I-5 PAVEMENT RECONSTRUCTION PROJECT

Existing Pavement Conditions and
Traffic Operations Analysis Results Report

November 2007

Washington State
Department of Transportation

Title VI

WSDOT ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin or sex in the provision of benefits and services resulting from its federally assisted programs and activities. For questions regarding WSDOT's Title VI Program, you may contact the Department's Title VI Coordinator at (360) 705-7098.

Americans with Disabilities Act (ADA) Information

If you would like copies of this document in an alternative format – large print, Braille, cassette tape, or on computer disk, please call (360) 705-7097. Persons who are deaf or hard of hearing, please call the Washington State Telecommunications Relay Service, or Tele-Braille at 7-1-1, Voice 1-800-833-6384, and ask to be connected to (360) 705-7097.

TABLE OF CONTENTS

LIST OF EXHIBITS

Executive Summary

This report documents 2004 pavement conditions in terms of faulting and panel cracking of the concrete pavement between on Interstate 5 in Seattle, between Boeing Access (MP158) and NE 175th (MP 177.76). The study found that the worse faulting and panel cracking of the 40+ year concrete pavement is between NE 175th and NE Northgate Way and is largely considered in extremely poor condition.

This report also provides one-page project summaries of operational improvement projects identified in WSDOT's 2003 Lane Continuity Report as well as some additional operational improvements that were subsequently identified. The summary pages report travel speeds and travel time with, and without the project in 2004 and 2030 using a VISSIM traffic simulation model.

Chapter 1 Project Background

The Washington State Department of Transportation (WSDOT) has identified the need to rehabilitate or reconstruct the pavement of Interstate 5 (I-5) through the city of Seattle between approximately Boeing Access Road and NE Northgate Way. As part of the I-5 Pavement Reconstruction Project, several short-range and long-range transportation improvements were evaluated. This report summarizes the pavement and traffic analysis conducted for the I-5 Pavement Reconstruction Project.

1 Why was the I-5 Pavement Reconstruction Project initiated?

The pavement on I-5 through much of Seattle is over 40 years old and is well beyond its design life. It is showing signs of failure at several locations along I-5. It is not unusual to see long cracks in the concrete panels and worn surfaces in the concrete that expose stone aggregate, creating rough and noisy driving conditions. The concrete will continue to deteriorate over time, and the ride quality for drivers will continue to worsen. Drivers will incur more vehicle maintenance costs for wheel alignments and other repairs, and traffic accidents will likely increase as traction on the freeway decreases over time.

WSDOT currently has funding programmed in 2017 to reconstruct or rehabilitate the pavement between Boeing Access Road and NE Northgate Way. WSDOT is taking the approach that while the I-5 pavement is going to be reconstructed, there may be additional benefits to improve traffic operations, safety, and possibly stormwater drainage at the same time.

WSDOT's goal is to complete a plan for the comprehensive pavement reconstruction of the freeway through the city of Seattle, together with operational, safety, and environmental improvements that are determined feasible. This report focuses on the pavement conditions and potential operational improvements that may be incorporated into the plan.

2 What information is provided in this report?

This report documents the existing pavement conditions and analyzes alternatives to improve traffic operations. Phase 1 of the I-5 Pavement Reconstruction Project initially identified several operational improvements to improve traffic flow on I-5 between NE Northgate Way and Boeing Access Road. Phase 2 analyzes these improvements, combinations of these improvements, and other improvements in more detail using a traffic micro-simulation package called VISSIM. This report summarizes the additional analysis and the underlying methodology used to determine the operational benefits or impacts of each proposed alternative.

What is VISSIM?

VISSIM is a microscopic, behavior-based traffic simulation program created by PTV, a German software company. The tool offers a wide variety of applications, including freeway modeling. Once models are created, they can also be converted into a 3-D format that can help better inform decision makers.

For each project analyzed, a one-page project summary is provided in Chapter 4 of this report. These summaries provide a high-level description of the improvement option, the benefits and drawbacks of the project, and the operational benefits of each project.

3 What is the project study area?

What is a collector-distributor road?

A collector-distributor roadway, or CD for short, is a one-way facility adjacent to a freeway that is used to minimize conflicts on the mainline lanes due to merging from on- and off-ramps. These roadways move vehicle weaving conflicts due to on- and off-ramps from the freeway mainline to these adjacent facilities.

The I-5 project traffic operations study area extends from Boeing Access Road to NE 205th Street. This area includes the northbound and southbound mainline lanes, the reversible roadway lanes, collector-distributor roadways in Downtown Seattle, and on- and off-ramps associated with all the interchanges along the study corridor. Although the Washington State Legislature only targeted construction dollars for the section of I-5 between NE Northgate Way and Boeing Access Road, the project evaluated capital improvement needs for a larger segment of I-5. The operational analysis also investigated traffic operational impacts of some project alternatives on several critical arterial street intersections and ramp terminals near the I-5 corridor. Exhibit 1-1 highlights the extent of the operational analysis.

Exhibit 1-1
Project Study Area

4 What information was included in prior project studies?

The first phase of the I-5 Pavement Rehabilitation Project consisted of a planning effort to develop a problem statement and assemble needed background data and information. The result of the Phase 1 effort, the *I-5 Pavement Reconstruction Project - Problem Definition Report* (WSDOT 2005), highlighted the following items:

- Establishing the need for I-5 pavement rehabilitation, including analyzing existing and future pavement conditions.
- Documenting existing conditions of the study area, including geometrics, transit usage, freight mobility, traffic operations, noise, and stormwater drainage conditions.
- Documenting funded and unfunded improvement projects along the study corridor.
- Identifying an initial list of operational and pavement reconstruction options.

