BergerABAM

Ballard Bridge Sidewalk Widening Concept Study

Seismic Retrofit Project Phase II PS&E
Ballard Bascule Bridge Approach

Submitted to
Seattle Department of Transportation
Seattle, Washington

Submitted by
BergerABAM

A10.0057.00

September 2014

Ballard Bridge Sidewalk Widening Alternative Study

Submitted to:

Seattle Department of Transportation
Seattle, Washington

5 September 2014

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Job No. SAPWT-10-057

BALLARD BRIDGE SIDEWALK WIDENING ALTERNATIVE STUDY

Seattle Department of Transportation

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EXECUTIVE SUMMARY

PURPOSE

The Ballard Bridge crosses the Lake Washington Ship Canal and connects Ballard to Queen Anne, Magnolia, and downtown via Interbay. Consistent with the City's safety and mobility goals, the goal for this study is to evaluate alternatives to make travel across the Ballard Bridge more comfortable for pedestrians and people on bicycles. The study evaluates the feasibility of widening the sidewalks on the bridge approaches, the feasibility of installing a railing between the travel lanes and the existing sidewalks, and the feasibility of providing a multi-use connector trail between the southwest corner of the Ballard Bridge, 15th Avenue West, and the South Ship Canal Trail.

EXISTING CONDITIONS

The Ballard Bridge is located on the west end of the Lake Washington Ship Canal. The bridge is approximately 2,854 feet long and it is considered one of the earliest examples of a double-leaf bascule bridge structure in the state of Washington. The bascule span, the section that is raised to allow boat traffic to pass, is 97 years old and 218 feet long. The bridge was completed in 1917 and various improvements have been made to the structure over the last century: in 1941 temporary approaches were replaced with permanent approach spans; in 1960 the four original towers were replaced by a single tower; in 1994 the structure underwent Phase 1 seismic retrofits; in 2002 improvements were made to the electrical and mechanical drive systems of the bridge; and in 2012 Phase 2 seismic retrofits were started; however, no modifications were made to the bascule span or piers.

The sidewalks on the bascule portion of the bridge are 6 feet wide, and narrow to approximately 3.5 feet at the external quadrants of the bascule to provide space for the mechanical infrastructure required to raise the bascule leaves. Along this portion of the bridge, there is a hand railing that separates the sidewalk from the travel lanes. For most of the length of the bridge's half-mile-long approaches, the sidewalks are 4 feet wide and narrow to 3.5 feet at the current and former streetlight pilasters, located at every third guardrail post. The high curb on the interior side of the sidewalk in each of the four quadrants has handrail for the 200 feet nearest the end of the bascule portion.

The 15th Avenue West roadway is designated as a Principal Arterial and a Major Truck Street, and the bridge has four 10-foot travel lanes. The average week day traffic on the bridge as of 2012 was 54,500 vehicles.

The bascule and steel approach spans are fracture critical because there are only two primary beams. This designation means that failure of a single component of the bridge can result in the full collapse of the bridge. For bridges that are designated as fracture critical, frequent inspections are federally mandated and access to all portions of the bridge beams are required during the inspection. Combined with the limits of inspection equipment, this limits the extent to which the bridge can be widened.

In evaluating the alternatives, the remaining useful service life of the structure should be considered. Bridges built in the 1930's were designed to last 60 years. The approaches to the Ballard Bridge are now 73 years old. Based on their age alone, the bridge's approaches might be considered to be at the end of their service life. However, the bascule portion and steel approaches are in good condition and are expected to remain in service for at least 25 to 30 more years. The anticipated remaining useful life of the concrete approaches is 10 to 20 years.

STUDY ALTERNATIVES EVALUATED

This study evaluated three potential improvements to the sidewalks on the bridge approaches, and one trail option to connect the South Ship Canal Trail and the bridge.

Sidewalk Improvements on the Bridge Approaches

This study evaluated the feasibility of three sidewalk improvement alternatives described below. The study did not review widening the sidewalks on the bascule portion of the bridge, where the current sidewalks are 6 feet wide, nor where the sidewalk narrows to 3.5 feet at the external quadrants of the bascule portion of the bridge (see Photo 1-1). The study assumed the existing vehicle travel lanes widths would remain the same. The three concepts evaluated were:

- Alternative 1 would modify the existing railing and barrier to increase the usable pedestrian/bicycle space without structurally widening the sidewalks, and would add a railing between the existing sidewalks and the travel lanes.
- Alternative 2 would widen the sidewalks using additional structural support, and would include a railing between the widened sidewalks and the travel lanes. For Alternative 2, both a 6-foot-wide and a 10-foot-wide sidewalk concept were analyzed. Refer to Figures E-1, E-3, and E-4 for details.
- Alternative 3 would install a railing on the inside barrier between the existing sidewalk and the travel lane.

Emerson Underpass Trail

This study evaluated the feasibility of providing a trail connection from the southwest corner of the Ballard Bridge to the South Ship Canal Trail and the sidewalk on 15th Avenue West, south of the bridge. This connection would go under West Emerson Street, providing an alternative to the at-grade crossing at West Emerson Street, as well as a better crossing of the West Nickerson Street southbound on-ramp (avoiding the merge at the south end). It could potentially also provide a direct connection to the Interbay area, but this aspect of the concept will need further evaluation.

Emerson Underpass Trail, as shown in Figure E-2, would begin on an elevated ramp at the southwest corner of the Ballard Bridge approach, north of Emerson. The two-way structure would descend to grade, pass under the West Emerson Street Bridge, and turn west to cross the

West Nickerson Street on-ramp. From there, the trail would split: turning north, it would tie into the existing South Ship Canal Trail; turning south, it would connect to the sidewalk on the west side of 15th Avenue West south of Emerson.

MAIN FINDINGS

The main study findings are summarized below. More detail is available in sections 1, 2 and 3, and the appendices.

Sidewalk Improvements on the Bridge Approaches

Alternative 1

The study concluded that Alternative 1, which provides one additional foot of width by modifying the existing barrier and railing, is technically feasible. It would require temporary construction closures, have potentially significant impacts to the historic character of the bridge, and may have significant right-of-way or business relocation costs.

Because the potential right-of-way costs and potential business relocation impacts are difficult to quantify, the cost estimate for this alternative ranges from $21.8 million to $35.8 million.

Alternative 2

The study concluded that structurally widening the sidewalks to either six or ten feet is technically feasible. Potential issues identified in the study include:

- The increased sidewalk load would use most of the reserve bridge load capacity, eliminating overload capacity and thereby reducing the service life of the bridge.
- The impacts to the historic character of the bridge are unknown and are potentially significant.
- The construction duration is estimated to be one year and impacts could include detours and closures in the vicinity of the project, with the potential to affect adjacent businesses.
- Separate from potential construction impacts, some businesses may need to be relocated and reestablished elsewhere due to the loss of working space as a result of the widened bridge.

Because the potential right-of-way costs and potential business relocation impacts are difficult to quantify, the cost estimate for this alternative ranges from $25.6 million to $47.8 million. Table 3-1 shows separate estimates for six and ten feet.

Alternative 3

SDOT concluded that this alternative is technically feasible. Installing the railing may increase the comfort of people traveling along the sidewalk; however, it may also make the sidewalk feel more constrained, requiring bicyclists to dismount when approaching pedestrians and bicyclists. Adding the railing does not impact the service life of the bridge and would have limited construction impacts. The cost estimate for this alternative is $3.2 million.

Emerson Underpass Trail
The study determined that the connector trail is technically feasible. Based on the preliminary design, the trail would meet current Americans with Disabilities Act (ADA) requirements, and vertical clearance requirements would be met under the West Emerson Street Bridge.

There is a potential business relocation impact, and trail construction would cause temporary construction impacts to drivers and pedestrians adjacent to the new facility because of closures and detours. The construction duration is estimated to be one year, and construction of the connector trail could be concurrent with sidewalk widening if both were pursued.

The cost estimate for this trail connection is approximately $17.9 million.

Figure E-1: Possible Improvements

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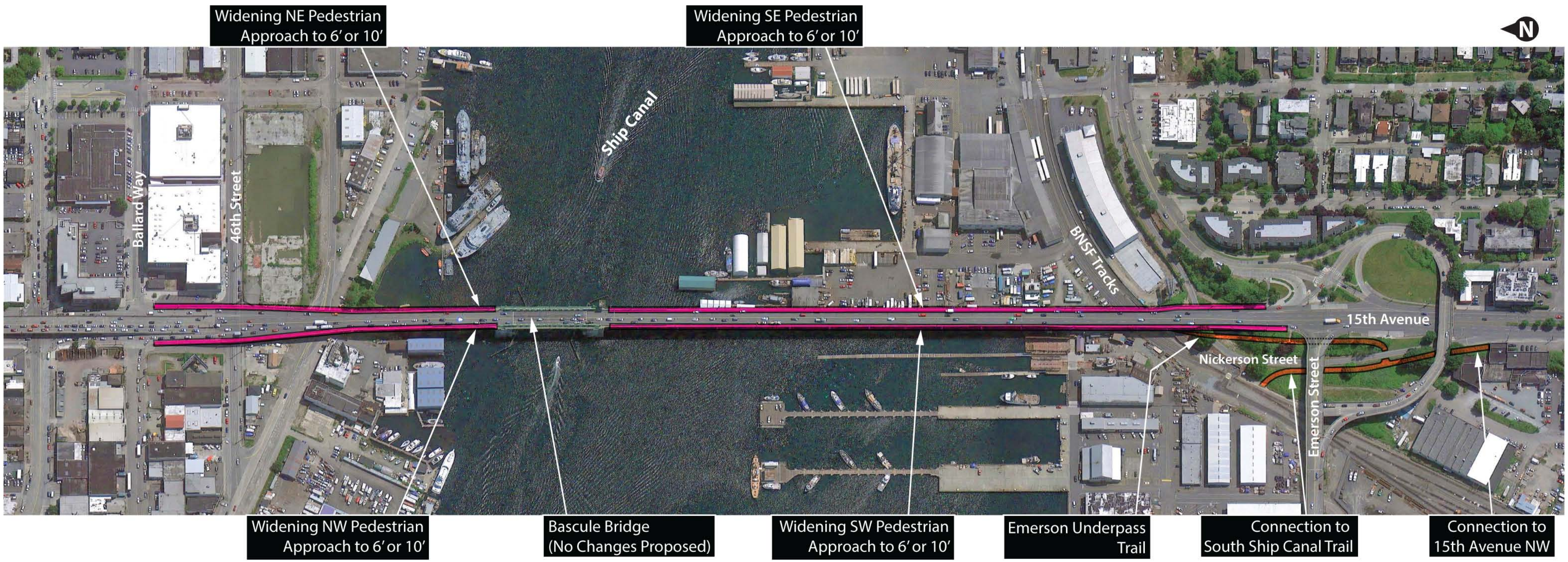


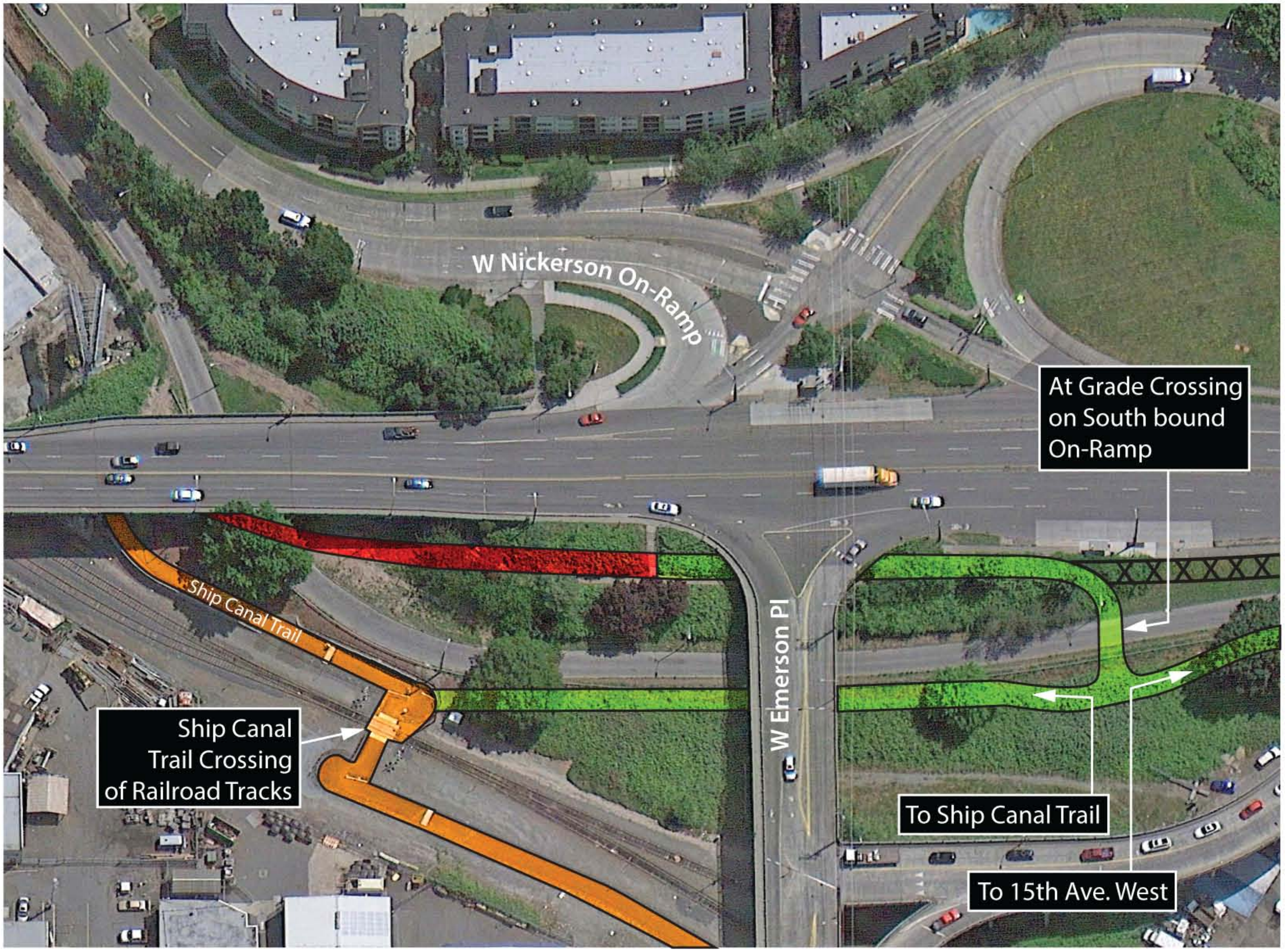
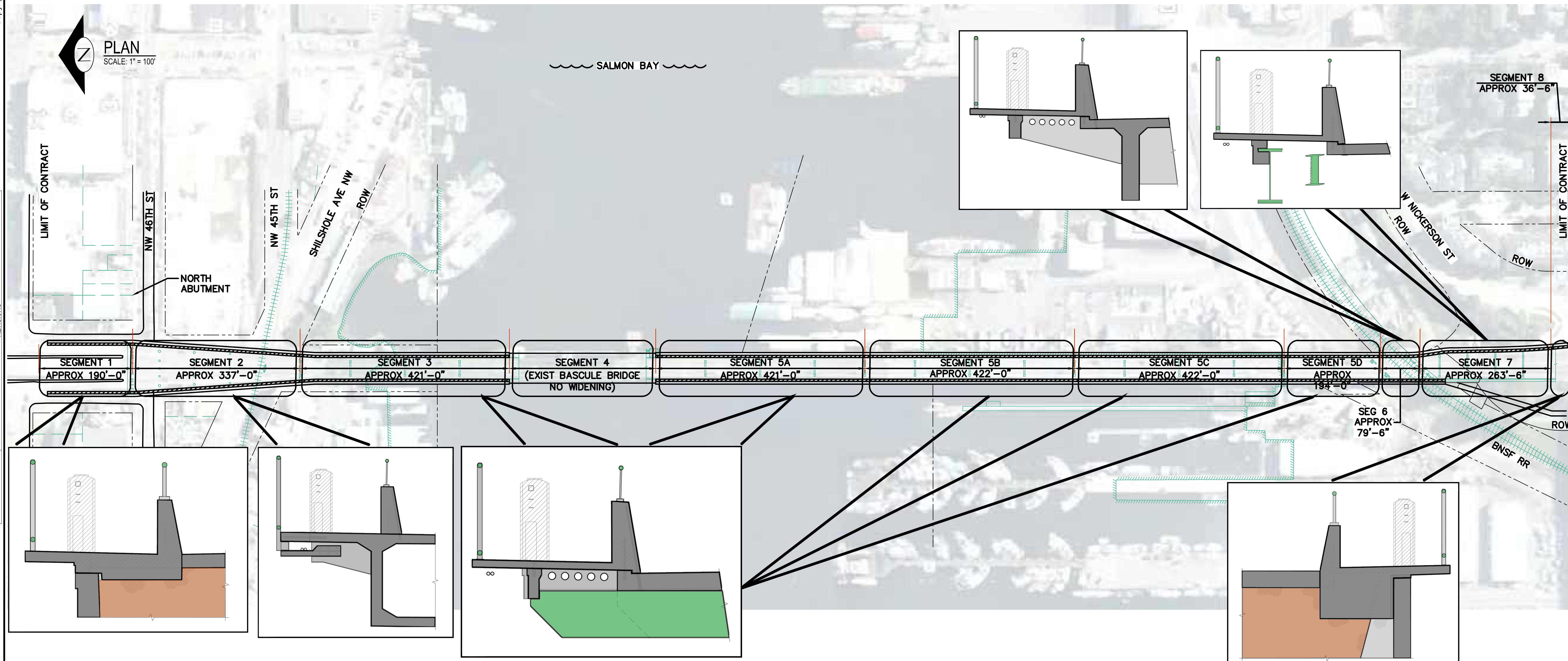


Figure E-2: Original Emerson Underpass Trail Concept Drawing as Proposed by SDOT and Modified by BergerABAM

Legend

- = Ship Canal Trail
- = Trail on Structure
- = At Grade Trail



6 FOOT WIDENING OPTION (SHOWN THIS FIGURE)

SEGMENT 1 – SECTION S6.00
SEGMENT 2 – SECTION S6.01/S6.02
SEGMENT 3 – SECTION S6.03/S6.04
SEGMENT 4 – N/A (BASCULE)
SEGMENT 5 – SECTION S6.03/S6.04
SEGMENT 6 – SECTION S6.05/S6.06
SEGMENT 7 – SECTION S6.07/S6.08
SEGMENT 8 – SECTION S6.09

NOTE:
REFER TO APPENDIX B FOR FURTHER DETAIL ON THESE SECTIONS. WIDTH ALTERNATIVES ARE SHOWN ON SHEETS S10.00 – S10.09.

