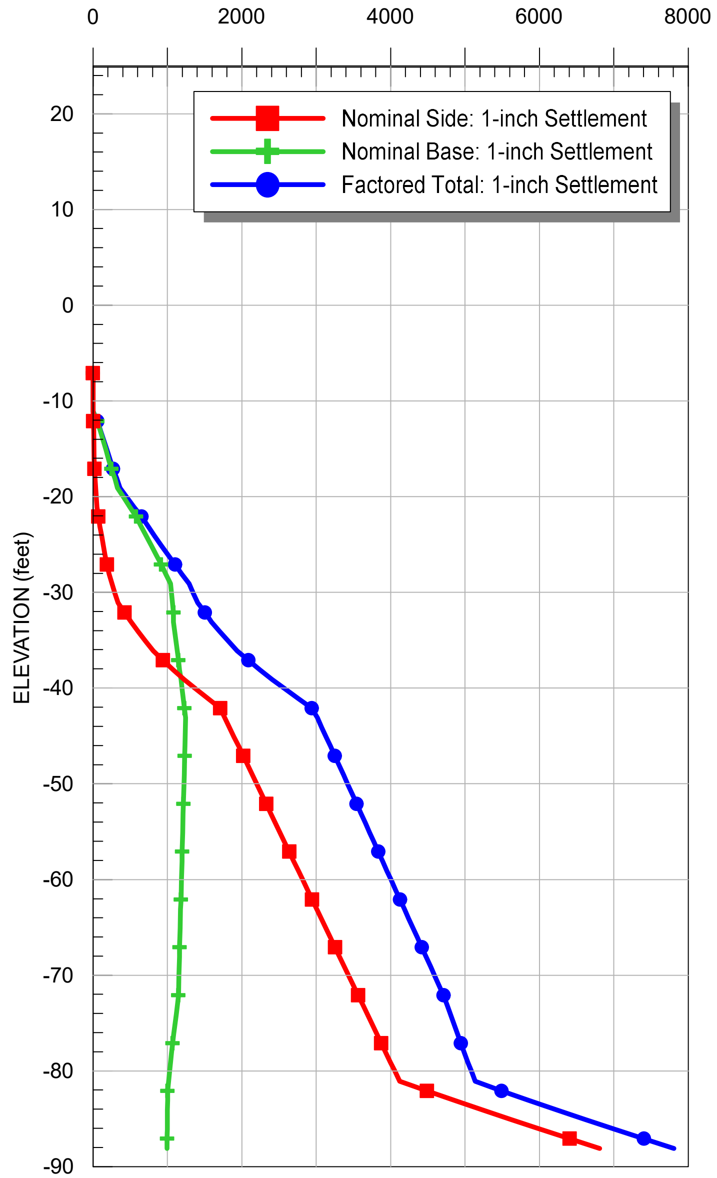
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 118+00 TO 121+00 (Boring BX-103) NOMINAL AXIAL SHAFT CAPACITIES 8-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 3A PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



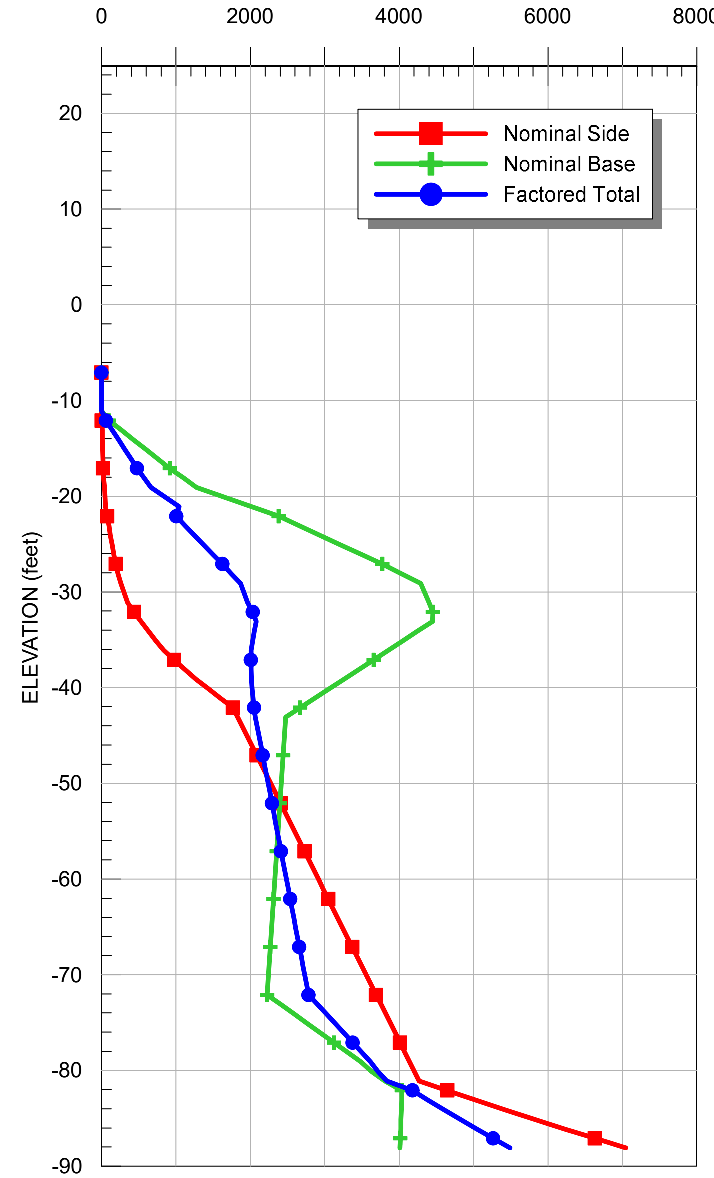
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

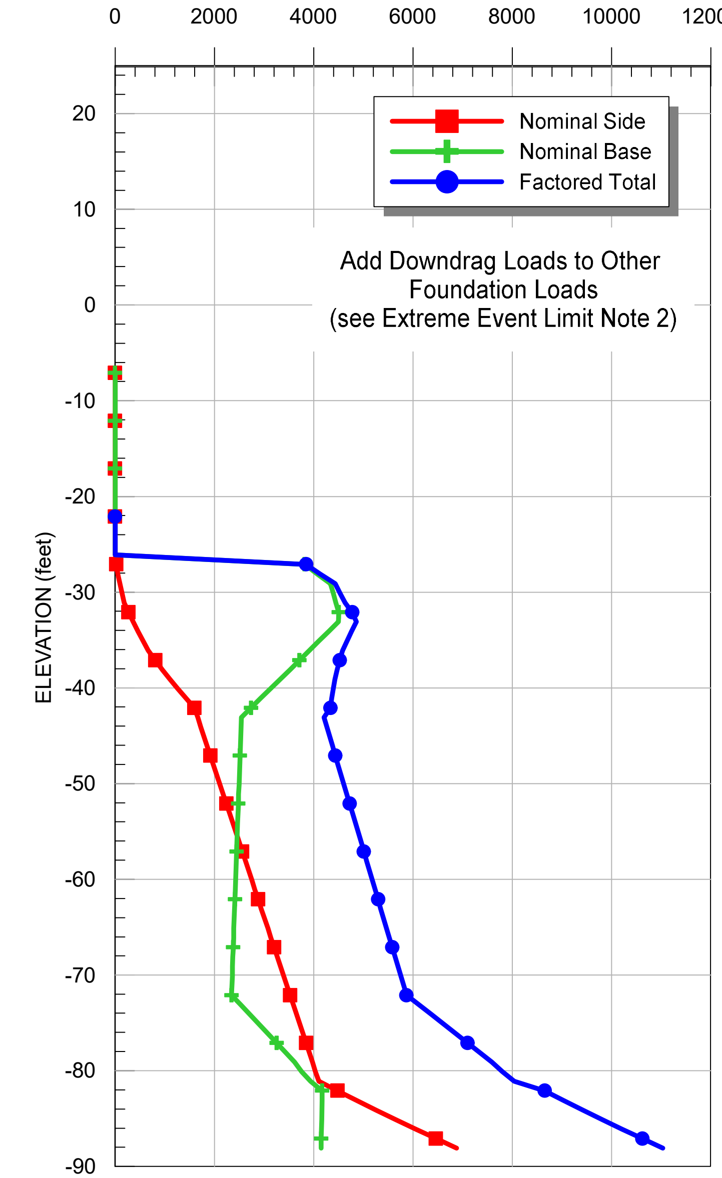
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Unfactored static downdrag force, due to liquefaction-induced settlement, for each shaft is estimated to be **140 kips**. A load factor of 1.05 should be applied to all downdrag loads (Allen, 2005) to determine factored downdrag force.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

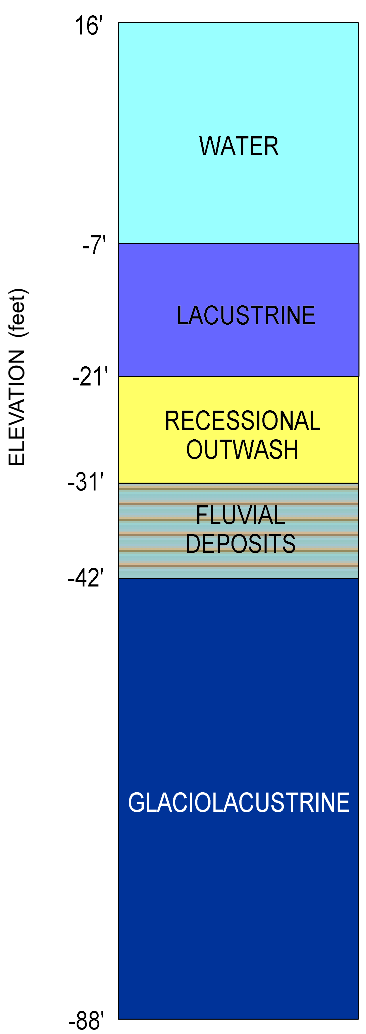
HWA GEOSCIENCES INC.

BALLARD BRIDGE
BRIDGE REHAB
SEATTLE, WASHINGTON

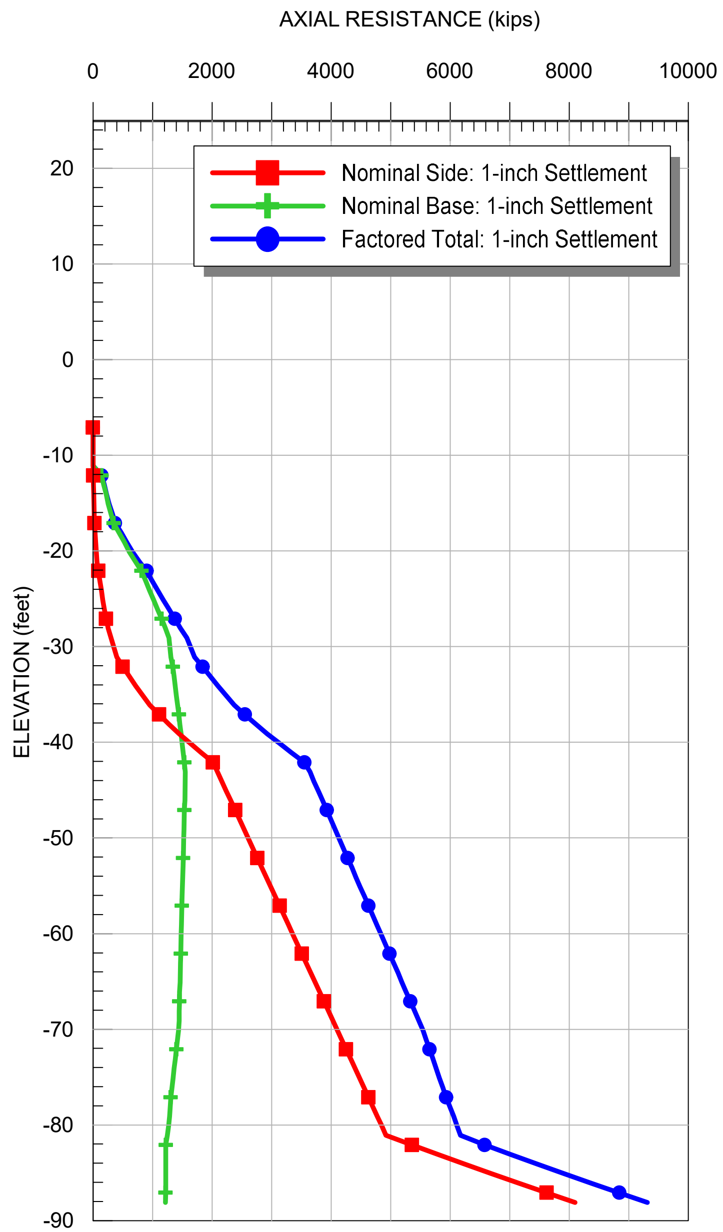
STATION 118+00 TO 121+00
(Boring BX-103)
NOMINAL AXIAL
SHAFT CAPACITIES
10-FOOT DIAMETER SHAFT

DRAWN BY SKS	FIGURE NO. 3B
CHECKED BY DJH	PROJECT NO. 2019-085-21
DATE 07.19.19	

ASSUMED SUBSURFACE PROFILE



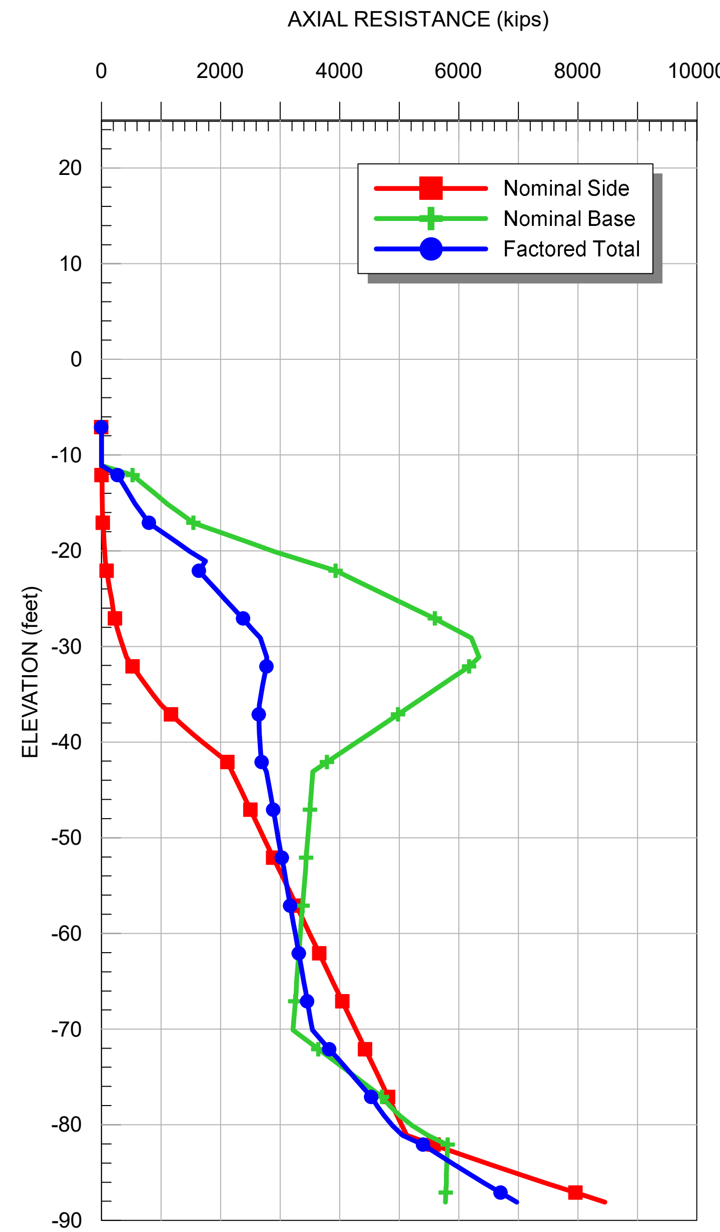
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

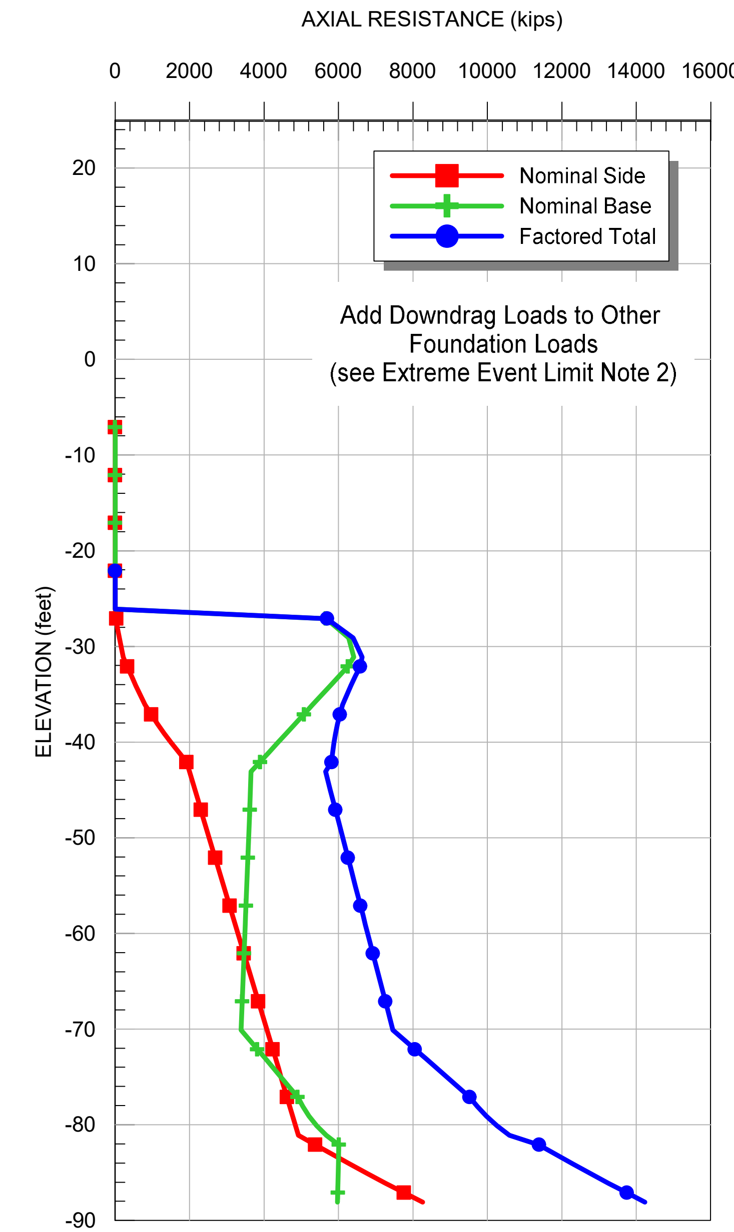
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

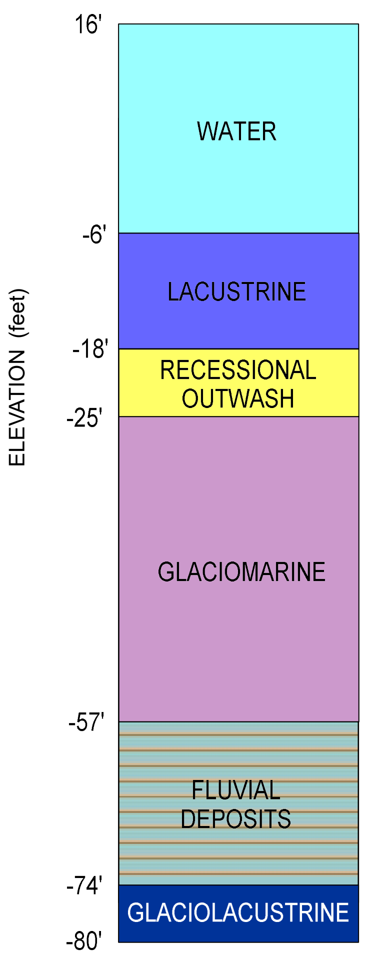
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Unfactored static downdrag force, due to liquefaction-induced settlement, for each shaft is estimated to be **170 kips**. A load factor of 1.05 should be applied to all downdrag loads (Allen, 2005) to determine factored downdrag force.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

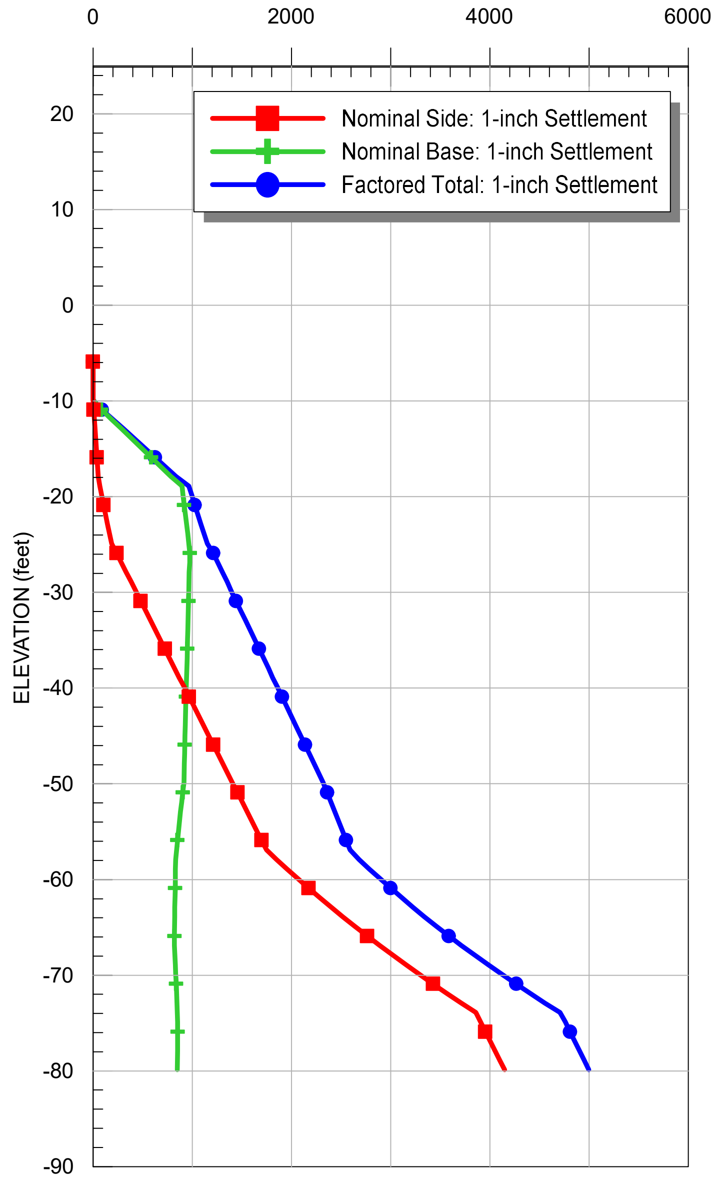
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 118+00 TO 121+00 (Boring BX-103) NOMINAL AXIAL SHAFT CAPACITIES 12-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 3C PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



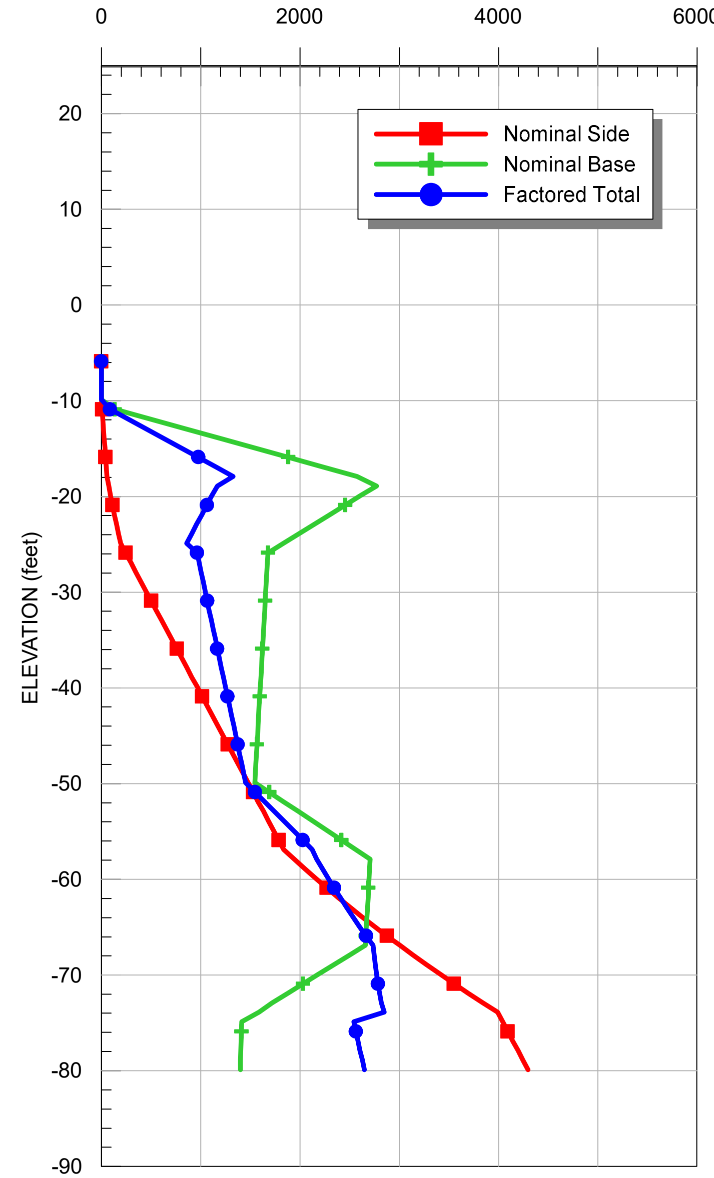
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

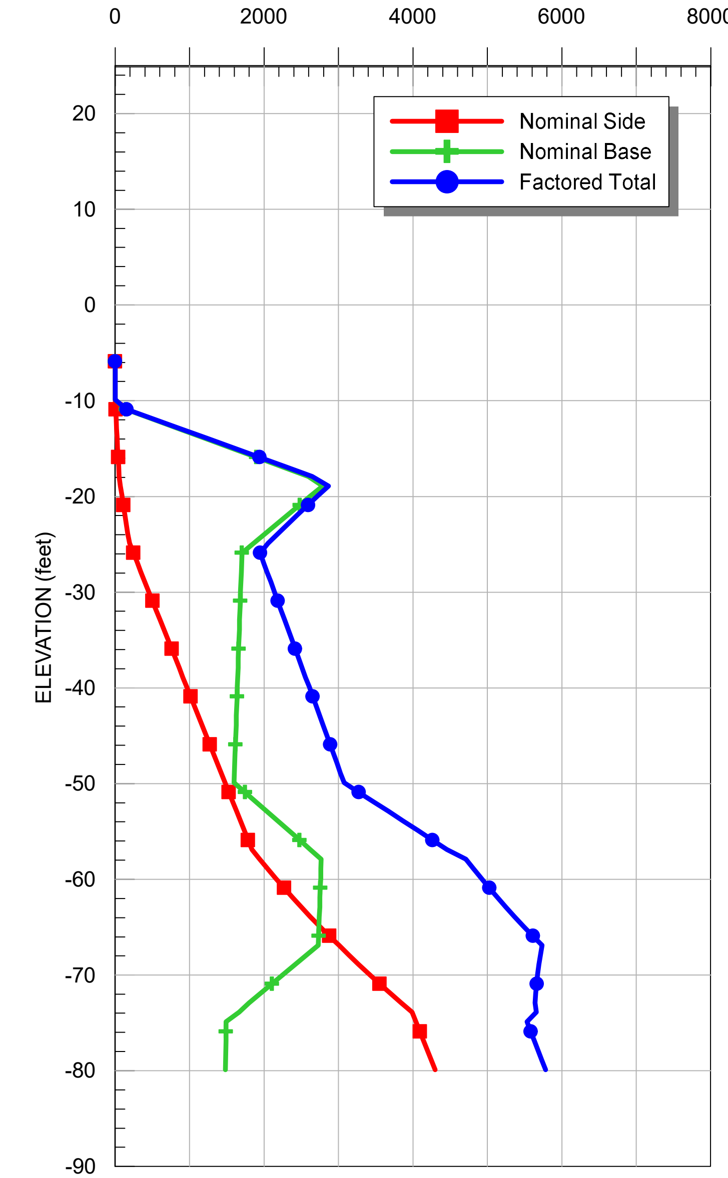
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

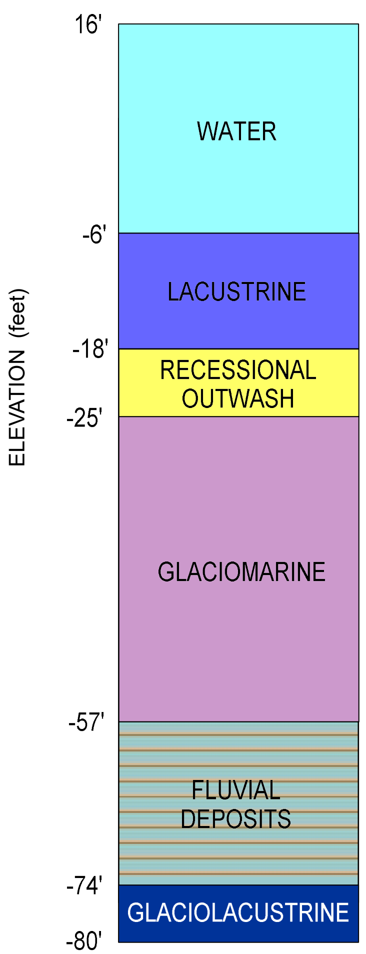
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

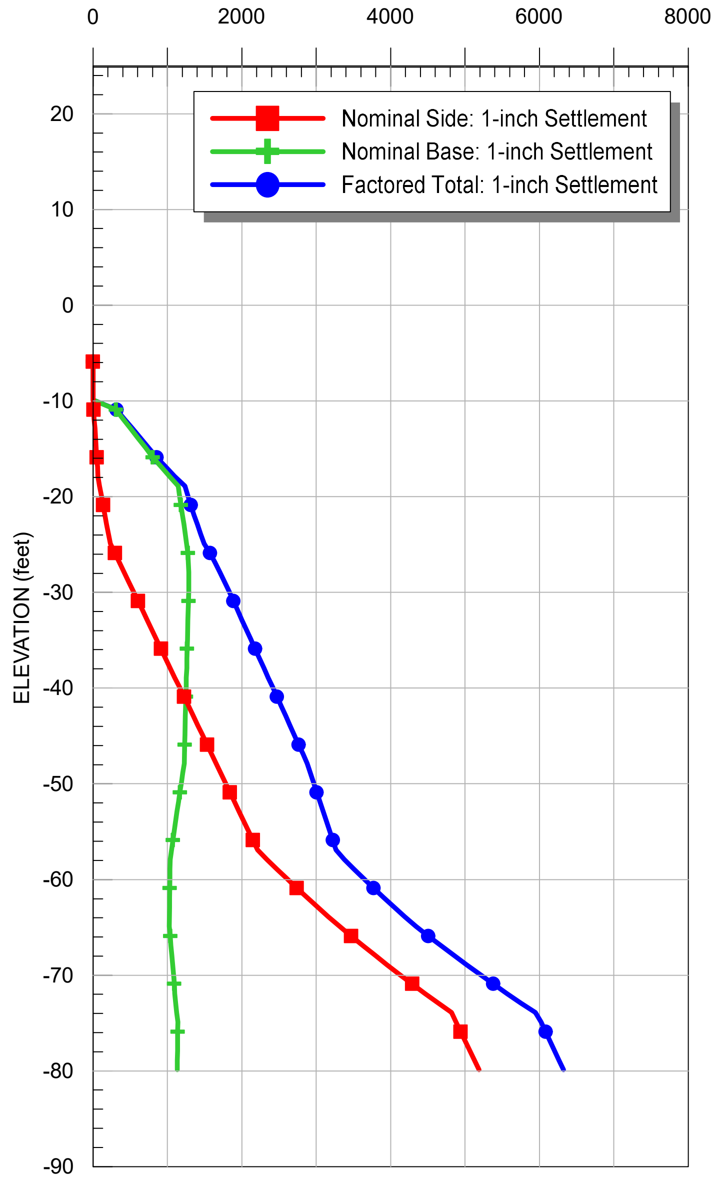
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 121+00 TO 124+00 (Boring BX-104) NOMINAL AXIAL SHAFT CAPACITIES 8-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 4A PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



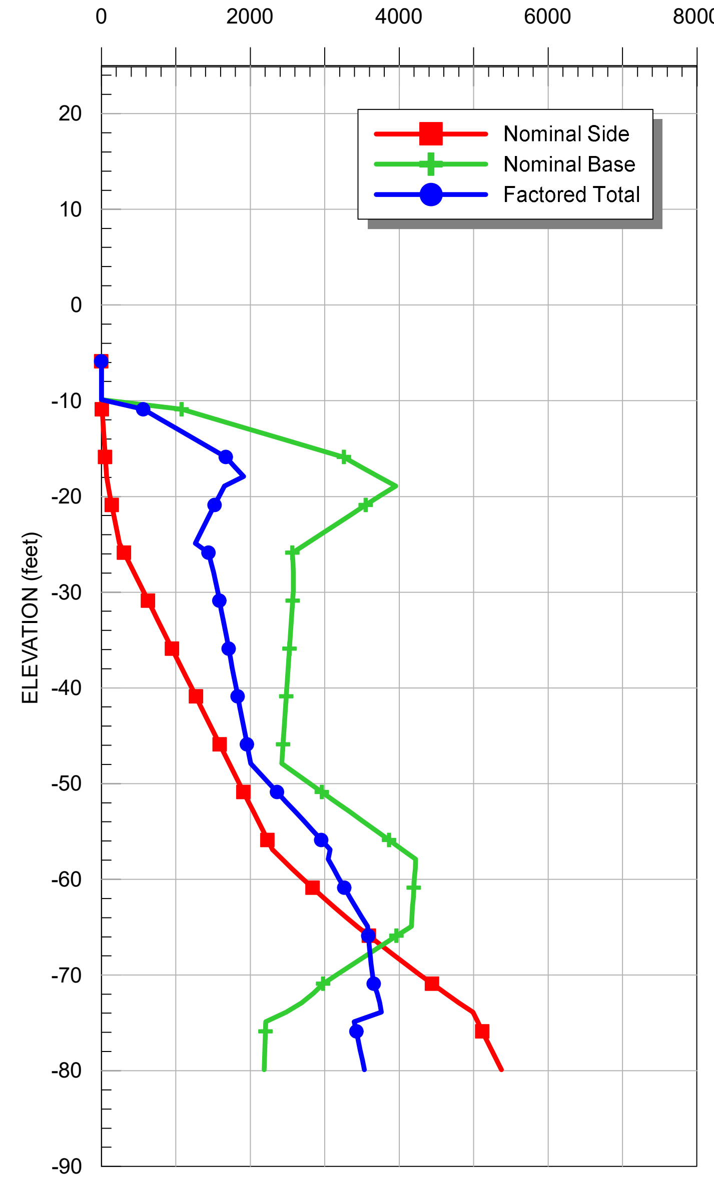
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

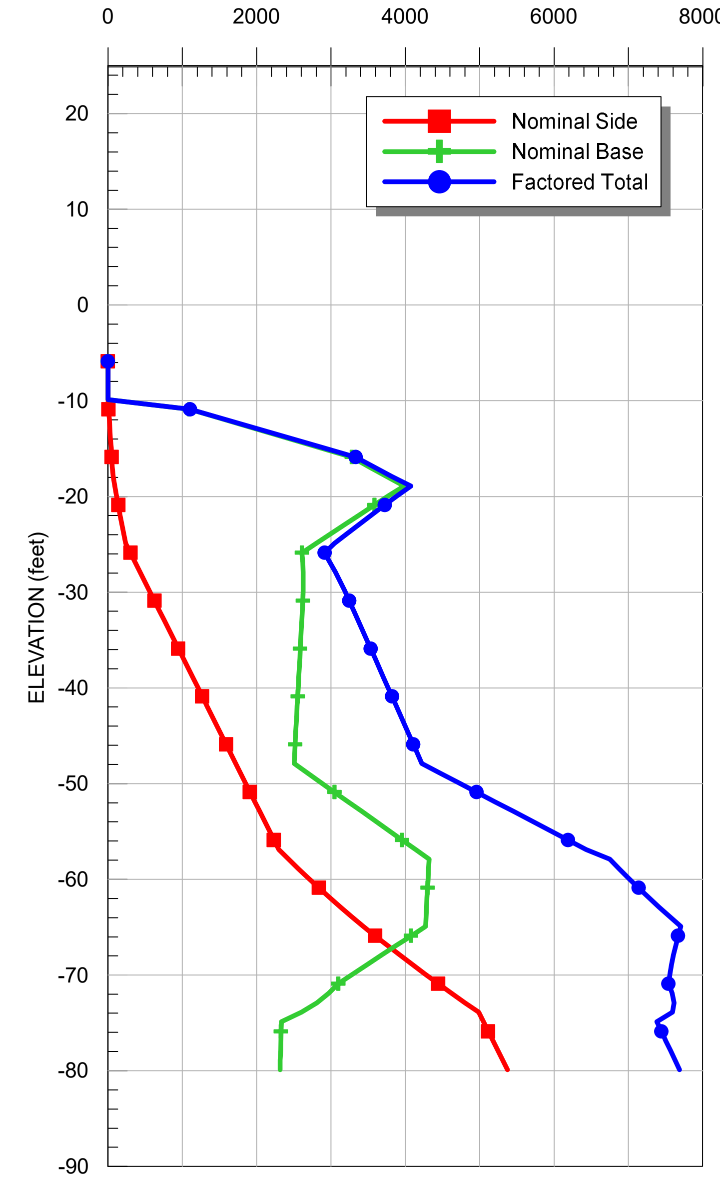
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

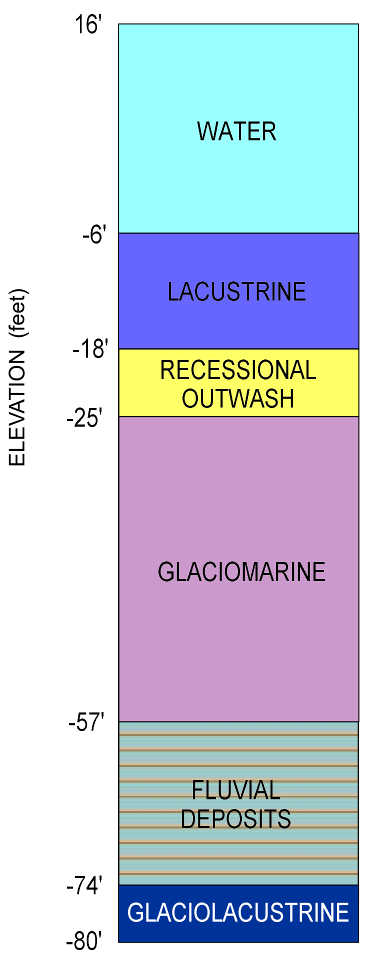
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

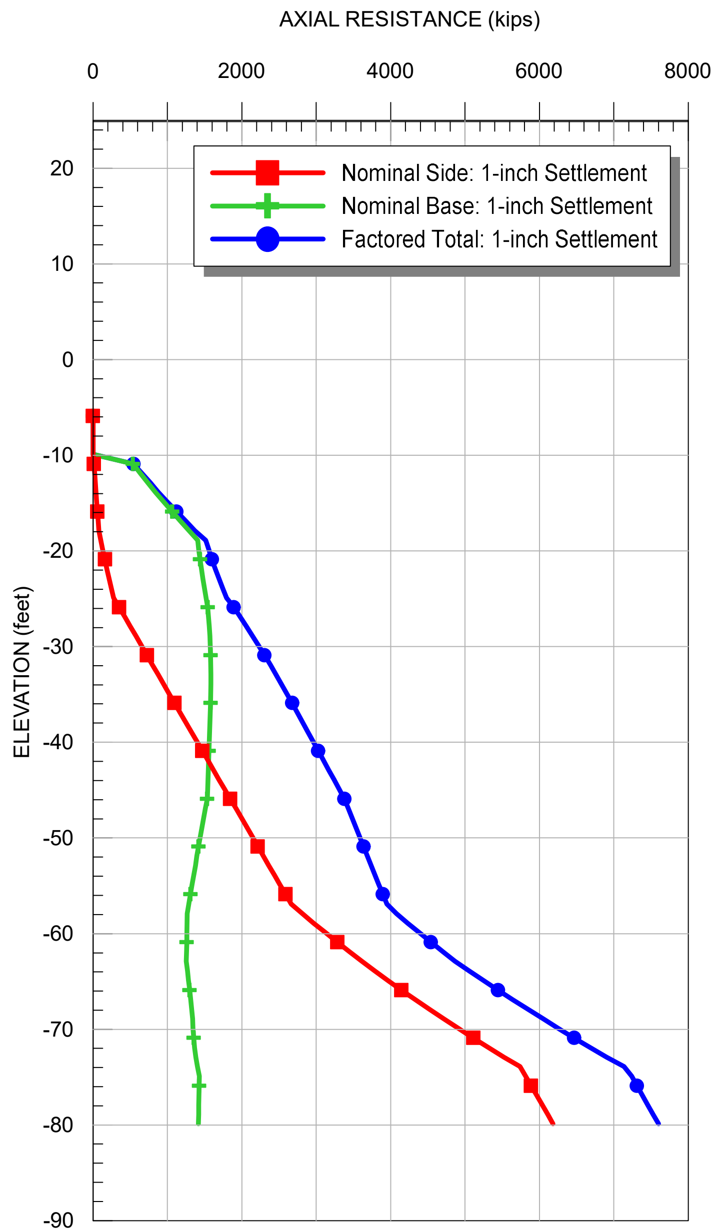
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 121+00 TO 124+00 (Boring BX-104) NOMINAL AXIAL SHAFT CAPACITIES 10-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 4B PROJECT NO. 2019-085-21

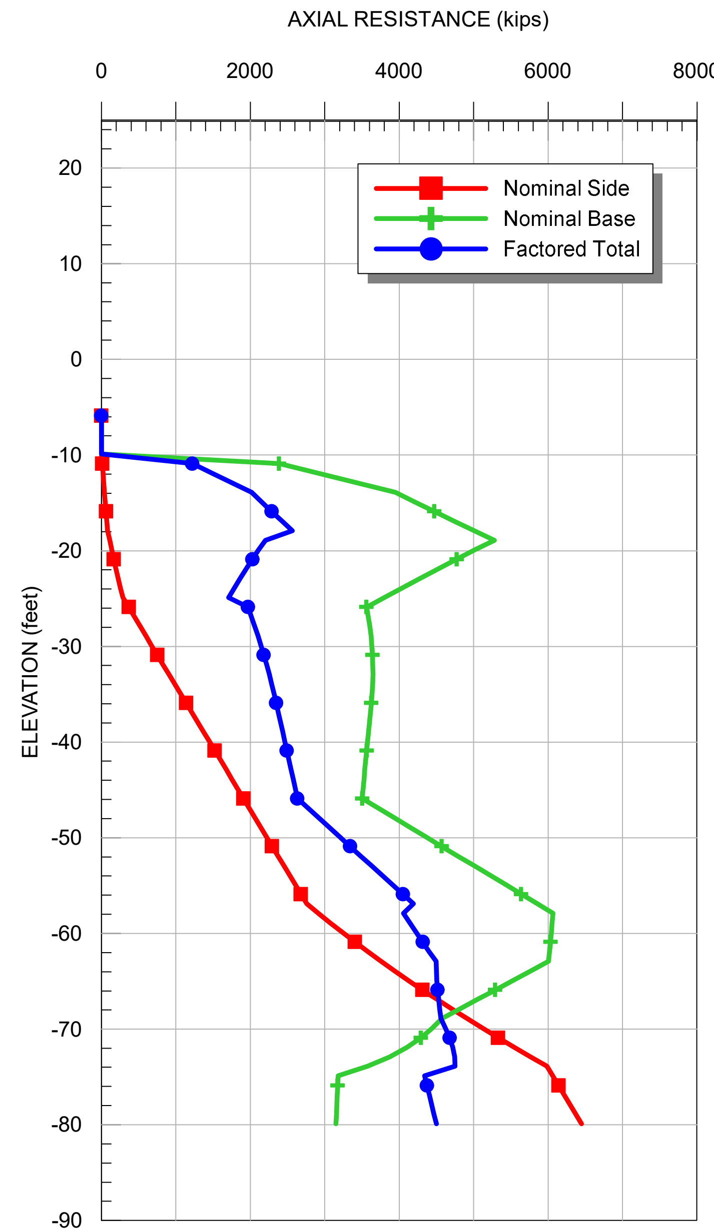
ASSUMED SUBSURFACE PROFILE



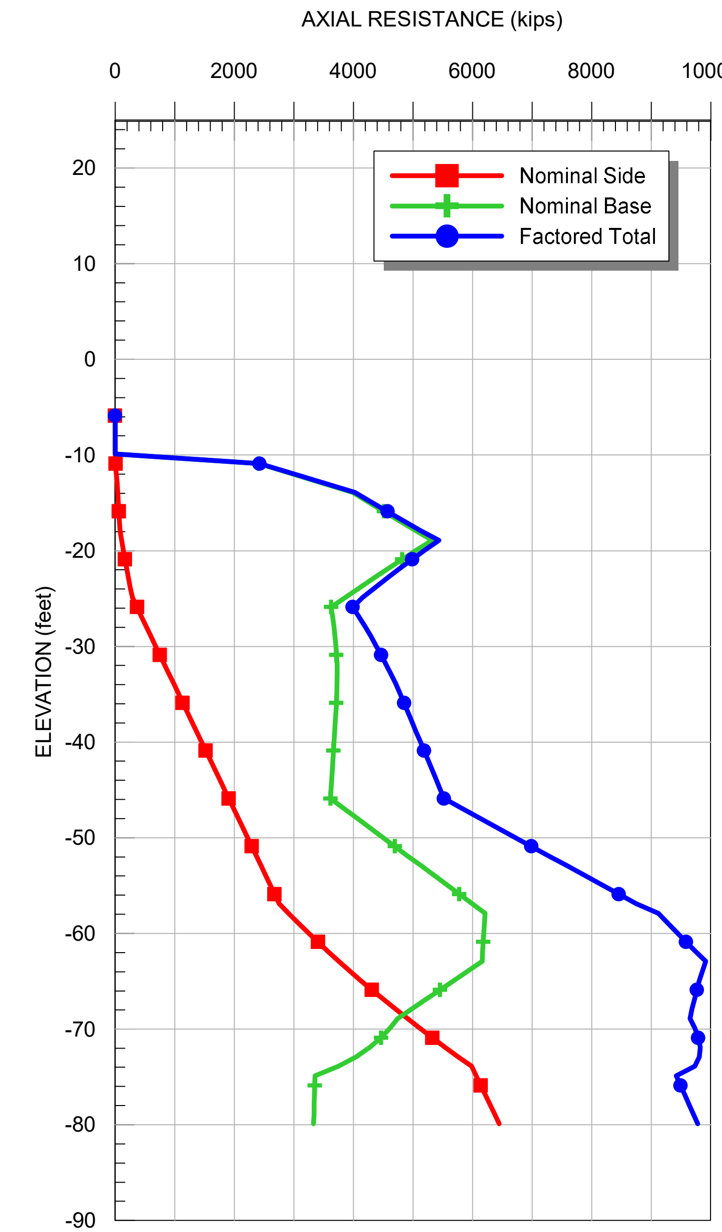
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT NOTES:

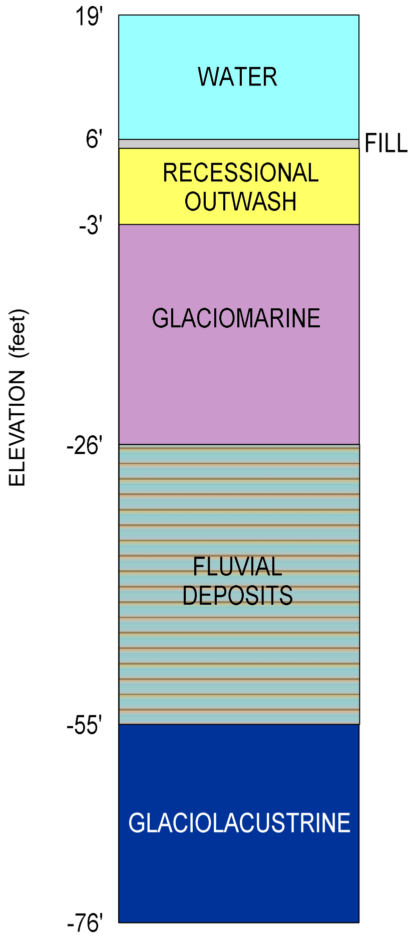
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

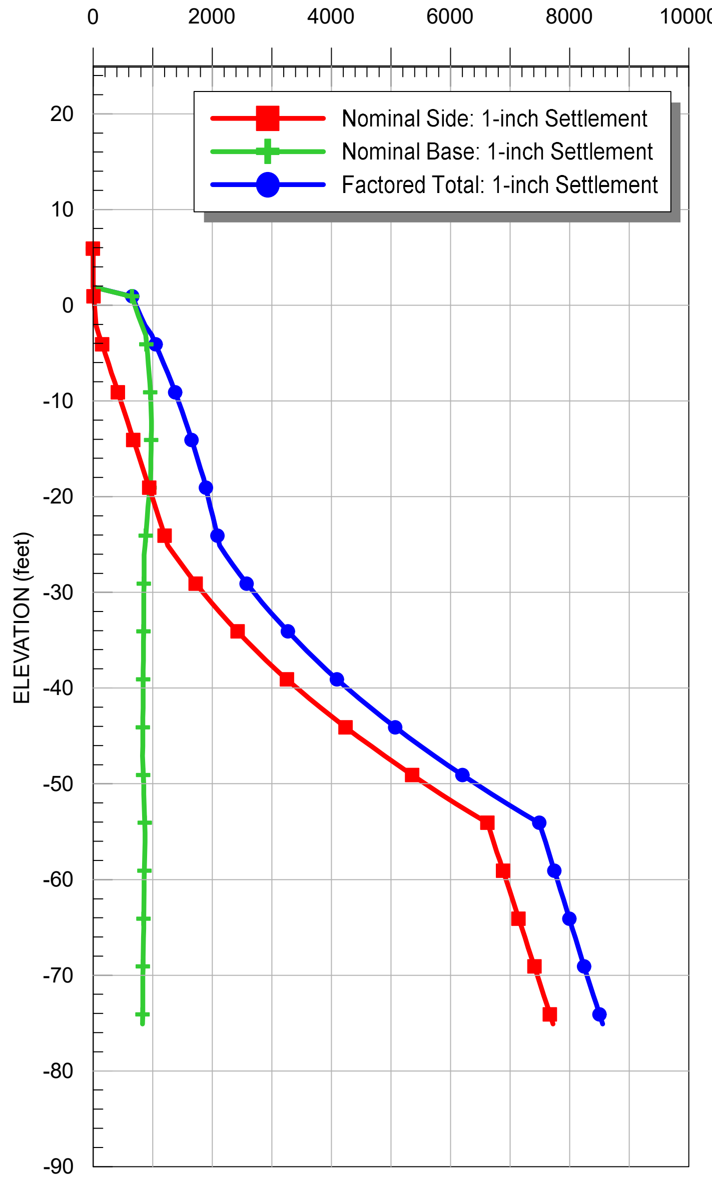
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	STATION 121+00 TO 124+00 (Boring BX-104) NOMINAL AXIAL SHAFT CAPACITIES 12-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 4C PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



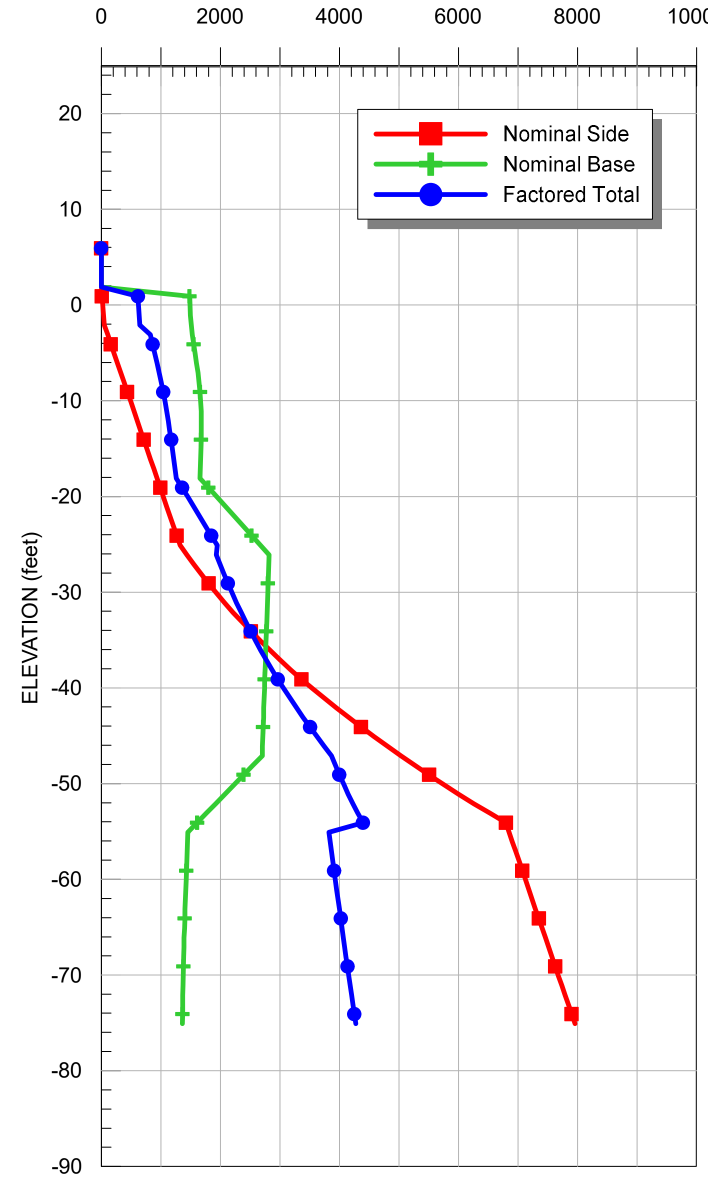
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

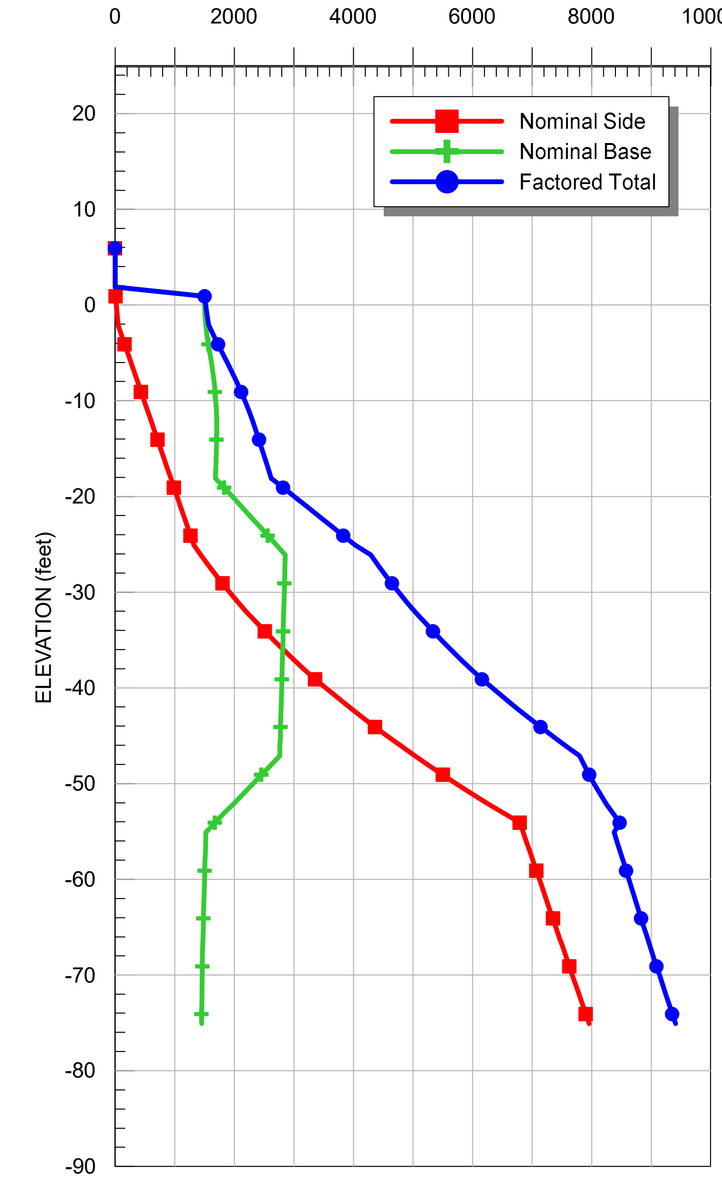
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

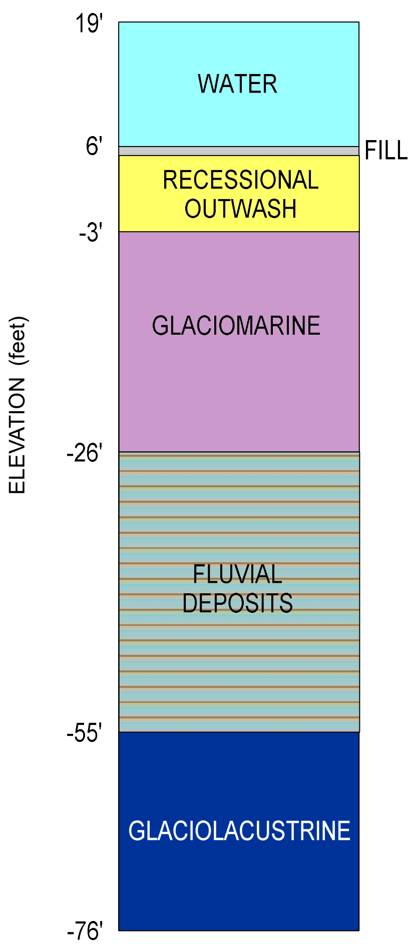
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

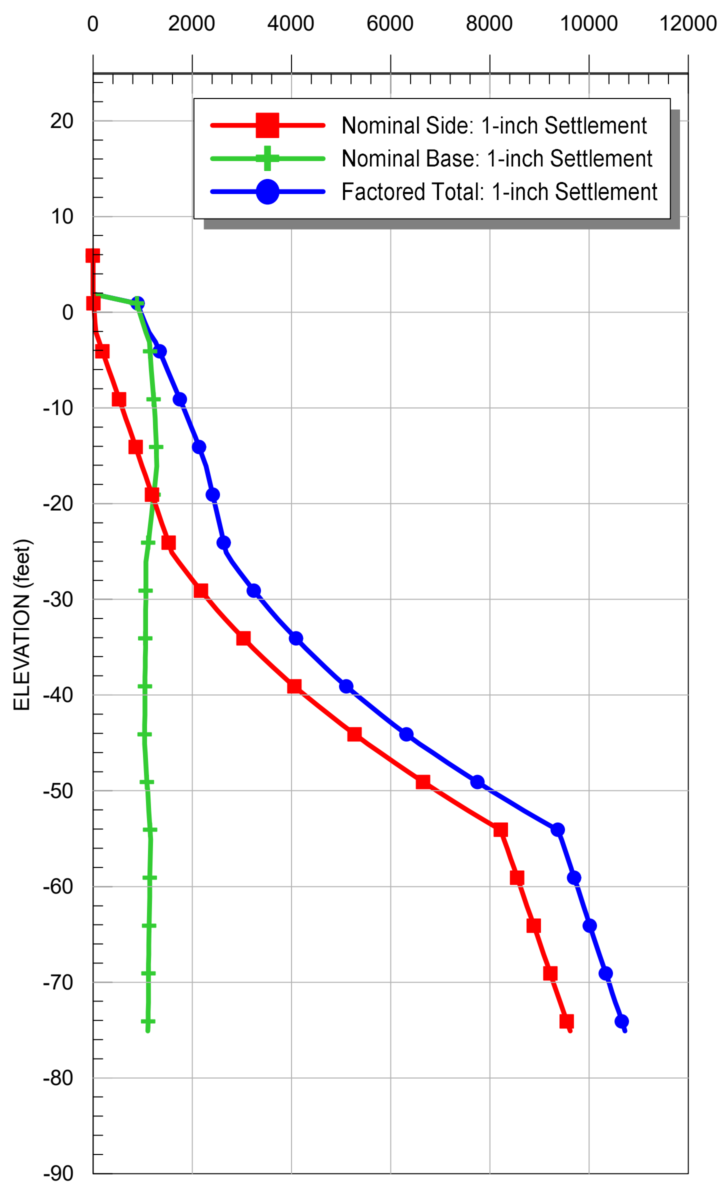
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	SOUTH BASCULE PIER AND STATION 124+00 TO 129+00 (Boring BX-106 & BX-105) NOMINAL AXIAL SHAFT CAPACITIES 8-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 5A PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



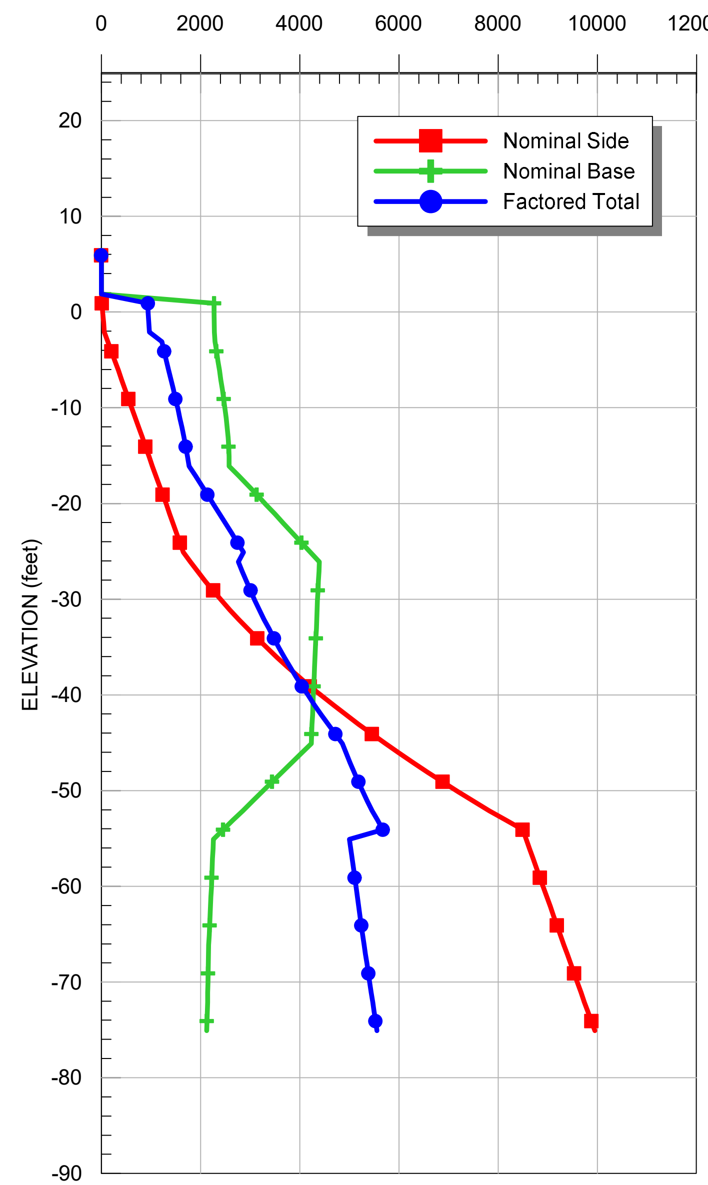
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

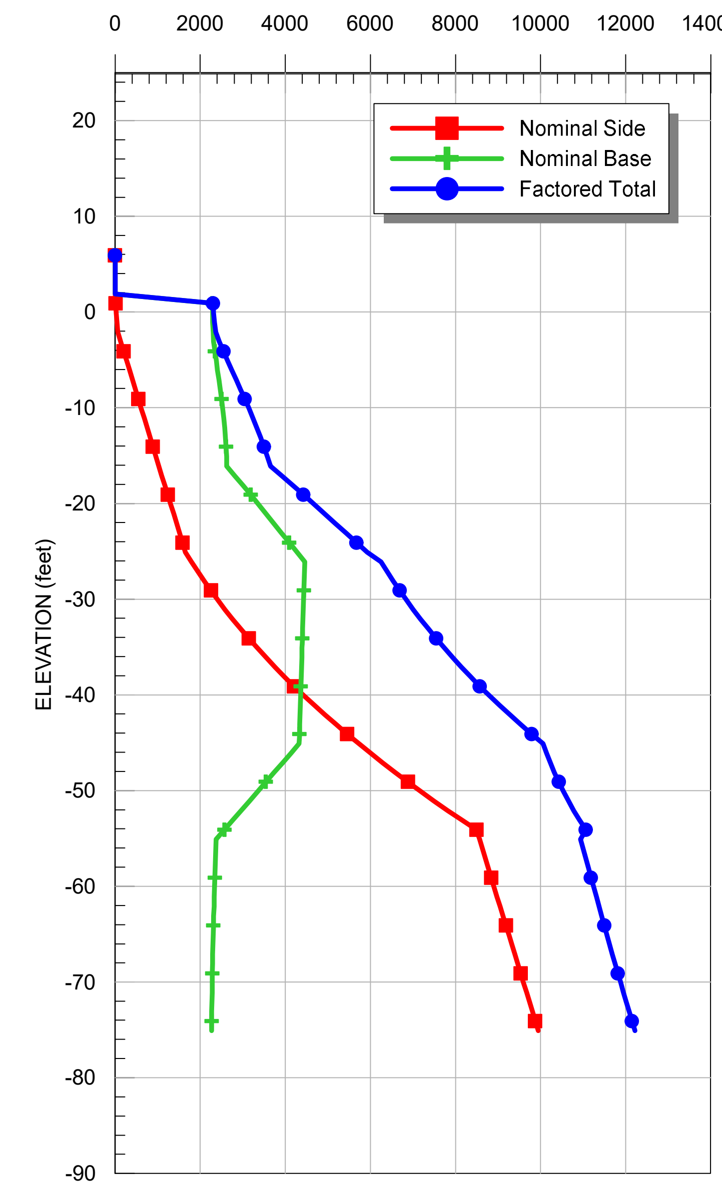
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

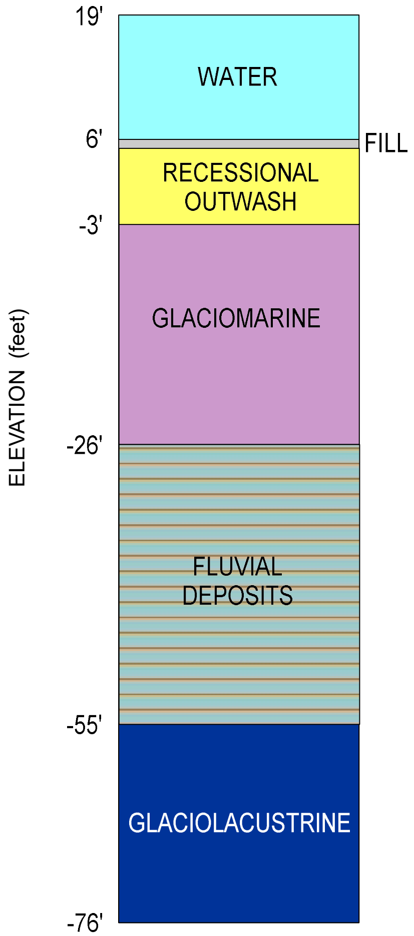
HWA GEOSCIENCES INC.