Chapter 2 Existing Pavement Conditions

1 What criteria were used to evaluate current pavement conditions?

WSDOT engineers conducted a comprehensive inventory of current pavement conditions in the I-5 corridor between Boeing Access Road and NE Northgate Way. This section summarizes overall pavement conditions by direction and segment based on faulting and panel cracking information. Faulting and panel cracking were the two criteria used to develop the general pavement condition information.

Information on two other criteria, International Roughness Index (IRI) and wheel path wear, was collected but not used in the pavement condition summary. IRI was not considered as important as faulting and panel cracking because it is a summation of all the pavement distresses (especially faulting). Wheel path wear was also not considered because it does not result in structural failure of portland cement concrete (PCC) pavement.

Although IRI and wheel path wear were not directly used in the pavement condition summary, both have operational and safety implications and affect ride quality, especially in wet weather conditions. For instance, the absence of traction in wet weather, related to roughness, can create unsafe conditions. Similarly, wet weather conditions, in combination with wheel path rutting, could result in hydroplaning, a condition that occurs when a thin layer of water builds between rubber tires and the road surface, preventing the vehicle from responding to driver control inputs.

Worst of the Worst

This method is based on the concept that all lanes of a roadway are controlled by the condition of the single worst lane. This method depicts the condition of the I-5 pavements in a worst-case condition. The images that follow have been developed using this method.

2 What method was used to evaluate and prioritize pavement conditions on I-5?

Three methods were examined for illustrating the general pavement condition of the I-5 PCC pavements: (1) worst of the worst, (2) average of dominating distress, and (3) average of distress. Each method is based on the assumption that faulting and cracking levels result in equivalent pavement distress. For instance, faulting of 0 to 1/8 inch is considered equivalent to 0 to 5 percent of panels with two or more cracks using the "worst of the worst" rating method. These pavement distress levels are shown graphically on the I-5 corridor maps (Exhibits 2-2 through 2-6) based on average assigned values of 1, 2, or 3, with **1 being the best condition** and **3 being the worst**. Exhibit 2-1, below, shows the correlation between faulting and cracking levels, overall pavement condition, and color coding on the maps.

Average Distress

For this method, the distress values of all lanes were averaged for each tenth of a mile section resulting in eight values, one for cracking and one for faulting, for each of the four lanes. This method is the most straightforward but does not have any significant basis for decision-making, and, as such, is not shown here.

Exhibit 2-1 Pavement Condition Matrix

Faulting	Cracking	Assigned Value	Color	Pavement Condition
0–1/8"	0–5%	1	Green	Good
1/8"–¼"	5%–10%	2	Yellow	Poor
¼"+	10%+	3	Red	Extremely Poor

Average Dominating Distress

With this method, the dominating distress of each lane in each tenth of a mile section was determined. The average values assigned to each lane were used to produce a representative overall pavement condition value. The ARC GIS plots produced using this method are not shown in this report.

3 What are the current pavement conditions on I-5?

The pavement on I-5 through much of Seattle is over 40 years old and is well beyond its design life. In many locations, it is showing signs of failure. It is not unusual to see long cracks in the concrete panels and worn surfaces in the concrete that expose stone aggregate, creating a rough and noisy condition. While most of the pavement has never been rehabilitated, some sections were rehabilitated to some degree in 1999 and 2001. The differences in performance levels associated with these various pavement states suggest that pavement failure rates accelerate over time. In other words, once concrete panels begin to fail, the rate of failure continues to increase over time. As such, the existing concrete panels will continue to deteriorate over time.

Exhibits 2-2 through 2-6 summarize current pavement conditions on northbound and southbound I-5 between NE 175th Street and Boeing Access Road. This information is based on data collected by WSDOT's Materials Laboratory during July 2004. Pavement conditions shown in Exhibits 2-2 through 2-6 and described below only include on-grade sections of I-5, since pavement conditions on bridge structures are treated differently. Most of these have already been or will soon be rebuilt and/or resurfaced.

- NE 175th Street to NE Northgate Way (Exhibit 2-2) – Pavement conditions in this segment are mostly extremely poor in both directions, with the exception of a short northbound segment north of NE 155th Street rated poor or good.
- NE Northgate Way to NE 45th Street (Exhibit 2-3) – Pavement conditions in this segment are mostly poor or extremely poor with similar conditions both northbound and southbound.
- NE 45th Street to I-90 (Exhibit 2-4) – Pavement conditions in this segment are primarily in poor condition, with short segments in the extremely poor or good category. This segment also has significant segments where pavement conditions are not rated because they are on bridges.
- I-90 to S Michigan Street (Exhibit 2-5) – Pavement conditions in this segment are mostly poor or good in the northbound direction, and extremely poor or good in the southbound direction. I-5 from Spokane Street to the I-90 interchange is an elevated bridge that is not rated in Exhibit 2-4. In August 2007, WSDOT construction crews will replace the expansion joints on the northbound bridge, resurface the northbound lanes, and repair the expansion joints on the southbound bridge.
- S Michigan Street to Boeing Access Road (Exhibit 2-6) – Pavement conditions in this segment are mostly good or poor, especially in the northbound direction.

