I-5 - SR 161/SR 18 (Triangle) Interchange Project

Interchange Justification Report Amendment

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Interchange Justification Report

I-5 – SR 161/SR 18 Interchange Project IJR Amendment

(MP 141.25 to 142.80)

This **Interchange Justification Report** has been prepared under my direct supervision, in accordance with Chapter 18.43 RCW and appropriate Washington State Department of Transportation manuals.

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
C-D	collector-distributor
CIP	capital improvement plan
DM	Design Manual (WSDOT)
EB	eastbound
EBL	eastbound left
FHWA	Federal Highway Administration
GP	general purpose
Green Book	*A Policy on Geometric Design of Highways and Streets* (AASHTO, 2011)
HAC	high accident corridor
HAL	high accident location
HOV	high-occupancy vehicle
HSM	*Highway Safety Manual*
HSP	Highway System Plan
HSS	Highway of Statewide Significance
I-5	Interstate 5
IC	interchange
IHSDM	Interactive Highway Safety Design Model
IJR	Interchange Justification Report
LOS	level of service
LT	left turn
MEV	million entering vehicles
MOE	measure of effectiveness
MP	milepost
mph	miles per hour
MVMT	million vehicle miles traveled
NB	northbound
NBT	northbound through
NEB	northeast bound
NHS	National Highway System
PAL	pedestrian accident location
PDO	property damage only

PSRC	Puget Sound Regional Council
RT	right turn
SB	southbound
SBR	southbound right
sec/veh	seconds per vehicle
S	south
SR	State Route
SW	southwest
TH	through
TIP	transportation improvement program
v/c	volume-to-capacity ratio
VE/PD	Value Engineering/Practical Design
veh/mi/ln	vehicles per mile per lane
vpd	vehicles per day
vph	vehicles per hour
WB	westbound
WBL	westbound left
WBR	westbound right
WSDOT	Washington State Department of Transportation
WSTC	Washington State Transportation Commission
WTP	Washington Transportation Plan

Project Introduction

The I-5 - SR 161/SR 18 (Triangle) Interchange Project in Federal Way, Washington, is a regional priority project to reduce congestion, improve safety, and increase freight mobility in the south King County area. The project area is shown in Exhibit Intro-1.

In early 2007 the environmental documentation for the project was completed, and in 2008, an Interchange Justification Report (IJR) was approved (*I-5 – SR 161/SR 18 Interchange Improvements IJR* (Washington State Department of Transportation [WSDOT], July 2008) for the project. As part of the IJR, several interchange improvements and configurations were analyzed in an effort to improve safety and mobility in the triangle area formed by Interstate 5 (I-5), State Route (SR) 161 (also known as Enchanted Parkway S), and SR 18 (also known as S 348th Street west of SR 161). As part of that original IJR effort in 2008, a preferred alternative was identified that has already been partially constructed and will be completed in multiple phases. Phase 1 of the Triangle Interchange Project was completed in July of 2012 and included the following improvements:

- A new collector-distributor (C-D) roadway for SR 18 westbound to I-5 northbound and southbound between Weyerhaeuser Way S and I-5
- A new two-lane flyover ramp for SR 18 westbound to I-5 southbound (eliminated northwest [NW] loop ramp at the interchange)
- A new flyover ramp for eastbound SR 18/S 348th Street to I-5 northbound (eliminated southeast [SE] loop ramp at the interchange)
- A direct access for SR 18 westbound to SR 161 via a new ramp
- New ramp meters at the I-5 northbound on-ramps from SR 18 eastbound and westbound and the I-5 southbound on-ramp from SR 18 eastbound

Elements of the previously approved Phase 2 design from the original IJR are illustrated in Exhibit Intro-2 and included:

- Providing a new two-lane off-ramp for I-5 southbound that connects to a C-D roadway that provides access to SR 18 eastbound and westbound and SR 161, and extending the off-ramp farther north on I-5
- Realigning the off-ramps from I-5 southbound to SR 18 westbound and eastbound to connect to the new C-D roadway
- Providing a new access from the C-D roadway to SR 161 via S 356th Street and the SR 18 westbound off-ramp to SR 161
- Providing a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street that realigns 16th Avenue S to create a five-leg signalized intersection

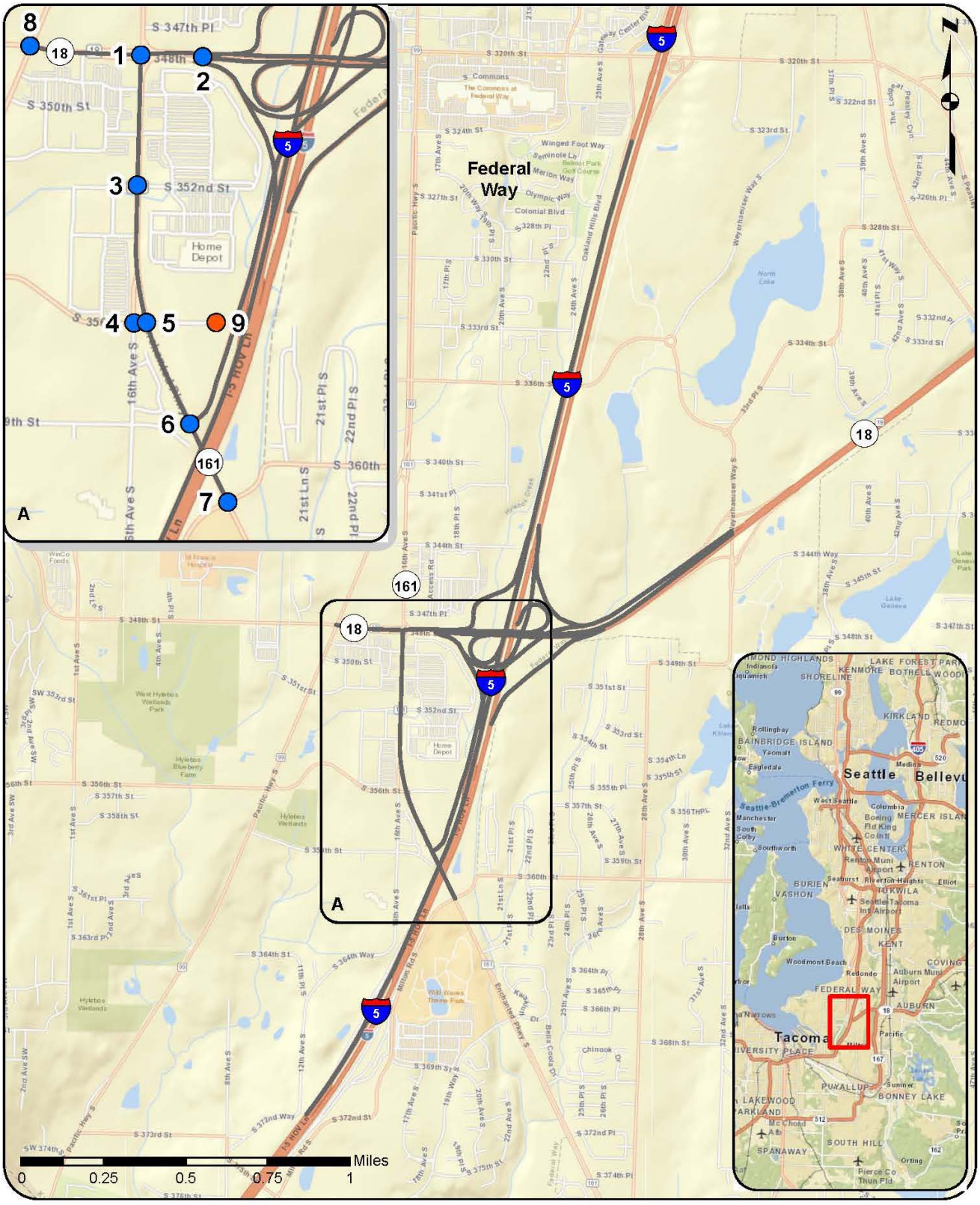
In December of 2014, WSDOT conducted a Value Engineering/Practical Design (VE/PD) study of the Phase 2 design, resulting in recommended modifications to the Phase 2 design. The current Phase 2 design that reflects those modifications is shown in Exhibit Intro-3, with conceptual design drawings provided in Appendix A. The current Phase 2 includes:

- Providing a new two-lane off-ramp for I-5 southbound to SR 18 eastbound and westbound, and extending the off-ramp farther north on I-5
- Eliminate the I-5 southbound off-ramp to SR 18 eastbound (SW loop ramp at the interchange). Southbound trips from I-5 destined to SR 18 eastbound and westbound would be accommodated on the new two-lane southbound off-ramp by left- and right-turn movements, respectively, at a signalized intersection.

- Providing a new single-lane off-ramp from I-5 southbound to SR 161 that provides access to both S 356th Street and the SR 18 westbound off-ramp to SR 161
- Providing a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street, and providing improvements to the intersection of S 356th Street/SR 161/16th Avenue S

The roadway connections associated with Phase 2 have already been analyzed in *I-5 – SR 161/SR 18 Interchange Improvements IJR* (WSDOT, July 2008), but the specific proposed infrastructure improvements for Phase 2 have been modified. The most significant modification with the current Phase 2 design is the elimination of the C-D system that accommodated traffic from I-5 southbound to both SR 18 and SR 161. This traffic is proposed to now be separated with two different I-5 southbound off-ramps. No other changes to the future phases are proposed at this time; therefore, this IJR is an amendment to the original IJR but for only the current Phase 2 design compared to the No Build condition that includes the Phase 1 improvements. Improvements beyond Phase 2 are not included in this IJR Amendment.

In this IJR Amendment, all eight policy points are addressed, but only Policy Points 3, 4, 5, 6, 7, and 8 are discussed in detail with updated information pertaining to the current Phase 2 design. The intent of Policy Points 1 and 2 has not changed, so a summary of the content and conclusions within those policy points from the original IJR approved in 2008 is included in this IJR Amendment for reference purposes.