BALLARD BRIDGE
BRIDGE REHAB
SEATTLE, WASHINGTON

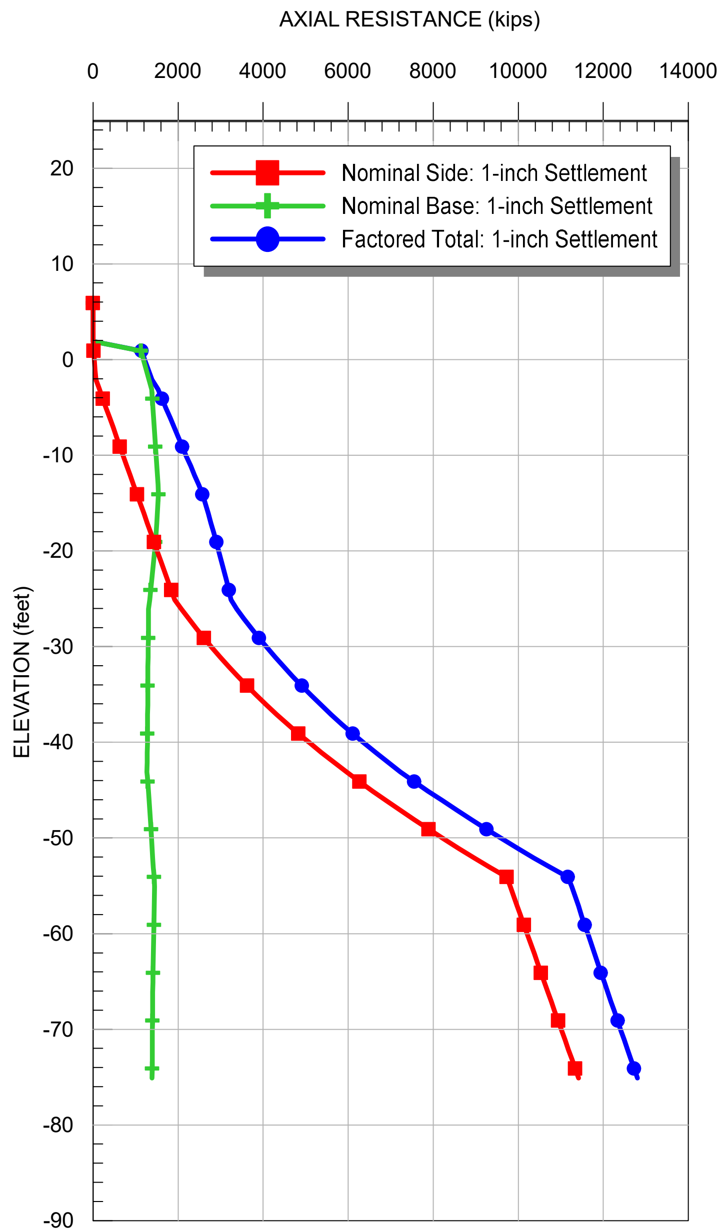
SOUTH BASCULE PIER AND STATION 124+00 TO 129+00
(Boring BX-106 & BX-105)
NOMINAL AXIAL SHAFT CAPACITIES
10-FOOT DIAMETER SHAFT

DRAWN BY SKS	FIGURE NO. 5B
CHECKED BY DJH	PROJECT NO. 2019-085-21
DATE 07.19.19	

ASSUMED SUBSURFACE PROFILE



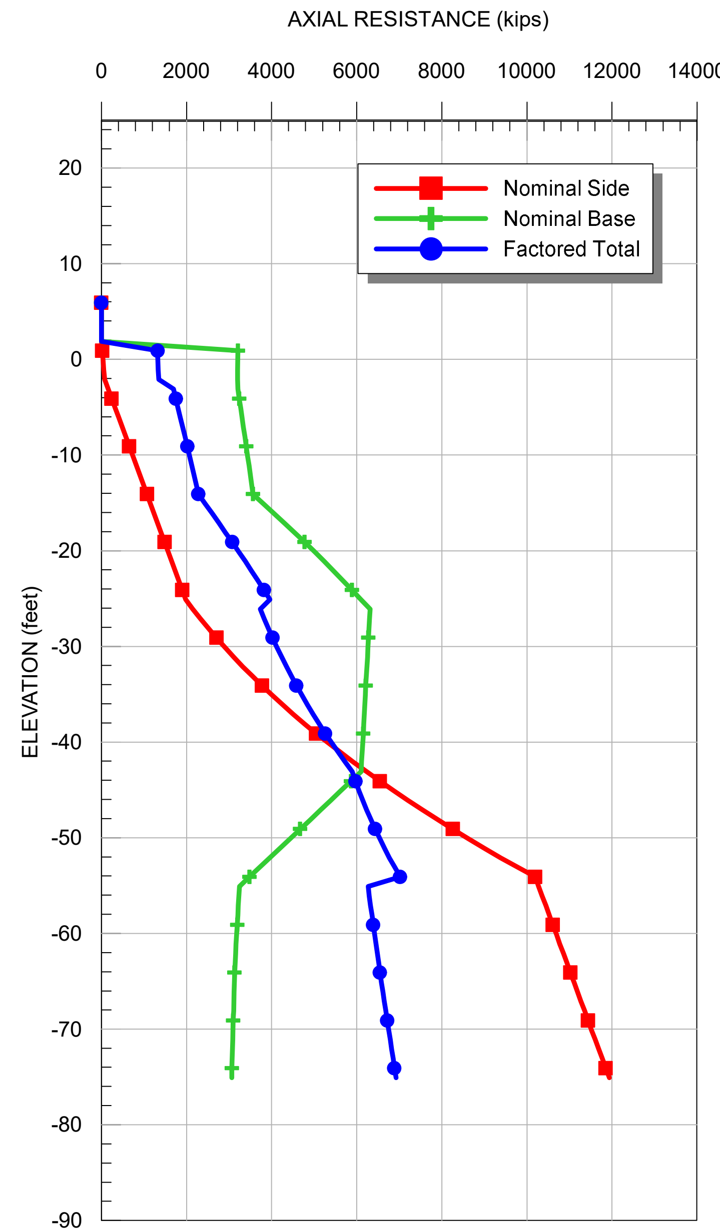
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

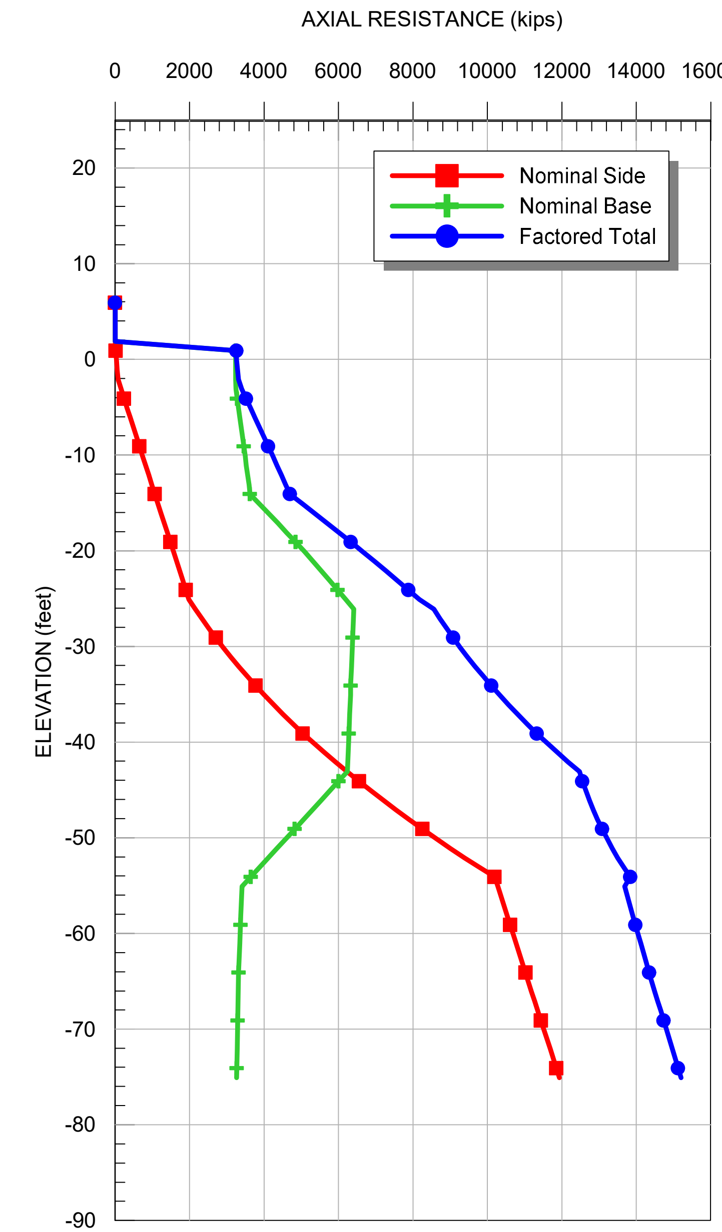
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

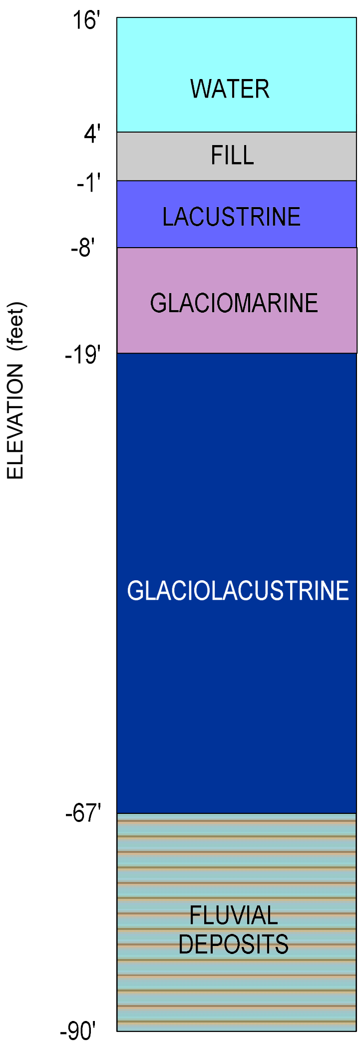
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

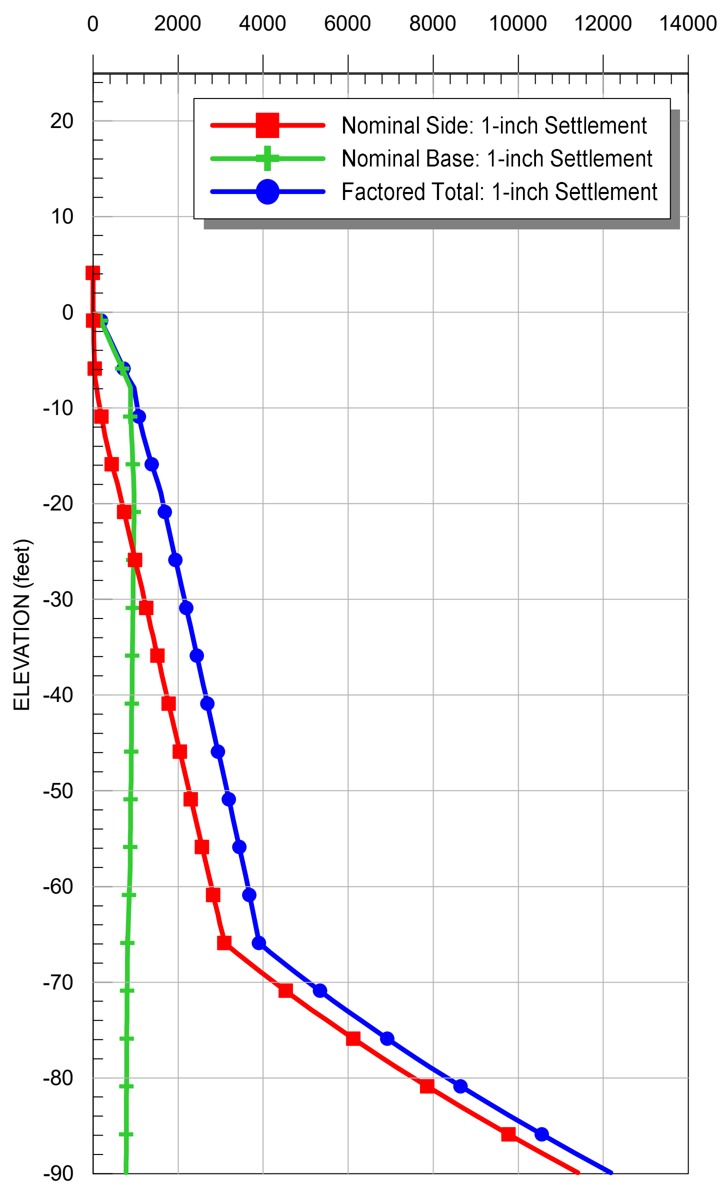
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	SOUTH BASCULE PIER AND STATION 124+00 TO 129+00 (Boring BX-106 & BX-105) NOMINAL AXIAL SHAFT CAPACITIES 12-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 5C PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



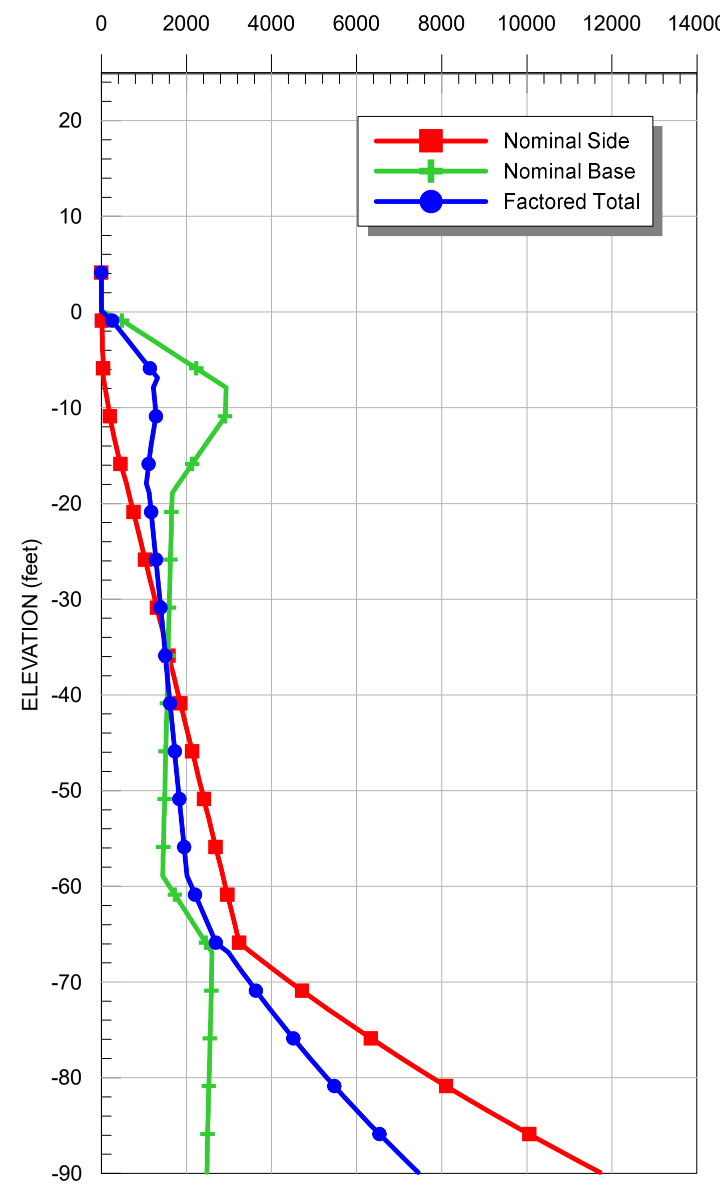
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

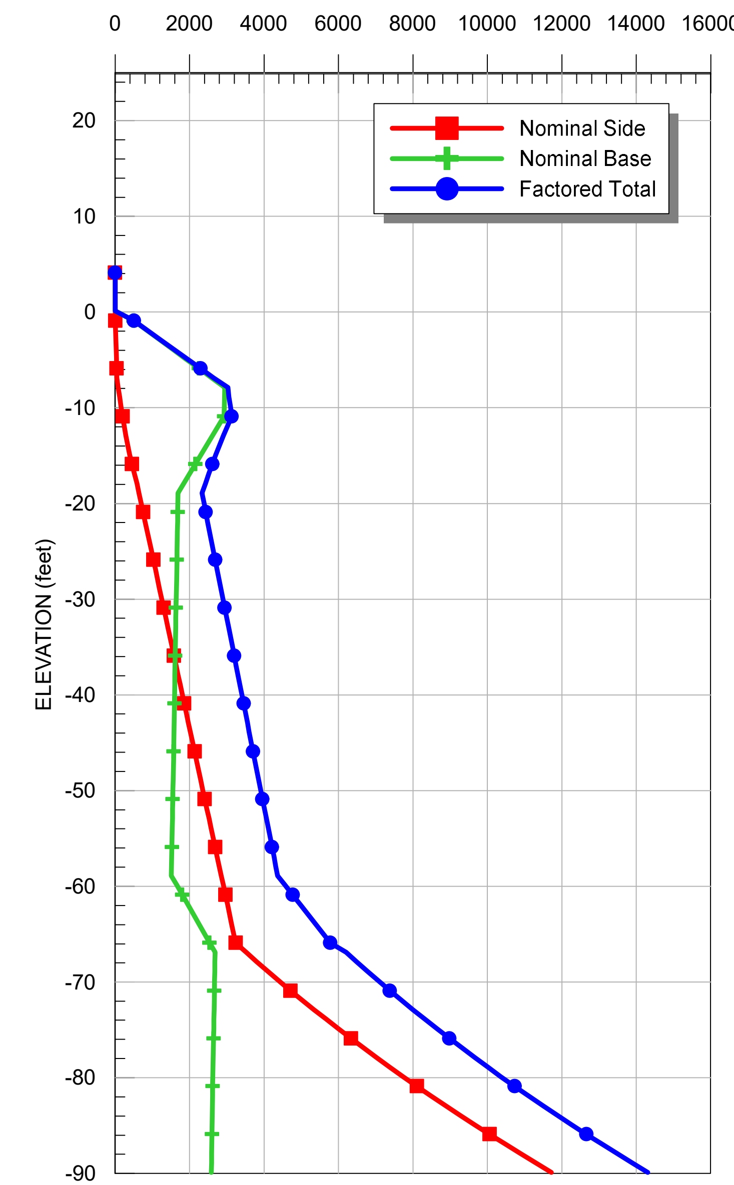
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.
5. Additional subsurface data is available extending to a depth of approximately 219 feet below mud line.

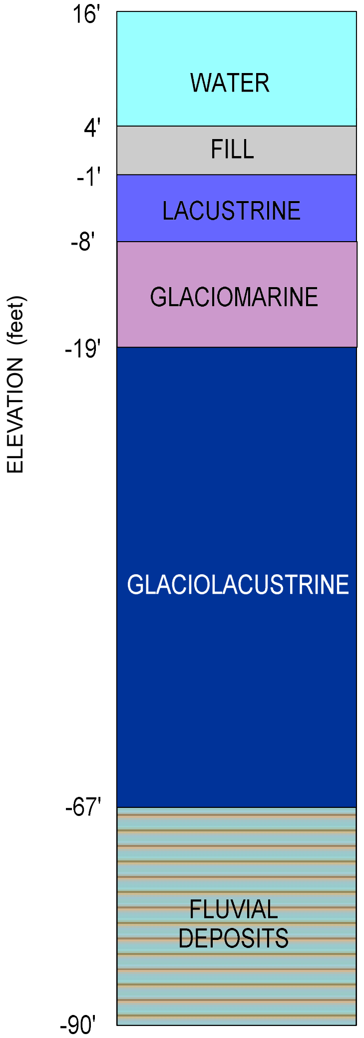
HWA GEOSCIENCES INC.

BALLARD BRIDGE
BRIDGE REHAB
SEATTLE, WASHINGTON

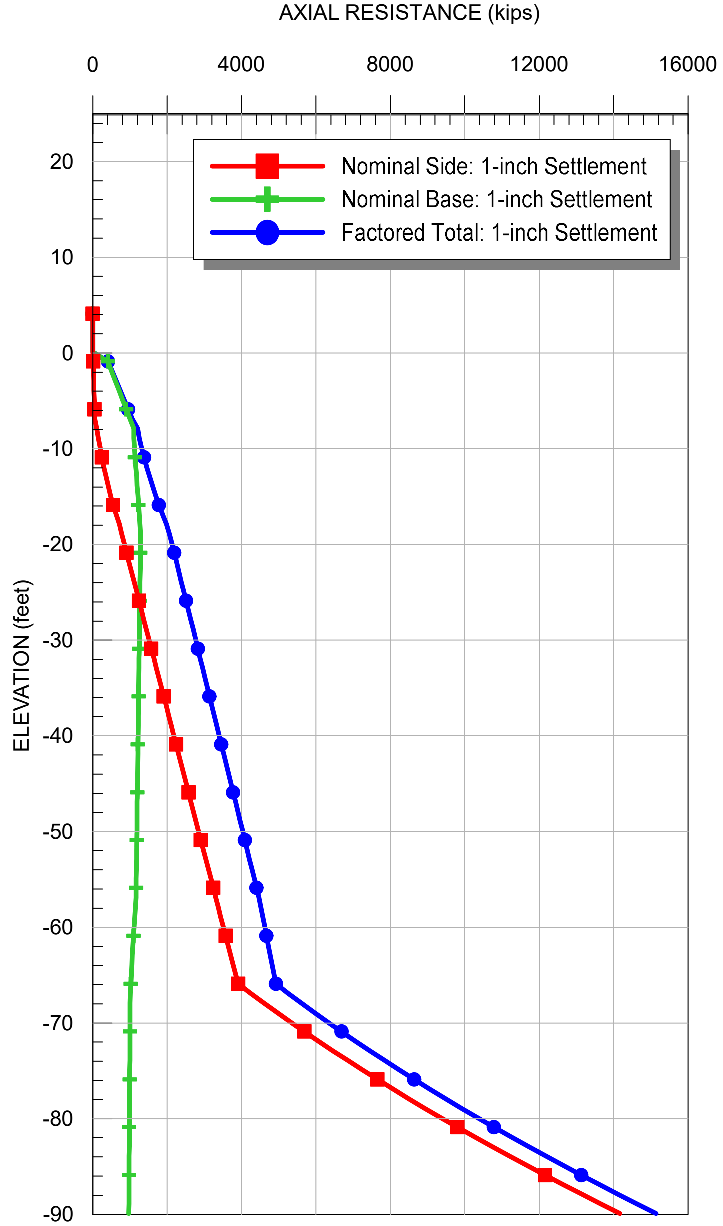
NORTH BASCULE PIER AND
STATION 129+00 TO 132+00
(Boring BX-107)
NOMINAL AXIAL
SHAFT CAPACITIES
8-FOOT DIAMETER SHAFT

DRAWN BY SKS
CHECKED BY DJH
DATE 07.19.19
FIGURE NO. 6A
PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



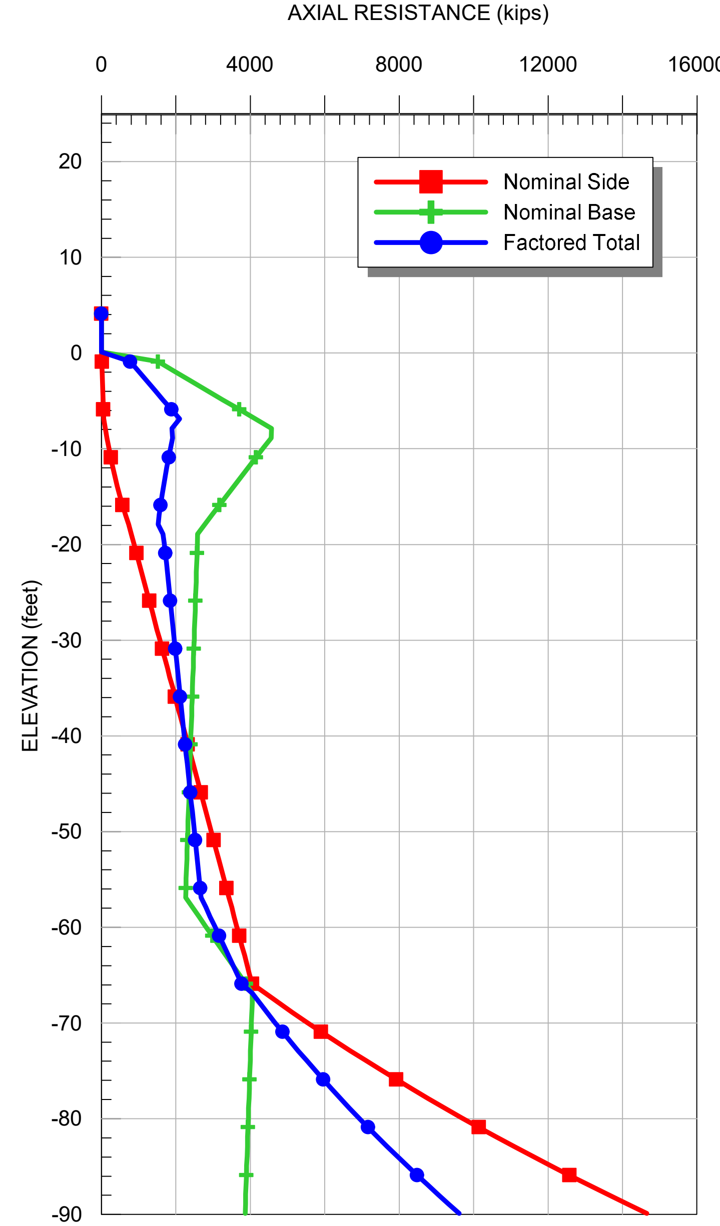
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

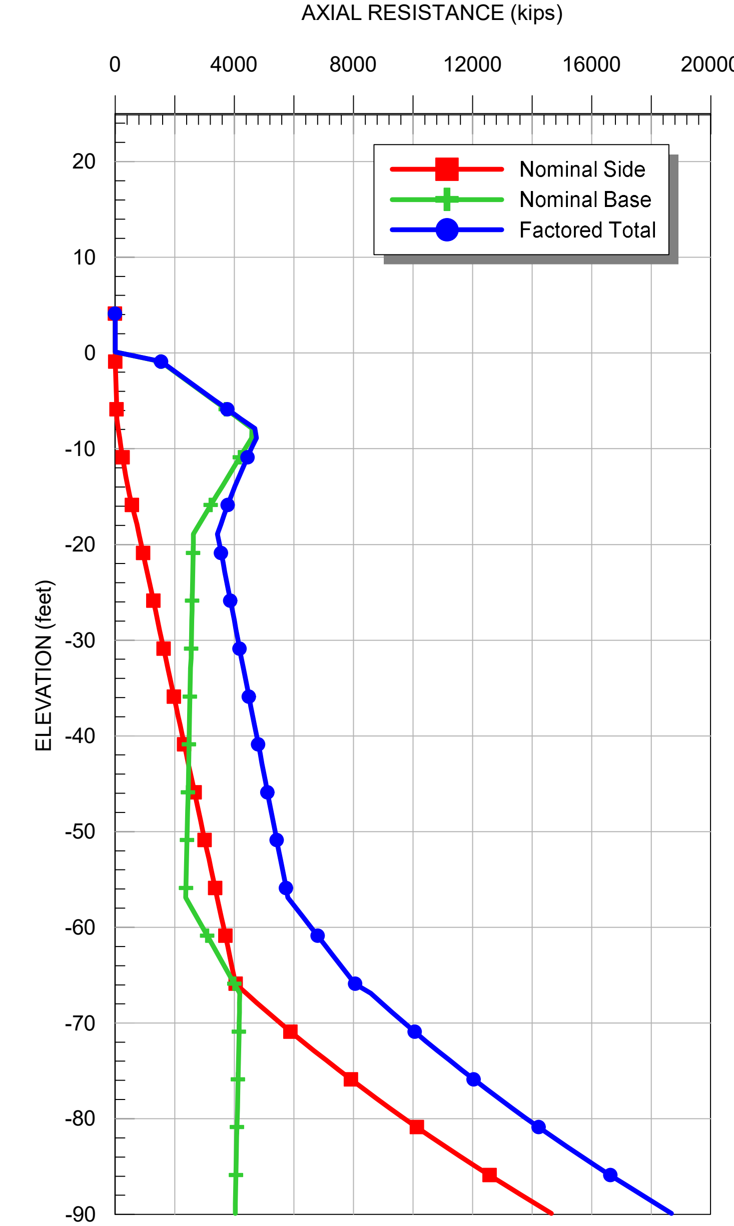
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

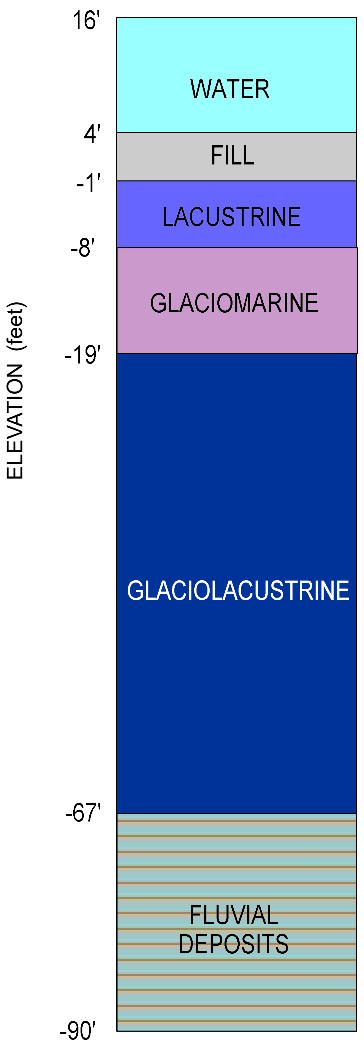
1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

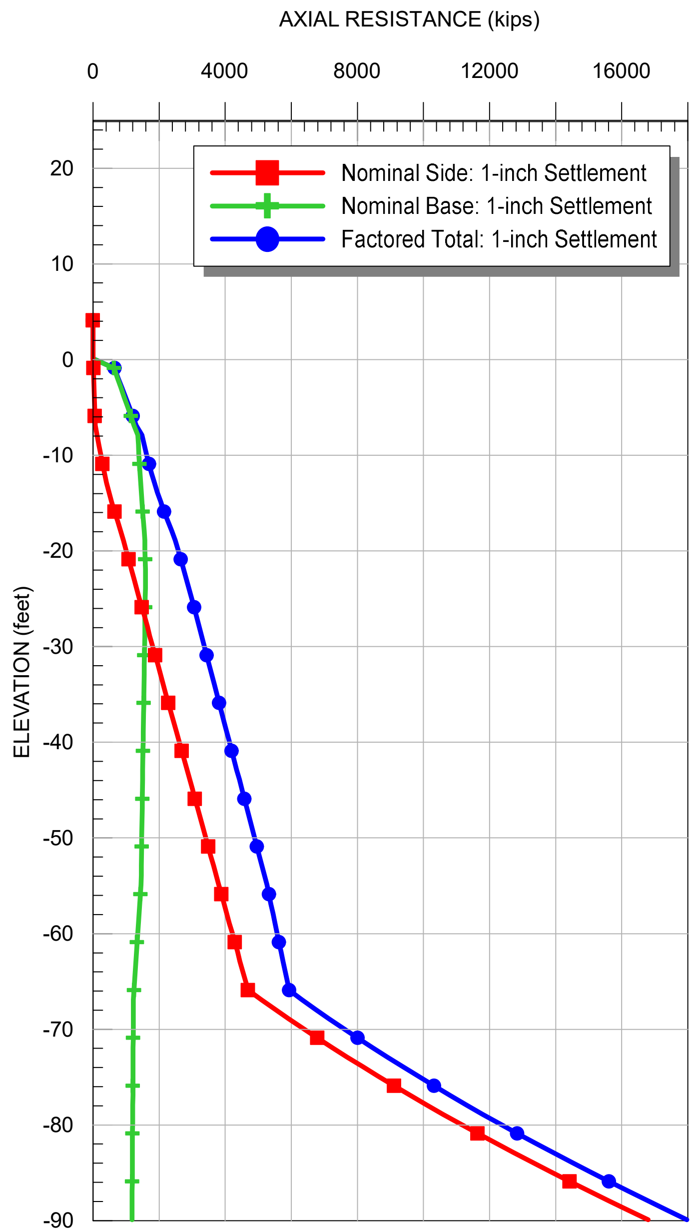
1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.
5. Additional subsurface data is available extending to a depth of approximately 219 feet below mud line.

HWA GEOSCIENCES INC.	BALLARD BRIDGE BRIDGE REHAB SEATTLE, WASHINGTON	NORTH BASCULE PIER AND STATION 129+00 TO 132+00 (Boring BX-107) NOMINAL AXIAL SHAFT CAPACITIES 10-FOOT DIAMETER SHAFT	DRAWN BY SKS CHECKED BY DJH DATE 07.19.19	FIGURE NO. 6B PROJECT NO. 2019-085-21

ASSUMED SUBSURFACE PROFILE



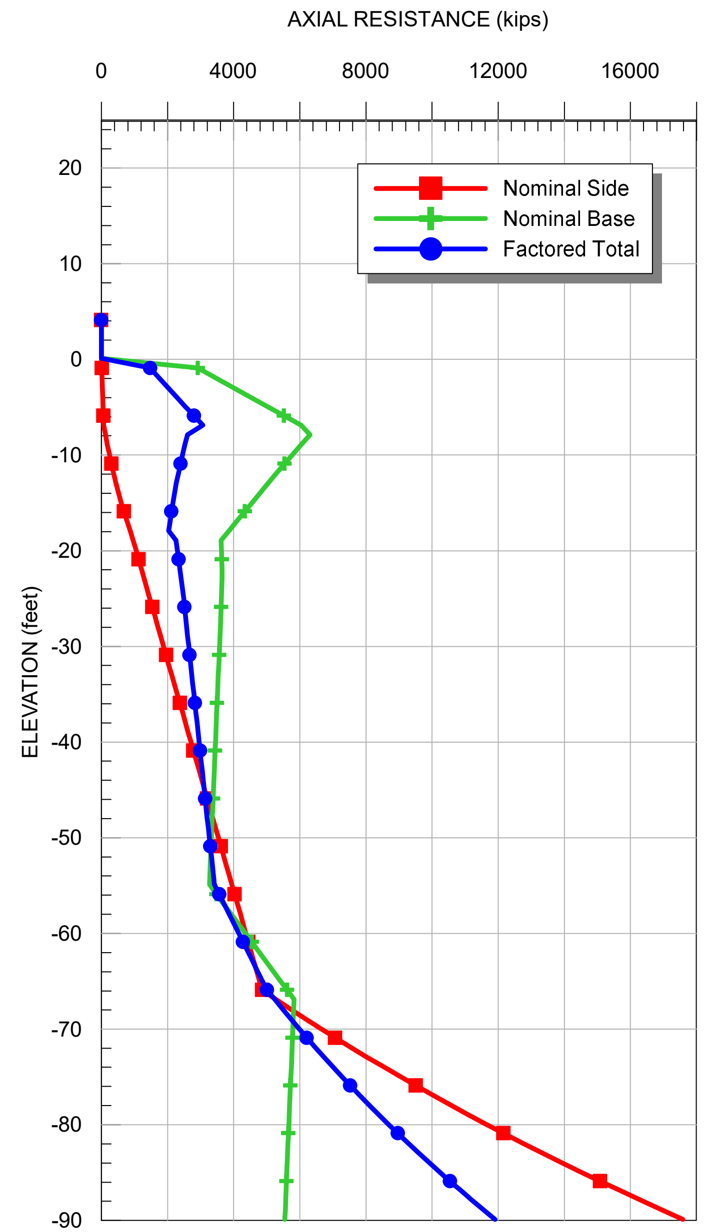
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification is 1.0 for side and base resistance.
2. Settlements is based on a single shaft. No group action is considered.
3. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

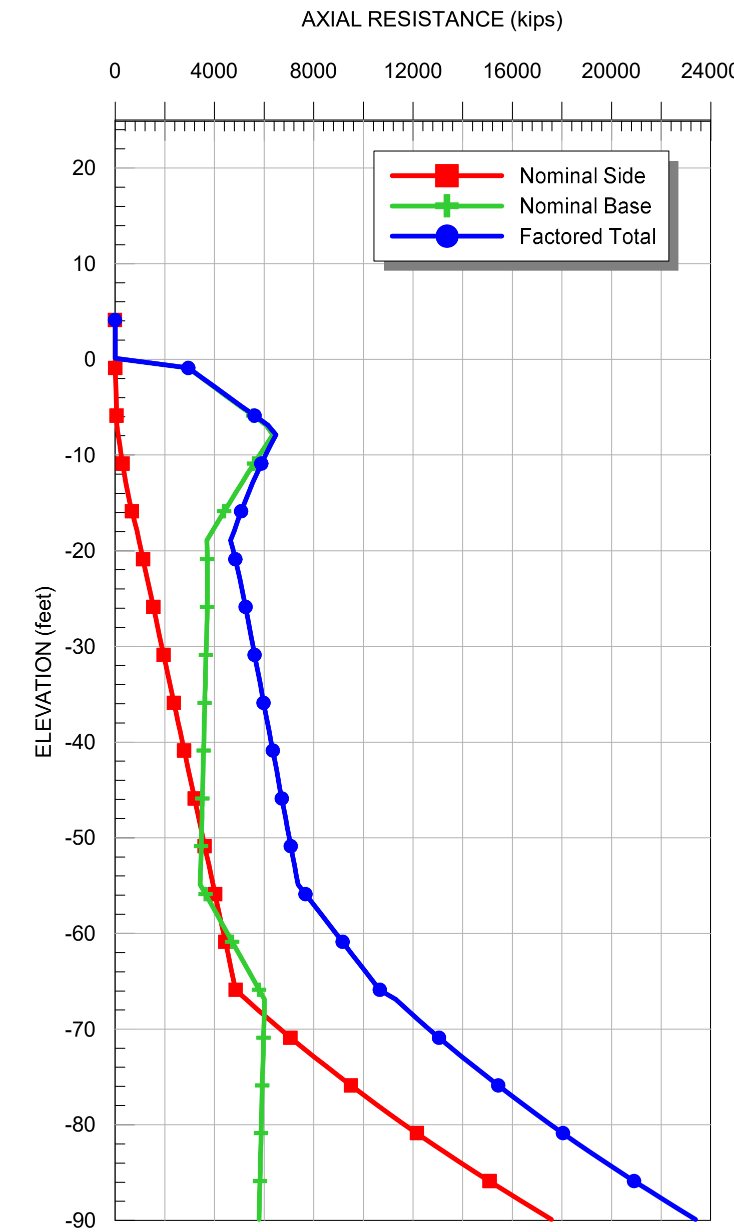
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Recommended resistance factors included in Factored Loads are 0.55 for cohesionless and 0.45 for cohesive for side resistance and 0.5 for cohesionless and 0.4 for cohesive for base resistance, as provided in AASHTO LRFD Bridge Design Specification.
2. Shaft uplift resistance can be estimated by using the nominal side resistance shown above and a recommended resistance factor of 0.35 (per AASHTO LRFD Bridge Design Specification).
3. Recommended load factor of 1.25 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

1. Recommended resistance factors per AASHTO LRFD Bridge Design Specification for both side and base resistance are 1.0 for compression and 0.8 for uplift.
2. Recommended load factor of 1.0 was applied to weight of shaft per AASHTO LRFD Bridge Design Specifications.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in the AASHTO LRFD Bridge Design Specification and local experience. The analyses are based on a single shaft and do not consider group action of closely spaced shafts.
2. Factored total shaft resistance shown on plots is determined by adding the shaft's nominal side and base resistances multiplied by the appropiate resistance factors as noted above.
3. Axial capacities shown are reduced to account for the weight of the shaft with appropiate load factors.
4. Shaft capacities in the upper 5 feet was neglected due to the presence of poor soils and the potential for future dredging activities.
5. Additional subsurface data is available extending to a depth of approximately 219 feet below mud line.

HWA GEOSCIENCES INC.

BALLARD BRIDGE
BRIDGE REHAB
SEATTLE, WASHINGTON

NORTH BASCULE PIER AND
STATION 129+00 TO 132+00
(Boring BX-107)
NOMINAL AXIAL
SHAFT CAPACITIES
12-FOOT DIAMETER SHAFT

DRAWN BY SKS	FIGURE NO. 6C
CHECKED BY DJH	PROJECT NO. 2019-085-21
DATE 07.19.19	

APPENDIX D

L-PILE PARAMETERS

BX-101 - Station 113+00 to 116+00 - LPILE Parameters

Existing Surface Elevation at BX-101 = 22.6 Feet

Static and Seismic

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, γ' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)
Fill	Sand (Reese)	0		100.0	30	-	25	25	-
			4	100.0	30	-	25	25	-
Fill	Sand (Reese)	4		37.6	30	-	20	20	-
			17	37.6	30	-	20	20	-
Peat	Soft Clay (Matlock)	17		12.6	-	100	30	-	0.02
			27	12.6	-	100	30	-	0.02
Recessional Outwash	Sand (Reese)	27		62.6	34	-	125	125	-
			43	62.6	34	-	125	125	-
Fluvial Deposits	Sand (Reese)	43		67.6	38	-	125	125	-
			80.4	67.6	38	-	125	125	-

Post Liquefaction

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, γ' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)	Recommended P-multilpiers for Liquefied Soil
Fill	Sand (Reese)	0		100.0	30	-	25	25	-	-
			4	100.0	30	-	25	25	-	-
Fill	Sand (Reese)	4		37.6	30	-	20	20	-	0.05
			17	37.6	30	-	20	20	-	0.05
Peat	Soft Clay (Matlock)	17		12.6	-	100	30	-	0.02	-
			27	12.6	-	100	30	-	0.02	-
Recessional Outwash	Sand (Reese)	27		62.6	34	-	125	125	-	-
			43	62.6	34	-	125	125	-	-
Fluvial Deposits	Sand (Reese)	43		67.6	38	-	125	125	-	-
			80.4	67.6	38	-	125	125	-	-

[1]: Total Unit Weight (pcf) = Effective Unit Weight + 62.4 (for layers below water table)

[2]: Undrained Shear Strength, C = Cu = Su

Project Name: Ballard Bridge
Project Number: 2019-085-21

BX-102 - Station 116+00 to 118+00 - LPILE Parameters

Existing Mudline Elevation at BX-102 = 9.6 Feet

Static and Seismic

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, y' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)
Peat	Soft Clay (Matlock)	0		12.6	-	100	30	-	0.02
			2.5	12.6	-	100	30	-	0.02
Lacustrine	Soft Clay (Matlock)	2.5		47.6	-	200	30	-	0.02
			36	47.6	-	500	90	-	0.02
Fluvial Deposits	Sand (Reese)	36		67.6	38	-	125	125	-
			61	67.6	38	-	125	125	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	61		52.6	-	4000	2000	800	0.004
			84.5	52.6	-	4000	2000	800	0.004

[1]: Total Unit Weight (pcf) = Effective Unit Weight + 62.4 (for layers below water table)
[2]: Undrained Shear Strength, C = Cu = Su

BX-103 - Station 118+00 to 121+00 - LPILE Parameters

Existing Mudline Elevation at BX-103 = -6.6 Feet

Static and Seismic

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, y' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)
Lacustrine	Soft Clay (Matlock)	0		47.6	-	200	30	-	0.02
			15	47.6	-	500	90	-	0.02
Recessional Outwash	Sand (Reese)	15		62.6	34	-	60	60	-
			25	62.6	34	-	60	60	-
Fluvial Deposits	Sand (Reese)	25		67.6	38	-	125	125	-
			36.5	67.6	38	-	125	125	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	36.5		52.6	-	4000	2000	800	0.004
			77.4	52.6	-	4000	2000	800	0.004

Post Liquefaction

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, y' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)	Recommended P-multilpiers for Liquefied Soil
Lacustrine	Soft Clay (Matlock)	0		47.6	-	200	30	-	0.02	-
			15	47.6	-	500	90	-	0.02	-
Recessional Outwash	Sand (Reese)	15		62.6	34	-	60	60	-	0.2
			20	62.6	34	-	60	60	-	0.2
Recessional Outwash	Sand (Reese)	20		62.6	34	-	60	60	-	-
			25	62.6	34	-	60	60	-	-
Fluvial Deposits	Sand (Reese)	25		67.6	38	-	125	125	-	-
			36.5	67.6	38	-	125	125	-	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	36.5		52.6	-	4000	2000	800	0.004	-
			77.4	52.6	-	4000	2000	800	0.004	-

[1]: Total Unit Weight (pcf) = Effective Unit Weight + 62.4 (for layers below water table)

[2]: Undrained Shear Strength, C = Cu = Su

BX-104 - Station 121+00 to 124+00 - LPILE Parameters

Existing Mudline Elevation at BX-104 = -5.4 Feet

Static and Seismic

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, y' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)
Lacustrine	Soft Clay (Matlock)	0		47.6	-	200	30	-	0.02
			13	47.6	-	500	90	-	0.02
Recessional Outwash	Sand (Reese)	13		62.6	34	-	125	125	-
			20	62.6	34	-	125	125	-
Glaciomarine	Stiff Clay with Free Water (Reese)	20		52.6	-	4000	2000	800	0.004
			52	52.6	-	4000	2000	800	0.004
Fluvial Deposits	Sand (Reese)	52		67.6	38	-	125	125	-
			69.5	67.6	38	-	125	125	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	69.5		52.6	-	4000	2000	800	0.004
			74.5	52.6	-	4000	2000	800	0.004

[1]: Total Unit Weight (pcf) = Effective Unit Weight + 62.4 (for layers below water table)

[2]: Undrained Shear Strength, C = Cu = Su

BX-106 - South Bascule Pier and Station 124+00 to 129+00 - LPILE Parameters

Existing Mudline Elevation at BX-106 = 6.4 Feet

Static and Seismic

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, y' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)
Fill	Soft Clay (Matlock)	0		37.6	-	200	30	-	0.02
			0.8	37.6	-	200	30	-	0.02
Recessional Outwash	Sand (Reese)	0.8		62.6	34	-	60	60	-
			9	62.6	34	-	60	60	-
Glaciomarine	Stiff Clay with Free Water (Reese)	9		52.6	-	4000	2000	800	0.004
			32	52.6	-	4000	2000	800	0.004
Fluvial Deposits	Sand (Reese)	32		67.6	38	-	125	125	-
			61	67.6	38	-	125	125	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	61		52.6	-	4000	2000	800	0.004
			82	52.6	-	4000	2000	800	0.004

[1]: Total Unit Weight (pcf) = Effective Unit Weight + 62.4 (for layers below water table)

[2]: Undrained Shear Strength, C = Cu = Su

BX-107 - North Bascule Pier and Station 129+00 to 132+00 - LPILE Parameters

Existing Mudline Elevation at BX-107 = 4.6 Feet

Static and Seismic

Soil Layer	Soil Type (p-y model)	Top of Layer (ft)	Bottom of Layer (ft)	Effective Unit Wt, γ' (pcf)[1]	Friction Angle (deg)	Undrained Cohesion, C (psf)[2]	p-y Modulus Static, k (pci)	p-y Modulus Seismic, k (pci)	Strain Factor, ε_{50} (dim)
Fill	Soft Clay (Matlock)	0		37.6	-	200	30	-	0.02
			5	37.6	-	200	30	-	0.02
Lacustrine	Stiff Clay with Free Water (Reese)	5		47.6	-	500	100	-	0.01
			12	47.6	-	500	100	-	0.01
Glaciomarine	Sand (Reese)	12		67.6	36	-	125	125	-
			23.5	67.6	36	-	125	125	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	23.5		52.6	-	4000	2000	800	0.004
			71	52.6	-	4000	2000	800	0.004
Fluvial Deposits	Sand (Reese)	71		67.6	38	-	125	125	-
			112	67.6	38	-	125	125	-
Glaciolacustrine	Stiff Clay with Free Water (Reese)	112		52.6	-	4000	2000	800	0.004
			165	52.6	-	4000	2000	800	0.004
Glaciolacustrine	Sand (Reese)	165		67.6	38	-	125	125	-
			195	67.6	38	-	125	125	-
Fluvial Deposits	Sand (Reese)	195		67.6	38	-	125	125	-
			219	67.6	38	-	125	125	-

[1]: Total Unit Weight (pcf) = Effective Unit Weight + 62.4 (for layers below water table)

[2]: Undrained Shear Strength, C = Cu = Su

Appendix E

Analysis of Potential Effects to Cultural Resources and/or Historic Properties

Historical Research Associates, Inc.

MEMORANDUM

To:	Paul Guenther and Matt Baughman, COWI
CC:	Seattle Department of Transportation
From:	Heather Lee Miller, PhD, Senior Historian, and Ron Adams, PhD, Archaeologist
Subject:	Ballard Bridge Planning Study, Analysis of Potential Effects to Cultural Resources and/or Historic Properties
Date:	March 10, 2020

Remarks

On behalf of Historical Research Associates, Inc. (HRA), we are pleased to present our initial assessment of the potential effects/impacts that the currently proposed alternatives for the Ballard Bridge rehabilitation and/or replacement project might have on cultural resources and/or historic properties (defined as a building, site, structure, object, or historic district that is listed in or eligible for listing in the National Register of Historic Places [NRHP] or otherwise listed in the Washington Heritage Register [WHR] or as a Seattle Landmark). As HRA understands, the proposed alternatives (as outlined in COWI's "Structural Feasibility and Constructability Analysis of Components") are as follows: a Low-Level Bridge Crossing that would rehabilitate and widen the existing bridge, a Mid-Level Replacement Bridge Crossing, and a High-Level Replacement Bridge Crossing. HRA also understands that a Replacement Tunnel Crossing was discarded in a previous phase but addresses its potential effects here in case a tunnel becomes an option again.

HRA believes that all proposed alternatives will require a U.S. Army Corps of Engineers (USACE) permit for in-water work thus invoking the need to comply with Section 106 of the National Historic Preservation Act (36 CFR 800, as amended); the U.S. Coast Guard may also be involved. HRA does not yet know who the lead agency will be for the Section 106 process, but assumes, for the purposes of this analysis, that it will be USACE. If for some reason Section 106 does not come into play, the alternatives will likely at minimum be subject to analysis under Seattle's Shoreline Management Program and SEPA.

In addition to the lead agency initiating consultation with the Washington State Historic Preservation Officer (SHPO), Advisory Council on Historic Preservation (ACHP), and other stakeholders (e.g., tribes or other local or interested groups), the Section 106 process involves four main steps: determining whether the project constitutes a federal undertaking (and initiating consultation, if so), defining an area of potential effects (APE), determining whether any historic properties exist within the APE, and assessing project effects to those historic properties. Additionally, if a project will have an adverse effect on a historic property and if that adverse effect cannot be avoided (always the preferred approach) or minimized (for example, redesigning the alternative to reduce the effect), then the project proponent, lead agency, SHPO, and potentially other stakeholders enter into a mitigation agreement (typically in the form of a memorandum of agreement [MOA]).

Because it will require a federal permit, the proposed Ballard Bridge Removal/Rehabilitation project does constitute an **undertaking**. As noted above, the second step of the Section 106 process is delineating an APE to include any immediate (direct) or reasonably foreseeable (indirect) effects on historic properties. Direct effects can be physical, visual, or audible. Indirect effects are typically reasonably foreseeable changes such as altered traffic patterns, increased or decreased access to, or a change in how people might use a specific resource within the APE. Although there is typically only one APE, HRA recommends for the purposes of future planning that the APE for each alternative encompass both a physical and visual effects APE.

The first recommended APE is a **physical effects APE** that includes a one-tax-parcel buffer around all proposed areas of ground disturbance (whether in water or on dry land), laydown or construction staging areas, and alterations to the existing bridge or other buildings or structures (Figures 1–3). Furthermore, the physical effects APE may also need to expand to include roadways on which significant construction traffic might occur.

The second recommended APE is a **visual effects APE,** which would presumably be larger than the physical effects APE but which should be a subject of consultation before the APE is finalized. Because the Ballard Bridge essentially sits in the bottom of a geographic "bowl" and is clearly visible from Phinney Ridge, the north side of Queen Anne hill, and parts of northeast Magnolia, consultation may result in a larger APE to include any historic properties for whom the removal of the existing bridge or construction of new bridge might constitute an adverse effect (e.g., diminishing a historic property's integrity of setting, feeling, or association).

Methods

Given that HRA cannot at this time predict whether consultation will result in including the Ballard Avenue Historic District or a larger visual effects APE (or what that APE might look like), we focused the current alternatives analysis on the recommended physical effects APE. To determine whether historic properties (precontact or historic period; archaeological or built environment) exist within the recommended physical effects APE, HRA archaeologist Ron Adams first reviewed the Seattle Landmarks list and then surveyed past cultural resources reports as well as archaeological site forms and historic property inventory (HPI) forms in the State of Washington's Washington Information System for Architectural and Archaeological Records Data (WISAARD) database. Adams also reviewed the Washington State Department of Archaeology and Historic Preservation's statewide archaeological probability model, which outlines areas of low, moderately low, moderate, high, and very high risk probability for archaeological sites (typically based on proximity to water and other geographical and geological factors). In addition to determining known historic properties within each alternative's recommended physical effects APEs, HRA attempted to determine how many buildings or structures within each of the recommended physical effects APEs were twenty-five years old or older (based on the fact that the project will likely not begin for another fifteen to twenty years and could continue for another ten—at which time, resources will have achieved or be close to reaching the NRHP's fifty-year threshold for eligibility). We made no attempt to survey or otherwise assess the eligibility of these resources, only to quantify approximately how many would need to be surveyed as part of the future Section 106 process. In what follows, HRA provides a preliminary assessment of the potential for each alternative to affect historic properties.

Alternatives Effects Analysis

Low-Level Bridge Crossing ("Rehabilitation")

HRA's research found no known archaeological resources (listed or otherwise) within the recommended physical effects APE for the Low-Level Bridge Replacement alternative (Figure 1). However, several precontact and historic-era archaeological resources exist in the general vicinity. The DAHP predictive model indicates that the Low-Level Bridge Rehabilitation alternative is in an area with a very high probability of containing both precontact and historic-era archaeological resources.

WISAARD depicts two historic properties within the recommended physical effects APE for the Low-Level Bridge Crossing alternative. The **Ballard Bridge** was listed in 1982 in both the NRHP and WHR.[1] Although the nomination unfortunately does not delineate the character-defining features of the bridge, author Lisa Soderberg indicated that the three bridges she was evaluating at the time were "the earliest examples within the State of a double-leaf bascule bridge," suggesting that she believed the bridges were eligible under Criterion C for their architectural or engineering features.[2] Completed in 1917 (actual dates vary according to source), the bridge has since undergone two major alterations: construction of permanent approaches in 1941 and replacement of the original four guard towers with one in 1969. If the Low-Level Bridge Crossing Rehabilitation could be done with strict adherence to the Rehabilitation Standards of Secretary of the Interior's *Standards and Guidelines for the Treatment of Historic Properties* and therefore not diminish the property's integrity and if the Project had no other effects on historic properties within the APE, the Project could potentially be determined to have no adverse effect on historic properties.[3]

As currently designed, the Low-Level Bridge Rehabilitation option may not qualify as "Rehabilitation" under the *Standards*, which defines Rehabilitation "*as the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values*. The Rehabilitation Standards acknowledge the need to alter or add to a historic [structure] to meet continuing or new uses while retaining the [structure's] historic character."[4] Most important for any new addition or related new construction, according to the *Standards*, is to create a compatible yet distinguishable addition. Ultimately, if SDOT chooses the Low-Level Bridge Rehabilitation alternative, they

[1] Lisa Soderberg, "Bridges, Trestles, and Aqueducts," section on Bascule Bridges, University Bridge, Fremont Bridge, and Ballard Bridge, NAER inventory form, September 1980, on file with Washington State Department of Archaeology and Historic Preservation, WISAARD.

[2] Soderberg, "Bridges, Trestles, and Aqueducts," [1].

[3] National Park Service (NPS), *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings*, rev. Anne Grimmer, 2017, https://www.nps.gov/tps/standards/treatment-guidelines-2017.pdf.

[4] NPS, *Secretary of the Interior's Standards and Guidelines*, 2.

would need to develop the final design during the Section 106 consultation process, specifically taking into account the following general guidance along with specifics laid out in the *Standards*.

> A new addition must preserve the [structure's] historic character, form, significant materials, and features. It must be compatible with the massing, size, scale, and design of the historic [structure] while differentiated from the historic [structure]. It should also be designed and constructed so that the essential form and integrity of the historic [structure] would remain if the addition were to be removed in the future. There is no formula or prescription for designing a compatible new addition or related new construction on a site, nor is there generally only one possible design approach that will meet the Standards.[5]

Also located within the recommended physical effects APE is the c. 1916–1920 **FVO Winch House** (2000 W. Emerson Pl.), which was determined NRHP eligible in 2003 but recommended not eligible in 2011 (current status unclear in WISAARD).[6] Additional research and/or discussion with DAHP will be needed to clarify the status of the FVO Winch House, but for the purposes of this analysis, HRA considers it eligible. Project-related impacts to the FVO Winch House (e.g., demolition, physical alterations to, or other impacts to a historic property's integrity of location, design, setting, materials, workmanship, feeling, or association) may also constitute an adverse effect.

HRA's mapping research located an additional twenty-five buildings or structures twenty-five years old or older within the recommended Low-Level Bridge Crossing alternative physical effects APE that would need inventory and evaluation during the Section 106 process. If consultation results in a broader visual effects APE, that number will likely increase. Inventory and evaluation of these resources may reveal the presence of additional historic properties within the recommended physical and/or visual effects APE (in whatever form it might take during consultation) on which the project may have direct or indirect effects (e.g., demolition, changes in traffic patterns, construction vibration, new visual intrusions, and other project-related impacts).

Mid-Level Bridge Crossing (Replacement)

HRA's research found no archaeological resources (listed or otherwise) within the recommended physical effects APE for the Mid-Level Bridge Crossing alternative (Figure 2). However, several precontact and historic-era archaeological resources exist in the general vicinity. The DAHP predictive model indicates that the Mid-Level Bridge Crossing alternative is in an area with a very high probability of containing both precontact and historic-era archaeological resources.

Three known historic properties exist within the recommended physical effects APE for the Mid-Level Bridge Crossing alternative: the Ballard Bridge, FVO Winch House, and c. 1904 **Brekke Steel Co.** building (1526 NW 46th St.), which was determined NRHP eligible in 2003 but recommended not eligible in 2018 (current status unclear in WISAARD).[7] Additional research and/or discussion with DAHP will be needed to

[5] NPS, *Secretary of the Interior's Standards and Guidelines*, 26

[6] "FVO Winch House," Property ID 159029, WISAARD.

[7] "Brekke Steel Co.," Property ID 46322, WISAARD.

clarify the status of the FVO Winch House and Brekke Steel Co. building, but for the purposes of this analysis, HRA considers both eligible. Removing the Ballard Bridge in and of itself will constitute an adverse effect to a historic property. Furthermore, project-related impacts (e.g., demolition, physical alterations to, or other impacts to a historic property's integrity of location, design, setting, materials, workmanship, feeling, or association) to the FVO Winch House or Brekke Steel Co. building may also constitute an adverse effect.

Additionally, because the **Ballard Avenue Historic District** (listed in the NRHP in April 1976) is located one block northwest of the Mid-Level Replacement Bridge alternative's recommended physical effects APEs (Figure 2), HRA anticipates that if SDOT chooses this alternative, consultation during the Section 106 process will result in an expanded APE that includes the district.[8] Project-related changes in traffic patterns, diminished or increased access to the historic district, construction vibration, and other project-related impacts all have the potential to create both direct and indirect effects (adverse or not) to the historic district.

HRA's mapping research located an additional forty buildings or structures twenty-five years old or older within the recommended Mid-Level Bridge Crossing alternative physical effects APE that would need inventory and evaluation during the Section 106 process. If consultation results in a broader visual effects APE, that number will likely increase. Inventory and evaluation of these resources may reveal the presence of additional historic properties within the recommended physical and/or visual effects APE (in whatever form it might take during consultation) on which the project may have direct or indirect effects (e.g., demolition, changes in traffic patterns, construction vibration, new visual intrusions, and other project-related impacts).

The Mid-Level Bridge Crossing alternative has a higher potential than the Low-Level Bridge Crossing Replacement alternative of introducing a significant visual intrusion onto the landscape, which may have an adverse effect on historic properties within the recommended physical effects APE as well as any future recommended visual effects APE.

High-Level Bridge Crossing (Replacement)

HRA's research found no archaeological resources (listed or otherwise) within the recommended physical effects APE for the High-Level Bridge Crossing alternative (Figure 3). However, several precontact and historic-era archaeological resources exist in the general vicinity. The DAHP predictive model indicates that the High-Level Bridge Crossing alternative is in an area with a very high probability of containing both precontact and historic-era archaeological resources.

Two known historic properties exist within the recommended physical effects APE for the Mid-Level Bridge Crossing alternative, the Ballard Bridge and FVO Winch House. As noted above, additional research and/or discussion with DAHP will be needed to clarify the status of the FVO Winch House, but for the purposes of this analysis, HRA considers it eligible. Removing the Ballard Bridge in and of itself will constitute an adverse effect to a historic property. Furthermore, project-related impacts to the FVO Winch House (e.g., demolition, physical alterations to, or other impacts to a historic property's integrity of location, design, setting, materials, workmanship, feeling, or association) may also constitute an adverse effect.

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[8] Elisabeth Walton Potter, "Ballard Avenue Historic District," National Register Nomination Form, April 1976, WISAARD.

HRA's mapping research located an additional forty-three buildings or structures twenty-five years old or older within the recommended High-Level Bridge Crossing alternative physical effects APE that would need inventory and evaluation during the Section 106 process. If consultation results in a broader visual effects APE, that number will likely increase. Inventory and evaluation of these resources may reveal the presence of additional historic properties within the recommended physical and/or visual effects APE (in whatever form it might take during consultation) on which the project may have direct or indirect effects (e.g., demolition, changes in traffic patterns, construction vibration, new visual intrusions, and other project-related impacts).

Of all alternatives, the High-Level Bridge Crossing has the highest potential of introducing a significant visual intrusion onto the landscape, which may have an adverse effect on historic properties within the recommended physical effects APE as well as any future recommended visual effects APE.

Tunnel Crossing

Although HRA understands that the Tunnel Crossing alternative is no longer under consideration, we feel it necessary to comment on it in case it returns as a potential alternative. HRA assumes for this analysis that a tunnel would be built in the same alignment as the existing Ballard Bridge and understands that this option would likely require substantial ground disturbance through soil with a very high archaeological probability, demolition of the existing bridge (an adverse effect to a historic property), and construction of a new pedestrian bridge over the Ship Canal (a potential visual effect). Additionally, a larger physical effects APEs would be required to account for the areas at which the road would daylight on either end of the underground crossing at the Ship Canal, as well as a larger area of potential traffic-pattern alterations, disruptions, increases (during and after construction), and noise and vibration; additional construction and laydown areas; and so on. Since HRA does not know where those tunnel entries might be located, we cannot at this time recommend a physical effects APE.

