SEATTLE DEPARTMENT OF TRANSPORTATION

# Additional Review of the Impacts of Deep Bored Tunnel Tolling Diversion on City Streets; Identification of Mitigation

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APRIL 2011

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Photo Source: Seattle Department of Transportation

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# APPENDIX A

# Impacts of a Tolled Tunnel

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This appendix provides information to supplement the assessment of tolled tunnel impacts described in Chapter 2.

## Increased Traffic Volumes and Congestion in Center City Neighborhoods

Addressed in Chapter 2.

## Travel Time on Downtown Streets

The SDEIS assesses impacts to travel times on downtown streets caused by traffic volume increases from diversion due to tolling. The primary effect is increased travel time for general purpose travel of up to three additional minutes at peak times on Second Avenue southbound and up to eight minutes of additional travel time on Fourth Avenue northbound between roughly Wall/Battery Streets and Royal Brougham Way, as shown in Figure A-1.[1] The SDEIS analysis shows little to no impact on transit travel time in these corridors, with the greatest effect being a two-minute increase on Second Avenue during the PM peak. The SDEIS categorizes the general purpose travel time impacts as "not acceptable" but simply concludes that "other scenarios would be evaluated and reasonable optimization measures would be applied and analyzed before tolling would be implemented," however such scenarios and measures are not identified or analyzed in the SDEIS.

A number of travel time analyses were conducted for the Partnership Process evaluation of the surface, transit, and I-5 (ST5) alternatives. During the Partnership Process, the technical team stressed the importance of point-to-point travel times, attempting to reflect the actual experience of travelers who most utilized the SR 99 corridor. For example, travel time analyses were made for trips such as Ballard to SODO, West Seattle to Uptown, Fremont to CBD, Burien to CBD, and Greenwood to Airport. In all cases, these analyses were conducted for general purpose traffic and for transit users to provide a full description of impacts.

Since SDEIS and Partnership Process travel time analyses used different end points, data comparison presents some challenges. However, there is some opportunity for comparison on Fourth Avenue, which is the highest volume downtown arterial street. Analysis conducted as part of the Partnership Process for the Surface and Transit Scenario B (four-lane Alaskan Way) estimated northbound travel time on Fourth Avenue between Edgar Martinez Way and Cedar Street at 12 minutes. This compares with SDEIS travel time estimates for northbound traffic on Fourth Avenue between Royal Brougham Way and Battery Street of 12 minutes for a non-tolled bored tunnel and 16 minutes for a tolled tunnel (Toll Scenario C). The segment analyzed for the ST5 analysis is three blocks longer than the segment analyzed in the SDEIS tunnel analysis.

1 2010 SDEIS, Figure 9-17, p. 215

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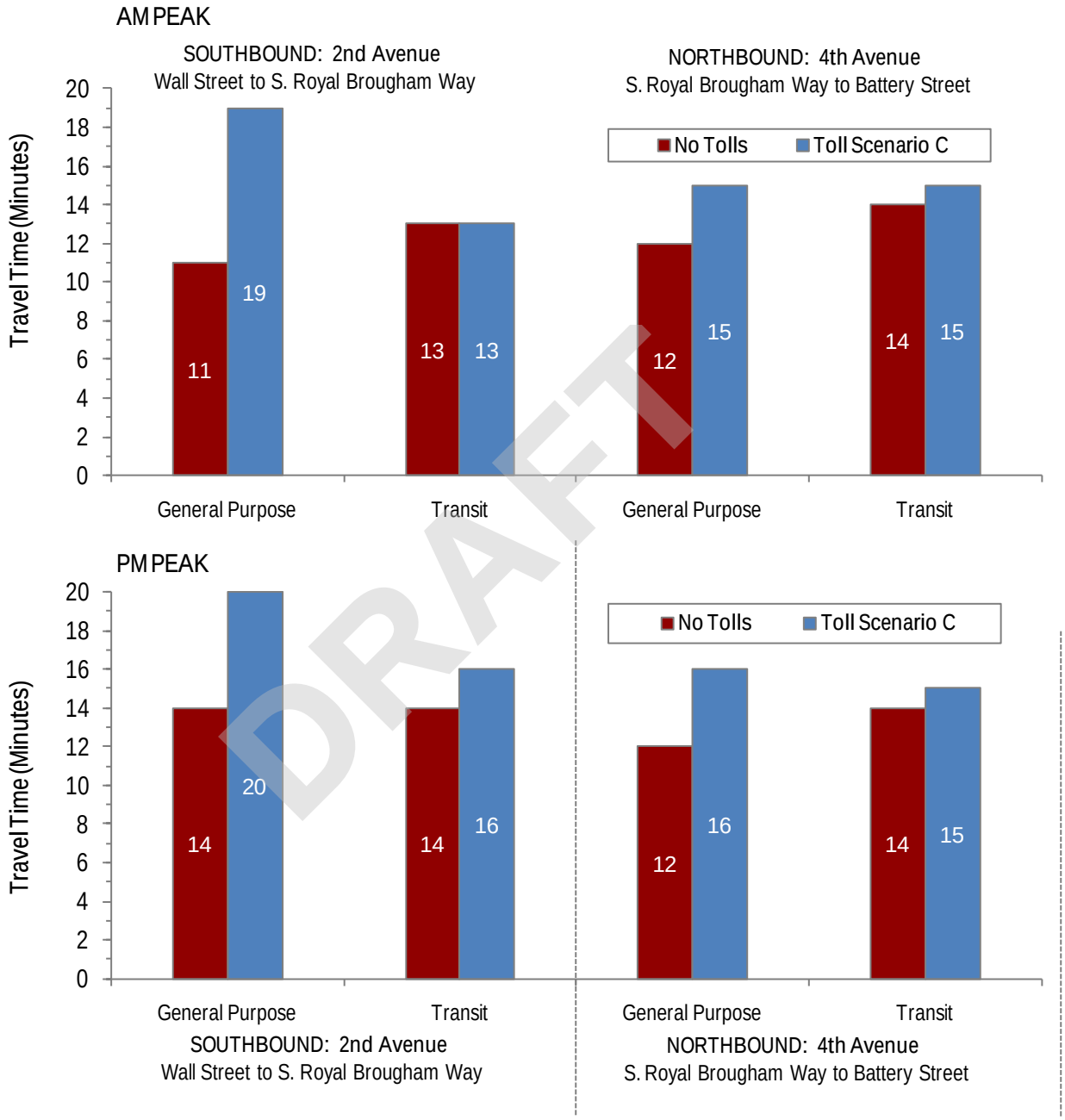
**Figure A-1 Comparison of Travel Times for General Purpose Travel and Transit with Untolled Bored Tunnel and Toll Scenario C, for AM Peak and PM Peak**




Source: WSDOT Alaskan Way Viaduct Replacement Project 2010 Supplemental Draft EIS, Chapter 9, Exhibit 9-17

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## Highway Ramps are a Key Cause of Congestion in Seattle's Center City

When compared with the existing Alaskan Way Viaduct, the SR 99 deep bored tunnel maintains a comparable mainline capacity and reduces the number of downtown ramps. When the tunnel is tolled, congestion impacts are projected to occur on surface streets connecting to the north and south portal ramps. The SDEIS tolling analysis illustrates that tolling the tunnel will magnify these impacts by relocating some trips from the tunnel to surface streets and to I-5. Increased surface street traffic has the potential to create a lower quality and/or level of service for pedestrians (e.g., potential for longer signal cycles for vehicles, reduced spacing for street crossings, more turning conflicts, etc.).

Figure A-2 and Figure A-3 illustrate where the highest levels of intersection delay exist in the downtown area, based on 2006 data. This data remains relevant since overall traffic volumes in the city have actually decreased over each of the last five years and there have been no major changes to highway ramps. Almost every intersection with peak period LOS of D, E, or F (poorest performance) is either affected by a nearby highway on/off-ramp or is at an intersection where downtown's many grid systems meet. With the deep bored tunnel project and tolling, higher volumes of traffic are projected to access downtown with fewer on and off opportunities than currently provided, funneling traffic onto a small number of surface streets.

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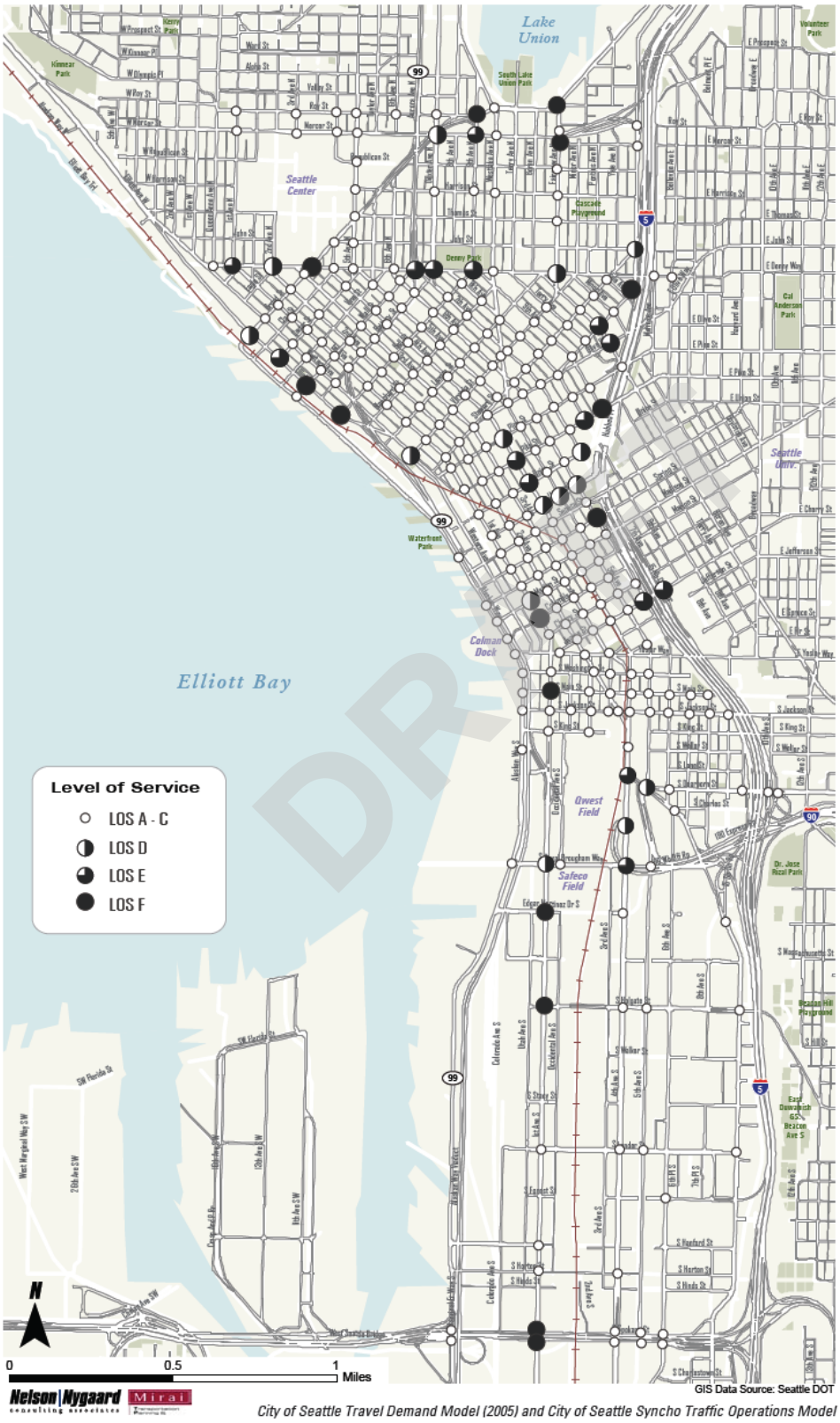
## Figure A-2 AM Peak Hour Intersection Level of Service (2006)

