Alaskan Way Viaduct & Seawall Replacement Program

U.S. Department of Transportation Federal Highway Administration | WSDOT | King County | City of Seattle

Draft SR 99 Bored Tunnel Alternative

Design Deviation No. 1: SR 99 Shoulder Width (Inside & Outside)

MP 30.40 to MP 32.83

Submitted to:
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Urban Corridors Office
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April 2009

The Alaskan Way Viaduct & Seawall Replacement Program

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Agreement No. Y-9715

Task CE.04

The Alaskan Way Viaduct & Seawall Replacement Program is a joint effort between the Federal Highway Administration (FHWA), the Washington State Department of Transportation (WSDOT), and the City of Seattle. To conduct this project, WSDOT contracted with:

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April 2009

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

Northwest Division
Urban Corridors Office
Seattle, Washington

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Project Engineer

Deviation Recommended for Approval:

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Matt Preedy, Deputy Project Director

Washington State Department of Transportation

Deviation Approval:

Date _____

By _____ , P.E.
Ed Barry, Assistant State Design Engineer for UCO

U. S. Department of Transportation
Federal Highway Administration

Deviation Approval:

Date _____

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1.0 Project Overview

The Alaskan Way Viaduct and Seawall Replacement Program (AWVSRP) design team has been working since 2001 to develop alternatives for the replacement of the Alaskan Way Viaduct. The team prepared and published a Draft Environmental Impact Statement (Draft EIS) in March 2004 and a Supplemental Draft Environmental Impact Statement (Supplemental Draft EIS) in September 2006. The team also prepared and submitted a Design Approval Package (DAP) to the Washington State Department of Transportation (WSDOT) for the preferred tunnel alternative in February 2007; however, the approval of that package was deferred while the project partners (City of Seattle, WSDOT, King County, and the U.S. Federal Highway Administration (FHWA)) re-evaluated the preferred configuration of State Route (SR) 99 in Seattle's waterfront area.

On March 14, 2007, the Project Team was directed by WSDOT to advance portions of the program that would contribute to improving safety and mobility, and that have fundamental consensus among the project partners. The Governor and WSDOT then identified six "Moving Forward: Early Safety and Mobility Projects" that are currently being implemented while the preferred SR 99 configuration in the central waterfront area was re-evaluated. One of these projects is the South Holgate Street to South King Street Viaduct Replacement, which is currently under design and scheduled for construction in fall 2009.

In January 2009 a letter of agreement between WSDOT, King County, and the City of Seattle identified a four-lane, single-bore tunnel as the recommended alternative for replacing the Alaskan Way Viaduct. The Single-bore Tunnel Alternative (Tunnel Alternative) connects to the proposed South Holgate Street to South King Street Viaduct Replacement Project (South Project) at approximately S. Royal Brougham Way (M.P. 30.40) in the south with a cut-and-cover section that runs to First Avenue and S. King Street. From here a tunnel boring machine would be used to construct the tunnel, following First Avenue to approximately Stewart Street, then veering east to the area of John Street and SR 99. The alternative includes another cut-and-cover section that connects to SR 99 near Mercer Street (M.P. 32.83) in the north. Interchange ramps are provided at both the north and south sections. Additionally,

a street connection between Alaskan Way and Elliott and Western Avenues is included (see Figure 1).

The SR 99 roadway for the SR 99 Bored Tunnel Project is functionally classified as a Principal Arterial Highway by WSDOT; its geometric design classification is that of a Principal Arterial P-1 Urban, per current *WSDOT Design Manual* Figure 440-6 (see approved *SR 99 Corridor Analysis Addendum C*). The project corridor has a WSDOT freight tonnage designation of T-1 (more than 10 million tons per year), and the City of Seattle classifies the roadway as a Major Truck Street.

Design Matrix 3, lines 3-7 (*WSDOT Design Manual* Figure 325-5) (May be Matrix 3, lines 3-11) is most applicable to the project, which requires a full design level. Standard shoulder widths for a P-1 design class at a full design level are 10 feet on the right and 4 feet on the left (*WSDOT Design Manual* Figure 440-6). This document requests a deviation for reduced shoulder widths.

The AWVSRP is partially funded through a combination of state funds from the 2003 Nickel Funding Package and the 2005 Transportation Partnership Account Package. It has also received funding from FHWA and the City of Seattle.