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FIGURE E-3

SEGMENT & SECTION LOCATIONS (ALTERNATIVE 2 - 6 FT WIDENING)

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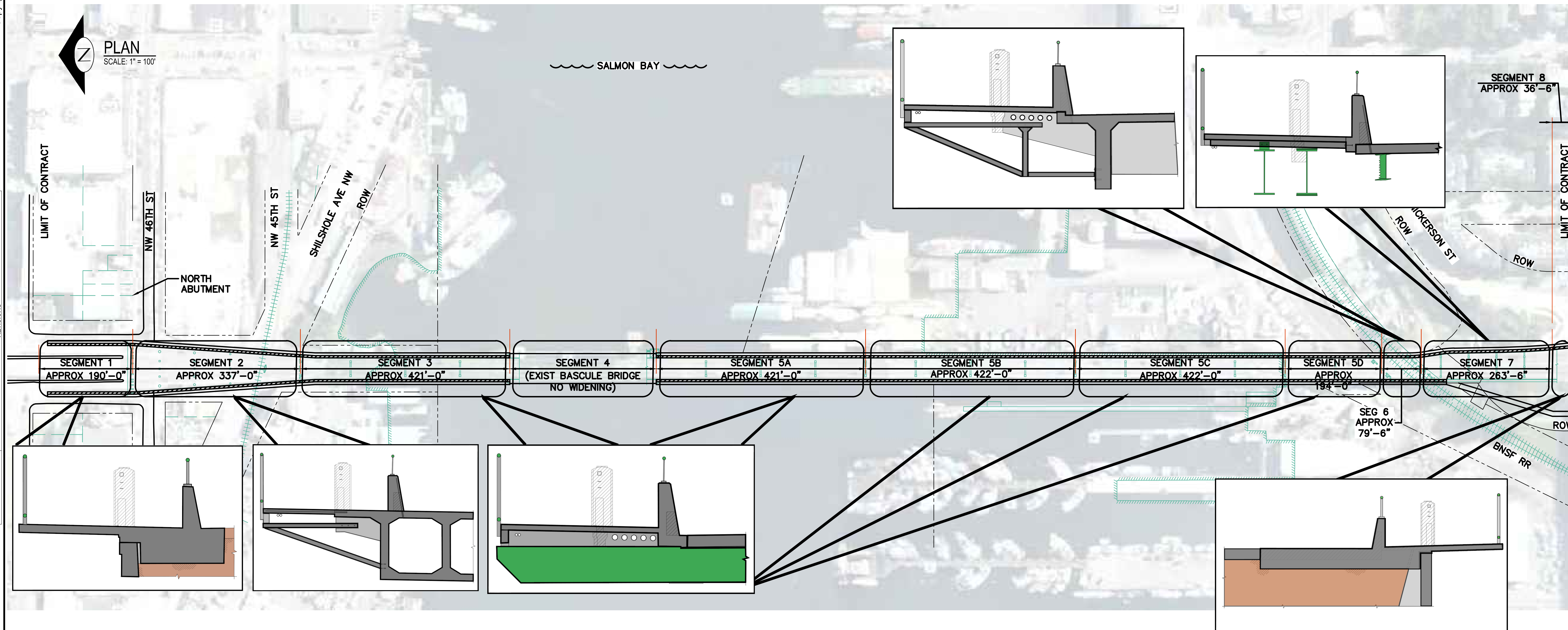

10 FOOT WIDENING OPTION

SEGMENT 1 – SECTION S10.00
SEGMENT 2 – SECTION S10.01/S10.02
SEGMENT 3 – SECTION S10.03/S10.04
SEGMENT 4 – N/A (BASCULE)
SEGMENT 5 – SECTION S10.03/S10.04
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SEGMENT 7 – SECTION S10.07/S10.08
SEGMENT 8 – SECTION S10.09

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1.0 OVERVIEW

This study analyzes potential improvements to the Ballard Bridge for pedestrians and bicyclists. The Seattle Department of Transportation (SDOT) funded this study, and BergerABAM was retained to perform the study because of their knowledge of the Ballard Bridge gained through previous work on the structure. All of the assumptions made as part of this study include the improvements made during the recent seismic retrofitting of the bridge. The first part of the study analyzes sidewalk widening alternatives on the bridge structure and approaches, and the second part analyzes the feasibility of a connector trail to provide pedestrian and bicyclist connectivity from the west side of the bridge, beneath West Emerson Street, continuing south on 15th Avenue West and to the South Ship Canal Trail, which currently connects Fisherman's Terminal to the Fremont Bridge. Included in the scope of work for this widening study is an outline of the criteria and data used for the analysis, a description of the structural alternatives and cross sections under consideration, and an issues and feasibility summary for both the bridge widening and the connector trail. The study did not review widening the sidewalks on the bascule portion of the bridge, where the current sidewalks are 6 feet wide, nor where the sidewalk narrows to 3.5 feet at the external quadrants of the bascule portion of the bridge (see Photo 1-1). The study assumed the existing vehicle travel lanes widths would remain the same.

Refer to Figure 1-1 for a vicinity map of the project location.

1.1 Purpose and Need

In alignment with Seattle's goals to increase bicycle and pedestrian travel and safety, this study evaluates options to make traveling on the bridge more comfortable and safer for people on bicycles and pedestrians by widening the sidewalks, and/or by improving connections on the south end.

The Ballard Bridge is one of a limited number of pedestrian and bicycle options for crossing the Lake Washington Ship Canal. The sidewalks that are used by pedestrians and people on bicycles are narrow (see Photo 1-2 and Photo 1-3). People on bicycles do not use the vehicle travel lanes because the grated bridge deck surface is not suitable for bicycle travel. In addition, the connection to the South Ship Canal Trail and the crossings of West Emerson Street and the Nickerson on-ramp are challenging.

Figure 1-1: Vicinity Map

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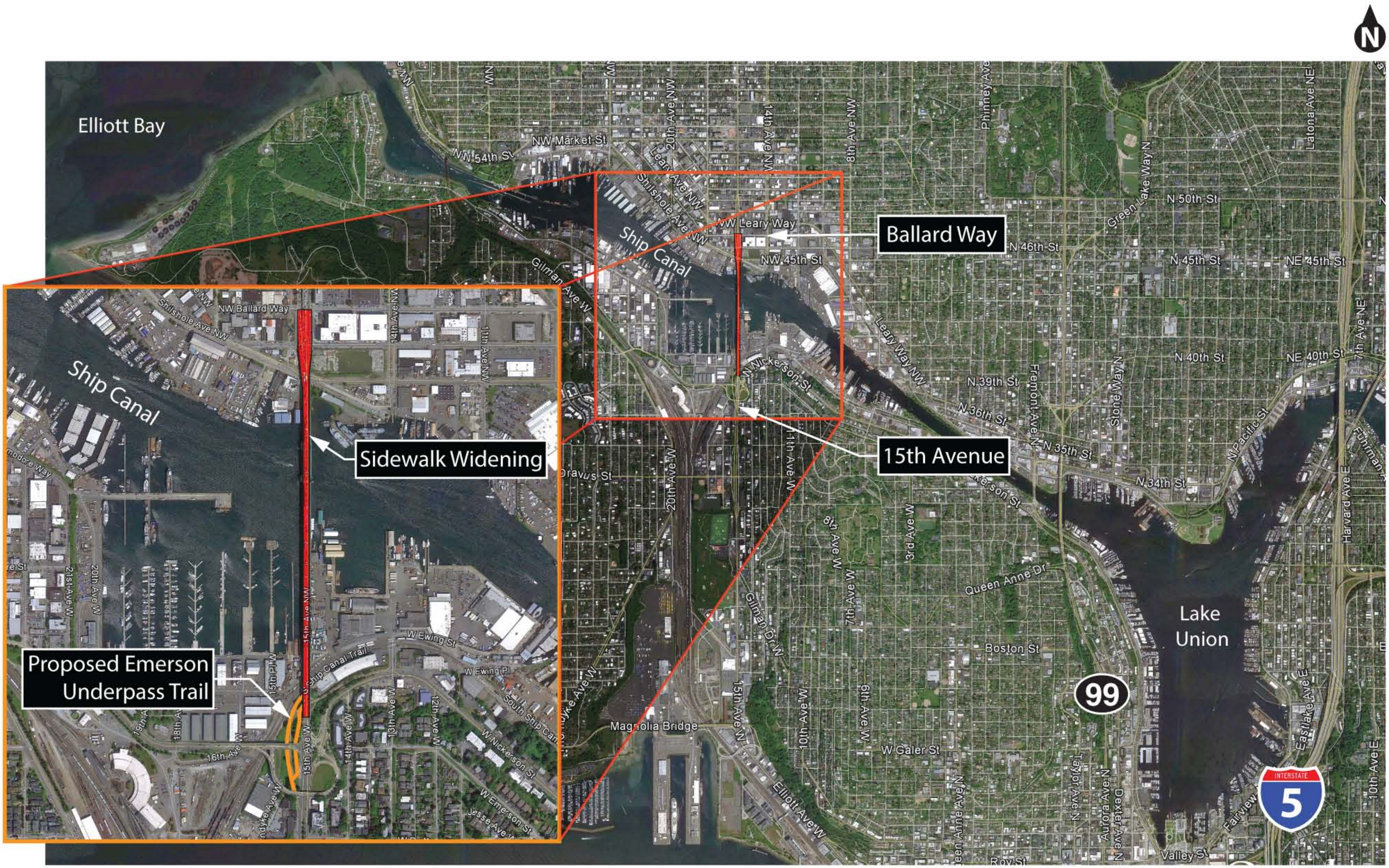

Photo 1-1: Existing conditions - narrowing sidewalks at corners of Ballard Bridge bascule

Photo 1-2: Existing conditions - opposing bicyclists along the northbound east side of Ballard Bridge

Photo 1-3: Existing conditions - narrow sidewalks on Ballard Bridge

1.2 Historical Significance of the Bridge

The Ballard Bridge is considered one of the earliest examples of a double-leaf bascule bridge structure in Washington. The bridge was completed in 1917 and various improvements have been made to the structure over the last century: in 1941 temporary approaches were replaced with permanent approach spans; in 1960 the four original towers were replaced by a single tower; in 2002 improvements were made to improve electrical and span drive systems; and in 2012 Phase 2 seismic retrofits were started; however, no modifications were made to the bascule spans or piers.

Based on information available from the Department of Archaeology and Historic Preservation (DAHP), the Ballard Bridge is an historic resource and is listed on the National Register of Historic Places (NRHP) and Washington Heritage Register (WHR). The bascule span is one of the earliest examples of this type of structure in Washington, along with two other bascule bridges across the Montlake Cut. The bridge was listed as a significant historic resource in two major areas: (1) Historical Significance because it is associated with an historic event and is a significant historic architectural /engineering structure, and (2) Historic Function as it is a significant historic transportation function. It is possible that the approaches may be considered eligible because of their association with the bascule span. If and when a decision is made to move forward, DAHP should be consulted to determine whether the modifications to the approaches would affect the historic character of the bridge and/or would be considered within the Area of Potential Effects (APE) for this structure. If it is determined that future work is considered to be within the APE and is impacting the historic character of the bridge, mitigation of those impacts would also be determined in consultation with DAHP.

In addition, the bridge is a City landmark and the Landmarks Board will need to be consulted and a Certificate of Approval obtained from the Department of Neighborhoods with regard to modifications.

Photos 1-4 to 1-6 provide a historical perspective of the Ballard Bridge bascule structure.

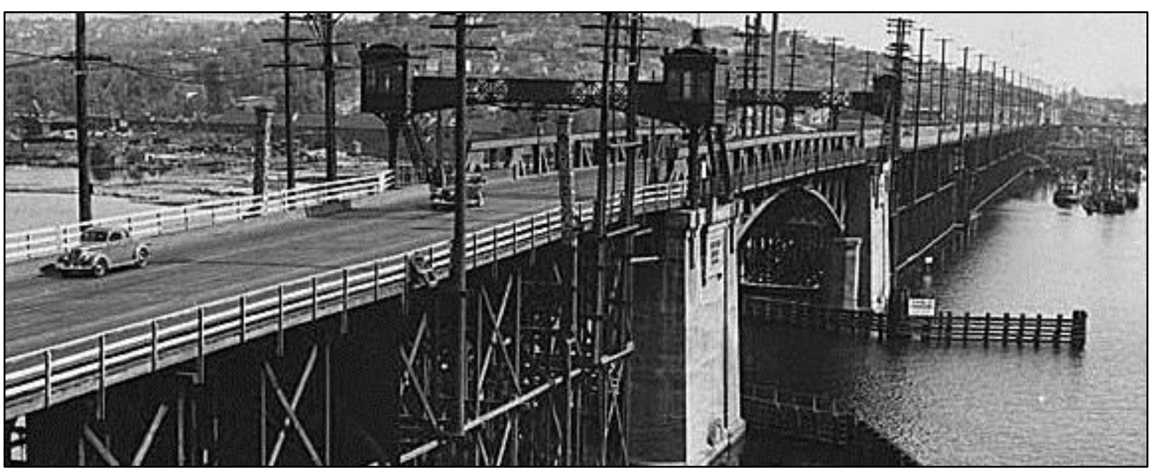

Photo 1-4: Historical conditions - Ballard Bridge, 1918 (courtesy of Seattle Museum of History & Industry)

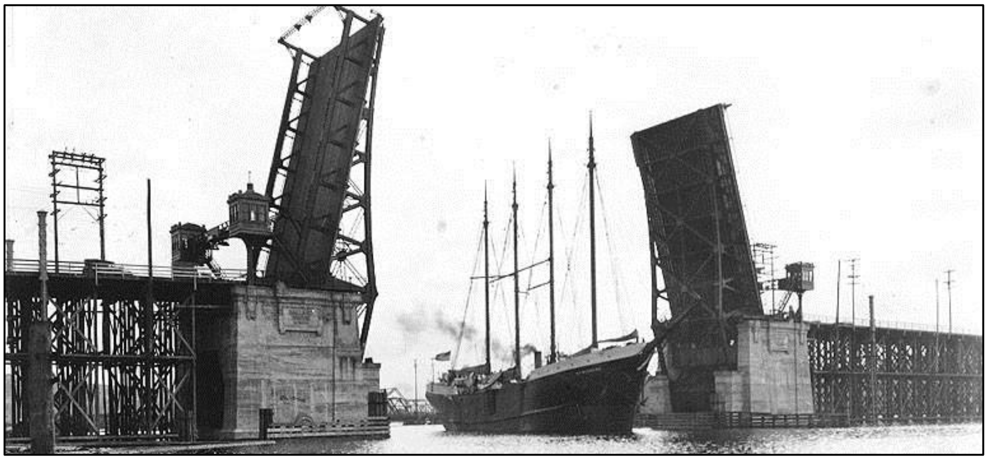

Photo 1-5: Historical conditions - Ballard Bridge, 1918 (courtesy of Seattle Museum of History & Industry)

Photo 1-6: Historical conditions - aerial view (courtesy of Seattle Museum of History & Industry)

1.3 Existing Conditions

Also referred to as the 15th Avenue Bridge, the Ballard Bridge connects the Magnolia, Queen Anne, and Ballard neighborhoods. The average week day traffic on the bridge in 2012 was 54,500 vehicles and the bridge is important for several modes, as reflected in adopted city plans and designations:

- The 15th Avenue W/NW corridor is designated as a Major Truck Street and a Principal Arterial;
- Seattle's 2012 Transit Master Plan identifies this as a priority transit corridor;
- The 2014 Bicycle Master Plan identifies the bridge as part of the Citywide Network and shows an off-street facility; and
- The 2009 Pedestrian Master Plan identifies high priority crossing locations at both ends of the bridge.