City of Seattle Travel Demand Model (2005) and City of Seattle Syncho Traffic Operations Model

## Figure A-3 PM Peak Hour Intersection Level of Service (2006)




*City of Seattle Travel Demand Model (2005) and City of Seattle Syncho Traffic Operations Model*

In addition to increased vehicle volumes on city surface streets, the Toll C scenario is projected to cause backups on the SR 99 mainline approaching the portal area ramps.

> *"Drivers using the bored tunnel for 2015 Bored Tunnel Toll Scenarios A and C are projected to have slightly longer travel times than they would for the 2015 Bored Tunnel due to expected backups on the SR 99 mainline. These back-ups would be due [to] heavier off-ramp volumes just before the bored tunnel, which would increase delay at intersections at the ramp termini."*[2]

The SDEIS analysis of I-5 mainline travel times suggests there is little impact to travelers from traffic diverted to I-5; this is likely due to already high levels of congestion. The more significant impacts may occur on surface streets feeding I-5 ramps, which are already the most congested areas of the Center City. In fact, the SDEIS analysis shows that Fourth Avenue would have the greatest increase in travel time. Other streets such as Fifth Avenue and streets east of I-5 are not analyzed.

Figure A-4 shows the impacts on I-5 as projected in the SDEIS tolling analysis. The change in travel time for Toll Scenario C is the difference in travel time from the No Toll tunnel case, shown here only for the PM peak.

**Figure A-4 Traffic Diversion to I-5 from SR 99 Tolling; Change in Travel Times on I-5 and SR 99 Due to Tolling**

| Bored Tunnel With: | I-5 (2015 Average Daily Traffic) | Additional I-5 Trips per Weekday | I-5 PM Peak Travel Time (Additional Minutes Northgate to Boeing Field) | | SR 99 PM Peak Travel Time (Additional Minutes Travel Time Woodlawn Park to S Spokane Street) | |
|---|---|---|---|---|---|---|
| | | | SB | NB | SB | NB |
| **No Toll** | 263,900 | 0 | - | - | - | - |
| **Toll Scenario C** | 279,100 | 15,200 | 2 | 1 | 2 | -1 |

Source: AWVRP SDEIS, Exhibit 9-8 (Travel Times), p. 212, and Exhibit 9-13 (Traffic Volumes) p. 214.

[2] *AWVRP 2010 SDEIS, Chapter 9, p. 209.*

## Increased Delay and Reduced Reliability for Critical Transit Services

Transit performance and the transit system's future contributions to mobility have the potential to be impacted by a SR 99 deep bored tunnel and tolling project. Traffic congestion on surface streets in particular has the potential to impact numerous transit users in Seattle Center City. Increased transit travel times due to congestion counteract the impact of planned service investments, consume valuable operating resources, and have the potential to reduce ridership growth over time. Transit connections to the SR 99 mainline are generally well conceived and transit has been provided priority lanes for most connections in the North Portal area. However, significant diversion from tolling can impact transit operations in the portal areas, particularly in the vicinity of the south portal where transit lanes have yet to be planned.

Reliable, fast transit access to downtown is critical to Seattle's ability to accommodate projected growth and ensure vulnerable populations have reliable access to downtown jobs and services.

The City of Seattle and King County Metro are making significant investments in transit in the Center City and planning is underway that could lead to future surface-running high or intermediate capacity transit investments. Design and management of the AWVRP could have a significant impact on surface street demands, particularly in corridors that are designated for surface street transit operations (for example, transit operational impacts from increased traffic on Jackson Street and First Avenue). The City plans to construct a new streetcar line that will operate primarily in mixed traffic on Jackson. Traffic volumes increase significantly on this street in a tolled tunnel scenario and key intersections become more congested. City plans have identified First Avenue as the potential future streetcar corridor. First Avenue also has potential to carry light rail service connecting outer neighborhoods such as Ballard into downtown. The City may want to ensure that transit priority treatments for streetcar operations on the First Hill line are included in the project if needed to ensure that anticipated levels of speed and reliability can be met. Further analysis of potential impacts on future Center City transit is needed.

Two specific concerns related to transit that arise from a tolled tunnel are:

- Retaining transit as an affordable, reliable alternative mode of access for non-drivers and low-income persons traveling to and through the Center City.
- Mitigating financial impacts on transit operations due to excessive delay and lack of reliability in the connecting corridors.

Each of these concerns is discussed below.

### *a. Impact on Low-Income and Vulnerable Populations*

The SDEIS identifies disproportionately high impacts of a tolled tunnel on low-income users as a "not acceptable" outcome. Analysis from the City of Seattle's Transit Master Plan, included in Figure A-5, shows that the SR 99 corridor travel markets include a number of areas with high concentrations of low-income people, people with disabilities, and seniors over the age of 65. Vulnerable populations living in the SR 99 corridor may also be among those in the city most likely to face challenges accessing transit.

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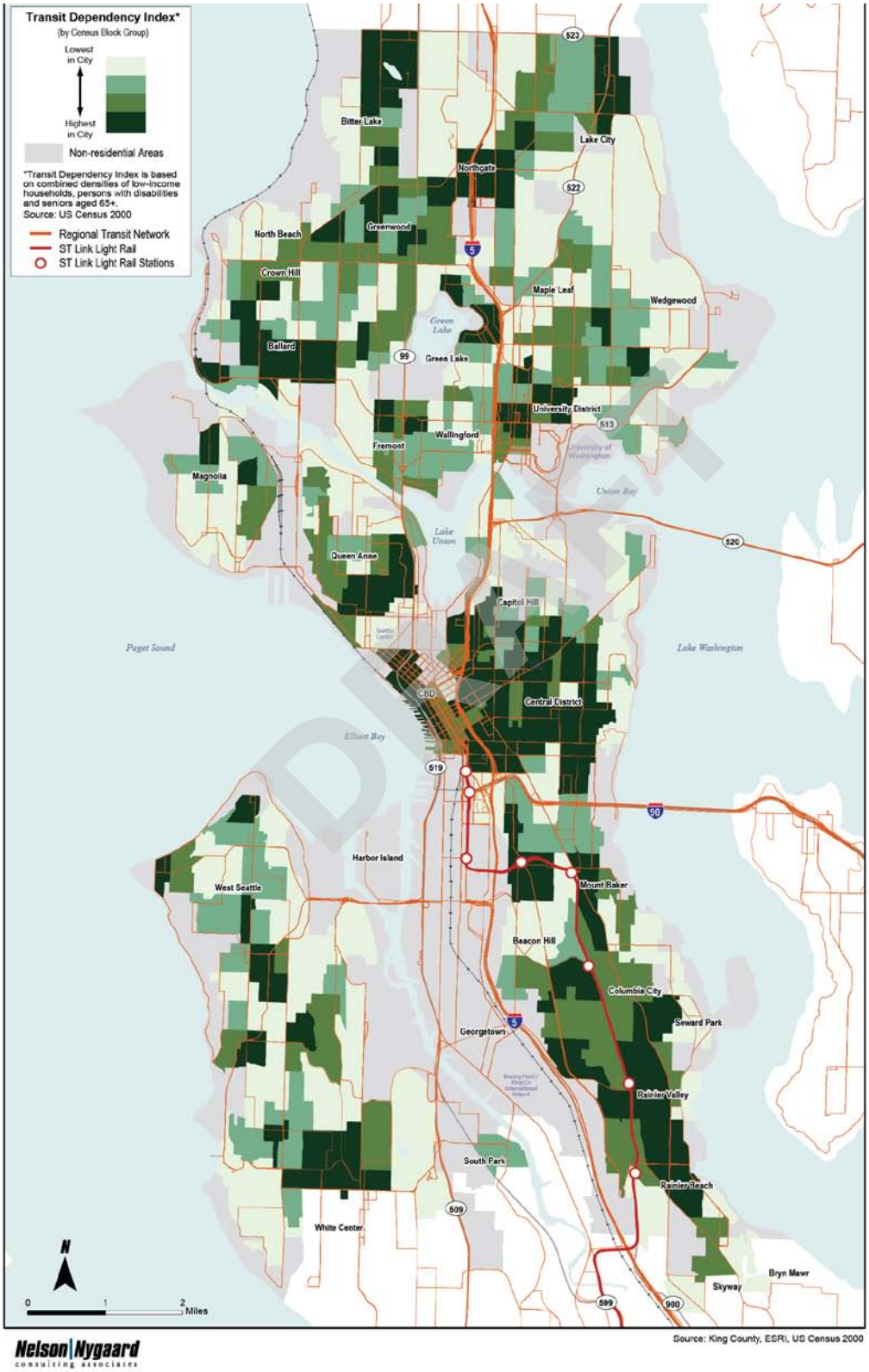
## Figure A-5 Transit Dependency Index



Transit improvements including increased service frequency, access improvements, shorter travel times, and single-seat trips through downtown could be a meaningful way for the project to address impacts on vulnerable populations. No such improvements are recommended in the SDEIS.