Figure 1. Proposed Project Corridor (Project limits per 2004 Corridor Analysis)

2.0 Existing Conditions in Vicinity of SR99

The existing SR 99 urban route within the project vicinity is located along the waterfront between S. King Street and Pine Street before turning northeast to the Battery Street Tunnel (BST) at First Avenue and Battery Street. It exits the BST at Denny Way and then turns north, crossing John, Thomas, Harrison, Republican, and Mercer Streets. The majority of the existing SR 99 runs along the waterfront and therefore parallels Alaska Way directly to the west. To the east, the viaduct closely shadows downtown buildings and Western Avenue with general parking directly underneath.

The existing SR 99 through the project vicinity is generally configured as a 40-foot-wide viaduct stacked structure. The number of existing lanes ranges from three to four in each direction, with lane widths varying from 9 to 12 feet and shoulder widths ranging from 0 to 3 feet. The SR 99 roadway width narrows to 25 feet with two lanes in each direction through the BST, and then widens to three to four lanes each approximately 10 feet wide north of the BST. WSDOT currently considers the BST a high accident location. The vertical alignment of the viaduct varies from 0 percent to 4 percent slope up to the BST, then SR 99 adjusts to approximately -2 percent north of the BST to Mercer Street before transitioning to a positive slope northward. The rolling terrain between Union and Ward Streets has a posted speed of 40 miles per hour (mph), while the southern portion of the route from S. Royal Brougham Way to Union Street is level and posted as 50 mph.

Many aspects of the existing horizontal and vertical curves do not meet today's roadway design standards for the posted speed limit. When compared to current design standards for stopping sight distance, horizontal curve radius, and vertical curve length, about two-thirds of the horizontal and vertical curves would coincide with a design speed of less than 40 mph.

The average daily traffic (ADT) peaks along the existing central waterfront mainline at 52,500 for the northbound direction and 50,500 for the southbound direction. In this area, the level-of-service (LOS) for northbound and southbound mainline traffic varies between LOS D and LOS E. Existing ADT truck traffic volumes are approximately 3 percent to 5 percent of total traffic. At the northern end of the project corridor, two existing High Accident Locations have been identified at northbound MP 31.9 to 32.1 and southbound MP 32.0 to 32.4 (see *SR 99 Corridor Analysis,* October 2004).

3.0 Proposed Roadway Configuration

The SR 99 Bored Tunnel Alternative would replace the existing viaduct and BST with a single bored tunnel east of the existing alignment. This project is comprised of a bored tunnel containing two stacked roadway decks with cut-and-cover sections at both the north and south ends. The tunnel would be constructed with an approximately 54-foot diameter tunnel boring machine (TBM). Southbound traffic would be on the top deck, and northbound traffic would be on the bottom deck. Enclosed roadways would meet or exceed current fire, life, and safety codes. The inside of the tunnel would be lined with an approximately 2-foot-thick concrete liner. The alignment would consist of a minimum of two northbound and two southbound lanes with shoulders varying on the left from 2 to 4 feet, and on the right from 3 to 8 feet. Both the South and North Segments of the project would contain fully directional interchange movements connecting with the City's surface street grid.

3.1 South Segment

In the south, the alignment matches the S. Holgate Street to S. King Street Project structure at S. Royal Brougham Way (RBW). SR 99 includes two lanes northbound and two lanes southbound, with shoulder widths of 4 feet on the left and 8 feet on the right (see Figure 2).

Access to and from the north would be via an interchange at RBW and the Alaskan Way frontage road. The northbound on-ramp would enter a retained cut section north of RBW and merge with the two SR 99 northbound lanes from the right side. The southbound off-ramp would diverge from the left side of SR 99 (see Deviation No. 2) and enter a retained cut section as it approaches RBW from the north.

Access to and from the south would be via an interchange at Alaskan Way north of RBW. The southbound on-ramp would enter the two SR 99 southbound lanes from a retained fill section as an added third southbound lane on the right. The northbound off-ramp would exit SR 99 as right-side drop lane with two lanes remaining on the SR 99 mainline, and would approach Alaskan Way on a retained fill section.

Ramp design speeds, grades, and cross-sections are within *WSDOT Design Manual* guidelines.