Exhibit 2-2. I-5 Pavement Condition: NE Northgate Way to NE 175th Street

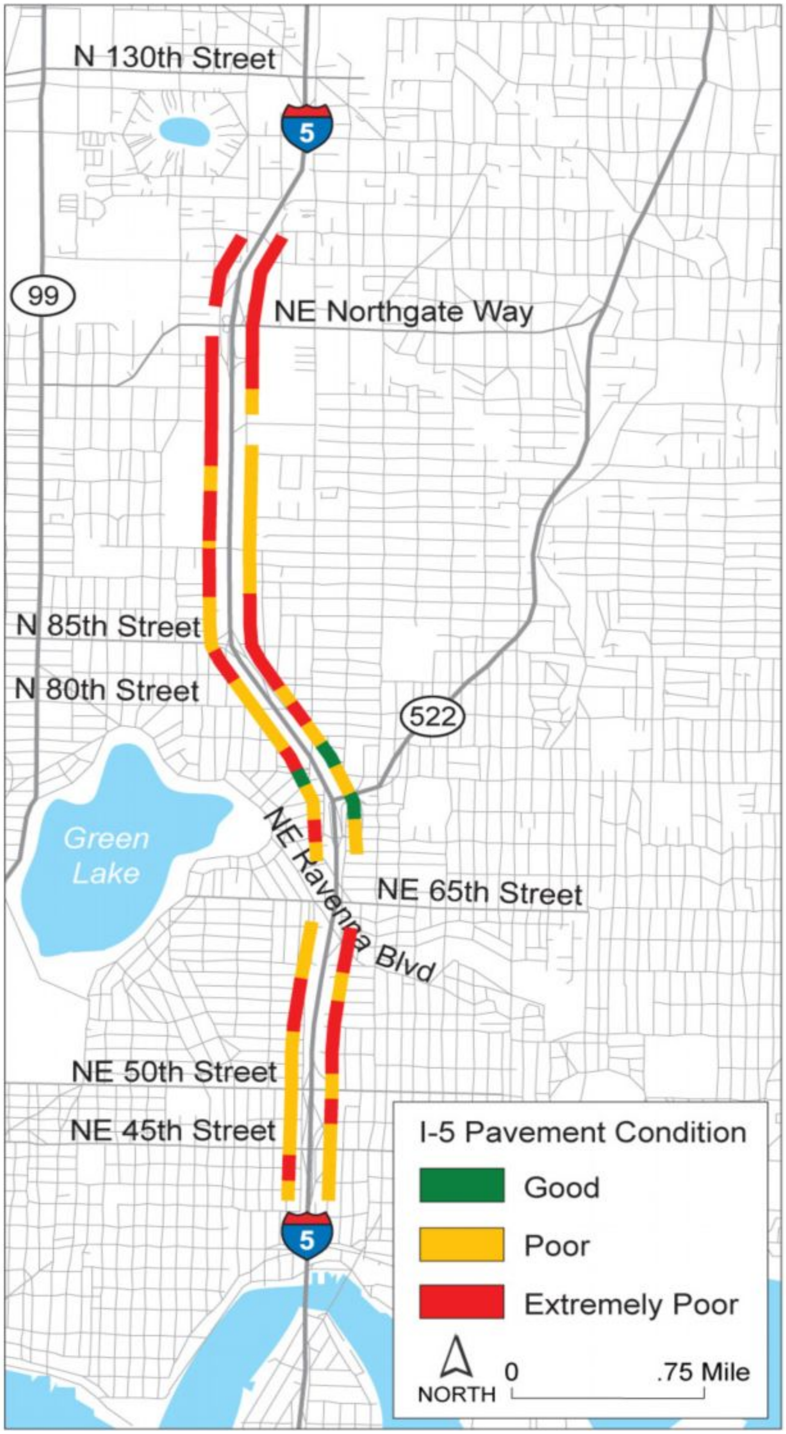

Exhibit 2-3. I-5 Pavement Condition: Ship Canal Bridge to NE Northgate Way

Exhibit 2-4. I-5 Pavement Condition: I-90 to the Ship Canal Bridge

Exhibit 2-5. I-5 Pavement Condition: S Albro Place to I-90

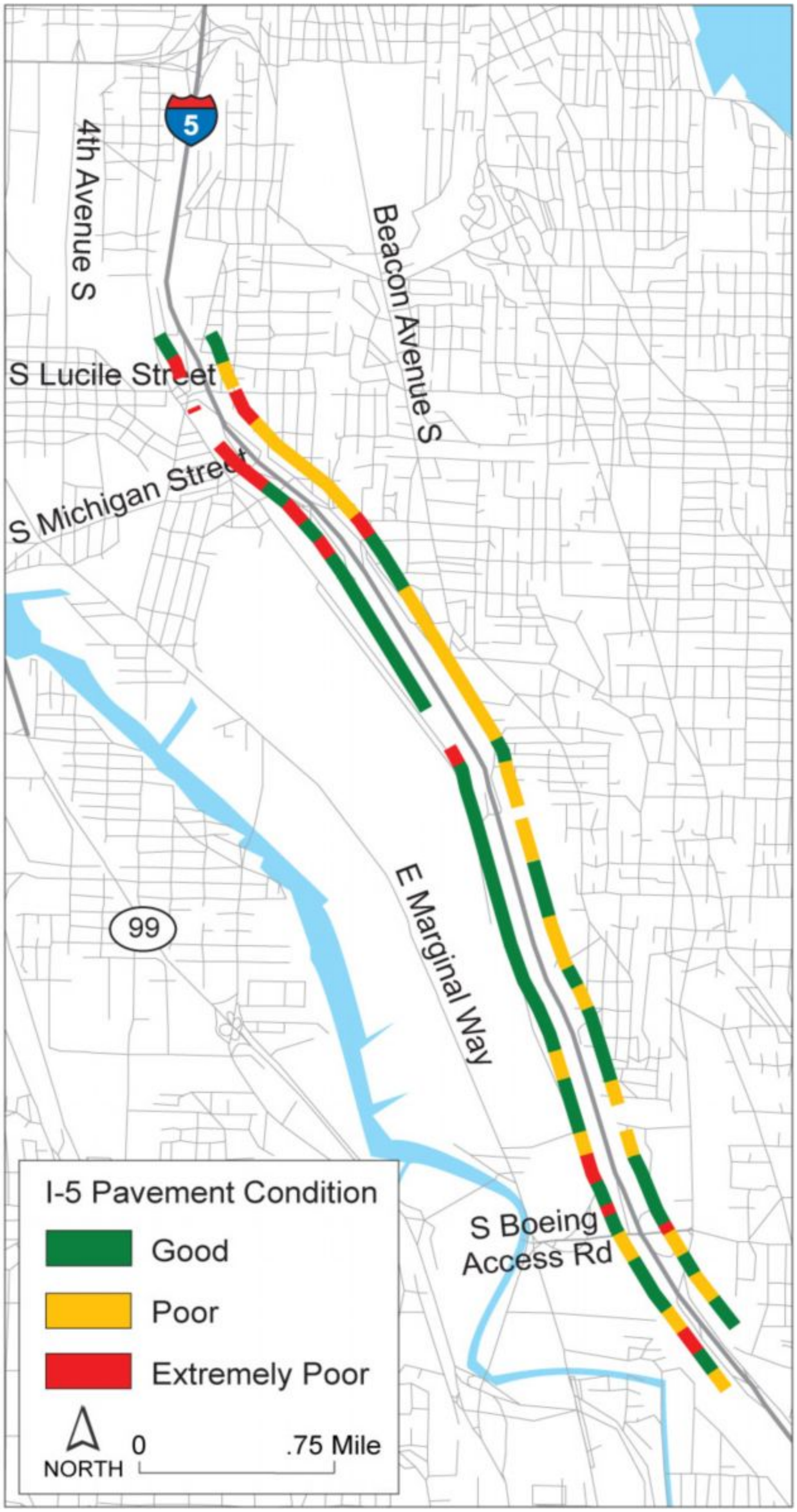

Exhibit 2-6. I-5 Pavement Condition: S Boeing Access Road to S Albro Place

Chapter 3 Existing and Future Conditions

1 Where and when is existing traffic congestion occurring on I-5?

Traffic congestion on I-5 is a typical daily occurrence for many sections of the corridor. Congestion in and around downtown Seattle primarily occurs during the morning and evening commute hours. Congestion is caused by several factors, including insufficient roadway capacity (number of lanes), substandard roadway design, traffic incidents, and driver behavior. For this analysis, only recurring congestion caused by roadway capacity or design constraints was modeled.

Many traffic engineers use speed diagrams to determine the intensity and duration of congestion. These diagrams show average vehicle speed contours plotted against time and location. They are very similar to topographical maps or temperature weather maps. Colors on the map change from green to blue to red indicating progressively slower travel speeds at a particular time and location. Engineers visually inspect these maps to identify areas of congestion.

Exhibits 3-1 through 3-6 show the existing (2004) traffic congestion for both travel directions of I-5 and the I-5 reversible lanes for a typical mid-week commute.