Legend

- Study Intersections
- Future Study Intersections
- Study Roads

Exhibit Intro-1. Study Area and Proposed Study Intersections

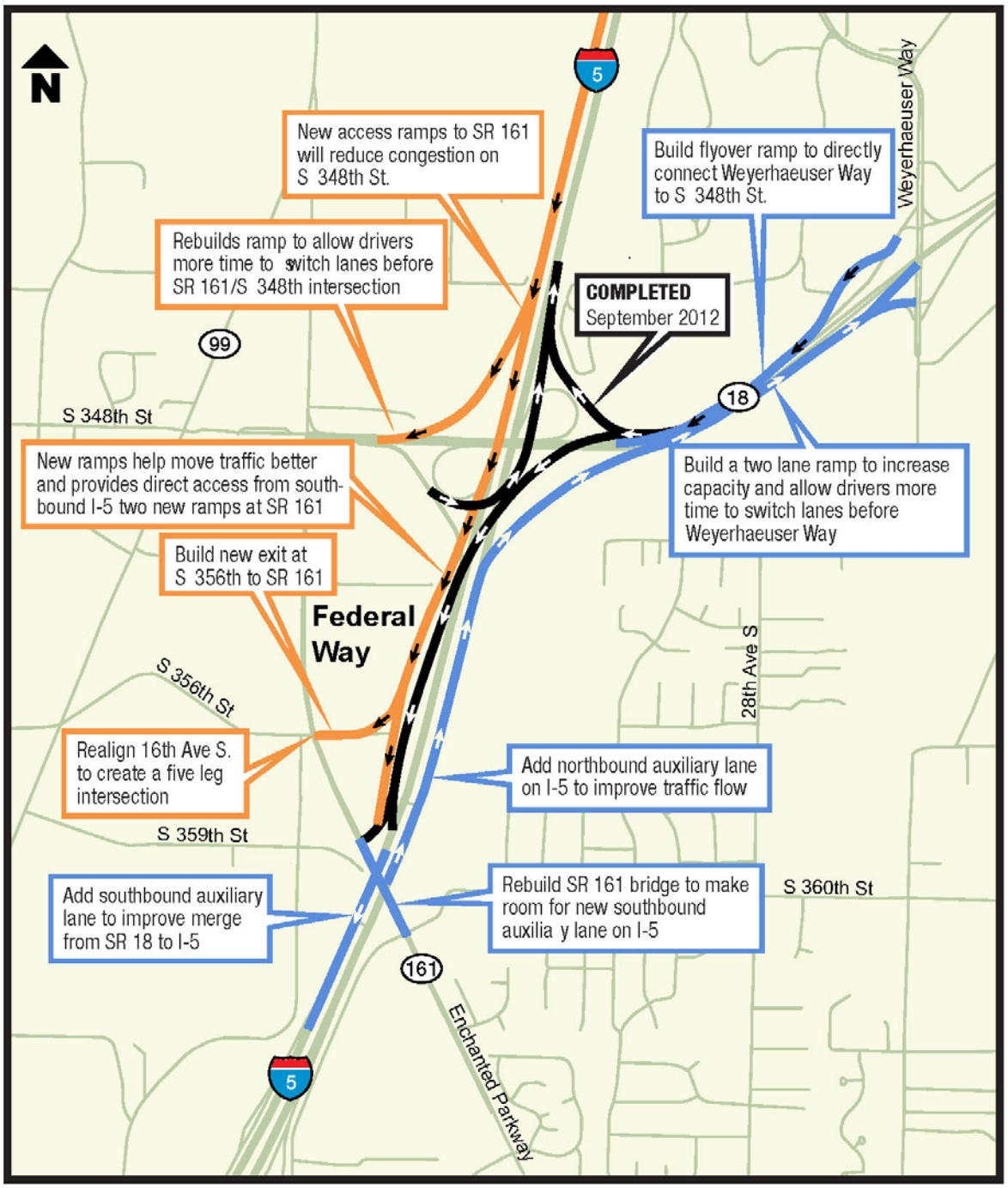


Exhibit Intro-2. Triangle Interchange Project Phases with Previous Phase 2

Note: Black lines show Phase 1, orange lines show the previously approved Phase 2, and blue lines show future phases.

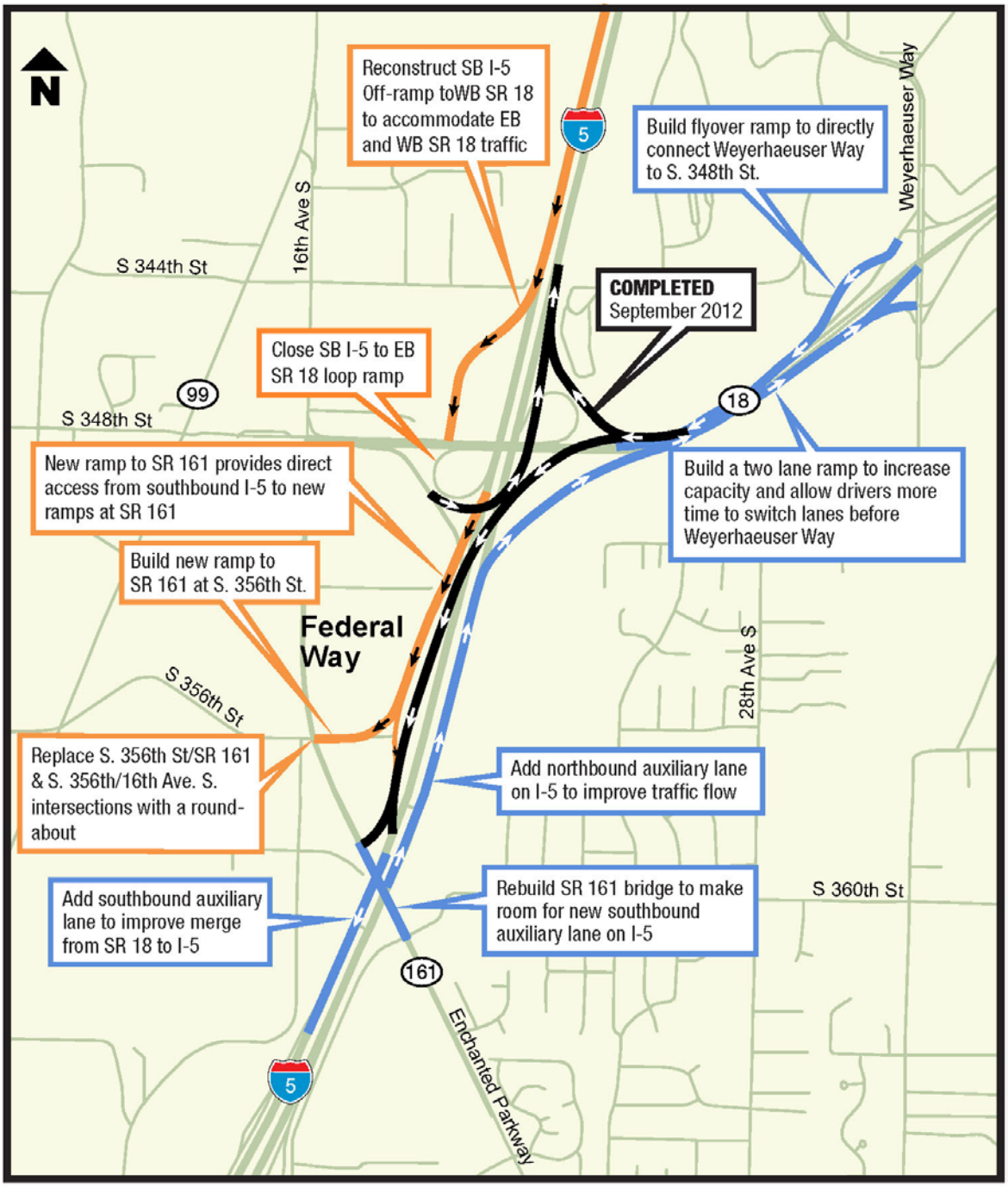


Exhibit Intro-3. Triangle Interchange Project Phases with Current Phase 2

Note: Black lines show Phase 1, orange lines show the current Phase 2 design, and blue lines show future phases.

Policy Point 1: Need for Access Point Revision

What are the current and projected needs? Why are the existing access points and the existing or improved local system unable to meet the proposal needs? Is the anticipated demand short or long trip? (WSDOT Design Manual, Chapter 550.)

1.1 Introduction

Subsection 1.2 summarizes the original content provided in Policy Point 1 of *I-5 – SR 161/SR 18 Interchange Improvements IJR* (WSDOT, July 2008). This IJR Amendment does not update Policy Point 1 because this amendment is not re-considering the project's need for interchange improvements as the conclusions documented in the original IJR were approved by WSDOT and Federal Highway Administration (FHWA) and have not changed.

1.2 Need for Access Summary[1]

The project stakeholders developed the following purpose and need statement to guide the development and evaluation of alternatives:

> The purpose of the project is to improve safety and traffic circulation (which will reduce congestion) for freight and people in the vicinity of I-5 near the SR 161 and SR 18 intersection and interchange.[2]

This project is identified as a "Congested" Highway of Statewide Significance (HSS) in the 2007 through 2026 Washington State Highway System Plan (HSP). Successive ramps, particularly merges and diverges resulting in weaving segments, are indicative of cloverleaf interchanges where high volumes or high-speed weaves can result in vehicle queuing and congestion, and in this case, a high accident location (HAL) at the I-5/SR 18 interchange. The initial I-5/SR 161/SR 18 Triangle Study was completed for the project in 2003. The focus of the initial study was I-5 from the King/Pierce county line through the "triangle" formed by I-5, SR 161, and SR 18. Potential road, intersection, and interchange improvement concepts were considered to reduce congestion and improve safety. The study recommended two ways to resolve safety problems associated with the I-5/SR 18 interchange: increase the capacity of the interchange and provide better access between I-5 and SR 161.