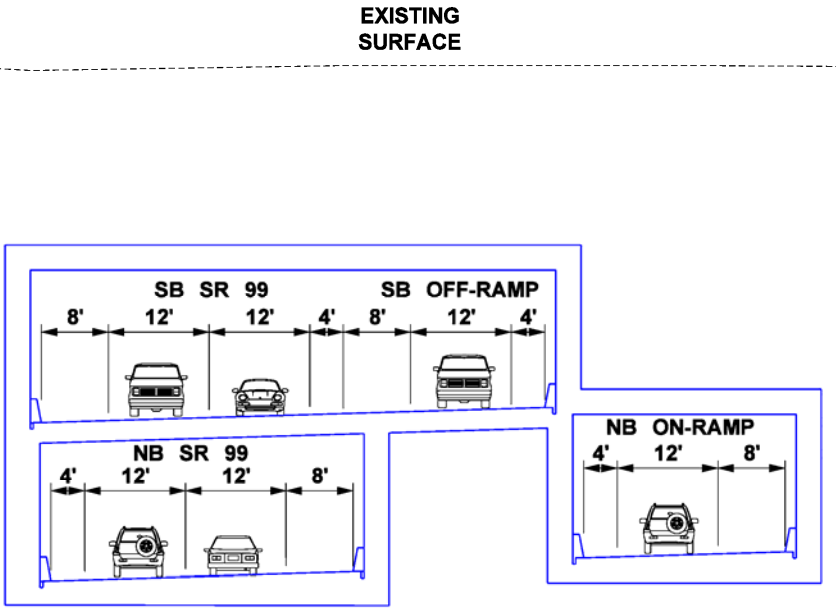

Figure 2. South Segment Typical Section

3.2 Central Segment

The bored tunnel's diameter of 54 feet was determined by setting two stacked roadway widths at 36 feet, with 16.5 feet of vertical clearance each, and building out structurally from there. Any additional clearance requirements would likely have a direct impact on the tunnel bore's outside diameter. The roadway cross-section is designed with a wall-to-wall width of 36 feet in both the northbound and southbound directions. Two 12-foot lanes take up 24 feet, leaving 12 feet for shoulders and possible barriers. There is ongoing discussion with regards to the need of barrier shape within the tunnel (see Appendix A). Currently the project is assuming the use of a barrier shape with a width of 9 inches for each barrier, the remaining area allows for approximately 3 feet-3 inches for left shoulders and 7 feet-3 inches for right shoulders (see Figure 3). Southbound traffic would be on the top roadway deck, and northbound traffic would be on the lower roadway deck.

As part of the fire and life safety requirements, emergency egress locations would be located at approximately 600-foot intervals. To provide sufficient space for safe egress, the current design would require the northbound shoulder to be reduced to

3 feet minimum. The egress structures would be approximately 100 feet long (see Figure 4).

The horizontal and vertical design speed is 50 mph, per *WSDOT Design Manual* guidelines.