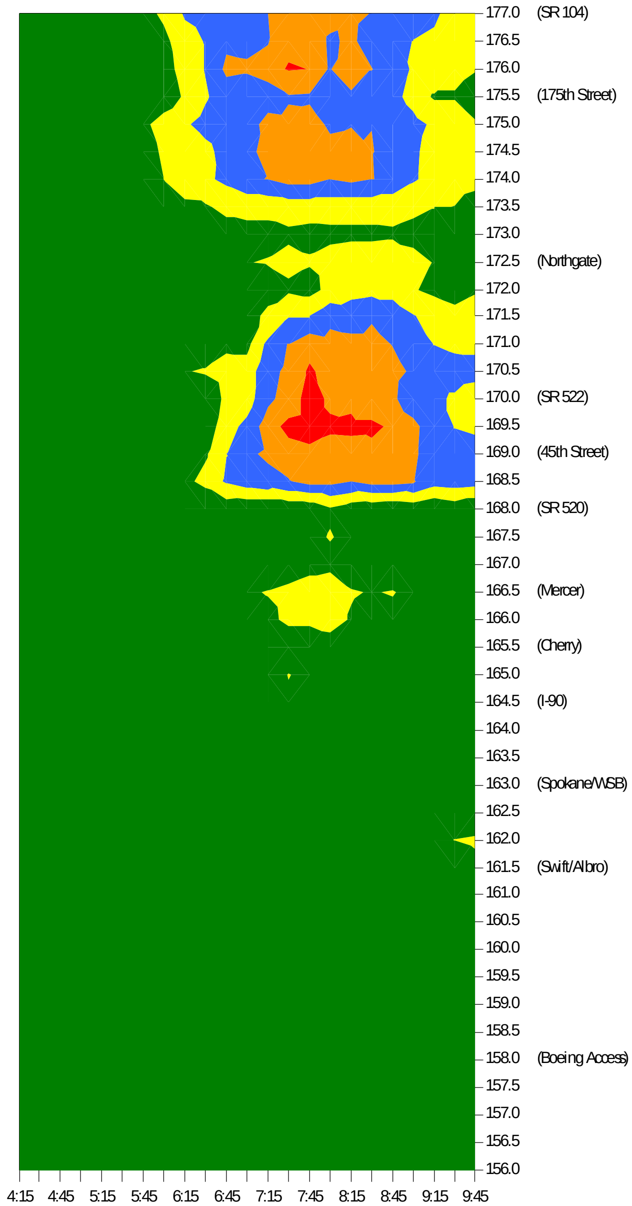

Exhibit 3-1 Existing Congestion - Morning Southbound Lanes

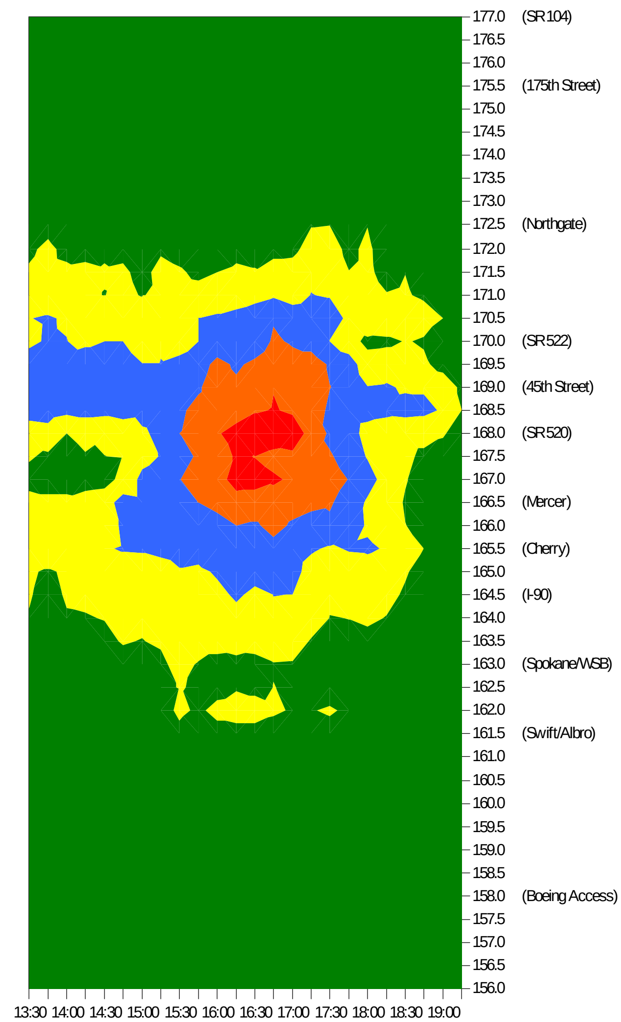

Exhibit 3-2 Existing Congestion - Evening Southbound Lanes

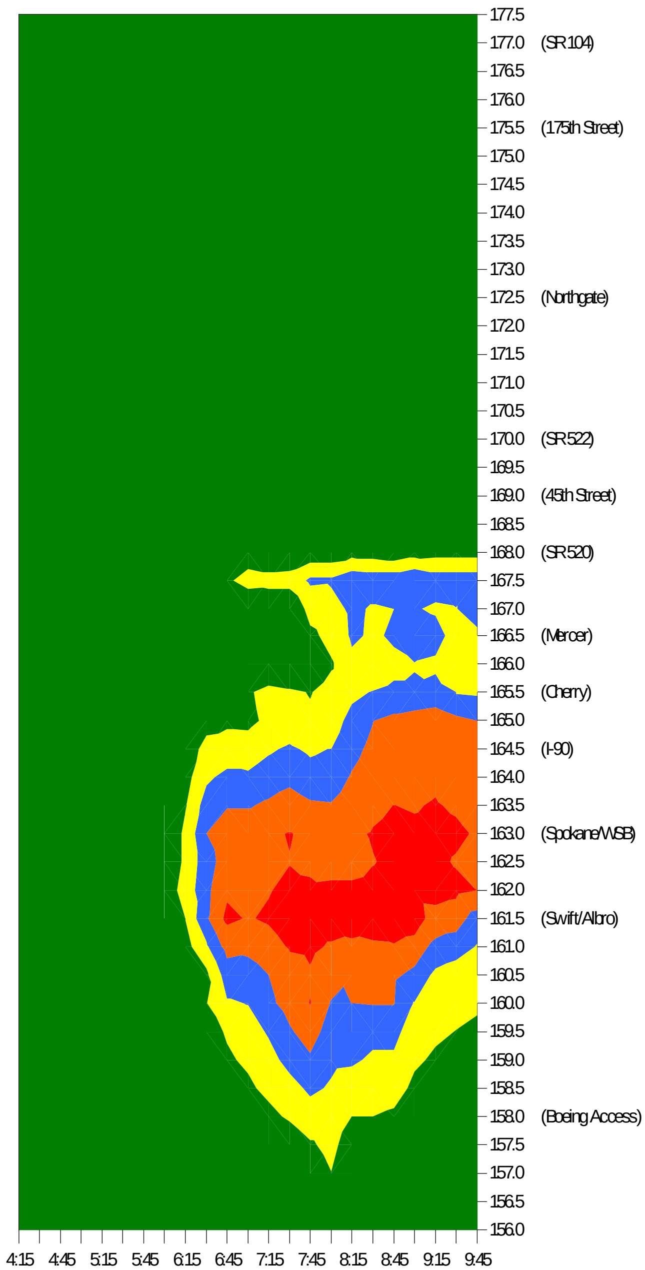

Exhibit 3-3 Existing Congestion - Morning Northbound Lanes

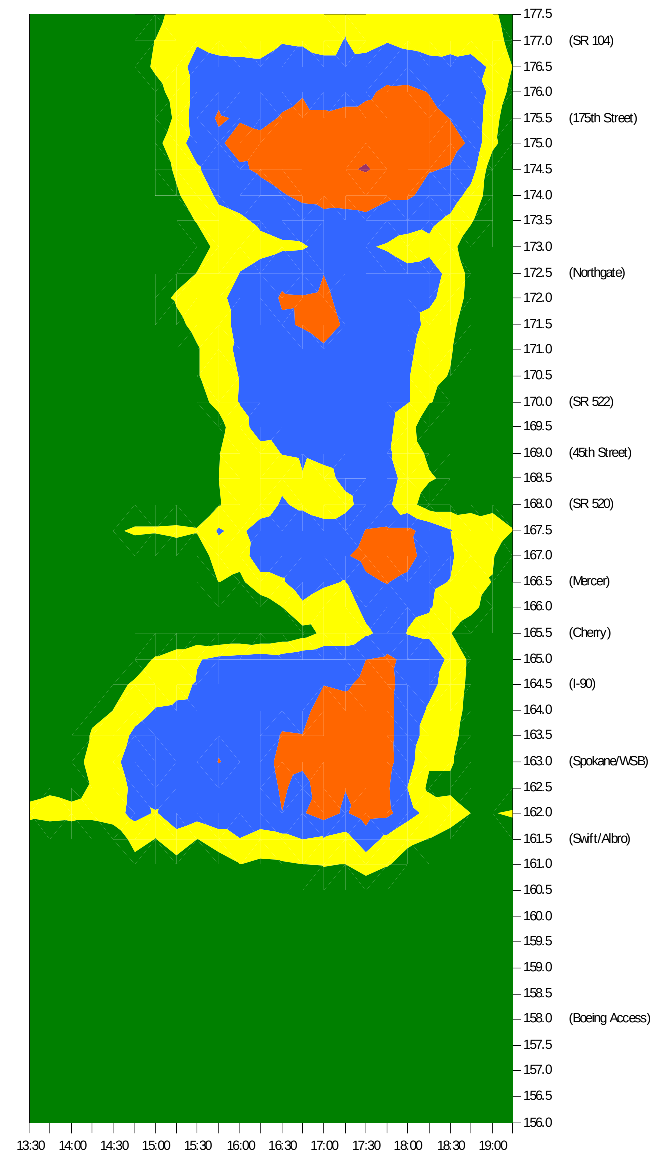

Exhibit 3-4 Existing Congestion - Evening Northbound Lanes

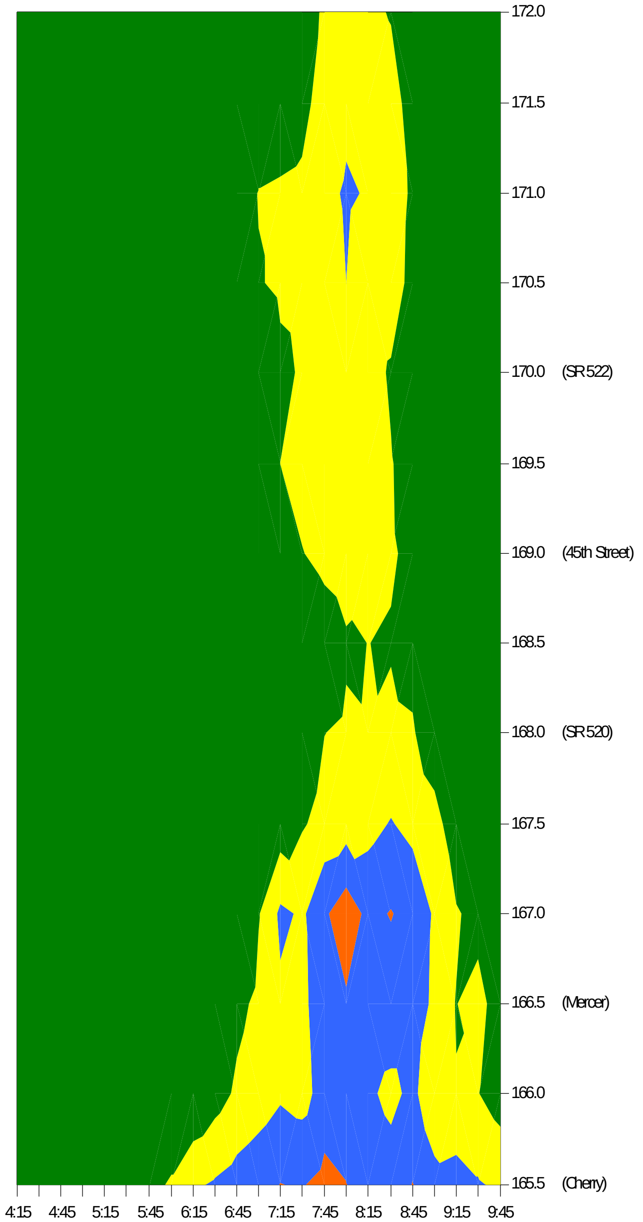

Exhibit 3-5 Existing Congestion - Morning Reversible Lanes

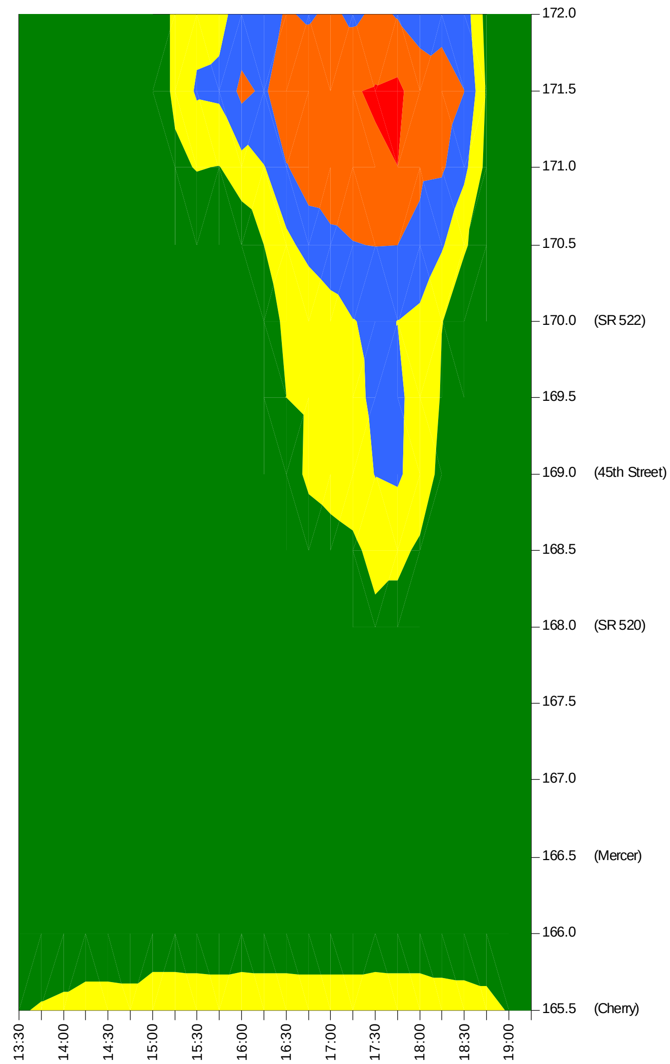

Exhibit 3-6 Existing Congestion - Evening Reversible Lanes

Morning:

Southbound – Congestion starts at SR 520 and extends north approximately 4 miles to around Northgate. The worst congestion occurs around the 45th Street NE on- and off-ramps, with travel speeds dropping to as low as 10 miles per hour (mph) during a typical weekday commute. Roadway capacity is highly constrained in this location, due to motorists weaving from the 45th/50th Street NE on-ramps to the SR 520 off-ramp and vehicle queuing that spills back onto southbound I-5 from eastbound SR 520. This congestion lasts over three hours, with noticeable congestion starting around 7:00 AM and extending until 10 AM. Other congestion occurs just north of 130th Street NE and extends north into South Snohomish County. No noticeable congestion occurs south of SR 520 on southbound I-5 during the typical AM peak commute period.

Northbound – On northbound I-5 during the AM peak period, motorists typically experience traffic congestion starting around Boeing Access Road. This congestion extends north through downtown and terminates at the SR 520 interchange. The worst congestion occurs around the Spokane Street/West Seattle Bridge interchange with average travel speeds dropping to as low at 10 mph between 6:30 AM and 10:00 AM. Traffic congestion also occurs through downtown Seattle near Seneca Street where only two general-purpose lanes are provided. Less congestion occurs between Cherry Street and the SR 520 interchange as typical travel speeds are 30 to 50 mph. North of SR 520, northbound traffic is typically free-flowing during the morning commute.