1.2.1 Safety

WSDOT has identified several HALs and high accident corridors (HACs) within the study limits. HACs and HALs are calculated by WSDOT, depending on the number of accidents and also on the severity of the accidents. Nine HALs are identified in the project area based on WSDOT's 2002 through 2004 data for the 2007 through 2009 biennium HAL list, indicating both severe and numerous accidents at the following locations:

1. I-5 southbound exit ramp to eastbound SR 18
2. I-5 northbound exit ramp to westbound SR 18
3. I-5 southbound exit ramp to westbound SR 18
4. SR 18 eastbound between SR 99 and SR 161
5. SR 18 both directions between SR 161 and the SR 18 eastbound-to-I-5 southbound entrance ramp

[1] The content within this summary is an excerpt from the original I-5 – SR 161/SR 18 Interchange Improvements IJR, WSDOT, July 2008

[2] Project Purpose and Need, CH2M HILL, October 28, 2004

6. SR 18 eastbound exit ramp to Weyerhaeuser Way S
7. SR 18 westbound exit ramp to Weyerhaeuser Way S
8. SR 161 at the S 356th Street intersection
9. SR 161 at the SR 18 intersection

While more recent accident data are available (2004 through 2006), trends remain the same and most of the accidents at the I-5/SR 18 interchange ramps are speed-related or associated with off-ramp traffic weaving and merging. In addition to these nine HALs, there are seven HALs within the study area limits at the following locations:

1. SR 99 from S 344th Street to 16th Avenue S
2. SR 99 at the S 330th Street intersection
3. SR 99 from S 327th Street to S 324th Street
4. I-5 northbound exit ramp to S 320th Street
5. I-5 northbound loop entrance ramp from S 320th Street eastbound
6. I-5 northbound slip entrance ramp from S 320th Street westbound
7. I-5 southbound exit ramp to S 320th Street

Within the project area limits, two segments of state highway are listed as HACs, based on WSDOT's 2007 through 2009 biennium HAC list.

- I-5 from the King/Pierce county line to the weigh station (Milepost [MP] 139.50 to 140.99)
- I-5 from S 356th Street to S 333rd Street (MP 141.50 to 142.99)

One additional HAC is located within the study area limits: I-5 from S 333rd Street to S 310th Street (MP 143.00 to 144.49). There is one pedestrian accident location (PAL) within the study limits, at the intersection of S 348th Street and SR 161.

Traffic accident data from the City of Federal Way (2002 through 2004) show that there are a number of accidents at the major signalized intersections within the project area:

- 70 accidents per year at SR 18/SR 161–16th Avenue S
- 15 accidents per year at SR 18–S 348th Street/SR 99
- 14 accidents per year at S 336th Street/SR 99

The accident types and severity are typical of congested conditions in areas with multiple traffic conflicts, such as closely spaced intersections.

1.2.2 Capacity/Congestion

I-5 is the major north-south interstate freeway in Washington and passes though the project area. I-5 is a HSS and a principal arterial of the major north-south National Defense System. SR 18 is a HSS and is designated as a principal arterial in the Federal Highway Administration (FHWA) Functional Classification System. Regionally, SR 18 provides an important route for freight, connecting I-90 and points east to Federal Way, Tacoma, and areas to the south.

SR 161 is not a HSS and is designated as an urban principal arterial by FHWA. SR 161 serves Federal Way and connects I-5 and the cities of Milton, Edgewood, and Puyallup. SR 161 becomes 16th Avenue S, a City of Federal Way principal arterial, at S 348th Street. The intersection of SR 161/SR 18 provides access to Enchanted Village/Wild Waves theme park to the south, 16th Avenue S to the north, and SR 99 to the east.

The Triangle Interchange experiences traffic congestion during both AM and PM peak periods, with congestion extending into midday. During the AM peak period, northbound I-5 operates at level of service (LOS) F throughout most of the study area. During the PM peak period, southbound I-5 operates at LOS E/F at the SR 18 interchange. During both peak periods, SR 18 operates at LOS E/F at the I-5 interchange weaves. Also during both peak periods, the eastbound SR 18 weave sections between I-5 and Weyerhaeuser Way S interchanges operate at LOS E/F. The congestion and operational problems in these areas are caused primarily by the heavy weave and resulting conflict volumes and short, inadequate weave distances between the cloverleaf style interchange's pair of loop ramps. The existing interchange loop ramps have limited capacity and are designed for speeds of 25 miles per hour (mph). The westbound to northbound ramp often backs up from I-5 to SR 167. While expanding the freeway to include high-occupancy vehicle (HOV) lanes will improve operations, the southbound and northbound I-5 weaving segment at SR 18 will operate at LOS F.

Intersection analyses indicate that the SR 18/SR 161 intersection operates at LOS F and LOS E in the 2005 AM and PM peak hours, respectively. Also, in the 2005 PM peak hour, four other intersections located at I-5 southbound ramps/S 320th Street, SR 99/S 348th Street, SR 161 and S 356th Street, and 16th Avenue S/S 356th Street, operate at LOS E. All other study area signalized intersections operate at LOS D or better. During the PM peak, long left-turn queues on westbound SR 18 at the SR 18/SR 161–16th Avenue S intersection affect operations at the southbound I-5 off-ramp/SR 18 intersection. This problem will occur more frequently and for longer durations as traffic volumes grow in the future.

1.2.3 Transportation Demand

Traffic volumes in the project area are expected to increase in the next 20 years as the ports of Seattle and Tacoma grow, trade with Canada increases, and growth continues in the urban areas of the Puget Sound region. To encourage growth and increased density, the Puget Sound Regional Council (PSRC) has designated the downtown core area of Federal Way an urban center. The I-5 - SR 161/SR 18 triangle area provides a link between it and other urban centers. Current PM Peak-hour traffic volumes on the section of I-5 between SR 161 and SR 18 are 7,710 southbound and 5,800 northbound. Freeway mainline traffic volumes exceed 170,000 vehicles per day (vpd) (beyond the capacity of an eight-lane freeway and two HOV lanes), with large freight vehicles comprising 7 to 10 percent of the traffic. Peak volumes exceed capacity, and overall traffic volumes on the I-5 mainline have grown at 2 percent per year and could continue to do so in the future.

The current eastbound and westbound PM peak hour volumes on SR 18 immediately east of the I-5 interchange are 3,140 and 3,130 vehicles per hour (vph), respectively. Traffic volume (2004) on SR 18 east of I-5 is 96,000 vpd, which has continued to grow at a rate of approximately 2 percent per year since 1990. SR 161 has also experienced increases in traffic volumes and is approaching capacity. Traffic volumes (2004) on SR 161 are 27,000 vpd, with an annual growth rate of 2 percent since 1990.

PSRC's *Destination 2030* includes the proposed Triangle Interchange Project to address long-term congestion, air quality, and safety deficiencies.

1.2.4 Roadway Deficiencies

A system interchange, as defined in *A Policy on Geometric Design of Highways and Streets* (Green Book, American Association of State Highway Transportation Officials [AASHTO], 2011) as an interchange that connects two or more freeways. A cloverleaf interchange is defined as:

> …the minimum design that can be used at the intersection of two fully controlled access facilities or where left turns at grade are prohibited. A cloverleaf interchange is adaptable in a rural environment where right-of-way is not prohibitive and weaving is minimal. When designing a cloverleaf interchange, careful attention should be given to the potential improvement in operational quality that would be realized if the design included collector distributor roads on the major roadway.

At one time, the current I-5/SR 18 cloverleaf interchange may have met this definition; however, it does not today. It is substandard because of the short weave sections and high ramp volumes. Additionally, each ramp has a small, low-speed radius inadequate for deceleration and insufficient for acceleration and merge onto the freeway, which results in mainline traffic slowing to allow the ramp traffic to merge or diverge. To meet standards, the interchange should be modified to allow acceleration onto and deceleration from the mainline design speed. Since the interchange's construction in 1965, considerable development has occurred in the area, creating higher traffic demand than anticipated. In addition, the I-5/SR 18 route is used for high-volume regional through trips, including freight. Interchange improvements to meet WSDOT standards are needed to meet current and future demand.

Policy Point 2: Alternatives

Describe the reasonable alternatives that have been evaluated.

2.1 Introduction

Subsection 2.2 summarizes the original content provided in Policy Point 2 of *I-5 – SR 161/SR 18 Interchange Improvements IJR* (WSDOT, July 2008). This IJR Amendment does not update Policy Point 2 except for the modifications proposed as part of the Phase 2 design, and therefore the overall project improvements continue to remain the preferred alternative. The specific improvements originally proposed as part of Phase 2 were modified through a VE/PD study conducted in 2014 (*I-5/SR 161/SR 18 Interchange Improvements – Stage 2: Value Engineering/Practical Design Workshop*, December 2014). The VE/PD study recommendations and the current Phase 2 design are described in Subsection 2.3.

2.2 Alternative Development/Screening Summary

In an effort to improve safety and traffic circulation at the I-5 - SR 161/SR 18 triangle interchange, all reasonable alternatives were developed and analyzed for efficiency. The goal of the analysis was to identify a proposed alternative that addresses the projected design year needs, is compatible with planned construction of other projects within the Washington HSP, and produces the least amount of deleterious impacts on the human or natural environment.

A total of 12 construction alternatives, along with 22 no-build/limited construction alternatives, were evaluated in a detailed screening process. This process, which resulted in the selection of the Proposed Alternative, included the development of alternatives, a two-level screening, a value analysis study, and refinement of the Proposed Alternative. Input from the project's technical advisory committee was considered at all levels of the screening and alternative selection process.

As summarized in Exhibit 2-1, Alternative W4 was identified as the Proposed Alternative because the analysis showed it to be the most efficient and cost-effective plan with the least social, economic, and environmental impacts. Alternative W4 has the following attributes:

- Eliminates current HALs at the I-5/SR 18 interchange
- Provides connections between I-5 and SR 18 with SR 161
- Is compatible with other state highway plan projects in the region, such as the I-5 Pierce County Line to Tukwila Interchange HOV – Stage 4, SR 509 Corridor Completion project, and the SR 167 Completion project
- Is compatible with planned local road improvements in the area
- Meets the forecasted travel demand while not precluding the construction of additional expansion projects in the future
- Maintains the most construction improvements within the existing right-of-way footprint, with the least environmental impacts