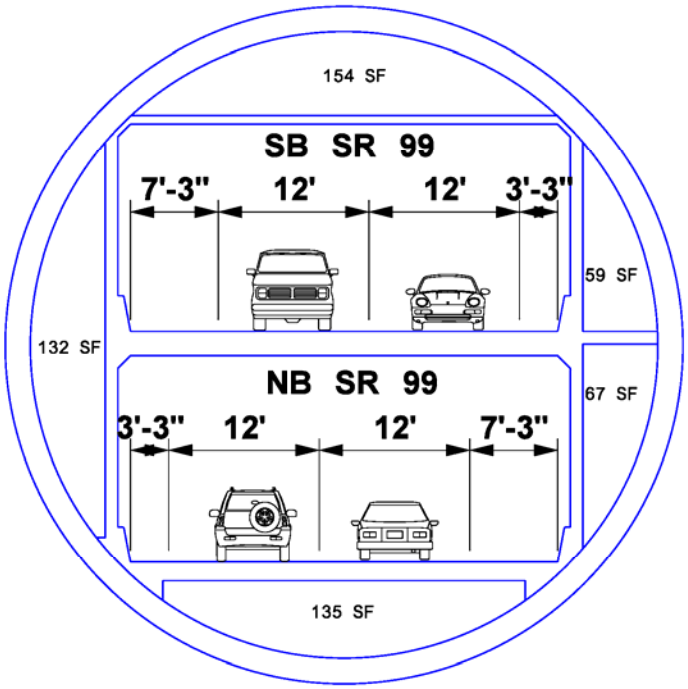

Figure 3. Proposed Standard Tunnel Section

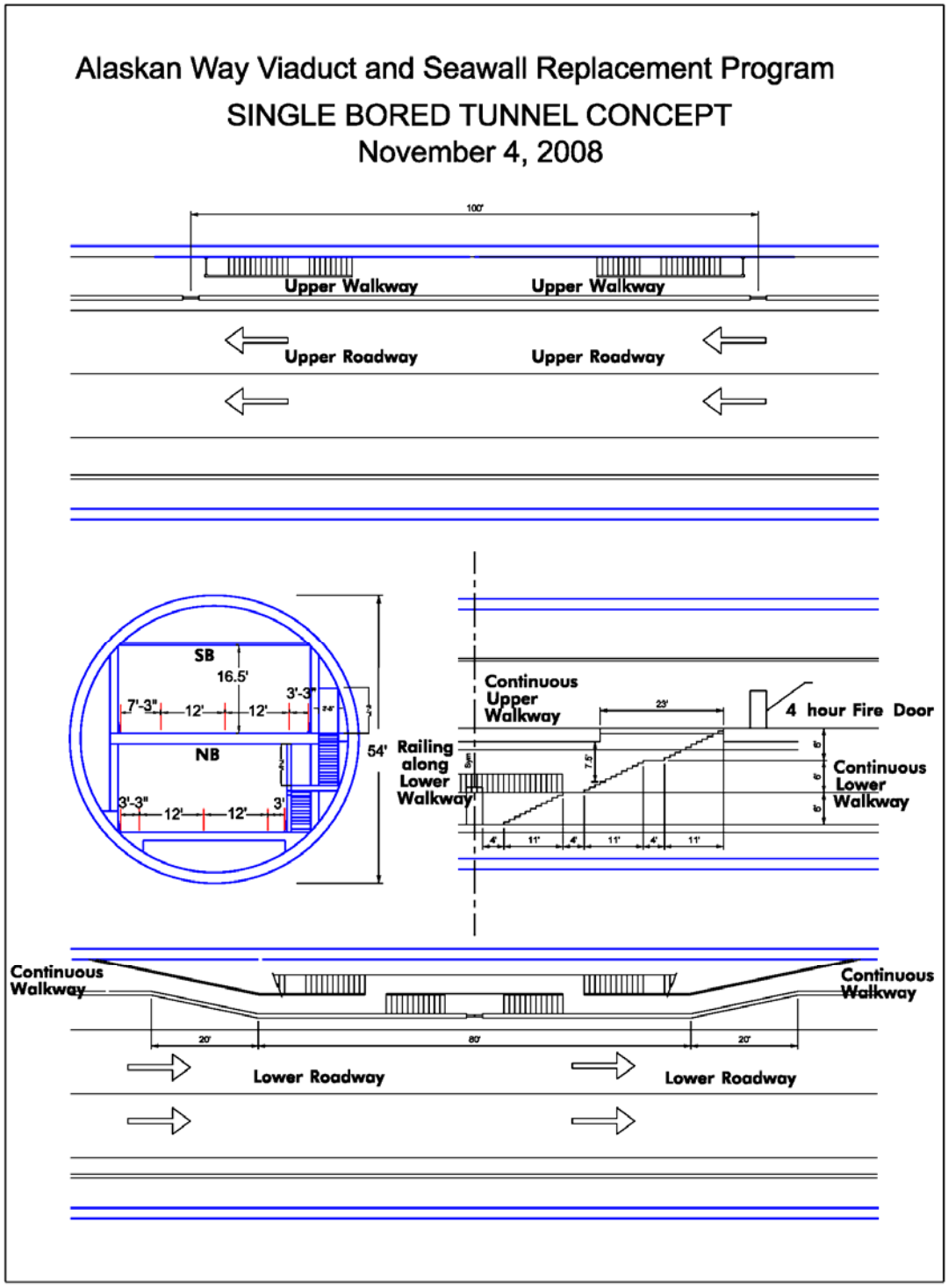

Figure 4. Proposed Tunnel Section with Emergency Egress

3.3 North Segment

The stacked roadways of the bored tunnel section would begin to unbraid and unstack north of John Street, entering a cut-and-cover section between John and Harrison Streets, and a retained cut section north of Harrison Street. Northbound and southbound SR 99 would meet the existing vertical grade between Republican and Mercer Streets. SR 99 would follow and match the existing alignment from Mercer to Ward Streets. The existing SR 99 north of Mercer Street consists of three southbound lanes and three northbound lanes, with a fourth northbound auxiliary lane ending north of Aloha Street. The existing lane width varies from 10.5 feet to 11feet, and there are no existing shoulders, only a gore stripe on the right adjacent to the curb and a 6-foot sidewalk. The existing posted speed is 40 mph.