1.3.1 Location

The Ballard Bridge is positioned on the west end of the Lake Washington Ship Canal and crosses over Salmon Bay. It is located within King County as part of Township 25, Range 03E, Section 13. The latitude and longitude at the center of the bascule structure are approximately 47° 39′ 35″ north and 122° 22′ 34″ west.

1.3.2 Physical Description

The structure is approximately 2,854 feet long with a 60-foot right-of-way width for most of the bridge length, and a double leaf bascule structure centered over the canal to raise and lower for marine traffic. The layout of the bridge consists of two 10-foot northbound lanes, two 10-foot southbound lanes, and sidewalks on each side. The sidewalks are separated from the travel lanes by a 6-inch high curb and from the outer edge of the bridge by a concrete and metal railing, which has luminaires spaced every 120 feet. For most of the length of the bridge's half-mile-long approaches, the sidewalks are four feet wide, narrowing to 3.5 feet at the current and former street light pilasters, which are located every 20 feet. The width of the sidewalks on the bascule portion is 6 feet, except at each of the quadrants of the bascule, where it is 3.5 feet because of the mechanical units required to open the bridge (refer to Figure 8 and 9 in Appendix D).

An analysis of the bascule structure was not within the scope of this study. However, it should be noted that even if the sidewalks on the approaches are widened, the sidewalk at the quadrants of the bascule will not meet ADA requirements.

The existing drainage system consists of a series of bridge drains along the face of the curbs that direct stormwater to standpipes attached to the bridge columns. The majority of the water discharges directly into Salmon Bay. Runoff generated by the northwest bridge approach is routed into a closed storm sewer that discharges at 20th Avenue NW. Runoff from the southern approach is conveyed to the West Point Metro/King County Sewer Treatment Plan.

1.3.3 Pedestrian and Bicycle Connections

At the north end of the bridge, the existing sidewalk connects to the on- and off-ramps to Ballard Way. At the south end of the bridge, the existing sidewalks connect to the existing sidewalks on 15th Avenue NW at Emerson Street on the west side and Nickerson Street on the east. Currently, in order to cross 15th Avenue NW, pedestrians and bicyclists are required to walk down a stairway on the north side of the W Emerson Place Bridge, cross under the bridge and back up another set of stairs on the south side of the W Emerson Place Bridge. There are no accommodations for disabled individuals. The four quadrants of the Ballard Bridge are shown on Figure 1-4. Existing conditions at these locations are shown on Figure 1-5 and Figure 1-6, along with photos (see Photos 1-7 through 1-14).

There are several shared-use trails in the vicinity of the bridge; including the South Ship Canal Trail near the south end of the bridge that provides a pedestrian and bicycle corridor along the entire length of the Ship Canal, west of the Fremont Bridge (see

Figure 1-2 for reference). Others nearby trails include the Lake Union Trail and the Burke-Gilman Trail, both of which are popular shared-use trails.

Figure 1-2: Existing Trail System

1.3.4 Structural Overview

The Ballard Bridge structure is composed of eight segments. See Figure 1-3 for an illustration of the segment designation and existing bridge layout. Each individual bridge segment has a distinct structural system. The approach structures are composed of three main bridge types: built-up riveted steel plate girders; cast-in-place concrete T-beams, and; rolled steel wide flange beams. A fourth structure type, cast-in-place concrete box girders was added to Segment 2 as part of a widening project. Schematics and photos illustrating the existing structure type for each segment are included in Appendix D. A site visit was conducted to review the existing condition of the bridge structure prior to the start of the study. Refer to photos in Appendix D for further details.

The existing elevated approach structures use a walkway support system that is similar on all segments, except Segment 2. The system consists of a concrete edge beam, which either spans between bridge transverse cantilever elements (Segments 3, 5, and 7) or is continuously supported by a bridge girder (Segment 6). The concrete edge beam is cast integrally with the concrete elements of the pedestrian railing, but is otherwise disconnected from the main bridge deck. A 3.5-inch-thick concrete slab element spans transversely between the edge beam and the bridge deck. Segment 2 uses a system where the sidewalk is the top slab of the bridge deck.

The existing sidewalks differ at the fill approaches of Segments 1 and 8. Segment 1 incorporates the sidewalk surface with the adjacent curb and vehicular slab and connects the pedestrian barrier to the top of the retaining wall. Segment 8 similarly connects the pedestrian barrier to the top of the retaining wall, but uses a more typical slab on-grade for the sidewalk, separate from the curb.

The following list identifies important features of the existing approach segments as they relate to potential sidewalk widening:

Segment 1: Cantilevered gravity retaining wall – Existing curb is monolithically tied to the concrete slab above the wall, any impact loadings under existing conditions would be distributed into the slab and not directly load the existing retaining wall.

Segment 2: Conventionally reinforced concrete – The existing sidewalk is directly attached to the concrete box girder structure.

Segment 3: Non-redundant structural steel girder bridge – The transverse floor beams are spaced at 10 feet on-center. The beams are not of equal length, and the beam extending to the limit of the existing sidewalk occurs at 20 feet on-center.

Segment 4: Bascule bridge – The bascule bridge was not part of this study.

Segment 5: Non-redundant structural steel girder bridge – Similar to Segment 3. Segments 3 and 5 represent approximately 1,876 feet of the total approximately 2,585 feet of bridge that would be modified, excluding Segment 4.

Segment 6: Structural steel wide flange bridge – This segment is formed of a structural steel wide flange bridge, with skewed interior beams that are partially supported by the abutment. The BNSF railroad crossing limits the depth of the structure.

Segment 7: Conventionally reinforced concrete T-beams – Core sample results from the existing bridge indicate concrete strengths of 8,000 pounds per square inch. Core samples were taken from Pier 25.

Segment 8: Counterfort gravity retaining wall – The counterfort wall face was designed to carry horizontal loads; vertical loads and bending about the top of the wall from potential future construction are not recommended.

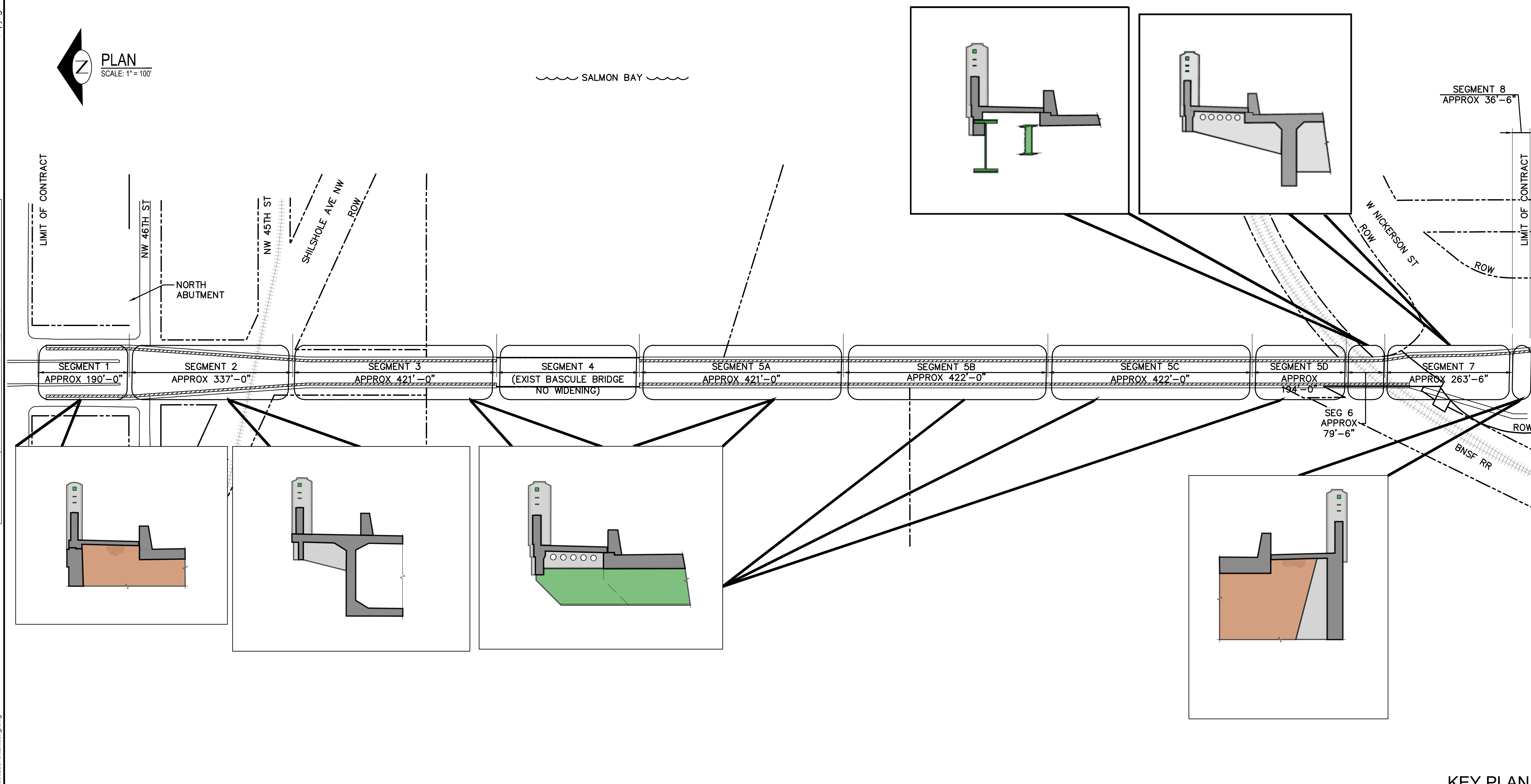

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FIGURE 1-3
EXISTING SEGMENT & SECTION LOCATIONS

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Figure 1-4: Ballard Bridge Quadrants

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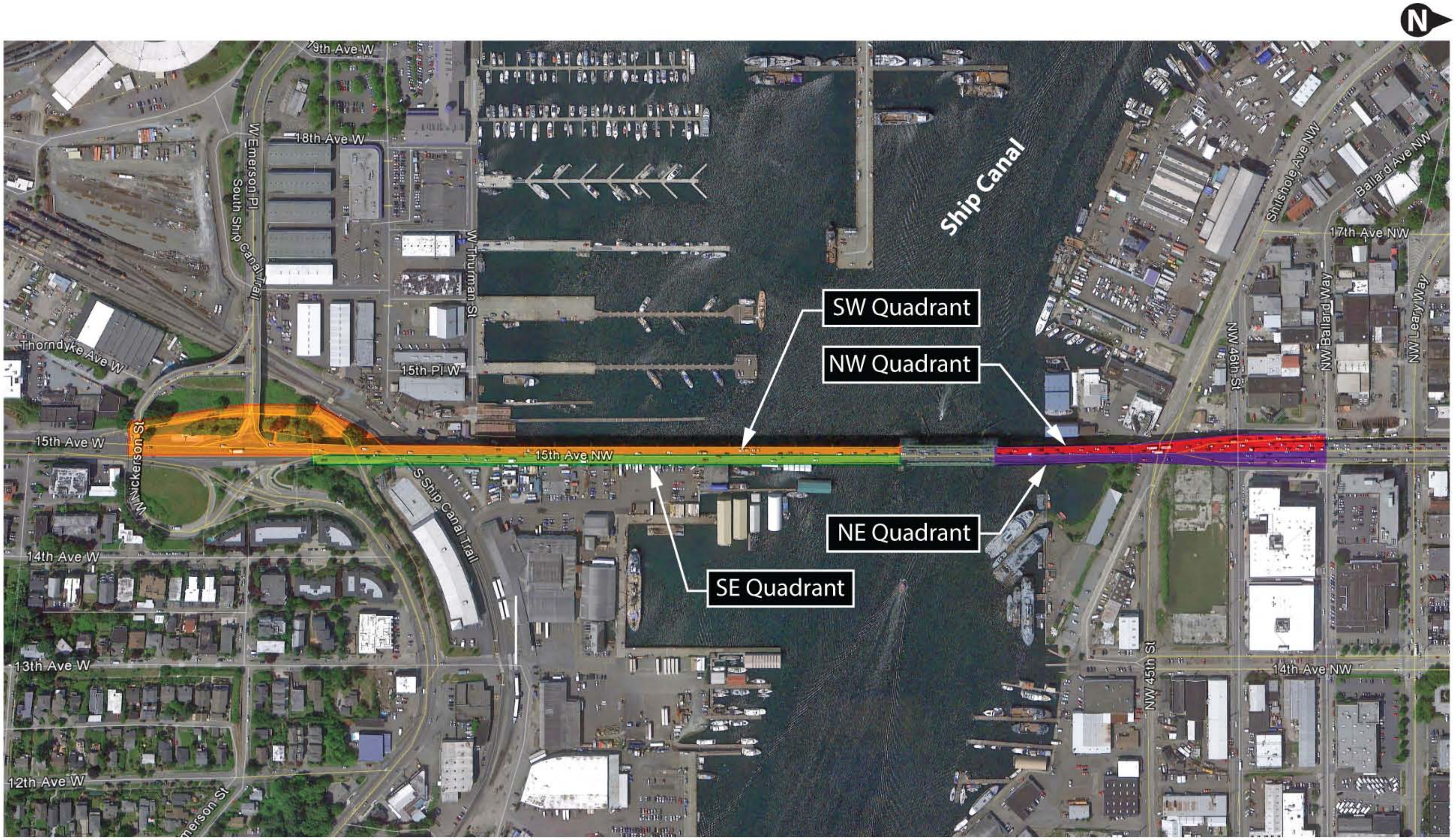