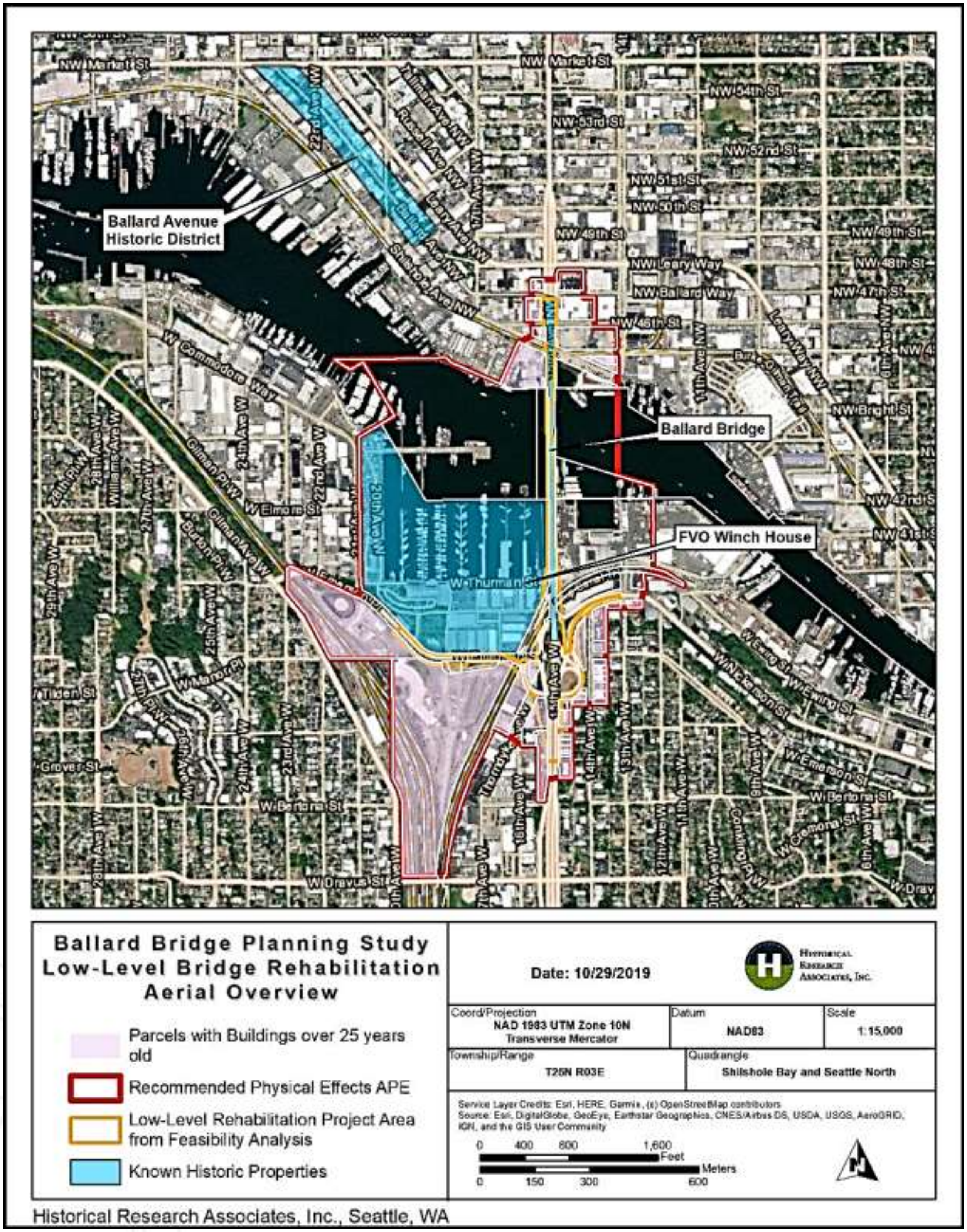

Figure 1. Ballard Bridge Planning Study, Low-Level Bridge Rehabilitation Alternative, Recommended Physical Effects APE

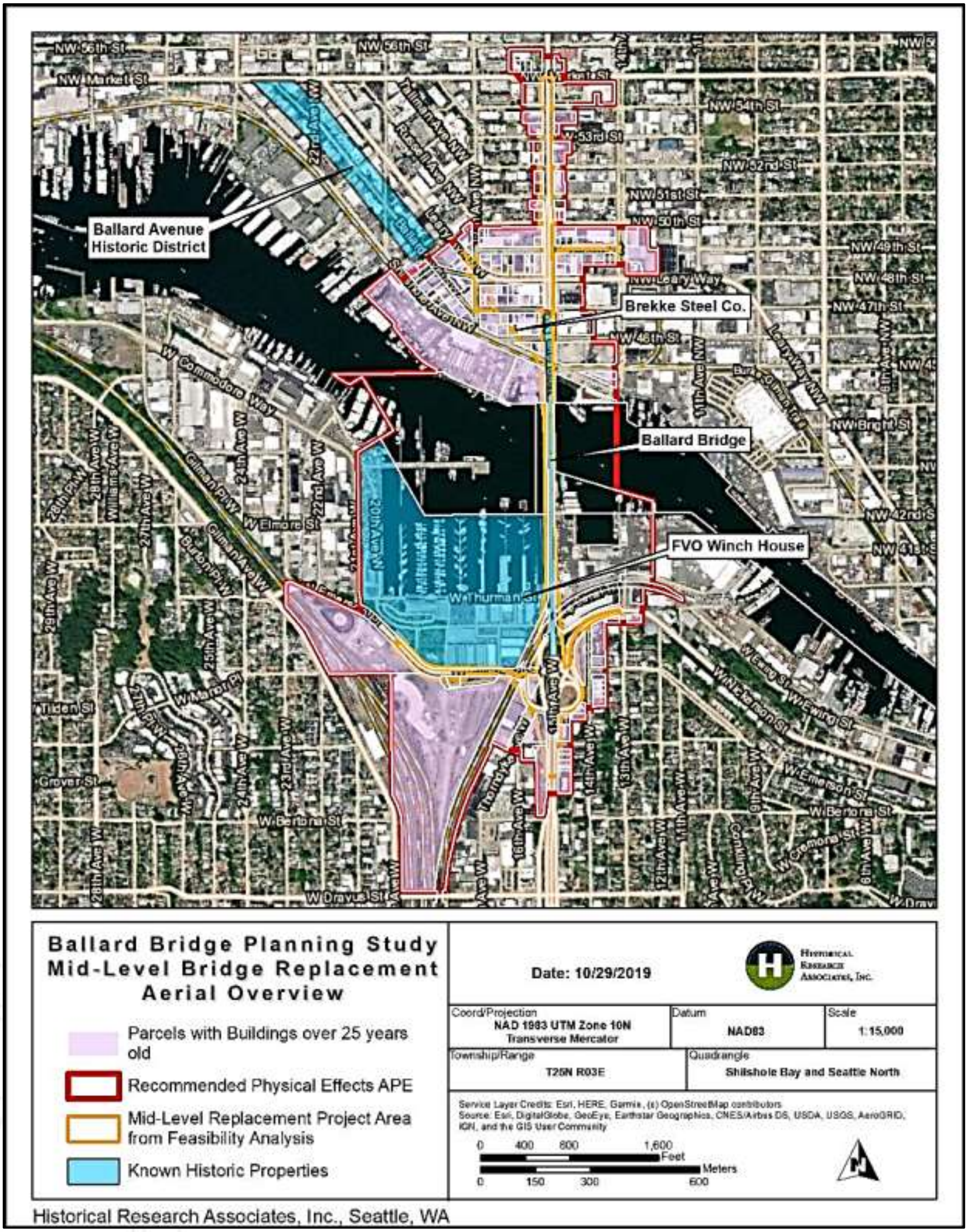

Figure 2. Ballard Bridge Planning Study, Mid-Level Bridge Replacement Alternative, Recommended Physical Effects APE

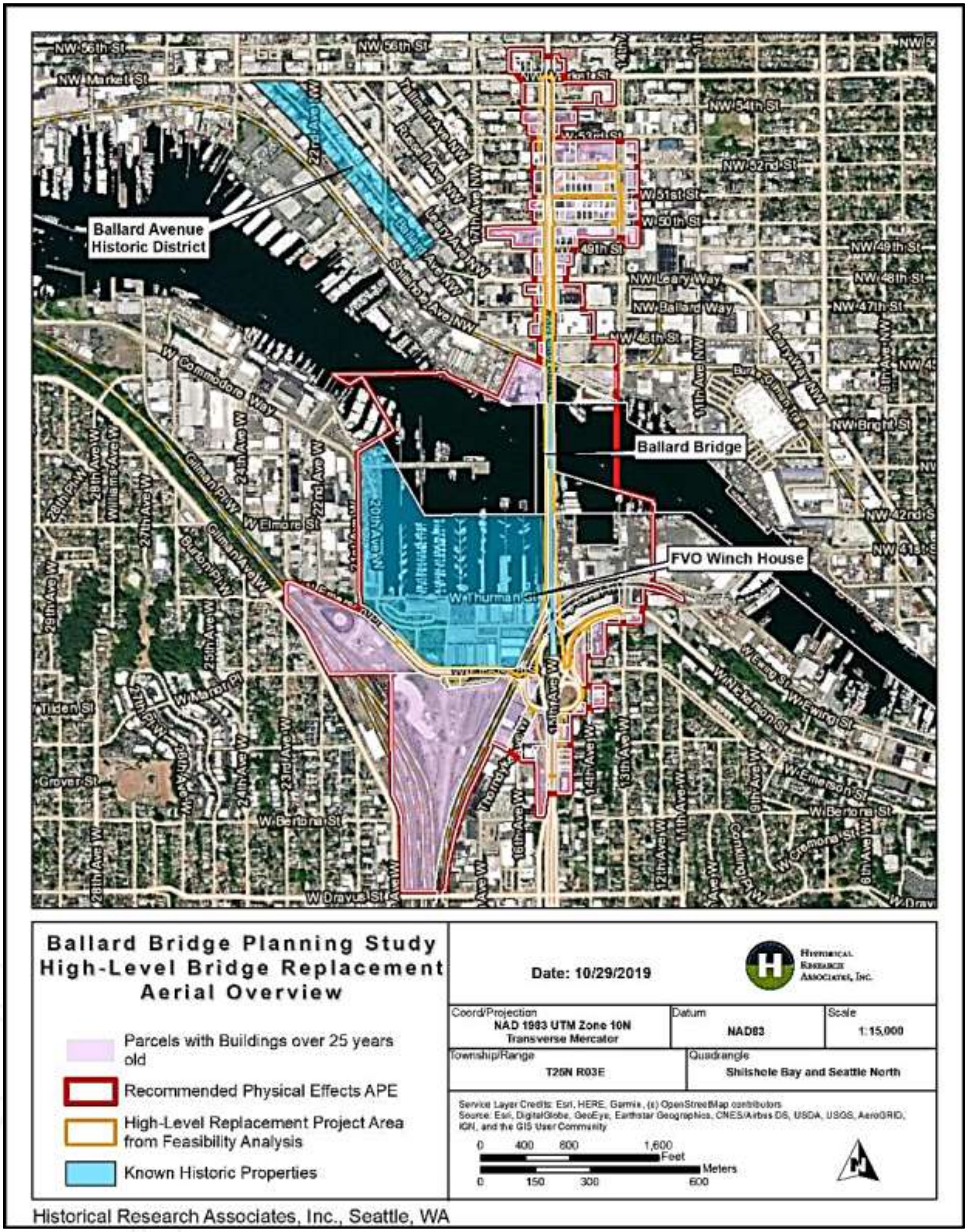

Figure 3. Ballard Bridge Planning Study, High-Level Bridge Replacement Alternative, Recommended Physical Effects APE

Appendix F

ROM Comparative Cost Estimates

Seattle Department of Transportation

TECHNICAL MEMORANDUM

PROJECT	Ballard Bridge Planning Study
TITLE	Task 7 – ROM Comparative Cost Estimates
DATE	7 August 2020
TO	Seattle Department of Transportation (SDOT)
FROM	COWI
PROJECT NO.	A115271

ADDRESS COWI North America Inc.
1191 2nd Avenue
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1 Introduction

The Ballard Bridge, located on the 15th Ave W/NW corridor, is a major north-south corridor in the City of Seattle, and one of just six vehicular and six pedestrian/cyclist connections across the Lake Washington Ship Canal. While the structure is still in good condition today, it is over 100 years old. And while SDOT continues to maintain its safety for daily travel, the likelihood that major maintenance or emergency repair work will be needed continues to increase with age. In addition, the structure is not up to current standards for providing space to people walking, biking, or traveling in a vehicle, hence it being categorized as "functionally obsolete".

The purpose of the Ballard Bridge Planning Study (Project) is to develop and evaluate initial bridge rehabilitation and replacement options, including implementation considerations, comparison of expected order-of-magnitude costs, and functional trade-offs for each option. The overall goal is to identify options and key considerations that take into account representative input from the City of Seattle and the community.

This technical memorandum supports Task 7 – Develop Cost Estimates, providing rough order-of-magnitude (ROM) comparative costs for the alternatives considered. The following alternatives have been considered as part of this study:

- Low-Level Bridge Crossing with Bascule Span:
  - Rehabilitate and Widen Existing Bridge
  - Replace Emerson-Nickerson Bridge with Modified SPUI structure
- Mid-Level Replacement Bridge with Bascule Span
  - Replace Ballard Bridge with higher structure, including movable bridge
  - Construct new SB on- and NB off-ramps to Leary Way
  - Replace Emerson-Nickerson Bridge with Modified SPUI structure
- High-Level Fixed Span Replacement Bridge
  - Replace Ballard Bridge with much higher structure, including fixed navigation span
  - Construct new ramp structure to Leary Way
  - Replace Emerson-Nickerson Bridge with Modified SPUI structure

This memo was produced in coordination with other relevant documents included with this Study including:

- Structural Feasibility and Constructability Memo (Appendix C)
- Geometric Analysis of Components Technical Memo (Appendix B)

- Preliminary Geotechnical Engineering Letter Report (Appendix D)
- Movable Bridge Alternatives Technical Memo (Appendix C)
- Ballard Bridge Planning Study Preliminary Design Criteria (Appendix G)

2 Rough-Order-of-Magnitude (ROM) Comparative Cost Estimates

Rough-Order-of-magnitude (ROM) comparative cost estimates based on 2019 dollars were developed for each alternative included with this study. The costs developed are considered "Alternative Screening" level costs based on a 0% to 2% level of project definition. Construction cost estimates were developed by applying historical cost-per-square-foot data to the various plan areas of proposed structures or at grade work, supplemented by more detailed take-offs of several project components such as movable bridges.

Table 2.1 provides a summary of the major cost items considered along with a brief description of how the cost components were assessed. Tables 2.2 through 2.4 provide a summary breakdown of the major cost components for each alternative. More detailed back-up of the cost estimate breakdown is provided in Attachment A.

The ROM costs presented do not explicitly include the following items:

- Operations and Maintenance costs
- Additional bridge seismic retrofit costs for low-level rehab (if needed)
- Environmental permitting or mitigation costs
- Contaminated material characterization, handling, or disposal
- Sales taxes
- Inflation - Costs should be adjusted to planned year of construction.
- Financing
- User costs

The costs presented herein were prepared for guidance in project evaluation and facility planning. Actual long-term and construction costs will differ from the costs shown. Final project costs are dependent upon many variable factors including, but not limited to, labor and material costs, site conditions, productivity, competitive market conditions, final project scope, and the contractor's implementation schedule.

TABLE 2.1 PRIMARY COST ELEMENTS AND ESTIMATING APPROACH FOR COST DEVELOPMENT		
NO.	**ITEM**	**ASSUMPTIONS AND APPROACH**
0	**Removals**	› Accounts for demolition and removal of existing structures and roadway within the anticipated project footprint. › WSDOT BDM reference costs used where available. Otherwise, 20% of new unit cost.
1	**At Grade**	› Accounts for new at-grade roadway work including traffic signals. › Based on WSDOT planning level cost estimate data for $/lane-mile cost for urban arterials in Puget Sound.
2	**Bridge**	› Typical Bridge - based on WSDOT BDM reference costs. › Movable Bridge –based on Movable Bridge Alternatives technical memo. › Long Span Bridge – based on COWI past long-span bridge project experience. › Rehabilitation, Repairs, and strengthening – based on WSDOT reference costs. › Temporary Bridge with Movable Span - based on COWI past project experience and consultation with temporary bridge suppliers.
3	**Retained Embankments**	› Accounts for roadway supported on retained fill. › Based on cost takeoff for representative wall embankment using WSDOT reference costs.
4	**Construction Items Subtotal**	› Sum of Items 0-3.
5	**Undefined Items (Design Contingency)**	› Accounts for work items not defined at this level of study such as utilities, traffic signage, illumination, pedestrian features, and similar items. › Assumes 20% for rehabilitation (Low-Level) and 30% for replacement (Mid-Level & High-Level) applied to the Construction Subtotal (Item 4).
6	**Mobilization**	› 10% applied to the Construction Subtotal (Item 4).
7	**Total ROM Construction Cost**	› Sum of Items 4 through 6.
8	**PE Costs**	› Accounts for Design Engineering and related administration costs. › Assumed 20% applied to the Total ROM Construction Cost (Item 7).
9	**Construction Contingency**	› Accounts for unexpected construction scope items or costs. › Assumes 30% applied to the Total Construction Cost (Item 7).
10	**Construction Engineering**	› Accounts for construction management and office engineering during construction. › Assumes 20% applied to the Total Construction Cost (Item 7).
11	**Right-of-Way Cost**	› Accounts for anticipated property impacts for proposed options. › Based on rough SF take-off using reference project data.
12	**ROM Comparative Cost Total**	› Sum of Items 7 through 11.
13	**ROM Comparative Cost Range**	› Includes assumed -30% / +50% of Item 12 per AACE International Recommended Practice No. 56R-08 (Class 5 Estimate, 0% to 2% Project Definition).

Table 2.2	*ROM Cost Estimate for Low-Level Bridge Alternative*	
No.	**Item**	**ROM Cost Estimate**
0	Removals	$6 M
1	At-Grade	$21 M
2	Bridges	$138 M
3	Retained Embankments	$11 M
4	**Construction Items Subtotal**	**$176 M**
5, 6	Undefined Items (Design Contingency) and Mobilization	$53 M
7	**Total ROM Construction Cost**	**$229 M**
8, 9, 10	PE, Construction Contingency, Construction Engineering	$161 M
11	Right-of-Way Costs	$81 M
12	**ROM Comparative Cost Total**	**$471 M**
13	**ROM Comparative Cost Range**	**$330 M to $710 M**

Table 2.3 ROM Costs for Mid-Level Bridge Alternative		
No.	**Item**	**ROM Cost Estimate**
0	Removals	$20 M
1	At-Grade	$57 M
2	Bridges	$268 M
3	Retained Embankments	$15 M
4	**Construction Items Subtotal**	**$360 M**
5, 6	Undefined Items (Design Contingency) and Mobilization	$144 M
7	**Total ROM Construction Cost**	**$504 M**
8, 9, 10	PE, Construction Contingency, Construction Engineering	$353 M
11	Right-of-Way Costs	$114 M
12	**ROM Comparative Cost Total**	**$971 M**
13	**ROM Comparative Cost Range**	**$680 M to $1,460 M**

Table 2.4 ROM Costs for High-Level Bridge Alternative

No.	Item	ROM Cost Estimate
0	Removals	$20 M
1	At-Grade	$44 M
2	Bridges	$267 M
3	Retained Embankments	$27 M
4	**Construction Items Subtotal**	**$358 M**
5, 6	Undefined Items (Design Contingency) and Mobilization	$143 M
7	**Total ROM Construction Cost**	**$501 M**
8, 9, 10	PE, Construction Contingency, Construction Engineering	$350 M
11	Right-of-Way Costs	$130 M
12	**ROM Comparative Cost Total**	**$981 M**
13	**ROM Comparative Cost Range**	**$690 M to $1,470 M**

3 Commentary on Life Cycle Cost Considerations

The comparative costs presented herein are intended to represent order-of-magnitude initial capital costs to support comparison of alternatives for planning purposes. Annual maintenance, operator costs, major rehabilitation, and emergency repairs vary for the alternatives and are unrealistic to predict for the life of these bridge alternatives at this level of design. That stated, a relative comparison of these life cycle costs can still be made.

While annual Operations and Maintenance (O&M) are fairly consistent, bridges also require larger, major rehabilitation or emergency repair activities on a less frequent basis. Alternatives that utilize existing infrastructure, such as the low-level bridge rehabilitation alternative, will have higher major maintenance and emergency repair costs associated with them in order to attain the same service life as a new structure.

Based on recent data provided by SDOT, annual O&M costs for the existing Ballard Bridge are approximately $1M. Based on the configuration of the existing bridge, estimated costs for common major maintenance items are:

- Major Mechanical and Electrical (Mech. & Elec.) Upgrades: Approx. $2 mil every 20 years*
- Bridge Painting: Approx. $5 mil every 20 years*
- Major Deck Rehabilitation/Repair/Joint Replacement: Approx. $3 mil every 25 years*

** Costs are rough-order-of-magnitude values based on anticipated scope of work, WSDOT reference data, and past project experience.*

Many of the annual O&M costs will be similar for options that maintain a movable bridge span (operator costs, etc.), but will be less for a fixed bridge. Major maintenance and emergency repair costs can be expected to increase slightly and/or become more frequent as the structure ages and would be significantly less for a new structure compared to a rehabilitated structure. Maintenance items like deck repair and joint replacement would be relative to the deck surface area and would therefore be higher for the Mid-Level and High-Level replacement alternatives. The table below provides a relative comparison of the anticipated types of major rehabilitation costs for our three alternatives.

TABLE 3.1 RELATIVE COST OF MAJOR MAINTENANCE AND EMERGENCY REPAIRS FOR ALTERNATIVES

BALLARD BRIDGE ALTERNATIVES	MAJOR DECK REHABILITATION	BRIDGE PAINTING	MECH. & ELEC. UPGRADES	EMERGENCY REPAIR
Cost relation	$ related to deck surface area & age	$ proportional to steel surface area	$ related to the age of the systems	$ related to the age & complexity of the bridge
LOW-LEVEL	$$	$$	$$	$$$$
MID-LEVEL	$$$	$	$	$$
HIGH-LEVEL	$$$	$*	-	$$

** assumes final High-Level alternative uses a structure type that incorporates steel.*

Considering the annual O&M as well as the relative major maintenance and emergency repair activities, the low-level rehabilitation bridge would likely have the highest life cycle costs, while the high-level replacement bridge would likely have the lowest life cycle costs.

A detailed life cycle cost analysis comparing the total costs (initial cost plus long-term O&M costs) of the different alternatives is beyond the scope of this study. If the rehabilitation/widen existing bridge alternative is selected to be advanced in subsequent phases of project development, a detailed life cycle cost analysis should be performed at a further level of structural design. This analysis would serve to inform SDOT decision making when comparing rehabilitation of aging infrastructure vs. replacement options when considered over the appropriate service life/planning horizon.

Attachment A – Rough Order of Magnitude (ROM) Comparative Cost Estimates

Attachment A - Rough Order of Magnitude (ROM) Comparative Cost Estimates

A(1) LOW-LEVEL ALTERNATIVE - SUMMARY COST SCHEDULE

No.	Item	Unit of Measure	Unit Cost*	Total Qty*	Line Cost*	Basis / Notes / Calculation Formula
(0)A	Removal: At Grade - South	SF	$15	191,000	$ 2,900,000	*Removal of at grade features taken as a factor of new cost*
(0)B	Removal: At Grade - North	SF	$15	5,600	$ 80,000	"
(0)C	Removal: Retaining Walls - W Emerson St	SF	$25	10,000	$ 250,000	*Removal of retaining walls taken as a factor of new cost*
(0)D	Removal: Retaining Walls - 15th Ave NW	SF	$25	18,600	$ 470,000	"
(0)E	Removal: Conc Bridge Above Water	SF	$0	18,200	$ -	*Removal cost included in unit price for position (2)B*
(0)F	Removal: Conc Bridge Above Land	SF	$0	7,500	$ -	*Removal cost included in unit price for position (2)C*
(0)G	Removal: Conc Bridge Along Movable Bridge	SF	$50	1,800	$ 90,000	*BDM high cost for "Concrete Bridge Removal"*
(0)H	Removal: Nickerson-Emerson Bridge	SF	$35	64,000	$ 2,200,000	*BDM Median Cost for "Concrete Bridge Removal"*
(1)A	At Grade: 15th Ave W - South	SF	$80	136,000	$ 10,900,000	*Derived from WSDOT PLCE tool cost per lane-mile (Puget Sound - Urban Setting, inflated from 2012$ to 2019$)*
(1)B	At Grade: 15th Ave NW - North	SF	$80	33,000	$ 2,600,000	"
(1)C	At Grade: W Nickerson St	SF	$80	51,000	$ 4,100,000	"
(1)D	At Grade: W Emerson St	SF	$80	32,000	$ 2,600,000	"
(1)E	At Grade: Traffic Signals	LS	$1 M	1	$ 1,000,000	*Order of magnitude cost for concept assumed*
(2)A	Widening Along Movable Bridge	SF	$7100	6,100	$ 43,000,000	*Line item cost per Attachment B (cost has been normalized based on widening SF)*
(2)B	Widening on Approach, Over Water	SF	$400	60,000	$ 24,000,000	*BDM high cost for 'Widening Existing Concrete Bridges (Including Removal)' increased for complexity*
(2)C	Widening on Approach, Over Land	SF	$300	25,000	$ 7,500,000	*BDM high cost for 'Widening Existing Concrete Bridges (Including Removal)'*
(2)D	New Emerson-Nickerson Bridge	SF	$320	142,000	$ 45,000,000	*BDM high cost for 'Prestressed Conc Girders - Dry Crossing w/piling'*
(2)E	Ramps to SPUI	SF	$320	17,000	$ 5,000,000	"
(2)F	Strengthening	LS	$2 M	1	$ 2,000,000	*Order of magnitude cost for concept assumed*
(2)G	Repairs	LS	$3 M	1	$ 3,000,000	"
(2)H	Ex. Deck Rehabilitation	SY	$270	13,000	$ 3,500,000	*Unit cost developed using BDM high costs for overlay removal and replacement, increased for deck repairs*
(2)I	Bridge Painting	SF	$35	120,000	$ 4,200,000	*BDM low cost for 'Painting Existing Steel Bridges (Lead Based)*
(2)J	Joint and Bearing replacement	LS	$1 M	1	$ 1,000,000	*Order of magnitude cost for concept assumed*
(3)A	Retaining Wall: W Nickerson St - East Approach	SF	$120	34,700	$ 4,200,000	*Derived from takeoff of key items for a representative RT wall embankment ramp structure*
(3)B	Retaining Wall: W Nickerson St - SB On-Ramp	SF	$120	27,800	$ 3,300,000	"
(3)C	Retaining Wall: W Emerson St - West Approach	SF	$120	20,900	$ 2,500,000	"
(3)D	Retaining Wall: 15th Ave NW@NW Ballard Way	SF	$120	4,500	$ 540,000	"
(0)	Remove Existing Bridge				$ 6,000,000	*sum of (0) subitems*
(1)	At Grade - Subtotal				$ 21,000,000	*sum of (1) subitems*
(2)	Bridge - Subtotal				$ 138,000,000	*sum of (2) subitems*
(3)	Wall - Subtotal				$ 11,000,000	*sum of (3) subitems*
(4)	Construction Items Subtotal				$ 176,000,000	*=(0)+(1)+(2)+(3)*
(5)	Undefined Items (Design Contingency)				$ 35,000,000	*20% applied to (4)*
(6)	Mobilization				$ 18,000,000	*10% applied to (4)*
(7)	**Total ROM Construction Cost**				**$ 229,000,000**	*=(4)+(5)+(6)*
(8)	PE Costs				$ 46,000,000	*20% applied to (7)*
(9)	Construction Contingency				$ 69,000,000	*30% applied to (7)*
(10)	Construction Engineering				$ 46,000,000	*20% applied to (7)*
(11)	Right of Way Cost				$ 81,000,000	*ROW cost per Attachment B*
(12)	**ROM Comparative Cost Total**				**$ 471,000,000**	*=(8)+(9)+(10)+(11)*
(13)	ROM Comparative Cost Range (Lower Bound)				$ 330,000,000	*70% of (12)*
(14)	ROM Comparative Cost Range (Upper Bound)				$ 710,000,000	*150% of (12)*

* Rounded value

NOTES:

1. Cost estimates are based on 2019 dollars and a 0% to 2% level of project definition.
2. Estimates do not include: Operations and Maintenance Costs, Additional bridge seismic retrofit costs, Environmental permitting or mitigation costs, Contaminated material characterization, handling, or disposal, Sales taxes, Inflation - Costs should be inflated to planned year of construction, and Financing.
3. The costs presented herein were prepared for guidance in project evaluation and facility planning. Actual long-term and construction costs will differ from the costs shown. Final project costs are dependent upon many variable factors including, but not limited to, labor and material costs, site conditions, productivity, competitive market conditions, final project scope, and the contractor's implementation schedule.

Attachment A - Rough Order of Magnitude (ROM) Comparative Cost Estimates

A(2) MID-LEVEL ALTERNATIVE - SUMMARY COST SCHEDULE

No.	Item	Unit of Measure	Unit Cost*	Total Qty*	Line Cost*	Basis / Notes / Calculation Formula
(0)A	Removal: At Grade - South	SF	$15	280,000	$ 4,200,000	Removal of at grade features taken as a factor of new cost
(0)B	Removal: At Grade - North	SF	$15	440,000	$ 6,600,000	"
(0)C	Removal: Retaining Walls - W Emerson St	SF	$25	10,000	$ 250,000	Removal of retaining wall supported embankments taken as a factor of new cost
(0)D	Removal: Retaining Walls - 15th Ave NW@NW 46th S	SF	$25	25,000	$ 630,000	"
(0)E	Removal: Retaining Walls - 15th Ave NW@NW 49th S	SF	$25	14,000	$ 350,000	"
(0)F	Removal: Ballard Bridge Above Water	SF	$35	90,000	$ 3,200,000	BDM Median Cost for "Concrete Bridge Removal"
(0)G	Removal: Ballard Bridge Above Land	SF	$35	57,000	$ 2,000,000	"
(0)H	Removal: Ballard Bridge - Movable Span	SF	$50	17,000	$ 850,000	BDM High Cost for "Concrete Bridge Removal"
(0)I	Removal: Nickerson-Emerson Bridge	SF	$35	64,000	$ 2,200,000	BDM Median Cost for "Concrete Bridge Removal"
(1)A	At Grade: 15th Ave W - South	SF	$80	123,000	$ 9,800,000	Derived from WSDOT PLCE tool cost per lane-mile (Puget Sound - Urban Setting, inflated from 2012$ to 2019$)
(1)B	At Grade: 15th Ave NW - North	SF	$80	323,000	$ 25,800,000	"
(1)C	At Grade: W Nickerson St	SF	$80	51,000	$ 4,100,000	"
(1)D	At Grade: W Emerson St	SF	$80	34,000	$ 2,700,000	"
(1)E	At Grade: 17th Ave NW/NW Leary Way/NW Ballard W	SF	$80	156,000	$ 12,500,000	"
(1)F	At Grade: 14th Ave NW/NW 49th St	SF	$80	19,000	$ 1,500,000	"
(1)G	At Grade: Traffic Signals	LS	$1 M	1	$ 1,000,000	Order of magnitude cost for concept assumed
(2)A	Ballard Bridge: Replaced Movable Span	SF	$2900	23,000	$ 67,000,000	Line item cost per Attachment B (cost has been normalized based on bridge plan area)
(2)B	Ballard Bridge: 15th Ave App Spans Over Water	SF	$420	147,000	$ 62,000,000	Prestressed Concrete Girder, Water Crossing w/piling, High Cost
(2)C	Ballard Bridge: 15th Ave App Spans Over Land	SF	$380	73,000	$ 28,000,000	Prestressed Concrete Girder, Dry Crossing w/piling, High Cost
(2)D	New Emerson-Nickerson Bridge	SF	$380	96,000	$ 36,000,000	"
(2)E	Bridge: 15th Ave Ramps to SPUI	SF	$380	62,000	$ 24,000,000	"
(2)F	Bridge: SB On Ramp @ NW Leary Way	SF	$380	42,000	$ 16,000,000	"
(2)G	Bridge: NB Off-Ramp@NW 49th St	SF	$380	7,300	$ 2,800,000	"
(2)H	Bridge: Temporary Detour Crossing	LS	$32 M	1	$ 32,300,000	Derived from Temporary Bridge cost and WSDOT BDM substructure unit costs
(3)A	Retaining Wall: 15th Ave - North Approach	SF	$120	16,000	$ 1,920,000	"
(3)B	Retaining Wall: W Nickerson St - East Approach	SF	$120	32,000	$ 3,840,000	Derived from takeoff of key items for a representative RT wall embankment ramp structure
(3)C	Retaining Wall: WNickerson St - SB On-Ramp	SF	$120	28,000	$ 3,360,000	"
(3)D	Retaining Wall: W Emerson St - West Approach	SF	$120	21,000	$ 2,520,000	"
(3)E	Retaining Wall: SB On-Ramp@NW Leary Way	SF	$120	16,000	$ 1,920,000	"
(3)F	Retaining Wall: NB Off-Ramp@NW 49th St	SF	$120	11,000	$ 1,320,000	"
(0)	Removal - Subtotal				$ 20,000,000	sum of (0) subitems
(1)	At Grade - Subtotal				$ 57,000,000	sum of (1) subitems
(2)	Bridge - Subtotal				$ 268,000,000	sum of (2) subitems
(3)	Wall - Subtotal				$ 15,000,000	sum of (3) subitems
(4)	Subtotal				$ 360,000,000	=(0)+(0')+(1)+(2)+(3)
(5)	Undefined Items (Design Contingency)				$ 108,000,000	30% applied to (4)
(6)	Mobilization				$ 36,000,000	10% applied to (4)
(7)	**Total ROM Construction Cost**				**$ 504,000,000**	=(4)+(5)+(6)
(8)	PE Costs				$ 101,000,000	20% applied to (7)
(9)	Construction Contingency				$ 151,000,000	30% applied to (7)
(10)	Construction Engineering				$ 101,000,000	20% applied to (7)
(11)	Right of Way Cost				$ 114,000,000	ROW cost per Attachment B
(12)	**ROM Comparative Cost Total**				**$ 971,000,000**	=(7)+(8)+(9)+(10)+(11)
(13)	ROM Comparative Cost Range (Lower Bound)				$ 680,000,000	70% of (7)
(14)	ROM Comparative Cost Range (Upper Bound)				$ 1,460,000,000	150% of (7)

NOTES: * Rounded value

1. Unit cost for bridges has been taken from WSDOT BDM App 12.3-A1 reference unit costs, but with additional 20% premium to account for increased construction heights required for Ballard Bridge.
2. Cost estimates are based on 2019 dollars and a 0% to 2% level of project definition.
3. Estimates do not include: Operations and Maintenance Costs, Environmental permitting or mitigation costs, Contaminated material characterization, handling, or disposal, Sales taxes, Inflation - Costs should be inflated to planned year of construction, and Financing.
4. The costs presented herein were prepared for guidance in project evaluation and facility planning. Actual long-term and construction costs will differ from the costs shown. Final project costs are dependent upon many variable factors including, but not limited to, labor and material costs, site conditions, productivity, competitive market conditions, final project scope, and the contractor's implementation schedule.

Attachment A - Rough Order of Magnitude (ROM) Comparative Cost Estimates

A(3) HIGH-LEVEL ALTERNATIVE - SUMMARY COST SCHEDULE

No.	Item	Unit of Measure	Unit Cost*	Total Qty*	Line Cost*	Basis / Notes / Calculation Formula
(0)A	Removal: At Grade - South	SF	$15	269,000	$ 4,000,000	*Removal of at grade features taken as a factor of new cost*
(0)B	Removal: At Grade - North	SF	$15	415,000	$ 6,200,000	"
(0)C	Removal: Retaining Walls - W Emerson St	SF	$25	10,000	$ 250,000	*Removal of retaining wall supported embankments taken as a factor of new cost*
(0)D	Removal: Retaining Walls - 15th Ave NW@NW 46th $	SF	$25	25,000	$ 630,000	"
(0)E	Removal: Retaining Walls - 15th Ave NW@NW 49th $	SF	$25	14,000	$ 350,000	"
(0)F	Removal: Ballard Bridge Above Water	SF	$35	90,000	$ 3,200,000	*BDM Median Cost for "Concrete Bridge Removal"*
(0)G	Removal: Ballard Bridge Above Land	SF	$35	57,000	$ 2,000,000	"
(0)H	Removal: Ballard Bridge - Movable Span	SF	$50	17,000	$ 850,000	*BDM High Cost for "Concrete Bridge Removal"*
(0)I	Removal: Nickerson-Emerson Bridge	SF	$35	64,000	$ 2,200,000	*BDM Median Cost for "Concrete Bridge Removal"*
(1)A	At Grade: 15th Ave W - South	SF	$80	23,000	$ 1,800,000	*Derived from WSDOT PLCE tool cost per lane-mile (Puget Sound - Urban Setting, inflated from 2012$ to 2019$)*
(1)B	At Grade: 15th Ave NW - North	SF	$80	361,000	$ 28,900,000	"
(1)C	At Grade: W Nickerson St	SF	$80	36,000	$ 2,900,000	"
(1)D	At Grade: W Emerson St	SF	$80	23,000	$ 1,800,000	"
(1)E	At Grade: 14th Ave NW / NW 51st St / NW 52nd St	SF	$80	98,000	$ 7,800,000	"
(1)G	At Grade: Traffic Signals	LS	$1 M	1	$ 1,000,000	*Order of magnitude cost for concept assumed*
(2)A	Ballard Bridge: Fixed Long-Span Bridge	SF	$1000	50,000	$ 50,000,000	*Based on COWI previous project experience*
(2)B	Ballard Bridge: 15th Ave App Spans Over Water	SF	$490	102,000	$ 50,000,000	*Prestressed Concrete Girder, Water Crossing w/piling, High Cost*
(2)C	Ballard Bridge: 15th Ave App Spans Over Land	SF	$450	189,000	$ 85,000,000	*Prestressed Concrete Girder, Dry Crossing w/piling, High Cost*
(2)D	Bridge: New Emerson-Nickerson Bridge	SF	$400	99,000	$ 40,000,000	"
(2)E	Bridge: 15th Ave Ramps to SPUI	SF	$450	64,000	$ 29,000,000	"
(2)F	Bridge: On/Off Ramp @ NW Leary Way	SF	$450	29,000	$ 13,000,000	"
(3)A	Retaining Wall: 15th Ave North Approach	SF	$120	26,000	$ 3,100,000	*Derived from takeoff of key items for a representative RT wall embankment ramp structure*
(3)B	Retaining Wall: 15th Ave South Approach	SF	$120	31,000	$ 3,700,000	"
(3)C	Retaining Wall: W Nickerson St - East Approach	SF	$120	50,000	$ 6,000,000	"
(3)D	Retaining Wall: W Nickerson St - NB Off-Ramp	SF	$120	31,000	$ 3,700,000	"
(3)E	Retaining Wall: W Nickerson St - SB On-Ramp	SF	$120	43,000	$ 5,200,000	"
(3)F	Retaining Wall: W Emerson St - West Approach	SF	$120	18,000	$ 2,200,000	"
(3)G	Retaining Wall: NW Leary Way Ramp	SF	$120	26,000	$ 3,100,000	"
(0)	Removal - Subtotal				$ 20,000,000	*sum of (0) subitems*
(1)	At Grade - Subtotal				$ 44,000,000	*sum of (1) subitems*
(2)	Bridge - Subtotal				$ 267,000,000	*sum of (2) subitems*
(3)	Wall - Subtotal				$ 27,000,000	*sum of (3) subitems*
(4)	Subtotal				$ 358,000,000	*=(0)+(1)+(2)+(3)*
(5)	Undefined Items (Design Contingency)				$ 107,000,000	*30% applied to (4)*
(6)	Mobilization				$ 36,000,000	*10% applied to (4)*
(7)	**Total ROM Construction Cost**				**$ 501,000,000**	*=(4)+(5)+(6)*
(8)	PE Costs				$ 100,000,000	*20% applied to (7)*
(9)	Construction Contingency				$ 150,000,000	*30% applied to (7)*
(10)	Construction Engineering				$ 100,000,000	*20% applied to (7)*
(11)	Right of Way Cost				$ 130,000,000	*ROW cost per Attachment B*
(12)	**ROM Comparative Cost Total**				**$ 981,000,000**	*=(7)+(8)+(9)+(10)+(11)*
(13)	ROM Comparative Cost Range (Lower Bound)				$ 690,000,000	*70% of (9)*
(14)	ROM Comparative Cost Range (Upper Bound)				$ 1,470,000,000	*150% of (9)*

* Rounded value

NOTES:

1. Unit cost for bridges has been taken from WSDOT BDM App 12.3-A1 reference unit costs, but with additional 40% premium to account for increased construction heights required for Ballard Bridge.
2. Cost estimates are based on 2019 dollars and a 0% to 2% level of project definition.
3. Estimates do not include: Operations and Maintenance Costs, Environmental permitting or mitigation costs, Contaminated material characterization, handling, or disposal, Sales taxes, Inflation - Costs should be inflated to planned year of construction, and Financing.
4. The costs presented herein were prepared for guidance in project evaluation and facility planning. Actual long-term and construction costs will differ from the costs shown. Final project costs are dependent upon many variable factors including, but not limited to, labor and material costs, site conditions, productivity, competitive market conditions, final project scope, and the contractor's implementation schedule.

Attachment B – Right-Of-Way (ROW)

Ballard Bridge Planning Study

ROW Impacts - Summary by Alternative

SCJ Alliance, November 25, 2019

Alternative	Total Take (SF)	Just Compensation	Total Cost of ROW Including Acquisition	Total Value of Remnant Sales	Net ROW Cost Including Acquisition	Rounded Net ROW Cost Including Acquisition	
Low-Level Alternative	164,043	$81,370,841	$91,875,639	-$11,264,850	$80,610,789	$81,000,000	◕
Mid-Level Alternative	304,751	$120,506,717	$136,282,911	-$22,591,389	$113,691,522	$114,000,000	◐
High-Level Alternative	282,734	$130,763,135	$147,665,866	-$18,082,241	$129,583,625	$130,000,000	◔

Constructed Evaluation Scale for Rating			
Best	$ -	$ 60,000,000	●
Better	$ 60,000,000	$ 90,000,000	◕
Netural	$ 90,000,000	$ 120,000,000	◐
Worse	$ 120,000,000	$ 150,000,000	◔
Worst	$ 150,000,000	$ -	○

ALTERNATIVE	RANGE OF COSTS		
Low-Level Alternative	$57,000,000	to	$122,000,000
Mid-Level Alternative	$80,000,000	to	$171,000,000
High-Level Alternative	$91,000,000	to	$195,000,000

Notes and Disclaimers:

This estimate was prepared as part of a conceptual engineering estimate based on percentages only with little consideration of actual impacts to specific properties (except to adjust percentages for costs to cure). It was intended to be a comparative cost estimate for ROW for Alternatives Analysis purposes as well as a conceptual level estimate. A True Cost Estimate should be prepared at the next state of this evaluation by a certified ROW expert that includes parcel-specific compensation, costs to cure, relocation, aquisition and condemnation costs for the City.

ROW just compensation cost is based on the appraised value plus 50% to account for actual market values. Where parcels have been recently sold, this methodology likely results in an overstating of the value of a parcel.

ROW costs are estimated in 2019 dollars and are not escalated.

Other assumed percentages are shown on the summary sheets.

Ballard Bridge Planning Study
ROW Impacts - Low-Level Alternative
SCJ Alliance, November 25, 2019

Adjusted Value (% Appraised Value)

Appraised Value x 140%

Aerial Easement Value Adjustment

Appraised Value x 50%

No	Parcel Number	Parcel Owner	Total Parcel Size (SF)	2019 Appraised Land Value	2019 Appraised Improvement Value	2019 Total Appraised Value	Appraised Land Value per SF	Aerial Easment or Land Purchase	Adjusted Land Value per SF	Adjusted Parcel Value	ROW Impacted (SF)	Total Take	ROW Take (SF)	ROW Cost	Observed Impacts
0A	2768303245	BLOCK AT BALLARD II LLC	48,388	$5,806,500	$2,681,100	$8,487,600	$120	Land	$168	$11,882,640	90	No	90	$15,120	Minor take at corner of property.
0B	2768400010	TREUER CHRISTIN L	5,618	$674,100	$33,000	$707,100	$120	Land	$168	$989,940	500	No	500	$83,993	Minor take at corner of property.
0C	2767702230	ARGONAUT PROPERTIES INC	4,270	$1,712,400	$940,800	$2,653,200	$401	Land	$561	$3,714,480	96	No	96	$53,898	Minor take at corner of property.
1	8847800000	URBAN TERRACE CONDOMINIUM B	22,441	$2,803,800	$4,242,200	$7,046,000	$125	Land	$175	$9,864,400	476	No	476	$83,261	No functional property use changes.
2	2770603425	PAYNE R GREGORY	2,825	$326,000	$184,000	$510,000	$115	Land	$162	$714,000	289	No	289	$46,680	No functional property use changes.
3	2770603430	PAYNE GREG	2,825	$326,000	$93,000	$419,000	$115	Land	$162	$586,600	340	No	340	$54,970	No functional property use changes.
4	2770603420	SANKIEWICZ PIOTR	5,650	$656,000	$69,000	$725,000	$116	Land	$163	$1,015,000	853	No	853	$138,635	Building impacts
5	2770603415	PEREZ PEDRO A & ASTRID	5,650	$656,000	$75,000	$731,000	$116	Land	$163	$1,023,400	1,121	No	1,121	$182,202	Building impacts, elimination of parking
6	2770603410	PEREZ PEDRO	5,650	$706,200	$163,700	$869,900	$125	Land	$175	$1,217,860	1,260	No	1,260	$220,495	Parking loss
7	2770603315	3600 INTERBAY LLC	16,887	$2,110,800	$2,375,400	$4,486,200	$125	Land	$175	$6,280,680	4,295	Yes	16,887	$6,280,680	Building Demolition
8	2770603295	REEVES SHERING	10,823	$1,352,800	$1,000	$1,353,800	$125	Land	$175	$1,895,320	2,831	Yes	10,823	$1,895,320	Building Impacts
9	2771101580	ESSEX PROPERTY TRUST INC	33,453	$4,181,600	$29,840,400	$34,022,000	$125	Land	$175	$47,630,800	8,518	Yes	33,453	$47,630,800	A portion of three buildings to be demolished.
10	2770605769	DSC CAPITAL	42,750	$8,466,700	$14,324,700	$22,791,400	$198	Land	$277	$31,907,960	4,609	No	4,609	$1,277,844	Potential Parking Impacts
11	2770605642	BNSF	115,775	$10,419,700	$0	$10,419,700	$90	Aerial	$63	$14,587,580	3,581	No	3,581	$225,602	No observable physical impacts
12	7666200120	SALMON BAY TERMINALS	570,278	$21,392,000	$1,827,500	$23,219,500	$38	Land	$53	$32,507,300	8,218	No	8,218	$431,571	Potential vehicle turning impacts for property below structure
13	2770603199	INTERBAY RISING NORTH LLC	53,325	$9,331,800	$90,000	$9,421,800	$175	Land	$245	$13,190,520	4,603	No	4,603	$1,127,657	Parking access impacts
14	2770603130	MOOERS BUILDING ASSOC LLC	24,088	$2,167,900	$4,778,700	$6,946,600	$90	Land	$126	$9,725,240	1,464	No	1,464	$184,451	Parking access impacts
15	2771101675	READ PRODUCTS INC	42,750	$3,847,500	$1,000	$3,848,500	$90	Land	$126	$5,387,900	18,959	Yes	42,750	$5,387,900	Building to be demolished
16s	2771101760	READ PRODUCTS INC (SOUTH)	76,763	$6,922,740	$850	$6,923,590	$90	Land	$126	$9,693,026	1,244	No	1,244	$157,063	Parking Impacts
16n	2771101760	READ PRODUCTS INC (NORTH)	13,731	$1,221,660	$150	$1,221,810	$89	Land	$125	$1,710,534	7,943	Yes	13,731	$1,710,534	Proposed structure would take most of parcel
17	2771101480	CITY OF SEATTLE FAS	7,750	$697,500	$0	$697,500	$90	Land	$126	$976,500					None
18	2771101465	CITY OF SEATTLE SDOT	360	$1,800	$0	$1,800	$5	Land	$7	$2,520					None
19	2771101445	CITY OF SEATTLE SDOT	275	$1,300	$0	$1,300	$5	Land	$7	$1,820					None
20	2770605643	CITY OF SEATTLE FAS	4,967	$447,000	$0	$447,000	$90	Land	$126	$625,800					None
21	2771102700	BNSF	250,470	$22,542,300	$0	$22,542,300	$90	Aerial	$63	$31,559,220	3,053	No	3,053	$192,323	No observable physical impacts
22	2771101800	BNSF	1,193,544	$107,418,900	$1,000	$107,419,900	$90	Aerial	$63	$150,387,860	2,141	No	2,141	$134,883	No observable physical impacts

ROW Impacts - Low-Level Alternative

SCJ Alliance, November 25, 2019

Appraised Value x 140%

Appraised Value x 50%

No	Parcel Number	Parcel Owner	Total Parcel Size (SF)	2019 Appraised Land Value	2019 Appraised Improvement Value	2019 Total Appraised Value	Appraised Land Value per SF	Aerial Easment or Land Purchase	Adjusted Land Value per SF	Adjusted Parcel Value	ROW Impacted (SF)	Total Take	ROW Take (SF)	ROW Cost	Observed Impacts
23	2771101802	PORT OF SEATTLE	11,507	$1,035,600	$0	$1,035,600	$90	Land	$126	$1,449,840	545	No	545	$68,619	Changes to property access
24	2771101801	PORT OF SEATTLE	32,600	$2,934,000	$0	$2,934,000	$90	Land	$126	$4,107,600	1,511	No	1,511	$190,441	Changes to property access
25	132503HYDR	CITY OF SEATTLE	N/A	$0	$0	$0	N/A	Aerial	N/A	N/A	5,957	No	5,957	N/A	Over water
26	7666200105	PORT OF SEATTLE	2,335,491	$112,717,200	$7,688,100	$120,405,300	$48	Aerial	$34	$168,567,420	4,449	No	4,450	$150,325	Over water and structures

TOTAL TAKES **164,043**

Ballard Bridge Planning Study
ROW Impacts - Low-Level Alternative
SCJ Alliance, November 25, 2019

Cost to Cure (% of Take)
Low = 10%
Medium = 15%
High = 20%

TCE Cost
TCE Width (LF) = 5
Duration (months) = 18
TCE Cost per Year (% of Adjusted $/SF) = 10%

Negotiation Costs
Low = $4,500
Medium = $6,750
High = $10,000

Condemnation and Incidental
15%

Turnback Value (Empty ROW)
= $150

No	Parcel Number	Parcel Owner	Additional Notes on ROW Impacts and Cure Needs	Cost to Cure	Cost to Cure	Length of Frontage	TCE Area	TCE Cost	Just Compensation	Appraisal Fee Costs	Appraisal Review Costs	Negotiation Fee Costs	Title, Escrow Costs	Condemnation & Incidental Costs	Statutory Evaluation Allowance	TOTAL COST PER PARCEL	ROW to Turnback	Adjusted Value of Turnback ROW per SF	VALUE OF TURNBACK
0A	2768303245	BLOCK AT BALLARD II LLC	No building impact.	Low	$1,512	-	-	$0	$16,632	$2,500	$1,000	$4,500	$1,500	$2,268	$750	$29,150	-	-$150	-
0B	2768400010	TREUER CHRISTIN L	Will impact some temporary structures.	High	$16,799	126	628	$10,541	$111,332	$2,500	$1,000	$10,000	$1,500	$12,599	$750	$139,681	-	-$150	-
0C	2767702230	ARGONAUT PROPERTIES INC	Gravel parking lot; minimal impact.	Low	$5,390	33	164	$9,180	$68,468	$2,500	$1,000	$4,500	$1,500	$8,085	$750	$86,803	-	-$150	-
1	8847800000	URBAN TERRACE CONDOMINIUM B	Retaining wall will need to be constructed.	Low	$8,326	98	488	$8,527	$100,114	$2,500	$1,000	$4,500	$1,500	$12,489	$750	$122,853	-	-$150	-
2	2770603425	PAYNE R GREGORY	Retaining wall will need to be constructed.	Low	$4,668	26	130	$2,100	$53,449	$2,500	$1,000	$4,500	$1,500	$7,002	$750	$70,701	-	-$150	-
3	2770603430	PAYNE GREG	Retaining wall will need to be constructed.	Low	$5,497	24	120	$1,939	$62,406	$2,500	$1,000	$4,500	$1,500	$8,245	$750	$80,901	-	-$150	-
4	2770603420	SANKIEWICZ PIOTR	A portion of the building would need to be reconstructed.	High	$27,727	50	250	$4,064	$170,425	$2,500	$1,000	$10,000	$1,500	$20,795	$750	$206,970	-	-$150	-
5	2770603415	PEREZ PEDRO A & ASTRID	A portion of the building would need to be reconstructed and the parking lot on west side of the parcel would be lost.	High	$36,440	51	253	$4,104	$222,747	$2,500	$1,000	$10,000	$1,500	$27,330	$750	$265,828	-	-$150	-
6	2770603410	PEREZ PEDRO	Parking stall on the west side of the property would be lost.	Low	$22,049	50	251	$4,392	$246,937	$2,500	$1,000	$4,500	$1,500	$33,074	$750	$290,261	-	-$150	-
7	2770603315	3600 INTERBAY LLC	A large portion of the building would be demolished. Unsure if a portion of the building could be salvaged and retain similar use.	High	$1,256,136	-	-	$0	$7,536,816	$2,500	$1,000	$10,000	$1,500	$942,102	$750	$8,494,668	12,592	-$150	(1,888,800)
8	2770603295	REEVES SHERING	A portion of the building would be demolished and all their parking and access off of 15th Ave NW would be lost. Potential for this to be a total take.	High	$379,064	-	-	$0	$2,274,384	$2,500	$1,000	$10,000	$1,500	$284,298	$750	$2,574,432	7,992	-$150	(1,198,800)
9	2771101580	ESSEX PROPERTY TRUST INC	Because of the significant demolition of three buildings on this parcel, it looks to be a total take.	High	$9,526,160	-	-	$0	$57,156,960	$2,500	$1,000	$10,000	$1,500	$7,144,620	$750	$64,317,330	24,935	-$150	(3,740,250)
10	2770605769	DSC CAPITAL	Property below structure. Large billboard structure to be relocated or demolished. Air space lease for this property for structure above?	Medium	$191,677	132	660	$18,300	$1,487,821	$2,500	$1,000	$6,750	$1,500	$191,677	$750	$1,691,998	-	-$150	-
11	2770605642	BNSF	BNSF property both sides of the Ballard Bridge structure, east and west side as noted in the roll plot figure. Air space lease for this property for structure above? Buildings on northwest section of parcel will be below new bridge structure. (Takes = 2,621 (east) + 679 (southwest) + 281 (northwest))	Low	$22,560	276	1,379	$8,685	$256,847	$2,500	$1,000	$4,500	$1,500	$33,840	$750	$300,937	-	-$150	-
12	7666200120	SALMON BAY TERMINALS	Need to investigate clearance from proposed Ballard Bridge structure expansion to existing building. Looks to be no impacts. Air space lease for this property for structure above? New bridge columns for structure expansion may impact truck vehicle turning operations.	Medium	$64,736	451	2,255	$11,842	$508,149	$2,500	$1,000	$6,750	$1,500	$64,736	$750	$585,385	-	-$150	-
13	2770603199	INTERBAY RISING NORTH LLC	Would need to reconfigure access to the parking lot and parcel	Medium	$169,149	280	1,402	$34,336	$1,331,142	$2,500	$1,000	$6,750	$1,500	$169,149	$750	$1,512,791	-	-$150	-
14	2770603130	MOOERS BUILDING ASSOC LLC	Would need to provide reconfigured access to the parcel.	Medium	$27,668	32	162	$2,041	$214,160	$2,500	$1,000	$6,750	$1,500	$27,668	$750	$254,327	-	-$150	-
15	2771101675	READ PRODUCTS INC	ROW take goes diagonally through parcel, with a large ROW take, so the assumption is total take	High	$1,077,580	-	-	$0	$6,465,480	$2,500	$1,000	$10,000	$1,500	$808,185	$750	$7,289,415	23,791	-$150	(3,568,650)
16s	2771101760	READ PRODUCTS INC (SOUTH)	Impacts a vehicle storage area	Low	$15,706	100	499	$6,300	$179,070	$2,500	$1,000	$4,500	$1,500	$23,559	$750	$212,879	-	-$150	-
16n	2771101760	READ PRODUCTS INC (NORTH)	Due to the percentage of property take for proposed structure, assume whole north section of parcel would need to be purchased. (Takes = 7,242 +710)	High	$342,107	-	-	$0	$2,052,641	$2,500	$1,000	$10,000	$1,501	$256,580	$751	$2,324,973	5,788	-$150	(868,200)
17	2771101480	CITY OF SEATTLE FAS	Maybe need to transfer ownership from FAS to SDOT	None	$0	-	-	$0	$0							$0	-	-$150	-
18	2771101465	CITY OF SEATTLE SDOT	SDOT City property. No need to purchase for project.	None	$0	-	-	$0	$0							$0	-	-$150	-
19	2771101445	CITY OF SEATTLE SDOT	SDOT City property. No need to purchase for project.	None	$0	-	-	$0	$0							$0	-	-$150	-
20	2770605643	CITY OF SEATTLE FAS	Building below structure on parcel. Maybe need to transfer ownership from FAS to SDOT?	None	$0	-	-	$0	$0							$0	-	-$150	-
21	2771102700	BNSF	Revision to air space lease for expansion of structure above track?	Low	$19,232	84	420	$2,646	$214,202	$2,500	$1,000	$4,500	$1,500	$28,848	$750	$253,300	-	-$150	-
22	2771101800	BNSF	Revision to air space lease for expansion of structure above track?	Low	$13,488	128	638	$4,016	$152,387	$2,500	$1,000	$4,500	$1,500	$20,232	$750	$182,870	-	-$150	-

ROW Impacts - Low-Level Alternative

SCJ Alliance, November 25, 2019

Low =	10%	TCE Width (LF) =	5	Low =	$4,500	15%	= $150
Medium =	15%	Duration (months) =	18	Medium =	$6,750		
High =	20%	TCE Cost per Year (% of Adjusted $/SF) =	10%	High =	$10,000		

No	Parcel Number	Parcel Owner	Additional Notes on ROW Impacts and Cure Needs	Cost to Cure	Cost to Cure	Length of Frontage	TCE Area	TCE Cost	Just Compensation	Appraisal Fee Costs	Appraisal Review Costs	Negotiation Fee Costs	Title, Escrow Costs	Condemnation & Incidental Costs	Statutory Evaluation Allowance	TOTAL COST PER PARCEL	ROW to Turnback	Adjusted Value of Turnback ROW per SF	VALUE OF TURNBACK
23	2771101802	PORT OF SEATTLE	Impacts to vehicle access to the property	Medium	$10,293	30	150	$1,890	$80,802	$2,500	$1,000	$6,750	$1,501	$10,293	$751	$103,596	-	-$150	-
24	2771101801	PORT OF SEATTLE	Impacts to vehicle access to the property	Medium	$28,566	41	205	$2,583	$221,591	$2,500	$1,000	$6,750	$1,502	$28,566	$752	$262,661	-	-$150	-
25	132503HYDR	CITY OF SEATTLE	No parcel owner, so no ROW compensation	None	$0														
26	7666200105	PORT OF SEATTLE	Revision to air space lease for expansion of structure above water?	Medium	$22,549	770	3,850	$13,007	$185,880	$2,500	$1,000	$6,750	$1,500	$22,549	$750	$220,929	1	-$150	(150)

TOTAL JUST COMPENSATION **$81,370,841**

TOTAL COST INCL ACQUISTION **$91,875,639**

TOTAL TURNBACK **(11,264,850)**

TOTAL COST OF ROW INCLUDING ACQUISITION = $91,875,639
TOTAL VALUE OF REMNANT SALES = -$11,264,850
NET ROW COST INCLUDING ACQUISITION = $80,610,789
ROUNDED NET ROW COST INCLUDING ACQUISITION = $81,000,000

ROUNDED NET ROW COST INCLUDING ACQUISITION
Rounded Net ROW Cost Including Acquisition

Ballard Bridge Planning Study
ROW Impacts - Mid-Level Alternative
SCJ Alliance, November 25, 2019

Adjusted Value (% Appraised Value)

Appraised Value x 140%

Aerial Value Adjustment

Appraised Value x 50%

No	Parcel Number	Parcel Owner	Total Parcel Size (SF)	2019 Appraised Land Value	2019 Appraised Improvement Value	2019 Total Appraised Value	Appraised Land Value per SF	Aerial Easment or Land Purchase	Adjusted Land Value per SF	Adjusted Parcel Value	ROW Impacted (SF)	Total Take	ROW Take (SF)	ROW Cost	Observed Impacts
1	8847800000	URBAN TERRACE CONDOMINIUM B	22,441	$2,803,800	$4,242,200	$7,046,000	$125	Land	$175	$9,864,400	476	No	476	$83,261	No functional property use changes.
2	2770603425	PAYNE R GREGORY	2,825	$326,000	$184,000	$510,000	$115	Land	$162	$714,000	289	No	289	$46,680	No functional property use changes.
3	2770603430	PAYNE GREG	2,825	$326,000	$93,000	$419,000	$115	Land	$162	$586,600	340	No	340	$54,970	No functional property use changes.
4	2770603420	SANKIEWICZ PIOTR	5,650	$656,000	$69,000	$725,000	$116	Land	$163	$1,015,000	853	No	853	$138,635	Building impacts
5	2770603415	PEREZ PEDRO A & ASTRID	5,650	$656,000	$75,000	$731,000	$116	Land	$163	$1,023,400	1,121	No	1,121	$182,202	Building impacts, elimination of parking
6	2770603410	PEREZ PEDRO	5,650	$706,200	$163,700	$869,900	$125	Land	$175	$1,217,860	1,260	No	1,260	$220,495	Parking loss
7	2770603315	3600 INTERBAY LLC	16,887	$2,110,800	$2,375,400	$4,486,200	$125	Land	$175	$6,280,680	4,295	Yes	16,887	$6,280,680	Building Demolition
8	2770603295	REEVES SHERING	10,823	$1,352,800	$1,000	$1,353,800	$125	Land	$175	$1,895,320	2,831	Yes	10,823	$1,895,320	Building Impacts
9	2771101580	ESSEX PROPERTY TRUST INC	33,453	$4,181,600	$29,840,400	$34,022,000	$125	Land	$175	$47,630,800	8,518	Yes	33,453	$47,630,800	A portion of three buildings to be demolished.
10	2770605769	DSC CAPITAL	42,750	$8,466,700	$14,324,700	$22,791,400	$198	Land	$277	$31,907,960	4,609	No	4,609	$1,277,844	Potential Parking Impacts
11	2770605642	BNSF	115,775	$10,419,700	$0	$10,419,700	$90	Aerial	$63	$14,587,580	3,581	No	3,581	$225,602	No observable physical impacts
12	7666200120	SALMON BAY TERMINALS	570,278	$21,392,000	$1,827,500	$23,219,500	$38	Land	$53	$32,507,300	8,218	No	8,218	$431,571	Potential vehicle turning impacts for property below structure
13	2770603199	INTERBAY RISING NORTH LLC	53,325	$9,331,800	$90,000	$9,421,800	$175	Land	$245	$13,190,520	4,603	No	4,603	$1,127,657	Parking access impacts
14	2770603130	MOOERS BUILDING ASSOC LLC	24,088	$2,167,900	$4,778,700	$6,946,600	$90	Land	$126	$9,725,240	1,464	No	1,464	$184,451	Parking access impacts
15	2771101675	READ PRODUCTS INC	42,750	$3,847,500	$1,000	$3,848,500	$90	Land	$126	$5,387,900	18,959	Yes	42,750	$5,387,900	Building to be demolished
16s	2771101760	READ PRODUCTS INC (SOUTH)	76,763	$6,922,740	$850	$6,923,590	$90	Land	$126	$9,693,026	1,244	No	1,244	$157,063	Parking Impacts
16n	2771101760	READ PRODUCTS INC (NORTH)	13,731	$1,221,660	$150	$1,221,810	$89	Land	$125	$1,710,534	7,943	Yes	13,731	$1,710,534	Proposed structure would take most of parcel
17	2771101480	CITY OF SEATTLE FAS	7,750	$697,500	$0	$697,500	$90	Land	$126	$976,500				$0	None
18	2771101465	CITY OF SEATTLE SDOT	360	$1,800	$0	$1,800	$5	Land	$7	$2,520				$0	None
19	2771101445	CITY OF SEATTLE SDOT	275	$1,300	$0	$1,300	$5	Land	$7	$1,820				$0	None
20	2770605643	CITY OF SEATTLE FAS	4,967	$447,000	$0	$447,000	$90	Land	$126	$625,800				$0	None
21	2771102700	BNSF	250,470	$22,542,300	$0	$22,542,300	$90	Aerial	$63	$31,559,220	3,053	No	3,053	$192,323	No observable physical impacts
22	2771101800	BNSF	1,193,544	$107,418,900	$1,000	$107,419,900	$90	Aerial	$63	$150,387,860	2,141	No	2,141	$134,883	No observable physical impacts
23	0467000385	TREUER CHRISTIN L	127,806	$6,886,800	$874,600	$7,761,400	$54	Land	$75	$10,865,960	10,314	No	10,314	$778,056	New structure over existing building footprint. 3 buildings to be demolished.
24	2768400015	TREUER CHRISTIN L	5,609	$673,000	$0	$673,000	$120	Land	$168	$942,200	1,616	No	1,616	$271,498	1 small building to be demolished, a small portion of a second building to be demolished and reconfigured.
25	2768400020	MAZZARELLA TONY	5,645	$677,400	$152,600	$830,000	$120	Land	$168	$1,162,000	3,083	Yes	5,645	$1,162,000	Building to be demolished
26	2767702270	1526 NW 46TH LLC	1,500	$1,800,000	$1,000	$1,801,000	$1,200	Land	$1,680	$2,521,400	5,830	Yes	1,500	$2,521,400	Portion of building to be demolished
27	2767702290	HUFF COMMERCIAL PROPERTIES	9,975	$1,197,000	$542,600	$1,739,600	$120	Land	$168	$2,435,440	637	No	637	$107,016	Portion of building to be demolished
28	2767702215	SPRUTE HERB TRUSTEE	5,000	$600,000	$22,600	$622,600	$120	Land	$168	$871,640	544	No	544	$91,392	Portion of building to be demolished for structure and cul-de-sac
29	2767702205	HUFF COMMERCIAL PROPERTIES	6,000	$720,000	$688,000	$1,408,000	$120	Land	$168	$1,971,200	4,363	Yes	6,000	$1,971,200	Building to be demolished
30	2767702190	LMI BUILDING LLC	21,200	$2,544,000	$377,500	$2,921,500	$120	Land	$168	$4,090,100	1,961	No	1,961	$329,448	Small Corner of northeast corner of the building to be demolished. Parking lot loss. Portion of northwest corner building demolished for cul-de-sac.