Reversible Lanes – The reversible lanes operate in the southbound direction in the morning. The reversible roadway segment between the northern terminus near NE 103rd Street and SR 520 generally operates free flow during the morning commute period. On an average weekday, the segment does experience some congestion between NE 85th Street and SR 520 between 7:30 and 8:30 AM when average speeds drop slightly below 50 mph.

Traffic congestion created by weaving and queue jumping movements near Mercer Street, Pine and Pike Streets, and the southern terminus results in severe southbound traffic congestion along the reversible roadway south of SR 520. The decrease in roadway capacity from two lanes to a single lane at the southern end of downtown Seattle also a major cause of congestion. The average travel speeds along the reversible roadway south of SR 520 are reduced to approximately 25 mph between 7:00 and 9:00 AM, except for the westernmost high-occupancy vehicle (HOV) lane that leads to the Cherry/Columbia ramp south of Roanoke Street.

Evening:

Southbound – The southbound traffic congestion along I-5 extends between the SR 522 interchange and south of the I-90 interchange during the PM peak commute period between 3:00 and 6:30 PM. The southbound I-5 sections north of the SR 522 interchange and south of the I-90 interchange generally operate free flow during the evening commute period.

The existing lane configuration along southbound I-5 south of the Mercer Street on-ramp results in major weave movements. Mercer Street on-ramp general-purpose vehicles are forced to weave to general-purpose lanes, I-5 southbound HOVs weave to the HOV lane that originates at the Mercer Street on-ramp, Yale on-ramp HOVs weave to the HOV lane, and some of the Mercer Street on-ramp vehicles weave to downtown exits. Other weaving movements between the Yale on-ramp and Union and Columbia/James off-ramps compound the weaving activity in this area and cause severe congestion to occur in downtown Seattle. This congestion, along with congestion near the SR 520 interchange, results in traffic queues that extend to the SR 522 interchange.