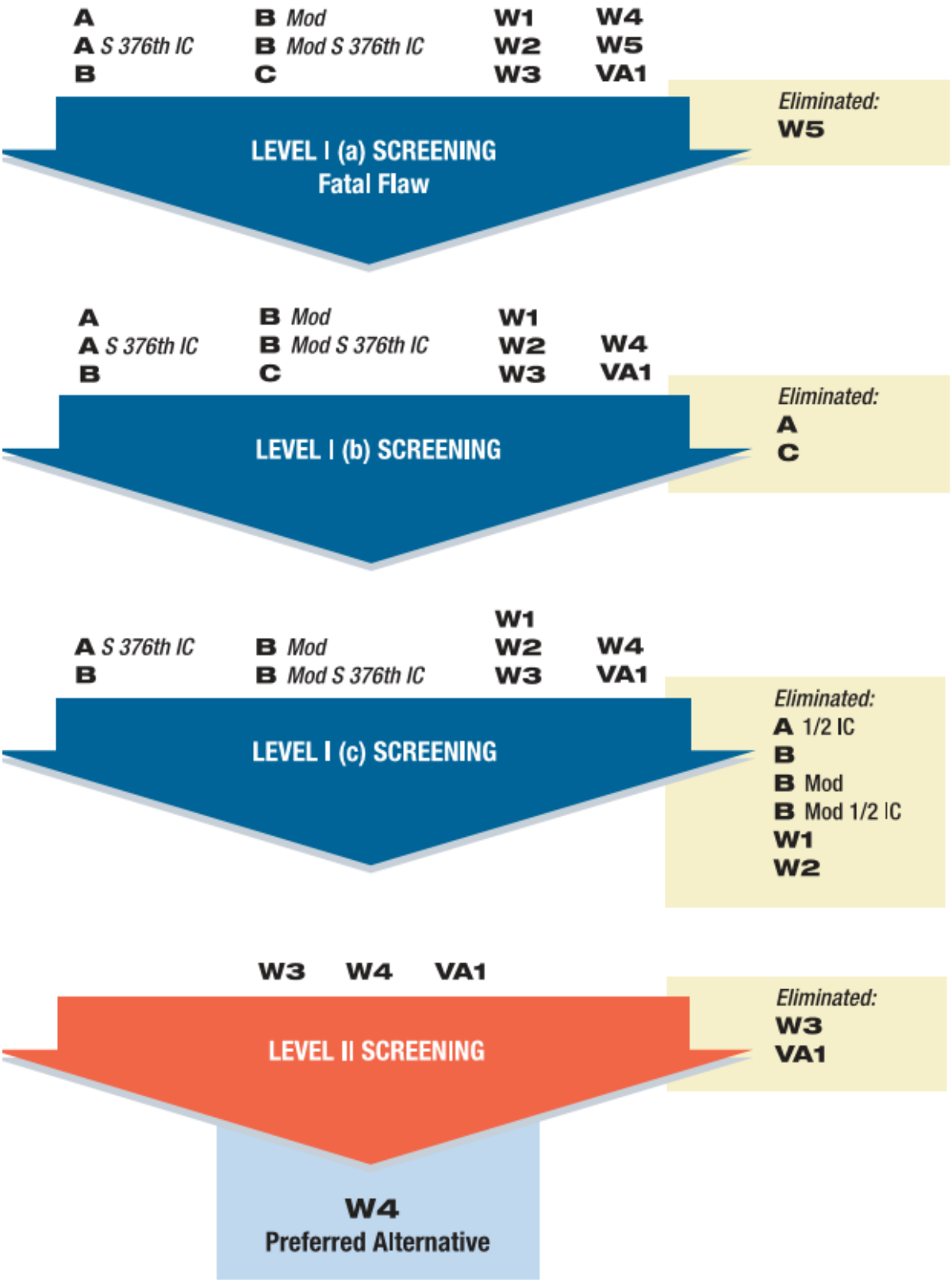


Exhibit 2-1. Triangle Interchange Improvement Project - Phase 2 Alternatives Screening Flow Chart

2.3 Value Engineering/Practical Design (VE/PD) Modifications

A VE/PD study was conducted for this project on December 2-4, 2014, with the presentation of findings held December 8, 2014. The workshop was conducted for WSDOT and facilitated by HDR Inc.

The VE/PD team generated 48 ideas for the project. These ideas were compared against the baseline concept developed by the project team. The ideas that performed the best were further developed by the VE/PD team. This resulted in 7 VE/PD recommendations being brought forward (Table 2-1) and 21 ideas to be considered further by the design team.

Table 2-1. VE/PD Summary of Recommendations

#	Description	Difference in Cost Compared to Baseline ($Millions)		Performance1
		Construction	Right-of-Way	
1	Reduced Widths	(- $3.10)		7%
2	Nested Guardrail	(- $0.06)		5%
3	Signal Operations	N/A		21%
4	Southbound I-5 to Eastbound SR 18 Ramp	(- $6.76)		18%
5	Roundabout @ 356th	+ $1.26	(- $3.07)	40%
6	Access Control		(- $4.08)	2%
7	Ramp Terminal	+ $1.60	(- $8.16)	42%
Total		**(- $8.66)**	**(- $7.15 to - $11.23)**	

Notes:
[1] Performance was defined and agreed upon by the stakeholders participating in the VE study and included attributes such as freeway mainline operations, local street operations, maintainability, construction impacts, and environmental impacts.

Following the VE/PD workshop, WSDOT reviewed the VE/PD recommendations and has proposed the following Phase 2 design elements to be analyzed and documented as part of the IJR Amendment:

- Provide a new two-lane off-ramp for I-5 southbound to SR 18 eastbound and westbound and extend the off-ramp farther north on I-5
- Eliminate the I-5 southbound off-ramp to SR 18 eastbound (SW loop ramp at the interchange). Southbound trips from I-5 destined to SR 18 eastbound and westbound would be accommodated on the new two-lane southbound off-ramp by left- and right-turn movements, respectively, at a signalized intersection.
- Provide a new single-lane off-ramp from I-5 southbound to SR 161 that would provide access to both S 356th Street and the SR 18 westbound off-ramp to SR 161.
- Provide a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street and provide improvements to the intersection of S 356th Street/SR 161/16th Avenue S.

These proposed Phase 2 improvements are shown on Exhibit Intro-3 and in Appendix A.

Policy Point 3: Operational and Accident Analysis

How will the proposal affect safety and traffic operations at year of opening and design year?

3.1 Introduction

This policy point summarizes the future No Build and Build (also described as the "Proposal" or "current Phase 2 design" of the Triangle Interchange Project) conditions in the study area by means of traffic forecasts, and highway and local street intersection and safety analyses for years 2020 (year of opening) and 2040 (the design year).

The traffic operations analysis conducted for this IJR Amendment only includes the current Phase 2 design as the Build condition and does not include any future phases of the Triangle Interchange Project that are not funded. The safety analysis compares the previous and current Phase 2 designs of the project with the No Build condition. The future year analysis of the complete Triangle Interchange Project that includes all future phases is provided in the original IJR.

3.2 Summary

Traffic forecasts and background improvement projects indicate that within the study area, I-5 southbound would have congestion by year 2040 caused by spillback from the local road system. The highway and local street system would be expected to have more congestion by year 2040 as the transportation system would not be able to accommodate the demand and therefore travel times would increase by as much as 75 percent, depending on the path, from existing 2015 conditions. The local street system, especially at intersections along SR 161 in the PM peak hour, would operate between level of service (LOS) D and F with long vehicle queues that equate to substantially longer travel times than currently experienced.

With the Proposal, congestion on I-5 southbound would be improved as queues from the local road system would be reduced and no longer spill back onto I-5. The Proposal would improve access and connectivity between the interstate, highway, and local street system with a new connection between I-5 and S 356th Street. Freeway and intersection vehicle throughput would increase between 5 percent and 15 percent, and travel time would improve by as much as 80 percent, depending on the path compared to No-Build conditions. Intersection operations are also expected to improve as the average delay at all study intersections would be reduced by 25 percent. The current Phase 2 design would also result in fewer predicted crashes than the previously approved Phase 2 design and would be expected to have less crashes on existing roads compared to the No Build condition.

3.3 Analysis Parameters and Assumptions

A summary of the key items in the analysis parameters and assumptions is provided in this section. For a description of the methodology and assumptions used for the travel demand forecasting and traffic operations and safety analysis, refer to the *I-5 – SR 161/SR 18 (Triangle) Interchange IJR Amendment Methods and Assumptions Document* (CH2M, September 2015) memorandum in Appendix B.

3.3.1 Study Area

The freeway study limits and proposed study intersections are shown on Exhibit Intro-1. Nine intersections are included in the study and are listed in Table 3-1. The IJR study area includes freeway mainline, ramps, ramp terminal intersections, and adjacent intersections along the following corridors:

- I-5 southbound: From just south of the S 320th Street southbound on-ramp to 1 mile south of the SR 18 westbound to I-5 southbound flyover ramp merge point (approximately 3 miles of I-5); also includes a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street and a proposed north-

south road connection between the off-ramp and S 352nd Street in the Build alternative. I-5 northbound is not included in this study area as there are no proposed changes in Phase 2.

- SR 18 westbound: East of the I-5 northbound loop off-ramp with SR 18 westbound to SR 99.
- SR 18 eastbound: From SR 99 to the eastbound off-ramp to Weyerhaeuser Way S.
- SR 161: All signalized intersections between S 348th Street and Milton Road S, including the intersection of 16th Avenue S/S 356th Street. Major driveways on SR 161 are also included in the VISSIM model to account for volume differences between intersections.
- S 356th Street: From the signalized intersection with 16th Avenue S to the new ramp terminal with the I-5 southbound off-ramp.

Table 3-1. Triangle Interchange Project IJR Amendment Study Intersections

No.	Intersection	Existing Intersection Control
1	SR 161 (Enchanted Parkway S)/SR 18 (S 348th Street)	Signalized
2	I-5 Southbound Off-ramp/SR 18	Signalized
3	SR 161/S 352nd Street	Signalized
4	16th Avenue S/S 356th Street	Signalized
5	SR 161/S 356th Street	Signalized
6	SR 18 Westbound Off-ramp/SR 161	Signalized
7	SR 161/Milton Road S	Signalized
8	SR 99 (Pacific Highway S)/SR 18 (S 348th Street)	Signalized
9	I-5 Southbound Off-ramp/S 356th Street/Proposed 18th Avenue S Extension[a]	Not Applicable

[a] The proposed 18th Avenue S Extension would not be completed until the 2040 design year.

3.3.2 Traffic Analysis Tools

Several software packages were used to conduct the traffic operations analysis in this IJR Amendment. Synchro (version 8, build 805, revision 881) and SIDRA (version 6.1) were used to create LOS, average vehicle delay, and volume-to-capacity ratios (v/c) for signalized intersections and roundabout intersections, respectively. VISSIM (version 7.00-09) was used to create travel times, queue lengths, and volume throughput results for both the freeway and surface streets in the study area. VISSIM results were used to supplement Synchro intersection results as VISSIM can capture the effects of oversaturated conditions and queue spillback between closely spaced intersections. Operational parameters for Synchro, SIDRA, and VISSIM are documented in *I-5 – SR 161/SR 18 (Triangle) Interchange IJR Amendment Methods and Assumptions Document* (CH2M, September 2015) in Appendix B.