Ballard Bridge Planning Study

ROW Impacts - Mid-Level Alternative

SCJ Alliance, November 25, 2019

Adjusted Value (% Appraised Value)

Appraised Value x 140%

Aerial Value Adjustment

Appraised Value x 50%

No	Parcel Number	Parcel Owner	Total Parcel Size (SF)	2019 Appraised Land Value	2019 Appraised Improvement Value	2019 Total Appraised Value	Appraised Land Value per SF	Aerial Easment or Land Purchase	Adjusted Land Value per SF	Adjusted Parcel Value	ROW Impacted (SF)	Total Take	ROW Take (SF)	ROW Cost	Observed Impacts
31	2767702160	ELLSTROM THOMAS A+ELISABETH	15,000	$1,800,000	$528,400	$2,328,400	$120	Land	$168	$3,259,760	922	No	929	$156,072	Small Corner of southwest corner of the building to be demolished. Small portion of structure take for cul-de-sac.
32	2767702170	ELLSTROM PROPERTIES LLC	10,000	$1,200,000	$20,000	$1,220,000	$120	Land	$168	$1,708,000	4,539	Yes	10,000	$1,708,000	Most of building to be demolished
33	2767702185	POWERS ELIZABETH	2,500	$300,000	$899,000	$1,199,000	$120	Land	$168	$1,678,600	626	No	626	$105,084	Portion of building to be demolished
34	2767702180	LOGAN DAVIDL	2,500	$300,000	$111,200	$411,200	$120	Land	$168	$575,680	610	No	610	$102,396	Portion of building to be demolished
35	2767702065	THOMPSON HARVEY E+THOMPSON	13,200	$1,584,000	$33,900	$1,617,900	$120	Land	$168	$2,265,060	9,814	Yes	13,200	$2,265,060	Most of building to be demolished, and majority of parcel taken for roadway.
36	2767702070	NELSON FAMILY ASSOCIATES LL	4,400	$528,000	$516,000	$1,044,000	$120	Land	$168	$1,461,600	933	Yes	4,400	$1,461,600	Portion of building to be demolished
36A	2767703340	OLD BALLARD L L C	5,700	$769,500	$1,051,400	$1,820,900	$135	Land	$189	$2,549,260	16	No	16	$3,024	Small corner of parcel take
37	2768302475	LAH LLC % SHELLEEN A HAIGHT	13,744	$1,649,200	$1,000	$1,650,200	$120	Land	$168	$2,310,280	2,480	No	2,480	$416,536	Portion of building to be demolished, and parking lot to be demolished.
38	2768302530	BALLARD FOOD BANK	5,000	$600,000	$0	$600,000	$120	Land	$168	$840,000	228	No	228	$38,326	No functional property use changes.
39	2767701995	MILLER PAINT CO INC	13,799	$1,862,800	$1,000	$1,863,800	$135	Land	$189	$2,609,320	844	Yes	13,799	$2,609,320	Sidewalk through building
40	2767701880	MALONEY JOHN W	5,945	$802,500	$1,000	$803,500	$135	Land	$189	$1,124,900	423	Yes	5,945	$1,124,900	Sidewalk through building
41	2767701830	SBFO CORP	61,066	$8,243,900	$1,000	$8,244,900	$135	Land	$189	$11,542,860	384	No	384	$72,631	Sidewalk through parking lot
42	2767701760	STANEY NELSON III LLC	6,972	$1,568,700	$0	$1,568,700	$225	Land	$315	$2,196,180	963	No	963	$303,395	Sidewalk and shoulder through parking lot
43	2767701750	PONTE LLC	9,607	$2,161,500	$1,000	$2,162,500	$225	Land	$315	$3,027,500	1,226	Yes	9,607	$3,027,500	Sidewalk, shoulder, and ramp through building
44	2767701640	CAR WASH ENTERPRISES INC	8,540	$1,921,500	$0	$1,921,500	$225	Land	$315	$2,690,100	1,685	Yes	8,540	$2,690,100	Sidewalk, shoulder, and ramp through building
45	2767701630	CAR WASH ENTERPRISES INC	8,540	$1,921,500	$1,000	$1,922,500	$225	Land	$315	$2,691,500	1,619	Yes	8,540	$2,691,500	Sidewalk, shoulder, and ramp through building
46	2767701520	14516 LINDEN LLC	4,270	$960,700	$1,000	$961,700	$225	Land	$315	$1,346,380	1,584	Yes	4,270	$1,346,380	Sidewalk, shoulder, and ramp through building
47	2767701510	TRAVERSO HOLDINGS I LLC	8,540	$1,921,500	$0	$1,921,500	$225	Land	$315	$2,690,100	141	No	141	$44,283	Sidewalk, shoulder, and ramp through landscape
48	2768302480	ALPHA PAPA 2 LLC	8,800	$1,056,000	$1,000	$1,057,000	$120	Land	$168	$1,479,800	8	No	8	$1,369	Impact on small corner only
49	2768302505	BALLARD HOLDINGS LLC	10,000	$1,200,000	$213,200	$1,413,200	$120	Land	$168	$1,978,480	-	Yes	10,000	$1,978,480	Access to property removed
50	2768302515	BALLACO LLC	10,000	$1,200,000	$624,100	$1,824,100	$120	Land	$168	$2,553,740	-	Yes	10,000	$2,553,740	Access to property removed
51	132503HYDR	CITY OF SEATTLE	N/A	$0	$0	$0	#VALUE!	Land	N/A	$0	9,976	No	2,603	N/A	Over water
52	7666200105	PORT OF SEATTLE	2,335,491	$112,717,200	$7,688,100	$120,405,300	$48	Land	$68	$168,567,420	16,295	No	16,295	$1,101,002	Over water and structures
53	2771101802	PORT OF SEATTLE	11,507	$1,035,600	$0	$1,035,600	$90	Land	$126	$1,449,840	545	No	545	$68,619	Changes to property access
54	2771101801	PORT OF SEATTLE	32,600	$2,934,000	$0	$2,934,000	$90	Land	$126	$4,107,600	1,511	No	1,511	$190,441	Changes to property access
												TOTAL TAKES	**304,751**		

Ballard Bridge Planning Study
ROW Impacts - Mid-Level Alternative
SCJ Alliance, November 25, 2019

Cost to Cure (% of Take)	TCE Cost	Negotiation Costs	Condemnation and Incidental	Turnback Value (Empty ROW)
Low = 10%	TCE Width (LF) = 5	Low = $4,500	15%	= $150
Medium = 15%	Duration (months) = 18	Medium = $6,750		
High = 20%	TCE Cost per Year (% of Adjusted $/SF) = 10%	High = $10,000		

No	Parcel Number	Parcel Owner	Additional Notes on ROW Impacts and Cure Needs	Cost to Cure	Cost to Cure	Length of Frontage	TCE Area	TCE Cost	Just Compensation	Appraisal Fee Costs	Appraisal Review Costs	Negotiation Fee Costs	Title, Escrow Costs	Condemnation & Incidental Costs	Statutory Evaluation Allowance	TOTAL COST PER PARCEL	ROW to Turnback	Adjusted Value of Turnback ROW per SF	VALUE OF TURNBACK
1	8847800000	URBAN TERRACE CONDOMINIUM B	Retaining wall will need to be constructed.	None	$0	98	488	$8,527	$91,788	$2,500	$1,000	$0	$1,500	$12,489	$750	$110,027	-	-$150	-
2	2770603425	PAYNE R GREGORY	Retaining wall will need to be constructed.	None	$0	26	130	$2,100	$48,781	$2,500	$1,000	$0	$1,500	$7,002	$750	$61,533	-	-$150	-
3	2770603430	PAYNE GREG	Retaining wall will need to be constructed.	None	$0	24	120	$1,939	$56,909	$2,500	$1,000	$0	$1,500	$8,245	$750	$70,904	-	-$150	-
4	2770603420	SANKIEWICZ PIOTR	A portion of the building would need to be reconstructed.	High	$27,727	50	250	$4,064	$170,425	$2,500	$1,000	$10,000	$1,500	$20,795	$750	$206,970	-	-$150	-
5	2770603415	PEREZ PEDRO A & ASTRID	A portion of the building would need to be reconstructed and the parking lot on west side of the parcel would be lost.	High	$36,440	51	253	$4,104	$222,747	$2,500	$1,000	$10,000	$1,500	$27,330	$750	$265,828	-	-$150	-
6	2770603410	PEREZ PEDRO	Parking stall on the west side of the property would be lost.	None	$0	50	251	$4,392	$224,887	$2,500	$1,000	$0	$1,500	$33,074	$750	$263,711	-	-$150	-
7	2770603315	3600 INTERBAY LLC	A large portion of the building would be demolished. Unsure if a portion of the building could be salvaged and retain similar use.	High	$1,256,136	-	-	$0	$7,536,816	$2,500	$1,000	$10,000	$1,500	$942,102	$750	$8,494,668	12,592	-$150	(1,888,800)
8	2770603295	REEVES SHERING	A portion of the building would be demolished and all their parking and access off of 15th Ave NW would be lost. Potential for this to be a total take.	High	$379,064	-	-	$0	$2,274,384	$2,500	$1,000	$10,000	$1,500	$284,298	$750	$2,574,432	7,992	-$150	(1,198,800)
9	2771101580	ESSEX PROPERTY TRUST INC	Because of the significant demolition of three buildings on this parcel, it looks to be a total take.	High	$9,526,160	-	-	$0	$57,156,960	$2,500	$1,000	$10,000	$1,500	$7,144,620	$750	$64,317,330	24,935	-$150	(3,740,250)
10	2770605769	DSC CAPITAL	Property below structure. Large billboard structure to be relocated or demolished. Air space lease for this property for structure above?	Medium	$191,677	132	660	$18,300	$1,487,821	$2,500	$1,000	$6,750	$1,500	$191,677	$750	$1,691,998	-	-$150	-
11	2770605642	BNSF	BNSF property both sides of the Ballard Bridge structure, east and west side as noted in the roll plot figure. Air space lease for this property for structure above? Buildings on northwest section of parcel will be below new bridge structure. (Takes = 2,621 (east) + 679 (southwest) + 281 (northwest))	None	$0	276	1,379	$8,685	$234,286	$2,500	$1,000	$0	$1,500	$33,840	$750	$273,877	-	-$150	-
12	7666200120	SALMON BAY TERMINALS	Need to investigate clearance from proposed Ballard Bridge structure expansion to existing building. Looks to be no impacts. Air space lease for this property for structure above? New bridge columns for structure expansion may impact truck vehicle turning operations.	Low	$43,157	451	2,255	$11,842	$486,571	$2,500	$1,000	$4,500	$1,500	$64,736	$750	$561,557	-	-$150	-
13	2770603199	INTERBAY RISING NORTH LLC	Would need to reconfigure access to the parking lot and parcel	Medium	$169,149	280	1,402	$34,336	$1,331,142	$2,500	$1,000	$6,750	$1,500	$169,149	$750	$1,512,791	-	-$150	-
14	2770603130	MOOERS BUILDING ASSOC LLC	Would need to provide reconfigured access to the parcel.	Medium	$27,668	32	162	$2,041	$214,160	$2,500	$1,000	$6,750	$1,500	$27,668	$750	$254,327	-	-$150	-
15	2771101675	READ PRODUCTS INC	ROW take goes diagonally through parcel, with a large ROW take, so the assumption is total take	High	$1,077,580	-	-	$0	$6,465,480	$2,500	$1,000	$10,000	$1,500	$808,185	$750	$7,289,415	23,791	-$150	(3,568,650)
16s	2771101760	READ PRODUCTS INC (SOUTH)	Impacts a vehicle storage area	Low	$15,706	100	499	$6,300	$179,070	$2,500	$1,000	$4,500	$1,500	$23,559	$750	$212,879	-	-$150	-
16n	2771101760	READ PRODUCTS INC (NORTH)	Due to the percentage of property take for proposed structure, assume whole north section of parcel would need to be purchased. (Takes = 7,242 +710)	High	$342,107	-	-	$0	$2,052,641	$2,500	$1,000	$10,000	$1,501	$256,580	$751	$2,324,973	5,788	-$150	(868,200)
17	2771101480	CITY OF SEATTLE FAS	Maybe need to transfer ownership from FAS to SDOT?	None	$0	-	-	$0	$0							$0	-	-$150	-
18	2771101465	CITY OF SEATTLE SDOT	SDOT City property. No need to purchase for project.	None	$0	-	-	$0	$0							$0	-	-$150	-
19	2771101445	CITY OF SEATTLE SDOT	SDOT City property. No need to purchase for project.	None	$0	-	-	$0	$0							$0	-	-$150	-
20	2770605643	CITY OF SEATTLE FAS	Building below structure on parcel. Maybe need to transfer ownership from FAS to SDOT?	None	$0	-	-	$0	$0							$0	-	-$150	-
21	2771102700	BNSF	Revision to air space lease for expansion of structure above track?	Low	$19,232	84	420	$2,646	$214,202	$2,500	$1,000	$4,500	$1,500	$28,848	$750	$253,300	-	-$150	-
22	2771101800	BNSF	Revision to air space lease for expansion of structure above track?	Low	$13,488	128	638	$4,016	$152,387	$2,500	$1,000	$4,500	$1,500	$20,232	$750	$182,870	-	-$150	-
23	0467000385	TREUER CHRISTIN L	New footprint of elevated structure is above or in direct conflict with the full height of the existing buildings.	High	$155,611	378	1,890	$14,258	$947,925	$2,500	$1,000	$10,000	$1,500	$116,708	$750	$1,080,384	-	-$150	-
24	2768400015	TREUER CHRISTIN L	This could be a full take because the potential use of the property is severely altered.	High	$54,300	72	360	$6,047	$331,845	$2,500	$1,000	$10,000	$1,500	$40,725	$750	$388,319	-	-$150	-
25	2768400020	MAZZARELLA TONY	ROW take goes through center of the property so the assumption is total take	High	$232,400	-	-	$0	$1,394,400	$2,500	$1,000	$10,000	$1,500	$174,300	$750	$1,584,450	2,563	-$150	(384,375)
26	2767702270	1526 NW 46TH LLC	ROW take goes diagonally through parcel, so the assumption is total take	High	$504,280	-	-	$0	$3,025,680	$2,500	$1,000	$10,000	$1,500	$378,210	$750	$3,419,640	(4,330)	-$150	649,538
27	2767702290	HUFF COMMERCIAL PROPERTIES	Portion of building to be demolished, northeast corner of the property	High	$21,403	104	520	$8,736	$137,155	$2,500	$1,000	$10,000	$1,500	$16,052	$750	$168,958	-	-$150	-
28	2767702215	SPRUTE HERB TRUSTEE	Portion of building to be demolished, southwest corner of the property	High	$18,278	49	243	$4,074	$113,744	$2,500	$1,000	$10,000	$1,500	$13,709	$750	$143,203	-	-$150	-
29	2767702205	HUFF COMMERCIAL PROPERTIES	ROW take goes diagonally through parcel, so the assumption is total take	High	$394,240	-	-	$0	$2,365,440	$2,500	$1,000	$10,000	$1,500	$295,680	$750	$2,676,870	1,637	-$150	(245,550)
30	2767702190	LMI BUILDING LLC	Over half the parcel parking lot with access off of NW Ballard Way would be lost	High	$65,890	45	225	$3,780	$399,118	$2,500	$1,000	$10,000	$1,500	$49,417	$750	$464,285	-	-$150	-

Ballard Bridge Planning Study
ROW Impacts - Mid-Level Alternative
SCJ Alliance, November 25, 2019

Cost to Cure (% of Take)	TCE Cost	Negotiation Costs	Condemnation and Incidental	Turnback Value (Empty ROW)
Low = 10%	TCE Width (LF) = 5	Low = $4,500	15%	= $150
Medium = 15%	Duration (months) = 18	Medium = $6,750		
High = 20%	TCE Cost per Year (% of Adjusted $/SF) = 10%	High = $10,000		

No	Parcel Number	Parcel Owner	Additional Notes on ROW Impacts and Cure Needs	Cost to Cure	Cost to Cure	Length of Frontage	TCE Area	TCE Cost	Just Compensation	Appraisal Fee Costs	Appraisal Review Costs	Negotiation Fee Costs	Title, Escrow Costs	Condemnation & Incidental Costs	Statutory Evaluation Allowance	TOTAL COST PER PARCEL	ROW to Turnback	Adjusted Value of Turnback ROW per SF	VALUE OF TURNBACK
31	2767702160	ELLSTROM THOMAS A+ELISABETH	Only a portion of the building would need to be demolished and reconfigured.	High	$31,214	25	125	$2,100	$189,386	$2,500	$1,000	$10,000	$1,500	$23,411	$750	$228,547	8	-$150	(1,125)
32	2767702170	ELLSTROM PROPERTIES LLC	ROW take goes diagonally through parcel, with half the parcel takend, so the assumption is total take	High	$341,600	-	-	$0	$2,049,600	$2,500	$1,000	$10,000	$1,500	$256,200	$750	$2,321,550	5,461	-$150	(819,150)
33	2767702185	POWERS ELIZABETH	4-plex apartment on the property. Should be possible to have partial demolition and retain use.	High	$21,017	51	255	$4,284	$130,385	$2,500	$1,000	$10,000	$1,500	$15,763	$750	$161,897	-	-$150	-
34	2767702180	LOGAN DAVIDL	Access for building is off of 17th Ave NW. No other access for this facility.	High	$20,479	49	243	$4,074	$126,949	$2,500	$1,000	$10,000	$1,500	$15,359	$750	$158,059	-	-$150	-
35	2767702065	THOMPSON HARVEY E+THOMPSON	Total square footage of parcel for full take is 13,374 sf	High	$453,012	-	-	$0	$2,718,072	$2,500	$1,000	$10,000	$1,500	$339,759	$750	$3,073,581	3,386	-$150	(507,900)
36	2767702070	NELSON FAMILY ASSOCIATES LL	This is the property just east of parcel 2767702065, which is a full take. This property appears to be same ownership and same building as the property to the west. Assume full take.	High	$292,320	-	-	$0	$1,753,920	$2,500	$1,000	$10,000	$1,500	$219,240	$750	$1,988,910	3,468	-$150	(520,125)
36A	2767703340	OLD BALLARD L L C	Planter would be elimated and business sign would need to be relocated.	Low	$302	10	50	$945	$4,271	$2,500	$1,000	$4,500	$1,500	$454	$750	$14,975	-	-$150	-
37	2768302475	LAH LLC % SHELLEEN A HAIGHT	Portion of building and parking lot with multiple stalls lost. Large billboard structure and business sign to be relocated.	High	$83,307	171	855	$14,363	$514,206	$2,500	$1,000	$10,000	$1,500	$62,480	$750	$592,437	-	-$150	-
38	2768302530	BALLARD FOOD BANK	Only a small northest corner of the parcel will be taken.	Low	$3,833	50	250	$4,200	$46,358	$2,500	$1,000	$4,500	$1,500	$5,749	$750	$62,357	-	-$150	-
39	2767701995	MILLER PAINT CO INC	Sidewalk goes through building, either demolish or reconstruct.	High	$521,864	190	950	$17,954	$3,149,138	$2,500	$1,000	$10,000	$1,501	$391,398	$751	$3,556,288	12,955	-$150	(1,943,319)
40	2767701880	MALONEY JOHN W	Sidewalk goes through building, either demolish or reconstruct.	High	$224,980	80	400	$7,559	$1,357,439	$2,500	$1,000	$10,000	$1,502	$168,735	$752	$1,541,928	5,522	-$150	(828,227)
41	2767701830	SBFO CORP	Sidewalk goes through building, either demolish or reconstruct.	Medium	$10,895	90	450	$8,505	$92,030	$2,500	$1,000	$6,750	$1,503	$10,895	$753	$115,431	-	-$150	-
42	2767701760	STANEY NELSON III LLC	Sidewalk goes through building, either demolish or reconstruct.	Low	$30,340	85	425	$13,388	$347,122	$2,500	$1,000	$4,500	$1,504	$45,509	$754	$402,890	-	-$150	-
43	2767701750	PONTE LLC	Improvements go through building, total take, demolish building.	High	$605,500	75	375	$11,812	$3,644,812	$2,500	$1,000	$10,000	$1,505	$454,125	$755	$4,114,697	8,381	-$150	(1,257,161)
44	2767701640	CAR WASH ENTERPRISES INC	Improvements go through building, total take, demolish building.	High	$538,020	100	500	$15,750	$3,243,870	$2,500	$1,000	$10,000	$1,506	$403,515	$756	$3,663,147	6,855	-$150	(1,028,193)
45	2767701630	CAR WASH ENTERPRISES INC	Improvements go through building, total take, demolish building.	High	$538,300	100	500	$15,750	$3,245,550	$2,500	$1,000	$10,000	$1,507	$403,725	$757	$3,665,039	6,921	-$150	(1,038,218)
46	2767701520	14516 LINDEN LLC	Improvements go through building, total take, demolish building.	High	$269,276	120	600	$18,899	$1,634,555	$2,500	$1,000	$10,000	$1,508	$201,957	$758	$1,852,278	2,686	-$150	(402,885)
47	2767701510	TRAVERSO HOLDINGS I LLC	Minor landscaping improvements.	Low	$4,428	50	250	$7,875	$56,586	$2,500	$1,000	$4,500	$1,509	$6,642	$759	$73,496	-	-$150	-
48	2768302480	ALPHA PAPA 2 LLC	Minor corner improvements.	Low	$137	50	250	$4,200	$5,706	$2,500	$1,000	$4,500	$1,510	$205	$760	$16,182	-	-$150	-
49	2768302505	BALLARD HOLDINGS LLC	Total take because removing only access to property. Demolish building.	Medium	$296,772	100	500	$8,400	$2,283,652	$2,500	$1,000	$6,750	$1,511	$296,772	$761	$2,592,946	10,000	-$150	(1,500,000)
50	2768302515	BALLACO LLC	Total take because removing only access to property. Demolish building.	Medium	$383,061	100	500	$8,400	$2,945,201	$2,500	$1,000	$6,750	$1,512	$383,061	$762	$3,340,786	10,000	-$150	(1,500,000)
51	132503HYDR	CITY OF SEATTLE	None	None	$0	-	-	$0	$0	$0	$0	$0	$0	$0	$0	$0	-	-$150	-
52	7666200105	PORT OF SEATTLE	Demolish or reconstruct structure.	High	$220,200	780	3,900	$26,351	$1,347,554	$2,500	$1,000	$10,000	$1,514	$165,150	$764	$1,528,482	-	-$150	-
53	2771101802	PORT OF SEATTLE	Revise property access and location of access.	Medium	$10,293	35	175	$2,205	$81,117	$2,500	$1,000	$6,750	$1,515	$10,293	$765	$103,939	-	-$150	-
54	2771101801	PORT OF SEATTLE	Revise property access and location of access.	Medium	$28,566	55	275	$3,465	$222,473	$2,500	$1,000	$6,750	$1,516	$28,566	$766	$263,571	-	-$150	-

TOTAL JUST COMPENSATION **$120,506,717**

TOTAL COST INCL ACQUISTION **$136,282,911**

TOTAL TURNBACK **-$22,591,389**

TOTAL COST OF ROW INCLUDING ACQUISITION =	**$136,282,911**
TOTAL VALUE OF REMNANT SALES =	**-$22,591,389**
NET ROW COST INCLUDING ACQUISITION =	**$113,691,522**
ROUNDED NET ROW COST INCLUDING ACQUISITION =	**$114,000,000**

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Adjusted Value (% Appraised Value)

Appraised Value x 140%

Aerial Value Adjustment

Appraised Value x 50%

No	Parcel Number	Parcel Owner	Total Parcel Size (SF)	2019 Appraised Land Value	2019 Appraised Improvement Value	2019 Total Appraised Value	Appraised Land Value per SF	Aerial Easment or Land Purchase	Adjusted Land Value per SF	Adjusted Parcel Value	ROW Impacted (SF)	Total Take	ROW Take (SF)	ROW Cost	Observed Impacts
1	8847800000	URBAN TERRACE CONDOMINIUM B	22,441	$2,803,800	$4,242,200	$7,046,000	$125	Land	$175	$9,864,400	476	No	476	$83,261	No functional property use changes.
2	2770603425	PAYNE R GREGORY	2,825	$326,000	$184,000	$510,000	$115	Land	$162	$714,000	289	No	289	$46,680	No functional property use changes.
3	2770603430	PAYNE GREG	2,825	$326,000	$93,000	$419,000	$115	Land	$162	$586,600	340	No	340	$54,970	No functional property use changes.
4	2770603420	SANKIEWICZ PIOTR	5,650	$656,000	$69,000	$725,000	$116	Land	$163	$1,015,000	853	No	853	$138,635	Building impacts
5	2770603415	PEREZ PEDRO A & ASTRID	5,650	$656,000	$75,000	$731,000	$116	Land	$163	$1,023,400	1,121	No	1,121	$182,202	Building impacts, elimination of parking
6	2770603410	PEREZ PEDRO	5,650	$706,200	$163,700	$869,900	$125	Land	$175	$1,217,860	1,260	No	1,260	$220,495	Parking loss
7	2770603315	3600 INTERBAY LLC	16,887	$2,110,800	$2,375,400	$4,486,200	$125	Land	$175	$6,280,680	4,295	Yes	16,887	$6,280,680	Building Demolition
8	2770603295	REEVES SHERING	10,823	$1,352,800	$1,000	$1,353,800	$125	Land	$175	$1,895,320	2,831	Yes	10,823	$1,895,320	Building Impacts
9	2771101580	ESSEX PROPERTY TRUST INC	33,453	$4,181,600	$29,840,400	$34,022,000	$125	Land	$175	$47,630,800	8,518	Yes	33,453	$47,630,800	A portion of three buildings to be demolished.
10	2770605769	DSC CAPITAL	42,750	$8,466,700	$14,324,700	$22,791,400	$198	Land	$277	$31,907,960	4,609	No	4,609	$1,277,844	Potential Parking Impacts
11	2770605642	BNSF	115,775	$10,419,700	$0	$10,419,700	$90	Aerial	$63	$14,587,580	3,581	No	3,581	$225,602	No observable physical impacts
12	7666200120	SALMON BAY TERMINALS	570,278	$21,392,000	$1,827,500	$23,219,500	$38	Land	$53	$32,507,300	8,218	No	8,218	$431,571	Potential vehicle turning impacts for property below structure
13	2770603199	INTERBAY RISING NORTH LLC	53,325	$9,331,800	$90,000	$9,421,800	$175	Land	$245	$13,190,520	4,603	No	4,603	$1,127,657	Parking access impacts
14	2770603130	MOOERS BUILDING ASSOC LLC	24,088	$2,167,900	$4,778,700	$6,946,600	$90	Land	$126	$9,725,240	1,464	No	1,464	$184,451	Parking access impacts
15	2771101675	READ PRODUCTS INC	42,750	$3,847,500	$1,000	$3,848,500	$90	Land	$126	$5,387,900	18,959	Yes	42,750	$5,387,900	Building to be demolished
16s	2771101760	READ PRODUCTS INC (SOUTH)	76,763	$6,922,740	$850	$6,923,590	$90	Land	$126	$9,693,026	1,244	No	1,244	$157,063	Parking Impacts
16n	2771101760	READ PRODUCTS INC (NORTH)	13,731	$1,221,660	$150	$1,221,810	$89	Land	$125	$1,710,534	7,943	Yes	13,731	$1,710,534	Proposed structure would take most of parcel
17	2771101480	CITY OF SEATTLE FAS	7,750	$697,500	$0	$697,500	$90	Land	$126	$976,500					None
18	2771101465	CITY OF SEATTLE SDOT	360	$1,800	$0	$1,800	$5	Land	$7	$2,520					None
19	2771101445	CITY OF SEATTLE SDOT	275	$1,300	$0	$1,300	$5	Land	$7	$1,820					None
20	2770605643	CITY OF SEATTLE FAS	4,967	$447,000	$0	$447,000	$90	Land	$126	$625,800					None
21	2771102700	BNSF	250,470	$22,542,300	$0	$22,542,300	$90	Aerial	$63	$31,559,220	3,053	No	3,053	$192,323	No observable physical impacts
22	2771101800	BNSF	1,193,544	$107,418,900	$1,000	$107,419,900	$90	Aerial	$63	$150,387,860	2,141	No	2,141	$134,883	No observable physical impacts
39	2768300925	REAL PROPERTY ASSOCIATES	18,730	$4,214,200	$748,400	$4,962,600	$225	Land	$315	$6,947,640	10,818	Yes	18,730	$6,947,640	Building to be demolished
40	2768300935	DEMETRE JAMES	4,614	$4,214,200	$748,400	$4,962,600	$913	Land	$1,279	$6,947,640	2,928	Yes	4,614	$6,947,640	More than half the building to be demolished.
41	2768300940	DEMETRE JAMES	4,700	$564,000	$1,842,000	$2,406,000	$120	Land	$168	$3,368,400	2,675	Yes	4,700	$3,368,400	More than half the building to be demolished.
42	2768300955	DEMETRE JAMES	28,200	$3,384,000	$712,000	$4,096,000	$120	Land	$168	$5,734,400	24,514	Yes	28,200	$5,734,400	Almost the entire property is a ROW take. The warehouse on the property would be completely demolished.
43	2768300975	DEMETRE JAMES	4,700	$564,000	$37,600	$601,600	$120	Land	$168	$842,240	2,596	Yes	4,700	$842,240	The warehouse on the property would be completely demolished.
44	2768300985	STOR TENKER LLC	4,500	$564,000	$0	$564,000	$125	Land	$175	$789,600	696	Yes	4,500	$789,600	A portion of the existing building on the parcel would need to be demolished.

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Adjusted Value (% Appraised Value)

Appraised Value x 140%

Aerial Value Adjustment

Appraised Value x 50%

No	Parcel Number	Parcel Owner	Total Parcel Size (SF)	2019 Appraised Land Value	2019 Appraised Improvement Value	2019 Total Appraised Value	Appraised Land Value per SF	Aerial Easment or Land Purchase	Adjusted Land Value per SF	Adjusted Parcel Value	ROW Impacted (SF)	Total Take	ROW Take (SF)	ROW Cost	Observed Impacts
45	2768300980	STOR TENKER LLC	4,500	$564,000	$834,700	$1,398,700	$125	Land	$175	$1,958,180	3,853	Yes	4,500	$1,958,180	The entire structure on this parcel would need to be demolished.
46	2768301805	R A HANSEN INVESTMENTS LLC	3,750	$450,000	$439,800	$889,800	$120	Land	$168	$1,245,720	1,431	Yes	3,750	$1,245,720	A large portion of the existing building on this parcel would need to be demolished.
47	2768301810	R A HANSEN INVESTMENTS LLC	4,300	$516,000	$1,000	$517,000	$120	Land	$168	$723,800	1,742	Yes	4,300	$723,800	A large portion of the existing building on this parcel would need to be demolished.
48	2768301895	BALLARD 14 LLC	33,703	$4,044,300	$1,000	$4,045,300	$120	Land	$168	$5,663,420	149	No	149	$25,074	Minimal impacts; 2-3 parking stalls would be lost
49	2768300875	KEYBANK NATIONAL ASSOC	25,000	$5,125,000	$1,000	$5,126,000	$205	Land	$287	$7,176,400	2,941	No	2,941	$844,067	Portion of O'Reilly's auto parts building may have to be rebuilt, minimal impacts to the parking lot, single parking stall lost, trees to be removed.
50	2768301800	THE 1409 NW LLC	3,750	$450,000	$1,422,000	$1,872,000	$120	Land	$168	$2,620,800	273	No	1,197	$201,151	Taking landscape area and partial building demo for cul-de-sac
51	2768300510	NWCC INVESTMENTS INC	4,000	$900,000	$1,000	$901,000	$225	Land	$315	$1,261,400	509	No	273	$86,071	partial take of parking area and building to add a sidewalk
52	2768300405	ET14 LLC	19,000	$3,230,000	$104,500	$3,334,500	$170	Land	$238	$4,668,300	544	No	509	$121,166	partial take of building to add a sidewalk
53	2767701520	14516 LINDEN LLC	4,270	$960,700	$1,000	$961,700	$225	Land	$315	$1,346,380	2,705	No	544	$171,253	Frontage road through most of building
54	2767701510	TRAVERSO HOLDINGS I LLC	8,540	$1,921,500	$0	$1,921,500	$225	Land	$315	$2,690,100	2,553	Yes	4,270	$2,690,100	Cutting off drive thru circulation with frontage road
55	2767701400	TRAVERSO HOLDINGS LLC	12,810	$2,882,200	$1,000	$2,883,200	$225	Land	$315	$4,036,480	2,725	No	2,553	$804,058	Taking over half the building and 3 parking spaces
56	2767701385	SEA WEND LTD	17,810	$4,007,200	$1,000	$4,008,200	$225	Land	$315	$5,611,480	2,603	Yes	12,810	$5,611,480	Partial building demo, losing 5 parking spots
57	132503HYDR	CITY OF SEATTLE	N/A	$0	$0	$0	N/A	Land	N/A	$0	9,976	No	2,603	N/A	Over water
58	7666200105	PORT OF SEATTLE	2,335,491	$112,717,200	$7,688,100	$120,405,300	$48	Land	$68	$168,567,420	15,475	No	9,976	$674,080	Over water and structures
59	2771101802	PORT OF SEATTLE	11,507	$1,035,600	$0	$1,035,600	$90	Land	$126	$1,449,840	545	No	15,475	$1,949,807	Changes to property access
60	2771101801	PORT OF SEATTLE	32,600	$2,934,000	$0	$2,934,000	$90	Land	$126	$4,107,600	1,511	No	545	$68,621	Changes to property access

TOTAL TAKES **282,734**

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Cost to Cure (% of Take)
Low = 10%
Medium = 15%
High = 20%

TCE Cost
TCE Width (LF) = 5
Duration (months) = 18
TCE Cost per Year (% of Adjusted $/SF) = 10%

Negotiation Costs
Low = $4,500
Medium = $6,750
High = $10,000

Condemnation and Incidental
15%

Turnback Value (Empty ROW)
= $150

No	Parcel Number	Parcel Owner	Additional Notes on ROW Impacts and Cure Needs	Cost to Cure	Cost to Cure	Length of Frontage	TCE Area	TCE Cost	Just Compensation	Appraisal Fee Costs	Appraisal Review Costs	Negotiation Fee Costs	Title, Escrow Costs	Condemnation & Incidental Costs	Statutory Evaluation Allowance	TOTAL COST PER PARCEL	ROW to Turnback	Adjusted Value of Turnback ROW per SF	VALUE OF TURNBACK
1	8847800000	URBAN TERRACE CONDOMINIUM B	Retaining wall will need to be constructed.	None	$0	98	488	$8,527	$91,788	$2,500	$1,000	$0	$1,500	$12,489	$750	$110,027	-	-$150	-
2	2770603425	PAYNE R GREGORY	Retaining wall will need to be constructed.	None	$0	26	130	$2,100	$48,781	$2,500	$1,000	$0	$1,500	$7,002	$750	$61,533	-	-$150	-
3	2770603430	PAYNE GREG	Retaining wall will need to be constructed.	None	$0	24	120	$1,939	$56,909	$2,500	$1,000	$0	$1,500	$8,245	$750	$70,904	-	-$150	-
4	2770603420	SANKIEWICZ PIOTR	A portion of the building would need to be reconstructed.	Medium	$20,795	50	250	$4,064	$163,493	$2,500	$1,000	$6,750	$1,500	$20,795	$750	$196,789	-	-$150	-
5	2770603415	PEREZ PEDRO A & ASTRID	A portion of the building would need to be reconstructed and the parking lot on west side of the parcel would be lost.	Medium	$27,330	51	253	$4,104	$213,637	$2,500	$1,000	$6,750	$1,500	$27,330	$750	$253,468	-	-$150	-
6	2770603410	PEREZ PEDRO	Parking stall on the west side of the property would be lost.	None	$0	50	251	$4,392	$224,887	$2,500	$1,000	$0	$1,500	$33,074	$750	$263,711	-	-$150	-
7	2770603315	3600 INTERBAY LLC	A large portion of the building would be demolished. Unsure if a portion of the building could be salvaged and retain similar use.	High	$1,256,136	-	-	$0	$7,536,816	$2,500	$1,000	$10,000	$1,500	$942,102	$750	$8,494,668	12,592	-$150	(1,888,800)
8	2770603295	REEVES SHERING	A portion of the building would be demolished and all their parking and access off of 15th Ave NW would be lost. Potential for this to be a total take.	High	$379,064	-	-	$0	$2,274,384	$2,500	$1,000	$10,000	$1,500	$284,298	$750	$2,574,432	7,992	-$150	(1,198,800)
9	2771101580	ESSEX PROPERTY TRUST INC	Because of the significant demolition of three buildings on this parcel, it looks to be a total take.	High	$9,526,160	-	-	$0	$57,156,960	$2,500	$1,000	$10,000	$1,500	$7,144,620	$750	$64,317,330	24,935	-$150	(3,740,250)
10	2770605769	DSC CAPITAL	Property below structure. Large billboard structure to be relocated or demolished. Air space lease for this property for structure above?	Medium	$191,677	132	660	$18,300	$1,487,821	$2,500	$1,000	$6,750	$1,500	$191,677	$750	$1,691,998	-	-$150	-
11	2770605642	BNSF	BNSF property both sides of the Ballard Bridge structure, east and west side as noted in the roll plot figure. Air space lease for this property for structure above? Buildings on northwest section of parcel will be below new bridge structure. (Takes = 2,621 (east) + 679 (southwest) + 281 (northwest))	None	$0	276	1,379	$8,685	$234,286	$2,500	$1,000	$0	$1,500	$33,840	$750	$273,877	-	-$150	-
12	7666200120	SALMON BAY TERMINALS	Need to investigate clearance from proposed Ballard Bridge structure expansion to existing building. Looks to be no impacts. Air space lease for this property for structure above? New bridge columns for structure expansion may impact truck vehicle turning operations.	None	$0	451	2,255	$11,842	$443,414	$2,500	$1,000	$0	$1,500	$64,736	$750	$513,899	-	-$150	-
13	2770603199	INTERBAY RISING NORTH LLC	Would need to reconfigure access to the parking lot and parcel	Medium	$169,149	280	1,402	$34,336	$1,331,142	$2,500	$1,000	$6,750	$1,500	$169,149	$750	$1,512,791	-	-$150	-
14	2770603130	MOOERS BUILDING ASSOC LLC	Would need to provide reconfigured access to the parcel.	Medium	$27,668	32	162	$2,041	$214,160	$2,500	$1,000	$6,750	$1,500	$27,668	$750	$254,327	-	-$150	-
15	2771101675	READ PRODUCTS INC	ROW take goes diagonally through parcel, with a large ROW take, so the assumption is total take	High	$1,077,580	-	-	$0	$6,465,480	$2,500	$1,000	$10,000	$1,500	$808,185	$750	$7,289,415	23,791	-$150	(3,568,650)
16s	2771101760	READ PRODUCTS INC (SOUTH)	Impacts a vehicle storage area	Low	$15,706	100	499	$6,300	$179,070	$2,500	$1,000	$4,500	$1,500	$23,559	$750	$212,879	-	-$150	-
16n	2771101760	READ PRODUCTS INC (NORTH)	Due to the percentage of property take for proposed structure, assume whole north section of parcel would need to be purchased. (Takes = 7,242 +710)	High	$342,107	-	-	$0	$2,052,641	$2,500	$1,000	$10,000	$1,501	$256,580	$751	$2,324,973	5,788	-$150	(868,200)
17	2771101480	CITY OF SEATTLE FAS	Maybe need to transfer ownership from FAS to SDOT?	None	$0	-	-	$0	$0							$0	-	-$150	-
18	2771101465	CITY OF SEATTLE SDOT	SDOT City property. No need to purchase for project.	None	$0	-	-	$0	$0							$0	-	-$150	-
19	2771101445	CITY OF SEATTLE SDOT	SDOT City property. No need to purchase for project.	None	$0	-	-	$0	$0							$0	-	-$150	-
20	2770605643	CITY OF SEATTLE FAS	Building below structure on parcel. Maybe need to transfer ownership from FAS to SDOT?	None	$0	-	-	$0	$0							$0	-	-$150	-
21	2771102700	BNSF	Revision to air space lease for expansion of structure above track?	Low	$19,232	84	420	$2,646	$214,202	$2,500	$1,000	$4,500	$1,500	$28,848	$750	$253,300	-	-$150	-
22	2771101800	BNSF	Revision to air space lease for expansion of structure above track?	Low	$13,488	128	638	$4,016	$152,387	$2,500	$1,000	$4,500	$1,500	$20,232	$750	$182,870	-	-$150	-
39	2768300925	REAL PROPERTY ASSOCIATES	ROW take is more than 50% of the property,and demolition of the building is required. The assumption is total take. King County Parcel Viewer data may be out of date. There is a new building this property as shown in google maps; an Amazon Fresh Pickup.	High	$1,389,528	-	-	$0	$8,337,168	$2,500	$1,000	$10,000	$1,500	$1,042,146	$750	$9,395,064	7,912	-$150	(1,186,763)
40	2768300935	DEMETRE JAMES	ROW take is more than 50% of the property,and demolition of the building is required. The assumption is total take.	High	$1,389,528	-	-	$0	$8,337,168	$2,500	$1,000	$10,000	$1,500	$1,042,146	$750	$9,395,064	1,687	-$150	(252,975)
41	2768300940	DEMETRE JAMES	ROW take is more than 50% of the property,and demolition of the building is required. The assumption is total take.	High	$673,680	-	-	$0	$4,042,080	$2,500	$1,000	$10,000	$1,500	$505,260	$750	$4,563,090	2,025	-$150	(303,788)
42	2768300955	DEMETRE JAMES	ROW take is nearly the entire property, and demolition of the warehouse is required. The assumption is total take. Total parcel area is 28,200 sf.	High	$1,146,880	-	-	$0	$6,881,280	$2,500	$1,000	$10,000	$1,500	$860,160	$750	$7,757,190	3,686	-$150	(552,900)
43	2768300975	DEMETRE JAMES	The warehouse on this property is the same structure as the property to the west.	High	$168,448	-	-	$0	$1,010,688	$2,500	$1,000	$10,000	$1,500	$126,336	$750	$1,152,774	2,104	-$150	(315,638)
44	2768300985	STOR TENKER LLC	The building looks to be one building on two parcels. The building on this parcel is connected to the building that will be completely demolished on the parcel to the east.	High	$157,920	-	-	$0	$947,520	$2,500	$1,000	$10,000	$1,500	$118,440	$750	$1,081,710	3,804	-$150	(570,638)

Ballard Bridge Planning Study
ROW Impacts - High-Level Alternative
SCJ Alliance, November 25, 2019

Cost to Cure (% of Take)	TCE Cost	Negotiation Costs	Condemnation and Incidental	Turnback Value (Empty ROW)
Low = 10%	TCE Width (LF) = 5	Low = $4,500	15%	= $150
Medium = 15%	Duration (months) = 18	Medium = $6,750		
High = 20%	TCE Cost per Year (% of Adjusted $/SF) = 10%	High = $10,000		

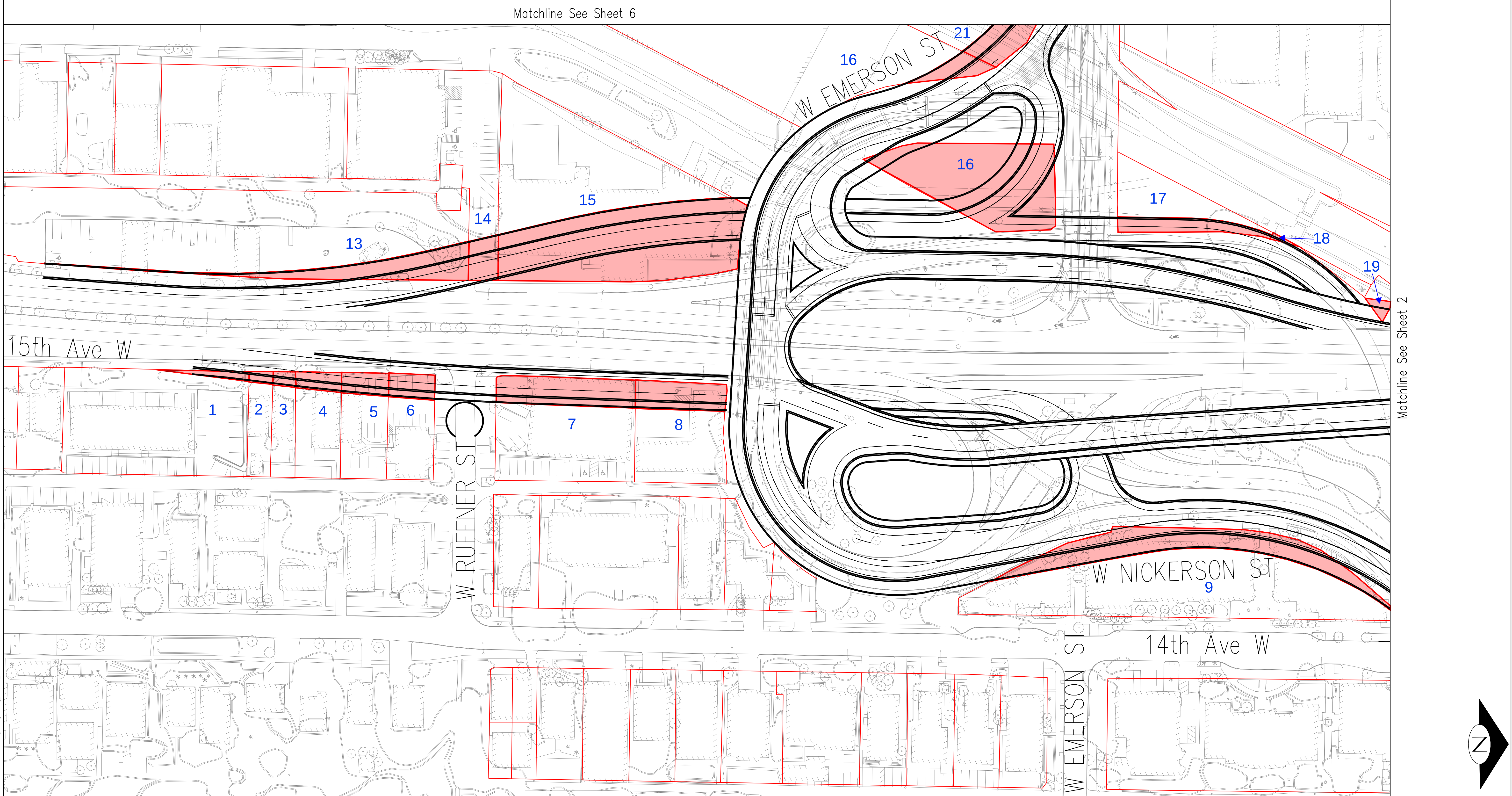
No	Parcel Number	Parcel Owner	Additional Notes on ROW Impacts and Cure Needs	Cost to Cure	Cost to Cure	Length of Frontage	TCE Area	TCE Cost	Just Compensation	Appraisal Fee Costs	Appraisal Review Costs	Negotiation Fee Costs	Title, Escrow Costs	Condemnation & Incidental Costs	Statutory Evaluation Allowance	TOTAL COST PER PARCEL	ROW to Turnback	Adjusted Value of Turnback ROW per SF	VALUE OF TURNBACK
45	2768300980	STOR TENKER LLC	ROW take is nearly the entire property, and demolition of the building is required. The assumption is total take. Total parcel area is 4,500. Building looks to new construction per google earth.	High	$391,636	-	-	$0	$2,349,816	$2,500	$1,000	$10,000	$1,500	$293,727	$750	$2,659,293	647	-$150	(96,993)
46	2768301805	R A HANSEN INVESTMENTS LLC	ROW take is almost 50% of the property, and demolition of the building is required. The assumption is total take.	High	$249,144	-	-	$0	$1,494,864	$2,500	$1,000	$10,000	$1,500	$186,858	$750	$1,697,472	2,319	-$150	(347,850)
47	2768301810	R A HANSEN INVESTMENTS LLC	ROW take is almost 50% of the property, and demolition of the building is required. The assumption is total take.	High	$144,760	-	-	$0	$868,560	$2,500	$1,000	$10,000	$1,500	$108,570	$750	$992,880	2,559	-$150	(383,775)
48	2768301895	BALLARD 14 LLC	Only a small portion of the northeast corner of the parking lot would be impacted.	Medium	$3,761	39	196	$3,284	$32,119	$2,500	$1,000	$6,750	$1,500	$3,761	$750	$48,380	-	-$150	-
49	2768300875	KEYBANK NATIONAL ASSOC	Medium cost to cure because of the potential building impacts. The design may be able to be slightly modified to not impact the building. Parking and part of the building	High	$168,813	200	1,000	$28,700	$1,041,580	$2,500	$1,000	$10,000	$1,500	$126,610	$750	$1,183,940	-	-$150	-
50	2768301800	THE 1409 NW LLC		High	$40,230	50	250	$4,200	$245,582	$2,500	$1,000	$10,000	$1,501	$30,173	$751	$291,506	924	-$150	(138,614)
51	2768300510	NWCC INVESTMENTS INC		High	$17,214	100	500	$15,750	$119,035	$2,500	$1,000	$10,000	$1,502	$12,911	$752	$147,699	(236)	-$150	35,379
52	2768300405	ET14 LLC		High	$24,233	100	500	$11,900	$157,299	$2,500	$1,000	$10,000	$1,503	$18,175	$753	$191,230	(35)	-$150	5,189
53	2767701520	14516 LINDEN LLC		High	$34,251	100	500	$15,749	$221,253	$2,500	$1,000	$10,000	$1,504	$25,688	$754	$262,699	(2,162)	-$150	324,258
54	2767701510	TRAVERSO HOLDINGS I LLC		High	$538,020	100	500	$15,750	$3,243,870	$2,500	$1,000	$10,000	$1,505	$403,515	$755	$3,663,145	1,717	-$150	(257,609)
55	2767701400	TRAVERSO HOLDINGS LLC		High	$160,812	100	500	$15,750	$980,620	$2,500	$1,000	$10,000	$1,506	$120,609	$756	$1,116,990	(173)	-$150	25,923
56	2767701385	SEA WEND LTD		High	$1,122,296	100	500	$15,750	$6,749,526	$2,500	$1,000	$10,000	$1,507	$841,722	$757	$7,607,012	10,207	-$150	(1,531,014)
57	132503HYDR	CITY OF SEATTLE		None	$0	-	-	$0	$0	$0	$0	$0	$0	$0	$0	$0	-	-$150	-
58	7666200105	PORT OF SEATTLE		High	$134,816	780	3,900	$26,351	$835,247	$2,500	$1,000	$10,000	$1,509	$101,112	$759	$952,127	(5,499)	-$150	824,816
59	2771101802	PORT OF SEATTLE		Medium	$292,471	35	175	$2,205	$2,244,483	$2,500	$1,000	$6,750	$1,510	$292,471	$760	$2,549,475	14,931	-$150	(2,239,575)
60	2771101801	PORT OF SEATTLE		Medium	$10,293	35	175	$2,205	$81,119	$2,500	$1,000	$6,750	$1,511	$10,293	$761	$103,934	(967)	-$150	145,025

TOTAL JUST COMPENSATION $130,763,135

TOTAL COST INCL ACQUISTION $147,665,866

TOTAL TURNBACK -$18,082,241

TOTAL COST OF ROW INCLUDING ACQUISITION = $147,665,866
TOTAL VALUE OF REMNANT SALES = -$18,082,241
NET ROW COST INCLUDING ACQUISITION = $129,583,625
ROUNDED NET ROW COST INCLUDING ACQUISITION = $130,000,000



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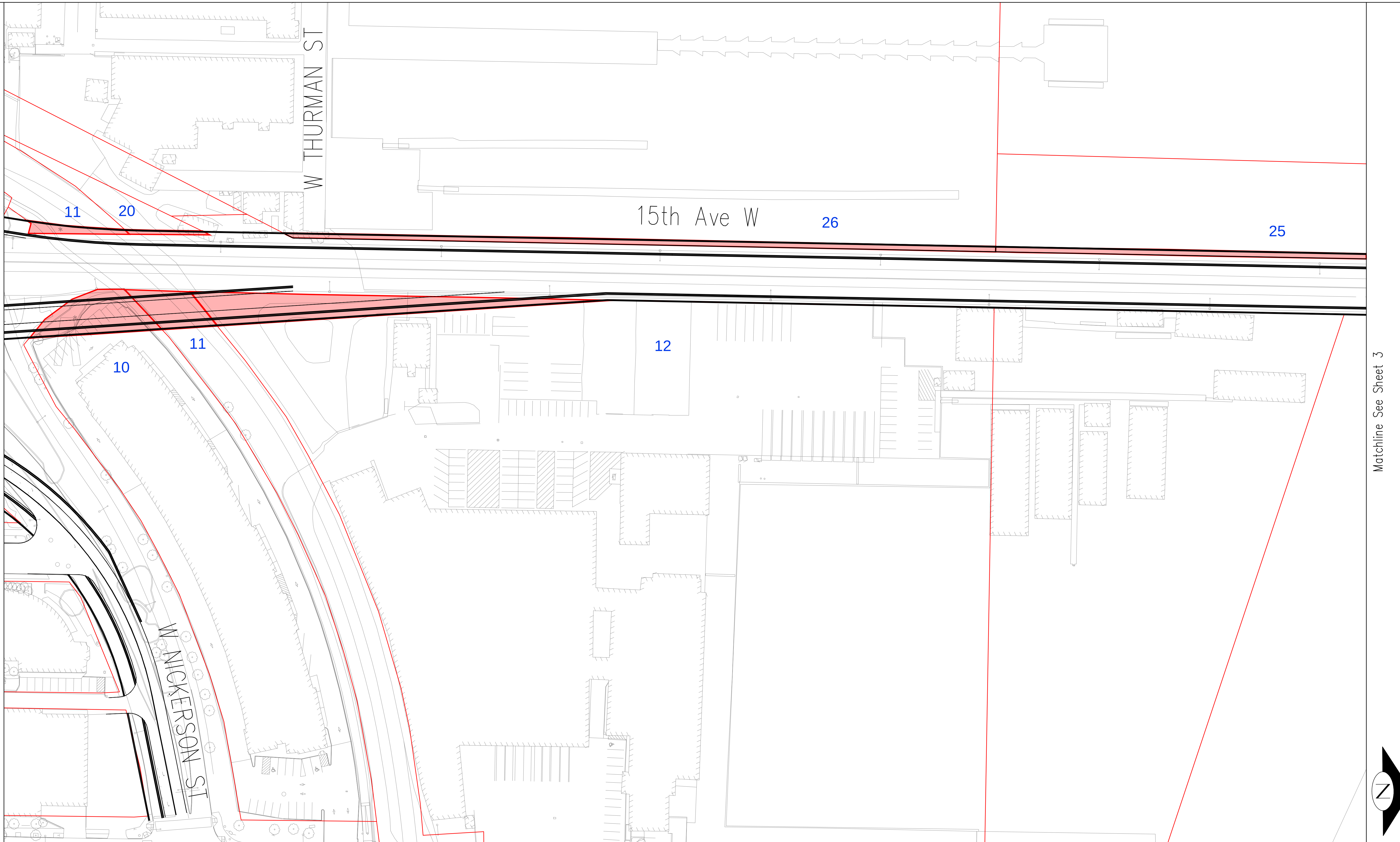

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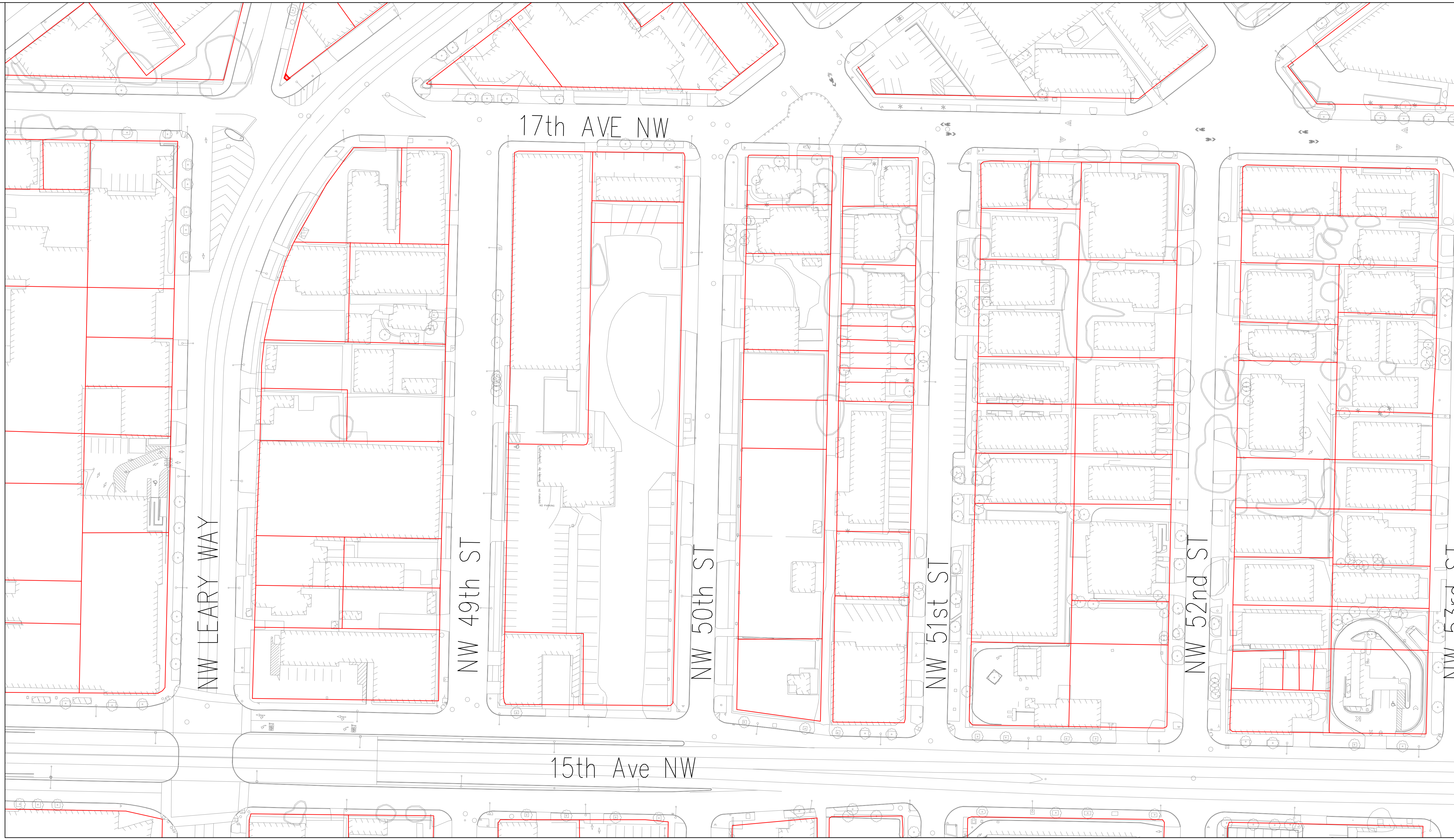

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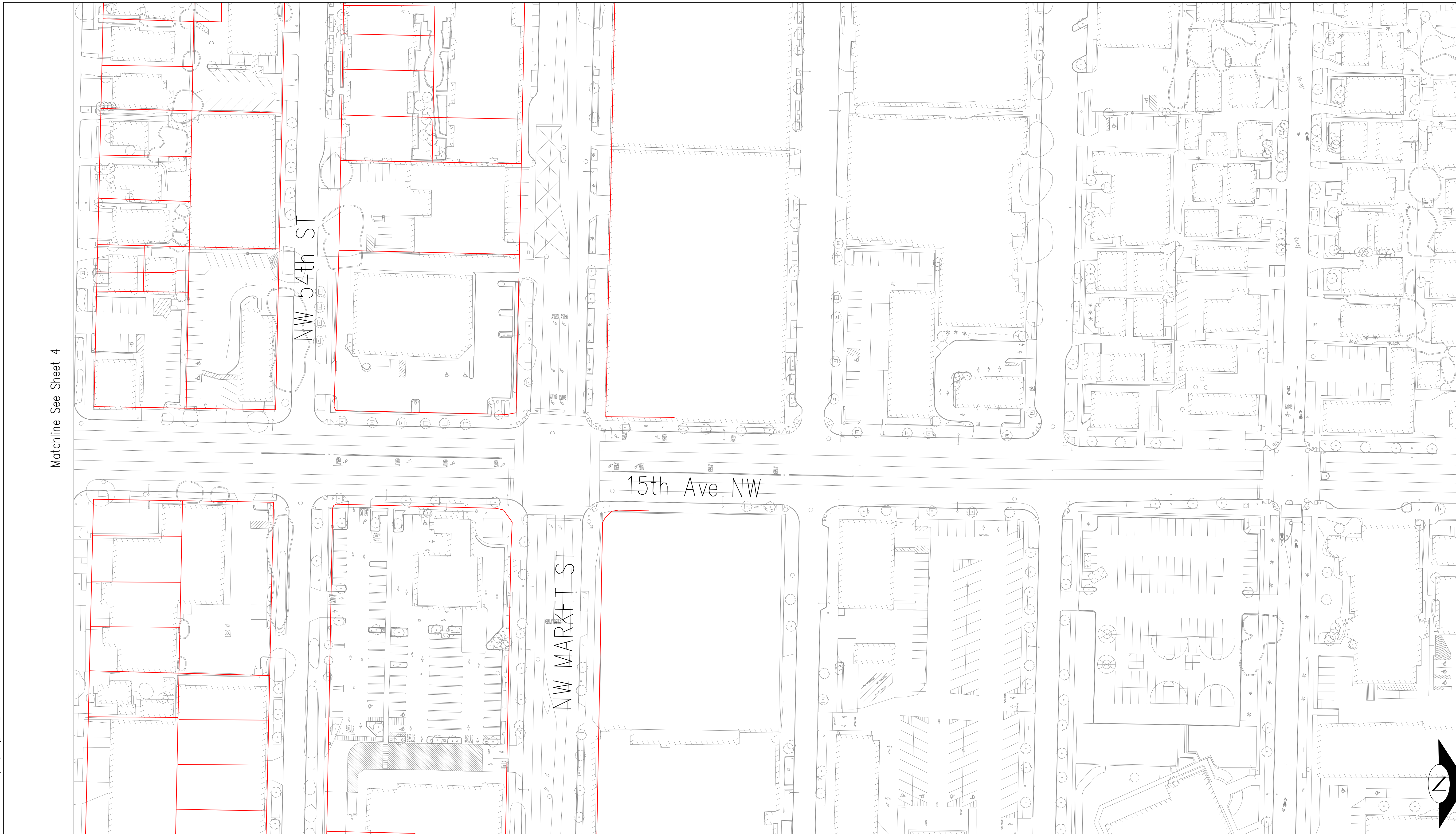