Figure 1-5: Existing Pedestrian/Bicyclist Conditions - South Quadrants

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Legend

1-X = Photo Orientation

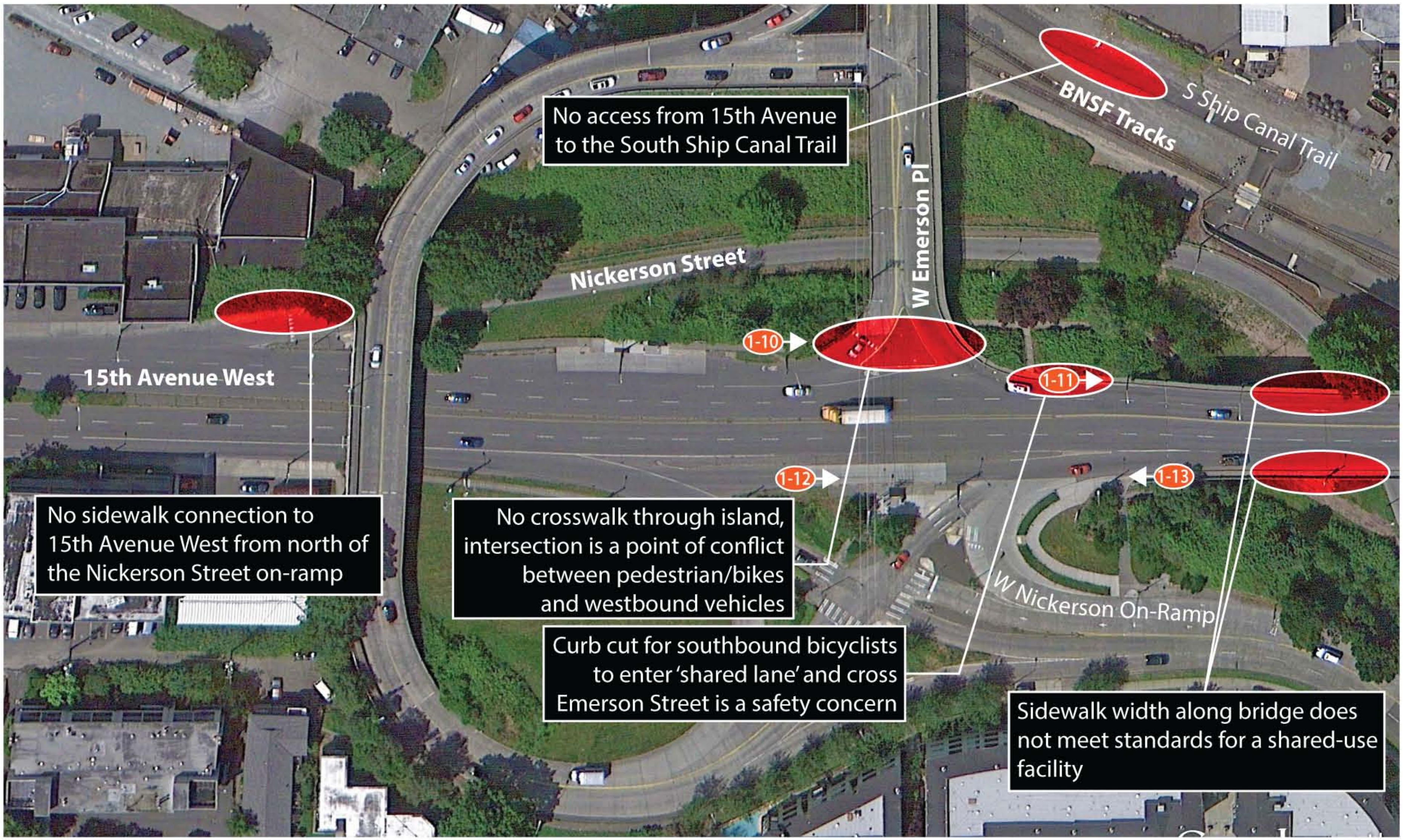

Figure 1-6: Existing Pedestrian/Bicyclist Existing Conditions - North Quadrants

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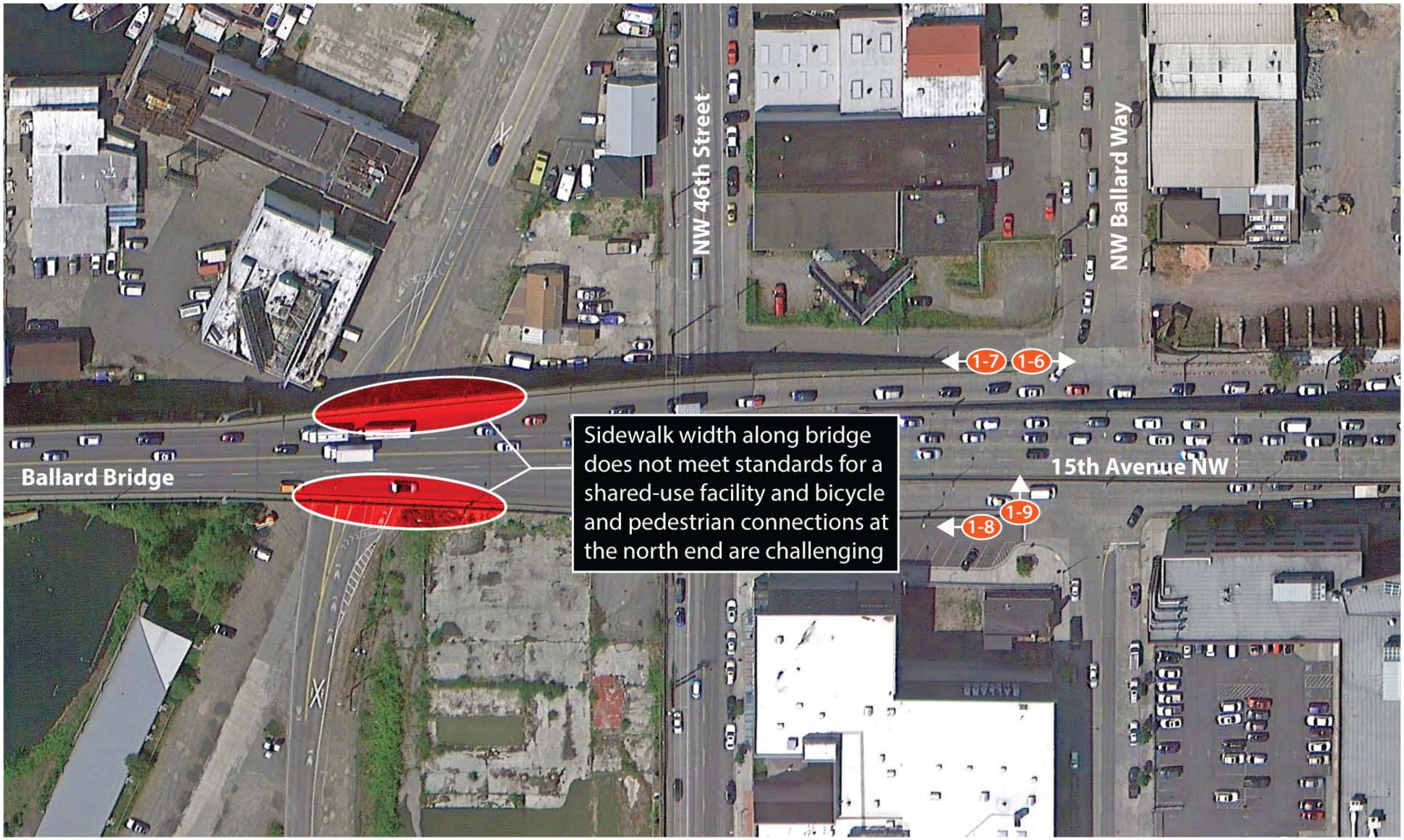
Legend

1-X = Photo Orientation



The Northwest Quadrant

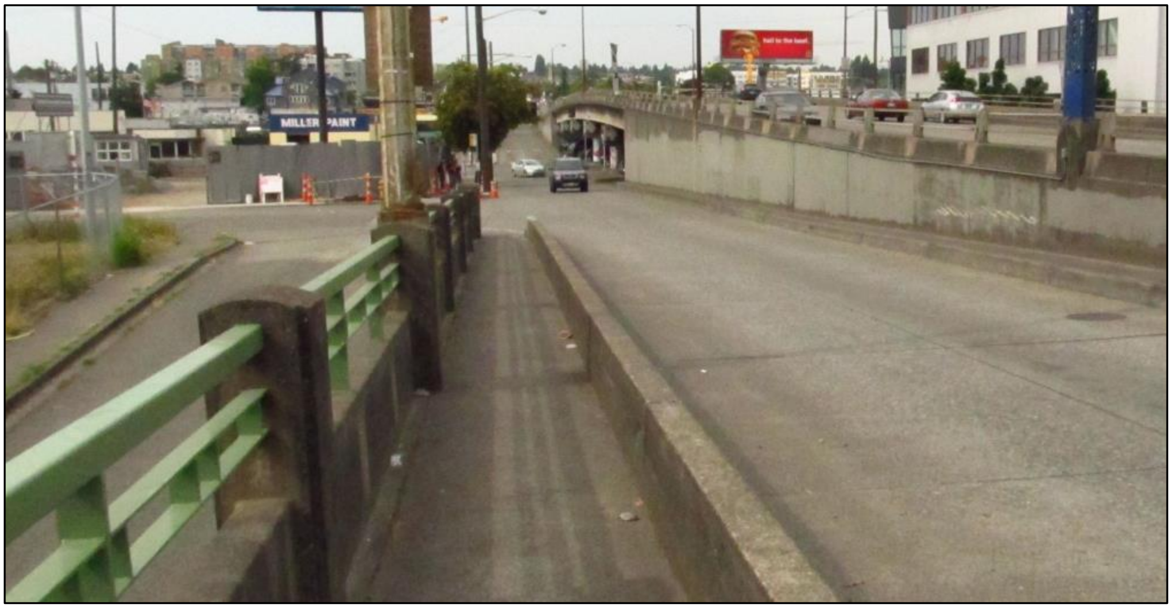


Photo 1-7: NW Quadrant - on-ramp to southbound Ballard Bridge from NW Ballard Way, looking north

Photo 1-8: NW Quadrant - on-ramp to southbound Ballard Bridge from NW Ballard Way, looking south

The Northeast Quadrant

Photo 1-9: NE Quadrant - off-ramp from northbound Ballard Bridge to NW Ballard Way, looking south

Photo 1-10: NE Quadrant - off-ramp from northbound Ballard Bridge to NW Ballard Way, looking west

The Southwest Quadrant

Photo 1-11: SW Quadrant - right turning movements from southbound 15th Avenue NW to Emerson Street, looking north

Photo 1-12: SW Quadrant - bicyclist traveling southbound along west side of 15th Avenue NW at Emerson Street curb-cut

The Southeast Quadrant

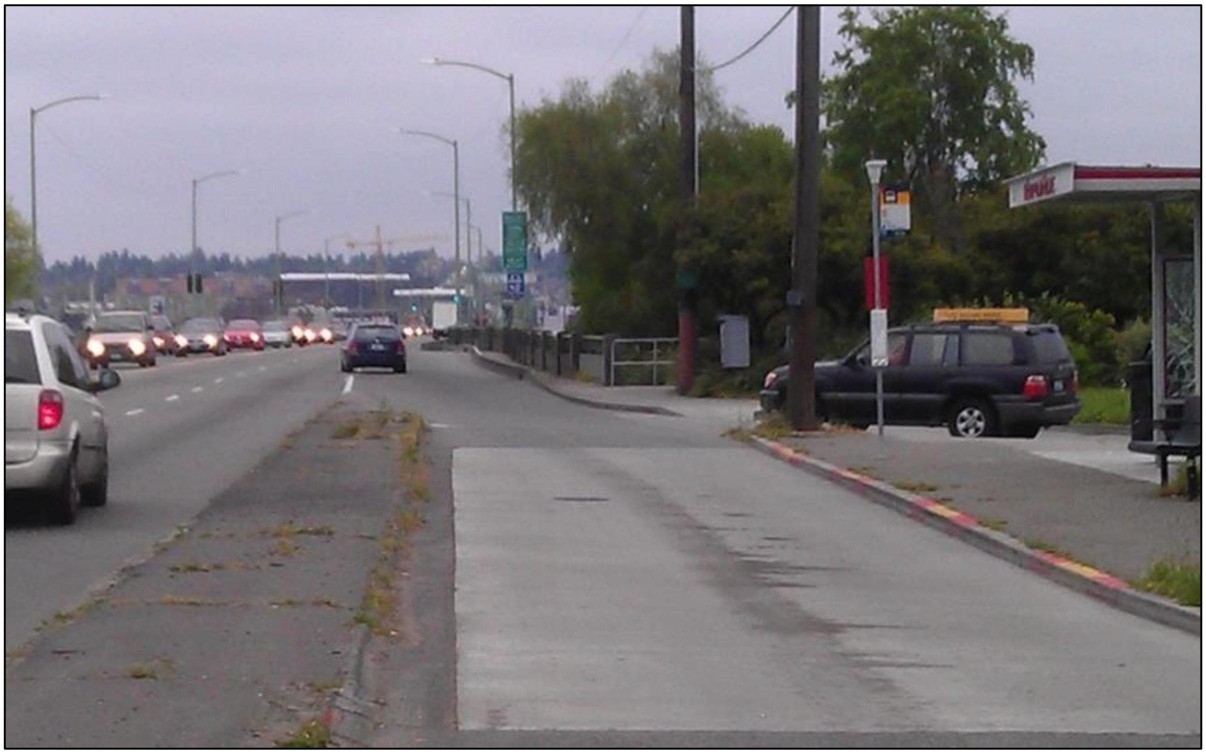


Photo 1-13: SE Quadrant - right turning movements from on-ramp north of bus stop, looking north

Photo 1-14: SE Quadrant - staircase and sidewalk north of bus stop, looking south

2.0 ALTERNATIVES EVALUATED

As part of this study, two sidewalk widening alternatives were considered (Alternatives 1 and 2), as well as an alternative that would add a railing between the travel lanes and the existing sidewalks (Alternative 3). All three alternatives would retain the four existing 10-foot travel lanes on the bridge. The study also evaluated a potential trail connection from the southwest end of the bridge (the Emerson Underpass Trail). Each is described briefly below and more detail is provided in Section 2.2.1.

Alternative 1 (See Appendix B for further details and typical cross-section)

This alternative would modify the existing barrier and railing to increase the usable sidewalk width without adding structure to the bridge.

- Construction limits are from W Emerson Place to NW Ballard Way.
- Remove and replace existing barriers/curbs/railings and lighting on both sides of the approaches.
- Gains 1 foot of width for pedestrians/bicyclists on each side.
- Compatible with the Emerson Underpass Trail described below.
- No changes to the bascule portion of the bridge.

Alternative 2 (See Appendix B for further details)

This alternative would widen the sidewalks on the approaches to either 6 or 10 feet.

- Construction limits are from W Emerson Place to NW Ballard Way.
- Remove existing barriers/curbs/railings and lighting on both sides.
- Construct new additional cantilevered sidewalks and associated support structure, railings, and lighting on both sides of the approaches.
- Sidewalk width does not necessarily need to be the same on both sides – it could be 6 feet on both, 10 feet on both, or 6 on one and 10 on the other (see Figures E-3 and E-4 for further detail).
- Both the 6- and 10-foot options are compatible with the Emerson Underpass Trail described below.
- No changes to the bascule portion of the bridge.

Alternative 3

This alternative would install a railing between the travel lanes and the existing sidewalks on the approaches, similar to what exists at the bascule portion of the bridge and the approaches adjacent to the bascule. Installing the railing would increase the safety and comfort of traveling along the sidewalk; however, it may also make the sidewalk feel more constrained. The railing would meet today’s standard for bike and pedestrian railings but not for vehicle railings.

- Construction limits are from W Emerson Place to NW Ballard Way.
- Of the 2,854 linear feet of the bridge, approximately 600 feet already have a railing along the interior edge of sidewalk on both sides.
- Does not impact the service life of the bridge.
- Would have limited construction impacts.

- No changes to the bascule portion of the bridge.

Emerson Underpass Trail (See Appendix I for further details)
This trail would connect the southwest end of the bridge to the South Ship Canal Trail and the sidewalk on the west side of 15th Avenue West, south of West Emerson Place.

- Approximate length is 1,025 feet
- Construct 14-foot-wide, two-way pedestrian/bicyclist path (10-foot trail width plus two 2-foot shoulders, as recommended by SDOT)
- Begin trail with tapered transition from existing sidewalk on 15th Avenue Northwest
- Crossing under West Emerson Place (maintain 10-foot minimum vertical clearance) removing the conflict of crossing at grade
- Crossing at-grade on West Nickerson Street on-ramp, U-turn configuration
- Trail splits west of Nickerson Street south to provide a connection to 15th Avenue West and north to provide a connection to the existing South Ship Canal Trail system
- Compatible with alternatives 1 through 3 above

2.1 Design Criteria

The guidelines used for developing the alternatives have been referenced from the governing documents listed below. These references do not necessarily provide for every possible contingency. Additional guidance to address conditions not covered in the scope of these documents is referenced where applicable.

1. City of Seattle *Standard Plans for Municipal Construction* (2011)
2. City of Seattle *Standard Specifications for Municipal Construction* (2011)
3. SDOT *Seattle Right-of-Way Improvements Manual*, 2E (2012)
4. SDOT *Bicycle Master Plan* (2007)
5. Washington State Department of Transportation (WSDOT) *Design Manual, M22-1.08 (*2011)
6. AASHTO *LRFD Bridge Design Specifications*, 6E (2012)
7. WSDOT *Bridge Design Manual*, M 23-50.12 (2012)
8. AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, 5E (2012)
9. AASHTO *Guide for the Development of Bicycle Facilities*, 4E (2012)
10. AASHTO *Guide for the Planning, Design and Operation of Pedestrian Facilities*, 1E (2004)
11. Access Board *Public Right-of-Way Accessibility Guidelines* (PROWAG), R302.4 (2011)

The following guidelines would be used during design if Alternative 1 or 2 moves forward. Alternative 3, which would install a railing between the existing sidewalks and the travel lanes on the approaches, would not meet some of these guidelines.

Curbs and Barriers

- The curb separating the vehicular lanes and the sidewalk shall be removed and replaced with a WSDOT 34-inch, single slope barrier, conforming to WSDOT 2012 *Bridge Design Manual* (*BDM*), §10.2.1.
- Per WSDOT BDM §10.2.1, the vehicular barrier shall have a 20-inch railing to meet the bicycle minimum total height of 54 inches, per WSDOT *BDM* §10.5.2(B).
- The proposed barrier shall satisfy the City of Seattle curb height requirement of 6-inches. Currently the existing curb meets the City Standard, but it is not typical for the sidewalk grade to be below the top of curb elevation.

Facility

- The essential operating space of the design bicyclist shall be given per *AASHTO Guide for Development of Bicycle Facilities*, 4E.
- Recommended shared-use path minimum width is 10 feet per AASHTO *Roadside Design Guide*, section 5.2.1. As recommended by SDOT, and to provide a more comfortable facility, the path is assumed to be 14 feet wide (10-foot trail width plus two 2-foot shoulders).
- 27-foot minimum centerline radius for shared-use path approaching intersection, per WSDOT *Design Manual* 1515.04(1) Exhibit 1515-2.

Americans with Disabilities Act Requirements

- Minimum path width requirements (4 feet with an additional foot for passing every 200 feet) shall be satisfied to comply with ADA requirements. (R302.4, PROWAG)
- By keeping the longitudinal slopes designed to a 5 percent maximum, the project meets ADA requirements: "Where an overpass, underpass, bridge, or similar structure is designed for pedestrian use only and the approach slope to the structure exceeds 5 percent, a ramp, elevator, limited use elevator, or platform lift must be provided." (R204, PROWAG)
- Maximum cross-slopes of proposed design shall not exceed 2 percent. "The maximum cross slope permitted on accessible routes in the 2004 ADA and ABA Accessibility Guidelines is 2 percent." (R302.6, PROWAG)
- Vertical surface discontinuities shall not exceed 6.4 millimeters, per ADA requirements. (R302.7, PROWAG)
- Detectable warnings with a 2-foot width will be provided in the direction of travel behind the back of curb line at the base of all ADA ramps, per ADA requirements. (R305.1.4, PROWAG)

Design Vehicle

- The design vehicle used for the bridge widening curb radius design is a WB-67 truck with a centerline turning radius of 41 feet.
- The design maintenance vehicle used for the proposed trail turn radius is a P (passenger) vehicle with a centerline turning radius of 21 feet.