***b. Financial Protection of Transit***

This report is being written at a time when King County Metro is facing one of the most difficult financial periods of its existence as a transit provider. Any increase in operating costs to maintain existing levels of service (e.g., due to increased delay on transit-carrying streets over the next decade), will mean less service is provided in some other part of the Metro system. The SDEIS establishes that surface street conditions, particularly at the tunnel portals, will be sub-optimal as a result of the project and the need to toll the project as a financial tool. The SDEIS clearly states that optimization of surface traffic will be required.[3]

The SDEIS finds that a tolled tunnel would create an additional one to two minutes of delay for buses operating on Second and Fourth Avenues between SODO and Belltown. This finding seems like a low estimate given that transit operates in dedicated transit lanes that share turning movements with vehicles. Additional auto queuing in these lanes will increase transit delays. Nonetheless, considering that over 250 buses use these corridors during a peak hour,[4] even small increases in delay will have a substantial impact on operating costs.

To simply illustrate the relationship between delay and transit operating costs one can imagine a transit route that takes 30 minutes to operate from end to end (or 60 minutes round trip). If the route runs at 5-minute headways, it would require 12 vehicles to be in operation at any time. Adding just a few minutes of running time to this route would require the addition of another vehicle to maintain the current headway. Conversely, reducing its travel time by five minutes would allow for a vehicle to be eliminated. Therefore, a seemingly minor difference in travel time for transit could carry significant costs—as much as $1500 per day ($330,000 per year) on a route that provides 18 hours of service. Considering the number of transit routes that enter downtown each day, even a half minute delay for each bus would carry a significant annual cost.

If a tolled tunnel is constructed, programmatic efforts to reduce surface street traffic (e.g., TDM measures and more effective downtown parking management) and transit capital investments to protect transit from traffic delay would be required to ensure transit remains timely, reliable and cost effective.

## Reduced Access to Center City Businesses

The deep bored tunnel proposed in the SDEIS is a downtown bypass facility. It provides access to downtown at two portals and is designed primarily to carry longer distance trips bypassing the Center City. Once traffic reaches the Center City it is distributed on surface streets.

[3] E.g., p. 215 of the SDEIS.

[4] Based on 2007 data collection by Nelson\Nygaard at 2nd Avenue & Marion Street and 4th Avenue & Pike Street, between 4:30 pm to 5:30 pm.



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Access to Center City businesses and services is more important for the Seattle economy than vehicle throughput. Transportation system performance should not be measured by the ability for vehicles to move freely, but rather on the ability for people to access goods and services, and for goods and freight to move reliably. To maximize economic benefit of transportation infrastructure, downtown streets should carry trips destined for downtown businesses and venues. One effect of a tolled tunnel, diverting single occupant vehicles from a deep bore tunnel to use surface streets to bypass downtown en-route to through destinations, is a questionable use of Seattle's most valuable street rights-of-way.

Various analyses and modeling efforts have shown that somewhere in the range of 70% to 80% of trips on the Alaskan Way Viaduct have at least one end in the Center City. In other words, the current highway is used largely for access to the Center City. To a lesser degree it acts as a surface arterial providing short circulation trips within the Center City and provides long distance trips with two ends outside the City of Seattle. Based on the 2005 analysis depicted in Figure A-6, of all northbound trips on the Viaduct (between Columbia Street and First Ave S. ramps), just 15%of travel north of 85$^{th}$ Street North and just 3% pass the Seattle city limits. For southbound traffic on the Viaduct (same location), there is more through downtown traffic bound for West Seattle and points south of the City limits. Most of these trips originate in the Center City area or just north of the Ship Canal.

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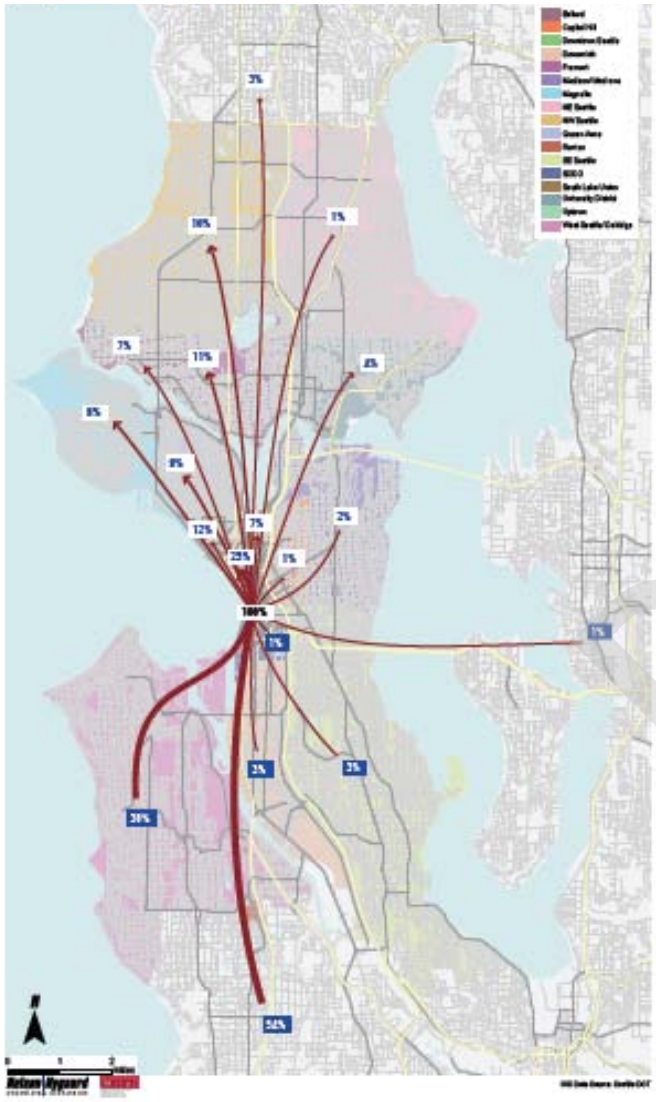
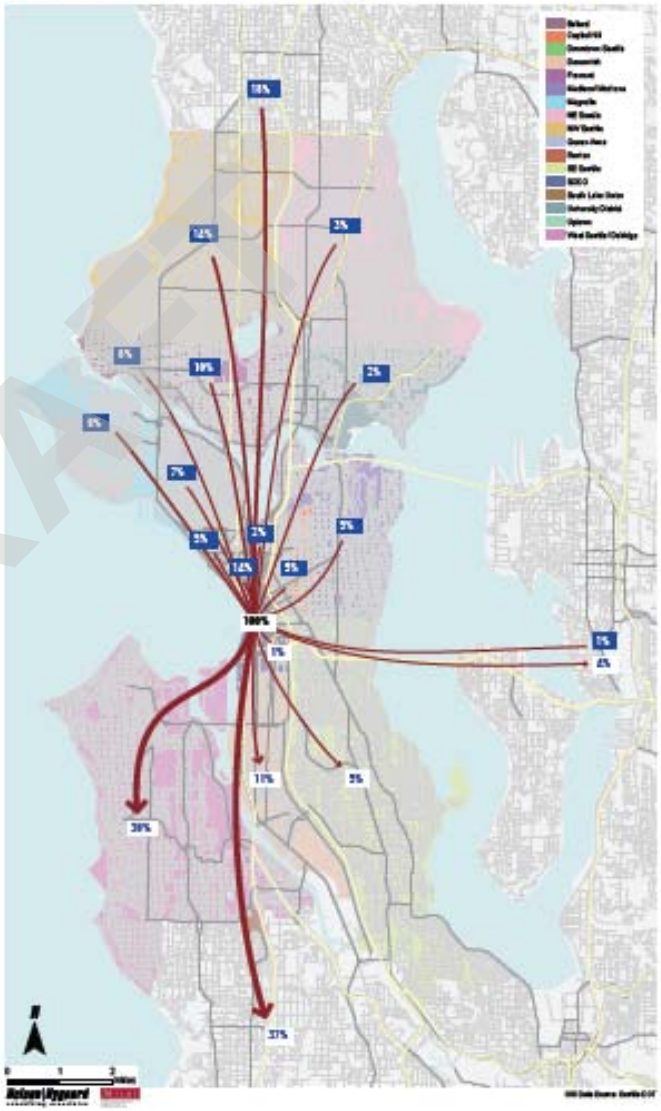
**Figure A-6 AM Peak Period (3-Hour) Origins and Destinations on SR 99: Northbound (left) and Southbound (right)**





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The AWVRP 2010 SDEIS helps to illustrate that more SR 99 travelers access the Center City than bypass it. Figure A-7, reproduced from the SDEIS, shows that with the Viaduct in place, projected 2015 traffic levels of nearly 53,000 daily vehicles approach downtown from the south. Approximately 36,000 vehicles exit the Viaduct's three northbound downtown off-ramps. Assuming that a relatively small amount of vehicles would make very short trips on the Viaduct entering at the First Avenue ramp and exiting at Western Avenue, this represents about 68% of directional trips. In the opposite direction, over 52,000 daily vehicles are projected southbound between the Stadium Area ramp and Spokane Street. Since about 39,000 vehicles enter the three southbound ramps in the downtown with no opportunity to exit, at least 74% of this volume has an origin in downtown. In addition, there is likely a significant amount of turnover at the multiple South Lake Union area access points. A similar analysis of 2015 ramp volumes during peak periods shows an even higher percentage of trips using the Viaduct to enter or exit downtown.[5]