Access to and from north SR 99 is via ramps at Harrison Street. A northbound on-ramp joins to the two SR 99 mainline lanes as an additional third lane from the left side at Republican Street (see Deviation No. 2). A southbound off-ramp exits from SR 99 as a left-side drop lane (see Deviation No. 2) near Republican Street, leaving two southbound mainline lanes (See Figure 5).

Access to and from the south is via ramps at Republican Street. A southbound on-ramp merges in to the two SR 99 mainline lanes from the right side of SR 99 in a retained cut section. A southbound off-ramp diverges from the two SR 99 mainline lanes in to a deceleration lane approaching Republican Street in a cut section.

SR 99 mainline horizontal and vertical design speed is 50 mph per *WSDOT Design Manual* guidelines. Ramp design speeds range from 10-45mph.

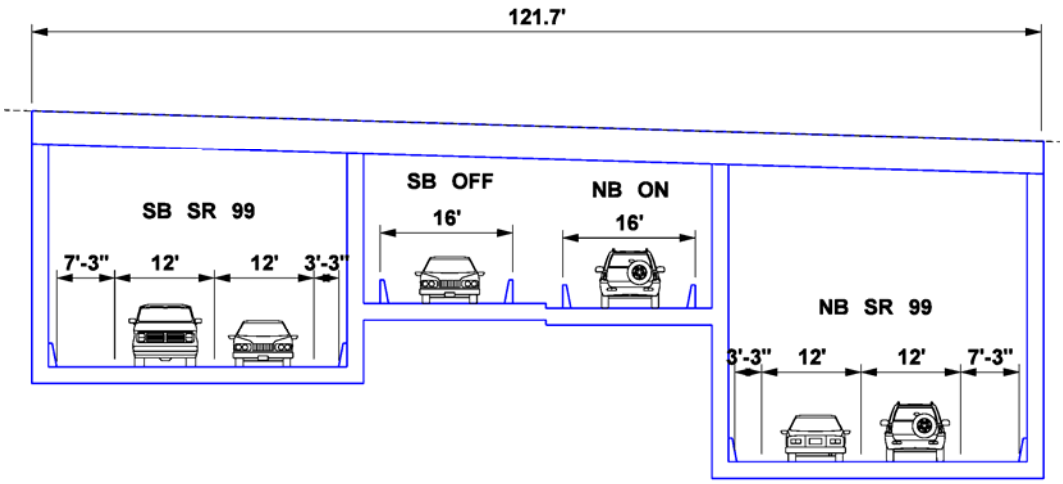

Figure 5. North Segment Typical Section

4.0 Deviation Description – Shoulder Width

The proposed design matrix for the project indicates a "Full Design Level" for shoulder widths. *WSDOT Design Manual* Figure 440-6 specifies a 10-foot right shoulder width and a 4-foot left shoulder width.

This deviation proposes shoulder widths along SR 99 between NB Sta. 178+00 and Sta. 319+90, and SB Sta. 178+00 and Sta. 319+90, as shown in Figures 2, 3, 4 and 5. Table 1 lists the design standard and proposed left and right shoulder widths for the project.

Table 1: Shoulder Widths

Direction	**Left Shoulder Width** (feet)		**Right Shoulder Width** (feet)	
	Standard (*Design Manual* Figure 440-6, May 2008)	Proposed	Standard (*Design Manual* Figure 440-6, May 2008	Proposed
Northbound	4 feet	178+00 to 200+00 4 feet	10 feet	178+00 to 200+00 8 feet
Northbound	4 feet	200+00 to 285+00 3 feet-3inches	10 feet	200+00 to 285+00 Varies 3 feet to 7 feet-3 inches
Northbound	4 feet	300+00 to 317+00 3 feet-3 inches	10 feet	300+00 to 319+90 Varies 7 feet-3 inches to 0 feet to match existing
Northbound	4 feet	317+00 to 319+90 Varies 3 feet-3 inches to 0 feet to match existing	10 feet	317+00 to 319+90 Varies 3 feet-3 inches to 0 feet to match existing
Southbound	4 feet	178+00 to 200+00 4 feet	10 feet	178+00 to 200+00 8 feet
Southbound	4 feet	200+00 to 285+00 3 feet-3inches	10 feet	200+00 to 285+00 7 feet-3 inches
Southbound	4 feet	300+00 to 317+00 3 feet-3 inches	10 feet	300+00 to 317+00 Varies 7 feet-3 inches to 3feet-3 inches
Southbound	4 feet	317+00 to 319+90 Varies 3 feet-3 inches to 0 feet to match existing	10 feet	317+00 to 319+90 Varies 3 feet-3 inches to 0 feet to match existing

Any additional horizontal and/or vertical clearance requirements would likely have a direct impact on the tunnel bore's outside diameter, and require a reassessment of current tunneling technology. Shoulder deviations are required at the north end of the project to match existing SR 99 substandard conditions.