Stormwater Requirements
The project shall comply with the stormwater guidelines listed in the City of Seattle *Stormwater Manual* (November 2009). According to the City of Seattle *Stormwater Manual*, minimum requirements for flow control, pollution prevention control, and amended soils are triggered. See Appendix E for details.

Lighting Requirements
The lighting design will comply with the *SDOT Right-of-Way Lighting Level Design Guidelines*. The conceptual illumination study was performed by DKS and Associates and was conducted using AGI32 Lighting Analysis Software. The existing luminaires along both sides of the Ballard Bridge will need to be relocated to accommodate the bridge widening. It was assumed for this analysis that all roadway lighting will use LED cobra head style fixtures. There is currently no lighting along the existing pedestrian path under Emerson Street. New luminaires will need to be installed to provide lighting to the connector trail. All lighting for the proposed trail will use pedestrian-scale lighting poles and LED fixtures. Refer to Appendix F for further information.

Aesthetics
The aesthetics of the bridge modifications may be of concern, as it may impact the structure's historic integrity. To minimize aesthetical impacts, the replacement railings should be selected for compatibility with the existing structure. One option would be the steel pipe handrail from an SDOT working plan (see Figure 2-1) or a specially designed railing that reflects the historic appearance of the existing conditions. Modifications to the bridge need to be approved by Department of Neighborhoods and the Landmarks Board, as well as negotiated with DAHP.

Structural Design Loads
The structural design loads and criteria have evolved since the original construction of the bridge structure. Details of the structural design criteria used for the widening concepts can be found in Appendix A. This includes criteria for material selection, component design, and structural evaluation. Increased dead loads, increased live loads, new load ratings, and lateral load impacts due to modified wind resistance and increased dead load were also evaluated and are included in Appendix A.

AASHTO Barrier Structural Design Criteria
Barrier and railing requirements have changed since the original construction of the bridge, and to comply with the WSDOT 2012 *Bridge Design Manual*, the incorporation of a WSDOT single slope, 32-inch barrier and 22-inch Type S-BP bridge railing, for a total height of 54 inches, will be required adjacent to the traveled way. The selected railing on the outside of the bridge has not been designed for vehicular impact loads, as it was assumed to be located outside the Design Clear Zone (Ch. 1600, WSDOT *Design Manual*). The new barrier will provide an ideal collision safety buffer for pedestrian and bicyclist use, having undergone full-scale crash testing by the Federal Highway Administration

(FHWA), and fulfilling the crash test performance criteria set forth by the National Cooperative Highway Research Program (NCHRP), Report 230.

Environmental Permits and Review

The environmental process involved in both elements of the project will differ if the project is funded by the FHWA or locally funded. If the project is funded by the FHWA, the environmental process will involve coordinating the following reviews, with WSDOT acting as the lead agency:

FHWA funded (WSDOT responsibilities)

- National Environmental Policy Act (NEPA)
- Section 106 of the National Historic Preservation Act
- Section 4f of the Department of Transportation Act of 1966
- Endangered Species Act of 1973

FHWA funded (City responsibilities)

- State Environmental Policy Act (SEPA)
- Permitting

Locally funded (City responsibilities)

- State Environmental Policy Act (SEPA)
- Permitting and coordination with DAHP

Additional permits potentially required for the project include, but are not limited to, the following:

- Shoreline Permit: Substantial Development Permit(City of Seattle Department of Planning and Development)
- Water Quality Certification, Clean Water Act Section 401 (Washington State Department of Ecology [Ecology])
- Clean Water Act Section 404 and Rivers and Harbors Act Section 10 permits (U.S. Army Corps of Engineers [USACE])
- Coastal Zone Management Program Consistency Determination (Ecology)
- Hydraulic Project Approval (Washington Department of Fish and Wildlife)
- General Bridge Permit (U.S. Coast Guard)
- Street Use Permit (SDOT)
- Landmarks Certificate of Approval (City of Seattle Department of Neighborhoods)
- National Pollutant Discharge Elimination System Construction Stormwater General Permit (Ecology)

For further information regarding the environmental process, please refer to Appendix K.

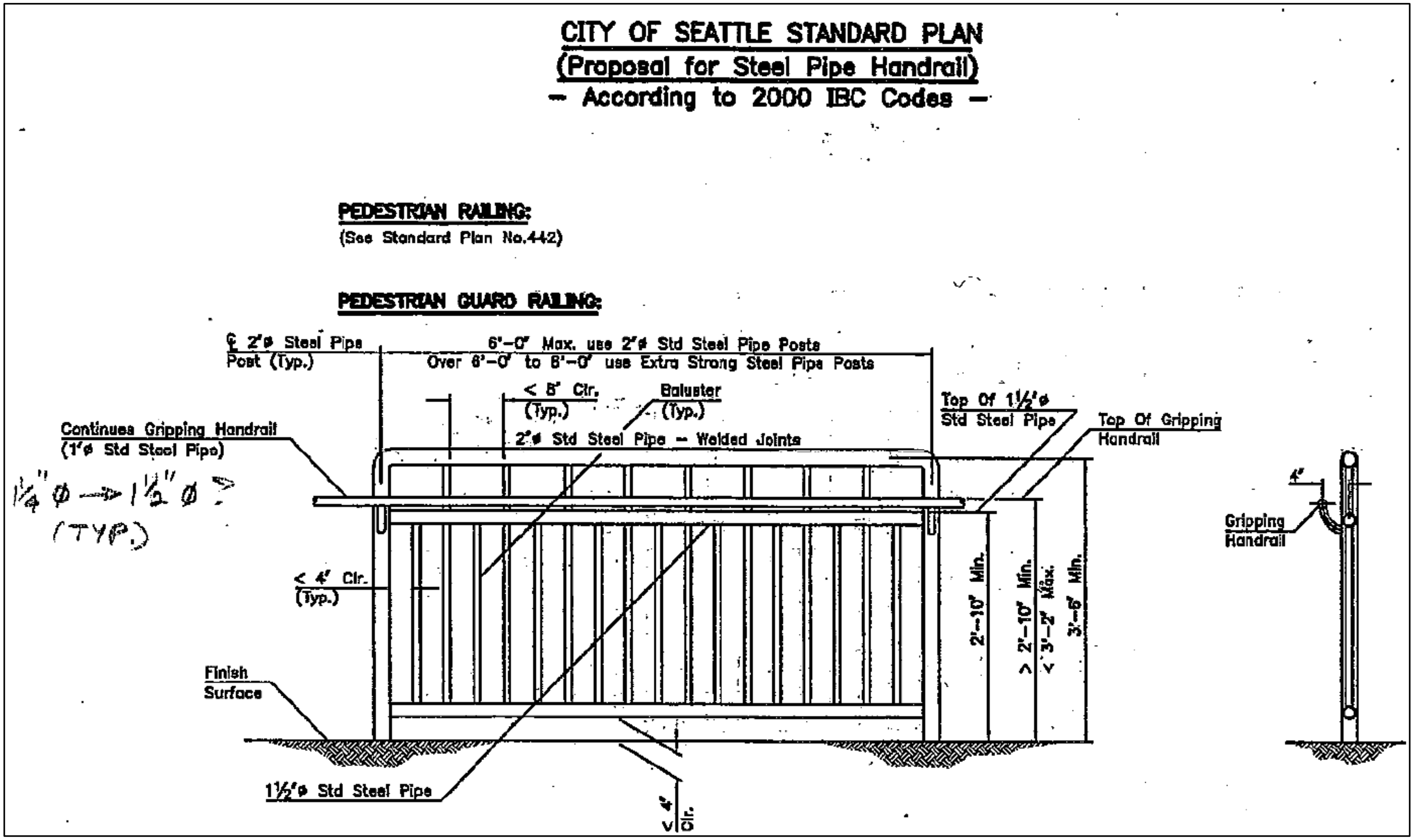


Figure 2-1: SDOT working plan for steel pipe handrail

2.1.1 Issues and Impacts

Design Load Reduction

Based on the 2012 load rating report, the Ballard Bridge has capacity for marginal live load increases. As a result, there may potentially be significant advantages to using alternative details and materials to minimize additional dead load demands on the structure, which would in turn, minimize the impacts to the allowable magnitudes of increased live loads. Also, the reduced additional dead load demands associated with the alternate materials and details would reduce the increase in lateral seismic forces. Some beneficial alternate materials/details to consider are: (1) lightweight concrete, (2) steel traffic barriers, and (3) aluminum railings. For more details, see Appendix A.

Utilities

The existing utilities in the vicinity of the bridge widening and the connector trail have been assessed for potential conflicts and/or the need for relocation.

- The existing Ballard Bridge approach structures have multiple utilities running under the existing sidewalk on both sides of the bridge. There are five asbestos-containing conduits located on the west and east sides of the bridge, attached to the bottom side of the cantilevered bridge deck, that contain power wire for Seattle City Light as well as communication fiber for the Seattle Department of Information Technology. The bridge widening concepts have been designed to avoid impacting any existing utilities; however, some utility relocation may be required as part of this component. Further investigation of these utilities should be performed in the next stage of the project. Conduits and other appurtenances to supply power will be connected to the new light pole locations.
- There is an existing buried gas line in the vicinity of the Emerson Underpass Trail elevated bridge structure alternative. Piers for the elevated bridge structure should be located to avoid impacts to the buried gas line. An existing sanitary sewer main also runs in the vicinity of the at-grade trail, but the pipe is deep enough that no conflicts are anticipated at this time. Limited location information is available and further survey investigation is advisable.
- The Emerson Underpass Trail alternative will not impact any existing utilities and no utility relocation will be required as part of this component. Power connections to the new pole locations will be made via new conduits and other appurtenances.

Right-of-Way Acquisition

Right- of-way acquisition would be required for both of the widening alternatives and for the Emerson Underpass Trail. That discussion is included in the following sections pertaining to each of the improvement alternatives.

Constructability and Impacts during Construction

Constructability and impacts during construction are discussed in the following sections pertaining to each of the improvement alternatives.

Impacts for Maintenance and Inspection

The steel approach spans and main bascule span of the Ballard Bridge are designated as "fracture critical" because there are only two primary beams. This designation means that failure of a component of the bridge can result in the full collapse of the bridge. For bridges that are designated as fracture critical, frequent inspections are federally mandated and access to all portions of the bridge beams are necessary during the inspection. Inspection and maintenance access at the Ballard Bridge is provided by a special piece of equipment known as an Under Bridge Inspection Truck (UBIT), which operates from the roadway surface to provide access below the bridge. Widening the sidewalk to a full width of 10 feet would make inspection and maintenance much more difficult because the combined width of the sidewalk, the pedestrian railing, and the vehicular railing would correspond to the maximum feasible lateral reach of the equipment. Although it would still be possible to inspect and maintain the bridge with a sidewalk width of 10 feet, great care would need to be taken during operation of the UBIT to prevent damage to the bridge and/or the UBIT. A sidewalk width of 6 feet would not pose this difficulty for inspection and maintenance.

2.1.2 Assumptions

Several assumptions were made throughout the development of the alternatives. These assumptions are as follows:

1. It was assumed that no work is to be done on the existing stairways in the southern quadrants. However, future improvements may be required.
2. The study is based on a seismically retrofitted structure (i.e. in accordance with the Phase II seismic retrofits, which are under construction and are scheduled to be completed in 2014).
3. The anticipated service life for the Ballard Bridge steel approach structures is at least 25 to 30 years. The anticipated service life for the concrete approaches is 10 to 20 years. The BergerABAM seismic retrofit design was completed in 2012 and was conducted in accordance with FHWA's *Seismic Retrofitting Manual for Bridges*. For the purpose of the seismic retrofit design, it was agreed that the anticipated service life of the Ballard Bridge is of category ASL 2, which is 16 to 50 years.
4. Typical materials and details were used in developing the widening concepts for the Ballard Bridge. Typical design materials provide a sound baseline for preliminary engineering design, and are usually less expensive than more specialized alternatives. For this study, the objective was to ensure that a widening concept was feasible, with the understanding that optimization would be addressed in final design efforts if any of the alternatives move forward.

Other assumptions were made to evaluate the design of the Emerson Underpass Trail alternative. Per coordination with the City, it was assumed that:

1. An at-grade crossing will be required at the Nickerson southbound on-ramp.

2. The proposed trail will connect to the existing South Ship Canal Trail crossing the BNSF railroad tracks and will also connect to 15th Avenue West.
3. The location and route of the trail was assumed per coordination efforts with the City of Seattle and input from the local biking community.
4. The width of the Emerson Underpass Trail will be 14 feet wide.

Refer to Figure E-2 in the Executive Summary for a recreated schematic from SDOT that illustrates these assumptions for the Emerson Underpass Trail alternative. Other options for the layout of an underpass trail may be feasible and should be considered if the project moves forward.

2.2 Sidewalk Widening Alternatives

This section provides additional information about Alternatives 1 and 2, and summarizes the impacts associated with each.

2.2.1 Bridge Improvement Alternatives

Two alternatives were developed for the pedestrian widening analysis as part of the Ballard Bridge Sidewalk Widening Alternative Study.

Alternative 1 – Would modify the existing luminaires, barriers, and railings on both sides of the sidewalk to increase the useable width as much as possible without adding additional structure to the bridge. The existing curb between the vehicular lane and sidewalks would be replaced with a WSDOT standard single-slope type vehicular barrier with railing, for vehicular impacts, tested under NCHRP guidelines (NCHRP-230). The exterior railing would be a 54-inch combined pedestrian/bicycle railing, not designed for vehicular impact loads.

This alternative would widen the sidewalks by 12 inches by cantilevering the luminaires beyond the pedestrian railing. A schematic of the Alternative 1 concept can be found in Appendix B.

It was determined that this nominal increase in width was relatively ineffective; therefore, Alternative 1 was not carried forward throughout the analysis. Additionally, Alternative 1 would require right-of-way acquisition and unfavorable construction closures. A schematic of the Alternative 1 concept can be found in Appendix B.

Alternative 2 – Would include demolition of the exterior rail, addition of new cantilevered sidewalk and attached rail, to achieve a 6-foot and/or 10-foot, clear-width sidewalk. Either sidewalk width meets the minimum ADA standards set by PROWAG (2005). The existing curb between the vehicular lane and sidewalks would be replaced with a WSDOT standard single-slope type vehicular barrier with railing, for vehicular impacts, tested under NCHRP-230 guidelines. The exterior railing would be a 54-inch combined pedestrian/bicycle railing, not designed for vehicular impact loads.

For Alternative 2, it was necessary to develop a series of location-specific sections due to each segment of the Ballard Bridge being of different construction and requiring unique sidewalk widening support details. The location of the replaced luminaires varies per bridge segment, and the structural elements supporting the additional sidewalk width also vary per bridge segment. Figure 1-3 outlines the locations of these distinct sections in aerial view, refer to Appendix B for complete technical sections of the proposed widening options.

Segment 1: Cantilevered Gravity Retaining Wall

The Segment 1 widening concept consists of a slab that cantilevers out beyond the face of the existing retaining wall. The cantilevered slab has been preliminarily estimated to be 6 inches thick in order to provide strength and stability for the pedestrian loads. The cantilevered slab will be cast integrally with a thicker anchor slab that will be supported vertically on the existing retaining wall stem and the approach fill material. No dowels or reinforcing will be used to positively attach the anchor slab to the wall. The retaining wall's vertical stem design is very strong for vertical loads, so this connection will be used for vertical load; however, without a steel connection, the anchor slab will not impart bending moments or significant lateral loads to the top of the existing wall.

As the widening increases, the size of the anchor slab must also increase. The depth of the anchor slab is estimated to be 1 foot 3 inches and 2 feet 3 inches thick for the 6- and 10-foot sidewalks, respectively. The anchor slab is estimated to extend to the existing curb line for the 6-foot sidewalk and to 1 foot 6 inches beyond the existing curb line for the 10-foot sidewalk. Extending the anchor slab beyond the existing curb line for the 10-foot sidewalk was not preferred; however, the existing concrete vehicular slab in Segment 1 contains longitudinal joints, so the joint nearest to the existing concrete curb was used. In both cases (i.e., the 6- and 10-foot widening), it is recommended that expandable material be located between the inside face of the retaining wall and the side of the anchor slab. This material is intended to prevent vehicle impacts on the traffic barrier to impart load directly into the top of the retaining wall.