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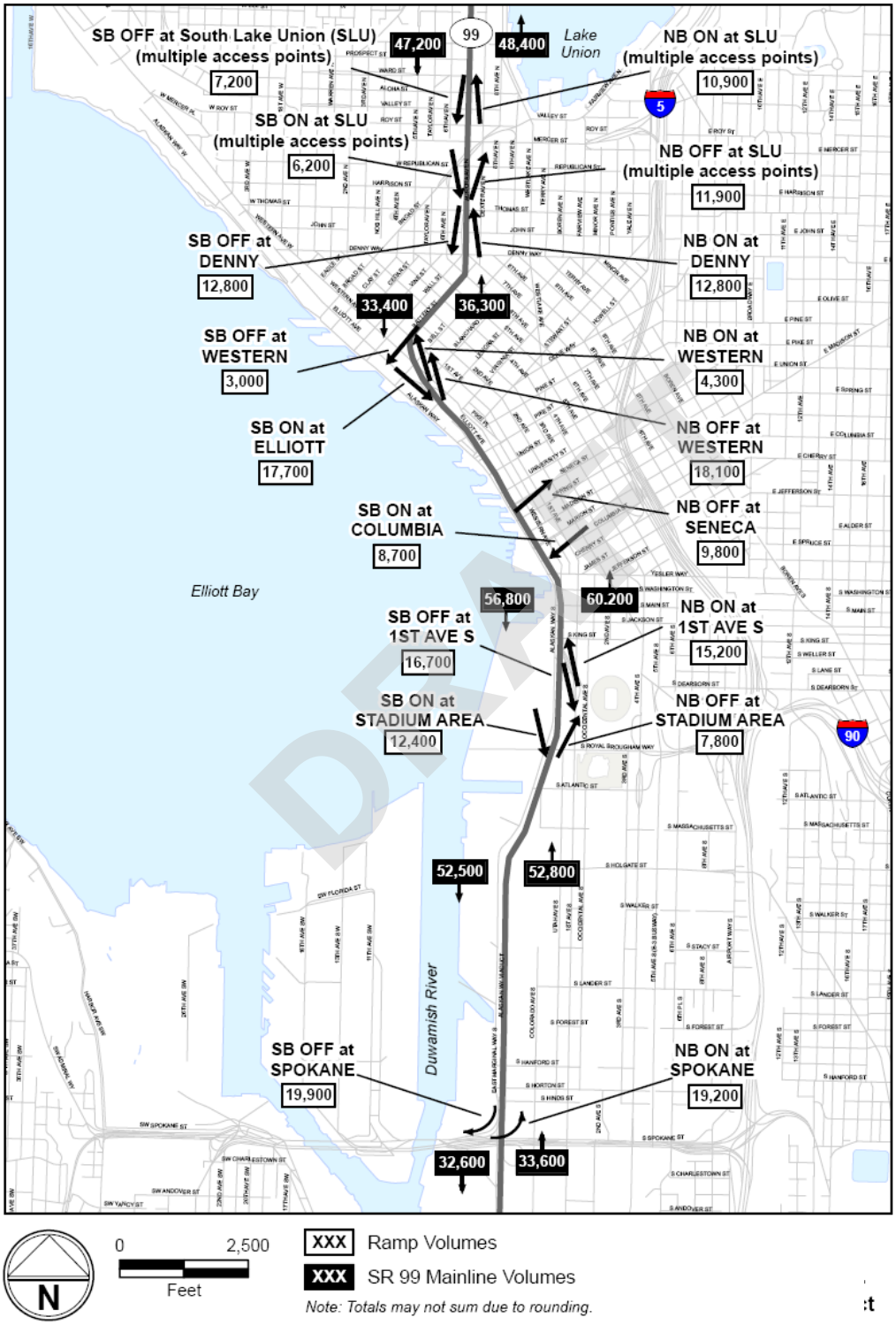
[5] See AWVRP 2010 SDEIS, Appendix C, p. 154 (AM Peak) and p. 160 (PM Peak).

## Figure A-7 2015 Mainline and Ramp Volumes, Existing Viaduct




Source: 2010 AWVRP SDEIS, Appendix C (Transportation Discipline Report), Exhibit 5-16, p. 182

It is worth noting that the construction of a deep bored tunnel would replace a freeway segment designed as part of a larger system planned at the peak of the highway building era, but never connected to the system. In fact, the original facility, completed in 1953 between Battery Street and Dearborn Street, did not have downtown on-ramps. The Seneca Street off-ramp and Columbia Street on-ramp were added in 1961,[6] shortly following completion of the southern extension to Spokane Street in 1959, illustrating the utility downtown access provided for travelers on SR 99.[7]

The change in downtown access patterns can be seen in the map of 2015 daily traffic volumes on SR 99 with a bored tunnel (Figure A-8). Without direct access to downtown between the tunnel portals, the deep bored tunnel becomes most attractive for trips that bypass downtown. This differs from current use of the AWV and may be part of the reason for high projected diversion levels when tunnel tolling is analyzed. Given that a high percentage of users on the AWV today are traveling to/from the Center City, it is not surprising that tolling diversion from a bored tunnel is projected to be high for a tolled tunnel replacement. Some travelers who would use a non-tolled tunnel are likely currently traveling past their destination and doubling back on surface streets due to the high speed connection provided by the tunnel. For example, a commuter traveling to the Denny Triangle from West Seattle might choose to travel through the tunnel, exit at the north portal and drive back southbound on surface streets to save a small amount of travel time. The value of this tunnel trip is marginal since it increases VMT and still uses surface street capacity, just on a different path. Offered for free, the marginal travel time savings is enough to encourage such a trip into the tunnel. In a tolled tunnel scenario, this traveler would likely exit in the Stadium area and approach through downtown.

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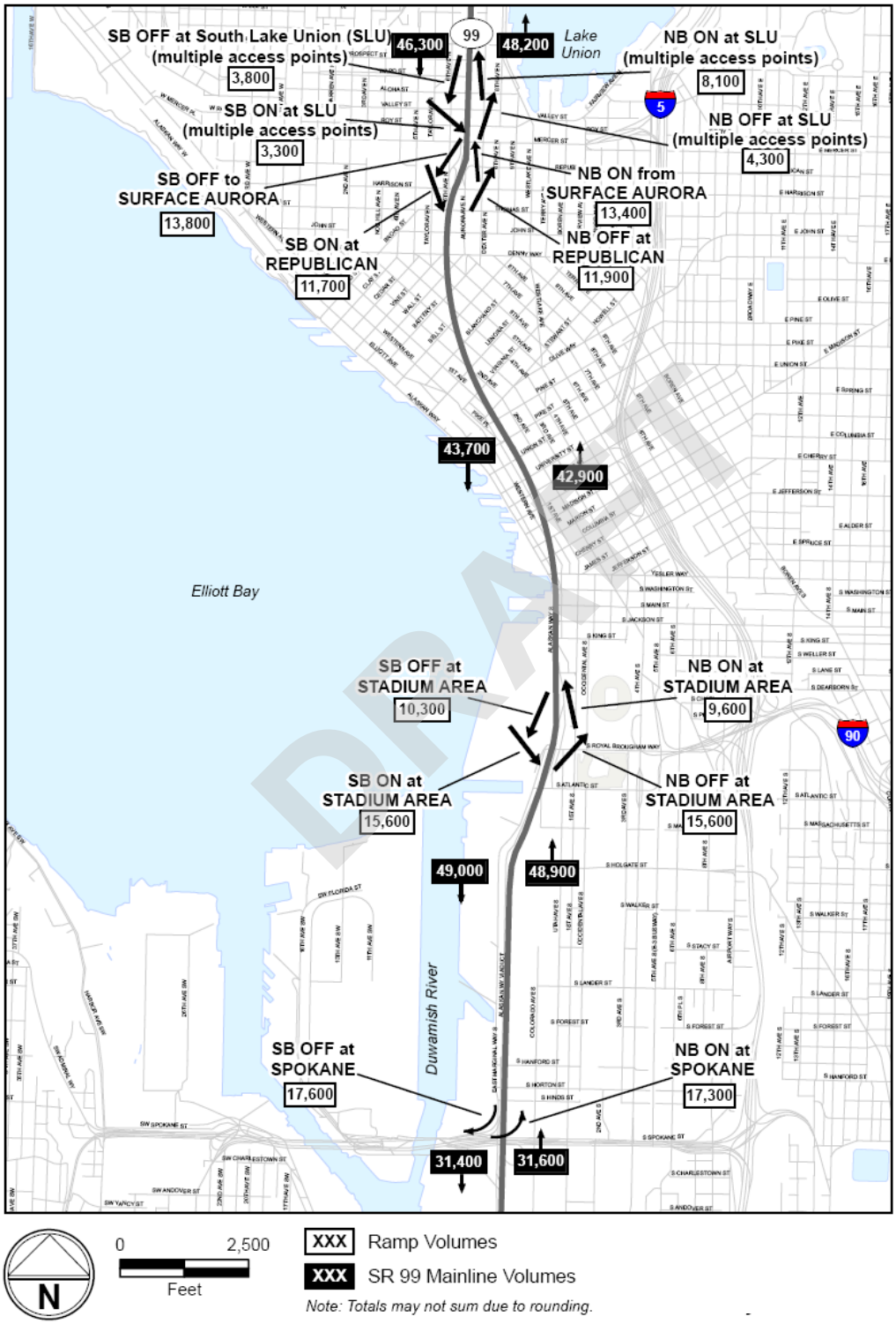
[6] http://content.lib.washington.edu/cgi-bin/viewer.exe?CISOROOT=/imlsmohai&CISOPTR=1736&CISORESTMP=&CISOVIEWTMP=&CISOMODE=thumb

[7] WSDOT – SR 99 Project Photo Gallery

## Figure A-8 2015 Mainline and Ramp Volumes, Bored Tunnel




Source: 2010 AWVRP SDEIS, Appendix C (Transportation Discipline Report), Exhibit 5-17, p. 167.

***Downtown Access Will Be Particularly Challenging during Later Phases of Construction***

There will be heightened access challenges during the 18 to 24 month time period between opening of the deep bored tunnel and the opening of the new Alaskan Way surface street, including the connection to Elliott and Western. Although the linking of the new SR 99 deep bored tunnel to surface highway segments will be relatively seamless, a fully connected Alaskan Way will not be available until approximately two years later. Alaskan Way is a critical path to providing vehicular, bicycle and pedestrian and possibly transit access to and from SR 99 south to downtown. While the Stage 8 construction phase will require 13 months, the completion of the Elliott/Western connector will require another 6 to 11 months (as estimated by the City of Seattle). A detailed traffic management plan has yet to be developed; however, it can be assumed that:

- The limited availability of this key facility will reduce functionality of the street network around the south portal
- Higher traffic volumes will occur on First, Second, and Fourth Avenues
- Transit routing may need to be established through south downtown (First or Fourth Aves rather than SR 99)
- A significant mitigation program will be needed to shift trips to transit or other high occupancy modes

***SR 99 is an Important, but not Heavily Used Freight Route***

Of the over 100,000 daily trips at the peak travel point on the AWV, approximately 5,000 are truck trips.