5.0 Alternatives Considered

The Project Team developed and assessed alternate alignments that would best meet WSDOT's design standards, minimize effects to properties, minimize impacts to the environment, minimize construction impacts, work within the limitations of current tunnel construction technology, and allow for efficient construction staging. The alignment alternatives for the mainline roadway are summarized in the following sections.

5.1 Alternative 1: Nonstandard Shoulder Width

Alternative 1 illustrates the preferred alignment. It maximizes shoulder widths, provides 12-foot lane widths, stays within the proposed tunnel diameter, and minimizes right-of-way impacts. This roadway configuration is illustrated in Figures 2, 3, 4 and 5. The tunnel design includes shoulder deviations for shoulder width as described in Section 4.0.

(Talk about TBM expanding technology and will be largest built in US. Initially used twin bore but due to costs, went with single bore – going to upper limits of current technology).

Justification for reduced shoulder widths includes tunnel boring machine technology, emergency egress location requirements by fire/life/safety codes, and matching existing non-standard condition north of the project.

The following constraints have been determined through preliminary design and discussion with the Project Team:

- Tunnel Boring Diameter Technology
- Match existing substandard shoulder widths in the North Segment
- Egress locations at 600 foot intervals in tunnel

Deviations from full design standard shoulder widths would avoid major reconfiguration of the tunnel's proposed diameter and reduce costs.

5.2 Alternative 2: Full Design Standards Alternative

Alternative 2 would apply a project design that used full design standards. This Full Design Standards Alternative was eliminated from further consideration because it would exceed the TBM diameter limits for the technology and would indefinitely extend the project limits where existing shoulder widths are nonstandard.

An approximately 58 foot diameter bore would be required to provide the standard shoulders of 4 feet and 10 feet. A 60 foot bore would be required to accommodate the emergency egress and standard shoulders. Further increasing diameter could prohibitively increase cost of construction and risk. Twin large diameter bores could also be used to accommodate the space restrictions, however this would be cost prohibitive.

6.0 Justification

Alternative 1 (Preferred Alternative) proposes nonstandard design elements for the SR 99 Bored Tunnel Project as follows:

- Northbound shoulder width: Varies 2 to 4 feet (left) and 7 to 10 feet (right)
- Southbound shoulder width: Varies 2 to 4 feet (left) and 3 to 10 feet (right)

The justifications for recommending nonstandard design elements are as follows:

1. The 54-foot-diameter single-bore tunnel is at the technological limit for the industry. The stacked roadway configuration within this diameter has horizontal width limitations when combined with the necessary two lanes, vertical clearance, emergency access points, and potential barriers.

2. The proposed shoulder widths must match the existing shoulder widths at the end of the project limits, which requires that a portion of the shoulder widths within the project limits be tapered down to match the non-standard shoulder widths of the existing roadway.

3. The horizontal stopping sight distances that are provided meet standards for a 50-mph design speed, which matches the design speed for the facility.

4. Shoulder widths on SR 99 were reduced south of Mercer Street to accommodate the project's mainline construction including on and off ramps and a construction detour carrying mainline traffic west of the project *(See Corridor Operation Plan Report)*. Providing full shoulders along this segment would increase the project width and require acquisition of additional properties either west or east of the project. These adjacent properties have buildings abutting the property line and any impacts would require full property acquisitions at a significant cost increase to the project *(see Right of Way Impact Report)*.

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7.0 Recommendation

Alternative 1 proposes a configuration that provides sufficient roadway facilities to fully accommodate vehicular traffic. This alternative also considers the urban environment and other users of the facilities, and balances pedestrian safety with appropriate roadway geometry. The proposed deviation would not adversely affect the safety or functionality of the vehicular traveled way. Impacts to adjoining property uses would also be minimized.

The Project Team recommends that shoulder widths of the mainline roadways be deviated from design guidelines for the SR 99 Bored Tunnel Project. The Project Team also recommends approval of these deviations based on the above justifications.