Segment 2: Conventionally Reinforced Concrete

The Segment 2 widening concept will attach directly to the existing cast-in-place concrete box girder structures that were added as a prior vehicular widening in the 1950s. Segment 2 is the only portion of the structure with the existing sidewalk integral to the bridge deck, and is 6.5 inches thick in lieu of 3.5 inches thick. The thicker slab allows for a doweled bar to be installed in the edge of the existing deck. The slab extension will not be cantilevered, but will sit on a longitudinal steel edge beam that is in turn supported by a new steel transverse beam. The proposed transverse support beam will be through-bolted to the existing concrete cantilever ribs/beams that extend off of the existing concrete box girder structures. This system is similar for both the 6- and 10-foot widening conditions.

Segment 3 and 5: Non-Redundant Structural Steel Girder Bridge
Segments 3 and 5 are similar in terms of structure type. The widening concept for Segments 3 and 5 widening differs for the 6- and 10-foot conditions. For the 6-foot condition, a new sidewalk slab would be cast starting at the existing curb line and cantilever over the top of the existing concrete edge beam. The construction contract documents should draw attention to the care that will be required for removing the existing pedestrian rail in order to preserve the integrity of the edge beam. It has been assumed that the new slab will be connected to the existing edge beam through doweled anchors.

For the 10-foot condition, a new concrete sidewalk slab would be cast similar to the 6-foot condition. A new steel longitudinal edge beam would be required, along with transverse floor beam extensions at each floor beam location. The transverse floor beam extensions will support the new steel sidewalk longitudinal edge beam. The existing pedestrian railing and edge beam would be completely removed, along with a portion of the deck to allow for the splicing of the new transverse floor beam extensions. The construction contract documents should note that it will be necessary to preserve the existing deck steel where the new steel transverse floor beams are to be installed.

Segment 6: Structural Steel Wide Flange Bridge
Segment 6 is a single span of structure that spans the BNSF right-of-way. The Segment 6 widening concept differs between the 6- and 10-foot conditions. The concept for the 6-foot condition is similar to that for Segments 3 and 5 (i.e., a new sidewalk slab would be cast, starting at the existing curb line and cantilevering over the top of the existing concrete edge beam). Again, the construction contract documents should draw attention to the care that will be required for removing the existing pedestrian rail in order to preserve the integrity of the edge beam.

The Segment 6 widening concept for the 10-foot condition is unique to the entire project. An entirely new girder is shown to support the widening, due to the capacity limitations of the existing exterior beam, the complicated geometry of the skewed interior beams, and the relatively short span. The addition of this proposed girder will require that a seat extension be provided at each supporting pier wall (i.e., Piers 22 and 23). The seat extension is proposed to be a cantilevered extension off of the pier wall. In elevation, the extension would be located vertically such that it would remain above the BNSF clearance envelope and, thus, the existing vertical and horizontal clearances within the BNSF clearance envelope would be maintained. To construct the seat extension, the formwork would need to be suspended off of the existing piers in order preserve horizontal clearance from the tracks. Also, construction activities will occur above the railroad tracks and, thus, containment measures may be required in order to prevent the drop of construction debris onto the tracks. The widening itself will consist of a new sidewalk slab that would be cast starting at the existing curb line and cantilevering over the top of the proposed girder.

Segment 7: Conventionally Reinforced Concrete T-beams
The Segment 7 widening concept for the 6-foot condition is similar to that for Segments 3 and 5 (i.e., a new sidewalk slab would be cast, starting at the existing curb line and cantilevering over the top of the existing concrete edge beam). Again, the construction contract documents should draw attention to the care that will be required for removing the existing pedestrian rail in order to preserve the integrity of the edge beam.

For the 10-foot condition, a new sidewalk slab would be cast, starting at the existing curb line. The slab will not be cantilevered but will sit on a new longitudinal steel edge beam that is in-turn supported by a series of new transverse steel truss systems. The proposed truss systems will be through-bolted to the existing concrete cantilever ribs/beams that extend off of the exterior face of the existing concrete T-beam girders to form a tension tie, and will be connected to the existing concrete tee beam girders with resin bonded anchors to form a compression strut.

Segment 8: Counterfort Gravity Retaining Wall
The Segment 8 widening concept is similar to Segment 1; a thin concrete slab will cantilever out beyond the face of the retaining wall, and a thick anchor slab will bear on the retained fill material behind the retaining wall. The existing retaining wall system in Segment 8 differs from Segment 1 in that Segment 8 uses a counterfort retaining wall system, whereby individual footings support large vertical triangular-shaped concrete structural members oriented perpendicular to a concrete fascia that retains the soil. In this system, the fascia collects the load from the soil and carries it horizontally to the large, concrete, triangular-shaped counterforts. The vertical reinforcement in the concrete fascia is minimal because the facing is not intended to carry load in that direction.

The counterfort wall does not lend itself well to carrying vertical loads or bending moments about the top of the facing wall. Therefore, the conceptual design shows the anchor slab fully isolated from the concrete wall with expandable material. The anchor slab was set to extend to the existing curb line for the 6-foot condition, which resulted in an anchor slab depth of 3 feet. For the 10-foot condition, the anchor slab was set to extend 10 feet out from the curb line as an attempt to locate the edge of the anchor slab at the adjacent driving lane. The associated depth of the anchor slab in this condition was 1 foot 10 inches.

2.2.2 Load Rating Impacts

The load rating analysis of the recently retrofitted approach structures did not indicate any operating live load deficiencies (per the LFR Method) that would result in needing to restrict live loading on the bridge. However, widening the sidewalks of the Ballard Bridge approach structures will impact the rating factors of the bridge. As part of this study, a separate load rating analysis was not conducted; however, modification factors were developed for the controlling HS-20 load rating factors. These factors cannot be directly applied to other live load vehicles; however, they do provide a good representation of the relative effect of widening the sidewalks. If the sidewalks are widened, a full load rating analysis should be conducted. For more details, see Appendix A of this report.

In terms of service life, widening the sidewalks may reduce the remaining service life of the bridge. The sidewalk widening contributes to the permanent load demands on the existing bridge elements, thus, leaving less reserve capacity for live loads. Over time, live loads have only increased and, if less reserve capacity exists, the service life potentially decreases.

2.2.3 Effects on Seismic Retrofit

The widening concepts of the bridge have not yet been fully reviewed for seismic performance. For this study, the increase in mass was recorded and compared to the mass of the existing structure. Per Section 4.3 of the WSDOT Bridge Design Manual, a seismic analysis of a bridge widening without new substructure may be waived with the owner's approval if the added mass from the widening is 10 percent or less of the original structure weight. The results of the preliminary analysis indicate that the added mass due to the bridge widening would not exceed the 10 percent threshold for Alternative 2 with all combinations of widths (see Table 2-1 for details). It should be noted that Table 2-1 compares the superstructure mass increases only. For the option with 10-foot width on both sides, the mass increase exceeds 10 percent of the superstructure mass, but it remains below 10 percent of the total structure mass. Based on precedent experience, the retrofitted capacity/demand ratios are high enough to accommodate the additional mass; however, further analysis should be performed if the City chooses to construct the 10-foot additional width on both sides. Details of the structural calculations conducted as part of this study can be found in Appendix A.

Table 2-1: Structure Mass Increase Percentages for Sidewalk Widening Alternatives

Bridge Segment	Alternative 2 - Widening Options				
	6 ft	10 ft	6 ft & 6 ft	6 ft & 10 ft	10 ft & 10 ft
1*	-	-	-	-	-
2	0.7%	1.0%	1.4%	1.7%	2.1%
3	1.4%	2.7%	2.7%	4.1%	5.5%
4**	-	-	-	-	-
5	1.4%	2.7%	2.7%	4.1%	5.5%
6	0.5%	0.9%	1.0%	1.4%	1.8%
7	1.3%	2.9%	2.6%	4.2%	5.7%
8*	-	-	-	-	-

*Segments 1 and 8 are fill approaches and do not include the same seismic restrictions as the elevated bridge structure approach segments (i.e. Segments 2 through 7). The widening system for Segments 1 and 8 have been designed as self-equilibrating moment-resisting anchor slabs in order to reduce the interaction between the new sidewalk widening and the existing walls.
**Segment 4 bascule span was not evaluated as part of this contract.

2.2.4 Right-of-Way Impacts

The City right-of-way aligns with the back of railing of the existing Ballard Bridge approach structure for Segments 5 and 6 and the southern portion of Segment 3. With the addition of the sidewalk widening and/or the addition of externally mounted luminaire poles, the bridge structure would extend beyond the existing right-of-way. If property acquisitions are necessary for the Ballard Bridge widening, there is a potential for business relocation. Given the specialized nature (water-related) of the businesses along the Ballard Bridge, the cost of business relocation could be high and the time frame could be lengthy.

The approximate extension beyond the right-of-way line is illustrated in widening concept schematics included in Appendix B. The approximate total square footage of extension beyond the existing City right-of-way for the different widening options is illustrated in Table 2-2. It should be noted that Table 2-2 does not address right-of-way needs associated with the Emerson Underpass Trail (refer to Section 2.3.3 of this report).

The proximity to the BNSF railroad tracks would be of concern both during construction and after completion of the project. Construction of the widening of the SW and SE quadrants has been evaluated for right-of-way impacts to the railroad, and it would be necessary to demonstrate the limits of construction over and adjacent to the railroad, the anticipated duration of the work, and mitigation for potential impacts to the railroad facility. The existing Segment 6 piers, Piers 22 and 23, do not fall within the AREMA or BNSF typical horizontal bridge clearance temporary and permanent envelopes. It is assumed to be a fatal flaw to further restrict the horizontal offset of the piers from the tracks unless it is above the vertical extents of the clearance envelope. Both Segment 6 widening alternatives involve work over/above the clearance envelope. The 10-foot widening concept involves adding seat extensions to Piers 22 and 23. The seat extensions have not been detailed as part of this study; however, it has been assumed that these seat extensions would be integrated into the pier walls above the vertical extents of the clearance diagram. To prevent potential falling objects from entering the BNSF right-of-way, a throw fence will need to be incorporated into the final bridge railing configuration (refer to the BNSF Standard Plan in Appendix C).

Table 2-2: Estimated Additional Right-of-Way Required for Bridge Widening

Bridge Segment	6-foot Widening Option (*sq ft*)			10-foot Widening Option (*sq ft*)			Alternative 1 (*sq ft*)		
	West	East	Total	West	East	Total	West	East	Total
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	470	470	940	1,030	1,030	2,060	421	421	842
4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5A	1,370	1,370	2,740	2,980	2,980	5,960	421	421	842
5B	1,375	1,375	2,750	2,990	2,990	5,980	422	422	844
5C	1,375	1,375	2,750	2,990	2,990	5,980	422	422	844
5D	630	630	1,260	1,375	1,375	2,750	194	194	388
6	275	275	550	615	615	1,230	79.5	79.5	159
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
Total	5,495	5,495	10,990	11,980	11,980	23,960	1,960	1,960	3,920

*Note: Areas are measured in square feet and are approximate. These quantities only provide Right-of-Way to the edge of the new rail. Additional Right-of-Way or permanent easements will be needed to facilitate the construction of the widening and maintenance of the bridge.

2.2.5 Constructability and Impacts during Construction

Traffic control and pedestrian navigation for the four bridge quadrants have been assessed for constructability issues. It is anticipated that a portion or all of the westernmost and easternmost travel lanes and the sidewalks would need to be closed intermittently in order to demolish, prepare, and construct the new sidewalk, barrier, rail, light poles, and other appurtenances. Therefore, traffic control would be required to temporarily reduce the number of lanes available to vehicles, and pedestrians would need to be detoured to the west and east sides of the bridge to avoid the construction activities. This is particularly relevant at the north and south ends of the bridge within Segments 1 and 8. At these locations, the existing roadway slab would need to be removed and replaced to accommodate the anchor slab. No impacts to the bascule span operation are anticipated during adjacent sidewalk widening construction. A fish window will restrict in-water work to between October 1 and April 15. No actual in-water work is anticipated; it is assumed that the contractor would work from a barge to deliver and erect structural members associated with the widening concepts. This activity may require securing temporary construction easements along the west and east sides of Segment 5, similar to what was required for the Seismic Retrofit Project. The construction time frame for both the bridge and the trail is assumed to be approximately 12 months and they could be constructed concurrently within that 12 months.

2.2.6 Operational Design Issues

There are some operational design issues that will need to be addressed during the design of the sidewalk widening. These potential issues are shown on Figure 2-2 and Figure 2-3.

2.3 Emerson Underpass Trail

This section summarizes the impacts associated with the addition of a connector trail. To route pedestrians and bicyclists off the bridge to the Ship Canal Trail, the Emerson Underpass Trail alternative has been schematically designed as part of the Ballard Bridge Study. The Emerson Underpass Trail would be located in the SW quadrant, as previously described. Refer to Figures 2-5 through 2-10 for a layout and various section views.

2.3.1 Emerson Underpass Trail Description

The alternative would route pedestrians and bicyclists onto a separate elevated path that crosses below W Emerson Place, thereby avoiding an at-grade crossing at Emerson and achieving a shorter crossing with better sight distance for both vehicle drivers and trail users at the southbound Nickerson Street on-ramp to 15th Avenue Northwest. Sight distance length requirements and any other operational changes due to this new crossing will need to be further evaluated in the next stage of project development. See photos 2-1 and 2-2 to view the existing trail under W Emerson Place.

The trail would begin with an elevated transition from the existing sidewalk on the west side of 15th Avenue Northwest, north of W Emerson Place, and cross under W Emerson Place, proceed south before turning west to cross West Nickerson Street on-ramp, then slope back down northward to connect to the South Ship Canal Trail system. A maximum grade of 5 percent would be used to comply with ADA standards set by PROWAG (2005), and all crossings, ramps, and other features will be designed to meet the PROWAG standards to the maximum extent practicable. An additional spur would be provided to direct pedestrian/bicyclist traffic back onto the existing sidewalk on the west side of 15th Avenue Northwest, just south of the West Nickerson Street flyover.

The existing guardrail between the trail and West Nickerson Street would need to be relocated to ensure that separation is maintained between pedestrians/cyclists on the connector trail and the vehicular traffic on West Nickerson Street.

A 27-foot curve radius was selected for the underpass trail, which is the minimum size allowed by WSDOT for curves approaching intersections, per Chapter 1515 of the *Design Manual*. The radii on the curves in the connector trail on the north and south side of the West Nickerson Street on-ramp would be designed per Washington State Department of Transportation's (WSDOT) criteria, which recommends slowing bike traffic down when approaching intersections.

The entire length of the new trail will be illuminated to meet lighting level requirements. Costs for the illumination system have been included in the preliminary cost estimates.

2.3.2 Elevated Trail Structural Summary

The first segment of the Emerson Underpass Trail alternative is an approximately 305-linear-foot, two-span elevated bridge structure stemming from the west edge of the sidewalk off of 15th Avenue West. The structure would extend in a southwestwardly direction, ending north of W Emerson Place, where the trail grade would be approximately 5 feet higher than the existing walkway grade (see Figure 2-4). The elevated bridge structure type has not been evaluated. For the purpose of costs, the elevated bridge structure has been assumed to be a precast, pre-stressed decked bulb-tee concrete girder bridge with an asphalt top surface. The substructure has been assumed to consist of circular concrete columns supported by drilled shafts. It has been assumed that there would be three piers: one adjacent to the existing 15th Avenue Northwest bridge, an abutment at the south end of the bridge, and an intermediate pier between the abutment and the pier adjacent to 15th Avenue Northwest. The pier adjacent to the existing 15th Avenue Northwest bridge would prevent the transfer any loads to the existing 15th Avenue Northwest bridge. This pier should ideally be located to fit within the site constraints and effectively balance the loads on the pier.

The Emerson Underpass Trail alternative would require the use of different types of structural walls, due to the sloped topography of the project site. The type of wall would vary dependent on the cut and fill locations. It has been assumed that the zones where fill would be required would use a structural earth wall with a concrete fascia, and the zones where a cut is required would use a soldier pile wall with concrete lagging. It has also been assumed that the existing soil is contaminated for cost estimate purposes, per City preference.

2.3.3 Right-of-Way Impacts

A new Emerson Underpass Trail connection to the Ballard Bridge would require acquisition of right-of-way from private property owners and with acquisition there would be a potential need for business relocation. Given the specialized nature of the businesses along the Ballard Bridge, the cost of business relocation costs could be high and the timeframe could be lengthy. Based on GIS, it is estimated that approximately 5,000 square feet of right-of-way would need to be acquired for the construction of the trail. Refer to Appendix I for right-of-way exhibit.

To prevent potential falling objects from entering the BNSF right-of-way, a throw fence would need to be incorporated into the final railing configuration. In addition, BNSF would require a Temporary Agreement for working near their tracks to connect to the Ship Canal Trail.