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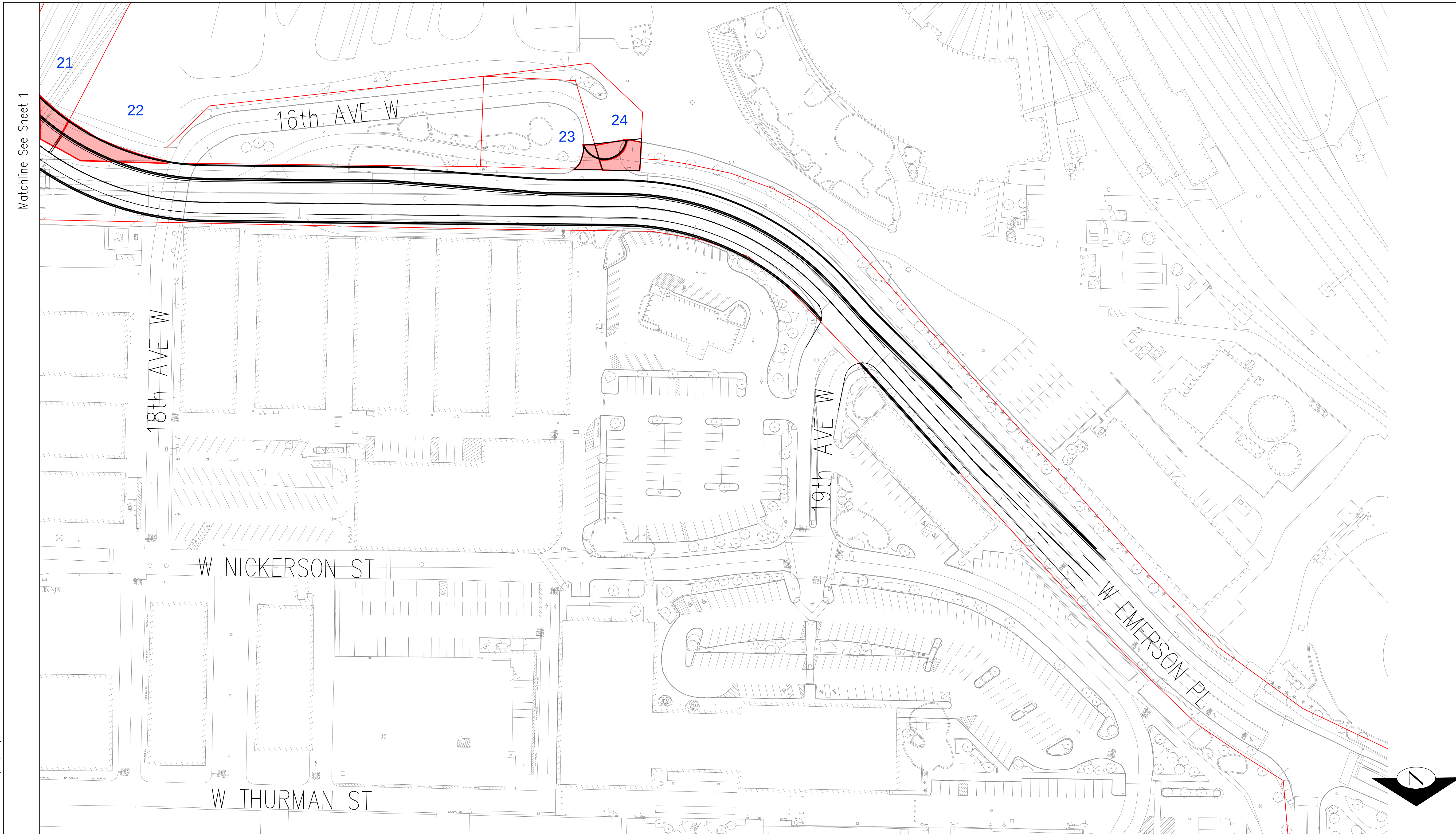

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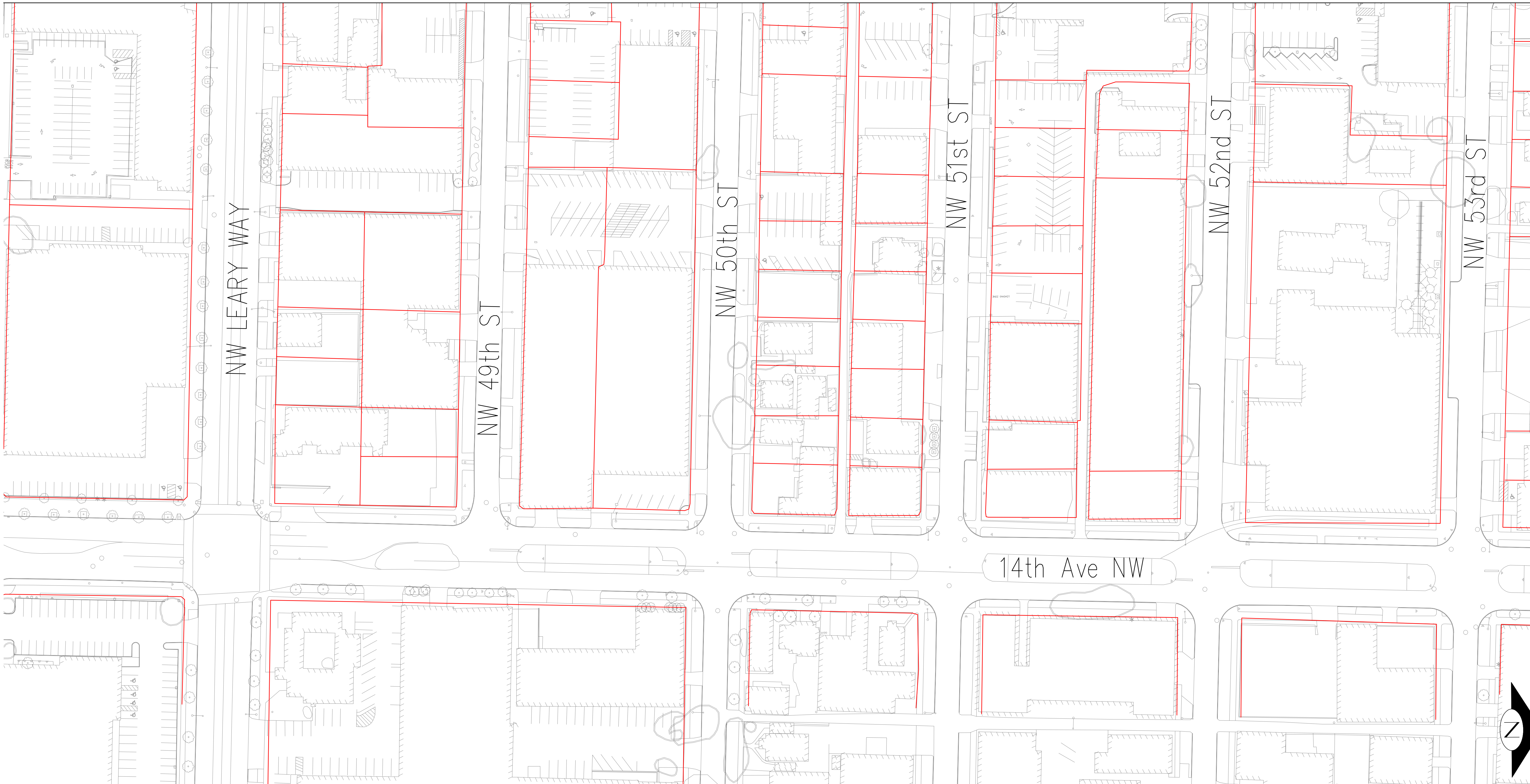

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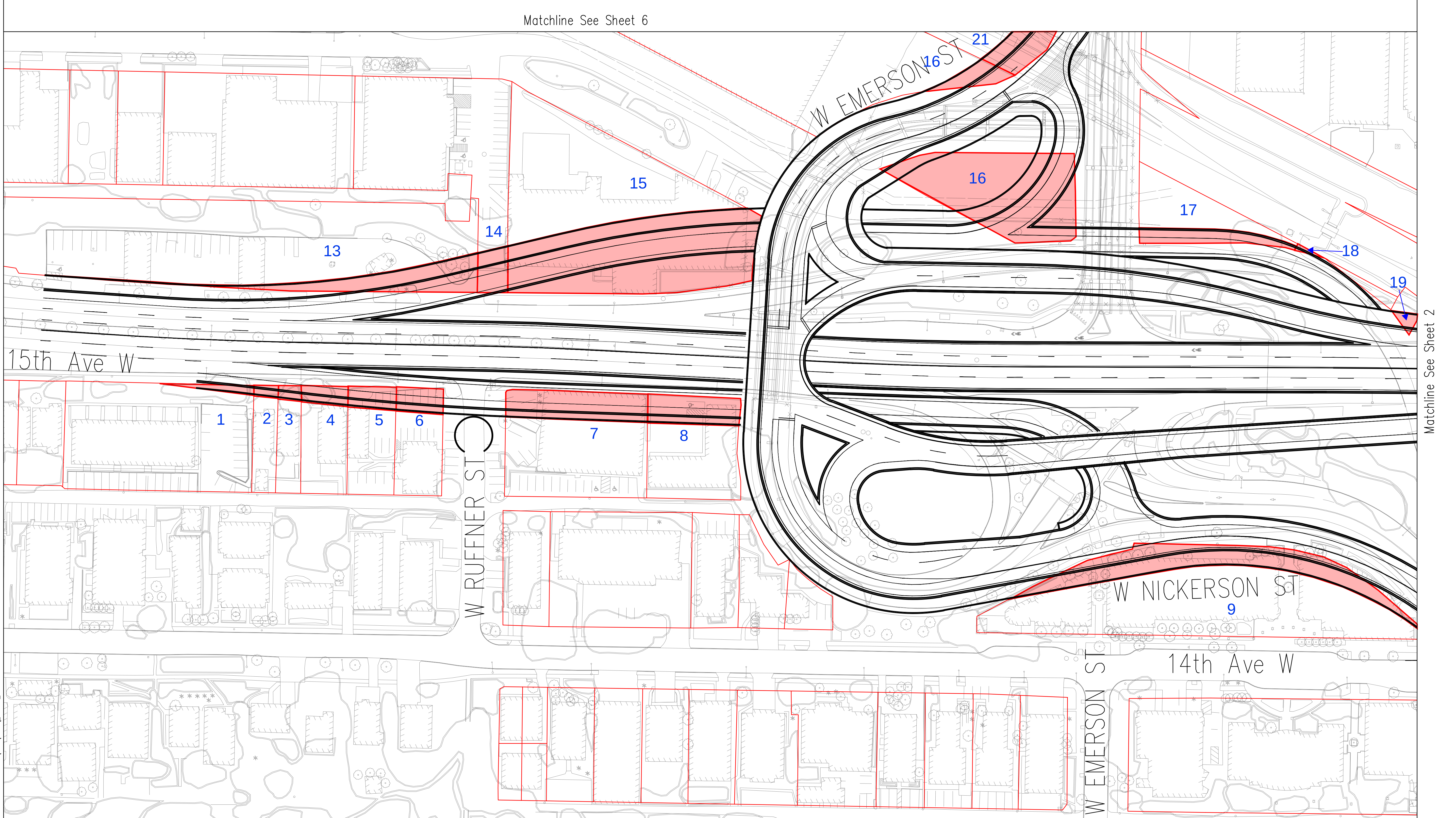

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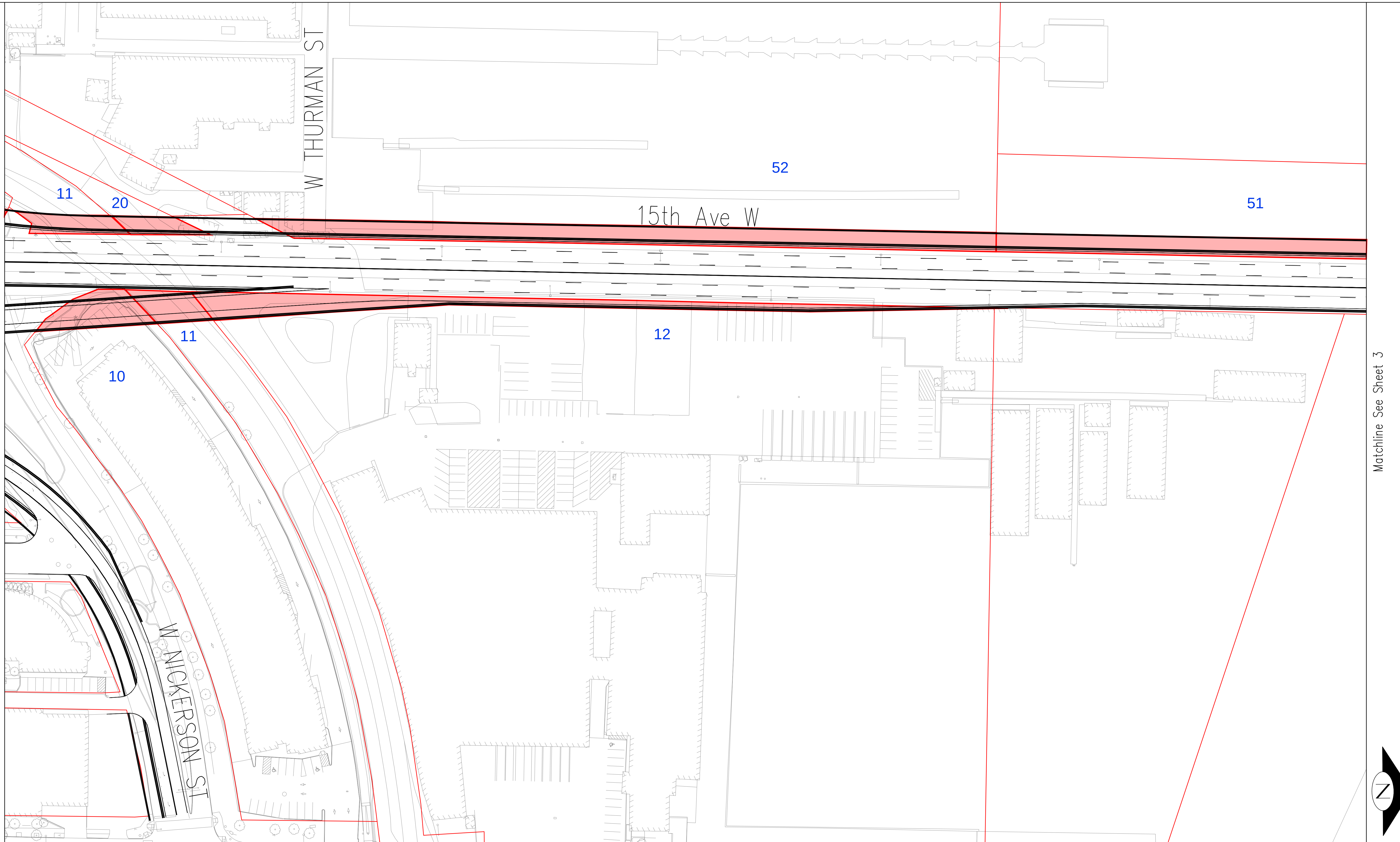

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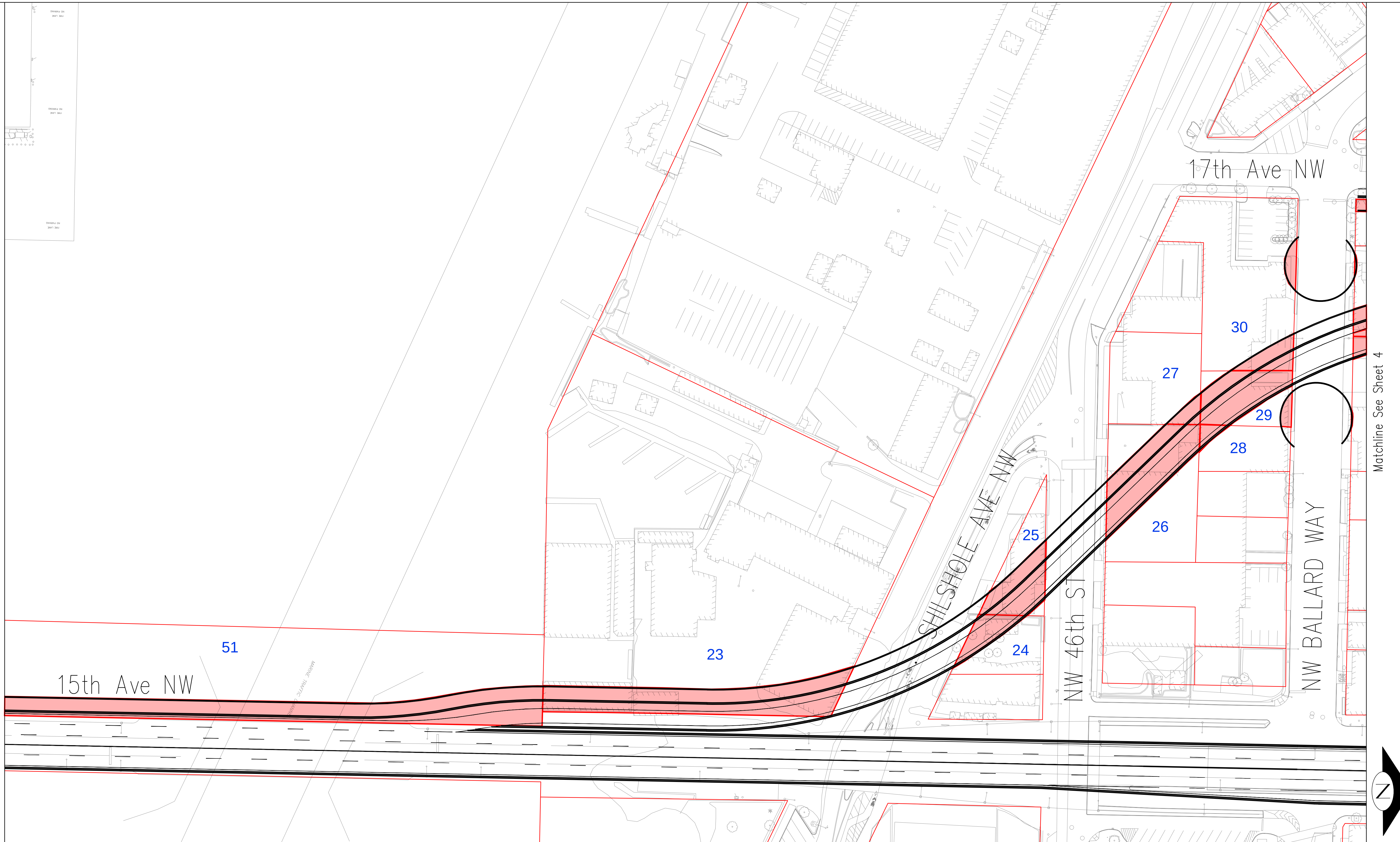

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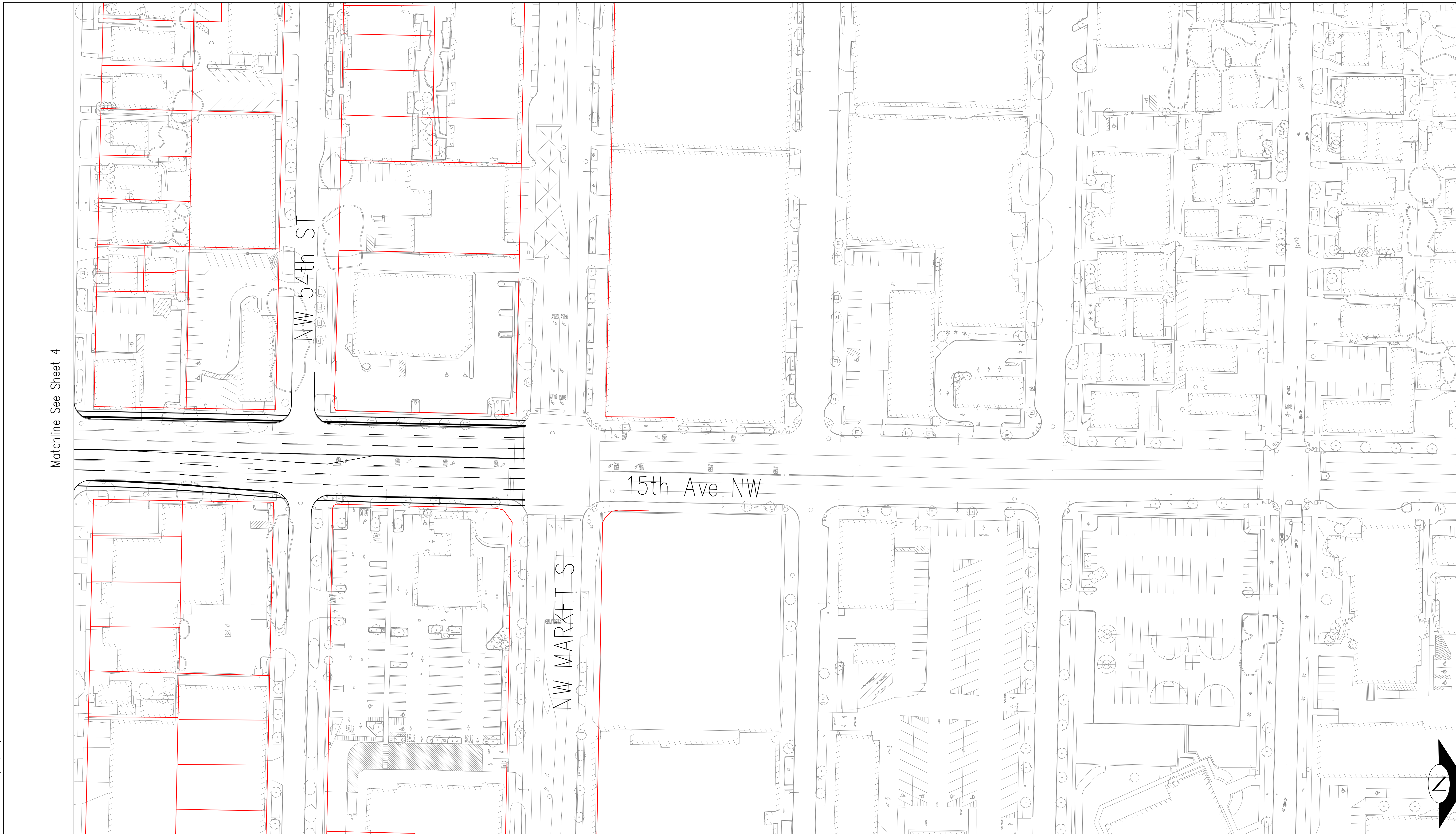

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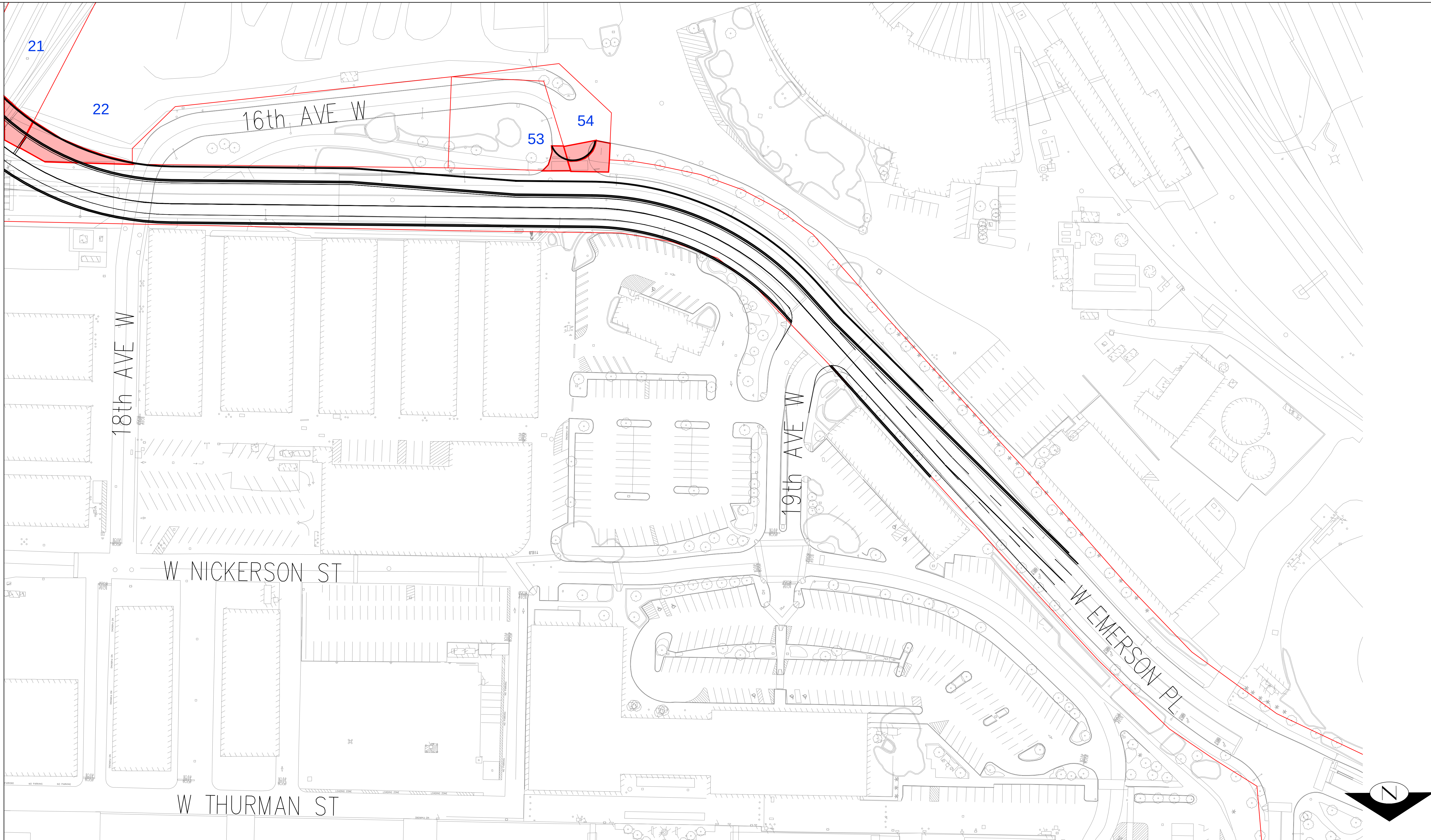

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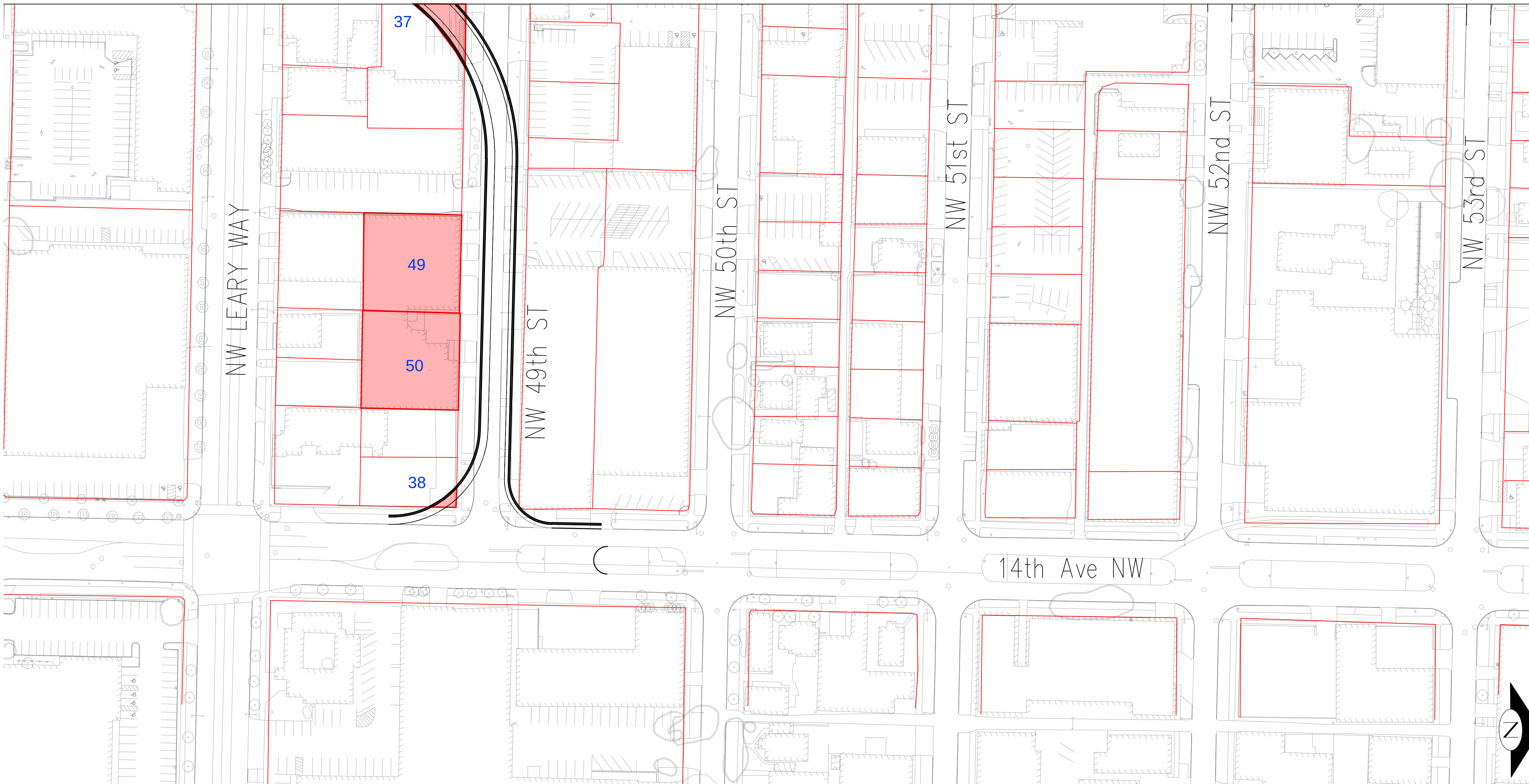

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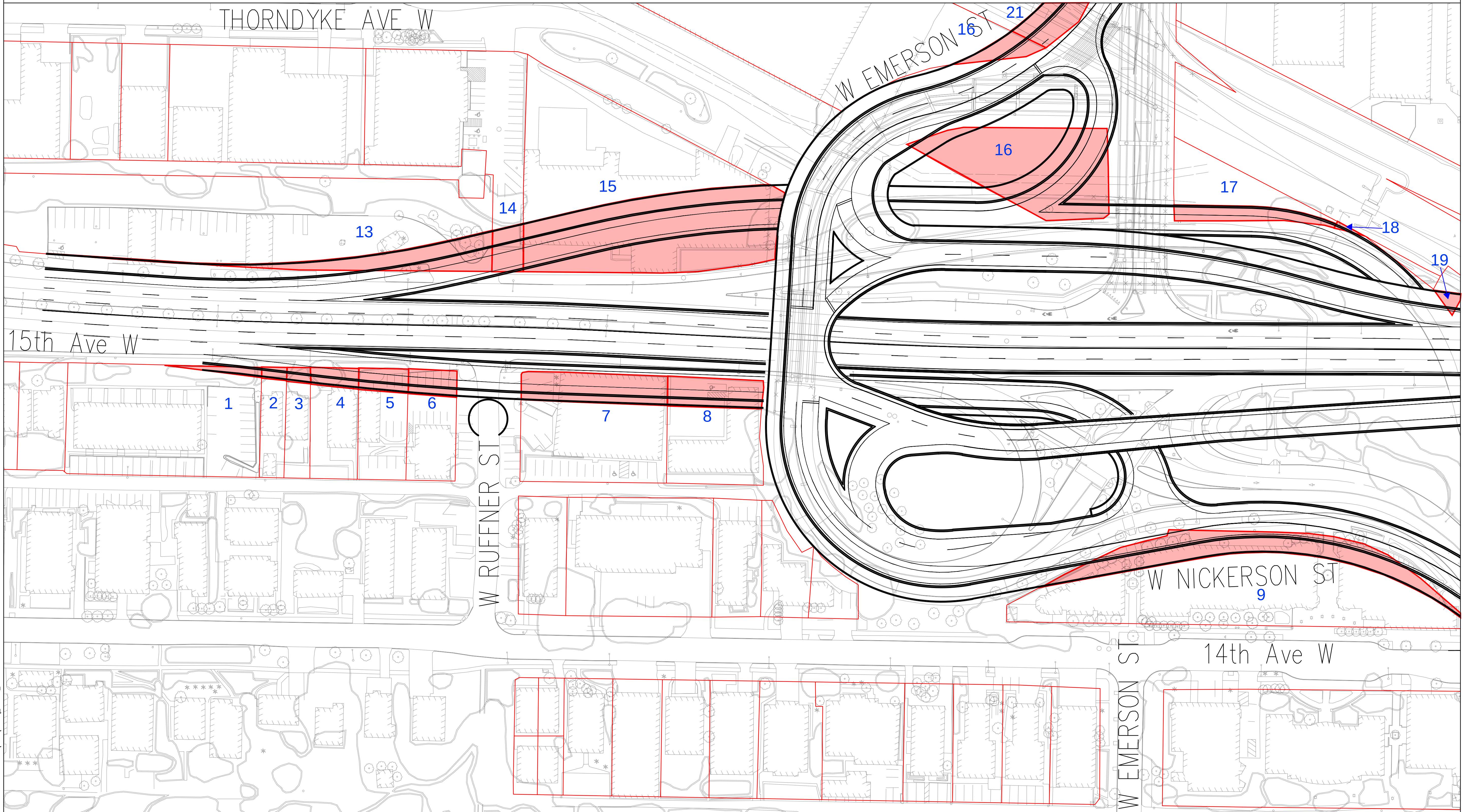

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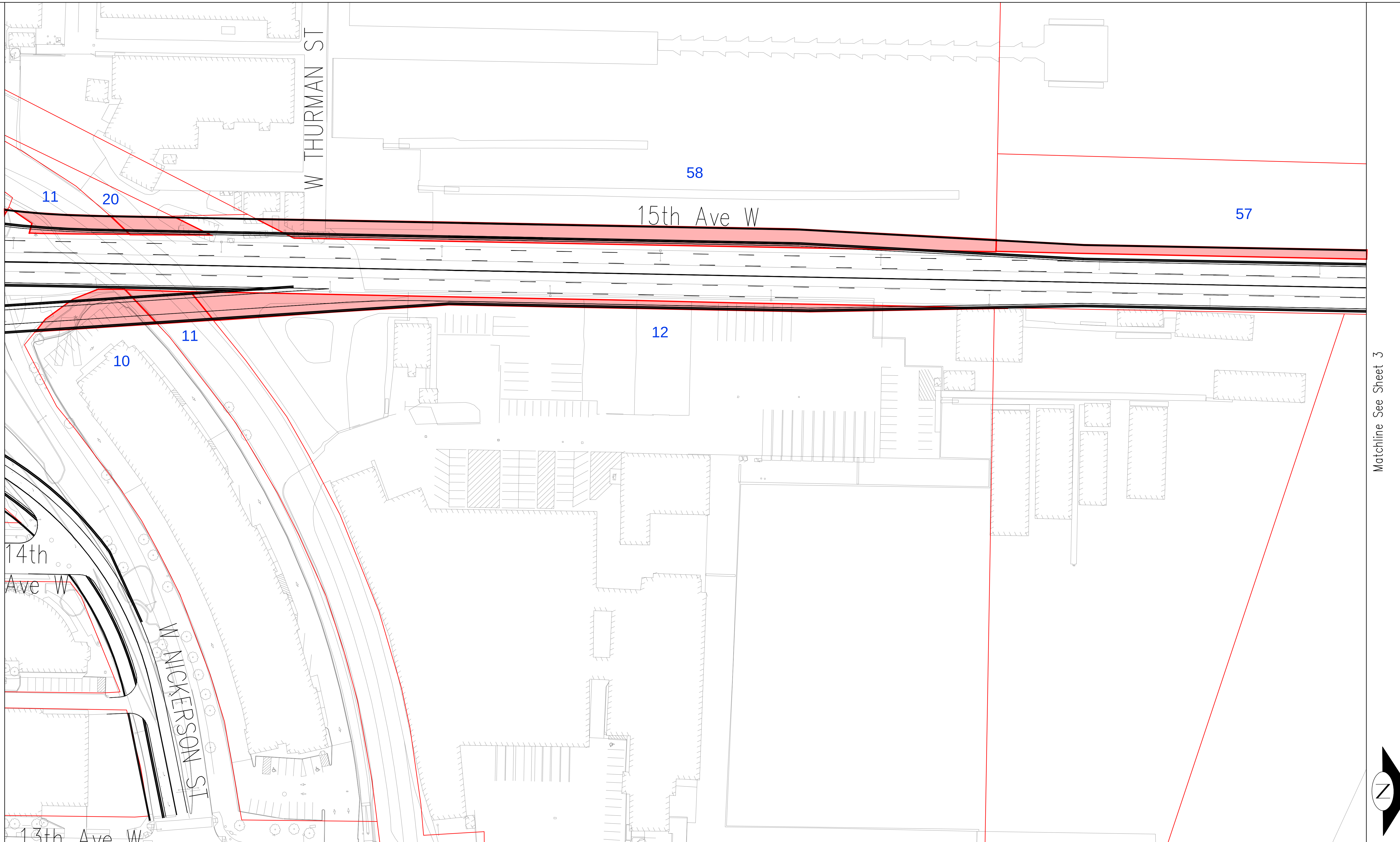

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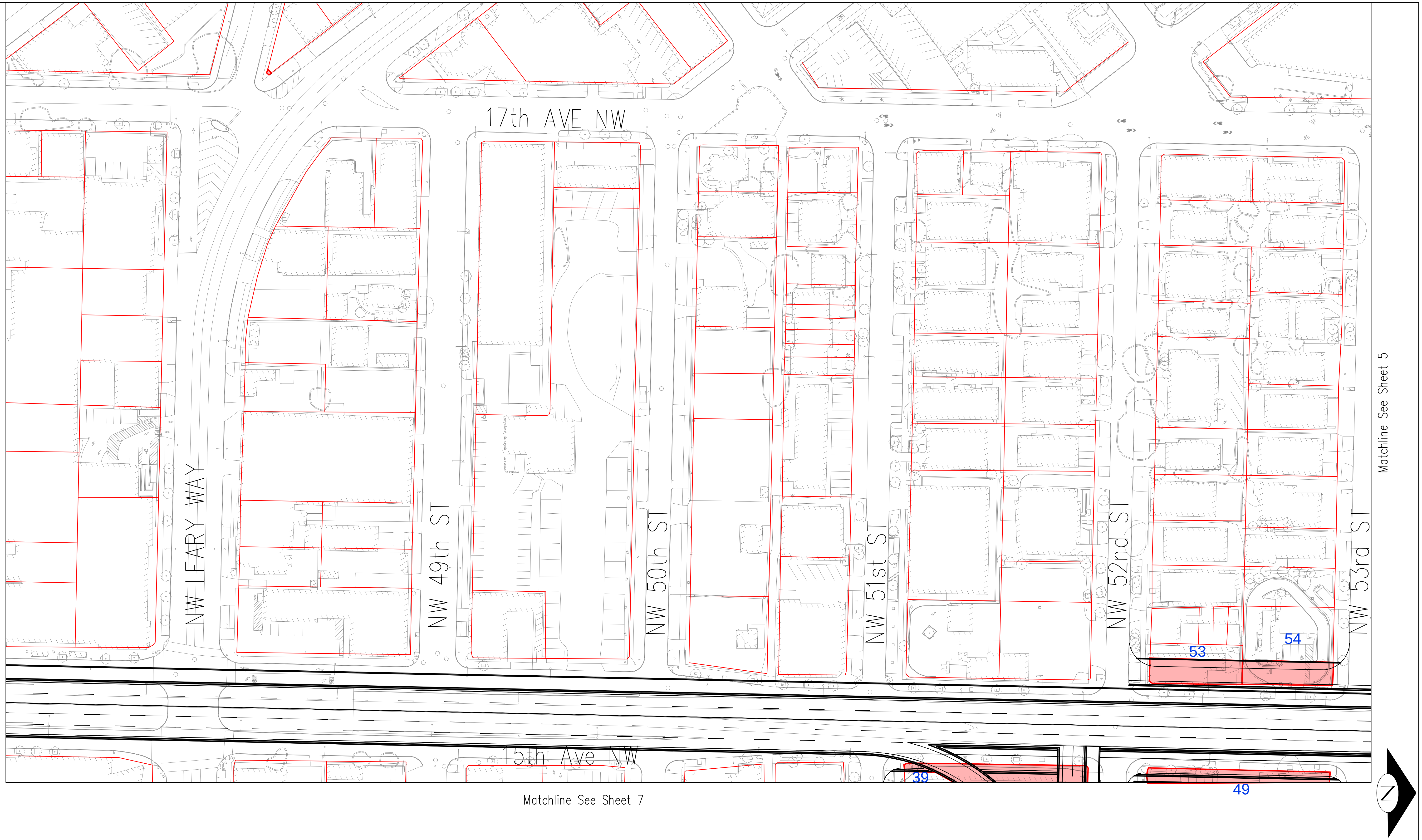

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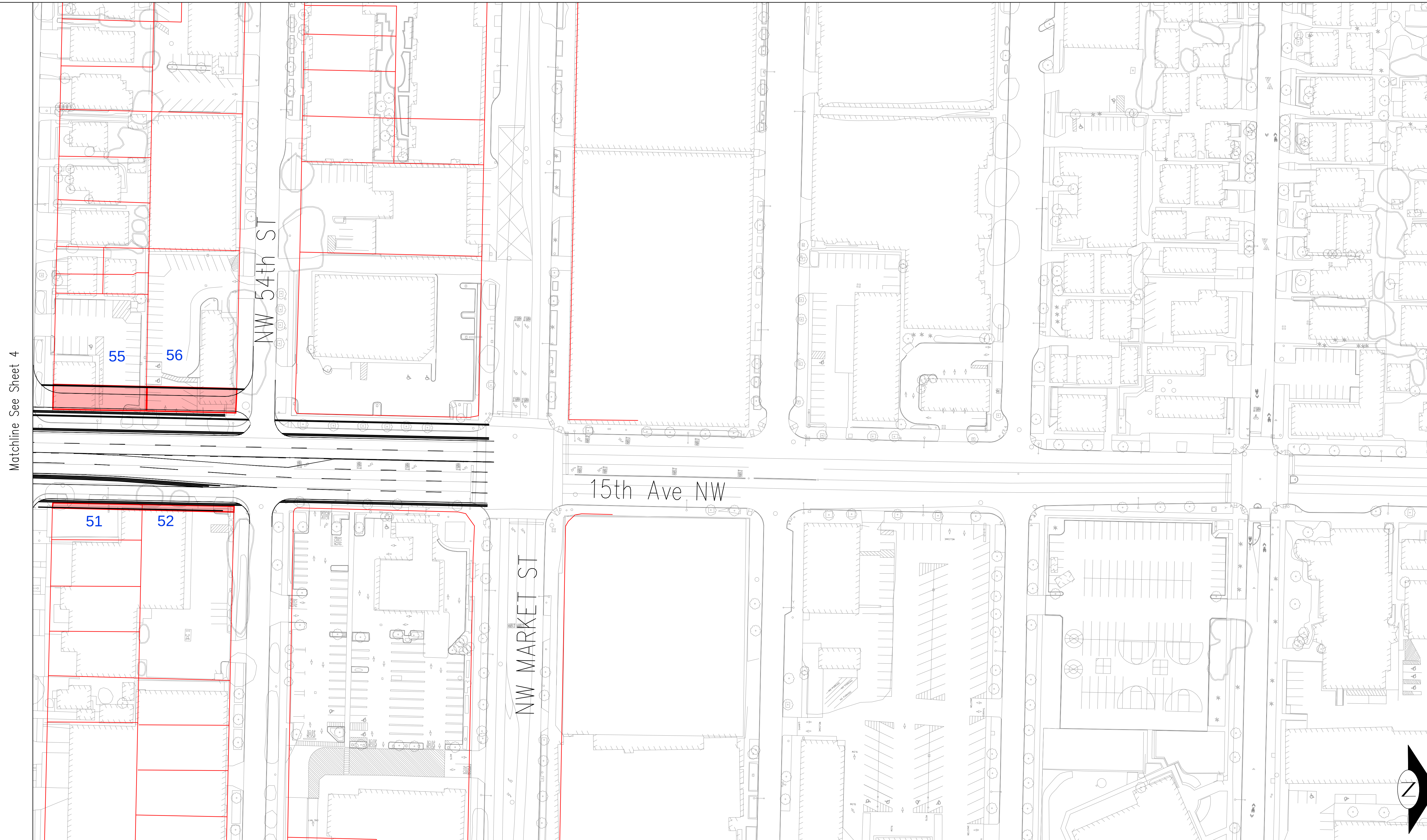

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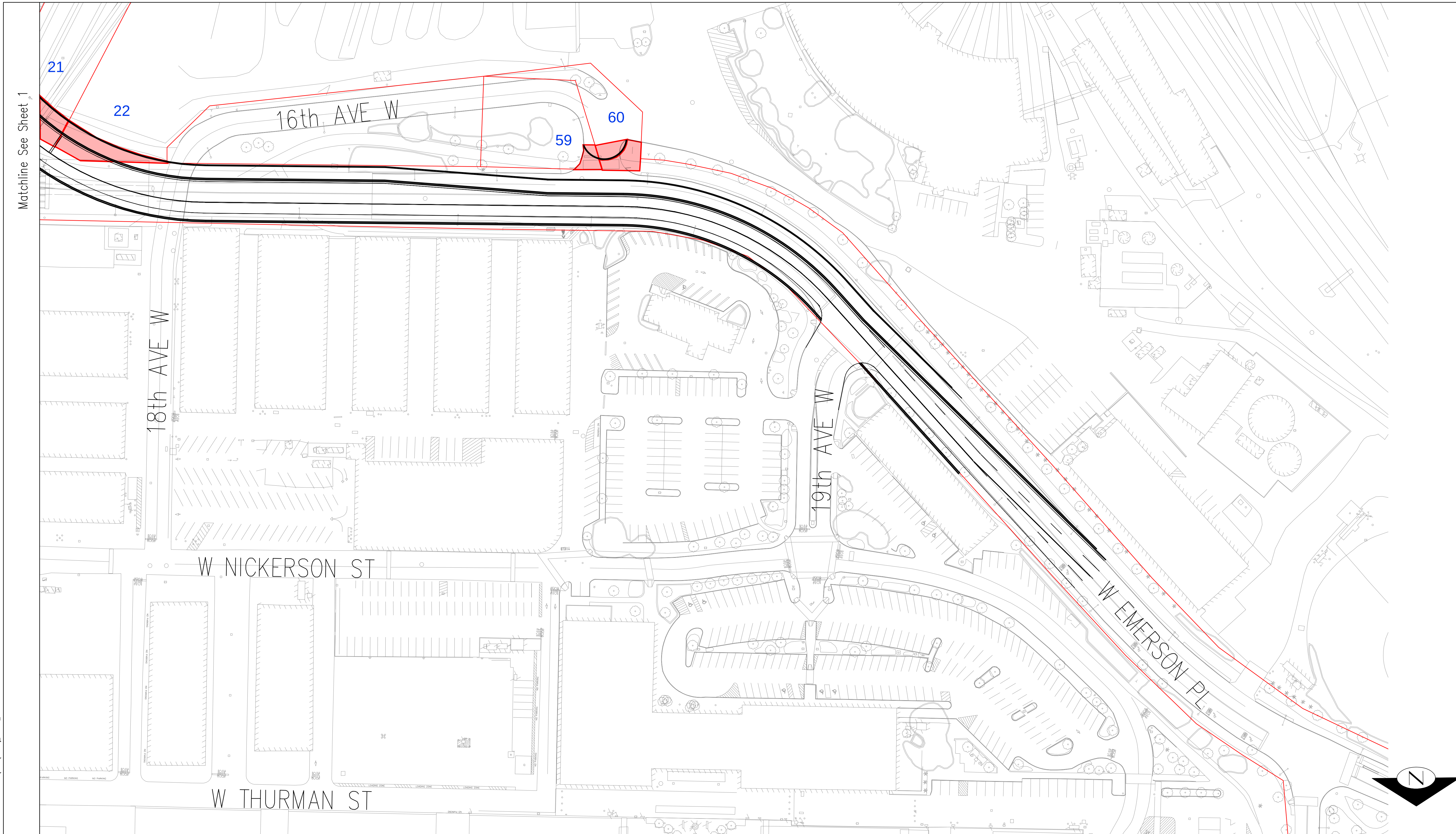

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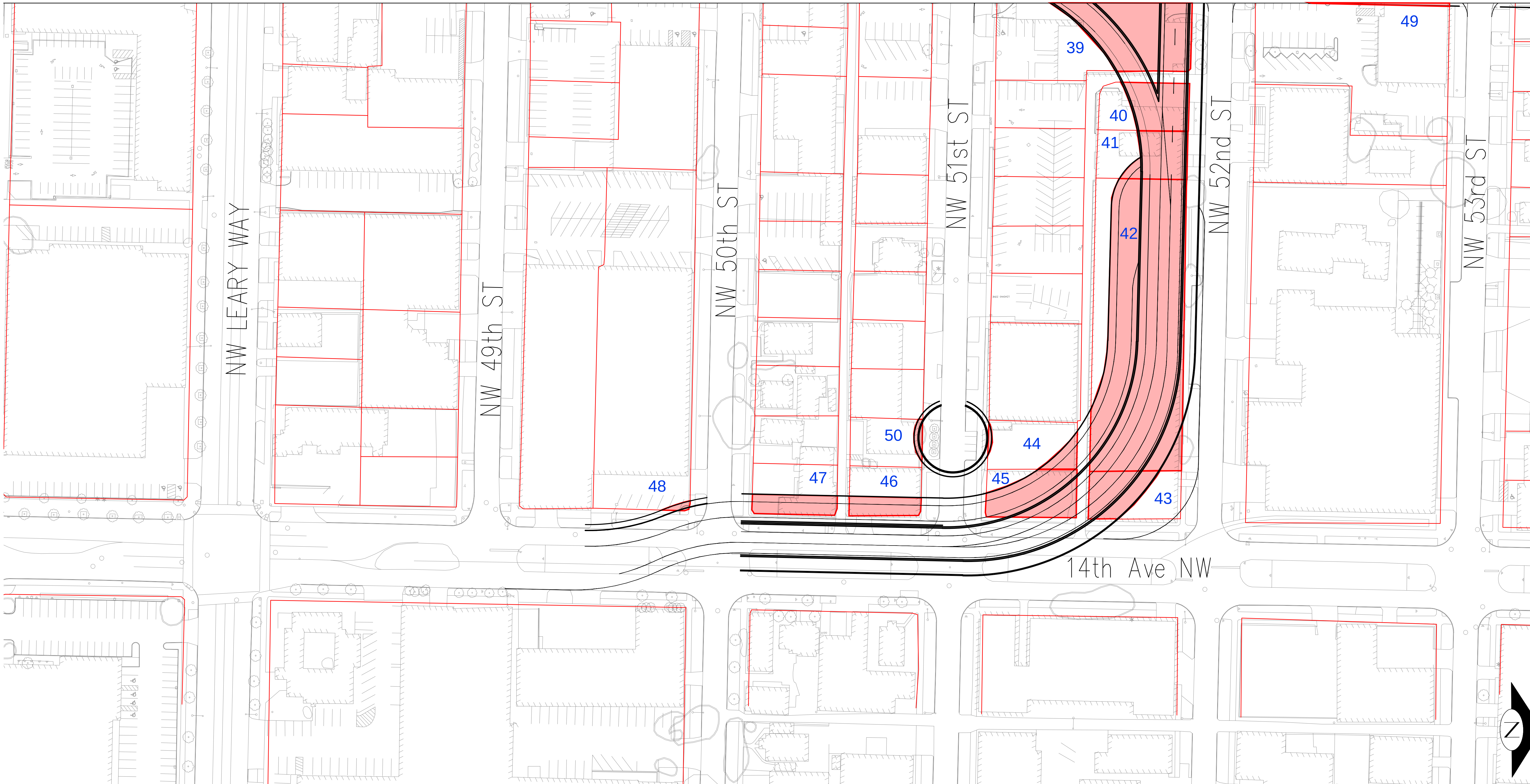

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Appendix G

Concept Design Criteria

Seattle Department of Transportation

Ballard Bridge Planning Study
Concept Design Criteria

CODES / STANDARDS

- City of Seattle Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition
- City of Seattle Standard Plans for Municipal Construction, 2017 Edition
- City of Seattle's Bridge Seismic Retrofit Program Philosophy, Policies and Criteria, 2009
- City of Seattle Streets Illustrated
- City of Seattle SDOT Design Standards for In-Street Bike Facilities
- Seattle Building Code, 2015 (design of control house for movable span alternatives)
- WSDOT Bridge Design Manual (M23-50.18) (BDM), 2018WSDOT Geotechnical Design Manual (M46-03.11) (GDM), 2015
- AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, Eighth Edition, 2017
- AASHTO LRFD Movable Highway Bridge Design Specifications, Second Edition, with Interim Revisions through 2018
- AASHTO Guide Specifications for LRFD Seismic Bridge Design, Second Edition, with Interim Revisions through 2015
- AASHTO Green Book – A Policy on Geometric Design of Highways and Streets, Seventh Edition, 2018
- AASHTO Manual for Bridge Evaluation*
- AASHTO Guide Specifications for Vessel Collision Design of Highway Bridges*
- FHWA Manual on Uniform Traffic Control Devices (MUTCD), 2009 with Revisions 1 and 2, May 2012
- AREMA Manual for Railway Engineering, 2018.
- BNSF Railway-Union Pacific Railroad Guidelines for Railroad Grade Separation Projects, 2016.
- WSDOT Standard Bridge Plans, 2018

REFERENCES

- Seattle Street Illustrated
- Ballard Bascule Bridge Geotechnical Recommendations, Shannon and Wilson, September 19, 2008
- 15th Avenue NW and Leary Way Bridge Seismic Retrofit, Hart Crowser, March, 2019
- Bridge Seismic Retrofit Ballard Bridge BRG 20 Bascule Piers and Movable Spans Concept Design Report, WSP, September 2019
- Ballard Bridge-Vessel Height Survey, July 2016
- Existing SR99 George Washington Bridge Vertical Clearance, April 19, 2019

* Not referenced at this level of study. To be referenced at future design efforts.

Ballard Bridge Planning Study
Concept Design Criteria

ROADWAY DESIGN

SDOT Street Classification

- 15^{th} Ave W/NW / Ballard Bridge:	Principal Arterial – Industrial Access
- NW Market St (West of 15^{th} Ave NW)	Minor Arterial – Urban Village Neighborhood
- NW Market St (East of 15^{th} Ave NW)	Principal Arterial – Urban Village Main
- NW Leary Way (West of 15^{th} Ave NW):	Principal Arterial – Urban Village Main
- NW Leary Way (East of 15^{th} Ave NW):	Principal Arterial – Industrial Access
- Emerson Street:	Principal Arterial – Industrial Access
- Nickerson Street:	Principal Arterial – Urban Center Connector

Existing Posted Speed

- 15^{th} Ave W/NW / Ballard Bridge:	30 MPH
- NW Market St	30 MPH
- NW Leary Way	30 MPH
- Emerson Street:	None posted-15 MPH advisory speed for curve
- Nickerson Street:	30 MPH with 25 MPH advisory speed for curve

Proposed Design Speed

- 15^{th} Ave W/NW / Ballard Bridge:	30 MPH
- NW Market St	30 MPH
- NW Leary Way	30 MPH
- Emerson Street:	30 MPH with 20 MPH advisory curve
- Nickerson Street:	30 MPH with 20 MPH advisory curve

Design Vehicle

- WB67 truck and Bus 40 with 5' front bike rack

Stopping Sight Distance

- 15^{th} Ave W/NW / Ballard Bridge:	min 200' on level terrain, and 215' upgrade
- NW Market St	min 200' on level terrain, and 215' upgrade
- NW Leary Way	min 200' on level terrain, and 215' upgrade
- Emerson Street:	min 200' on level terrain, and 215' upgrade
- Nickerson Street:	min 200' on level terrain, and 215' upgrade

Grade

- Minimum:	1% (except vertical curves)
- Maximum:	5%
- Vertical Curves	Crest K value per AASHTO or 3X design speed

Cross Slope

- 2% Normal Crown (Urban Low Speed)
- Maximum Super Elevation of 4%

Ballard Bridge Planning Study
Concept Design Criteria

Travel Lanes

- Inner Lane: 11-ft
- Outer Lane: 12-ft
- Turn Lane: 11-ft
- Single Lane Ramps: 16-ft
- Double Lane Ramps: 12-ft

Shoulder Widths

- Outside (multi-lane): 2-ft
- Ramp (outside): 8-ft
- Ramp (inside): 4-ft

Sidewalk and Bike Lane (At Grade)

- Bike Lanes Width (not used): 5-ft with a 3-ft separation from vehicle lanes
- Sidewalks width (not used): 6-ft with a 6-ft planter zone between sidewalk and bike lane

Sidewalk and Bike Lane (On Structures)

- On One Side of Bridge: 14-ft Wide Shared-Use Path separated from vehicle lanes with 1.5-ft wide traffic barrier
- On Both Sides of Bridge (not used): 10-ft Wide Shared-Use Path separated from vehicle lanes with 1.5-ft wide traffic barrier.
- On Both Sides of Bridge (not used):
    - Bike Lanes Width: 5-ft separated from vehicle lane with 1.5-ft wide traffic barrier
    - Sidewalks width: 6-ft separated from bike lane with 1.5-ft wide traffic barrier

Ballard Bridge Planning Study
Concept Design Criteria

BRIDGE GEOMETRY

-	Back to Back of Pavement Seats:		TBD
-	Width (Curb to Curb):		TBD
-	Horizontal Clearance:	Streets	Per WSDOT
-		BNSF tracks	Per AREMA
-		Maritime	Not less than current navigational channel
-	Vertical Clearance:	Streets	20' for critical urban freight streets
-			16'-6" for other streets
-		BNSF	23'-6"
-		Trails	10'-0"
-		Maritime	maintain existing for Low-Level Option
-			65' +/- 5' for Mid-Level Option (*)
-			150' +/- 10' for High-Level Option (*)
-			(*) For 18.75ft high water elevation, NAVD88.

BRIDGE MATERIAL PROPERTIES

Concrete

-	Compressive Strength:	f'c	4000 psi to 6000psi
-	Coefficient of Thermal Expansion:		α= 6.0 X 10^{-6} in/in/°F
-	R/C Shrinkage (BDM 3.15):		2.0 X 10^{-4} feet/foot

Lightweight Concrete (for bridge deck on movable span alternatives)

-	Compressive Strength:	f'c	4000 psi to 6000psi
-	Coefficient of Thermal Expansion:		α= 5.0 X 10^{-6} in/in/°F

Reinforcing Steel

-	Yield Strength:	Typical	60 ksi
		Shafts	60 or 80 ksi
		Columns & Crossbeams	60 ksi Typical

Permanent Casing

-	Casing:	ASTM A252- GRADE 2
	o Fy	35 ksi
	o Fu	60 ksi
-	Corrosion Rate:	Allowance provided, to be determined during final design
-	Minimum thickness	Allowance provided, to be determined during final design

Ballard Bridge Planning Study
Concept Design Criteria

BRIDGE DESIGN LOADS

Dead Loads:

- Unit Weight of Material:	Concrete:	155 pcf (CIP Concrete)
		165 pcf (Precast Girders)
		125 pcf (Movable Span Bridge Deck)
	Steel:	490 pcf
	MMC:	150 pcf
- Future Overlay:		2" MMC
- Traffic Barrier (42" single slope TL-4):		710 lb/ft
- Throw Fence (over railroad tracks):		Allowance provided, to be determined during final design
- Pedestrian Rail:		Allowance provided, to be determined during final design
- Bridge Utilities:		Allowance provided, to be determined during final design

Live Loads:

- Pedestrian Loading:	75 psf
- Design Vehicle Loading:	HL-93
- Future Streetcar Loading:	None
- Railroad Surcharge Loading:	Consider during final design
- Vessel Collision Loading:	In accordance with AASHTO LRFD 3.14

Temperature:

- Temperature Range:	
o Concrete Superstructure	0 to 100 degrees F
o Steel Superstructure	0 to 120 degrees F
- Base Temperature:	64 degrees F

Wind Load:

- Pressure:	WSDOT BDM Section 3.11

Ballard Bridge Planning Study
Concept Design Criteria

SEISMIC DESIGN CRITERIA

Seismic Design Criteria for Replacement Options – per WSDOT BDM

- Seismic Design to conform to the WSDOT two-level seismic performance requirements for Critical and Essential Bridges
- Bridge Importance: Essential
- Earthquake Level, Service Level and Damage states:
  - <u>Functional Evaluation Earthquake Level (FEE):</u>
    - 210-year return period event
    - Expected Post-Earthquake Service Level: Full service. Full access to normal traffic is available almost immediately after the earthquake
    - Expected Post-Earthquake Damage State: Minimal
  - <u>Safety Evaluation Earthquake Level (SEE):</u>
    - 975-year return period event
    - Expected Post-Earthquake Service Level: Limited Service. Bridge is open for emergency vehicle traffic. A reduced number of lanes for normal traffic is available within three months of the earthquake. Vehicle weight restriction may be imposed until repairs are completed. It is expected that within three months of the earthquake, repair works on a damaged bridge would have reached the stage that would permit normal traffic on at least some portion of the bridge.
    - Expected Post-Earthquake Damage State: Moderate

Seismic Design Criteria for Rehabilitation (including widening) Options

- Seismic Design to conform to the Seattle's Bridge Seismic Retrofit Program Philosophy, Policies and Criteria, 2009 and WSDOT BDM Section 4.3 Seismic Design Requirements for Bridge Modifications and Widening Projects
- Bridge Importance: Essential
- Earthquake Level, Service Level and Damage states:
  - <u>Lower Level Earthquake</u>
    - 100-year return period event
    - Seismic performance: Essentially operational performance (essentially elastic response)
  - <u>Upper Level Earthquake</u>
    - 1000-year return period event
    - Seismic performance: Life-safety protection.

Seismic Design Response Spectrum

- Seismic Design Spectrum per AASHTO Guide Specifications for LRFD Seismic Bridge Design. Several seismic design spectra are to be developed for the different earthquake levels considered.

Appendix H

Outreach Summary Report

Seattle Department of Transportation

BALLARD BRIDGE PLANNING STUDY

OUTREACH SUMMARY REPORT

2019

Contents

STUDY PURPOSE

The Ballard Bridge, built in 1917, spans the eastern edge of Salmon Bay and connects Ballard to Magnolia, Queen Anne, and Downtown via Interbay. The 2,854-foot bridge carries more than 57,000 vehicles per day across the Lake Washington Ship Canal. Similar to the Fremont Bridge to the east, this bridge is a bascule bridge that opens to allow taller ships to pass through the Ship Canal.

We perform regular maintenance and frequent inspections on the bridge to ensure it is operational and safe for both roadway and marine traffic. However, due to the age of the structure, more significant rehabilitation may be needed to sustain its current level of operational use. Since the bridge is still in good condition today, we have an opportunity to plan and look beyond just maintaining its current form and function. We have launched the Ballard Bridge Planning Study to evaluate improvements that will bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving.

The planning study, funded by the Levy to Move Seattle, explores feasible rehabilitation and replacement options for the long-term future of the bridge. It is the second of ten studies to help us assess and manage roadway structure maintenance needs and maximize future investments. This study will not recommend a preferred alternative but will provide a comparison of alternatives as we, in coordination with our elected officials, evaluate funding options.

Project Schedule

Activity	**Timing**	**Purpose**
Online Survey	Spring 2019	To introduce the project scope and schedule and to better understand behaviors for users of the Ballard Bridge
Stakeholder Meetings	Spring 2019	To introduce the project scope and schedule and to better understand behaviors for users of the Ballard Bridge
Advisory Board Briefings	Spring-Summer 2019	To involve and seek assistance from Bike, Pedestrian, Transit, and Freight advisory boards
Drop-In Sessions & Community Events	Summer-Fall 2019	To describe the Ballard Bridge history, review evaluation process, present analyses and collect community input
Community Councils & Other Community Group Briefings	Spring-Fall 2019	To inform the public of the study purpose and progress, and to provide more opportunities for community comments and questions
Finalize Alternatives Analysis and Share Results	Fall-Winter 2019-20	Finalize and share results with SDOT directors, the Mayor, and our local, county and state elected officials

OUTREACH OVERVIEW

Outreach Objectives	• **Create public awareness** of the study and opportunities for participation
	  o Provide continued communication and transparency to the stakeholders and the public throughout the process
	  o Encourage participation and disseminate information through effective and focused messaging
	• **Promote an understanding** of the purpose, need, outcome, and timeline of the study
	  o Clearly, describe how the planning study will be used and the role that stakeholder and public input plays
	  o Ensure people understand the long-term timing of potential design and construction of the project
	  o Ensure people understand the study will not recommend a preferred alternative
	• **Get key stakeholder and community feedback** and foster an environment where all stakeholders feel heard
	  o Recruit diverse and representative community participation across demographic indicators such as gender, age, and race/ethnicity
	  o Use past SDOT planning processes to identify key stakeholders and the public invested in the study area to participate in engagement opportunities, including freight, pedestrian, bicycle, transit, and emergency response interests
	  o Provide ample opportunities for the stakeholders and the public to voice their needs and be clear on our intent for the engagement—whether we're informing, consulting, or collaborating with stakeholders and public

Media & Stakeholders	• Local media outlets including the Queen Anne & Magnolia News, Queen Anne View, MyBallard and Ballard News Tribune • Queen Anne, Interbay, Magnolia and Ballard neighborhood organizations and groups • Adjacent property owners, residents, and businesses • Modal advisory boards and transportation interest groups including freight, pedestrian, bike, and maritime • Partner agencies including Port of Seattle, King County Metro and Sound Transit

OUTREACH ACTIVITIES

ACTIVITIES LOG

The table below details the outreach activities completed to date. Future planned activities are on the PIP cover sheet.