3.3.3 Measures of Effectiveness and Agency Standards

In order to evaluate the effectiveness of the Triangle Interchange Project Phase 2 elements, a combination of traffic analysis software tools was used to assess and compare future No Build and Build conditions.
The evaluation of intersection performance is based on Synchro output for signalized/unsignalized stop-controlled intersections and SIDRA output for roundabouts. Synchro and Sidra are macroscopic deterministic models that report results based on 100 percent of demand volume, regardless of volume constraints caused by bottlenecks in the network (i.e., v/c ratios over 1.0 are allowed in the results). Synchro is also used to optimize signal timing plans for use in the VISSIM model. The following data are summarized for intersections/roundabouts from the Synchro/Sidra models for the peak hour:

- LOS
- Delay
- V/c ratio

VISSIM performance data were collected and reported on freeway segments and arterials within the study area. VISSIM is a microscopic stochastic simulation model that accounts for individual vehicles in the network, and performance results are based on throughput volumes (i.e., v/c ratios are not allowed to exceed 1.0). The VISSIM model includes a seeding period long enough to replicate queue lengths and congestion patterns observed at the start of the recording period followed by a 2-hour recording period to capture traffic conditions from 7:00-9:00 a.m. and 4:00-6:00 p.m. The length of the seeding period for the Existing Conditions model was held constant for all future year models. Measures of effectiveness (MOEs) are reported only for the single peak hour within the 2-hour period that contains the highest traffic volumes considering all roads in the study area (which is 7:30-8:30 am and 4:30-5:30 pm). The following data are summarized from VISSIM for the peak hour:

- Freeway and arterial volume (throughput versus demand)
- Freeway density (and corresponding LOS)
- Freeway temporal congestion charts
- Freeway and arterial travel times
- Intersection and off-ramp queues

All results are based on the latest *Highway Capacity Manual* methodologies (or an equivalent) with the exception of any roundabout analysis that is based on SIDRA's methodology. The LOS thresholds for this IJR are as shown in Table 3-2.

Table 3-2. LOS Standards

Facility	LOS Threshold
SR 161 and SR 18	LOS E/Mitigated
I-5	LOS D
Signalized Intersections (City of Federal Way)	v/c ratio of 1.2
Unsignalized Intersections (City of Federal Way)	v/c ratio of 1.0
Intersections (WSDOT)	LOS E/Mitigated

3.3.4 Analysis Years and Time Periods

The IJR analyzes both AM and PM peak periods. The existing year to serve as a basis of analysis is 2015. An approximate opening year for the project is 2020. For the purposes of this IJR Amendment, 2040 is assumed as the future design year. This meets a 20-year design horizon and is consistent with the City of Federal Way recent transportation plan update as well as PSRC's 2040 "Local Targets" land use forecasts.

3.3.5 Project Conditions and Alternatives

The alternatives that are analyzed in this IJR Amendment include 2015 Existing, and 2020 and 2040 No Build and Build alternatives. The No Build Alternative includes all funded background projects in the study area and only Phase 1 of the Triangle Interchange Project (which was completed in 2012). The Build Alternative includes all of the background projects assumed in the No Build condition plus the current design of Phase 2 of the Triangle Interchange Project. Analysis of the full build-out condition of the Triangle Interchange Project is not part of this Amendment, as this condition has already been analyzed in the previously approved IJR. Table 3-3 summarizes the analysis scenarios.

Table 3-3. Traffic Operations Analysis Scenarios

Analysis Peak Hours	2015 Existing	2020 Year of Opening		2040 Design Year	
		No Build	Build	No Build	Build
A.M. Peak	✓	✓	✓	✓	✓
P.M. Peak	✓	✓	✓	✓	✓

Note: ✓ indicates peak hour will be analyzed.

3.4 Existing VISSIM Model Calibration/Validation and Results

3.4.1 VISSIM Model Calibration/Validation

Traffic data were collected in order to create the VISSIM and Synchro models and conduct traffic operations analysis. Traffic count data include freeway mainline and ramp counts from WSDOT during midweek days between March and June of 2015, intersection counts from the City of Federal Way collected within the past 3 years, and additional intersection counts collected in July of 2015. Intersection and freeway counts were conducted during the AM peak period (7:00-9:00 a.m.) and PM peak period (4:00-6:00 p.m.). Traffic signal timing data were provided by the City of Federal Way and WSDOT and confirmed by field observation. Travel time data and observations of queues and delays were collected in July on the same day as intersection counts were conducted.

The 2015 Existing VISSIM model calibration and validation process follows guidelines and criteria from *Traffic Analysis Toolbox, Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (FHWA, July 2004) and *Protocol for VISSIM Simulation* (WSDOT, September 2014) for determining the acceptability of model results. Three primary MOEs were used to validate the VISSIM model:

- Throughput volume (field counts versus VISSIM model throughput volumes)
- Travel time (field measured versus VISSIM model output)
- Visual (temporal speed charts from WSDOT occupancy data versus VISSIM speed data)

Existing freeway and arterial demand volumes, saturation flow rates, lane-changing parameters, and lane-change look-back distances were modified in the calibration process. A detailed list of calibration changes to the VISSIM model is located in Appendix C. The VISSIM models include a 15-minute seeding interval followed by a 2-hour recording interval, with 15-minute intervals to capture volume peaking characteristics. The temporal speed charts of I-5 southbound report all 2 hours of the AM and PM peak periods. However, all other MOEs for both the freeway and surface street systems are reported from a common system single peak hour (7:30-8:30 a.m. and 4:30-5:30 p.m.).

After calibration, the model is validated by comparing model results to field data to see if they are within accepted tolerances. The 2015 Existing AM and PM VISSIM models pass both FHWA and WSDOT validation criteria for throughput volumes and travel times for both the arterial and freeway roads within the study area. In addition, the temporal speed chart for I-5 southbound from the VISSIM models matches closely with occupancy data from WSDOT, as can be seen in Exhibit 3-1. Therefore, the 2015 Existing VISSIM models are considered validated to existing field data. Detailed results of the VISSIM calibration and validation are presented in Appendix C.

3.4.2 Existing Freeway Operations

Existing freeway results from VISSIM, including volume throughput, speed, density, and LOS, are summarized in Table 3-4. Temporal speed maps of I-5 southbound are shown on Exhibit 3-1. Detailed freeway results from VISSIM are provided in Appendix D.

I-5 southbound in the AM peak period is the off-peak direction within the study area and does not experience congestion. Average speeds are at or above 60 mph and all demand volume is served. The average density on I-5 southbound in the AM peak is approximately 25 vehicles per mile per lane (veh/mi/ln) or less, which corresponds to LOS C or better. SR 18 eastbound and westbound also operate well during the AM peak (all segments are LOS C or better).

In the PM peak period, I-5 southbound is the peak direction and is very congested within the study area. A bottleneck forms on I-5 southbound south of the study area in the vicinity of Fife and Tacoma, which causes queues that extend upstream into the study area, as can be seen in Exhibit 3-1. The congestion on I-5 southbound typically spills back to the on-ramp from SR 18 westbound, which eventually spills back to SR 18 westbound at Weyerhaeuser Way S. Average speeds on I-5 southbound within this bottleneck are less than 10 mph, with average density exceeding 120 veh/mi/ln (which is LOS F) and throughput up to 5 percent less than demand. North of the queue, between SR 18 and S 320th Street, I-5 southbound is operating at LOS E with average speeds of 47 mph. These existing AM and PM peak hour freeway results are presented in Table 3-4.

Table 3-4. 2015 Existing Freeway Results, AM/PM Peak Hour

Facility	Type	Dir.	Segment Type/Location	AM Peak Hour				PM Peak Hour			
				% Demand Served	Speed	Density	LOS	% Demand Served	Speed	Density	LOS
I-5	GP Lanes	SB	Basic - S 320th St On to SR 18 Off	101%	66	17	B	98%	47	40	E
			Diverge - to SR 18 EB Off (SW Loop)	101%	66	15	B	97%	23	60	F
			Basic - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	102%	66	13	B	98%	6	140	F
			Merge - from SR 18 EB On (SW Slip)	102%	63	15	B	96%	5	178	F
			Merge - from SR 18 WB On (Flyover)	101%	63	25	C	98%	8	143	F
			Basic - SR 18 WB On to Southern Study Area Boundary	101%	65	22	C	95%	9	123	F
SR-18	GP Lanes	EB	Basic - I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	97%	55	11	A	98%	54	16	B
			Weave - I-5 NB On (SE Slip) to Weyerhaeuser Way Off	97%	52	20	B	98%	41	30	D
			Basic - Weyerhaeuser Way off to Eastern Study Area Boundary	97%	62	22	C	98%	59	26	D
		WB	Basic - east of Weyerhaeuser Way to I-5/SR 161 CD Off	99%	66	16	B	93%	55	23	C
			Basic - I-5/SR 161 CD Off to I-5 NB On (NE Loop)	99%	55	7	A	78%	9	99	F
	CD Road	WB	Basic - SR 18 WB Mainline to Weyerhaueser Way WB On	99%	57	20	C	98%	43	39	E
			CD Weave - Weyerhaeuser Way On to I-5 NB Off (NE Slip)	100%	48	19	B	99%	41	36	E
			Basic - I-5 NB Off (NE Slip) to SR 161 Off	100%	48	20	C	99%	24	66	F
Average Results =			**I-5 SB GP =**	**101%**	**65**	**18**		**97%**	**16**	**114**	
			SR 18 EB GP =	**97%**	**56**	**17**		**98%**	**52**	**24**	
			SR 18 WB GP =	**99%**	**60**	**11**		**85%**	**32**	**61**	
			SR 18 WB CD =	**100%**	**51**	**20**		**99%**	**36**	**47**	

Notes:
SB = southbound; EB = eastbound; WB = westbound; SW = southwest; SE = southeast; NE = northeast; GP = general purpose; CD = collector-distributor. Speed is in miles per hour. Density is in vehicles per mile per lane. Results shaded in yellow are at LOS standard while those shaded in red are below LOS standards.