Photo 2-1: Pedestrian path crossing under Emerson Street, looking south

Photo 2-2: South Ship Canal Trail adjacent to BNSF tracks and Nickerson Street

Figure 2-2: Potential Issues Pertaining to Sidewalk Widening - South Quadrants

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Ballard Bridge Sidewalk Widening Concept Study

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September 2014

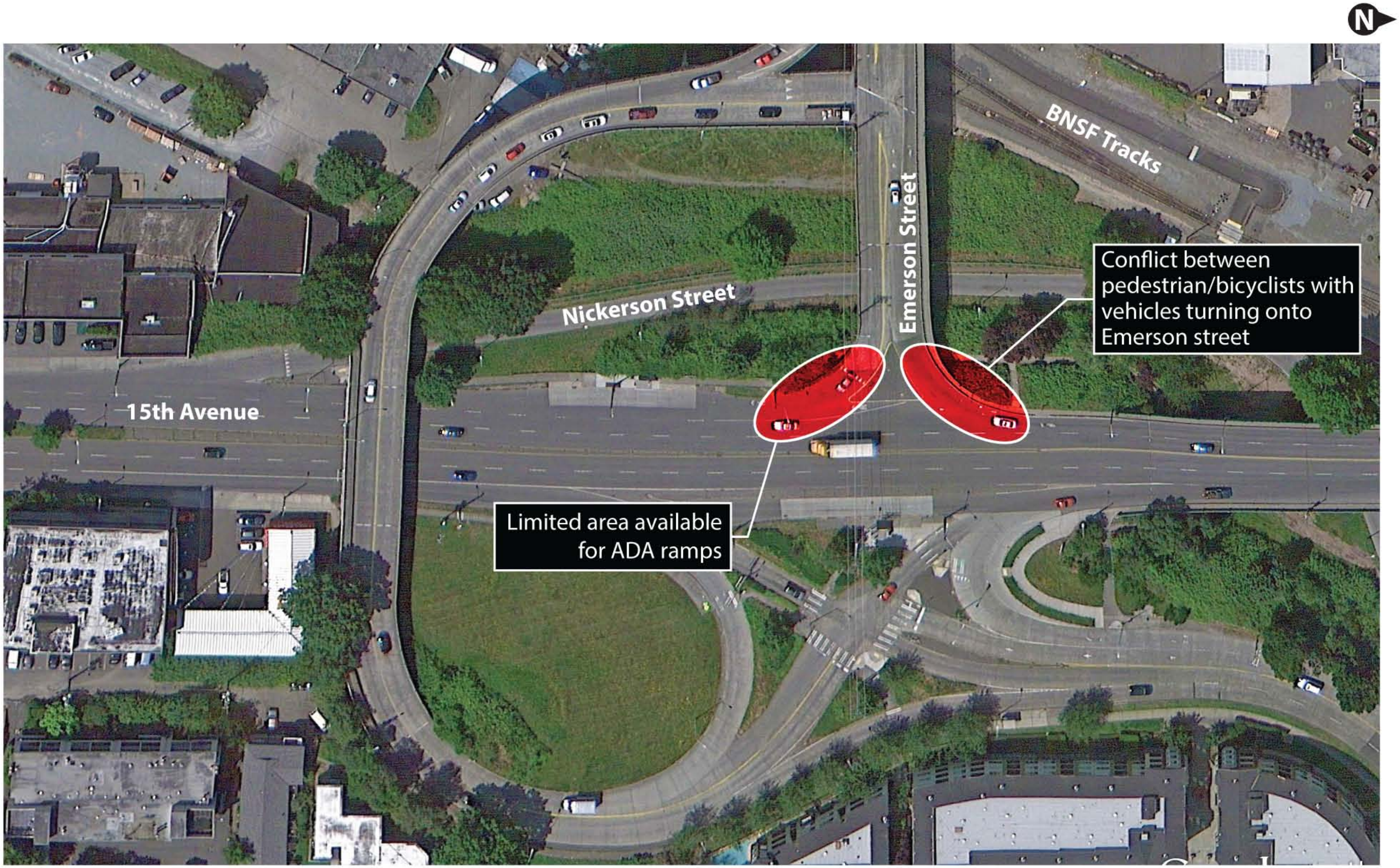

Figure 2-3: Potential Issues Pertaining to Sidewalk Widening - North Quadrants

Ballard Bridge Sidewalk Widening Concept Study

Seattle Department of Transportation

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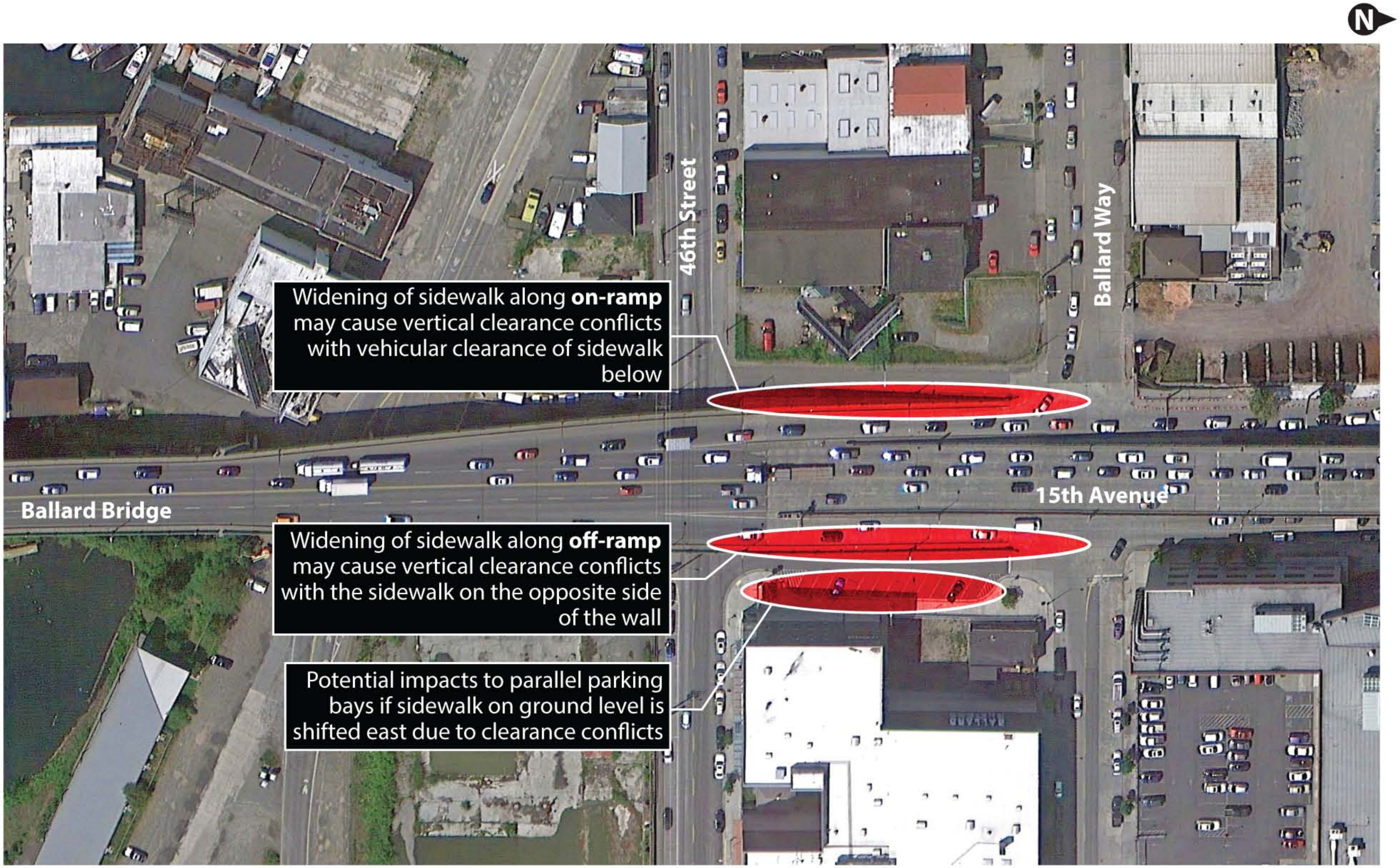

2.3.4 Constructability

Traffic control and pedestrian navigation for the Emerson Underpass Trail have been assessed for constructability issues. It is anticipated that travel lanes and/or sidewalks would need to be closed for short durations, typically at night, in order to demolish, prepare, and construct the new underpass trail and bridge. Therefore, traffic control would be required, and pedestrians would be temporarily detoured around work areas to avoid the construction activities. Some short term closures of the South Ship Canal Trail, also at night, would be required.

The elevated bridge structure for the Emerson Underpass Trail would require the use of large equipment for the construction of deep foundations and erection of the bridge girders. This study did not evaluate the exact location of the bridge piers and, thus, did not evaluate the feasibility of fitting the construction equipment within the project site without potential intermittent disruption to traffic along Nickerson Street. However, some closures of short duration would likely be required to construct the bridge. The construction timeframe for both the bridge and the trail is assumed to be 12 months and they could be constructed concurrently within that 12 months.

2.3.5 Maintenance Access

The trail would require maintenance access. It is anticipated that access to the east and west segments of the trail would be via the underpass trail ramps on both sides of Nickerson Street. The design maintenance vehicle has a centerline turning radius of 21 feet, which is less than the 27-foot alignment curve. The vehicle load for the Emerson Underpass Trail would differ from the rest of the project, in that maintenance vehicles will be accessing the proposed trail. Table 3.2.1 of the AASHTO *LRFD guide Specifications for the Design of Pedestrian Bridges* outlines the vehicle design load used for the analysis of the underpass trail. This table has been reproduced in the structural design provided in Appendix A of this report.

2.3.6 Potential Issues

There are some potential issues that would need to be addressed during the design of the Emerson Underpass Trail. Constructability issues include connections to the existing stairways and path near Emerson Street, construction adjacent to the railroad right-of-way, the reconstruction of existing retaining walls, and the relocation of the existing guardrail. Portions of the existing retaining wall on the east side of the railroad tracks where the Emerson Underpass Trail meets the South Ship Canal Trail would need to be removed and reconfigured due to the new trail connection. These potential issues are shown on Figure 2-9.

Figure 2-4: Emerson Underpass Trail - Elevated Structure Location

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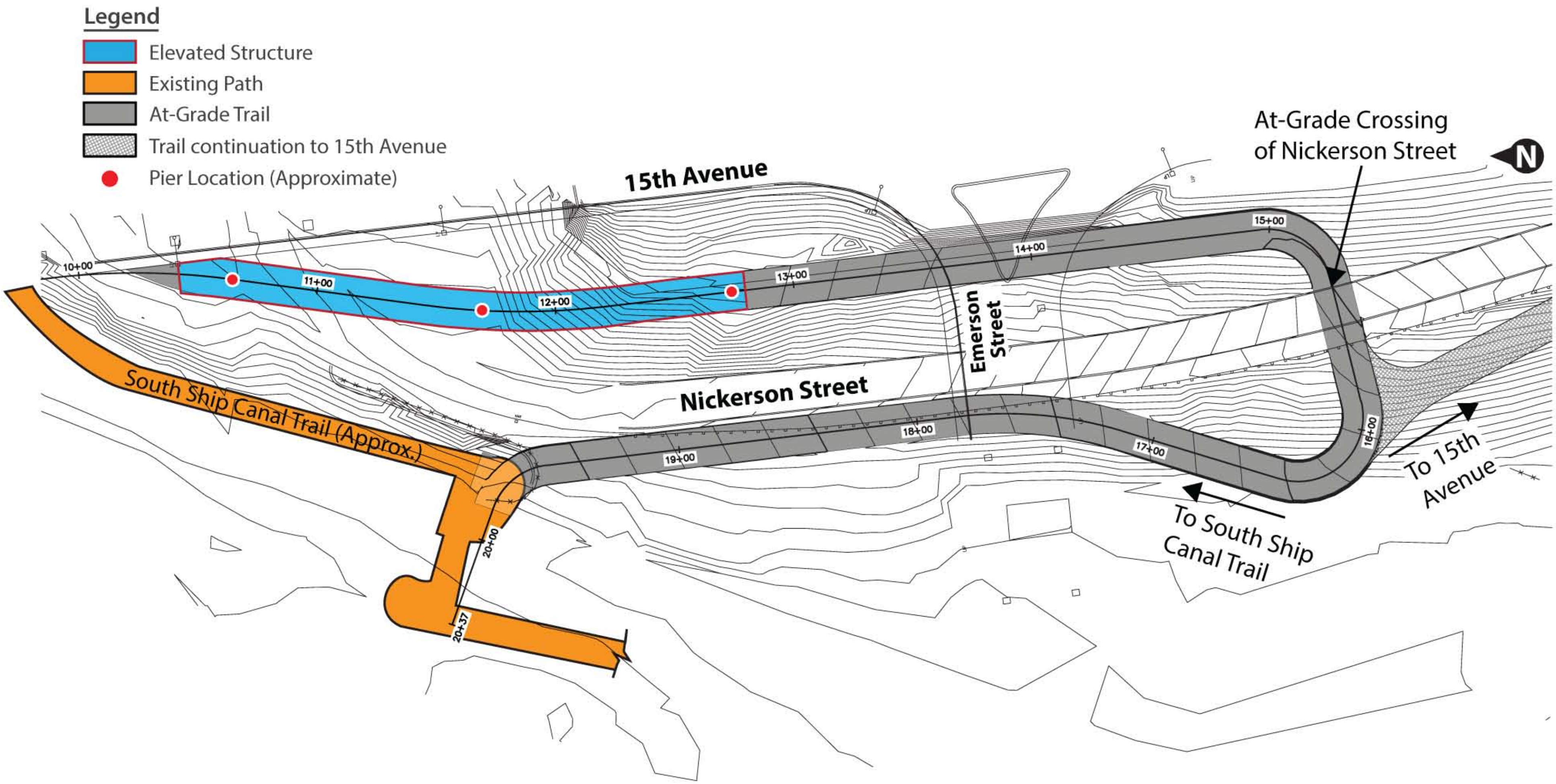

Figure 2-5: Emerson Underpass Trail - Section Key Map

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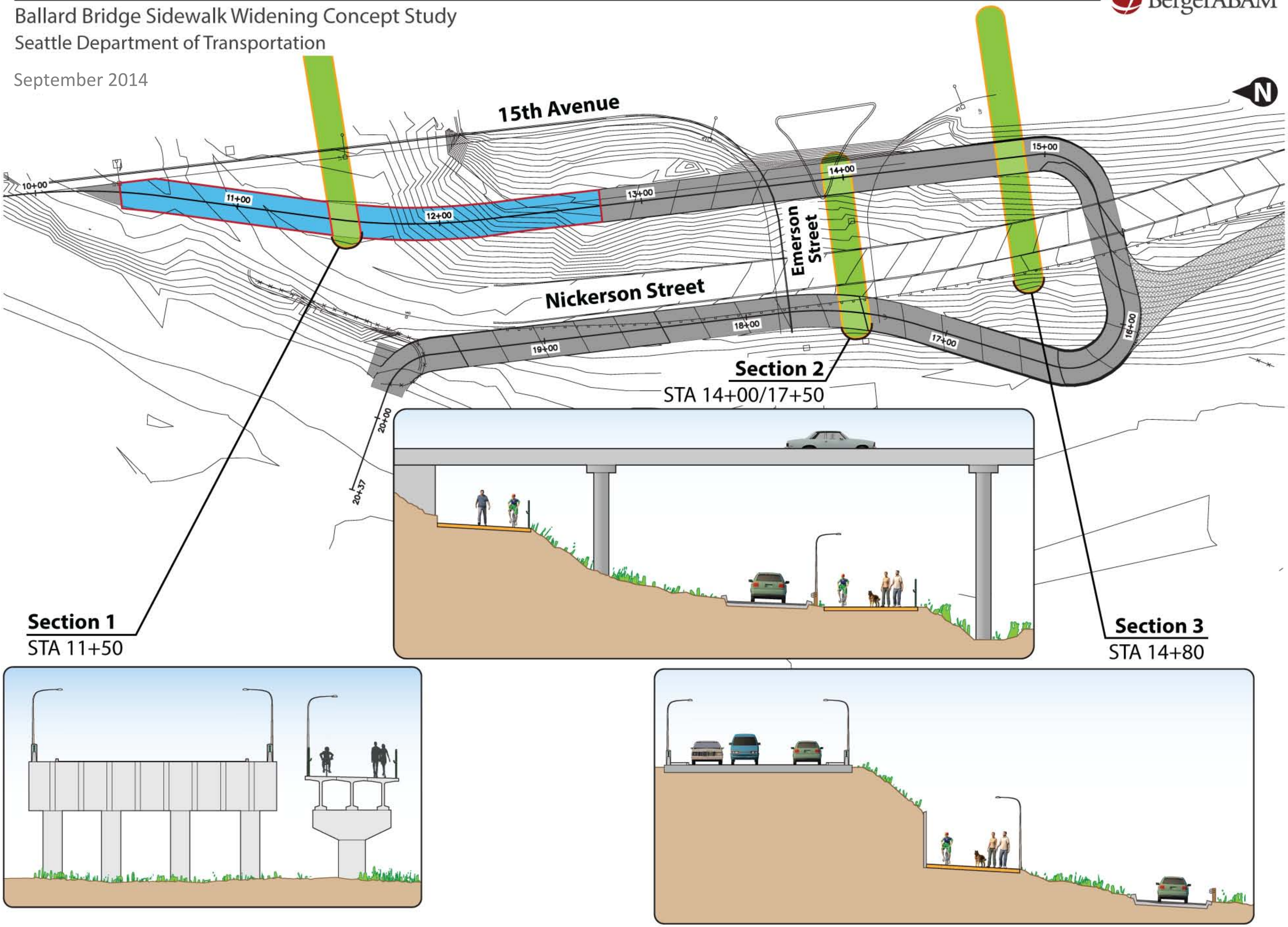