Northbound – During the PM peak period, congestion starts around the Swift Avenue/Albro Place interchange and extends north to the 205th Street NE/SR 104 interchange within the project study limits.

With a one-lane ramp entrance to the reversible roadway from the northbound I-5 mainline, a bottleneck is created at the southern entry to the reversible roadway. This bottleneck, in addition to other capacity constraints between the Spokane Street interchange and the I-90 interchange, results in severe traffic congestion along the I-5 mainline during the evening commute period between 3:00 and 7:00 PM.

The short weaving segment between the Mercer Street on-ramp and SR 520 off-ramp creates a bottleneck between the Mercer Street off-ramp and SR 520 interchange. The other major bottleneck occurs near the 175th Street NE interchange due to capacity constraints resulting in severe traffic congestion between 205th Street NE and 130th Street NE. The congestion lasts for over 3 hours with travel speeds dropping to 10 to 20 mph.

Reversible Lanes – The reversible roadway segment between downtown Seattle and NE 42nd Street generally operates free flow during the evening commute period.

Of the two remaining general-purpose lanes north of SR 522, only one lane continues through the northern terminus of the reversible roadway to enter the I-5 mainline at Northgate. Traffic back-ups in the segment between SR 522 and the northern terminus produce severe traffic congestion along the reversible roadway extending from NE 42nd Street north, mainly between 4:00 and 6:30 PM. This congestion affects both general-purpose traffic and HOV traffic including transit south of SR 522. North of SR 522 the HOV lane operates free flow onto the I-5 mainline at Northgate.