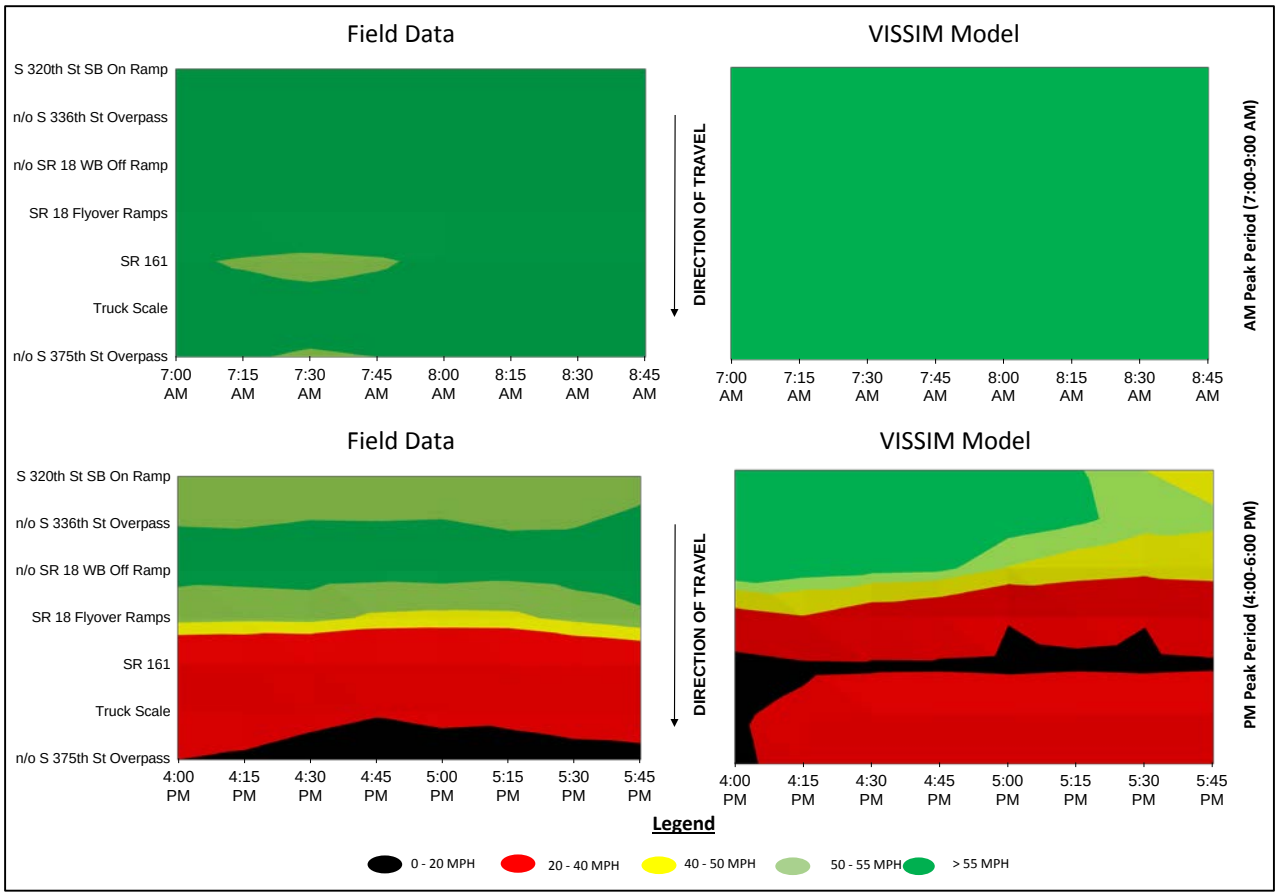


Exhibit 3-1. 2015 Existing Freeway Temporal Speed Maps, AM/PM Peak Period, I-5 Southbound

3.4.3 Existing Intersection Operations

Existing intersection LOS and delay results from Synchro are presented below in Table 3-5. In addition, intersection turn movement volumes and queue lengths from the VISSIM model are presented in Appendix E.

In the AM peak, all intersections operate above the LOS standards within the study area. Two intersections along S 348th Street are at LOS D (at SR 99 and SR 161), while all other intersections operate at LOS C or better.

Most intersections in the study area operate over capacity and are congested in the PM peak. There are currently three intersections on SR 161 in the study area that operate below LOS standards: S 348th Street, S 356th Street, and Milton Road S. Along S 348th Street, the intersection at SR 161 operates at LOS F, while the two adjacent intersections on S 348th Street at SR 99 and I-5 southbound off-ramp operate at LOS E. The intersection of SR 161/S 348th Street experiences high demand volumes from all approaches, especially the westbound approach, which serves vehicles from I-5 southbound and SR 18 westbound. The intersection of SR 99/S 348th Street also contributes to the congestion on SR 18 as westbound queues from this intersection spill back to SR 161, exacerbating westbound congestion that causes long delays and causes queues that spill back through the I-5 southbound off-ramp/SR 18 ramp terminal intersection.

Table 3-5. 2015 Existing Intersection Results, AM/PM Peak Hour

ID#	North-South Street	East-West Street	Synchro Results						VISSIM Results	
			AM Peak			PM Peak			Delay	
			LOS	Delay	v/c	LOS	Delay	v/c	AM Peak	PM Peak
1	SR 161 (Enchanted Pkwy S)	SR 18 (S 348th St)	D	52	0.87	F	93	1.14	33	90
2	I-5 SB Off-Ramp	SR 18	B	15	0.71	E	57	1.00	8	242
3	SR 161 (Enchanted Pkwy S)	S 352nd St	B	18	0.60	D	42	0.71	8	44
4	16th Ave S	S 356th St	C	35	0.24	D	42	0.38	37	39
5	SR 161 (Enchanted Pkwy S)	S 356th St	C	30	0.80	F	95	1.15	15	52
6	SR 161 (Enchanted Pkwy S)	SR 18 WB Off-Ramp	A	6	0.51	C	23	0.81	4	52
7	SR 161 (Enchanted Pkwy S)	Milton Rd S	C	26	0.55	F	126	1.02	15	38
8	SR 99 (Pacific Hwy S)	SR 18 (S 348th St)	D	42	0.79	E	65	0.90	33	47
		Average =		*27*	*0.69*		*72*	*0.96*	17	81

Notes:
All study intersections in Existing Conditions are signalized and are the average of all movements in seconds per vehicle. Synchro results for signals are from HCM 2000 methodology. VISSIM delay values are provided to supplement Synchro results and account for oversaturated conditions and queue spillback to closely spaced intersections.
Results shaded in yellow are at agency LOS standards while results shaded in red are belowagency LOS standards.

Although the Synchro results for the I-5 southbound off-ramp/SR 18 intersection are LOS E and 57 seconds per vehicle (sec/veh) of delay, observations in the field and discussions with WSDOT and City of Federal Way staff indicate conditions in the field are more congested than Synchro indicates. This is because the Synchro software package does not capture the effects of oversaturated intersections with queues spilling back from adjacent intersections as it currently occurs in the field. However, the VISSIM model is calibrated to throughput volumes, travel times, and queues actually observed in the field. Vehicle delays from VISSIM during the PM peak hour at the I-5 southbound off-ramp/SR 18 intersection are over 300 sec/veh (LOS F) with queue lengths extending upstream on SR 18 westbound back to Weyerhaeuser Way S in the VISSIM model. Intersection results from VISSIM are provided in Appendix E.

Further south on SR 161, the intersections of S 356th Street and Milton Road are both at LOS F with high delays and long queues along SR 161 southbound.

3.4.4 Existing Travel Time Results

Existing travel times from the VISSIM model are presented below in Exhibit 3-2 and in Appendix C. Key points within the study area, including freeway and local street intersections, were chosen to create travel paths to compare data collected in the field to results from the VISSIM model. The key locations for these travel paths are:

- Point A: I-5 Southbound Mainline at the S 320th Street On-ramp
- Point B: I-5 Southbound Mainline at the SR 161 Overpass
- Point C: SR 18 (both directions) just west of Weyerhaeuser Way S
- Point D: SR 161/S 348th Street Intersection
- Point E: SR 161/S 356th Street Intersection
- Point F: SR 161/Milton Road S Intersection

Path Description	From - To	AM Peak		PM Peak	
		Travel Time	Speed	Travel Time	Speed
I-5 SB Mainline: S 320th St to SR 161 Overpass	A - B	2.0	66	9.2	14
I-5 SB at S 320th St to SR 18 EB at Weyerhauser Way Exit	A - C	2.3	57	3.2	40
I-5 SB at S 320th St to SR 161/S 348th St	A - D	2.5	39	8.0	12
I-5 SB at S 320th St to SR 161/S 356th St via SR 161/S 348th St	A - E	4.2	31	14.4	9
I-5 SB at S 320th St to SR 161/Milton Rd S via SR 161/S 348th St	A - F	4.9	31	16.2	9
SR 18 WB: Weyerhaueser Way to SR 161/S 348th St	C - D	2.3	20	11.7	4
SR 18 WB at Weyerhaueser to SR 161/S 356th St via SR 18 WB Flyover Ramp	C - E	2.0	37	3.8	20
SR 18 WB at Weyerhaueser to SR 161/Milton Rd via SR 18 WB Flyover Ramp	C - F	2.0	47	4.1	23
SR 161/S 348th St to I-5 SB Mainline at SR 161 overpass	D - B	1.1	47	6.2	8
SR 18 EB: SR 161 to Weyerhauser Way Exit	D - C	1.0	45	1.0	45
SR 161 SB: S 348th St to Milton Rd	D - F	1.5	33	6.8	7
SR 161 NB: Milton Rd to S 348th St	F - D	2.6	20	3.6	14

Note:
NB = northbound; EB = eastbound; SB = southbound; WB = westbound.
Results are from VISSIM. Travel time is in minutes. Speed is in miles per hour.

Exhibit 3-2. 2015 Existing Travel Time Results, AM/PM Peak Hour

During the AM peak, speeds on I-5 and SR 18 are at or close to free-flow conditions. The time to travel on I-5 southbound between S 320th Street and the SR 161 Overpass (path A to B) is 2.0 minutes, while the time to travel from S 320th Street to SR 161 at Milton Road (path A to F) would take just under 5 minutes. Travel time on SR 161 northbound between Milton Road and S 348th Street (path F to D) is 2.6 minutes (or 20 mph), while the opposite direction on SR 161 is 1.6 minutes (or 33 mph).