The Partnership Process focused significant analysis on the role of AWV for carrying freight and the tradeoffs with various replacement options for freight travel. It was found that only freight using SR 99 between the stadium area and Mercer is impacted by the choice of an alternative to replacing SR 99. Freight traffic bound to and from Port of Seattle facilities at Terminal 46 and to the south is enhanced by the "Moving Forward" projects currently under construction and is essentially unaffected by the choice of a Central Waterfront replacement alternative. The freight pathways most impacted by differing alternatives on SR 99 are those that connect the SODO/Duwamish Industrial area, along with I-5, I-90 and SR 99 to the south, with the Ballard/Interbay Industrial area. For this particular freight route, the Deep Bored Tunnel produced travel time results closest to the Surface and Transit Alternatives in Partnership Process analysis. This is primarily due to the fact that the Elliott/Western connection can only be reached by surface Alaskan Way in the Deep Bored Tunnel Alternative as well as ST5 alternatives. It should be noted, however, that travel times for the Alaskan Way and Elliott/Western corridor were not evaluated for a *tolled* Deep Bored Tunnel as part of the Partnership Process.

Finally, it must be recognized that SR 99, as a freight route, is very different than I-5. I-5 has a very high percentage of trucks, many full sized semis. SR 99 has a much lower percentage of truck traffic with very few semis. For example, as illustrated in Figure A-9, the AWV mainline south of Seneca Street carries just over 5,000 trucks per day comprising 5% of daily traffic, while I-5 at Olive Way carries about three times as many trucks making up over 7% of daily traffic volumes. In addition, most freight

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traffic on SR 99 is local in nature and is accommodated on lightweight trucks, including many vans and small commercial vehicles. Trucks traveling in the Battery Street Tunnel daily total 1,900, signifying that many of the 5,000 trucks at the Seneca measurement point enter from Elliott/Western or are making deliveries to downtown. Many of these trucks are likely to use Alaskan Way if a deep bored tunnel is constructed.

## Figure A-9 Truck Trips to and from Seattle

| Truck Market | Count Location | Trucks per Day (Average Weekday) | % of Daily Traffic |
|---|---|---|---|
| **Through Trucks on I-5** | I-5 at Olive Way*<br>I-5 at N 185th Street* | 15,800<br>12,700 | 7.2%<br>6.7% |
| **Through Trucks on AWV** | AWV mainline south of Seneca Street*<br>Elliott Ave & Western Ave Ramps*<br>Battery Street Tunnel<br>Columbia & Seneca Street Ramps | 5,200<br>2,600<br>1,900<br>700 | 5.0%<br>7.8%<br>3.2%<br>4.1% |
| **Port Truck Trips**<br>**Total Port Trips**<br>**Dray Trips to Rail yards**<br>**Trips to/from Region** | Terminal trip estimates* | <br>5,950<br>1,950<br>4,000 | <br>n/a<br>n/a<br>n/a |
| **Deliveries to Downtown Businesses** | Sample of downtown access points<br>Stewart Street south of Denny Way*<br>4th Avenue north of James Street*<br>Seneca Street off-ram rom AMV*<br>Boren Avenue north of 12th Ave.* | <br>810<br>1,630<br>500<br>1,570 | <br>6.1%<br>11.1%<br>5.6%<br>13.6% |
| **Construction Trucks** | Volume depends on location and quantity of construction projects | Up to 170 trucks per day per downtown highrise site | n/a |
| **Over-dimension Trucks** | Volume varies daily. The City issues annual permits to some companies, and cannot track the number of times the permit may be used. | | |

Source: Seattle Urban Mobility Plan Briefing Book, Transportation in the Center City Today, p. 3E-2, http://www.seattle.gov/transportation/briefingbook.htm.

Detailed Source Notes: [a] AM and PM peak period manual classification counts performed in September 2003 by Parametrix, Inc. The six hours of peak period data were expanded to a 4-hour volume using detailed count information on I-5 at NE 185th (see reference b.). [b] Truck classification counts performed by WSDOT Permanent Traffic Recording Station P-3 (I-5 at NE 185th Street), October 2003. These counts were compiled for the "I-5 Pavement Reconstruction Projects Final Existing Transportation Conditions Technical Report," Washington State Department of Transportation (WSDOT) and Parametrix, March 2005. [c] SR 99: Alaskan Way Viaduct & Seawall Replacement Project. "Memorandum: Updated SR 99 Truck Volumes, September 6, 2006." Counts were performed in June 2006 using video and visual survey. Vans and "similarly sized small delivery trucks" are not included in the counts because it was unknown whether such vehicles were in commercial use. [d] "Port of Seattle Container Sustainable Growth Plan, Draft Transportation Analysis," Heffron Transportation, Inc. May 17, 2006. The truck volumes reflect an annual average condition for 2002. [e] Truck Needs Assessment for City of Seattle, Truck Volume and Classification Data Base, Heffron Transportation, Inc., September 20, 2007. All counts performed in May 2007.

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# Appendix B

# TRAVEL DEMAND MODELING AND TRANSPORTATION SYSTEM ADAPTABILITY

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This appendix provides a brief overview of the travel demand models in use in Seattle and the region; these are key tools used to evaluate alternatives for replacing the Alaskan Way Viaduct. It then discusses the importance of incorporating the dynamic relationship between land use and transportation into modeling practice, a key issue affecting the model's analysis of the AWVRP alternatives. Finally, the appendix describes two research efforts, summarized briefly:

- A local study where a dynamic land use modeling process was applied to SR 99/AWV travel time analysis. Based on the results, the researchers suggest that simply removing the Viaduct with no improvements would create no to relatively insignificant travel time changes for many important regional trips. Their model predicted that SR 99/AWV corridor trips are likely to have a higher travel time in such a scenario, but model variability suggests the possibility that the difference could be small.
- A study released by the Oregon Transportation Research and Education Consortium (OTREC), evaluated two hypothetical scenarios of freeway investment and an arterial street network investment in the Twin Cities region and concluded that "a 'No-More-Freeway' policy is more efficient from a mobility point of view than invests in more freeway capacity."

Finally, the appendix presents findings from a review of modeling work performed for the 2010 SDEIS.

## Overview of Traffic Modeling in Seattle and the Region

The Seattle travel model is based on the one used by the Puget Sound Regional Council (PSRC). These models have been enhanced to address many of the limitations of the basic four-step model, [1] including:

- The PSRC model uses additional trip purpose classifications to account for work, school, college, shopping and "other" trips from home as well as trips not originating at home and commercial vehicle trips.
- PSRC makes extensive use of household surveys which accurately measure current behavior on the regional level. The sample size of these surveys may not allow for more subtle analysis of differences in behavior in smaller areas, such as downtown Seattle, compared to other parts of the region.
- The PSRC model has a component called the Time of Day module, which accounts for "peak spreading" when trips cannot be accommodated on a given facility at the busiest times of day.
- The Seattle model has reduced TAZ sizes. This allows the model to be smarter about mode choice, particularly for short-distance trips that people are more likely to make by walking or cycling.
- The Seattle model has recently adjusted future parking cost increases, particularly in areas that are increasing in density and undergoing redevelopment.

[1] These steps are: (1) Trip Generation, (2) Trip Distribution, (3) Mode Choice, and (4) Route Assignment. The Seattle Urban Mobility Plan Briefing Book provides a more detailed overview. See http://www.seattle.gov/transportation/briefingbook.htm, Chapter 4: What Do We Know About the Future, p. 4C-1

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While improvements have been made to the model, it is not a perfect predictor of behavior. For example, the model has predicted increasing traffic volumes on I-5 and on downtown streets, which have both been essentially unchanged for a number of years, despite overall growth.

While the travel demand model is far from perfect, it remains the only analysis tool available to predict future travel behavior that has been subjected to rigorous regional scrutiny. The travel demand model remains an important analysis tool, though not the only tool for evaluating the effectiveness of alternatives in the future.

## The Role of Dynamic Land Use-Transportation Modeling

The Seattle metropolitan area does not use a system of modeling that evaluates the dynamic effects of transportation investments on land use and vice versa. The PSRC region's econometric/real estate model, which evaluates the changes in land use created by transportation investments, is not used to evaluate changes in land use allocation for a specific transportation project, such as the Alaskan Way Viaduct Replacement. This is a significant gap in project planning since we know that transportation infrastructure projects change household and employment location choice and affect how and where developers chose to build.

In Portland, the regional governing body Metro, uses such a model (actually a series of models), called MetroScope, in tandem with its travel demand model to evaluate land use changes resulting from investments programmed in the Regional Transportation Plan. MetroScope consists of model elements that include:

- Economic Model: predicts region-wide employment by industry and the number of households in the region by demographic category.
- Travel Model: predicts travel activity levels by mode (bus, rail, car, walk, or bike) and road segment and estimates travel times between transportation analysis zones (TAZs) by time of day.
- Real Estate Model: predicts the locations of households and employment and also measures the amount of land consumed by development, the amount of built space produced, and the prices of land and built space by zone in each time period.

While PSRC is working to incorporate these types of capabilities into its regional model, it will be several years before the results of this effort could be applied to the SR 99 dialogue. Researchers at the University of Washington have employed a similar modeling process to examine some very specific transportation metrics related to the Alaskan Way Viaduct, as discussed below. It is difficult to address questions about project impacts, particularly related to emissions, without fully understanding the land use response to the transportation investment. Transportation market needs change dynamically based on location decisions made by residents and businesses, in which both accessibility to employment and accessibility to population play essential roles.[2] Research shows that a typical city dweller changes home location approximately every seven years; many younger people and urban renters move much more frequently. A Pew Research study shows that each year 10% to 15% of Americans

[2] Hansen, 1959; Guttenberg, 1960; Huff, 1963).

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move their place of residence.[3] While industrial job center locations tend to be stable, office employment and retail locations are more transitory and redevelopment of attractive office settings can cause major shifts in employment, as evidenced in South Lake Union.

While finite analysis of these dynamics is not currently available, this "model issue" should be considered in contemplating the outputs of the AWVRP 2010 SDEIS or the Partnership Process evaluation based on current travel demand model outputs.

## Dynamic Modeling for the AWV (University of Washington Research)

The 2015 and 2030 land use forecasts used in modeling for the SDEIS and Partnership Process analysis are fixed forecasts, based on a regional transportation network that includes the SR 99 highway corridor. There is no modeling feedback loop that provides indicators of how a deep bored tunnel bypass or a surface and transit solution would alter future land use patterns. If experience from other cities is an indicator, highway investment will promote higher levels of auto use and increase reliance on private vehicles for access to jobs and businesses. Given the heated public policy discussions currently playing out in Seattle around reallocation of limited street rights-of-way (e.g., road diets, bike lane additions, etc), a forward-looking transportation strategy must consider heightened demand for all modes. Basic geometry dictates that use of private single-occupant automobiles in dense urban areas is spatially inefficient, heightens conflicts with other modes, and if retained as the dominant mode, limits access to jobs, businesses, freight mobility, and recreational opportunities.