When	What	Who	Details
5/9	*Interagency Kick-off Meeting*	*Agency & Department partners (Sound Transit, King County Metro, Port of Seattle, SDOT Transportation Operations and Transit & Mobility, SPU, SCL)*	*Provide introduction to study scope and confirm interagency interest and contact information*
5/29	*Stakeholder Tour: Coastal Transportation*	*Project Team, North Seattle Industrial Association Members, Coastal Transportation staff*	*Provide overview of study scope and tour stakeholder facilities*
5/31	*Stakeholder Tour: Fisherman's Terminal*	*Project Team, Port of Seattle representative, Fisherman's Terminal Staff, Fishing Vessel Owners Staff*	*Provide overview of study scope and tour stakeholder facilities*
6/5	*Seattle Bicycle Advisory Board*	*Project PM and Advisory Board members and liaison*	*Provide overview of scope, concepts, and study schedule and process*
6/18	*Seattle Freight Advisory Board*	*Project PM and Advisory Board members and liaison*	*Provide overview of scope, concepts, and study schedule and process*
6/19	*Online Community Survey*	*Open to everyone*	*Online community survey to understand needs and values for users of the bridge*
6/19	*Blog Post*	*SDOT Blog*	*Blog post to announce launch of project and share information about online survey*
6/19	*Listserv #1*	*People who signed up for listserv emails for nearby projects*	*Announce launch of project, share information about goals, and encourage people to*

			take online community survey
6/27	*Interagency Technical Coordination Meeting #1*	*Agency & Department partners (Sound Transit, King County Metro, Port of Seattle, SDOT Transportation Operations and Transit & Mobility, SPU, SCL)*	*Discuss initial concepts, review alignments, and capture areas for further consideration*
7/2	*Listserv #2*	*People who signed up to the BBPS listserv via listserv #1, webpage, and survey*	*Reminder to take and share online community survey*
7/18	*Mobile Display*	*Ballard Library, Queen Anne Library*	*Project info, background, and drop-in session dates*
7/24	*Mailer*	*Businesses and residences right by the bridge (see map in EL)*	*Invitation to drop-in session on 7/31*
7/24	*Listserv #3*	*BBPS Listserv*	*Updates on project, invitation to upcoming drop-in session on 7/31*
7/31	*July Drop-In Session – Fishermen's Terminal*	*Open to everyone (advertised through listserv, A-Frames near the bridge, mailer, webpage, mobile display)*	*Initial survey results, overview of the project, high-level concepts being considered*
9/6	*Listserv #4*	*BBPS Listserv*	*Updates on project, key takeaways from online community survey and drop-in session on 7/31*
9/12	*Technical Workshop #1*	*Freight and Bike stakeholders & members of advisory boards*	*Allow stakeholders to react to initial concepts and provide feedback and considerations*
9/26	*Interagency Technical Coordination Meeting #2*	*Agency & Department partners (Sound Transit, King County Metro, Port of Seattle, SDOT Transportation Operations and Transit & Mobility, SPU, SCL)*	*Allow agency partners to react to refined concepts and provide feedback and considerations*
10/4-10/22	*SDOT Roadway Structures Staff Input*	*All SDOT Roadway Structures Operations, Maintenance, Design & Management Staff*	*Provided overview of alternatives and asked for input in the context of their daily work and expertise*

10/11	*Listserv #5*	*BBPS Listserv*	*Updates on project, invitation to upcoming drop-in sessions*
10/24	*October Drop-In Session #1 – Peddler Brewing*	*Open to everyone (advertised through listserv, A-Frames near the bridge, mailer, webpage, mobile display)*	*Updated, detailed concepts, considerations criteria, voting on preferred alternatives*
10/29	*October Drop-In Session #2 – Fishermen's Terminal*	*Open to everyone (advertised through listserv, A-Frames near the bridge, mailer, webpage, mobile display)*	*Updated, detailed concepts, considerations criteria, voting on preferred alternatives*
11/1	*Listserv #6*	*BBPS Listserv*	*Updates on project, information about online open house and open house survey closed on 11/15*
11/1	*Online Open House*	*Open to everyone*	*Sharing updates on project, reflecting October drop-in sessions' boards and format on an online platform*
11/1	*Online Open House Survey*	*Open to everyone*	*Online community survey to understand people's most and least preferred alternatives, closed on 11/15*

Attachment A: July Drop-In Session

EVENT OVERVIEW

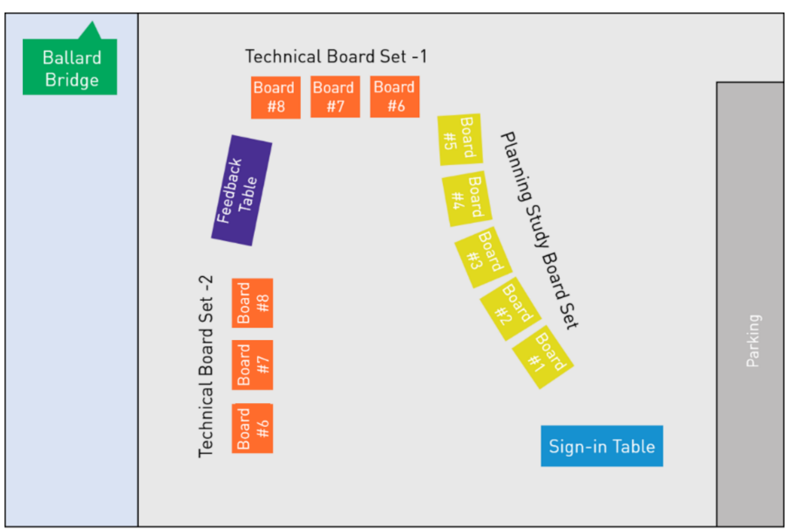
On July 31, 2019, we hosted a drop-in session for the Ballard Bridge Planning Study at Fisherman's Terminal (3919 18th Ave W) in Interbay. The drop-in session was from 6 PM to 7:30 PM; attendees could come drop in anytime within that window.

There were 4 Seattle Department of Transportation (SDOT) staff members and 6 SDOT consultants in attendance.

EVENT LAYOUT

The room was set up with multiple stations:

- SDOT sign-in table
    - Project factsheet
- SDOT Ballard Bridge Planning Study board set
    1. Welcome and Project Overview board
    2. History of the Ballard Bridge board
    3. Timeline and Funding board
    4. Online Community Survey Results: Current Use board
    5. Online Community Survey Results: Desired Use board
- SDOT technical information board sets (x2)
    6. Ballard Bridge Considerations board
    7. Interactive Additional Considerations board
    8. Ballard Bridge Options board
- Feedback table
    - Sticky notes and pens for written feedback
    - Comment cards



*Drawing not to scale

ATTENDANCE

Anecdotally, approximately 50 people attended. 22 people signed in, though the layout of the event did not require all attendees to visit the sign-in table. The photos below show the plaza and how people interacted with the different stations and staff.

Figure 1: Attendees viewing display boards

Figure 2: Staff answering questions at the technical boards

Figure 3: Staff speaking with attendees at the 3 stations

WHAT WE HEARD

Throughout the drop-in session, we were looking for feedback from the community on their transportation needs and values for the bridge. We shared the initial feedback heard through the online community survey and had boards for attendees to offer considerations for the technical team. We gathered feedback using sticky notes, comment cards, and verbal comments on transportation needs in the area.

Written Feedback on Sticky notes and Comment Cards

- Bi-directional bike and pedestrian path to allow safe travel
- Lane reconfiguration to allow more efficient travel, including:
    - Bus lane only
    - Wider lanes
- On/off ramp improvements
    - Widening them
    - Rerouting vehicle traffic to I-5 so it’s more localized
    - Using a toll system for vehicles once transit is efficiently in place
    - Enhancing signage at intersections and calming traffic speeds

- Importance of freight connections to local Ballard/Interbay businesses
- Coordination with the ST3 and the future Link light rail
- Near-term improvements to address present safety and traffic concerns
- Address climate change through transportation
- Reduce the amount of bridge openings
    - Less wait time
    - Greater predictability
- Improve/prioritize the bridge for car travel

DISPLAY BOARDS

WELCOME TO THE BALLARD BRIDGE PLANNING STUDY DROP-IN SESSION

What Is the Ballard Bridge Planning Study?

We've launched the Ballard Bridge Planning Study to evaluate how to bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. While we perform regular maintenance and frequent inspections on the bridge to ensure it's operational and safe for road and marine traffic, due to the age of the structure, more significant rehabilitation may be needed. Since the bridge is in good condition today, we have an opportunity to plan.

The Ballard Bridge Planning Study will...

- Explore feasible rehabilitation and replacement options
- Survey community members on their transportation needs and values
- Evaluate multimodal mobility and access options based on geometric and traffic analysis
- Investigate cost-effective and constructible structure types
- Identify associated costs, risks, benefits, and trade-offs of each feasible alternative
- Provide a comparison of alternatives to inform future investments along the Interbay Corridor

We look forward to working with you and your neighbors throughout the planning study process!

JULY 2019 — Seattle Department of Transportation — The Levy to MOVE SEATTLE

HISTORY OF THE BALLARD BRIDGE

1917 – The Ballard Bridge Opens
Work on the Ballard Bridge began in 1915 in conjunction with construction of the Lake Washington ship canal. The bridge opened to traffic on December 15, 1917.

1933 – Deck Replacement
The original creosoted wood deck was replaced with an open-mesh steel deck. A 1934 census counted 12,679 vehicles crossing the bridge over a 15-hour period.

1940 – New Approaches
The original wooden approaches were replaced with approaches made of steel and concrete. The bridge was closed for a year and a half during construction. A parade was held to celebrate the re-opening of the Ballard Bridge.

1969 – Consolidated Control Tower
The four original control towers we replaced with a single control tower on the Eastern side of the Southern bascule pier.

2003 – Ballard Gateway
Eight statues depicting Ballard's Native American and Scandinavian heritage were erected on the bridge's north approach. These sculptures, titled the "Ballard Gateway," were created by Washington artists Tom Askman and Lea Anne Lake.

2014 – Seismic Retrofits
Funded by the 2006 "Bridging the Gap" transportation levy, SDOT made necessary seismic improvements to 7 bridges, including the Ballard Bridge. The bridge received seismic retrofits to strengthen existing columns.

2014 – Bridge Sidewalk Widening Study
We conducted the Ballard Bridge Sidewalk Widening Study to evaluate alternatives to make travel across the Ballard Bridge more comfortable for pedestrians and people on bicycles. This study informs our rehabilitation concept.

2019– Ballard Bridge Planning Study
We've launched the Ballard Bridge Planning Study to evaluate how to bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. The study, funded by the Levy to Move Seattle, will explore feasible rehabilitation and replacement options for the long-term future of the bridge.

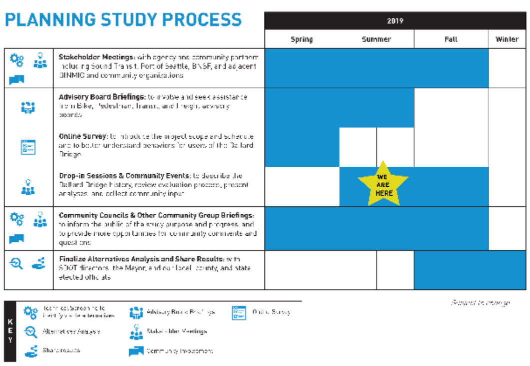
Citations:

- *HistoryLink Encyclopedia of Washington State History*, "Ballard Bridge Seattle" Essay 11260 [by Priscilla Long], April 4, 2017.
- *King County Municipal Archives*, Ballard Bridge Photographs. Accessed July 3, 2019.
- *Ballard Bridge, with original wooden approaches*, Seattle, March 10, 1918. Photo by James P. Lee, Courtesy UW Special Collections [LL 7?7]

JULY 2019 — Seattle Department of Transportation — The Levy to MOVE SEATTLE

PLANNING STUDY TIMELINE & FUNDING

PLANNING STUDY PROCESS



This planning study is funded by the Levy to Move Seattle, approved by voters in 2015. The 9-year, $930 million Levy to Move Seattle provides funding to improve safety for all travelers, maintain our streets and bridges, and invest in reliable, affordable travel options for a growing city. Learn more about the levy at www.seattle.gov/LevyToMoveSeattle.

The State has marked $700K in the 2019-2021 budget to investigate the Ballard-Interbay Regional Transportation System and provide recommendations to our elected officials on maintaining and improving capacity to move people and goods along this important corridor. The study is expected to launch later this year.

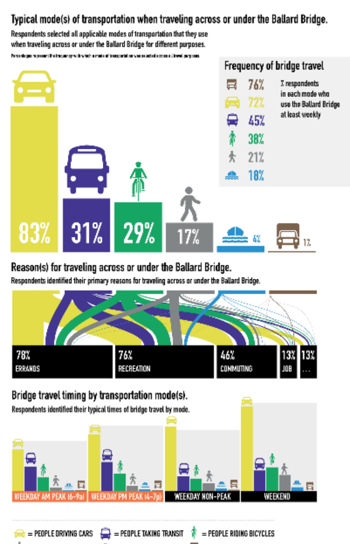
JULY 2019 — Seattle Department of Transportation — The Levy to MOVE SEATTLE

WHAT WE'VE HEARD

Online Community Survey Results

CURRENT USE

To ensure we develop bridge options that incorporate the broad needs and values of the community and people using the Ballard Bridge, we conducted an online survey on current and desired bridge use.



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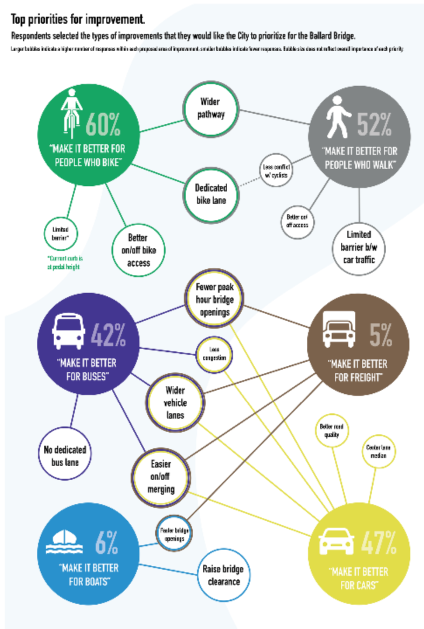
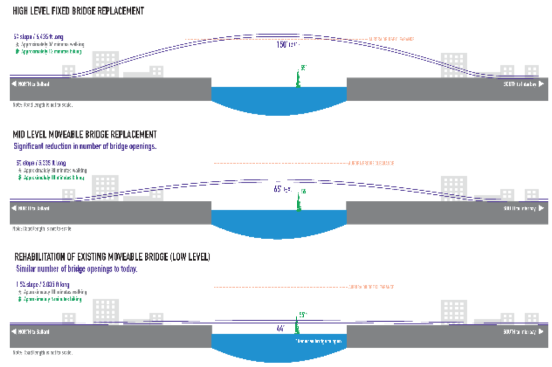
WHAT WE'VE HEARD

Online Community Survey Results

DESIRED USE



BALLARD BRIDGE OPTIONS



This graphic represents the technical options being considered by the planning study. It does not represent a design or proposed alternatives.

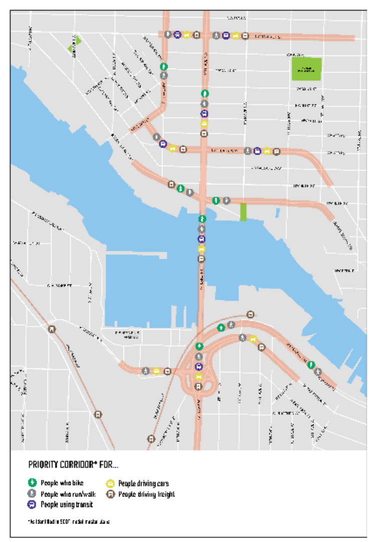
WHAT ELSE SHOULD WE CONSIDER?

Write your feedback on sticky notes

BALLARD BRIDGE CONSIDERATIONS

As we explore options for the Ballard Bridge, we must consider factors such as structural feasibility, cost, and community transportation needs. Specific considerations include:

- Maintain multimodal access to Leary Way NW
- Maintain multimodal access to W Emerson St & W Nickerson St
- Provide safe multimodal merges, diverges, and connections
- Improve pedestrian and bicycle facilities
- Maintain pedestrian and bicycle access to Burke Gilman & Ship Canal Trails
- Aim for roadway grades at or less than 5% (max grade of 7% as necessary)
- Maintain access for over-legal loads (20-ft x 20-ft)
- Minimize property effects
- Predictability of bridge openings for marine and roadway traffic



NOTIFICATIONS

In addition to the notifications shown below, an email announcement was sent to the project listserv and an announcement posted on the webpage.

MAILER

Seattle Department of Transportation

PO Box 34996
Seattle, WA 98124-4996

PRSRT STD
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PAID
Seattle, WA
Permit No. 2871

Ballard Bridge Planning Study Drop-In Session

JOIN US!

Wednesday, July 31
Stop by at any time between
6 PM – 7:30 PM

Fishermen's Terminal
Seattle Fishermen's Memorial Plaza —Dock 7
3919 18th Ave W, Seattle, WA 98119

If you need this information translated, please call 206-775-8894.

Servicios de traducción e interpretación disponibles bajo petición 206-775-8894.

Matutulungan ka naming maintindihan kung hihingi kang tulong 206-775-8894.

요청하시면 번역이나 통역을 제공해드립니다 206-775-8894.

Dịch và thông dịch viên sẵn sàng nếu có sự yêu cầu 206-775-8894.

Haddii aad dooneyso turjubeen fadlen wac 206-775-8894.

BALLARD BRIDGE PLANNING STUDY DROP-IN SESSION

Seattle Department of Transportation

The Levy to MOVE SEATTLE

PROJECT OVERVIEW

We've launched the Ballard Bridge Planning Study. While we perform regular maintenance and frequent inspections on the bridge to ensure its operational and safe for road and marine traffic, due to the age of the structure, more significant rehabilitation may be needed. Since the bridge is in good condition today, we have an opportunity to plan.

The Ballard Bridge Planning Study, funded by the Levy to Move Seattle, will explore feasible rehabilitation and replacement options for the long-term future of the bridge.

Through the end of the year, we'll work with our agency partners, advisory boards, and community members to identify needs and values and propose options that work to meet them.

UPCOMING DROP-IN SESSION

We're hosting a drop-in session and invite you to join us. The drop-in session is a good opportunity to learn about the Ballard Bridge Planning Study and to talk to the project team about your needs and values for the bridge. We'll share information about the study scope, goals, and timeline, as well as a summary of the feedback we received from our online community survey.

You can drop-in any time between 6 PM—7:30 PM. We look forward to seeing you there!

GET INVOLVED

We're committed to keeping you informed throughout the study. If you'd like more information, please use one of the following resources:

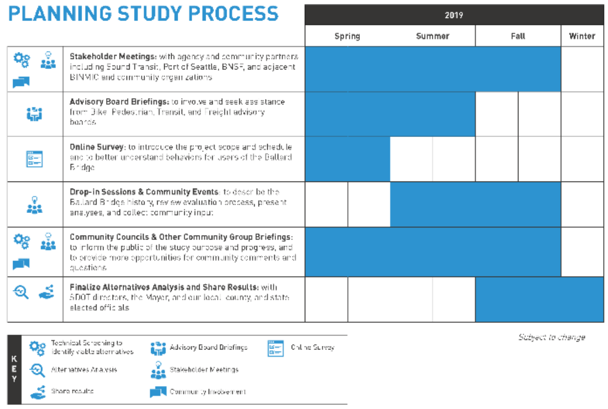
- Learn more about the study and to sign up for the project listserv visit our webpage: www.seattle.gov/transportation/BallardBridge
- Email the study team at BallardBridge@seattle.gov
- Call the study team at (206) 775-8894

This study is funded by the 9-year Levy to Move Seattle, approved by voters in 2015. Learn more about the levy at: www.seattle.gov/LevytoMoveSeattle.

PROJECT CONTACT INFORMATION

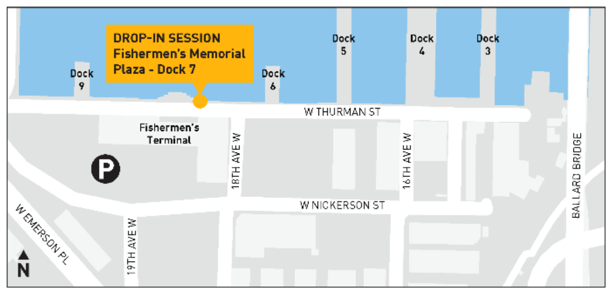
206-775-8894 | BallardBridge@seattle.gov
www.seattle.gov/transportation/BallardBridge

PLANNING STUDY PROCESS



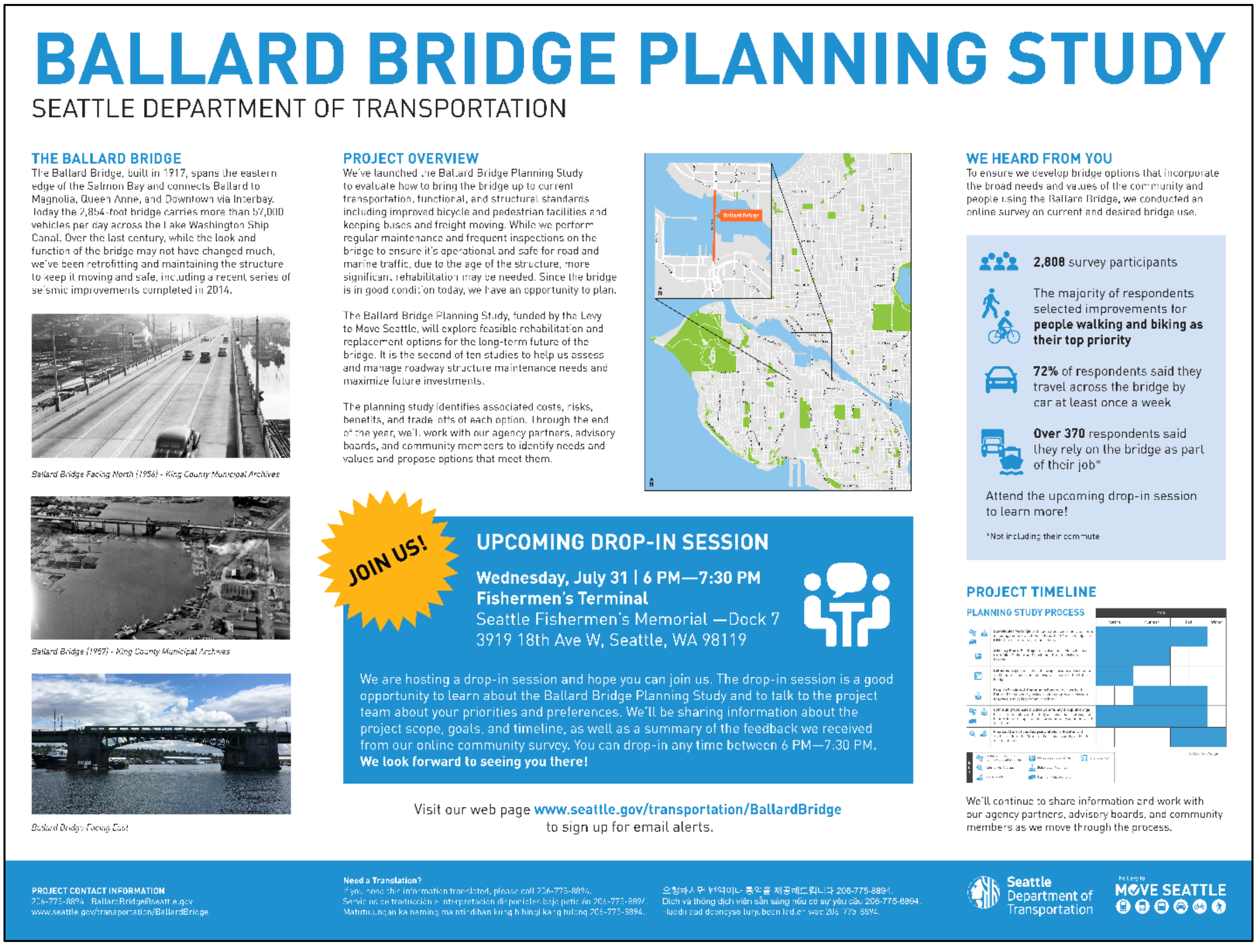
JOIN US!

Wednesday, July 31 | 6 PM—7:30 PM
Fishermen's Terminal
Seattle Fishermen's Memorial Plaza —Dock 7
3919 18th Ave W, Seattle, WA 98119



MOBILE DISPLAY

A trifold display board was placed at Magnolia Library, Queen Anne Library, and Ballard Library approximately 2 weeks before the drop-in session.



A-FRAME SIGNS

4 A-Frame signs were placed at the on and off ramps to the Ballard Bridge on July 30, 2019.

Attachment B: Online Community Survey

OVERVIEW

The Ballard Bridge, built in 1917, spans the eastern edge of Salmon Bay and connects Ballard to Magnolia, Queen Anne, and Downtown via Interbay. The 2,854-foot bridge carries more than 57,000 vehicles per day across the Lake Washington Ship Canal. Over the last century, while the look and function of the bridge may not have changed much, we've been retrofitting and maintaining the structure to keep it moving and safe, including a recent series of seismic improvements completed in 2014.

We've launched the Ballard Bridge Planning Study to evaluate how to bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. While we perform regular maintenance and frequent inspections on the bridge to ensure it's operational and safe for road and marine traffic, due to the age of the structure, more significant rehabilitation may be needed. Since the bridge is in good condition today, we have an opportunity to plan.

We conducted a community online survey to better understand the uses and values for the Ballard Bridge and to hear thoughts, comments, or concerns about the future of the bridge. The survey was available from June 20 to July 7 and administered through SurveyMonkey. The survey was marketed via SDOT Twitter, SDOT Facebook, a listserv to nearby project audiences, a banner on the project webpage, an SDOT blog post, and an SDOT press release. The press release was picked up by local print, online, and televised news outlets.

KEY FINDINGS

Key findings include:

- Most respondents (83%) currently travel the bridge by car. Participants travel by car most on weekends.
- Respondents prefer bridge improvements for people who bike (60%), people who walk (52%), cars (47%), and buses (42%).

SURVEY RESPONSE SUMMARY

We received 2,809 total responses with a 64% completion rate. Below, we've shared each question and how respondents answered as raw data and a percentage. For some of the questions, respondents could choose more than one response (questions noted below). If respondents chose "less than once a month" in question 3, they did not receive questions for these modes of transportation in questions 6-19. Percentages for each question are based on the number of the respondents who answered the question, not the total number of respondents who took the survey. Note that totals may not sum to 100%.

For open-ended responses, we've summarized what we heard by sharing popular and notable themes. The full questionnaire and all responses are available by request.

Question 1: I travel across or under the Ballard Bridge to (select all that apply):

- Commute to/from work or school:
- Do my job, not including commute (freight, deliveries, rideshare, etc.)
- Run errands:
- Participate in recreational activities:
- Other:
- Visiting friends/family
- Traveling to appointments
- Traveling to other parts of the city

Question 2: What mode of travel do you use when traveling across or under the bridge to…

	Car	Freight	Bus	Bike	Walking	Boat
Run errands	1,990 (92%)	3 (0.1%)	571 (27%)	509 (24%)	291 (13%)	17 (0.8%)
Participate in recreational activities	1,657 (79%)	2 (0.1%)	679 (32%)	821 (39%)	593 (28%)	196 (9%)
Commute to/from work	960 (75%)	6 (0.5%)	573 (45%)	363 (28%)	120 (94%)	19 (1%)

Do my job, not including commute	317 (88%)	29 (8%)	52 (14%)	44 (12%)	21 (6%)	23 (6%)
Other	299 (82%)	4 (1%)	92 (25%)	67 (18%)	45 (12%)	19 (5%)

Question 3: How often do you travel the bridge by…

	At least once a day	At least once a week	At least once a month	Less than once a month
Car	700 (29%)	1,073 (44%)	452 (18%)	221 (9%)
Freight	14 (41%)	12 (35%)	5 (15%)	3 (9%)
Bus	213 (19%)	296 (26%)	368 (33%)	243 (22%)
Bike	87 (9%)	279 (29%)	291 (30%)	315 (32%)
Walking	19 (3%)	126 (18%)	227 (33%)	317 (46%)
Boat	9 (4%)	30 (14%)	53 (24%)	127 (58%)

Question 4: What time do you typically travel the bridge by… (select all that apply)

	Weekday morning peak (6-9AM)	Weekday evening peak (4-7PM)	Weekday non-peak	Weekends
Car	793 (36%)	1,084 (49%)	1,232 (56%)	1,610 (73%)
Freight	15 (52%)	12 (41%)	21 (72%)	3 (10%)
Bus	470 (54%)	554 (64%)	282 (33%)	393 (45%)
Bike	259 (40%)	327 (51%)	237 (37%)	454 (70%)
Walking	60 (16%)	99 (27%)	148 (41%)	307 (84%)
Boat	17 (19%)	33 (36%)	43 (47%)	73 (80%)

Question 5: What types of improvements to the Ballard Bridge would you like us to prioritize? Please select up to 3.

- Make it better for people who bike: 1,636 (60%)
- Make it better for people who walk: 1,417 (52%)
- Make it better for buses: 1,141 (42%)
- Make it better for cars: 1,273 (47%)
- Make it better for freight: 136 (5%)
- Make it better for boats: 174 (6%)
- I'm not sure: 137 (5%)
- Other: 225 (8%)
    - Make alternative better for boat crossings (e.g., build a higher bridge, do not have bridge openings during commute periods)
    - Make bridge improvements for all transportation modes
    - Make better merge lanes on each end of the bridge
    - Coordinate with light rail

Question 6: What are current barriers for people who bike?
Top barriers:

- Pathway is too narrow
- Pathway is shared with people who walk
- Riding conditions on the roadway with vehicles are unsafe
- There is no dedicated bike lane to ride in traffic on bridge

- Barrier between roadway and pathway is too short
- It is difficult to merge at each end of the bridge

Question 7: What improvements would you like to see for people who bike?
Top improvements:

- Protected bike lane
- Wider path for people who bike
- Better connections to bike facilities at either end of the bridge
- Higher barriers between cars and people who bike

Question 8: What are current barriers for people who walk?
Top barriers:

- Pathway is too narrow
- Pathway is shared with people who bike
- Barrier between roadway and pathway is minimal
- Poor walking connections at each end of the bridge

Question 9: What improvements would you like to see for people who walk?
Top improvements:

- Wider path for people who walk
- Better separation from people who bike
- Better barrier between cars and people who walk

Question 10: What are current barriers for buses?
Top barriers:

- Buses get stuck in traffic with cars
- Buses have difficulty merging at each end of the bridge
- Bridge openings cause bus delays
- Roadway lanes are too narrow for buses

Question 11: What improvements would you like to see for buses?
Top improvements:

- Dedicated bus lane or queue jumps
- Wider roadway lanes for buses
- No bridge openings during express bus hours
- Improved connections for people who walk to help with bus transfers

Question 12: What are current barriers for cars?
Top barriers:

- Bridge openings for boats during rush hour, especially over the summer
- Too few lanes for cars, leading to increased congestion
- Narrow lanes without barriers between northbound and southbound lanes
- Difficulty merging on each end of the bridge
- Poor conditions of pavement and grating on bridge

Question 13: What improvements would you like to see for cars?
Top improvements:

- Install a center barrier between northbound and southbound lanes
- Create a higher bridge or do not open the bridge during highly congested periods
- Widen roadway lanes
- Improve merging at each end of the bridge

Question 14: What are current barriers for freight?
Top barriers:

- Roadway lanes are too narrow for trucks
- There are too few lanes for freight, leading to increased congestion
- Opening the bridge for boats leads to vehicle backups during congested periods
- Merging is difficult on each end of the bridge

Question 15: What improvements would you like to see for freight?
Top improvements:

- More lanes in each direction on the bridge
- Wider roadway lanes on the bridge and on- and off-ramps
- Higher bridge or no bridge openings during highly congested periods

Question 16: What are current barriers for boats?
Top barriers:

- There are not bridge openings during commute hours
- Waiting for the bridge to open and close is slow
- Bridge height is too low, which causes delays for people traveling on the bridge

Question 17: What improvements would you like to see for boats?
Top improvements:

- Create a higher bridge to accommodate most, if not all, boat traffic
- Have fewer scheduled openings for the bridge
- Improve communications on wait times

Question 18: What are current barriers for your selected priority [other]?
Top barriers:

- Bridge openings for boats lead to vehicle backups during congested periods
- Cars are prioritized over other transportation modes

Question 19: What improvements would you like to see for your selected priority [other]?
Top improvements:

- Higher bridge
- Wider roadway lanes on the bridge
- Fewer bridge openings for boats
- Notifications for bridge openings

- Enhanced safety on bridge for all modes of transportation
- No bridge openings during highly congested periods

Question 20: What else should we consider about the future of the Ballard Bridge and its community?

- Consider general safety/traffic improvements for all modes of transportation; the current bridge is not safe for everyday use
- Improve current roadway conditions
- Do not reduce the number of vehicle travel lanes for improvements for people who bike and people who walk
- Consider future development/increased congestion in the area
- Create announcements for bridge openings
- Create better connections at both ends of the bridge
- Promote modes of transportation to decrease car congestion
- Focus on improvements for people who bike and walk
- Connect bridge bike and pedestrian facilities to other bike and pedestrian facilities
- Include better lighting on the bridge
- Replace the bridge with a tunnel
- Concern about cost of potential alternatives
- Coordinate with Sound Transit and include light rail in bridge improvements
- Include artwork in the design, including historic art for Ballard's Nordic heritage
- Consider preserving the old bridge for historic purposes

Question 23: How did you learn about this project?

- Neighborhood blog: 469 (19.69%)
- Friend, neighbor, family member: 290 (12.17%)
- Facebook: 476 (19.98%)
- Twitter: 310 (13.01%)
- Nextdoor: 97 (4.07%)
- City of Seattle/SDOT mail: 13 (0.55%)
- City of Seattle/SDOT email: 257 (10.79%)
- City of Seattle/SDOT website: 114 (4.79%)
- My employer: 52 (2.18%)
- An organization I'm involved with: 93 (3.90%)
- Other: 608 (25.52%)
    - Media outlets, including print, online and television
    - Online blogs
    - Reddit

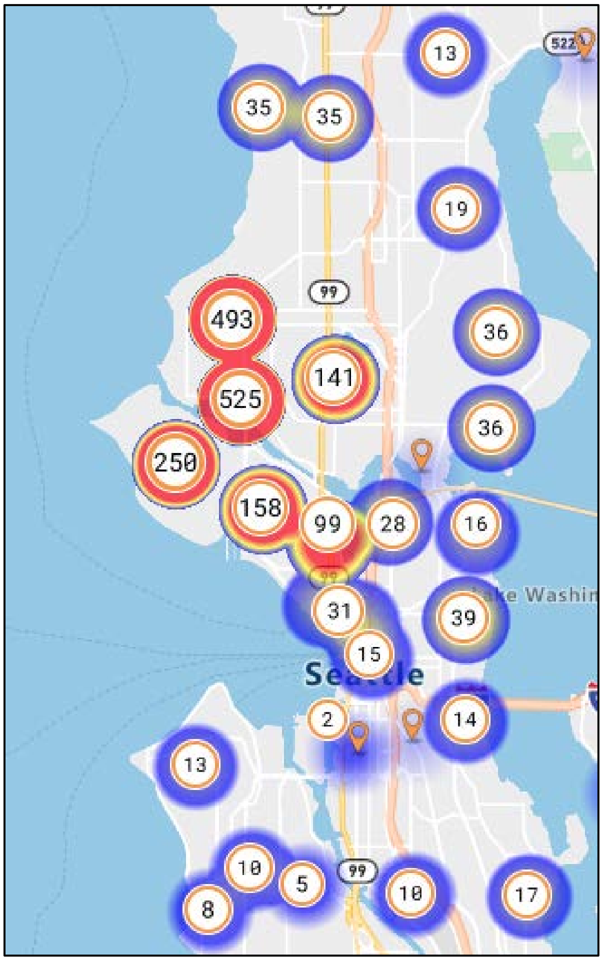
OPTIONAL: DEMOGRAPHICS

Question 24: What is your home zip code?

Top five zip codes:

- 98107: 525 (24%)
- 98117: 493 (23%)
- 98199: 250 (11%)

- 98119: 158 (7%)
- 98103: 141 (6%)
- Other: 616 (28%)



This map shows number of survey participants by zip code in the Seattle. Areas outside of Seattle are included in the above percentage for “Other.”

Question 25: What gender do you most identify with?

- Man: 53%
- Woman: 40%
- Non-binary: 1%
- Other: 1%

Question 26: What’s your age?

- Less than 18 years old: less than 1%
- 18-24 years old: 2%
- 25-34 years old: 23%
- 35-44 years old: 25%
- 45-54 years old: 19%
- 55-64 years old: 14%

- 65 years of age or older: 11%
- I’d rather not say: 4%

Question 27: What race/ethnicity best describes you? (select all that apply)

- American Indian or Alaskan Native: 1%
- Asian or Pacific Islander: 5%
- Black or African American: 1%
- Latino or Hispanic: 3%
- White or Caucasian: 80%
- I’d rather not say: 12%
- Other: 3%

Question 28: Do you have a disability? (select all that apply)

- None: 85%
- Cognitive: Less than 1%
- Hearing: 3%
- Mobility: 4%
- Vision: 1%
- I'd rather not to say: 7%
- Other: 2%

Question 29: What is your annual household income?

- $7,500 or less: Less than 1%
- $7,501 to $15,000: Less than 1%
- $15,001 to $25,000: 1%
- $25,001 to $35,000: 2%
- $35,001 to $55,000: 5%
- $55,001 to $75,000: 9%
- $75,001 to $100,000: 11%
- $100,001 to $150,000: 18%
- $150,001 to $200,000: 12%
- More than $200,000: 16%
- I’d rather not say: 24%

Attachment C: Technical Workshop

EVENT OVERVIEW

On September 12, 2019, we hosted a technical workshop for the Ballard Bridge Planning Study at the Ballard Branch Library Meeting Room (5614 22nd Ave NW). The workshop was from 10:30 AM to 1:00 PM. Key stakeholders from the bike and freight community were invited to participate. The workshop consisted of a short presentation, display boards, and roll plots showing the various options for the interactive group discussions.

Agenda

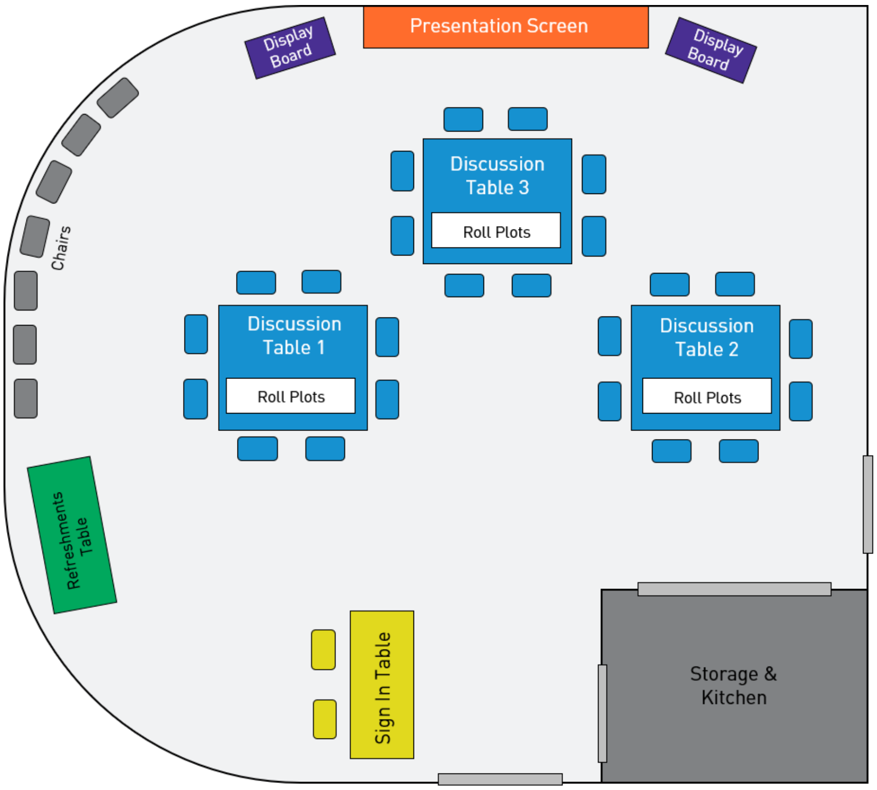
Time	Topic	Lead
10:30 – 10:40 AM	Welcome and Introductions	Wes Ducey, SDOT
10:40 – 10:50 AM	Ballard Bridge Planning Updates	Wes Ducey, SDOT
10:50 – 11:00 AM	Overview of Three Bridge Options	Matt Baughman, COWI Marni Heffron, Heffron Transportation
11:00 AM – 12:30 PM	Small Group Discussions on Bridge Options (40 minutes each for north end and south end with a 10-minute break in between)	All
12:30 – 12:45 PM	Report Out & Summarize	Wes Ducey, SDOT
12:45 – 1:00 PM	Next Steps & Adjourn	Wes Ducey, SDOT

EVENT LAYOUT

The room was set up with a welcome table, refreshments table, presentation screen, two display boards, and three discussion tables. Each discussion table had markers, sticky notes, a flip chart, and a set of 7 technical roll plots:

- High-level Fixed Bridge Replacement – North
- Mid-level Moveable Bridge Replacement – North
- Low-level Moveable Bridge Rehabilitation – North
- Existing Connections - North
- SPUI (High-level and Mid-level Bridge Replacement) – South
- Low-level Moveable Bridge Rehabilitation – South
- Existing Connections - South

The diagram below shows the room layout.



ATTENDANCE

There were 8 stakeholders at the workshop. Attendance included members from the Ballard Alliance, Seattle Freight Advisory Board, Port of Seattle, North Seattle Industrial Association (NSIA), East Side Ballard, Cascade Bicycle Club, and the Seattle Bicycle Advisory Board.

There were 4 Seattle Department of Transportation (SDOT) staff members and 6 consultants at the workshop.

Community & SDOT Stakeholder Attendees

- Tom Malone (local attorney), Ballard Alliance
- Elliott Strong, East Side Ballard
- Warren Aakervik, Seattle Freight Advisory Board
- Haley Keller, Ballard Alliance, Cascade Bicycle Club
- Serena Lehman, SDOT
- Patrick Mayovsky, Port of Seattle
- Geri Poor, Port of Seattle
- Eugene Wasserman, NSIA
- Serena Lehman, Bicycle Advisory Board

Project Team

- Wes Ducey, SDOT
- Kit Loo, SDOT Program Manager
- Matt Baughman, COWI
- Lisa Reid, SCJ Alliance
- Susann Babei, SCJ Alliance
- Marni Heffron, Heffron Transportation
- Jasmine Beverly, Cascadia Consulting
- Kate Graham, Cascadia Consulting

- Chris Saleeba, SDOT Policy and Planning
- John Marek, SDOT Transportation Operations
- Andrew Natzel, SDOT Transportation Operations
- Venu Nemani, SDOT Transportation Operations

Figure 1: Attendees listening to presentation from SDOT.

WHAT WE HEARD

The workshop started with a presentation from SDOT staff, Wes Ducey, and technical consultants, Marni Heffron and Matt Baughman, on the Ballard Bridge Planning Study process and current considerations. Following the presentation attendees broke into 2 groups to discuss the North and South side connection options being considered. Each group had representation from the bike and freight community, as well as representatives from the technical team. SDOT gathered feedback using sticky notes, drawings, and verbal comments from group members.

Group Discussion Feedback & Observations

High-level Fixed Bridge Replacement – North

- 5% grade is the maximum that is reasonable for people who bike
- Interest in a sidewalk and/or bicycle facility on the 51st/Leary ramp
    - Consider adding an east/west crosswalk at the signalized intersection at the top of the ramp
- Freight would like a right turn onto 15th Ave NW from the NW 51st St/Leary Way NW ramp
    - The turn radius would need to accommodate large trucks (WB-67)
- Evaluate turning radii at the intersection of 14th Ave NW and NW Leary Way

- Concerns about possible property impacts

Mid-level Moveable Bridge Replacement – North

- Would like to see safety improvements for people who bike and walk at 17th Ave NW/ NW Leary Way intersection
- Freight has concerns about making the U-turn from 17th Ave NW onto the southbound on ramp
- Freight would like to be able to turn right from southbound 14th Ave NW onto NW 46th St

Low-level Moveable Bridge Rehabilitation – North

- Disappointed in the lack of reduction in bridge openings
- Prefer the 14-feet wide 2-direction path on 1 side

SPUI (Mid-level and High-level Bridge Replacement) – South

- General support for the SPUI concept
    - Interest in including it with a low-level rehabilitation option
- Would like a wider multi-use path on the west side of the Emerson to SB 15th Ave W ramp
- Would like a connection from the future light rail station (near 16th Ave W & Thorndyke Ave) to the bridge for people who walk and bike
- Would like to connect the Ship Canal Trial to 16th Ave W

Low-level Moveable Bridge Rehabilitation – South

- Concern for access to the southbound bus stop for people who walk and bike
- Interest in improved east-west crossings on 15th Ave W/Ballard Bridge for people who walk and bike
- Would like more signage for people who walk and bike directing them to the west side facilities
- Concerns about the turn radii in the bicycle off ramp to the Ship Canal Trail, specifically for people on cargo bikes
- Would like facilities for people who walk and bike to connect to future Link light rail station (near 16th Ave W & Thorndyke Ave W)
- Concerns from freight drivers about people crossing the bridge at Emerson
    - Freight drivers have limited visibility while turning right

General Feedback

- Concern about constructability of the mid-level moveable bridge replacement
- Interest in understanding the challenges of a tunnel option
- Would like information about in-water touchdown points and impacts
- Interest in an independent bridge for people who walk and bike
- Interest in ship canal crossing height requirements for fixed structures

Feedback received during the technical workshop will be considered by the technical team as they continue to develop and refine the feasible alternatives, associated risks, opportunities, and trade-offs.

PRESENTATION

Welcome!

Project Team

- Wes Ducey, SDOT Project Manager
- Moein El-Aarag, Project Manager
- Matt Baughman, Consultant, Structures Lead
- Marni Heffron, Consultant, Traffic Lead
- Lisa Reid, Consultant, Civil Engineering Lead
- Kate Graham & Jasmine Beverly, Consultant, Outreach & Communications

Stakeholders – Please introduce yourselves

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Agenda

10:30 – 10:40 AM	Welcome and Introductions
10:40 – 10:50 AM	Ballard Bridge Planning Updates
10:50 – 11:00 AM	Overview of Three Bridge Options
11:00 AM – 12:30 PM	Small Group Discussions on Bridge Options (40 minutes each for north end and south ends + 10-min break)
12:30 – 12:45 PM	Report Out & Summarize
12:45 – 1:00 PM	Next Steps and Adjourn

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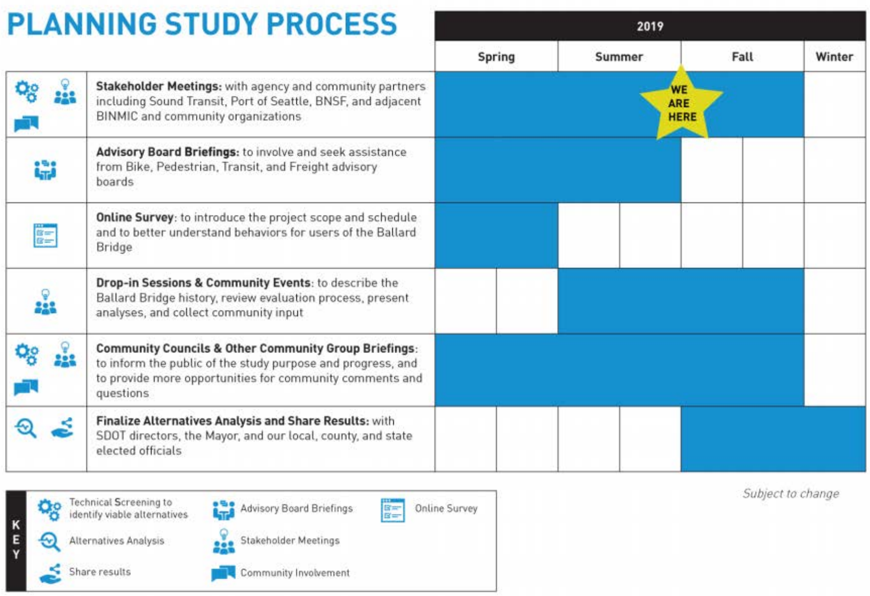
PLANNING STUDY PROCESS



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What We've Heard

Key takeaways from Online Community Survey and July Drop-In Session

- Improve accessibility for people walking and biking across the bridge
- Improve marine traffic access (reduce wait times and marine traffic congestion)
- Reduce bridge openings during peak hours
- Widen travel lanes on the bridge to accommodate larger vehicles, including buses, trucks, and other freight vehicles
- Ensure coordination with Sound Transit's future Ballard Link Extension

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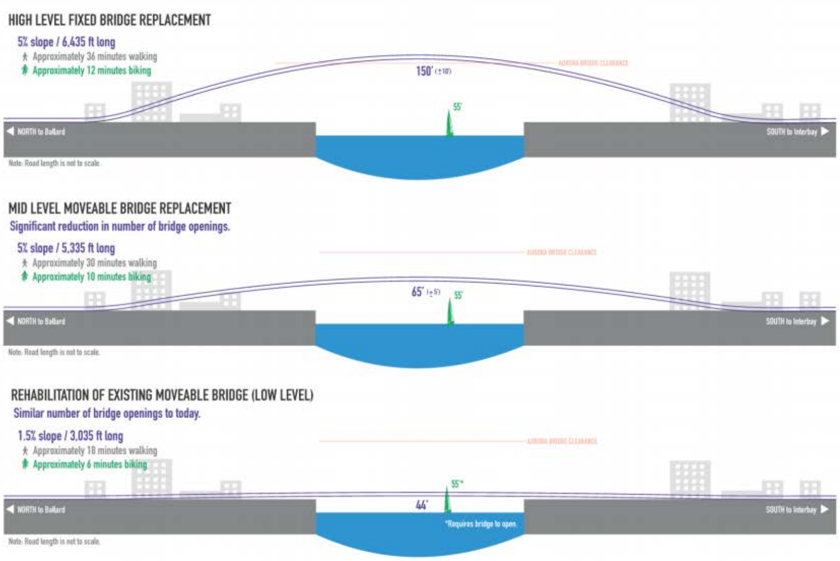
BALLARD BRIDGE OPTIONS



Note: Images are not to scale.

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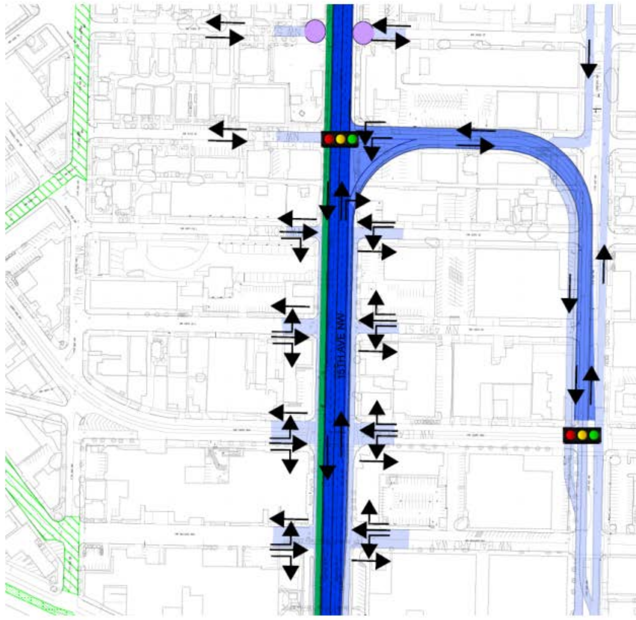
North Side Connections



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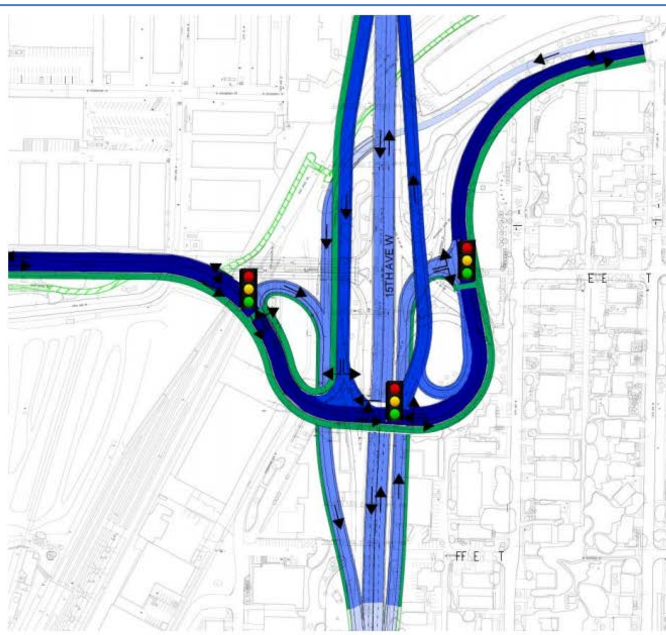
South Side SPUI



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Considerations

- Geometric Feasibility
- Structural Design
- Constructability and Construction Impacts
- Bike & Pedestrian Safety
- Adjacent Project Coordination
- Cost
- Multimodal Mobility and Connectivity
- Transit and Freight Reliability
- Industrial Operations
- Marine Traffic Impacts
- Environmental Impacts

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Ground rules for discussion

- Engage in active listening (please limit phone time)
- Act and communicate with respect
- Share “air time”: Ask yourself **W.A.I.T= Why Am I Talking?**
- Commit to being open to new concepts and ideas
- Use “I” statements/speak for yourself & from your own experiences
- Critique ideas, not people
- The goal is not to agree -- it is to gain a deeper understanding

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BREAK OUT SESSION BEGINS

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SHARE OUT AND REPORT BACK

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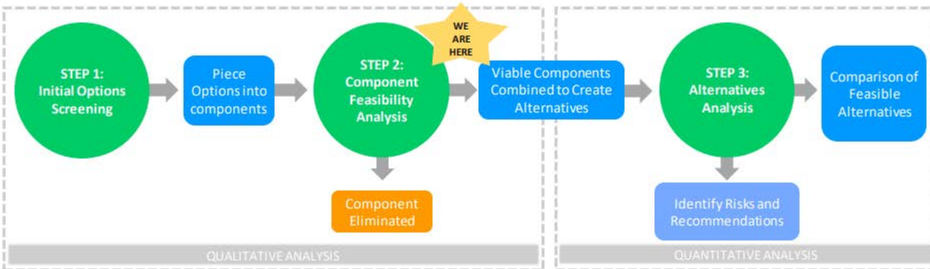
Evaluation Process



Initial Screening Criteria:
- *Provide safe multimodal merges, diverges, and connections*
- *Maintain multimodal access to Leary Way NW, W Emerson St & W Nickerson St*
- *Improve pedestrian and bicycle facilities and connections to Burke Gilman and Ship Canal trails*
- *Design road grades to 5%*
- *Maintain 20'x20' access for over-legal loads*

Feasibility Analysis includes:
- *Multimodal traffic analysis*
- *Geometric feasibility*
- *Structural analysis*
- *Constructability evaluation*
- *Rough Order of Magnitude (ROM) costs*

Alternative Analysis Criteria:
- *Multimodal Mobility and Connectivity*
- *Community Support*
- *Environmental Impact*
- *Cost Estimate*
- *Implementation Characteristics*

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Next steps

Date	Activity/Action
October 2019	Public Drop-In Sessions
Winter 2019	Draft Alternative Comparison Report

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Questions?

BallardBridge@seattle.gov | (206) 775-8894

www.seattle.gov/transportation/BallardBridge

www.seattle.gov/transportation

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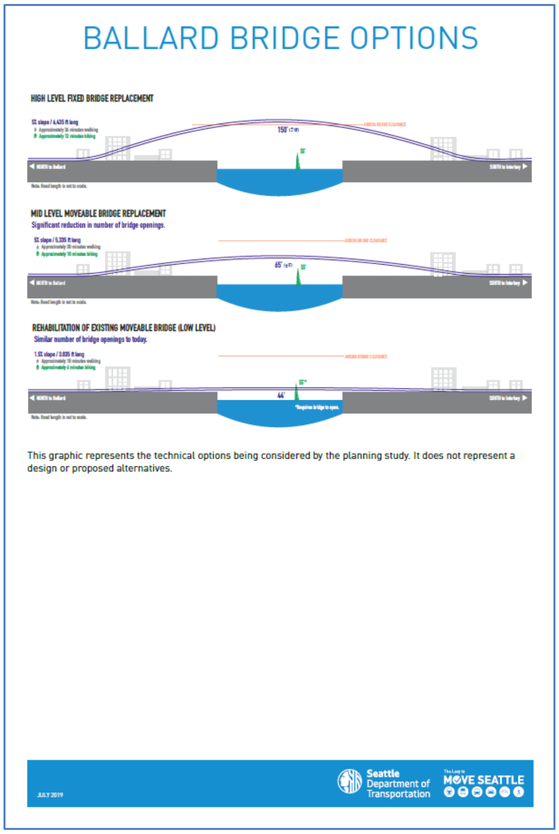
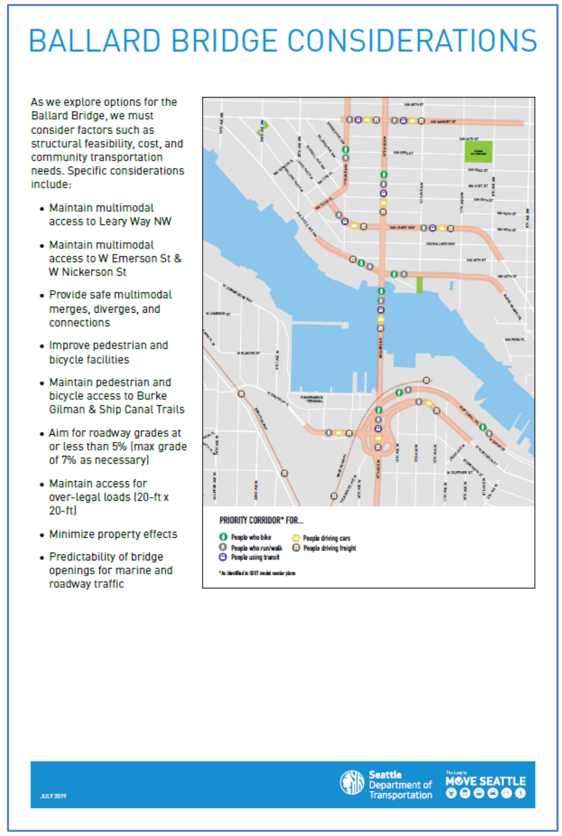
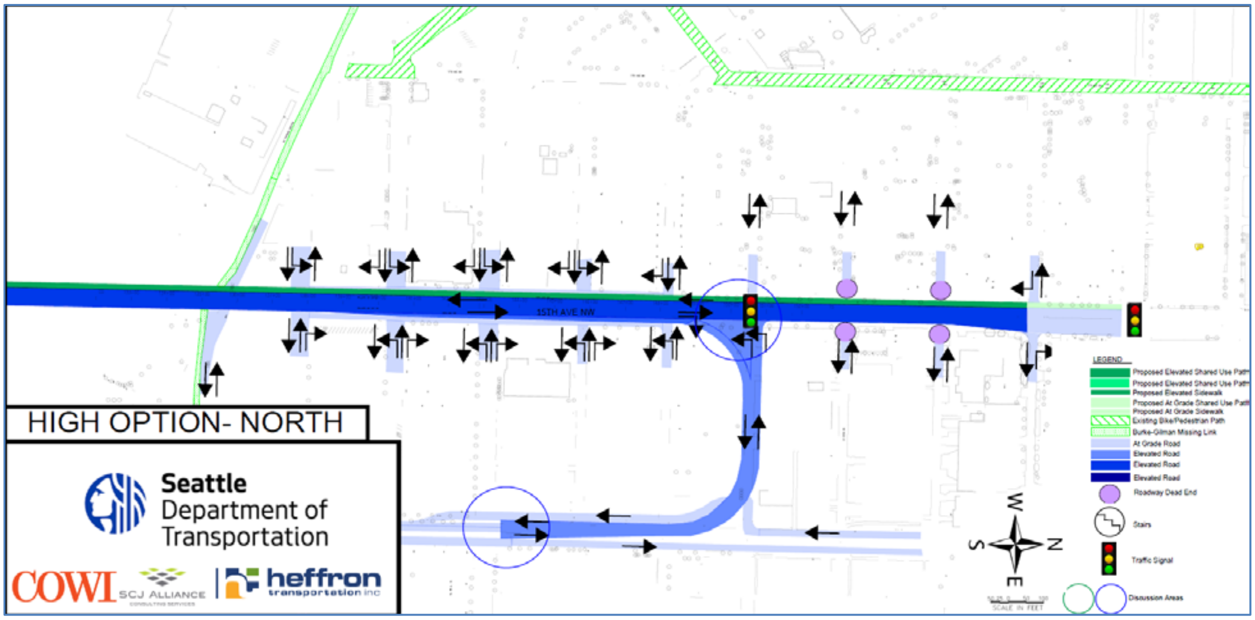
DISPLAY BOARDS





ROLL PLOTS


HIGH OPTION- NORTH
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15TH AVE NW
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Proposed Elevated Shared Use Path
Proposed Elevated Sidewalk
Proposed At Grade Shared Use Path
Proposed At Grade Sidewalk
Existing Bike/Pedestrian Path
Burke-Gilman Missing Link
At Grade Road
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Roadway Dead End
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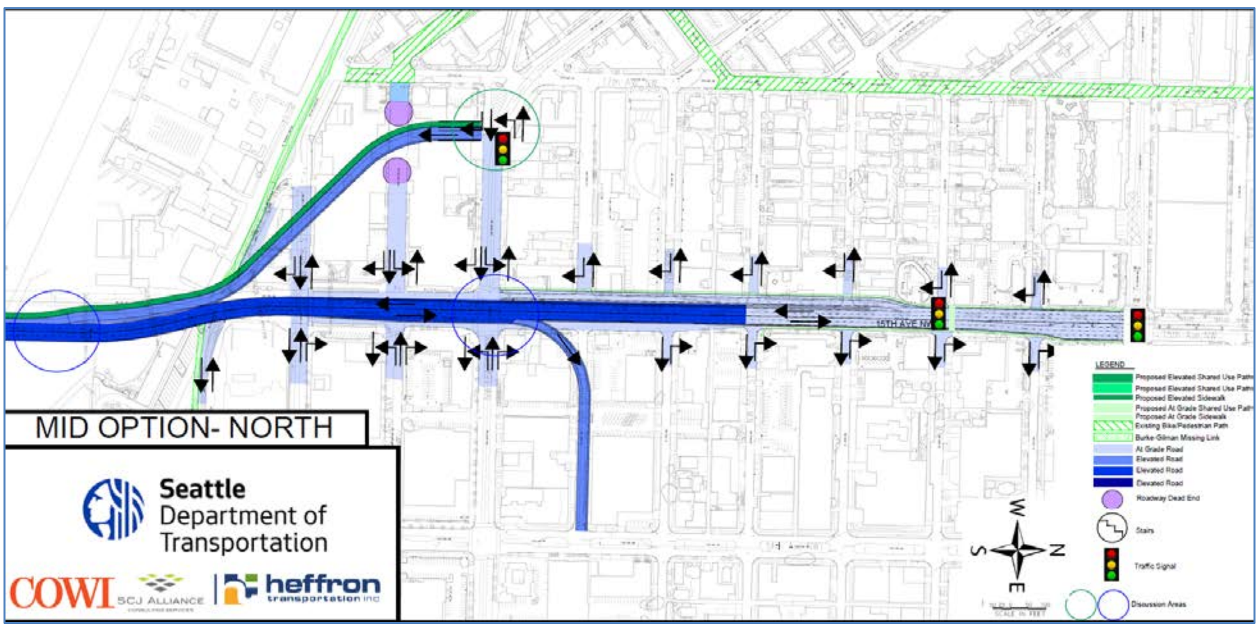
MID OPTION- NORTH
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Stairs
Traffic Signal
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LOW OPTION- NORTH
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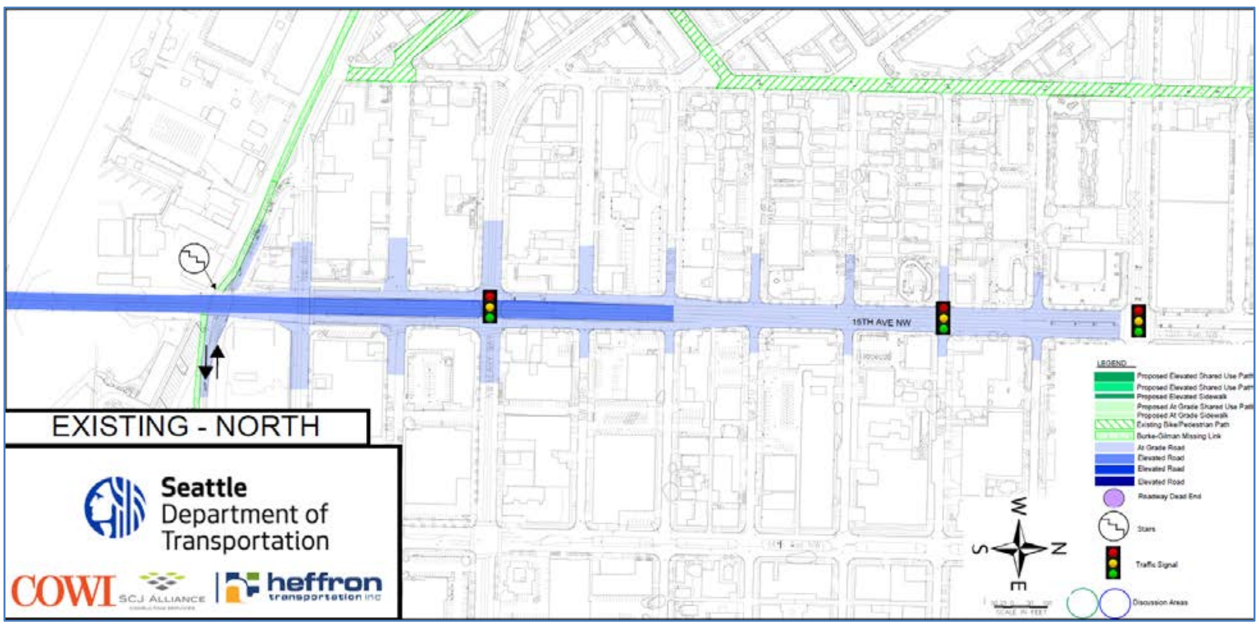
EXISTING - NORTH
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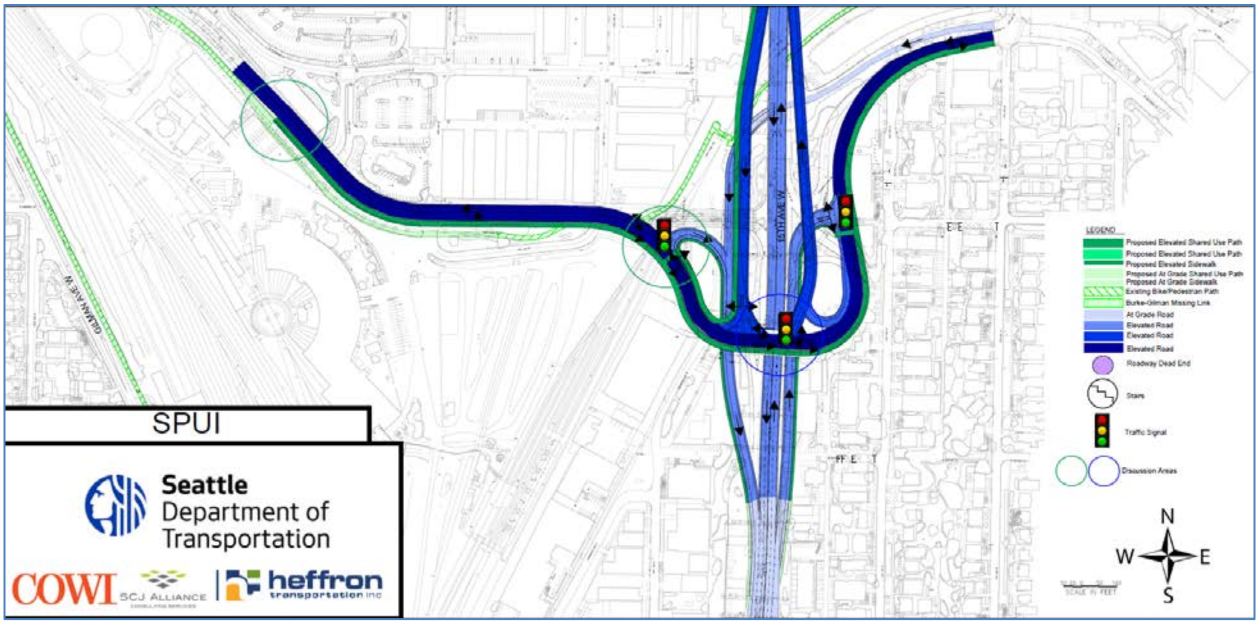

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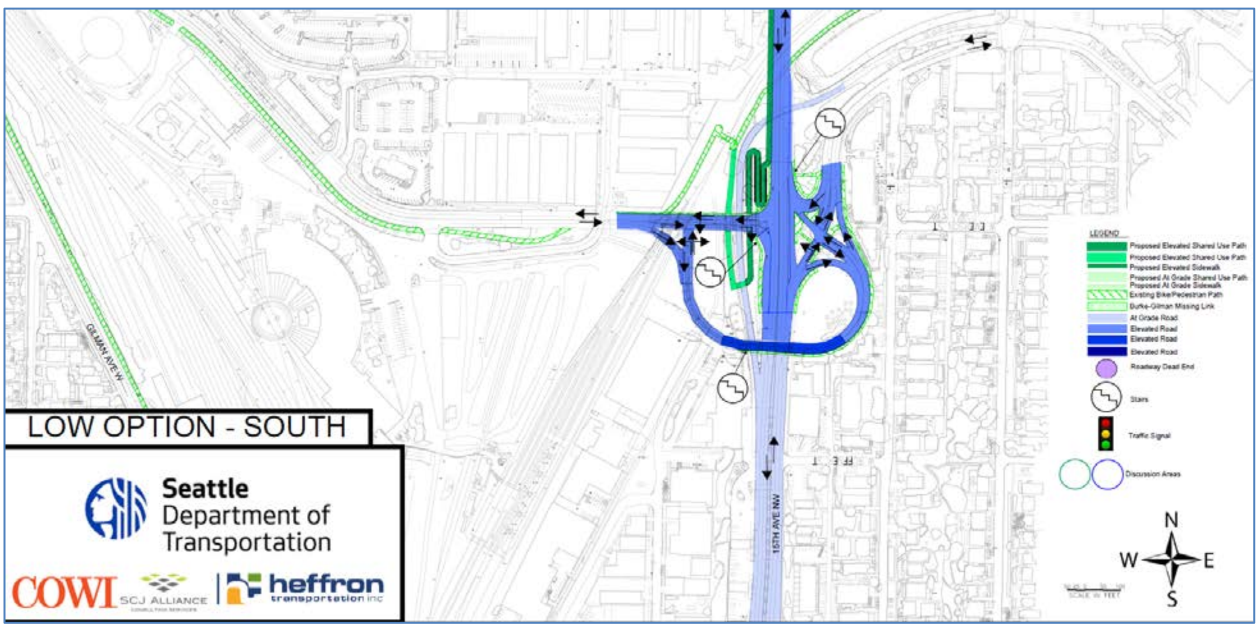

LOW OPTION - SOUTH
Seattle Department of Transportation
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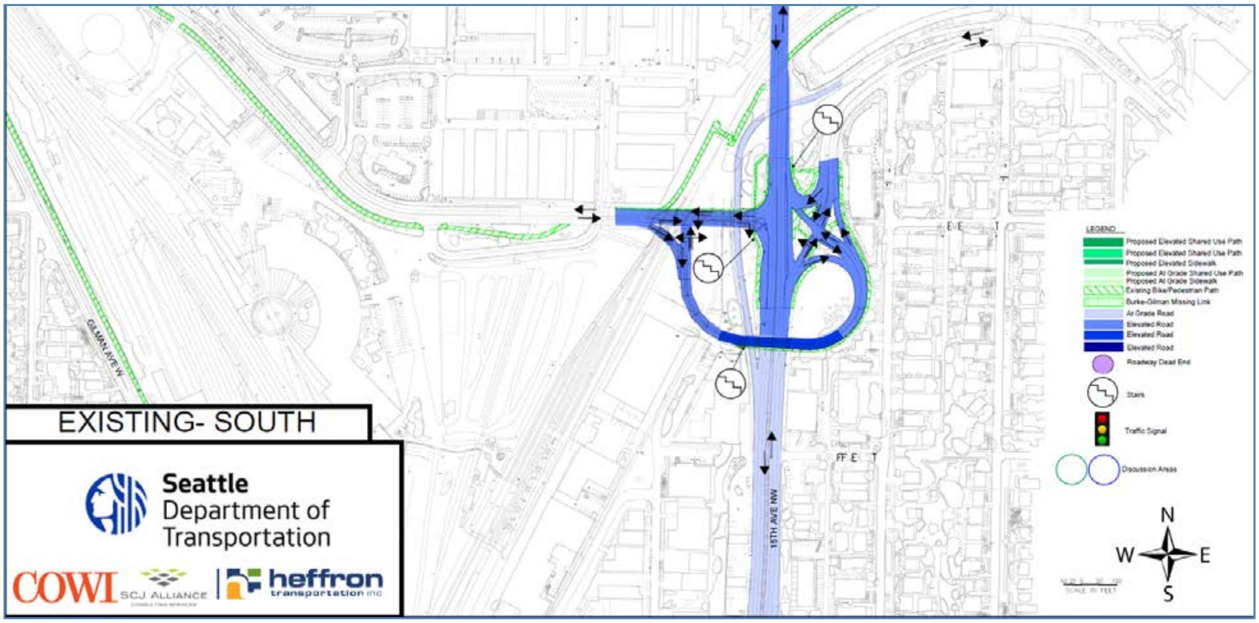
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Proposed At Grade Sidewalk
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Burke-Gilman Missing Link
At Grade Road
Elevated Road
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Elevated Road
Roadway Dead End
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SCALE IN FEET

INVITATION

Dear Ballard Bridge Stakeholders,

We've kicked-off the long-term Ballard Bridge Planning Study, which explores feasible rehabilitation and replacement options and evaluates how to bring the bridge up to current transportation, functional, and structural standards.