In the PM peak, travel times for all paths are longer than the AM peak, with the exception of path D to C (SR 18 eastbound from SR 161 to Weyerhaeuser Way S), which is the same. Key travel paths that highlight the heavy congestion in the study area include:

- I-5 southbound from S 320th Street to the SR 161 Overpass (path A to B): It takes 9.2 minutes (which is equivalent to 14 mph) to travel along this I-5 segment because of congestion extending into this interchange south of the study area.
- SR 18 westbound to SR 161/S 348th Street intersection (path C to D): Travel time on SR 18 westbound takes 11.7 minutes (or 4 mph) in the PM peak.
- SR 161 from S 348th Street to Milton Road (path D to F): SR 161 southbound in the PM peak direction experiences travel time of 6.8 minutes (or 7 mph).
- I-5 southbound at S 320th Street to SR 161/S Milton Road intersection (path A to F): This path has the longest travel time in the study area during the PM peak. It takes 16.2 minutes, or an average speed of 9 mph.

3.5 Future I-5/SR 18 and SR 161 Channelization and Ramps

3.5.1 No Build Condition

All reasonably foreseeable and funded projects in the study area that are documented in relevant local and state plans were included in the project analysis for the future No Build and Build conditions. A detailed list of all projects included in the travel demand forecast model is in Appendix B. The future improvement projects within the study area that would have the most relevant impacts for this analysis by the 2020 opening year include:

- Tacoma/Pierce County (TPC) HOV Program – Extend I-5 HOV Lanes to SR 16, provide capacity improvements and auxiliary lanes at spot locations.
- S 352nd Street Extension – Construct a new 2- to 3-lane street extension from SR 99 to SR 161.
- SR 161/S 348th Street – Add a third southbound through lane at the intersection.
- SR 99 HOV Lane Phase 5 – Construct northbound and southbound HOV lanes on SR 99 from S 340th Street to S 356th Street.
- SR 161 at SR 18 Westbound Off-Ramp and Milton Road S – Signal coordination.

By the year 2040, these additional key projects would be constructed within and near the study area:

- Puget Sound Gateway Program – The program includes two unique projects
    - SR 167 Completion – Extend SR 167 from its current terminus in Puyallup west to I-5 and SR 509 at the Port of Tacoma
    - SR 509 Corridor Completion - Extend SR 509 as 6-lane freeway (including HOV lanes) from S 188th Street to I-5 in SeaTac. Adds new lanes on I-5 from SeaTac to S 320th Street.
- 18th Avenue S Extension – Construct a new 2 lane road between S 352nd Street and S 356th Street to improve access at the Costco/Home Depot shopping centers
- I-5 HOV Lane Designation – By the year 2040, the HOV lane designation is proposed to change to 3 or more occupants

Based on the *Tacoma Pierce County HOV Program Final Supplemental IJR* (WSDOT, June 2008), this project is predicted to reduce the severity of congestion and queue lengths in the PM peak period on the I-5 southbound bottleneck that originates from the Fife/Tacoma area such that it would no longer spill back into the Triangle study area. This is accounted for in all future conditions PM peak VISSIM models.

The other projects listed for both 2020 and 2040 would change travel patterns in the area compared to 2015 existing conditions. However, aside from the third southbound through lane at the SR 161/S 348th Street intersection, none of the other improvement projects would change the channelization or ramp configuration at the Triangle Interchange or along I-5 and SR 18.

3.5.2 Proposal (Build) Condition

The currently proposed Phase 2 improvements, previously described and illustrated in Exhibit Intro-3 and Appendix A, includes the following elements:

- Provide a new two-lane off-ramp for I-5 southbound to SR 18 eastbound and westbound, and extend the off-ramp farther north on I-5 (shown below in Exhibit 3-3).
- Eliminate the I-5 southbound off-ramp to SR 18 eastbound (SW loop ramp at the interchange). Southbound left- and right-turn movements would be accommodated by the re-aligned two-lane southbound off-ramp.

- Provide a new single-lane off-ramp from I-5 southbound to SR 161 that provides access to both S 356th Street and the SR 18 westbound off-ramp to SR 161.
- Provide a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street, and provide improvements to the intersection of SR 161/S 356th Street/16th Avenue S (shown in Exhibit 3-4).

Exhibit 3-3. Triangle Interchange Phase 2 Improvements – I-5 Southbound Off-Ramp to SR 18

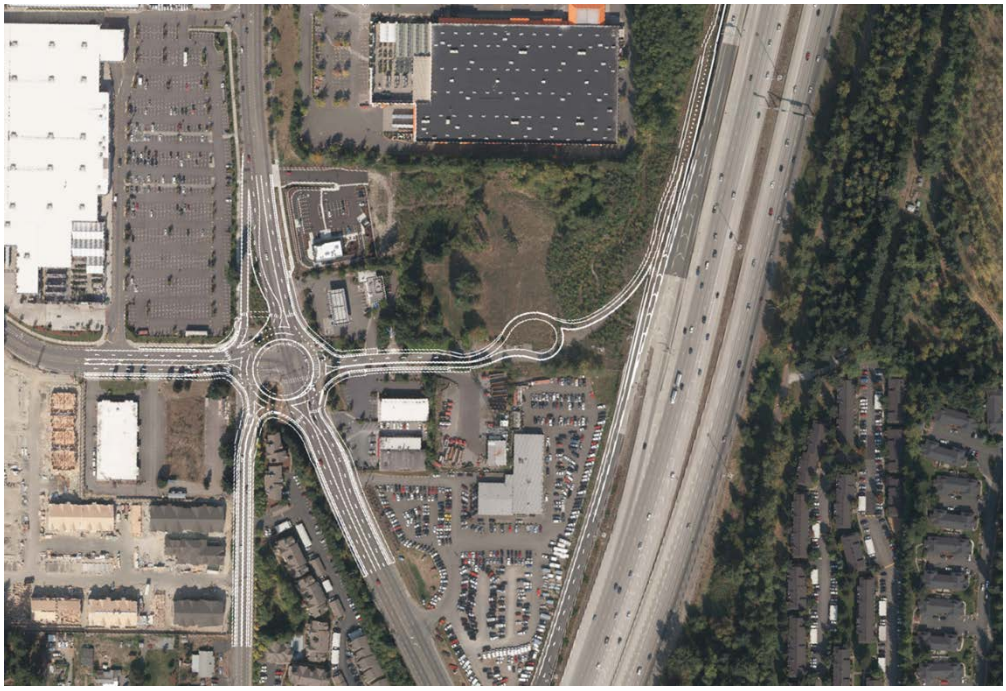


Exhibit 3-4. Triangle Interchange Phase 2 Improvements – I-5 Southbound Off-Ramp to S 356th St/SR 161

The Build condition is therefore defined as including all of these project improvements in addition to all of the background projects assumed as part of the No Build conditions.

These project elements are included in both the 2020 year of opening and 2040 design year traffic analysis of the Build condition. One difference between the year 2020 and year 2040 configuration is the proposed 18th Avenue extension, which would connect with the I-5 southbound off-ramp terminal at S 356th Street as the north leg of the proposed tear-drop roundabout. This connection is not planned by year 2020, so the tear-drop roundabout ramp terminal would only have east and west leg approaches.

3.6 Future Travel Demand Forecasts

3.6.1 Future Baseline Land Use and Transportation Network

The future year analysis described in this policy point was conducted for the Proposal's opening year (2020) and the design year (2040). The City of Federal Way's EMME travel demand model was used to develop future year traffic forecasts for this IJR Amendment. This model had traffic forecasts developed for years 2019 and 2040 based on the latest version of the PSRC EMME model. Within the city of Federal Way, the land use and road network is more refined than PSRC's model and was modified based on the City of Federal Way's recent transportation plan update.

All environmentally approved and partially/fully funded projects in the study area that are included in relevant local, regional, and state plans are assumed for the No Build (baseline) and Build conditions. The following sources were used to develop the project list:

- PSRC's *Transportation 2040* (http://www.psrc.org/transportation/t2040/transportation-2040-update)
- *Washington Transportation Plan* (WTP; http://www.wsdot.wa.gov/planning/wtp) and Washington *Highway System Plan* (HSP) (http://www.wsdot.wa.gov/planning/HSP.htm)
- Washington State Transportation Funding Package (http://leap.leg.wa.gov/leap/budget/detail/2015/ht1517p.asp)
- City of Federal Way 2016-2021 Transportation Improvement Program (TIP) (*Federal Way Comprehensive Plan 2015 Update*, Federal Way 2015)
- City of Milton TIP (http://www.cityofmilton.net/files/library/f01258f2cd3be3b9.pdf)
- Sound Transit Long-Range Plan (http://www.soundtransit.org/Projects-and-Plans/Long-range-Plan-update)
- King County Comprehensive Plan (http://www.kingcounty.gov/property/permits/codes/growth/CompPlan.aspx) and King County Metro Transit Strategic Plan for Public Transportation (http://metro.kingcounty.gov/planning/)
- Pierce County Transit Development Plan (http://www.piercetransit.org/documents/)

Depending on their planned implementation schedule, the background projects are assumed to be built by either the year 2020 or 2040 conditions. Table 3-6 includes the future projects included in the travel demand forecasts and traffic analysis models, where appropriate.

Once the forecasts were produced, a comparison was conducted between the City of Federal Way and PSRC's EMME models. The overall traffic growth in the study area is similar for both models, while the annual traffic growth is slightly higher in the City's model on I-5 and SR 18. The growth forecasted from the City of Federal Way EMME model is consistent with historical trends in travel patterns, and is consistent with future land use forecasts, which predict that growth would occur in the area and ultimately would result in slightly higher traffic forecasts. The forecast volumes used in the traffic operations models have been post-processed based on procedures described in National Cooperative Highway Research Program Report 755.