2 How were year 2030 traffic volume forecasts developed?

The project team selected 2030 as the future analysis year for improvements in the corridor. Year 2030 traffic volumes were derived using the Puget Sound Regional Council (PSRC) travel demand forecasting model. This travel demand model is calibrated to a 2000 base year and reflects regional travel demand patterns. Along the I-5 corridor, this model was used to

What is a screenline?

A screenline is an imaginary line that is used to report vehicle volumes. For the I-5 Pavement Reconstruction Project, a total of eight screenlines were used to capture vehicle volumes on the corridor. The total of these volumes includes northbound and southbound general-purpose and HOV volumes and the reversible lanes.

The local area screenlines captured all on-ramps, off-ramps, and arterial streets that cross the I-5 corridor in between each screenline. The local area screenline represents the growth occurring near the I-5 corridor, but not necessarily on the corridor.

obtain traffic volumes at eight screenline locations on the I-5 corridor, and in between screenlines at on-ramps, off-ramps, and arterial streets that cross over the highway network. Future transportation network improvements assumed for the year 2030 consisted of PSRC's "medium investment" scenario, which includes capacity improvements on I-405; additional HOV lane facilities on SR 520, SR 99, and I-90; and several interchange improvements on I-405. These improvements are anticipated to divert a small percentage of vehicle trips off of the I-5 corridor to these other corridors.

Traffic volumes at each of the I-5 screenline locations for existing conditions and the year 2030 were reviewed to develop an annual growth rate for each screenline. These growth rates were applied to existing 2004 count data to determine planning level traffic volume forecasts for the year 2030. The overall annual growth rate varied from a negligible growth rate upwards to 0.5 percent annual growth. While these growth rates may appear low, increases in daily traffic volumes on I-5 have been minimal in the past 10 years since the roadway has been operating at capacity for some time now. Without any further improvements to the I-5 corridor, traffic forecasts indicate an overall maximum traffic volume growth of 16 percent between 2004 and 2030 during the morning and evening peak periods.

3 How was the micro-simulation model used and calibrated?

To evaluate the improvement alternatives, the project team needed a model of existing and future traffic conditions in the I-5 corridor. Using VISSIM, an industry leading micro-simulation tool, the project team developed a model that realistically simulates existing traffic flow and congestion conditions on the freeway through an extensive calibration process. Engineers used the model to simulate a 5-hour AM peak period and a 5-hour PM peak period for an average weekday. Using an average of hourly traffic counts from Tuesdays, Wednesdays, and Thursdays in October 2004, and with observed knowledge of current traffic congestion on the

Why is calibrating the simulation model important?

The model calibration process is often a long and tedious step in developing a micro-simulation model. Model calibration is an iterative process to match existing traffic flow as closely as possible. The calibrated model is then used to evaluate future conditions on the corridor. Calibration accuracy is necessary to ensure that model results from evaluating corridor improvements are accurate and reliable.

freeway, engineers calibrated the simulation model to mirror existing weekday travel conditions on I-5. This model was calibrated to closely match the traffic volumes and congestion on the corridor during both morning and afternoon 5-hour analysis periods.

At most locations, the simulation model matched existing volumes at on-ramps, off-ramps, and mainline sections within 15 percent for all time periods. Using data from the model, engineers estimated travel times and speeds along various segments in the study area for a variety of improvements. The existing travel times and vehicle speeds were used as a basis to analyze the operational benefits or impacts in future years.

4 Where and when is traffic congestion expected to occur in the year 2030?

The year 2030 volume forecasts were applied to the calibrated 2004 VISSIM model to develop a baseline 2030 model. Traffic congestion is expected to increase significantly compared to existing conditions. Congestion is anticipated to last longer and affect longer I-5 segments compared to today, and new areas of congestion are expected to develop.

Morning:

Southbound – Severe traffic congestion is expected to occur at SR 520 and extend north of 205th Street NE. This congestion is anticipated to last over 4 hours compared to the current 3 hours, with noticeable congestion starting around 6:00 AM and extending beyond 10 AM. No noticeable congestion is anticipated to occur south of SR 520 on southbound I-5 during the typical AM peak commute period.

Northbound – The 2030 analysis indicates that the northbound I-5 traffic congestion would begin near Interurban Avenue during the AM peak period. This congestion would extend north through downtown and terminate at the SR 520 interchange. The worst congestion would occur around the Spokane Street/West Seattle Bridge interchange with average travel speeds dropping to as low as 10 mph between 6:00 AM and 11:00 AM. North of SR 520, traffic would be typically free-flowing during the morning commute.

Reversible Lanes – The reversible roadway segment between the northern terminus near NE 103rd Street and SR 520 would operate free flow during the morning commute period. Traffic congestion created by weaving and queue jumping movements near Mercer Street, Pine and Pike Streets, and the southern terminus would continue to cause severe southbound traffic congestion along the reversible roadway south of SR 520.

Evening:

Southbound – The southbound traffic congestion would deteriorate significantly by 2030, and the congestion along I-5 would extend from north of the 205th Street NE/SR 104 interchange to south of the I-90 interchange during the PM peak commute period between 2:30 and 7:30 PM. The southbound I-5 section south of the Spokane Street interchange would continue to operate free flow during the evening commute period.

Northbound – During the PM peak period, congestion would begin south of the Swift Avenue/Albro Place interchange and extend north to the 205th Street NE/SR 104 interchange within the project study limits. The congestion would last over 4 hours along several segments of the study corridor.

Reversible Lanes – The reversible roadway congestion during the evening commute would deteriorate significantly by 2030, and the congestion would extend between Mercer Street and the northern terminus of the roadway.