Figure 2-6: Emerson Underpass Trail - Section 1 (STA 11+50)

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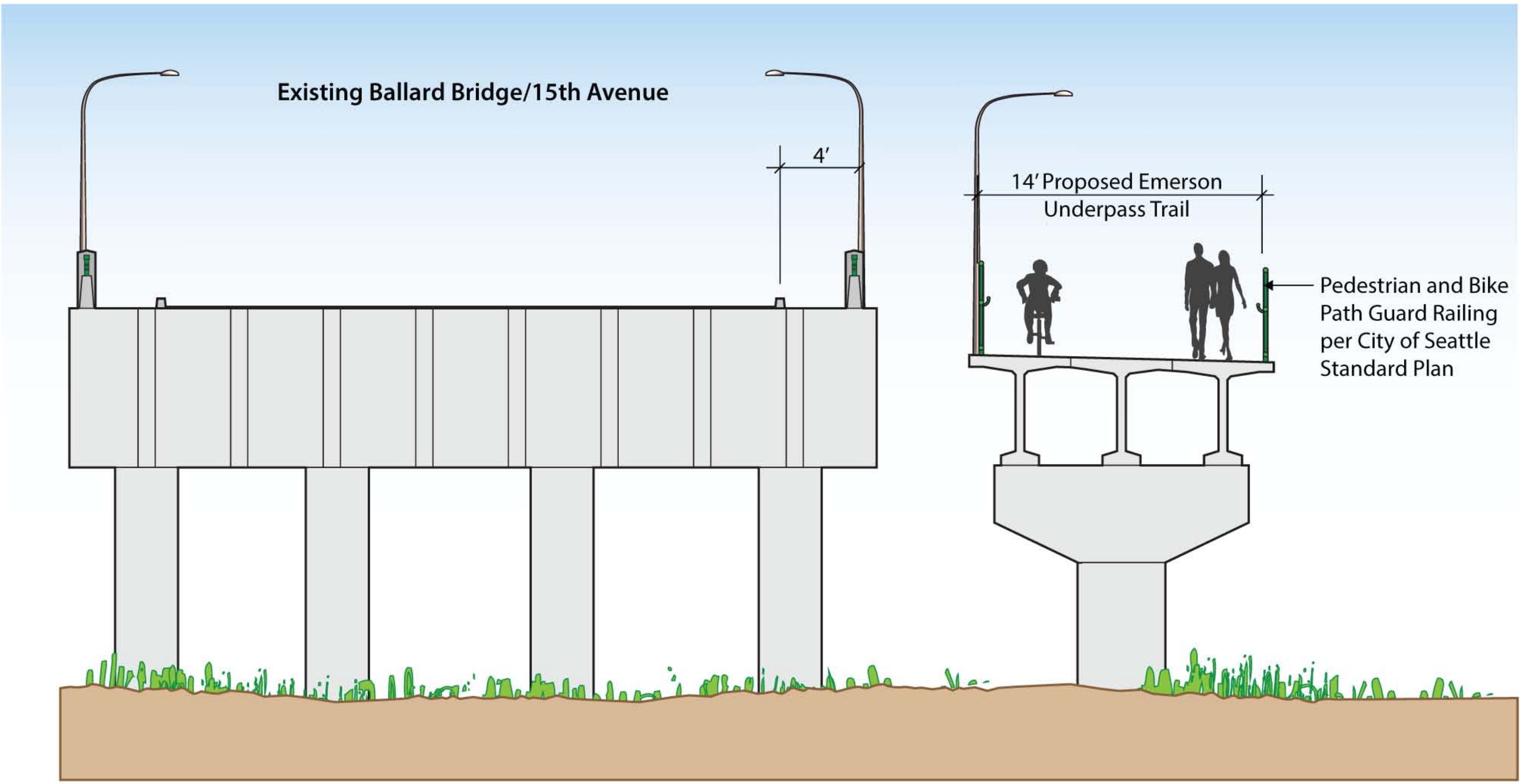

Figure 2-7: Emerson Underpass Trail - Section 2 (STA 14+00/17+50)

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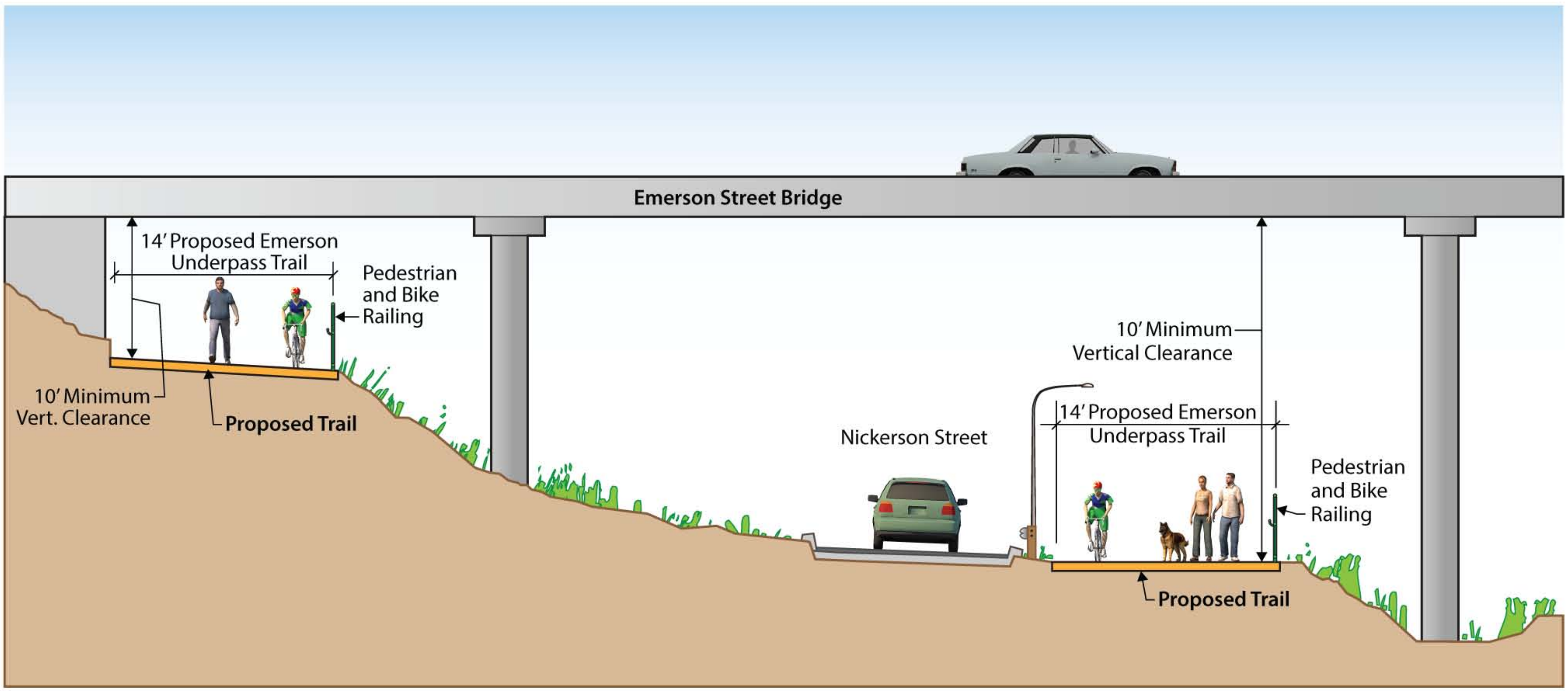

Figure 2-8: Emerson Underpass Trail - Section 3 (STA 14+80)

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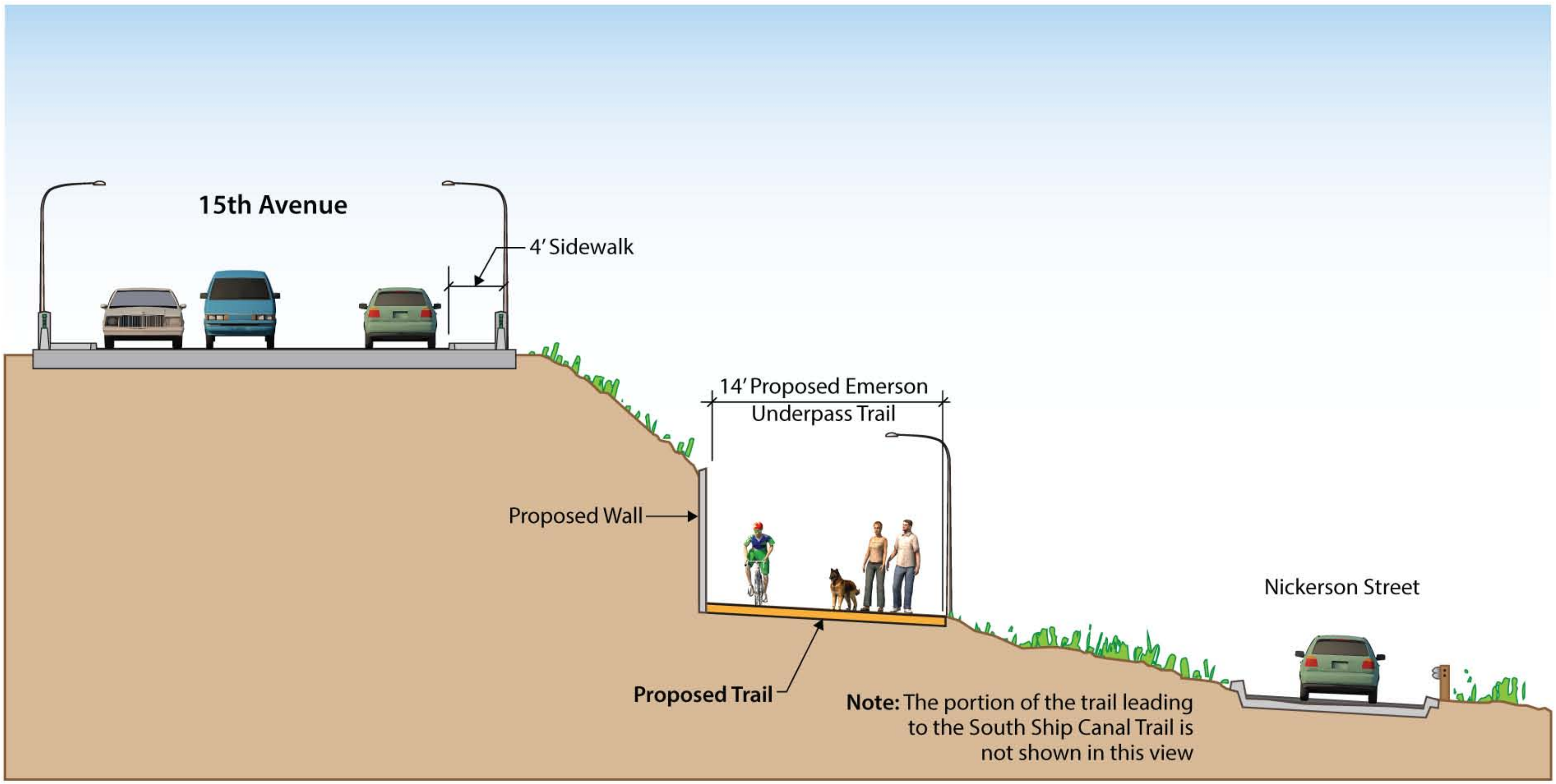

Figure 2-9: Emerson Underpass Trail - Constructability Issues

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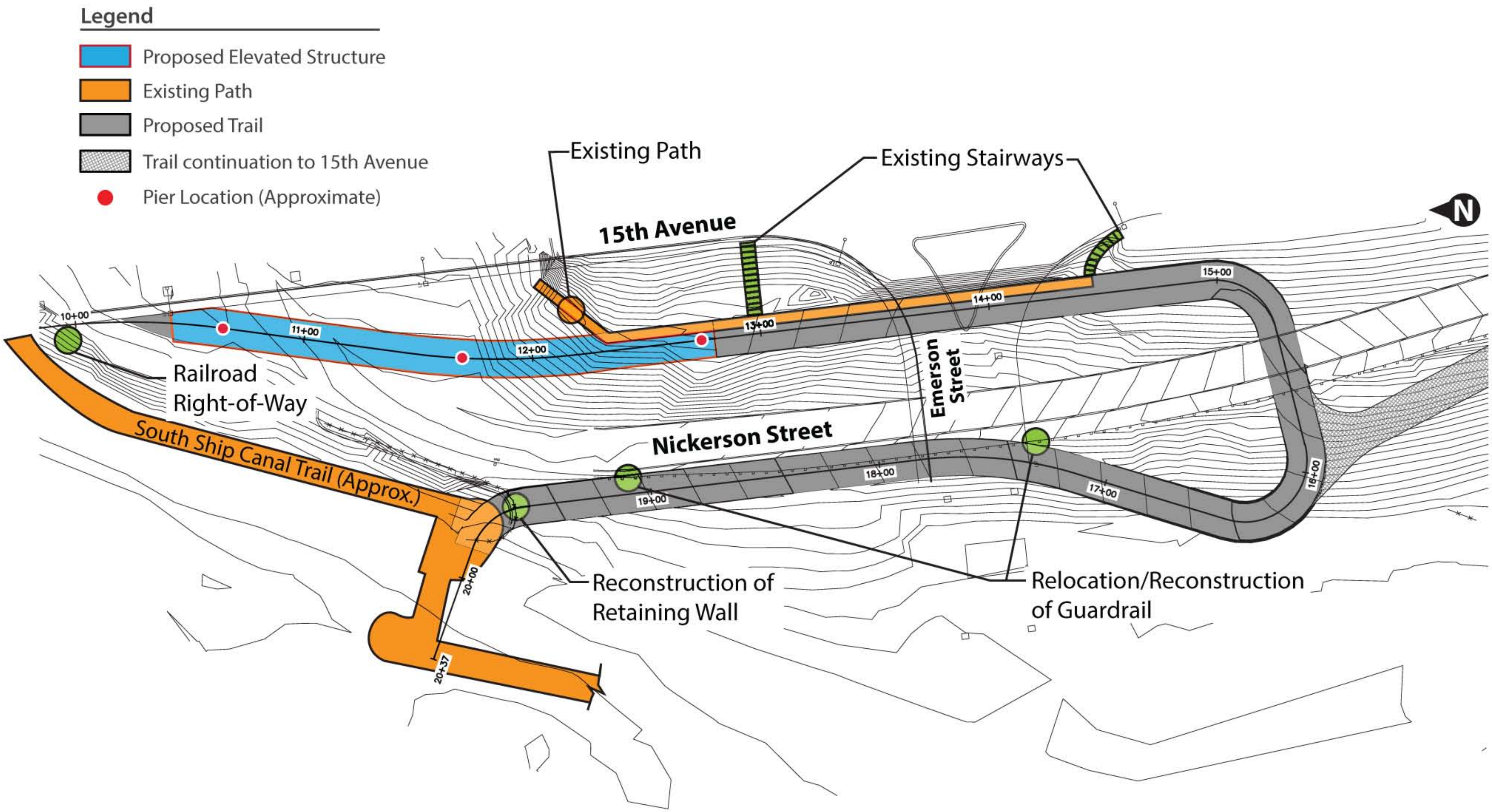

3.0 COST ESTIMATE SUMMARY

Costs associated with each sidewalk improvement alternative and the connector trail are summarized in Table 3-1.

Table 3-1: Summary of Total Costs

Program Element and Description	Alternative 1	Alternative 2			Alternative 3	Emerson Underpass Trail
	Sidewalk Widening	Sidewalk Widening			Railing between sidewalk and travel lane	Connector trail to South Ship Canal Trail and sidewalk on 15th Avenue
	To 4 ft 5 in. both sides	To 6 ft both sides	To 10 ft both sides	To 10 ft one side		
Project Engineering	$3,895,000	$4,841,000	$6,915,000	$3,457,000	$710,000	$4,291,000
Construction [1]	$11,406,000	$14,175,000	$20,248,000	$10,124,000	$2,510,000	$12,566,000
ROW [2]	$6,526,000 – $20,526,000	$6,600,000 – $20,600,000	$6,700,000 – $20,700,000	$6,600,000 – $20,600,000	$0	$1,000,000
Total Costs	**$21,827,000–$35,827,000**	**$25,616,000–$39,616,000**	**$33,863,000–$47,863,000**	**$20,181,500–$34,181,500**	**$3,220,000**	**$17,857,000**

1 Includes construction contract, construction management, contingency, mobilization and inflation to 2016
2 Includes acquisition, construction easements and business relocation and re-establishment costs