Come to our upcoming Ballard Bridge Planning Study technical workshop on **Thursday, September 12th from 10:30 AM – 1:00 PM at the Ballard Library** to:

- Learn where we've been and what we've heard
- Discuss technical screening findings
- Share insights into multi-modal routes and connections
- Give input on feasible options
- Hear what's next

The planning study began with an online survey followed by a public drop-in session to better understand what community members need, value, and envision for the bridge. As we continue to receive and review community feedback, we'll evaluate cost-effective and constructible structure types. Through the end of the year, we'll work with our agency partners, advisory boards, and community members to propose options that meet these standards and community needs. The final, feasible options will be compared among their associated costs, risks, benefits, and other trade-offs.

This study will not recommend a preferred alternative but rather provide a comparison of feasible alternatives as we coordinate with our elected officials in evaluating funding options.

Be on the lookout for an outlook invitation along with the meeting's agenda.

Thank you,
Wes Ducey

Outreach Team
Ballard Bridge Planning Study
206-775-8894
BallardBridge@seattle.gov

Attachment D: SDOT Roadway Structures Staff Input

EMAIL REQUEST FOR ROADWAY STRUCTURES (RS) STAFF INPUT

From: Donahue, Matthew
To: Abelhauser, Barbara; Albarracin, Edwin; Alexenko, Meghan; Alexenko, Traice; Anderson, Kim; Araque, Eric; Beckwith, Jason; Beyer, Matthew; Broughton, Nathaniel; Brown, Mary; Buchholz, Bow; Burgan, Kurt; Burke, Hudson; Carlin, Christopher; Carter, Ryan; Christiansen, Clarence; Chun Fook, Gabriel; Cuestas, Margarito; Donahue, Matthew; Engeseth, David; Ericsen, Fred; Finnick, Larry; Funk, Greg; Garcia, Adam; Guisa Vargas, Oscar; Hickman, Jared; Hovde, Richard; Husted, Todd; Ivanek, Benjamin; Jackson, Paul; Jenkins, Aaron; Ketzenberg, Justin; Kleinschmidt, Timothy; Leask, David; Liechti, Kristan; Lorenzana, Paulo; Louman, Angelina; Molla, Ainalem; Nguyen, Alvin; Nguyen, TrinhK; Olsen, Shane; Ongque, Prizroy; Polk, William; Porter, James; Roberts, Kerry; Santana, Francisco; Santana, Frank; Silcox, Greg; Singleton, Damon; Smith, Constantinos; Smith, DonaldJ; Smith, Michael; Soakai, Sione; Solusod, Steve; Stephens, Adrian; Suckie, Alexander; Sui, James; Vao, Maka; Wallace, Brace; Weida, Suzie; Williamson, Donald; Zuleta, Paul
Cc: Williams, Lorelei; Zimbabwe, Sam; Ducey, Wes; Loo, Kit
Subject: Request for Input: Ballard Bridge Replacement Study
Date: Friday, October 04, 2019 4:51:37 PM
Attachments: Ballard Bridge - RS Staff Input Memo_2019_0920.pdf

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Good Afternoon RS Team:

Given the bridge engineering, maintenance and operation expertise possessed by Roadway Structures Division staff I am respectfully requesting your help with the Ballard Bridge Replacement Study. This study is being delivered as part of the Levy to Move Seattle under the Bridge Rehab and Replacement levy subprogram. Please note the following:

- All staff have a maximum of 1.5 hours to review the attached brief summary and provide comments;
- Time for this effort can be charged to TRC0826-S0001;
- Please arrange with your Crew Chief/Supervisor/Manager to have time on a City computer to perform your review and provide comments electronically (via the attached PDF memo with comment form on page 3) or to be given hardcopies of the attached for handwritten comments;
- Please be as open or specific with your comments as you'd like… we want to know what you think about any aspect of bridge replacement (or major rehab) or operation that you are interested in… don't be shy and please understand that your opinion matters!
- Electronic or handwritten comments are due back to your Supervisor by COB, Thursday, 10/17;
- Collected comments are due back from Supervisors to Paul and I by COB, Tuesday, 10/22.

Thanks, and please let me know if you have any comments or questions.

Matt

Matthew James Donahue, P.E. (he, him, his)
Interim Division Director (OOC) | Roadway Structures
City of Seattle Department of Transportation

RS STAFF INPUT REQUEST MEMO

Roadway Structures' Crews, Operators, & Engineers Share your thoughts on the Ballard Bridge Rehabilitation and Replacement options.

Date: 9/20/2019
To: SDOT Roadway Structures Operations & Maintenance Staff
From: Wes Ducey, Project Development PM
Subject: Ballard Bridge Planning Study – Share your thoughts

Why are We Completing a Planning Study for the Ballard Bridge?
(*skip to Page 2 for the options and questions for you to consider)*

The Ballard Bridge spans the eastern edge of Salmon Bay and connects Ballard to Magnolia, Queen Anne, and Downtown via Interbay. The 2,854-foot bridge is part of our City's Critical Urban Freight Corridor and carries more than 57,000 vehicles per day across the Lake Washington Ship Canal. This bascule bridge typically opens to allow taller ships to use the Ship Canal over 4,000 times per year. The bike and pedestrian facilities on the bridge are obsolete. We'll stop there; you know this bridge better than most folks in the city.

Many of you perform regular maintenance, frequent inspections, and daily operation on the bridge to ensure it is working and safe for all modes of roadway and water traffic. But, the bridge is old and isn't getting younger. Due to its age, more significant rehabilitation may be needed (and has been needed recently) to sustain its current level of operation. Thanks to your hard work at keeping it working day-to-day, we have an opportunity to plan ahead and look beyond just maintaining its current form and function. So, this year, with funds from the Levy to Move Seattle, we've launched a planning study to evaluate how we would bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian access and better transit and freight mobility.

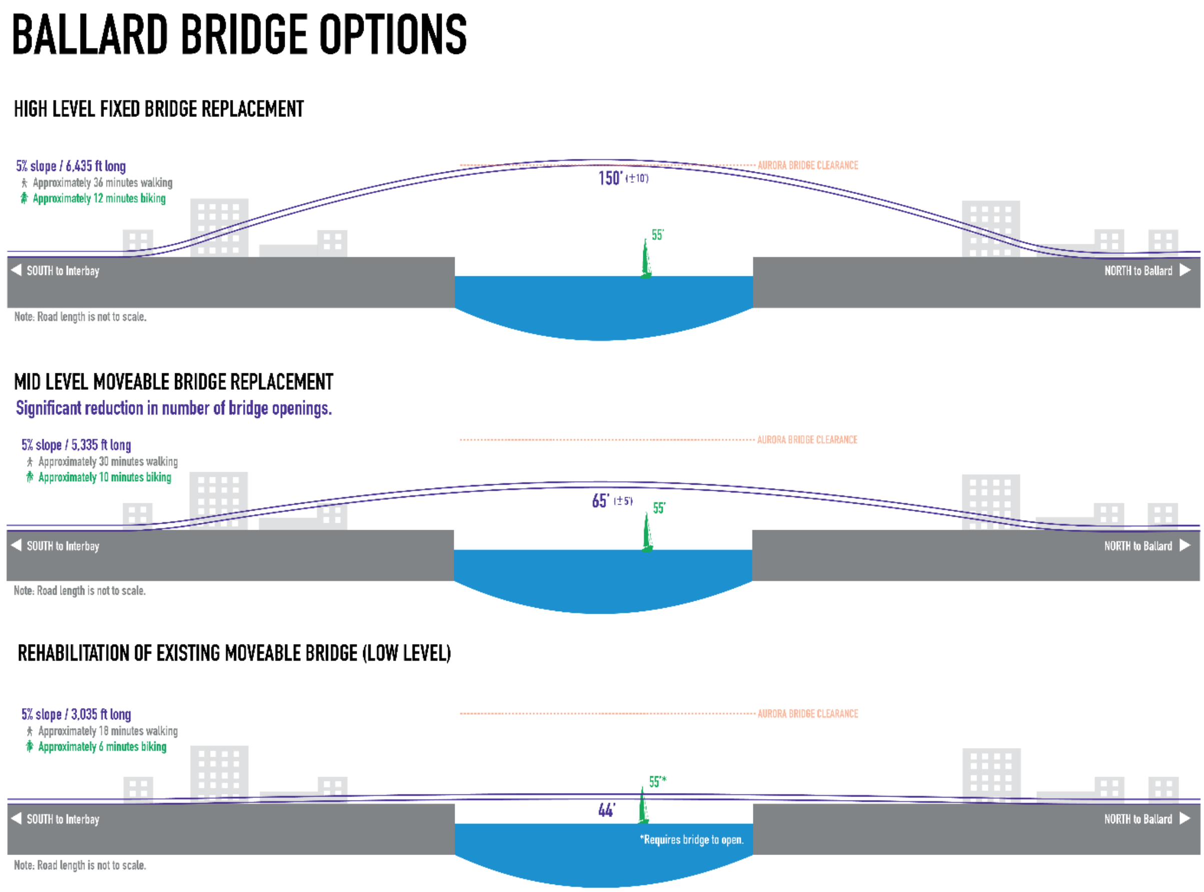
What will the Study Deliver?
Throughout this year, the planning study has been exploring feasible rehabilitation and replacement options for the long-term future of the bridge. We've been filtering through options by applying traffic, geometric, and structural analysis and have penciled out three seemingly viable options. Later this year, the planning study will deliver a report that summarizes the risks, recommendations, and trade-offs of each option. Comparison criteria include multimodal mobility and connectivity, community support, environmental impact, cost estimate, and implementation characteristics.

What won't the Study Deliver?
This study will not recommend a preferred option. It will not design options beyond a ~5% level nor will it provide a timeline for replacement. This study will also not yet incorporate the elements of an environmental impact analysis. It is a starting place to try to understand what kind of funding we need to pursue in the future.

How can You Help? Flip to page 2, check out the options we're considering, and give feedback.

The Three Options

Over this last year our consultant team has identified three options for the future of the Ballard Bridge. These options are not presented here in any order of preference. The first is a high-level fixed bridge replacement with approximately 150’ of clearance underneath. The second is a mid-level movable bascule bridge replacement with approximately 65’ of clearance when closed. The third is a major rehabilitation of the existing structure and the addition of a 14’ shared use bicycle and pedestrian path along the entire West side of the structure. See the figure below for a graphical summary of the three options.



This memo packet includes high-level design plans for you to reference as well. If you have questions about how the team arrived at these three options or what else has been considered, feel free to reach out to project PM, Wes Ducey: @4-7033 or wes.ducey@seattle.gov

Formal Request for Comments

As we acknowledged earlier in this memo, you all know bridges better than most folks in the city. Related to your daily work and observations, please identify desired operational, maintenance, emergency service, and/or design characteristics that you would like to see in a future Ballard Bridge. In other words, what design features would make your work on a future structure more efficient?

What’s Next

Your input will help inform the options of this study. By the end of the year, we plan to summarize these comments (and the names of the commenters) and include them in the recommendations section of the study’s report for further consideration once design funding is secured.

Seattle Department of Transportation

Please share your questions, comments and concerns. All information provided on the comment sheet is subject to public disclosure.

COMMENT SHEET

Meeting Name: Roadway Structures Staff Input

Project Name: Ballard Bridge Planning Study

Date: September 2019

(Official Use Only)

Name: ______________________ Email: ______________________

Comments: ______________________

Appendix A – Conceptual Figures

Figure 1 = Existing Layout

Figure 2 = Existing Bridge Approach Spans

Figure 3 = Low-Level Rehabilitation Layout

Figure 4 = Low-Level Rehabilitation Approach Spans – 10 Ft Sidewalks Both Sides

Figure 5 = Low-Level Rehabilitation Approach Spans – 14 Ft Multi-Use Path West Side

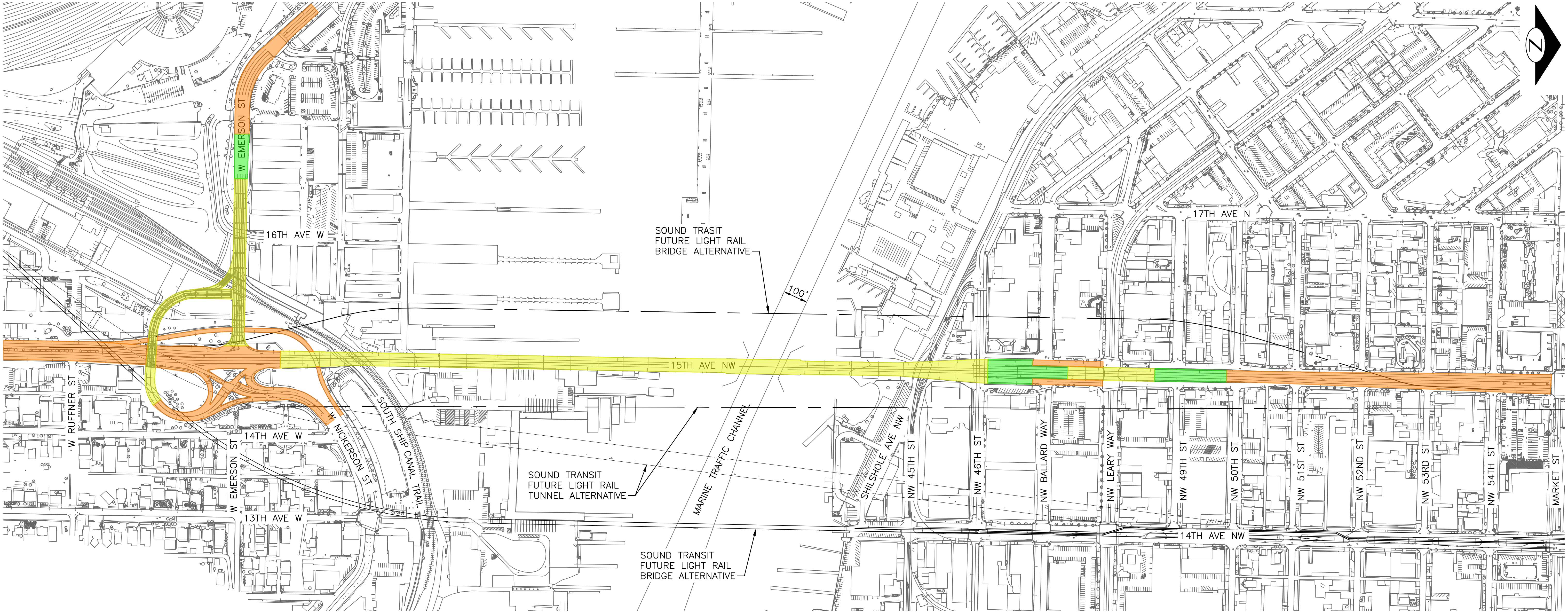
Figure 6 = Mid-Level Replacement Layout

Figure 7 = Mid-Level Replacement – New Approach Bridge Next to Existing Bridge

Figure 8 = High-Level Replacement Layout

Figure 9 = High-Level Replacement – Main Span Bridge Concepts

Figure 10 = High-Level Replacement – New Approach Bridge Over Existing Bridge



EXISTING LAYOUT

LEGEND:

- AT GRADE
- BRIDGE
- RETAINING WALL

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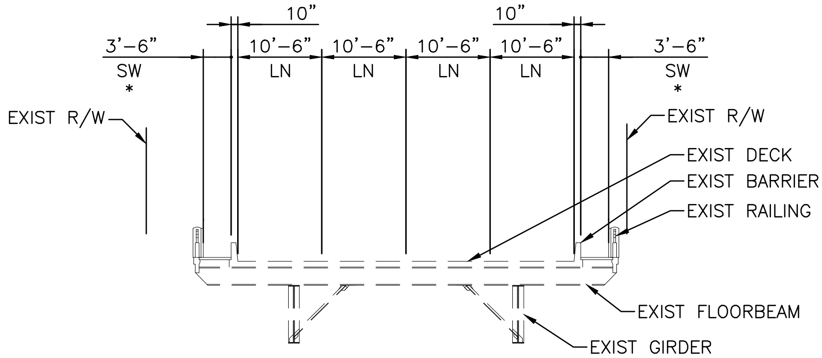
City of Seattle
Seattle Department of Transportation
ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

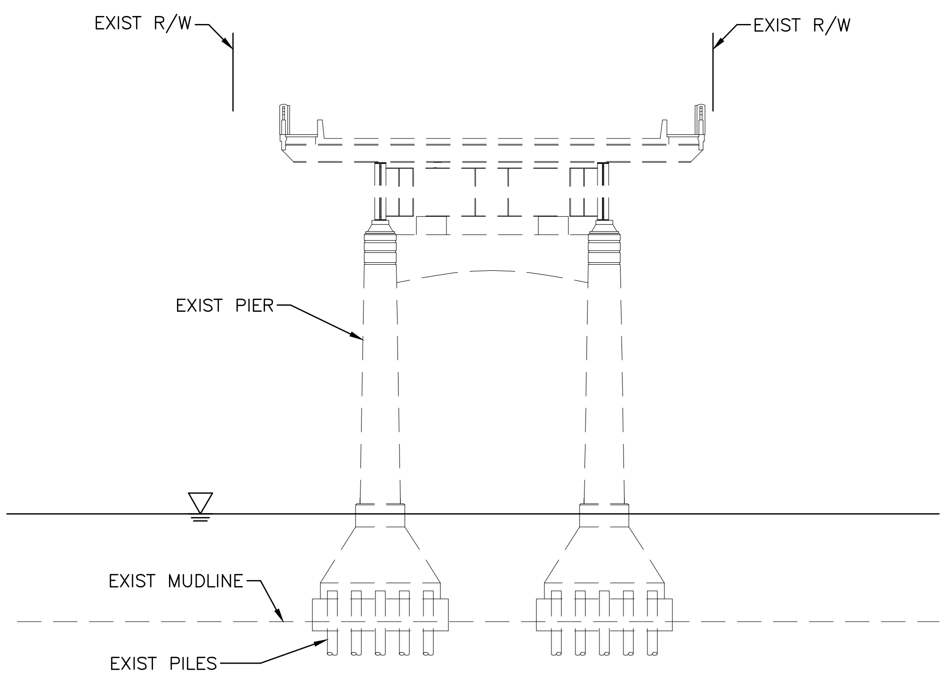
EXISTING LAYOUT

FIGURE
1



EXISTING TYPICAL SECTION

* MIN SIDEWALK WIDTH AT
LIGHT POLE PILASTER



EXISTING TYPICAL PIER

COWI	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE:	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA EXISTING BRIDGE APPROACH SPANS	FIGURE 2

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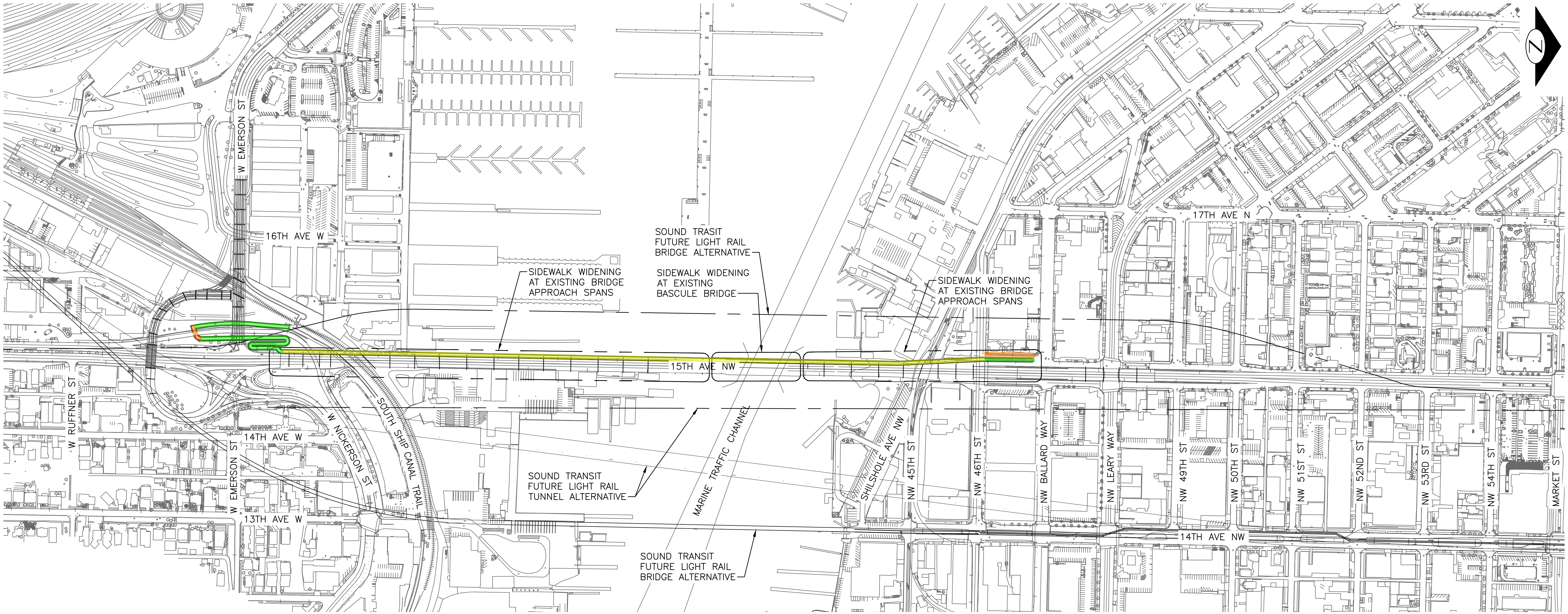

LOW LEVEL REHABILITATION LAYOUT

LEGEND:

- AT GRADE SIDEWALK
- BRIDGE WIDENING (SUP ONLY)
- RETAINING WALL (SUP ONLY)

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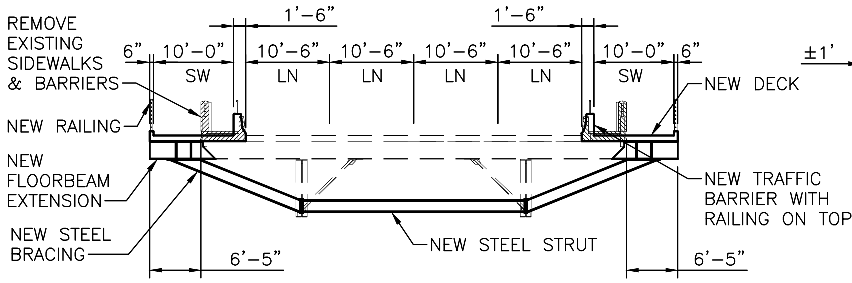
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

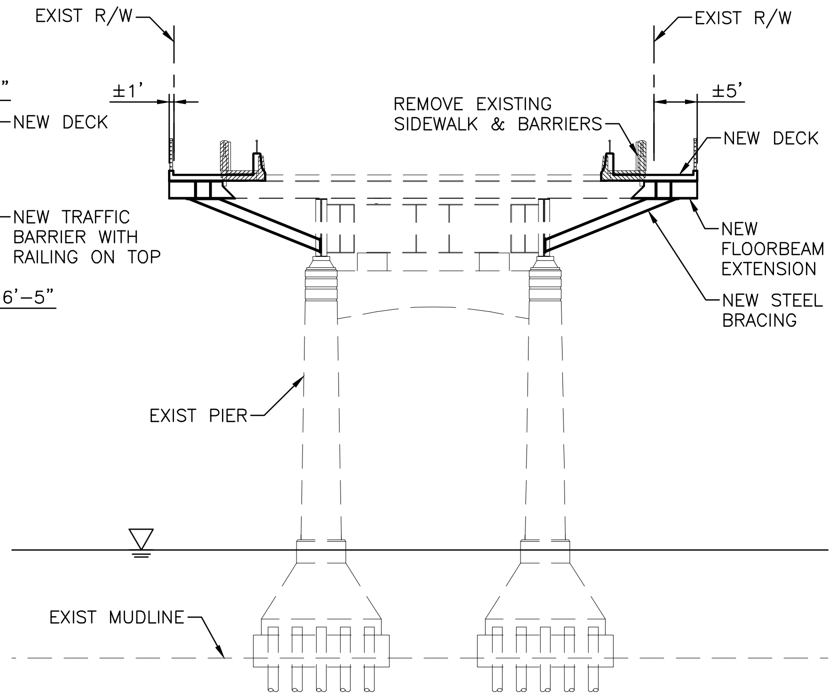
BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

LOW-LEVEL REHABILITATION LAYOUT

FIGURE
3

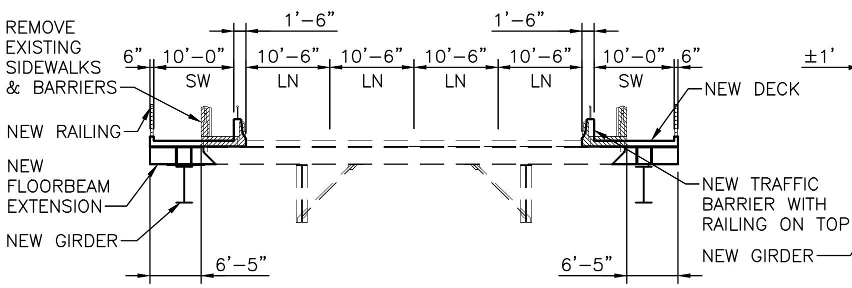


TYPICAL SECTION

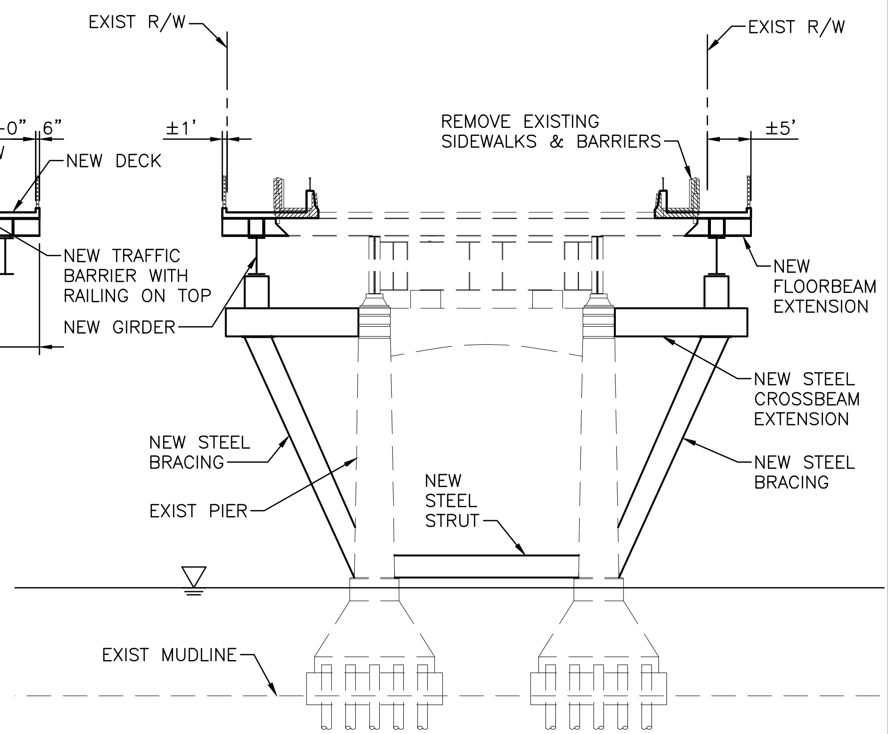


AT PIERS

STEEL OUTRIGGER CONCEPT



TYPICAL SECTION



AT PIERS

NEW GIRDERS CONCEPT

COWI	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE:	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA LOW–LEVEL REHABILITATION APPROACH SPANS 10 FT SIDEWALKS BOTH SIDES	FIGURE 4

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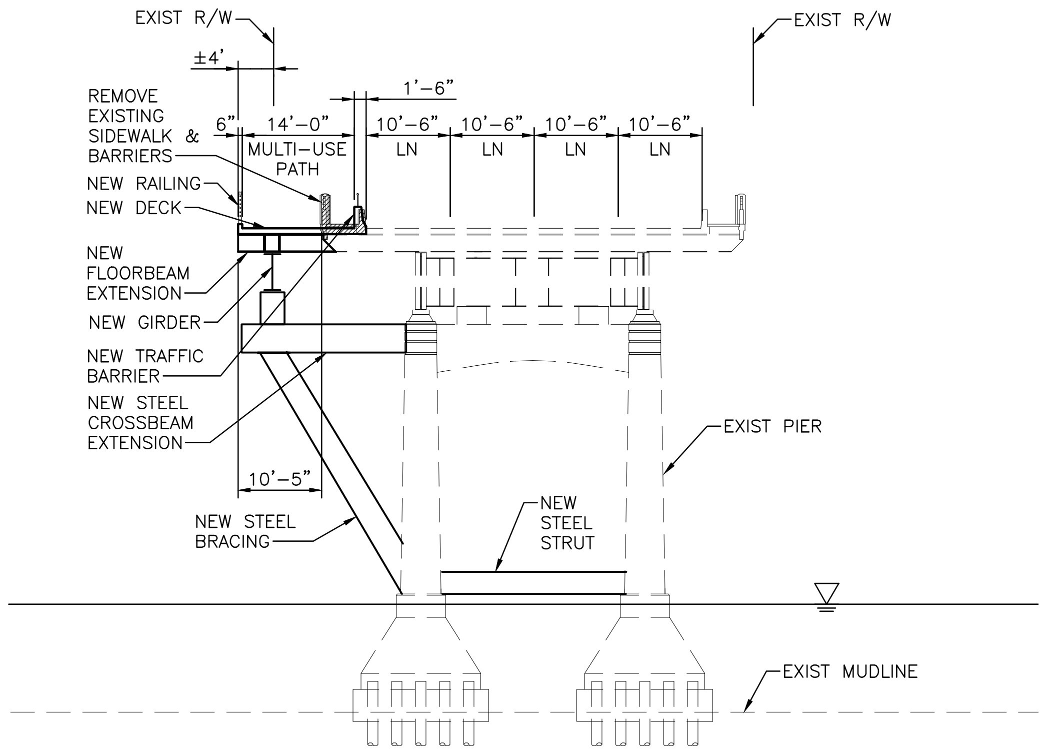
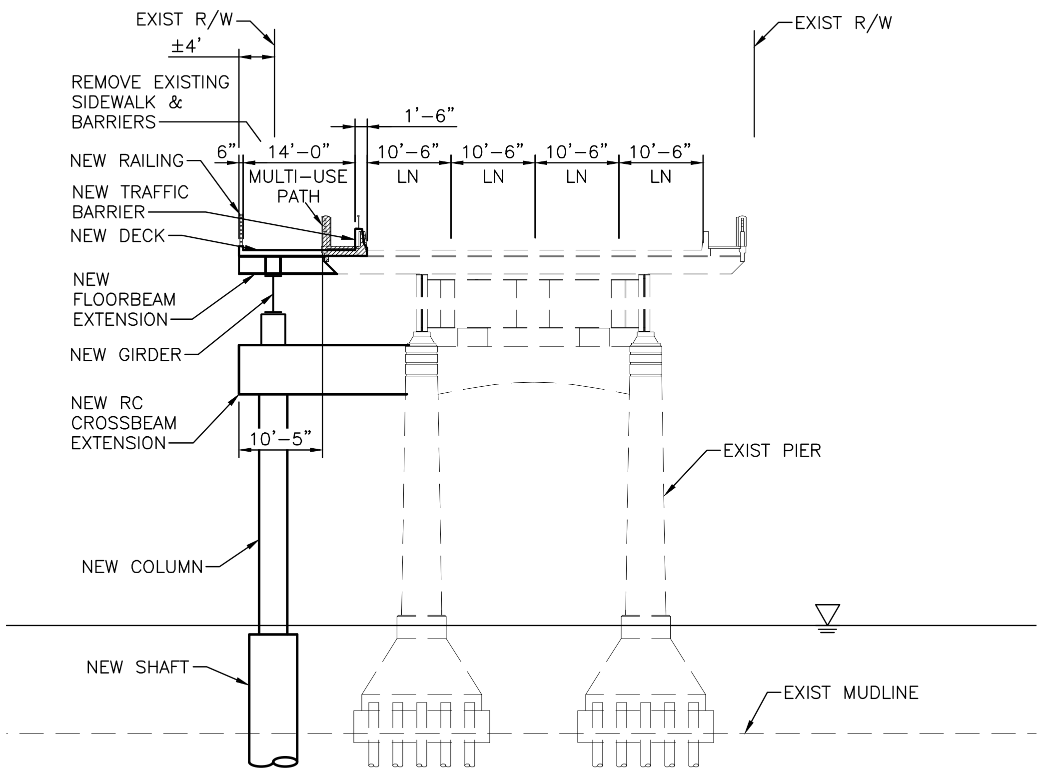


USING EXISTING FOUNDATION CONCEPT

(LOOKING NORTH)



NEW FOUNDATION CONCEPT

(LOOKING NORTH)

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

LOW-LEVEL REHABILITATION
APPROACH SPANS
14 FT MULTI-USE PATH WEST SIDE

FIGURE
5

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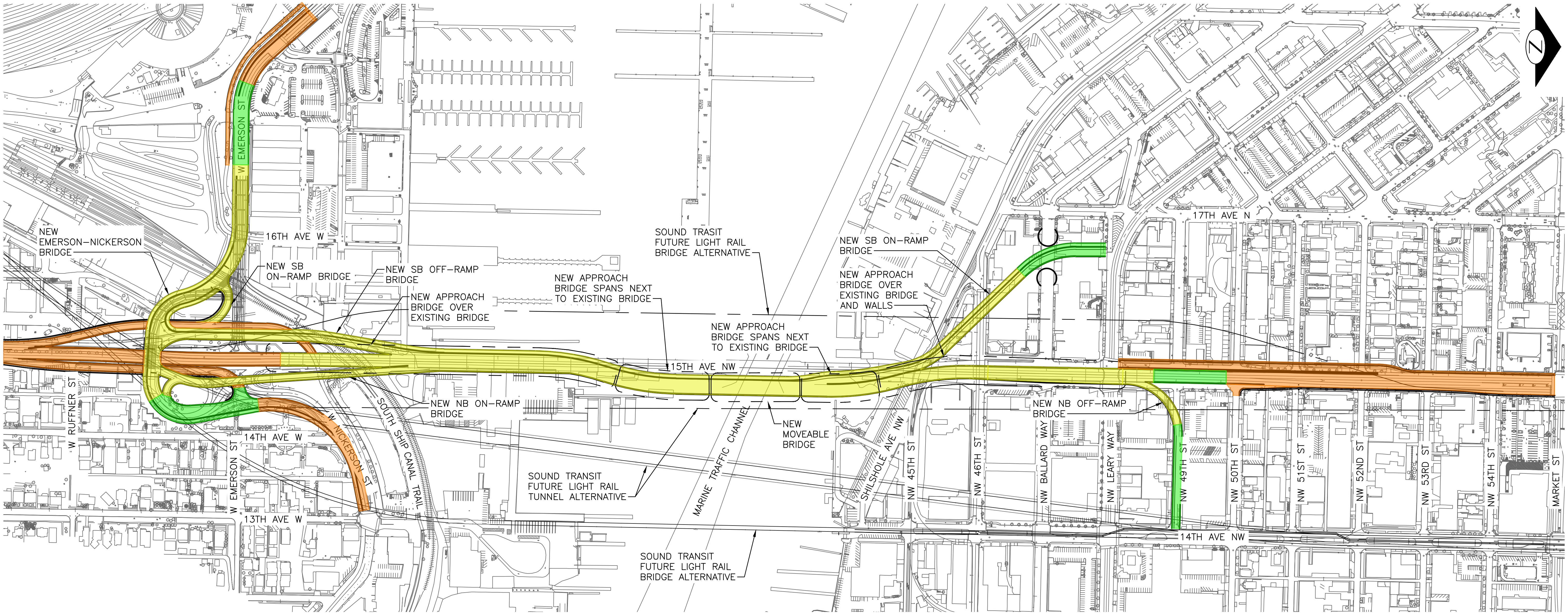

MID LEVEL REPLACEMENT LAYOUT

LEGEND:

	AT GRADE
	BRIDGE
	RETAINING WALL

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Sep–13–19 1:55pm

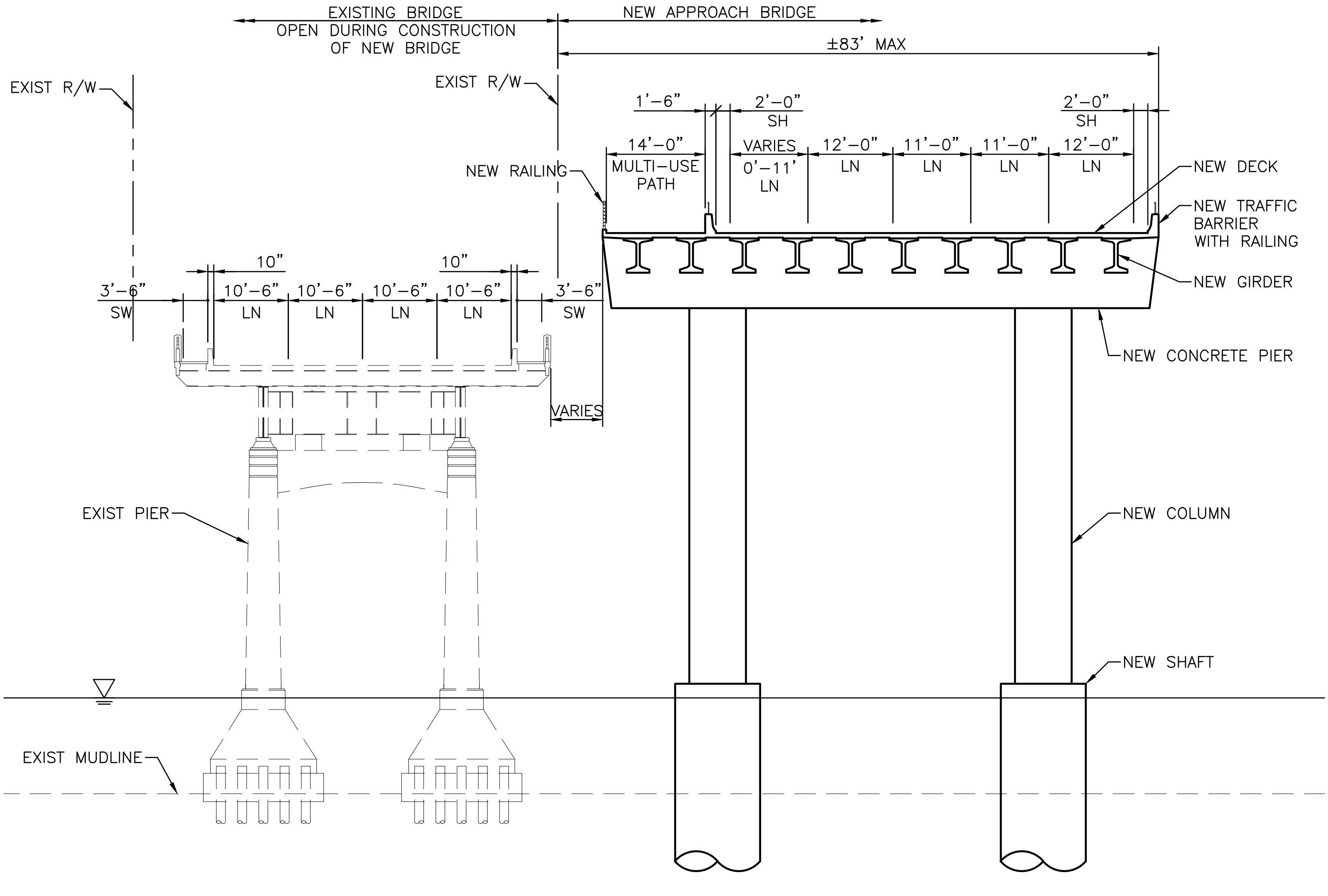
COWI

City of Seattle
Seattle Department of Transportation
ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE PLANNING STUDY
SEATTLE, WA

MID–LEVEL REPLACEMENT LAYOUT

FIGURE 6



NEW APPROACH BRIDGE NEXT TO EXISTING BRIDGE CONCEPT

(LOOKING NORTH)

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

MID-LEVEL REPLACEMENT
NEW APPROACH BRIDGE NEXT TO
EXISTING BRIDGE

FIGURE
7

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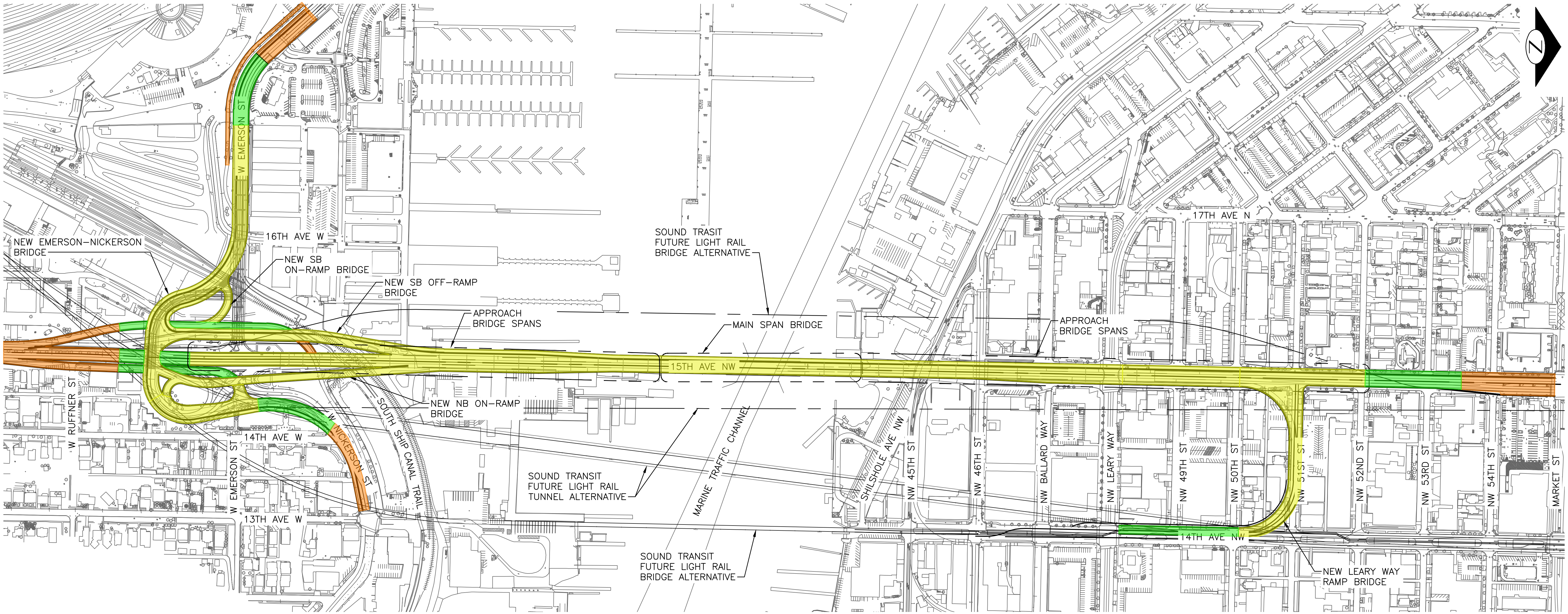

HIGH LEVEL REPLACEMENT LAYOUT

LEGEND:

- AT GRADE
- BRIDGE
- RETAINING WALL

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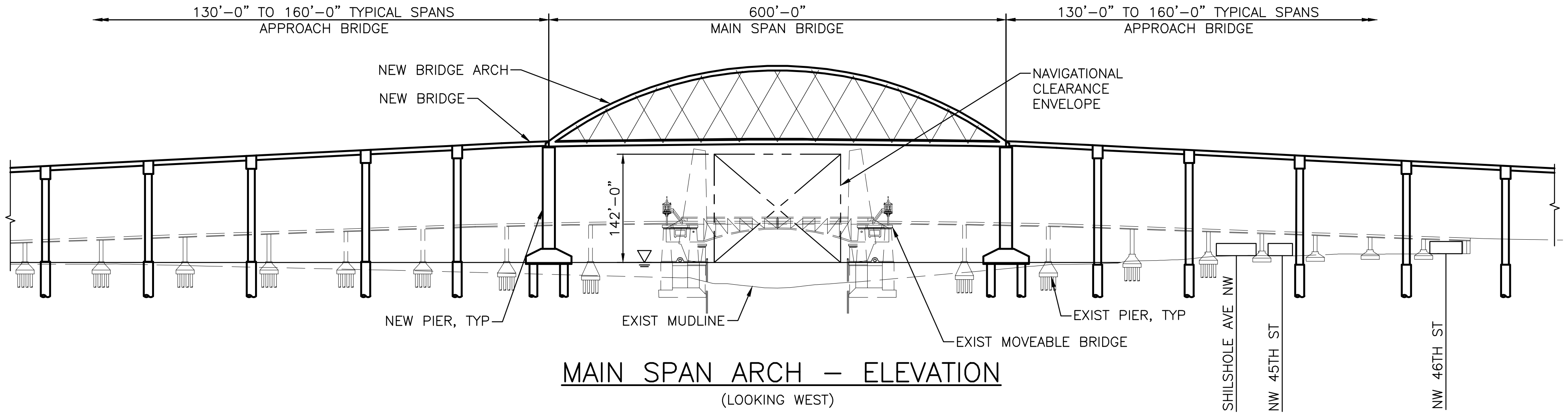
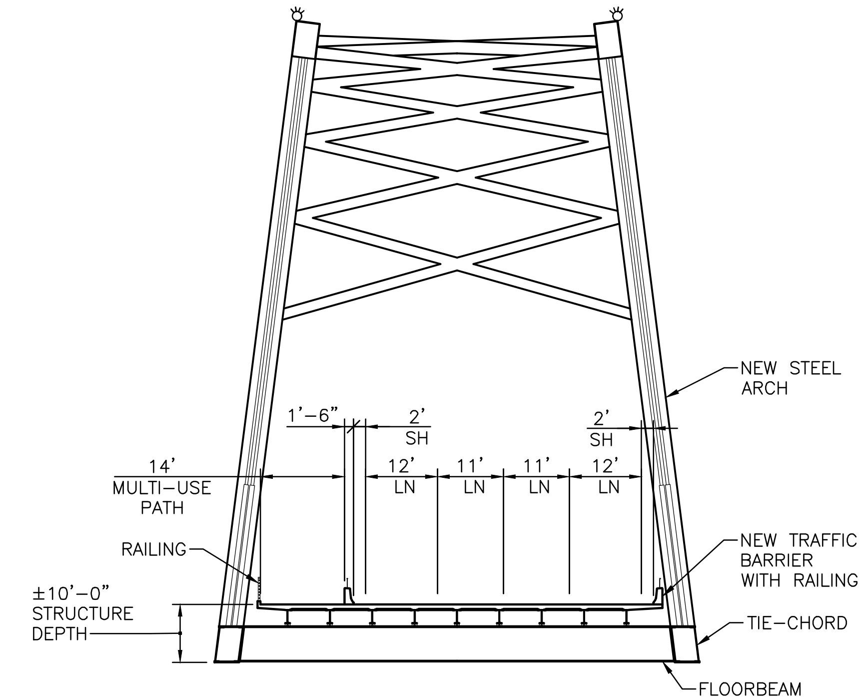
Sep-13-19 1:57pm

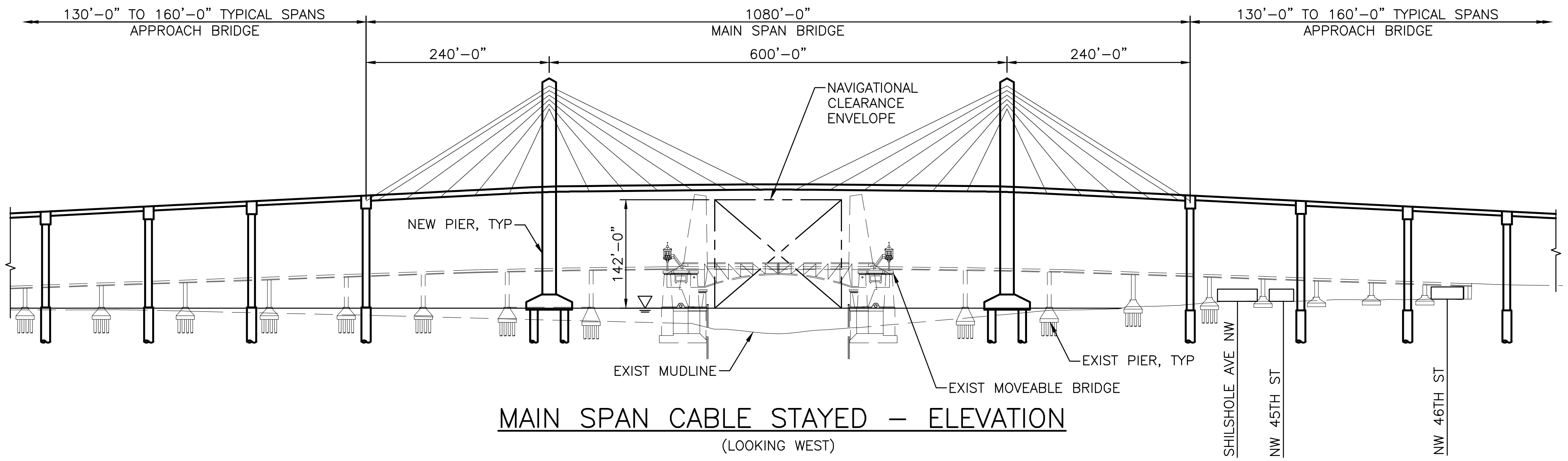
COWI	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE:	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA	HIGH–LEVEL REPLACEMENT LAYOUT	FIGURE 8



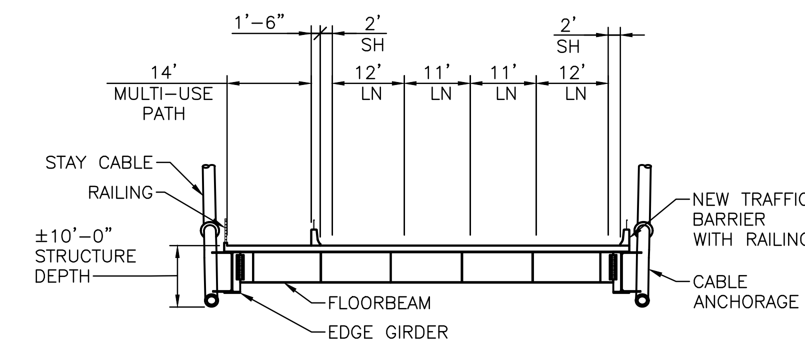
MAIN SPAN ARCH – ELEVATION
(LOOKING WEST)



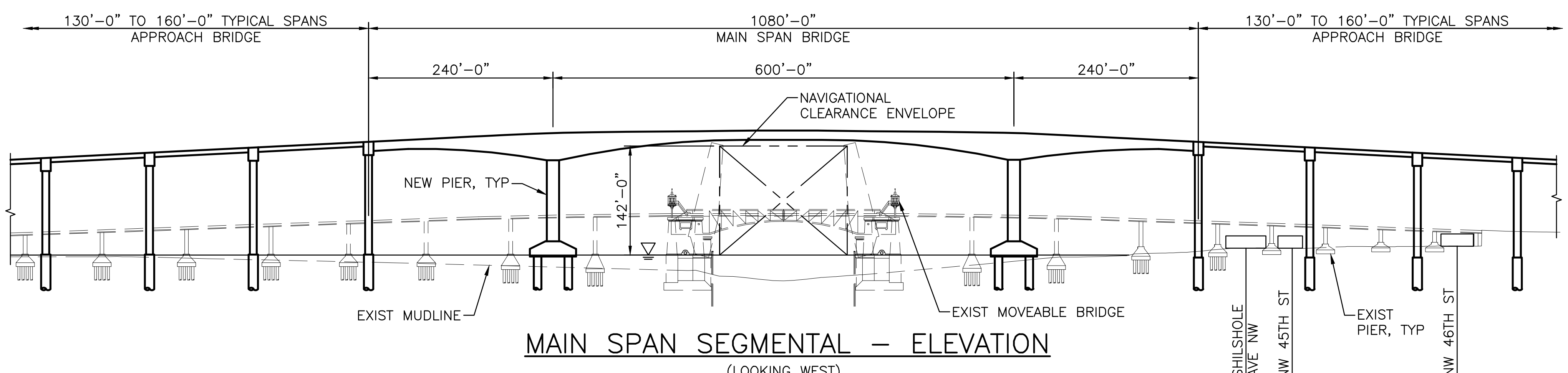
ARCH – TYPICAL SECTION



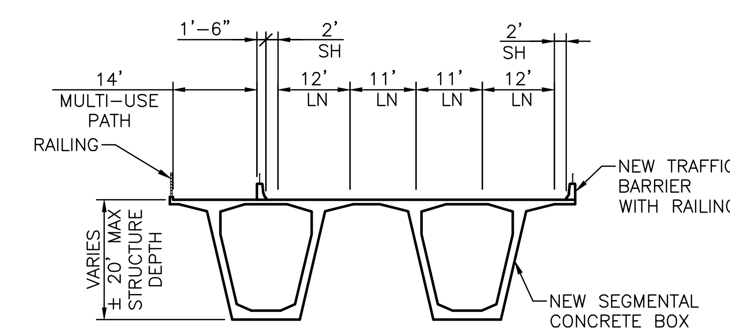
MAIN SPAN CABLE STAYED – ELEVATION
(LOOKING WEST)



CABLE STAYED – TYPICAL SECTION



MAIN SPAN SEGMENTAL – ELEVATION
(LOOKING WEST)



SEGMENTAL – TYPICAL SECTION

COWI

City of Seattle
Seattle Department of Transportation

ORDINANCE NO. PW NO.
FUND:
SCALE:

BALLARD BRIDGE
PLANNING STUDY
SEATTLE, WA

HIGH-LEVEL REPLACEMENT
MAIN SPAN BRIDGE CONCEPTS

FIGURE
9

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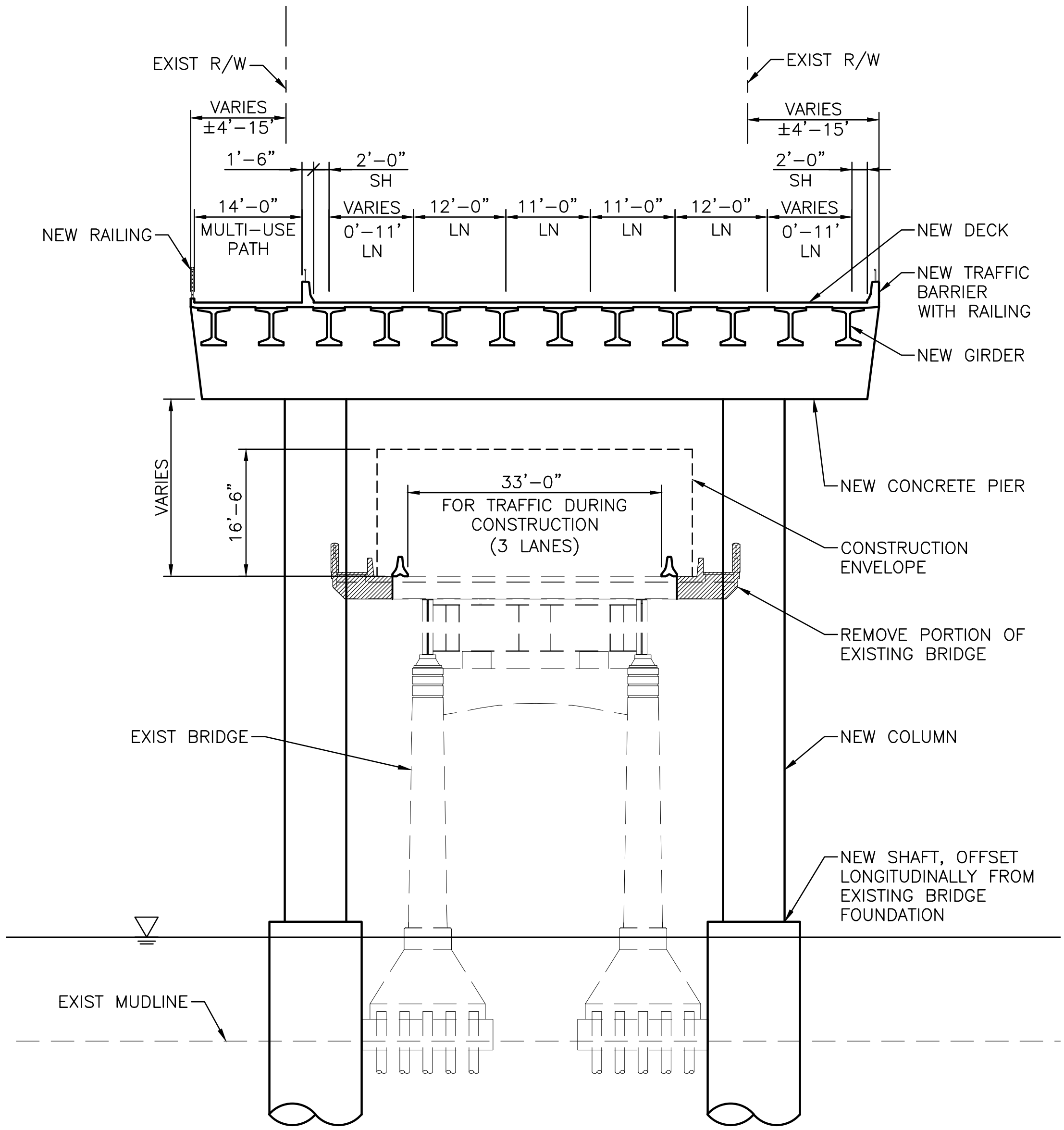

NEW APPROACH BRIDGE OVER EXISTING BRIDGE CONCEPT

(LOOKING NORTH)

COWI	City of Seattle Seattle Department of Transportation ORDINANCE NO. PW NO. FUND: SCALE:	BALLARD BRIDGE PLANNING STUDY SEATTLE, WA HIGH–LEVEL REPLACEMENT NEW APPROACH BRIDGE OVER EXISTING BRIDGE	FIGURE 10

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Sep–13–19 8:16am

RS STAFF INPUT

Seattle Department of Transportation

Please share your questions, comments and concerns. All information provided on the comment sheet is subject to public disclosure.