A study by Hana Ševčíková, Adrian Raftery and Paul Waddell used the Alaskan Way Viaduct to assess the relevance of fixed land use forecasts for modeling future transportation conditions.[4] Importantly, the study also illustrated the uncertainty of travel modeling forecasts, which are often presented as factual outcomes rather than the broad ranges of outcomes that are possible. The research conducted for the report incorporates UrbanSim modeling, an example of the software citied above, into an integrated econometric (real estate location choice) and travel model platform. Much like the Portland process, the UW team was able to predict shifts in residential and employment location choice driven by real estate trends and travel conditions,

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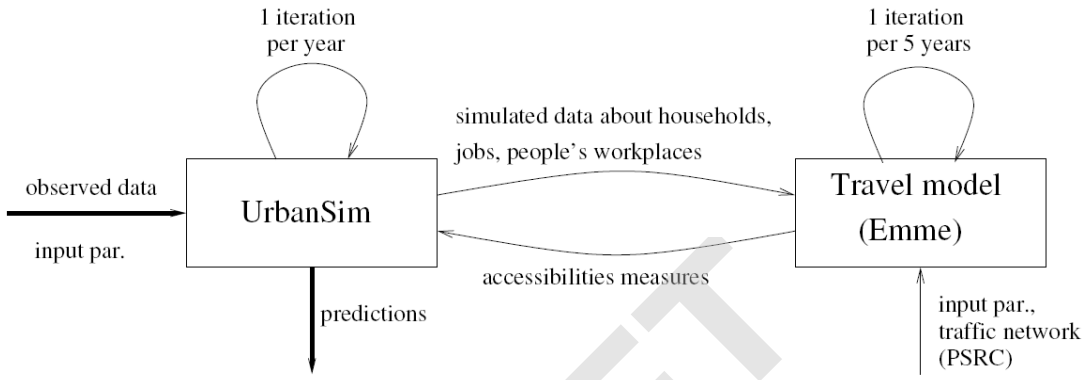
[3] Morin And Cohn, *Who Moves? Who Stays Put? Where's Home?,* Pew Research Center, December, 2008.

[4] Hana Ševčíková, Adrian E. Raftery and Paul A. Waddell, Assessing Uncertainty About the Benefits of Transportation Infrastructure Projects Using Bayesian Melding: Application to Seattle's Alaskan Way Viaduct, 3/26/2009. University of Washington , Center for Statistics and the Social Sciences, Working Paper no. 90.

creating a more realistic 2020 forecast. The report focuses on one important element of project evaluation—end-to-end travel time for representative regional trips.

Figure B-1 is an illustration from the study that describes how real estate and job location choice and travel conditions are jointly considered.

**Figure B-1 Illustration of Integrated UrbanSim and Emme Travel Demand Models**




Source: Ševčíková, Raftery, and Waddell, 2009.

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The study tracks travel times for two transportation scenarios for 14 regional trips both using and not using the SR 99/AWV corridor, illustrated in Figure B-2 and Figure B-3, respectively. The two scenarios include:

- **Capacity-Neutral Replacement.** Uses the travel model networks provided by PSRC for years 2005, 2010, 2015 and 2020. Approximates a Viaduct rebuilt or tunnel. (SHOWN IN GRAY VERTICAL BARS)
- **Worst-Case: Demolish Viaduct in 2010.** Removes links from the 2010, 2015 and 2020 networks that represent the viaduct. This not comparable to a surface and transit alternative since no investments are made to the surface streets, I-5 or transit. (SHOWN IN RED VERTICAL BARS)

At a macro level, the capacity-neutral replacement scenario approximates an untolled Deep Bored Tunnel alternative. The worst case scenario should not be compared to a surface and transit scenario, however, since there is no optimization of other systems. Figure B-2 illustrates travel time ranges estimated by the UW study for regional trips not routed through the SR 99/AWV corridor. Figure B-3 shows the same data for regional trips routed through the SR 99/AWV corridor. Findings are:

- The range of possible travel times for all modeled trips is significant ranging from up to 2 minutes to 15 minutes between the low and high estimate.
- Regional trips not routed through the SR 99/AWV corridor are not substantially impacted by AWV removal/no replacement. Margins of projected travel time are comparable in range for both options for most trips.
- Regional trips routed through the SR 99/AWV corridor show a wider range of travel time diversity and trips made under the worst case option have wider travel time ranges and higher top-end travel times. However, the low-end estimate for many of the trips falls within the range of the baseline scenario.

The UW research suggests that simply removing the Viaduct with no improvements would create no to relatively insignificant travel time change for many important regional trips. Although the modeling process predicted that SR 99/AWV corridor trips are probable to have a higher travel time, model variability suggests the possibility that the difference could be small. The study's conclusions suggest that changes in land use allocation had a role in the resulting 'no difference' in travel times:[5]

> *What our results suggest, in short, is that even using a worst-case scenario and comparing it to a capacity-neutral replacement of the Alaskan Way Viaduct, the travel time benefits of the higher capacity alternative are modest, and fairly localized to the viaduct corridor. There does not appear to be much effect on longer commutes or on I-5 in the vicinity of downtown, as evidenced by the overlapping distributions of the predicted travel times. Further, our combined analysis of land use and transportation reveals considerably more adaptive capacity than the analysis done by the WSDOT, which considers only travel changes and excludes by assumption any adaptation in location choices of households, firms and real estate development. Accounting for uncertainty, in short, the expectations of benefits from maintaining the current level of extra capacity in the viaduct corridor may be higher than can be scientifically supported by the available models and evidence.*

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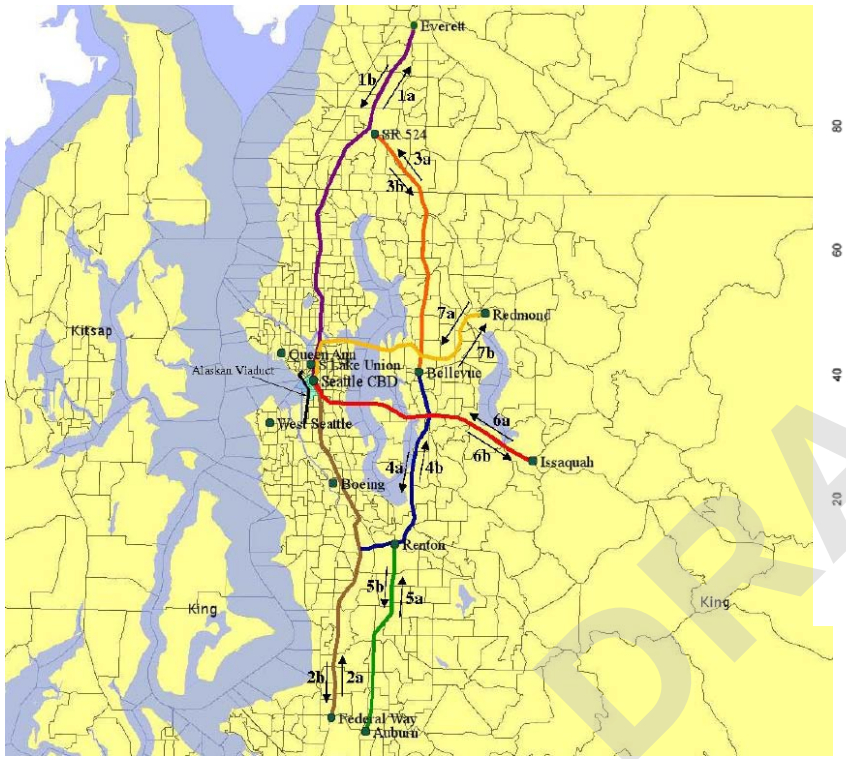
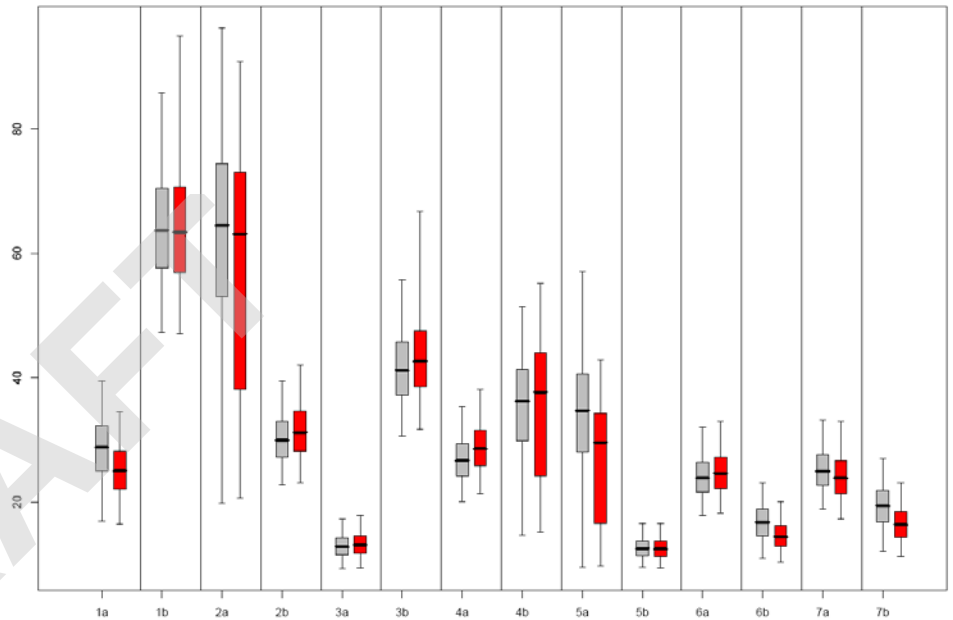
[5] Ševčíková, Raftery, and Waddell, 2009, p. 17.