COMMENT SHEET

Meeting Name: Roadway Structures Staff Input

Project Name: Ballard Bridge Planning Study

Date: September 2019

(Official Use Only)

Name: Barb AbelHauser

Email: babelhauser@gmail.com

Comments:

- Needless to say, as a bridge operator I am NOT in favor of a fixed span. I don't think the community would be either. People get very attached to their drawbridges. They add personality to a city.
- Having said that, though, a 65' span would be ideal so that traffic isn't slowed for sailboats.
- But there are several ways a drawbridge design could be improved at Ballard
    - Provide a 3-car-length parking cut out by the tower for staff (similar to what we have at University, but longer to allow for electricians and mechanics). Following that, there needs to be a MUCH more secure and better lighted parking area at street level.
    - Hook the tower toilet up to a sewer system rather than a holding tank.
    - Design access to the lower levels within the tower, rather than having to go outside, as done with all other bridges.

Seattle Department of Transportation

Please share your questions, comments and concerns. All information provided on the comment sheet is subject to public disclosure.

COMMENT SHEET

Meeting Name: Roadway Structures Staff Input

Project Name: Ballard Bridge Planning Study

Date: September 2019

(Official Use Only)

Name: Mary Brown

Email: brownme1@seattle.gov

Comments:

1) Since there are some alternates for Sound Transit to go near the Ballard Bridge, piggy back of those alternates to provide peds and bike access across the Ship Canal.

2) For rehab and mid-level replacement have the operator's tower on the north end of the bridge, this will allow hook up to the sanitary sewer, while still providing good visibility up the Ship Canal, vessels pulling out of Fisherman's Terminal, and the Locks. Also, I would increase the size of the tower and bring it all the way down to street level and have the stairs inside, with the bathroom, galley and lockers on a different level than console, like Spokane, South Park and Fremont.

3) As much as possible I would have it so ped and bike were not an issue when working or coming or going from work on the bridge, where the door doesn't open right into the sidewalk example like Montlake and South Park, it's turned a little with its own area . On Montlake you don't have to go out on the side walk to get to the other side or the centerlock, there is a catwalk that goes from the operator's tower side to the far side right along the lower cord.

4) Have water and electricity on the bridge deck so you don't have run cords and hose for miles.

5) It would be nice to have the high-level replacement and keep the current bridge with some changes. Think Spokane St. Swing Bridge. Only the sidewalks would be only for peds, bikes going in either direction would have one lane, one lane in each direction for local traffic, and one lane for our crews and emergency vehicles.

6) If a new bridge is the option, design it so there are no lips or over-hangs for birds to perch or roost. This would save on painting, maintenance and much healthier for our crews. Have all areas that need to be inspected accessible without any other equipment. Do not mingle any modes of transportation, sidewalk for people walking, a bike lane and lanes for traffic. Over build, remember this bridge has to last 200 years.

Seattle Department of Transportation

Please share your questions, comments and concerns. All information provided on the comment sheet is subject to public disclosure.

COMMENT SHEET

Meeting Name: Roadway Structures Staff Input

Project Name: Ballard Bridge Planning Study

Date: September 2019

(Official Use Only)

Name: Fred Ericsen________________________ Email: ______________________________

Comments:

Ballard Bridge recently passed its one hundredth year of service. The bridge came into being as part of an economic plan to extend water borne transportation from Puget Sound to the fresh water of Lake Washington. This water route provided a means of carrying agricultural, forest and mining products to the cities of western Washington and for export to the nations of the world.

Capital investment in transportation, water and energy are unseen benefits to the people that use them. The long term amortization of these expenditures pay back the community in service many times their original cost.

Replacement of the Ballard Bridge is a serious undertaking. The 1917 structure was built at the time of a revolution in transportation. Horse drawn wagons were giving way to vehicles powered by internal combustion engines. The size and load carrying capacity of transport moved steadily upwards. The specifications for the Ballard Bridge may have seemed generous in the early 1900’s are now inadequate. The bridge runs at capacity seven days a week now with little deviation from week day to week end.

The bridges along the Lake Washington Ship Canal were constructed with moderate clearance heights. In the last fifty years more recreational vessels with mast heights that exceed those clearances have come into general use by the public. Thus more bridge openings take place which in turn delay the movement of surface traffic.

Raising the over water clearance would reduce the number of times the bridge would be required to open during each day. Deciding on the height of a new structure would be a primary criterion for a replacement bridge. The designed height also affects the grades necessary to reach that elevation which also determines the over all scope of the project.

Another major factor in the design is the consideration to the number of traffic lanes and the width allocated to light vehicles and pedestrians.

In all a new bridge design needs to look forward not just one hundred years but more like two hundred years. When capital costs are spread over such long periods the benefit to the public and the economy are great.
Fred Ericsen, Ballard Bridge 10-11-19. (206 684 4801)

Seattle Department of Transportation

Please share your questions, comments and concerns. All information provided on the comment sheet is subject to public disclosure.

COMMENT SHEET

Meeting Name: Roadway Structures Staff Input

Project Name: Ballard Bridge Planning Study

Date: September 2019

(Official Use Only)

Name: Rich Hovde

Email: Richard.Hovde@seattle.gov

Comments:

1. No tunnel option is listed

2. No highway + light rail bridge option is listed

3. For the rehab option #1 with 10' sidewalk on both sides or the 14' multi-use sidewalk on the west side, was having the ability to inspect the bridge considered?

4. Not sure if I understand option #2. I don't believe the extra cost of an elevated movable bridge will be less than the cost of rehabbing (option #1) and posting an operator. Would like to see life-cycle cost analysis between these two options.

#5 Of the three high fixed spans, I like option #3B the best. A signature bridge in this location makes sense and a cable stay is my choice. Not fond of tied arches (option #3A) because of the continued problems they experience. Option #3C is rather bland, not sexy.

Seattle Department of Transportation

Please share your questions, comments and concerns. All information provided on the comment sheet is subject to public disclosure.

COMMENT SHEET

Meeting Name: Roadway Structures Staff Input

Project Name: Ballard Bridge Planning Study

Date: September 2019

(Official Use Only)

Name: Constantinos Smith

Email: Constantinos.Smith@Seattle.gov

Comments: Tower relocation: Relocating the tower to the north end of the bridge would have multiple benefits. <---Attachment.

1. Increases the operator's line of sight towards Fremont Bridge and Ballard Locks.
   - Monitor waterway more effectively, ergo, better assisting larger vessel's navigation through the bridge.
   - Easier to plan openings ahead of time. Group vessels to decrease opening totals.
2. Moving the tower north of the waterway would join University as the only bridges accessible via north of Seattle during an unforseen disaster or catastrophe. (I watch way too many movies)
3. Safer and quicker for operators to exit and enter the tower.
   - Operators parking would be next to the control tower.
   - Quicker service for graveyard requests.

Areas underneath the bridge are exposed to roadway debris.

1. The NW and SE rack & pinion area are exposed to roadway debris.
2. The NW and SE stairs leading from the roadway to the electrical room are also exposed to debris.

Security concerns.

1. Individual had entered NW secured area of the bridge through an opening on the side of the bridge.
2. Individual had entered the center locks.

Thoughts: I like the idea of removing the west sidewalk and incorporating one multi-use path on the tower side. Lastly, I prefer the rehab option of the existing bridge.

Attachment E: October Drop-In Session and November Online Open House

EVENT OVERVIEW

We hosted 2 drop-in sessions for the Ballard Bridge Planning Study to share project updates and gather community feedback on the alternatives. Both drop-in sessions were from 6-7:30 PM. Attendees could drop by anytime and the same content was provided at both sessions. The drop-in sessions were shared on the project webpage, SDOT's social media pages, the project listserv, and through Peddler Brewing's own social media accounts. A-Frame signs were also placed at the on and off ramps to the Ballard Bridge. Additionally, a mobile display was posted at the Queen Anne, Magnolia, and Ballard libraries to provide an overview of the project and share event details. The event details for each drop-in session are below:

October 24, 2019
Peddler Brewing Company
1514 NW Leary Way, Seattle, WA 98107
6 PM – 7:30 PM

October 29, 2019
Fishermen's Terminal – Seattle Fishermen's Plaza
3919 18th Ave W, Seattle, WA 98119
6 PM – 7:30 PM

At both drop-in sessions there were 3 Seattle Department of Transportation (SDOT) staff members and 5 SDOT consultants in attendance.

EVENT LAYOUT

Both drop-in sessions were set up with multiple stations:

- SDOT sign-in table
    - Project factsheet
    - Comment cards
    - Green and red sticky dots
- SDOT Ballard Bridge Planning Study board set
    6. Welcome and Project Overview board
    7. History of the Ballard Bridge board
    8. Timeline and Funding board
    9. Ballard Bridge Considerations board
- SDOT Alternatives Analysis board set
    9. Ballard Bridge Options board
    10. Low Level Moveable Bridge Rehabilitation board (x2)
    11. Mid-Level Moveable Bridge Replacement board (x2)
    12. High Level Fixed Bridge Replacement board (x2)
    13. Alternatives Analysis Ranking board

- Feedback board set

    14. Attendee Ranking board

ATTENDANCE

Anecdotally, approximately 60 people attended the October 24 session at Peddler Brewing Company in Ballard; 43 people signed in. Approximately 20 people attended the October 29 session at Fishermen's Terminal in Interbay; 8 people signed in. The layout of the events did not require all attendees to visit the sign-in table. The photos below show the events and how people interacted with the different stations and staff.

October 24, 2019 – Peddler Brewing Company

Figure 1: Attendees at the sign in table.

Figure 2: Attendees reading the Ballard Bridge Planning Study board set.

Figure 3: Attendees interacting with the Alternatives Analysis board set.

October 29, 2019 – Fishermen's Terminal

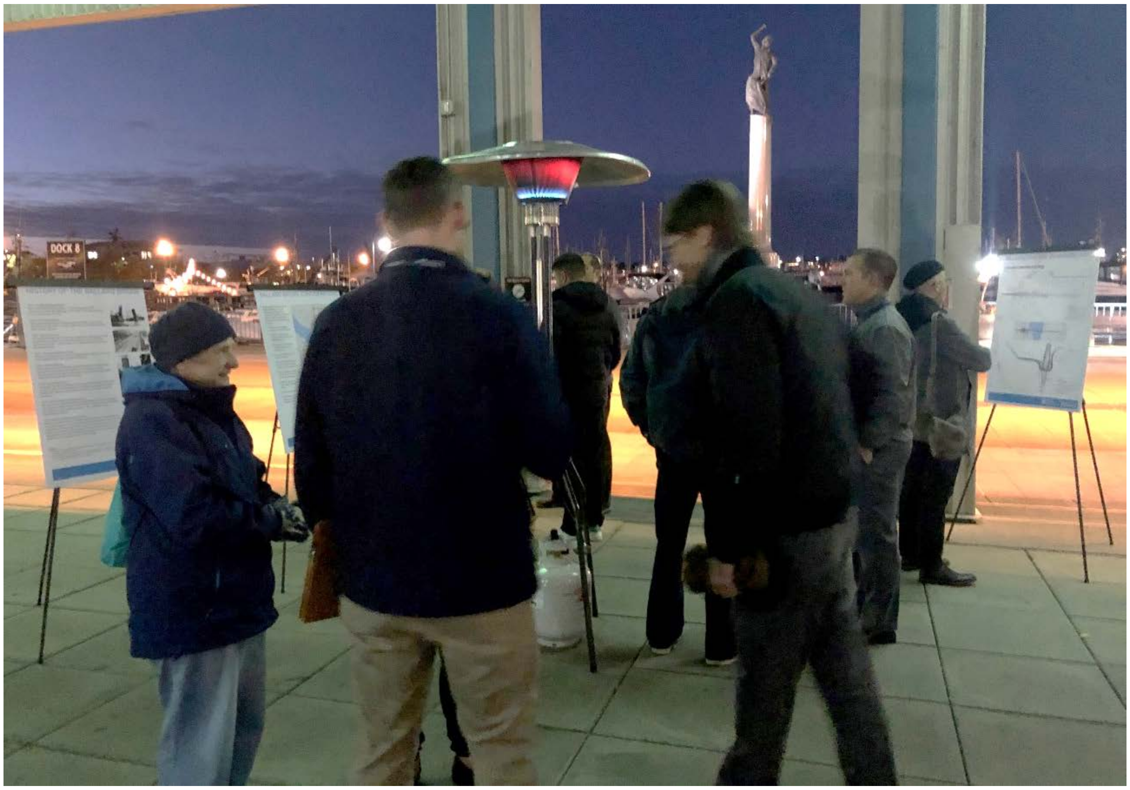


Figure 4: Attendees speaking with SDOT staff.

Figure 5: Attendees speaking with project staff at different stations.

ONLINE OPEN HOUSE

In addition to the 2 in-person events the same content was shared via an online open house. The online open house was hosted at BallardBridgeOpenHouse.com. The open house included a page for each display board from the drop-in sessions, as well as additional written descriptions of the key features for each alternative.

The online open house included a survey modeled after the in-person dot ranking exercise (described in more detail below in the 'What We Heard' Section). The survey was available from Friday, November 1, 2019 through Friday, November 15, 2019.

Figure 6: Online Open House Home page

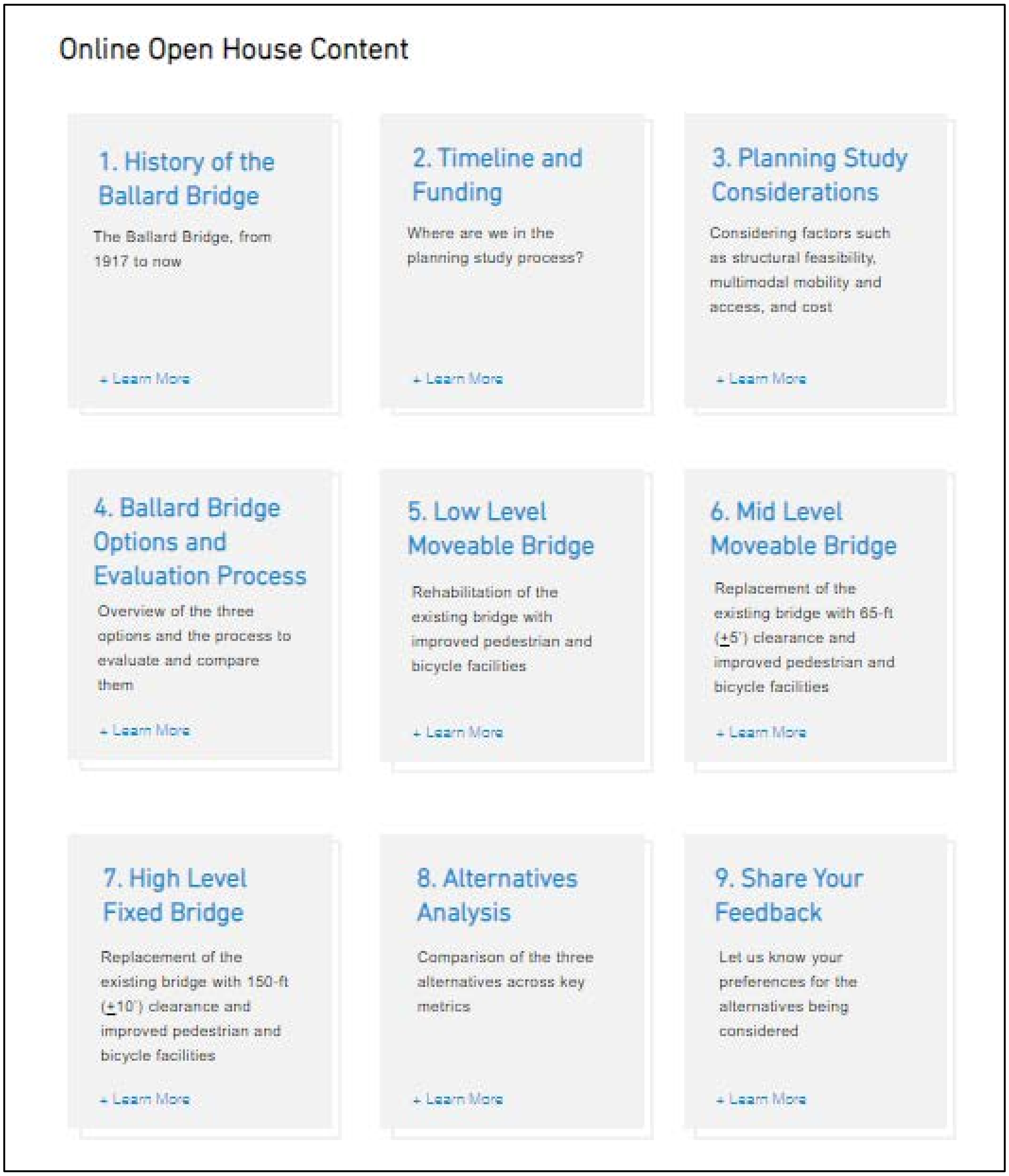


Figure 7: Online Open House contents page

WHAT WE HEARD

At the drop-in sessions we were looking for feedback on the alternatives being considered and the priority of certain considerations. We gathered feedback through an interactive sticky dot exercise. Attendees were given 1 green sticky dot and 1 red sticky dot to place on a ranking board. The board listed the 3 alternatives being considered. Attendees were asked to mark their most preferred alternative with the green dot and their least preferred with the red dot. Between both drop-in sessions approximately 56 people participated in the sticky dot ranking exercise. The project team also received feedback via comment cards and verbal comments.

We also received feedback through the online open house. The online open house included a survey that asked participants to choose their most and least preferred alternatives and rank their 3 most important and 3 least important considerations There was also an open-ended question for participants to share additional feedback. 91 people participated in the online open house survey.

From the combined ranking results, the most preferred alternative was the Low Level Movable Bridge (35%). The least preferred alternative was the High Level Fixed Bridge (38%). Below is a table of the combined preference rankings from the online open house survey and in-person dot ranking exercises.

	High Level Fixed Bridge	Mid Level Moveable Bridge	Low Level Moveable Bridge
Most Preferred	12	37	98
Least preferred	107	13	14

Dot Ranking Exercise

The most preferred alternative from the drop-in session dot ranking exercises was the Low Level Moveable Bridge (73%). The least preferred alternative was the High Level Fixed Bridge (85%). See a summary of the results in the table and pictures below.

	High Level Fixed Bridge	Mid Level Moveable Bridge	Low Level Moveable Bridge
Green – Most Preferred	3	12	41
Red – least preferred	45	4	4

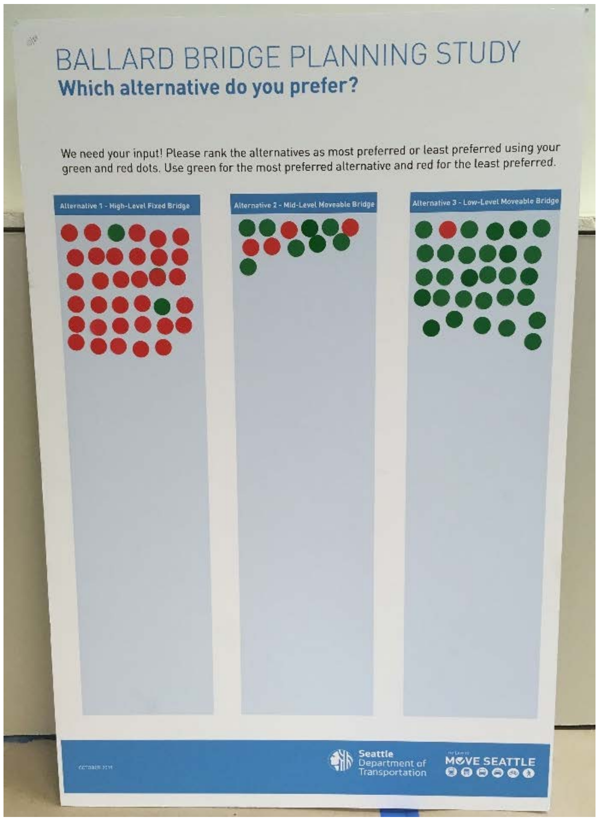


Figure 8: Ranking board from October 24

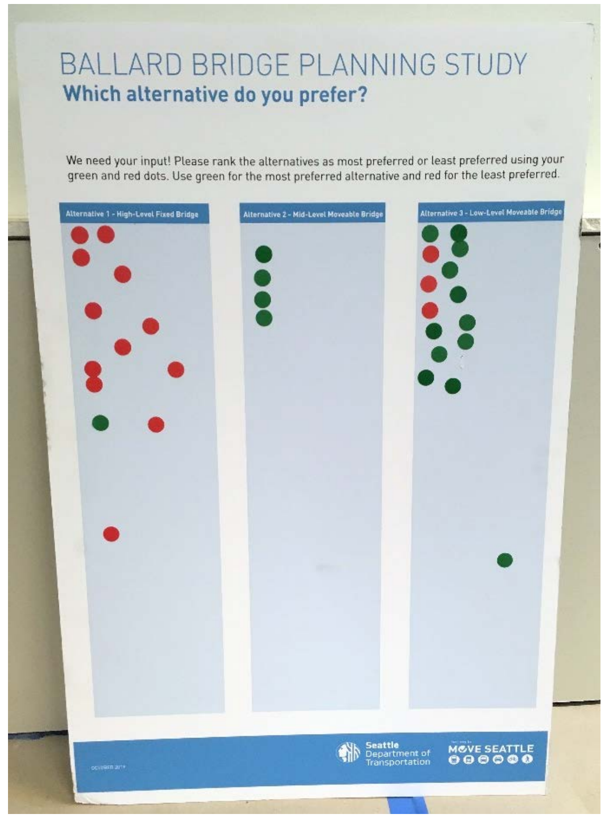


Figure 9: Ranking board from October 29

Online Open House Ranking Survey

The most preferred alternative from the online open house was the Low Level Moveable Bridge (33%). The least preferred alternative was the High Level fixed Bridge (36%). The majority of respondents ranked "Improved pedestrian and bicycle facilities" as the most important consideration. See a summary of the results in the tables below.

	High Level Fixed Bridge	**Mid Level Moveable Bridge**	**Low Level Moveable Bridge**
Most Preferred	9	25	57
Least Preferred	62	9	10

Most Important Considerations from Online Open House Survey

Improved pedestrian and bicycle facilities	72%	
Access to Burke Gilman and Ship Canal/Interbay Trail	48%	
Sound Transit coordination	36%	

Cost and design of construction	25%	
Access to Leary Way NW	18%	

Least Important Considerations from Online Open House Survey

Traffic and congestion	42%
Visual impacts and bridge aesthetics	42%
Marine navigation	35%
Bascule opening delays	34%
Level of construction impact	29%

Comment Cards and Survey Feedback

We received 15 comment cards, which identified the following considerations:

- Coordinate with Sound Transit Light Rail alignments
- Provide a Bus-only lane
- Provide a dedicated/protected bike-lane
- Widen the existing path and prioritize people walking and biking; enhance accessibility
- Improve existing connections (e.g., 15th Ave NW, Pier 91/Interbay trail)
- Reduce bridge openings
- Choose the bridge alternative that will address climate change and long-term use over short-term effects
- Ballard Bridge horn is loud, looking for ways to reduce the noise and improve overall quality
- Add water fountains at the ends of the bridge and benches along the bridge (such as SR 520) to make it more accessible for people walking and biking, should they need to rest (bathroom would be great as well)

The 57 open-ended comments, we received through the online open house, identified similar themes:

- Concerns about the Single Point Urban Interchange (SPUI)
    - A handful of comments expressed a dislike for the SPUI design
    - Many comments expressed concern for the mobility of people who walk and bike on the SPUI
    - Many comments expressed a dislike for the “freeway” like design
    - Some comments expressed concern for how transit access would function on the SPUI
    - Some comments expressed frustration that the SPUI appeared to prioritized vehicle traffic
    - Priority for people who walk and bike
    - Many comments like the 14’ wide mixed-use path design
    - Some comments expressed a desire for a 14’ mixed-use path on both sides

- Some comments asked that immediate action be taken to improve safety for people who walk and bike across the bridge
- Some comments expressed a desire for improved east-west crossings for people who walk and bike
- Some comments expressed concern for the walkability and bikability of the high level alternative
- Local Connections
    - Many comments expressed a desire to improve bike connections to the Burke Gilman and Ship Canal Trail
    - Some people expressed a preference for the low level alternative because it maintained connections on the north end
- Many comments expressed a desire for coordination with Sound Transit and the future Link Light Rail
- Some comments expressed a desire for bus only lanes
- Some comments expressed a concern for the impacts of climate change
- Some comments expressed a concern for the visual impact of the high level alternative
- One comment expressed concern for the negative impact that the high level alternative could have on ship canal commerce

DISPLAY BOARDS

WELCOME TO THE BALLARD BRIDGE PLANNING STUDY DROP-IN SESSION

PROJECT OVERVIEW

The Ballard Bridge Planning Study is evaluating how to bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. While we perform regular maintenance and frequent inspections on the bridge to ensure it's operational and safe for road and marine traffic, due to the age of the structure, more significant rehabbilitation may be needed. Since the bridge is in good condition today, we have an opportunity to plan.

The Ballard Bridge Planning Study, funded the Levy to Move Seattle, explores feasible rehabilitation and replacement options for the long-term future of the bridge. Learn more about the levy at: www.seattle.gov/LevytoMoveSeattle.

The planning study aims to compare a range of feasible rehabilitation and replacement options and will identify the associated costs, risks, benefits, and trade-offs of each option. Through the end of the year, we're working with our agency partners, advisory boards, and community members to identify the needs and values and develop options that work to meet them.

We look forward to working with you and your neighbors throughout the planning study process!

HISTORY OF THE BALLARD BRIDGE

1917 – The Ballard Bridge Opens
Work on the Ballard Bridge began in 1915 in conjunction with construction of the Lake Washington ship canal. The bridge opened to traffic on December 15, 1917.

1933 – Deck Replacement
The original creosoted wood deck was replaced with an open-mesh steel deck. A 1934 census counted 12,679 vehicles crossing the bridge over a 15-hour period.

1940 – New Approaches
The original wooden approaches were replaced with approaches made of steel and concrete. The bridge was closed for a year and a half during construction. A parade was held to celebrate the re-opening of the Ballard Bridge.

1969 – Consolidated Control Tower
The four original control towers we replaced with a single control tower on the Eastern side of the Southern bascule pier.

2003 – Ballard Gateway
Eight statues depicting Ballard's Native American and Scandinavian heritage were erected on the bridge's north approach. These sculptures, titled the "Ballard Gateway," were created by Washington artists Tom Askman and Lea Anne Lake.

2014 – Seismic Retrofits
Funded by the 2006 "Bridging the Gap" transportation levy, SDOT made necessary seismic improvements to 7 bridges, including the Ballard Bridge. The bridge received seismic retrofits to strengthen existing columns.

2014 – Bridge Sidewalk Widening Study
We conducted the Ballard Bridge Sidewalk Widening Study to evaluate alternatives to make travel across the Ballard Bridge more comfortable for pedestrians and people on bicycles. This study informs our rehabilitation concept.

2019– Ballard Bridge Planning Study
We've launched the Ballard Bridge Planning Study to evaluate how to bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. The study, funded by the Levy to Move Seattle, will explore feasible rehabilitation and replacement options for the long-term future of the bridge.

Citations:
- *HistoryLink Encyclopedia of Washington State History.* "Ballard Bridge Seattle" Essay 11260 (by Priscilla Long). April 4, 2017.
- *King County Municipal Archives.* Ballard Bridge Photographs. Accessed July 5, 2019.
- *Ballard Bridge, with original wooden approaches,* Seattle, March 13, 1918. Photo by James P. Lee, Courtesy UW Special Collections [LEE254]

PLANNING STUDY TIMELINE & FUNDING

PLANNING STUDY PROCESS

Activity	2019 Spring	Summer	Fall	Winter
Stakeholder Meetings: with agency and community partners including Sound Transit, Port of Seattle, BNSF, and adjacent BINMIC and community organizations				
Advisory Board: to involve and seek assistance from Bike, Pedestrian, Transit, and Freight advisory boards				
Online Survey: to introduce the project scope and schedule and to better understand behaviors for users of the Ballard Bridge				
Drop-in Sessions & Community Events: to describe the Ballard Bridge history, review evaluation process, present analyses, and collect community input.			WE ARE HERE	
Community Councils & Other Community Group Briefings: to inform the public of the study purpose and progress, and to provide more opportunities for community comments and questions				
Finalize Alternatives Analysis and Share Results: with SDOT directors, the Mayor, and our local, county, and state elected officials				

Subject to change.

KEY: Technical Screening to identify viable alternatives; Advisory Board Briefings; Online Survey; Alternatives Analysis; Stakeholder Meetings; Share results; Community Involvement

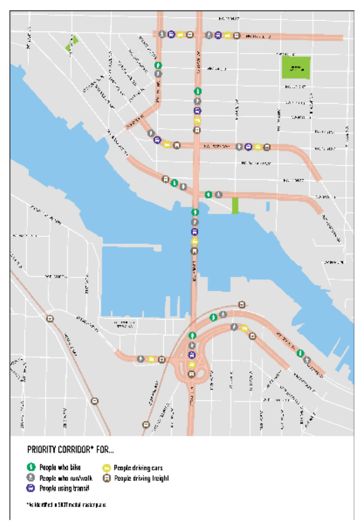
This planning study is funded by the Levy to Move Seattle, approved by voters in 2015. The 9-year, $930 million Levy to Move Seattle provides funding to improve safety for all travelers, maintain our streets and bridges, and invest in reliable, affordable travel options for a growing city. Learn more about the levy at www.seattle.gov/LevyToMoveSeattle.

The State has marked $700K in the 2019-2021 budget to investigate the Ballard-Interbay Regional Transportation System and provide recommendations to our elected officials on maintaining and improving capacity to move people and goods along this important corridor. The study is expected to launch later this year.

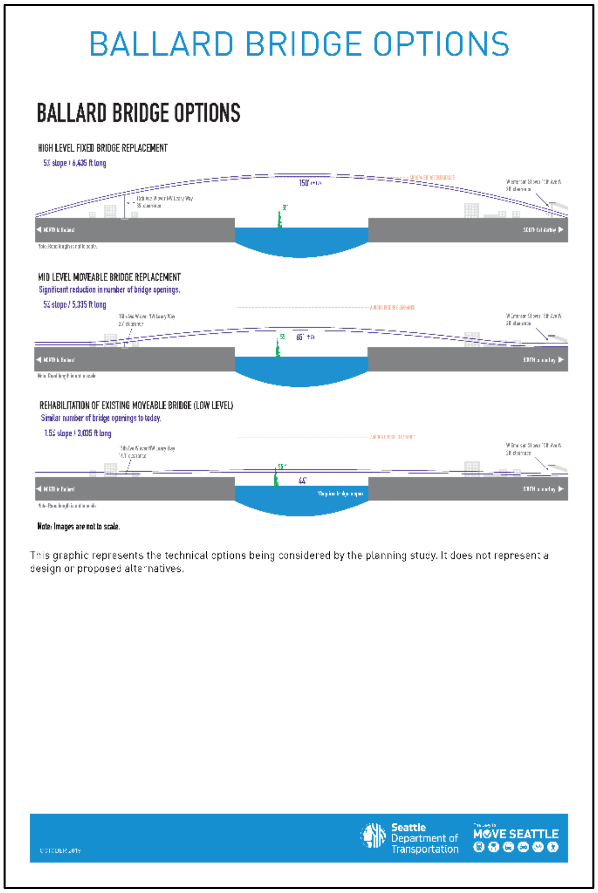
BALLARD BRIDGE CONSIDERATIONS

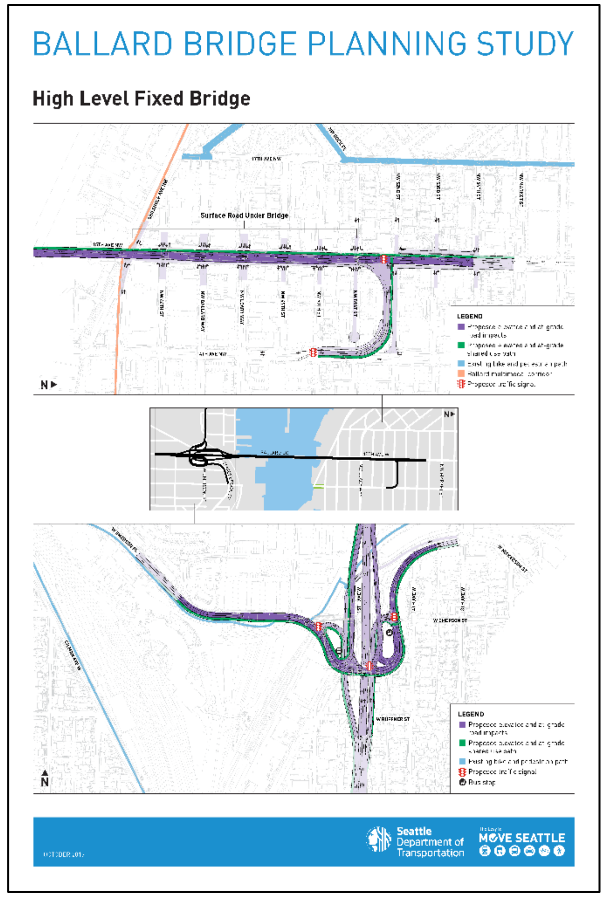
As we explore options for the Ballard Bridge, we must consider factors such as structural feasibility, cost, and community transportation needs. Specific considerations include:

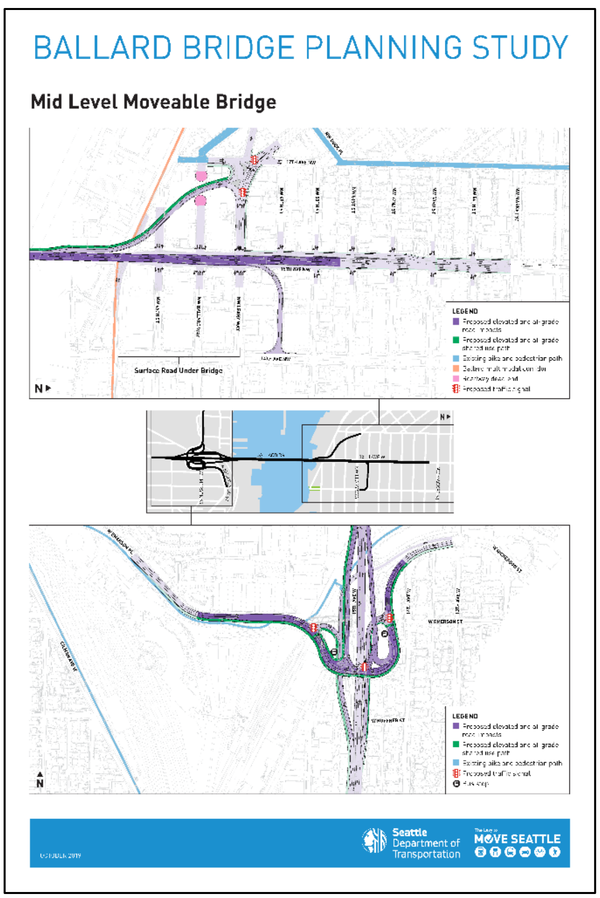
- Maintain multimodal access to Leary Way NW
- Maintain multimodal access to W Emerson St & W Nickerson St
- Provide safe multimodal merges, diverges, and connections
- Improve pedestrian and bicycle facilities
- Maintain pedestrian and bicycle access to Burke Gilman & Ship Canal Trails
- Aim for roadway grades at or less than 5% (max grade of 7% as necessary)
- Maintain access for over-legal loads (20 ft x 20-ft)
- Minimize property effects
- Predictability of bridge openings for marine and roadway traffic

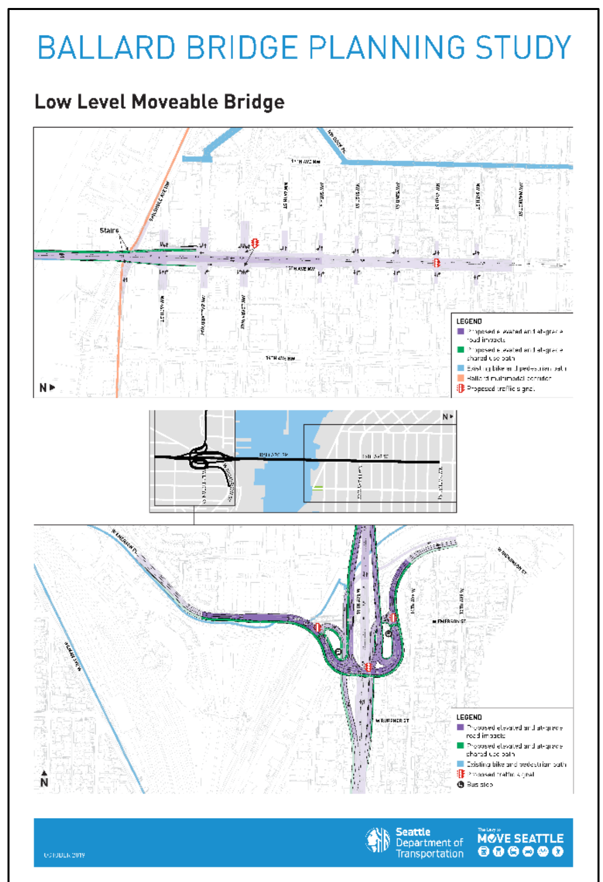


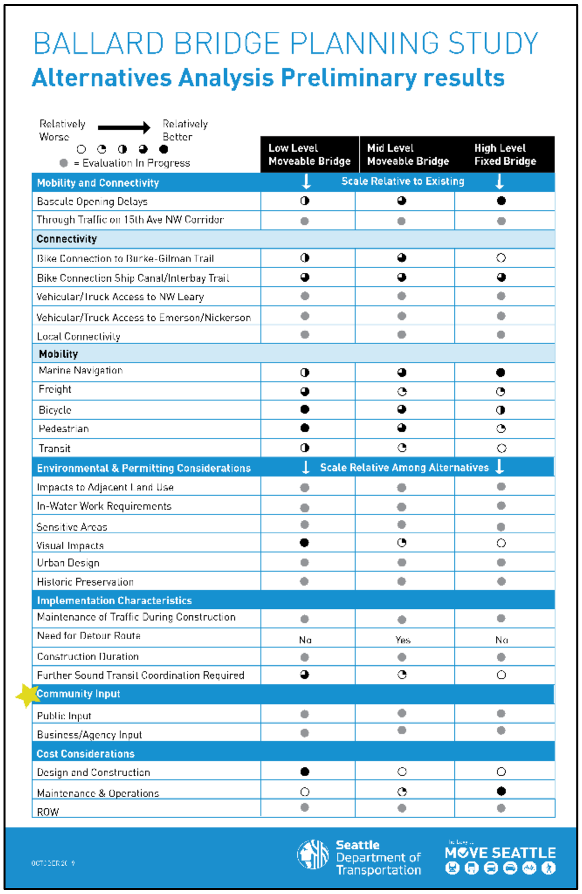
Seattle Department of Transportation — The Levy to MOVE SEATTLE


BALLARD BRIDGE OPTIONS
BALLARD BRIDGE OPTIONS
HIGH LEVEL FIXED BRIDGE REPLACEMENT
5% slope / 6,635 ft long
150'
MID LEVEL MOVEABLE BRIDGE REPLACEMENT
Significant reduction in number of bridge openings.
5% slope / 5,335 ft long
65'
REHABILITATION OF EXISTING MOVEABLE BRIDGE (LOW LEVEL)
Similar number of bridge openings to today.
1.5% slope / 3,035 ft long
44'
Note: Images are not to scale.
This graphic represents the technical options being considered by the planning study. It does not represent a design or proposed alternatives.
Seattle Department of Transportation
MOVE SEATTLE


BALLARD BRIDGE PLANNING STUDY
High Level Fixed Bridge
Surface Road Under Bridge
LEGEND
Seattle Department of Transportation
MOVE SEATTLE


BALLARD BRIDGE PLANNING STUDY
Mid Level Moveable Bridge
Surface Road Under Bridge
LEGEND
Seattle Department of Transportation
MOVE SEATTLE


BALLARD BRIDGE PLANNING STUDY
Low Level Moveable Bridge
Stairs
LEGEND
Seattle Department of Transportation
MOVE SEATTLE



BALLARD BRIDGE PLANNING STUDY

Alternatives Analysis Preliminary results

Relatively Worse → Relatively Better

○ ◔ ◑ ◕ ●

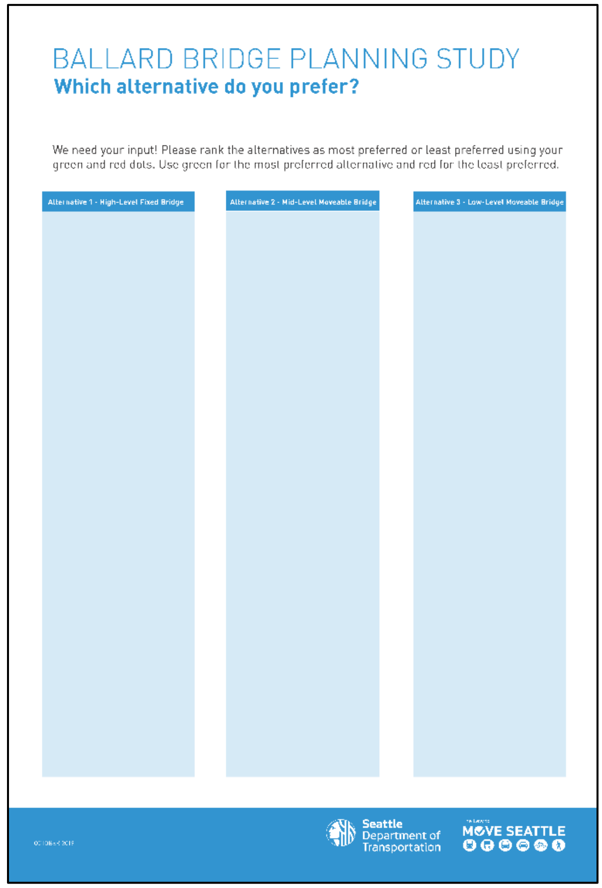
• = Evaluation In Progress

	Low Level Moveable Bridge	Mid Level Moveable Bridge	High Level Fixed Bridge
Mobility and Connectivity	Scale Relative to Existing		
Bascule Opening Delays	◑	◕	●
Through Traffic on 15th Ave NW Corridor	•	•	•
Connectivity			
Bike Connection to Burke-Gilman Trail	◑	◕	○
Bike Connection Ship Canal/Interbay Trail	◕	◕	◕
Vehicular/Truck Access to NW Leary	•	•	•
Vehicular/Truck Access to Emerson/Nickerson	•	•	•
Local Connectivity	•	•	•
Mobility			
Marine Navigation	◑	◕	●
Freight	◕	◔	◔
Bicycle	●	◕	◑
Pedestrian	●	◕	◔
Transit	◑	◔	○
Environmental & Permitting Considerations	Scale Relative Among Alternatives		
Impacts to Adjacent Land Use	•	•	•
In-Water Work Requirements	•	•	•
Sensitive Areas	•	•	•
Visual Impacts	●	◔	○
Urban Design	•	•	•
Historic Preservation	•	•	•
Implementation Characteristics			
Maintenance of Traffic During Construction	•	•	•
Need for Detour Route	No	Yes	No
Construction Duration	•	•	•
Further Sound Transit Coordination Required	◕	◔	○
Community Input			
Public Input	•	•	•
Business/Agency Input	•	•	•
Cost Considerations			
Design and Construction	●	○	○
Maintenance & Operations	○	◔	●
ROW	•	•	•

OCTOBER 2019

Seattle Department of Transportation

MOVE SEATTLE



BALLARD BRIDGE PLANNING STUDY

Which alternative do you prefer?

We need your input! Please rank the alternatives as most preferred or least preferred using your green and red dots. Use green for the most preferred alternative and red for the least preferred.

Alternative 1 - High-Level Fixed Bridge	Alternative 2 - Mid-Level Moveable Bridge	Alternative 3 - Low-Level Moveable Bridge

Seattle Department of Transportation

MOVE SEATTLE

FACTSHEET

BALLARD BRIDGE PLANNING STUDY

Investing in the future of our bridges

FACT SHEET | October 2019

PROJECT OVERVIEW

The Ballard Bridge Planning Study explores feasible rehabilitation and replacement options for the long-term future of the bridge by identifying associated costs, risks, benefits, and trade-offs of each option. It is the second of 10 studies to help us assess and manage roadway structure maintenance needs and maximize future investments. While we perform regular maintenance and frequent inspections on the bridge to ensure it's operational and safe for road and marine traffic, due to the age of the structure, more significant rehabilitation may be needed. Since the bridge is in good condition today, we have an opportunity to plan.

PLANNING STUDY PROCESS	2019
Stakeholder Meetings: with agency and community partners including Sound Transit, Port of Seattle, BNSF, and adjacent BINMIC and community organizations	Spring/ Fall
Advisory Board: to involve and seek assistance from Bike, Pedestrian, Transit, and Freight advisory boards	Spring/ Summer
Online Survey: to introduce the project scope and schedule and to better understand behaviors for users of the Ballard Bridge	Spring
Drop-in Sessions & Community Events: to describe the Ballard Bridge history, review evaluation process, present analyses, and collect community input	Summer/ Fall
Community Councils & Other Community Group Briefings: to inform the public of the study purpose and progress, and to provide more opportunities for community comments and questions	Spring/ Fall
Finalize Alternatives Analysis and Share Results: with SDOT directors, the Mayor, and our local, county, and state elected officials	Fall/ Winter

FUNDING

This planning study is funded by the Levy to Move Seattle, approved by voters in 2015. The 9-year, $930 million Levy to Move Seattle provides funding to improve safety for all travelers, maintain our streets and bridges, and invest in reliable, affordable travel options for a growing city. Learn more about the levy at www.seattle.gov/LevyToMoveSeattle

PROJECT UPDATE

In the early stages of the project we conducted an online survey asking the community to share how they use and value the bridge. Key findings showed:

- 83% currently travel the bridge by car with the majority of travel taking place on weekends
- The majority of respondents prioritized improvements for people biking (60%) and people walking (52%)

For more information, checkout the online survey summary on our webpage.

Through the end of the year, we will continue refining cost estimates, feasibility, traffic analyses, and constructability for the 3 alternatives. We expect to present a comparison of the alternatives in a final report this winter.

For translation and interpretation, please call 206-775-8894

如果您需要把下列資訊翻譯成中文，請致電 206-775-8894.

Si usted necesita esta información traducida al español por favor llame al 206-775-8894.

Nếu quý vị cần thông tin này chuyển ngữ sang tiếng Việt, xin gọi số 206-775-8894.

Kung kailangan ninyong isalin sa Tagalog ang impormasyong ito, paki-tawag lang sa 206-775-8894.

요청하시면 번역이나 통역을 제공해드립니다 206-775- 8894.

PROJECT INFORMATION & CONTACT
www.seattle.gov/transportation/BallardBridge
(206) 775-8894 | BallardBridge@seattle.gov

Seattle Department of Transportation

The Levy to MOVE SEATTLE

ONLINE OPEN HOUSE SURVEY

Ballard Bridge Planning Study Online Open House Survey

* 1. Please select your **most preferred** alternative.

- ◯ Low Level Moveable Bridge (rehabilitation)
- ◯ Mid Level Moveable Bridge (replacement)
- ◯ High Level Fixed Bridge (replacement)

* 2. Please select your **3 most important** considerations

	1 - Most Important	2 - Second Most Important	3 - Third Most Important
Access to Burke Gilman & Ship Canal/Interbay Trail	◯	◯	◯
Access to Leary Way NW	◯	◯	◯
Access to W Emerson St & W Nickerson St	◯	◯	◯
Bascule opening delays	◯	◯	◯
Cost of design and construction	◯	◯	◯
Cost of maintenance and operations	◯	◯	◯
Impacts to Adjacent Land Use	◯	◯	◯
Improved Pedestrian and Bicycle facilities	◯	◯	◯
Level of construction impact	◯	◯	◯
Local connections	◯	◯	◯
Marine Navigation	◯	◯	◯
Mobility and access for freight	◯	◯	◯
Sound Transit Coordination	◯	◯	◯
Traffic and congestion	◯	◯	◯
Visual impacts and bridge aesthetics	◯	◯	◯

Next

Ballard Bridge Planning Study Online Open House Survey

* 3. Please select your **least preferred** alternative.

- Low Level Moveable Bridge (rehabilitation)
- Mid Level Moveable Bridge (replacement)
- High Level Fixed Bridge (replacement)

* 4. Please select your 3 **least important** considerations

	1 - Least Important	2 - Second Least Important	3 - Third Least Important
Access to Burke Gilman & Ship Canal/Interbay Trail	○	○	○
Access to Leary Way NW	○	○	○
Access to W Emerson St & W Nickerson St	○	○	○
Bascule opening delays	○	○	○
Cost of design and construction	○	○	○
Cost of maintenance and operations	○	○	○
Impacts to Adjacent Land Use	○	○	○
Improved Pedestrian and Bicycle facilities	○	○	○
Level of construction impact	○	○	○
Local connections	○	○	○
Marine Navigation	○	○	○
Mobility and access for freight	○	○	○
Sound Transit Coordination	○	○	○
Traffic and congestion	○	○	○
Visual impacts and bridge aesthetics	○	○	○

Prev Next

Ballard Bridge Planning Study Online Open House Survey

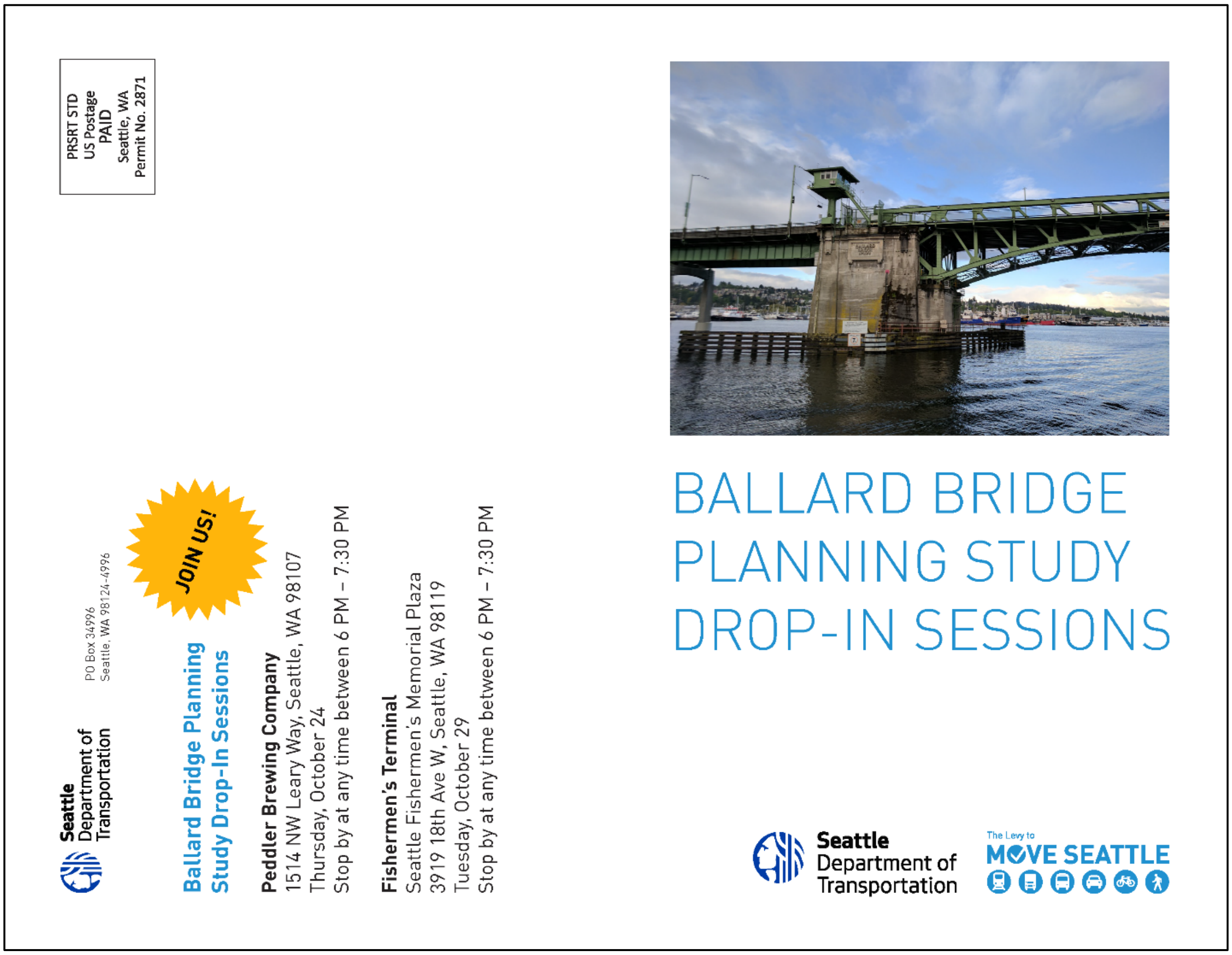
5. Do you have any further comments, feedback, concerns, and/or questions regarding the Ballard Bridge Planning Study?

Prev Next

NOTIFICATIONS

In addition to the notifications shown below, an email announcement was sent to the project listserv, an announcement posted on the webpage, and reminders were posted on the SDOT twitter and Facebook accounts.

MAILER



PROJECT OVERVIEW

The Ballard Bridge Planning Study will evaluate how to bring the bridge up to current transportation, functional, and structural standards including improved bicycle and pedestrian facilities and keeping buses and freight moving. While we perform regular maintenance and frequent inspections on the bridge to ensure its operational and safe for road and marine traffic, due to the age of the structure, more significant rehabilitation may be needed. Since the bridge is in good condition today, we have an opportunity to plan.

The Ballard Bridge Planning Study, funded by the Levy to Move Seattle, explores feasible rehabilitation and replacement options for the long-term future of the bridge. Learn more about the levy at: www.seattle.gov/LevytoMoveSeattle.

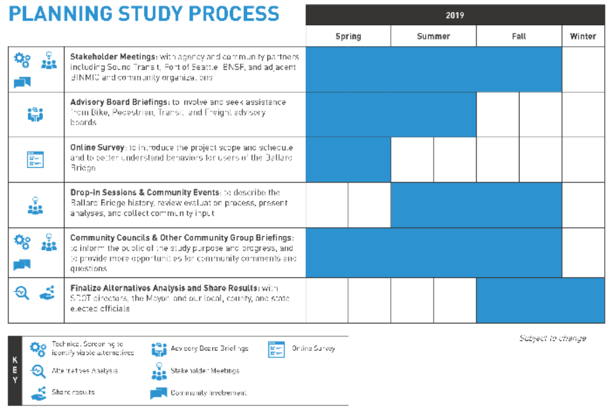
Through the end of the year, we're working with our agency partners, advisory boards, and community members to identify needs and values and propose options that work to meet them.

UPCOMING DROP-IN SESSION

We're hosting drop-in sessions at the Peddler Brewing Company and Fishermen's Terminal and invite you to join us. The drop-in sessions are a good opportunity to learn about the Ballard Bridge Planning Study, to talk to the project team about your needs and values for the bridge, and to provide feedback on possible alternatives. Along with sharing information about the possible alternatives we'll share details about constructability, feasibility, cost, and connections to nearby destinations.

You can join us for either session and drop-in any time between 6 and 7:30M. Information and materials will be the same at both sessions. We look forward to seeing you there!

PLANNING STUDY PROCESS



Subject to change

GET INVOLVED

We're committed to keeping you informed throughout the study. If you'd like more information, please use one of the following resources:

- Learn more about the study and to sign up for the project listserv visit our webpage: www.seattle.gov/transportation/BallardBridge
- Email the study team at BallardBridge@seattle.gov
- Call the study team at (206) 775-8894

If you need this information translated, please call 206-775-8894.
Servicios de traducción e interpretación disponibles bajo petición 206-775-8894.
Matutulungan ka naming maintindihan kung hihingi kang tulong 206-775-8894.
요청하시면 번역이나 통역을 제공해드립니다 206-775-8894.
Dịch và thông dịch viên sẵn sàng nếu có sự yêu cầu 206-775-8894.
Haddii aad dooneyso turjubeen fadlen wac 206-775-8894.

PROJECT CONTACT INFORMATION

206-775-8894 | BallardBridge@seattle.gov
www.seattle.gov/transportation/BallardBridge

Seattle Department of Transportation

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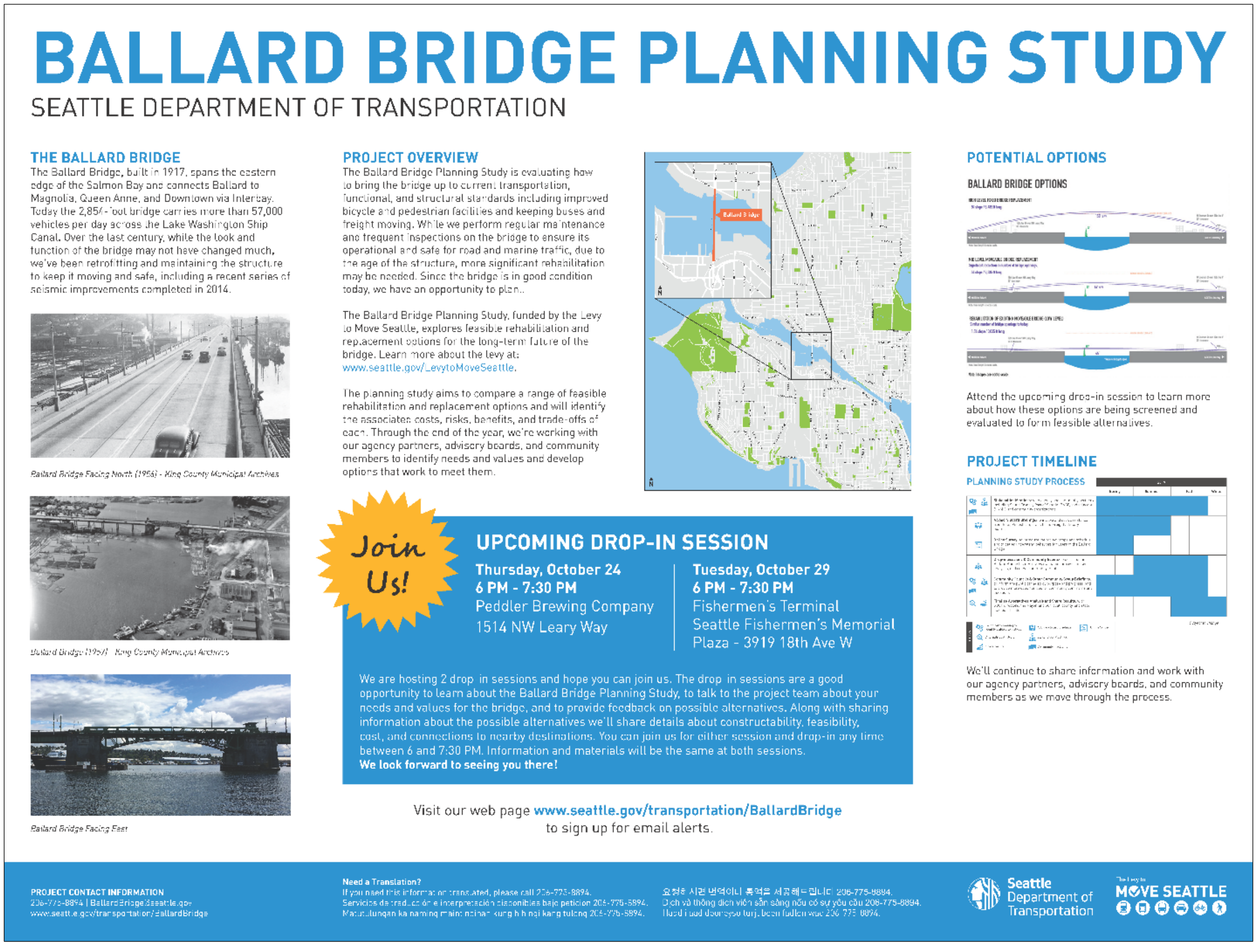
MOBILE DISPLAY

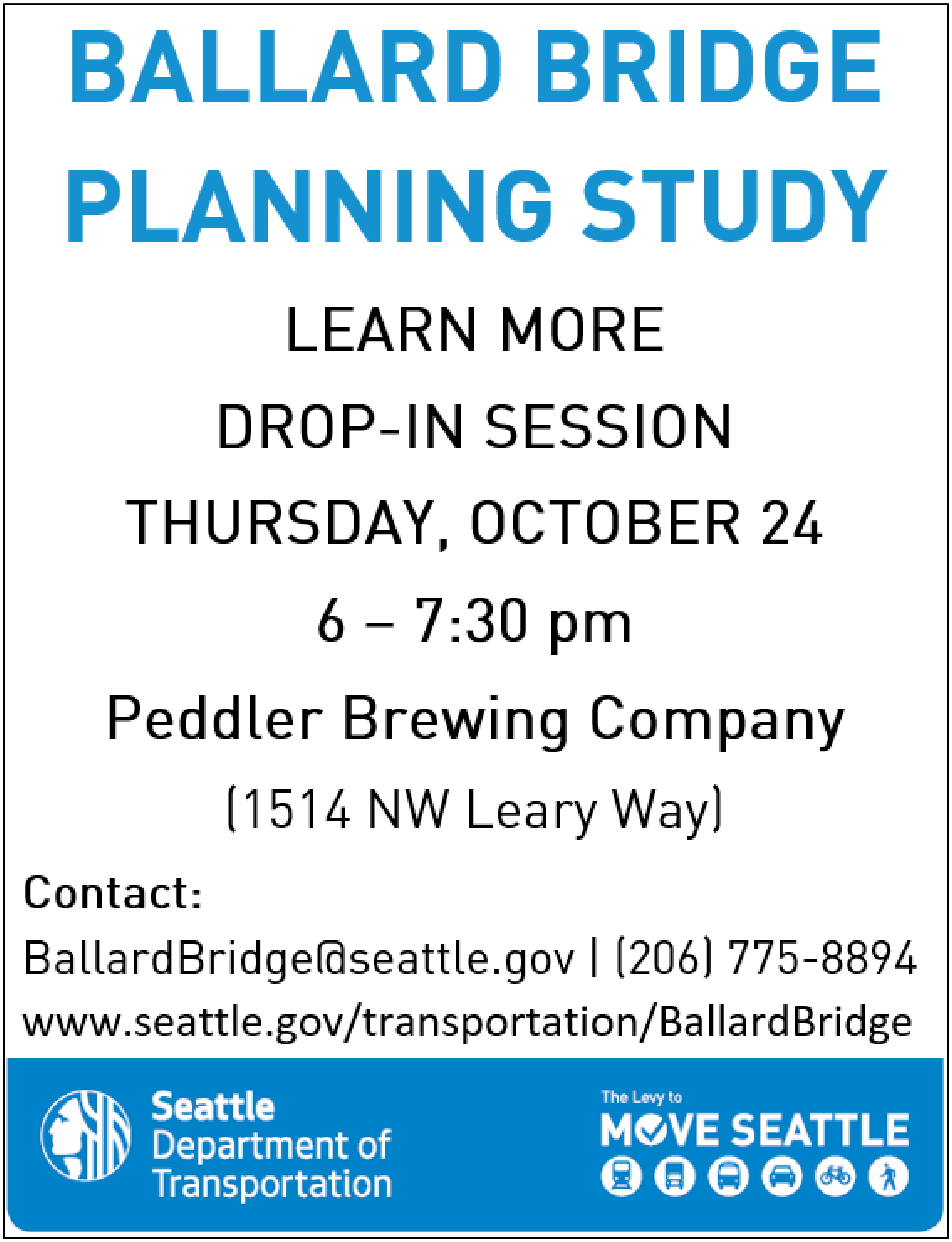
A trifold display board was placed at Magnolia Library, Queen Anne Library, and Ballard Library approximately 2 weeks before the drop-in session.



A-FRAME SIGNS

4 A-Frame signs were placed at the on and off ramps to the Ballard Bridge on October 16, 2019. All signs were double-sided to include information for each drop-in session.

Side 1. Information for Drop-In Session at Peddler Brewing



Side 2. Information for Drop-In Session at Peddler Brewing

BALLARD BRIDGE PLANNING STUDY

LEARN MORE

DROP-IN SESSION

TUESDAY, OCTOBER 29

6 – 7:30 pm

Fishermen's Terminal – Dock 7

(3919 18th Ave W)

Contact:

BallardBridge@seattle.gov | (206) 775-8894

www.seattle.gov/transportation/BallardBridge

Seattle Department of Transportation

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