**Figure B-2 Average 2020 Travel Time Ranges for Regional Trips not using AWV/SR 99 Corridor (UW Study)**

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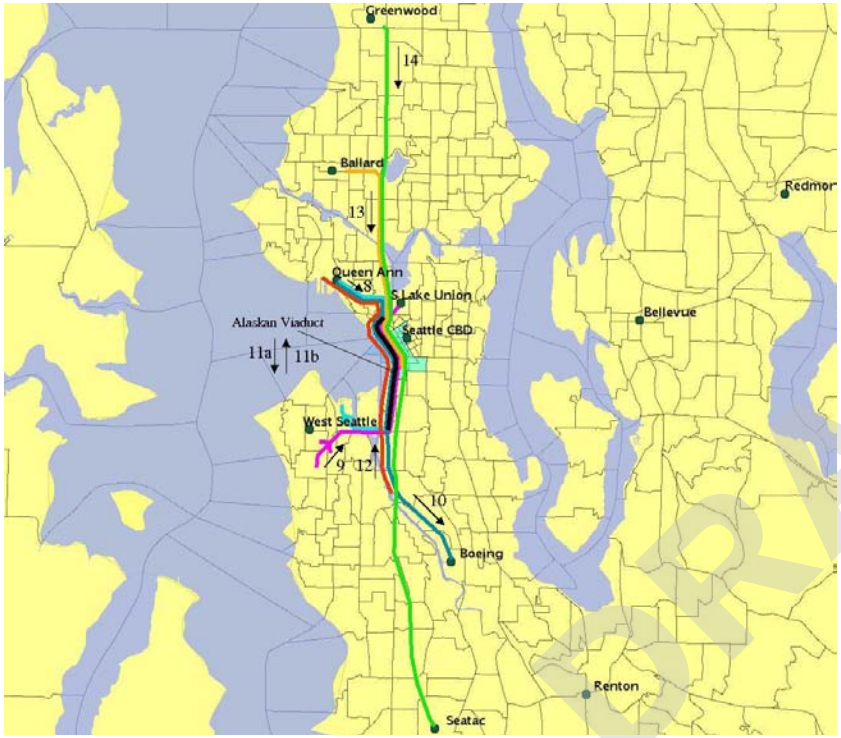
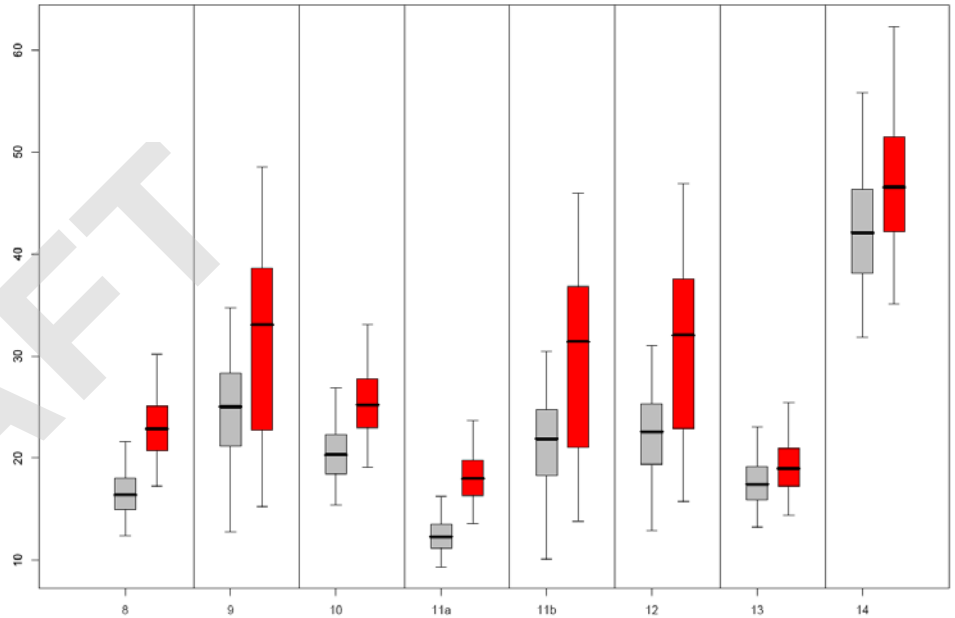
Source: Ševčíková, Raftery and Waddell, 2009.

The vertical lines in the chart above illustrate little change in average travel times changes for the seven regional corridors shown on the map above between the baseline, capacity-neutral replacement scenario (grey vertical bars) and a worst-case no-viaduct case with no surface/transit investments (red vertical bars). The horizontal line dividing each gray or red bar indicates the median change in travel time while the caps at the end of the lines indicate the variability in the modeling (95% confidence interval).

## Figure B-3 Average 2020 Travel Time Ranges for Regional Trips Routed through SR 99/AWV Corridor




The vertical lines in the chart illustrate the change in average travel times for trips using the SR99/AWV corridor, shown on the map above. Route 11 is the viaduct itself; 11a goes from north to south while 11b goes from south to north. Grey bars represent the capacity-neutral, baseline scenario while red bars depict a worst-case no-viaduct case with no investment in surface/transit alternatives. The horizontal line dividing each bar indicates the median change in travel time. Trips made under the worst case option have higher top-end travel times and wider travel time ranges. However, even in a worst-case scenario the low-end estimate for many of the trips falls within the range of the baseline scenario.

Source: Ševčíková, Raftery and Waddell, 2009.

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## Evaluation of Freeway Removal (OTREC Research)

As of 2011, many modern cities have undertaken freeway removals. In no case has any of these projects led to significant traffic congestion or loss of business revenue. "Maintaining the status quo," while expensive, is the most politically saleable solution and at least on the surface, seemingly the one that carries the least risk. Altering the status quo direction in the face of concerned citizens and business groups is never easy, but an increasing body of research shows that it could be the solution most responsive to City goals, which presumably respond to the desires of local citizens and stakeholder groups.

In an era of aging infrastructure, constrained funding for transportation, and increased urbanization, decision-makers around the nation face challenging questions about the interaction of land use and transportation; in particular a dilemma exists regarding the need for road capacity expansion as cities grow. A report released in January 2011 by the Oregon Transportation and Research and Education Consortium (OTREC), called No-More-Freeways: *Dynamics Without Freeway Capacity Expansion,* addresses this issue head on: [6]

> *Conventional wisdom appears to suggest that some freeway capacity expansion is necessary to cope with congestion, even when land use and travel demand management strategies are present. Empirical evidence suggests that cities are unlikely to be able to build their way out of congestion. As new freeway capacity attracts even more users, traffic gridlocks persist and attempts to build even more capacity usually become increasingly more difficult and expensive. There are various limitations to freeway capacity expansion in urban areas. As the road network grows, the unit cost of building an extra unit of freeway capacity increases because: (1) land that is cheap and easily acquirable for freeway projects is likely to have already been used for road construction; (2) construction materials, energy and labor costs increase at a much faster pace than the general price index; and (3) building new freeway capacity on an already-mature road network tends to create significant friction between the capacity-expansion projects and the existing built environment. In contrast, the marginal benefit of building additional freeway capacity diminishes over time. Induced demand causes the congestion on newly constructed/expanded freeway sections to reach its pre-construction level within several years. In addition, removing a specific freeway bottleneck with capacity expansion can often create multiple new bottlenecks elsewhere on the road network.*

*The OTREC study* evaluated transportation system and land use dynamics under two scenarios: a freeway investment scenario and an arterial street grid network investment scenario. In the freeway scenario a singular freeway corridor with new downtown interchanges is evaluated. In the alternative scenario, titled the "No-More-Freeway" scenario, this freeway is replaced by several parallel high-capacity arterial

[6] OTREC, Lei Zhang and Wei Xu, No More Freeways: Urban Land Use Transportation Dynamics Without Freeway Capacity Expansion, 2011, Final Report, OTREC-RR-11-02, http://otrec.us/news/entry/report_explores_the_end_of_the_freeway_era

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streets that serve all parts of the urban area. The study summarizes the findings as follows:

> *The resulting land use distribution as measured by the employment and housing distributions in land use cells is also less concentrated under the "No-More-Freeway" policy. This implies more evenly distributed employment and housing opportunities in the urban area. It is also found that the transportation network under the "No-More-Freeway" policy is actually more efficient from a mobility point of view than the current investment policy that invests in more freeway capacity. These conclusions based on the hypothetical urban system need to be tested again in future analyses in real-world urban systems.*

The study also explores whether development of toll highways may be better relegated to the private sector, where financial risk can be assumed by private shareholders rather than the public. The value of this model has played out in Brisbane, Australia where a recently constructed bypass tunnel has attracted only one-third of projected traffic. The tunnel was designed and is operated by a public-private consortium and was financed through a public stock offering. Low toll revenue resulting from underwhelming use has left shares nearly valueless. Private investors have carried the brunt of the poorly conceived project, although the Brisbane City Council is still responsible for some of the financial risk.[7]

Extensive urban planning literature has documented the negative effects of freeway capacity expansion, including excess travel, urban sprawl, unsustainable transportation options, poor quality of life, and socioeconomic disparities. While the induced demand effect is most often applied to freeway expansion projects (the SR 99 project is not an expansion over the existing condition) it also applies in reverse to reduction of highway capacity. Recent research shows that, given the same financial investment, congestion can be more effectively mitigated with a well-connected network of main arterial streets than with a smaller number of freeway lanes.[8]

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[7] See a sidebar in Chapter 2 for a more detailed discussion of the Brisbane tunnel.

[8] OTREC, 2011, citing previous research by Lei Zhang and David Levinson, 2005.

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# Appendix C

# COMPARISON OF ST5 AND DBT ALTERNATIVES

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The table provided in Figure C-1 details the elements included in the ST5 Scenario B alternative analyzed in the 2008 Partnership Process and compares it to the existing Viaduct and deep bored tunnel alternatives analyzed in the 2010 SDEIS, including Toll Scenario C. The comparison uses ST5 Scenario B because the Alaskan Way design included in this alternative is most consistent with the current City direction.

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**Figure C-1 Project Elements of Compared Alternatives, 2015**

| | Existing Viaduct & Surface Street Conditions (2015) | Deep Bored Tunnel – Not Tolled / "Toll C" (2015) | Surface, Transit & I-5 "Scenario B" (2015) |
|---|---|---|---|
| **Central Waterfront Alaskan Way** Surface Street | No change from existing | 4-lane street with two additional lanes south of Madison<br>New connection from Alaskan Way to Elliott and Western | 4-lane street with two additional lanes south of Madison<br>New connection from Alaskan Way to Elliott and Western |
| **SR 99 Mainline** | Alaskan Way Viaduct/Battery Street Tunnel | 4-lane deep bored tunnel | No limited access highway along Seattle Waterfront |
| **SR 99 Tolling** | No change from existing | Toll Scenario C Only: Deep bored tunnel tolled at entry with variable toll. Peak toll of $4.21 and average daily toll of $2.44 | None |
| **I-5** | Variable speed signs | Variable speed signs | Variable speed signs; add managed lane from Seneca to SR-520; Industrial Way Transit Ramps; Southbound HOV from Mercer to Spokane |
| **Battery Street Tunnel** | No change from existing | Decommissioned | Reused as connector between Aurora Ave N. and Elliott/Western |
| **City Surface Streets—** *North Portal* | No Change | New grid connections at John, Thomas and Harrison; 2-way Mercer w/ widened underpass; new 6th Ave connection | New grid connections at Thomas, Harrison, Republican, and Roy; 2-way Mercer w/ widened underpass |
| **City Surface Streets—** *South Portal* | No Change | New Dearborn Street from Alaskan Way to 1st Ave S | 4-lane 1st Ave (King – Cherry)<br>Surface street connections at Atlantic<br>New street(s) connecting Alaskan Way to 1st Ave S (e.g., Dearborn)<br>Qwest Field North Lot Connector Street |
| **City Surface Streets—** *Other* | No Change | No Change | Additional general purpose travel lane on 2nd Ave and 4th Ave<br>Additional general purpose travel lane on several east-west downtown streets |

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| | Existing Viaduct & Surface Street Conditions (2015) | Deep Bored Tunnel – Not Tolled / "Toll C" (2015) | Surface, Transit & I-5 "Scenario B" (2015) |
|---|---|---|---|
| **Freight Routes** | I-5 & Alaskan Way Viaduct | I-5, Tunnel & Surface Alaskan Way | I-5, Surface Alaskan Way |
| **Permanent Transit Investments** *(Beyond Currently Planned and Funded)* | None | None<br>$190 million projects<br>(Not funded) | Rapid Trolley Network improvements<br>Enhanced service on planned RapidRide routes<br>3 new rapid ride routes (Delridge, Lake City, & Ballard – UW)<br>Ballard/Fremont, U-District,& First Ave Streetcars<br>Enhanced peak express bus service |
| **Bicycle** *(Beyond Currently Planned and Funded)* | No change | Lanes/trails on Alaskan Way, with possible west side cycle track<br>Trails connecting Alaskan Way to East Marginal Way and Mountain to Sound Greenway Trail<br>New east-west connections between Uptown and South Lake Union | Lanes/trails on Alaskan Way<br>Trails connecting Alaskan Way to East Marginal Way and Mountain to Sound Greenway Trail<br>New east-west connections between Uptown and South Lake Union<br>Bicycle lanes eliminated on 2nd and 4th Ave<br>Other Bike Master Plan elements in Center City |
| **Pedestrian** *(Beyond Currently Planned and Funded)* | No Change | Improved east-west connections to Waterfront<br>Improved north-south connections along the waterfront<br>Signalized intersections and connectivity improvements on Aurora<br>Sidewalks on Mercer Street (Dexter to Fifth Ave N.)<br>Broad Street removed (Ninth to Taylor) | Improved east-west connections to Waterfront<br>I-5 crossing improvements<br>Improved north-south connections along the waterfront<br>Aurora at grade from Denny to John, with grid connections and additional signalized intersections<br>Sidewalks on Mercer Street (Dexter to Fifth Ave N.)<br>Broad Street removed (Ninth to Taylor) |

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| | Existing Viaduct & Surface Street Conditions (2015) | Deep Bored Tunnel – Not Tolled / "Toll C" (2015) | Surface, Transit & I-5 "Scenario B" (2015) |
|---|---|---|---|
| **Transportation Demand Management** *(Beyond Currently Planned and Funded)* | No Change | No Change | Aggressive TDM package including: parking management, parking regulation, transit pass programs, employer-based programs, educational programs and policies |

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# APPENDIX D

# PARTNERSHIP PROCESS
# SURFACE, TRANSIT AND I-5 HYBRID
# FACT SHEET
# (DECEMBER 2008)

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Alaskan Way Viaduct & Seawall Replacement Program | Central Waterfront

12.08

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

## I-5/Surface/Transit Hybrid Scenario

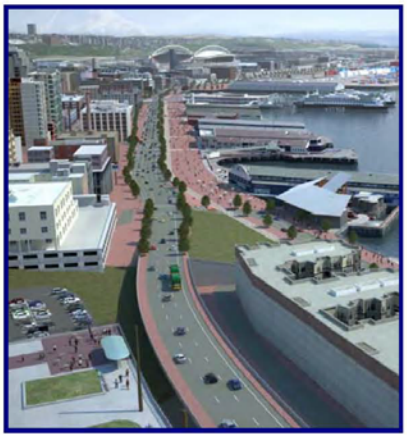
WSDOT, King County, and the City of Seattle are working together to find a solution for the Alaskan Way Viaduct and Seawall's central waterfront section. After developing and evaluating eight scenarios, or comprehensive solutions, for the central waterfront, the three transportation agencies created two hybrid scenarios that combine the most promising components of the earlier scenarios. These hybrids include not only investments on the central waterfront, but also investments in I-5, transit, surface streets, and demand management. Further analysis will be done on investigating a bored bypass tunnel.

Governor Christine Gregoire, King County Executive Ron Sims, and Seattle Mayor Greg Nickels are committed to reaching agreement on a solution by the end of 2008, and to begin taking down the central section of the viaduct in 2012. Regardless of what solution is chosen, we are moving forward to remove or repair about half of the viaduct in the south and north ends.

The following describes one of the two hybrid scenarios. The other is an SR 99 elevated bypass hybrid scenario.

**What is the I-5/surface/transit hybrid scenario?**

This scenario would create a pair of north and southbound one-way streets, called a couplet, along the waterfront. Alaskan Way would become a one-way southbound street with three lanes and a bike lane. Starting near Yesler Way, Western Avenue would become a one-way northbound street with three lanes and a bike lane. It would connect to the Battery Street Tunnel at a signalized intersection at Battery Street.



Aerial view near Victor Steinbrueck Park looking south.

The street grid north of the Battery Street Tunnel would be reconnected with signalized intersections on Aurora Avenue. Examples of other surface street changes include new transit lanes on Madison, Stewart, Olive and Howell streets, among others, and converting Third Avenue to transit-only all day in downtown. Mercer Street would become two-way between I-5 and Elliott Avenue. Sixth Avenue

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would also become two-way between Westlake Avenue and Denny Way, with a new extension to Mercer Street.

At the south end, the couplet would connect to the new south end project at S. King Street. The Spokane Street Viaduct would also be widened and an off-ramp would be built at Fourth Avenue S.

Transit improvements include more all-day service than the elevated hybrid scenario. This would include increased service on Metro's RapidRide routes for Ballard/Uptown, Aurora Avenue and West Seattle and new RapidRide routes on Delridge Way and Lake City Way. The waterfront streetcar would be replaced with a new First Avenue line between King Street and Seattle Center. Park and rides would be expanded in Burien, White Center and Shoreline. The Rapid Trolleybus Network would be expanded with new connections such as Madison Park to Colman Dock, Queen Anne to Capitol Hill, and Beacon Hill to Capitol Hill. Moderate investment would be made in other express and local routes in Seattle.

Changes to I-5 would allow for more efficient operations through downtown. Northbound, a new lane would be created between Seneca Street and SR 520 using the existing shoulder of the highway. This new lane would be managed and the Cherry Street on-ramp would be closed at night. Other improvements include allowing general purpose traffic to use the southbound HOV lane between Mercer Street and S. Spokane Street during peak periods, automating the express lane switch-over, converting the Stewart Street express lane ramp to HOV only, converting the Cherry Street and Columbia Street express lane ramps to general purpose, and implementing additional active traffic management.

A number of transportation policies and incentives would be introduced to change how people travel. These would include a parking management system; smart, or adaptive, traffic signals; and increased incentives for alternative commutes.

**Why is this scenario being considered?**

This alternative is put forward for further consideration as it offers a lower-cost SR 99 option that maintains the economic vitality of the city and region while reconnecting the city's historic waterfront with downtown. System-wide improvements maintain regional traffic flows even with expected population growth. Removal of the viaduct in the existing SR 99 corridor creates a unique opportunity to re-envision the city's waterfront, providing quality open space, reducing noise impacts and improving views from downtown and along the waterfront.

This alternative has the lowest construction impacts to the waterfront, and it is expected to have no long-term economic impacts within the waterfront and region. However, there will likely be changes to local businesses as a result of change in transportation access. Travel times on the SR 99 corridor through the central waterfront would take five to 10 minutes longer than the bypass scenarios and 10 to 15 minutes more than today. Most trips to or through the Center City would have minimal changes in travel time. Other advantages include:

- It is a low cost SR 99 option compared to the bypass options studied.



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- Substantial improvements to I-5 expected to improve functionality of that critical highway, maintaining primary thru-corridor freight route.
- Substantial transit improvements would improve overall system capacity and reduce use of single-occupancy vehicles.
- Creates a 104-foot-wide promenade along the waterfront.

**How much will it cost?**

| | Capital cost (escalated to year of expenditure) |
|---|---|
| SR 99 Alaskan Way/Western Avenue couplet and seawall replacement | $ 929 million |
| Changes to I-5 | $ 553 million |
| Changes to city surface streets | $ 216 million |
| Transit improvements | $ 476 million |
| Transportation policies and management | $ 37 million |
| **Scenario total** | **$ 2.2 billion** |
| Construction traffic mitigation | $ 30 million |
| Alaskan Way Viaduct's Moving Forward projects and prior program expenditures | $ 1.1 billion |
| **Alaskan Way Viaduct and Seawall Replacement Program total** | **$ 3.3 billion** |

Note: Total annual operating costs for this scenario would be $55 million in 2008 dollars.

**What are the potential issues that will need further analysis?**

- Additional funding necessary.
- Changes to Western Avenue near Pike Place Market.
- Efficient movement of freight through city center.
- Managing traffic during stadium events.
- Managing traffic near the cruise ship terminals.
- Parking loss partially replaced by 300-space joint use facility on central waterfront.
- Access from West Seattle to downtown.

**Further work on the bored bypass tunnel**

The bored tunnel was not carried forward due to its high cost. However, it does have advantages associated with avoiding some of the construction on the central waterfront. The agencies will continue to investigate the costs of the bored tunnel as a future project that could be constructed if the I-5/surface/transit hybrid alternative is agreed upon.

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