Table 3-6. Future No Build (Baseline) Projects Included in Travel Demand Forecast Models

#	Project	Description	Source	2020	2040
1	City Center Access Phase 2	Add HOV lanes on S 320th St, realign ramps in SE quadrant	Federal Way TIP	✓	✓
2	10th Ave SW/SW Campus Dr	Add SB right-turn lane	Federal Way TIP	✓	✓
3	SW 344th St (12th Ave SW to 21st Ave SW)	Extend 3-lane principal collector	Federal Way TIP	✓	✓
4	SR 99/S 312th St	Add 2nd left-turn lane northbound.	Federal Way TIP	✓	✓
5	S 304th St/28th Ave S	Add northbound right-turn lane, signal.	Federal Way TIP	✓	✓
6	S 352nd St (SR 99 to SR 161)	Extend 3-lane principal collector.	Federal Way TIP	✓	✓
7	SW 320th St/21st Ave SW	Add 2nd westbound left-turn lane, interconnect to 26th Ave SW.	Federal Way TIP	✓	✓
8	S 312th St/28th Ave S	Add southbound right-turn lane.	Federal Way TIP	✓	✓
9	SW 336th Wy/SW 340th St (26th Pl SW to Hoyt Rd SW)	Widen to 5 lanes, add signal at 26th Pl SW.	Federal Way TIP	✓	✓
10	S 356th St (SR 99 to SR 161)	Widen to 5 lanes.	Federal Way TIP	✓	✓
11	S 320th St/1st Ave South	Add EBL, WBL, WBR, NBT, SBR; widen to 5 lanes N to S 316th St.	Federal Way TIP	✓	✓
12	SR 99 HOV Lane Phase 5: S 340th St to S 356th St	Add HOV Lanes on SR 99, turn lanes at S 348th St.	Federal Way TIP	✓	✓
13	16th Ave S: S 344th St – S 348th St	Add southbound auxiliary lane.	Federal Way TIP	✓	✓
14	Tacoma/Pierce County HOV Program	Extend HOV lanes on I-5 from King/Pierce County Line to SR 16 and associated interchange improvements.	WSDOT	✓	✓
15	New 18th Ave S: S 352nd St - S 356th St	New north-south road connection between S 352nd St and S 356th St that connects to new I-5 SB off-ramp at S 356th St.	Federal Way CIP		✓
16	SR 167 Completion Project Phase 1 - SR 509 to I-5	One lane each direction from existing SR 167 terminus at Meridian interchange in Puyallup to I-5, and a single lane each direction continues to connection at SR 509 in Tacoma. Full interchanges at N Meridian and Valley Avenue in Puyallup and freeway-to-freeway interchange connections with I-5.	WSDOT		✓
17	SR 167 Completion Phases 2 and 3 - SR 509 to SR 161	Widen SR 167 Extension Project, complete 2 general purpose lanes each direction from SR 509 (Port of Tacoma) to the Meridian interchange (SR 161) in Puyallup. Phase 3 will add HOV lanes each direction between I-5 and Meridian interchange.	WSDOT		✓
18	SR 167 HOV lane completion - SR 410 to 15th St SW	Extend HOV/HOT lanes from current termini to SR 410 in Sumner.	WSDOT		✓
19	SR 509 Corridor Completion Project	Complete SR 509 as 6-lane freeway (including HOV lanes) from S 188th St to I-5 in SeaTac. Adds 6 miles of new lanes on I-5 from SeaTac to S 320th. Improve I-5/SR 516 interchange and add a new interchange between I-5 and S 228th St. Add a new interchange on SR 509 that will connect with a new South Access roadway serving Sea-Tac International Airport.	WSDOT		✓
20	Federal Way Link Extension	Extend light rail from S 200th St to Kent-Des Moines area.	Sound Transit		✓
21	I-5 HOV lane designation	Modify the lane designation to only allow vehicles with 3 or more people.	WSDOT		✓

CIP = Capital Improvement Plan; EBL = eastbound left; WBL = westbound left; WBR = westbound right; NBT = northbound through; SBR = southbound right

3.6.2 2020 and 2040 No Build Forecast Volumes

From the City of Federal Way EMME model, annual vehicle growth rates were calculated for the AM and PM peak hours. By year 2040, the cities of Federal Way and Milton combined are forecasted to experience annual growth in population and employment by approximately 0.7 percent and 2.0 percent, respectively (PSRC Land Use Targets, March 2014). As population and employment grow in these communities, traffic volumes are also expected to grow compared to existing conditions. The City of Federal Way's EMME model shows similar annual growth rates for the two study years 2020 and 2040 and is described further in the subsequent paragraphs.

Year 2020 AM and PM peak hour traffic volume forecasts for No Build and Build conditions are shown in Exhibits 3-5 and 3-6, respectively. Year 2040 AM and PM peak hour forecasts for No Build and Build conditions are shown in Exhibits 3-7 and 3-8, respectively. These figures also provide the 2015 Existing Conditions volumes for comparison purposes.

Traffic volumes on I-5 southbound between S 320th Street and the King County Line are predicted to grow at an annual rate of 0.5 percent and 0.4 percent in the AM and PM peak hours, respectively. On SR 18 in both directions between SR 161 and Weyerhaeuser Way S, traffic volumes are predicted to grow 0.7 and 0.4 percent annually in the AM and PM peak hours, respectively. The highest growth in traffic volumes is predicted on SR 161 between S 348th Street and Milton Road S, where the northbound direction would see an increase of 1.2 percent annually in the AM peak and the southbound direction an increase of 1.0 percent annually in the PM peak.

3.6.3 2020 and 2040 Build Forecast Volumes

Year 2020 AM and PM Peak hour forecasts for No Build and Build conditions are shown in Exhibits 3-5 and 3-6, respectively, while Exhibits 3-7 and 3-8 illustrate Year 2040 AM and PM peak hour forecasts, respectively. Between the No Build and Build forecasts, the overall growth rate in the area is expected to remain similar as Phase 2 of the Triangle Interchange Project does not change the capacity of the streets or freeway entering or exiting the study area. While the total number of trips travelling in the area is expected to remain the same as in the No Build condition, the pattern (or distribution) of these trips would change as drivers can use the proposed I-5 southbound off-ramps to S 356th Street and SR 161 in the Build condition rather than the current route through the I-5 southbound off-ramp at SR 18 and the SR 161/S 348th Street intersection.

In the 2020 year of opening, the proposed I-5 southbound off-ramp to S 356th St and SR 161 would shift slightly less than 300 vehicles from the I-5 southbound off-ramp at SR 18 in the AM peak hour, and slightly more than 700 vehicles in the PM peak hour. This shift would be similar but slightly higher by the 2040 design year with 300 vehicles and slightly more than 800 vehicles in the AM and PM peak hours, respectively.

Because of drivers shifting to use this new proposed connection, volumes on SR 161 southbound between S 348th Street and the SR 18 westbound off-ramp would decrease by about 250 vehicles in the AM peak hour and 600 vehicles in the PM peak hour by year 2040. This shift would specifically decrease the westbound left turn at the SR 161/S 348th Street intersection by as much as 60 percent (from about 1,100 vehicles in the No Build condition to slightly more than only 400 vehicles in Build condition during the 2040 PM peak hour). No change in traffic volume on SR 161 north of S 348th Street or south of Milton Road S is expected with Phase 2 of the project.

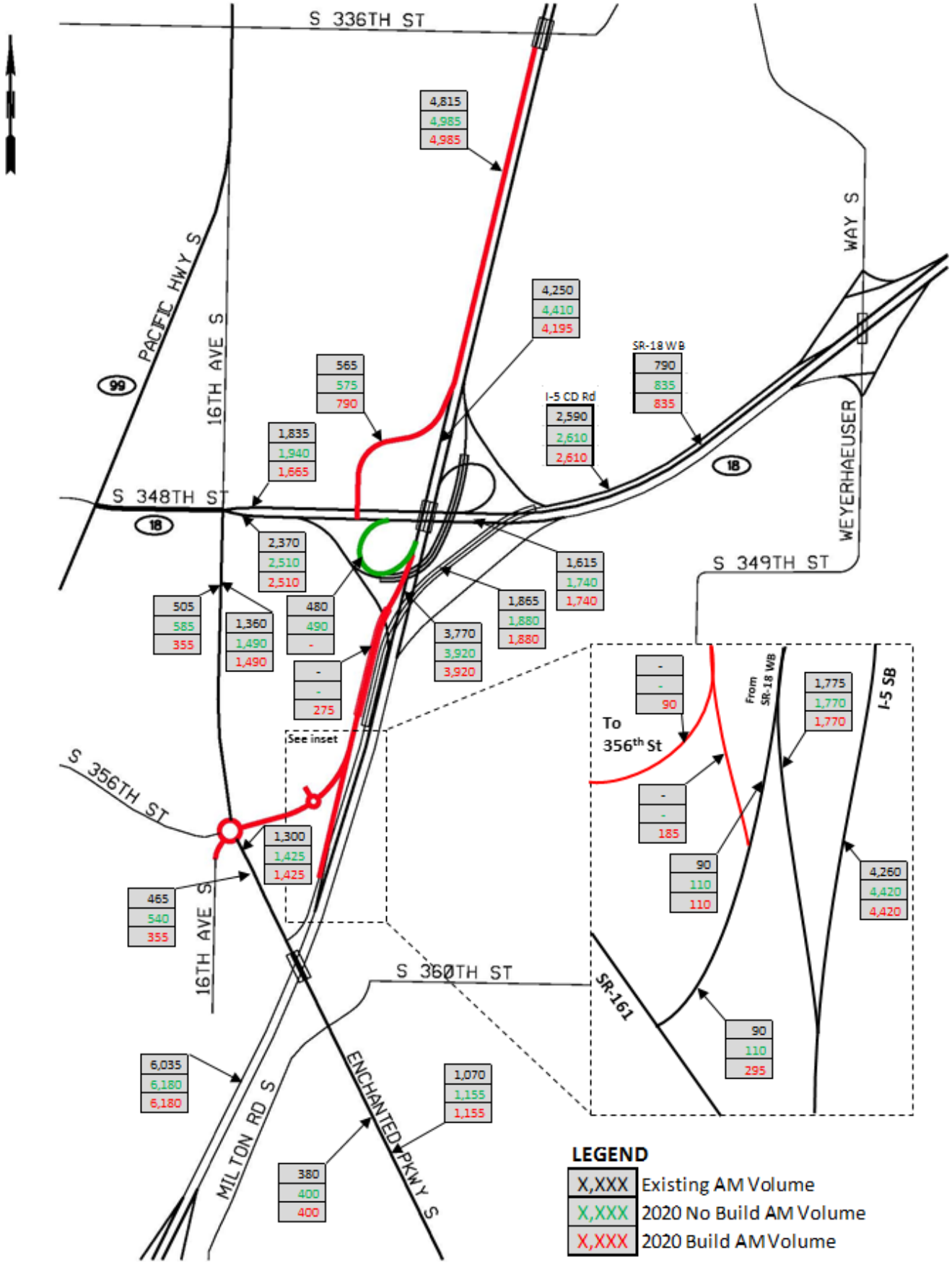


Exhibit 3-5. Existing (2015) and Year of Opening (2020) Forecast Volumes (vph), AM Peak Hour

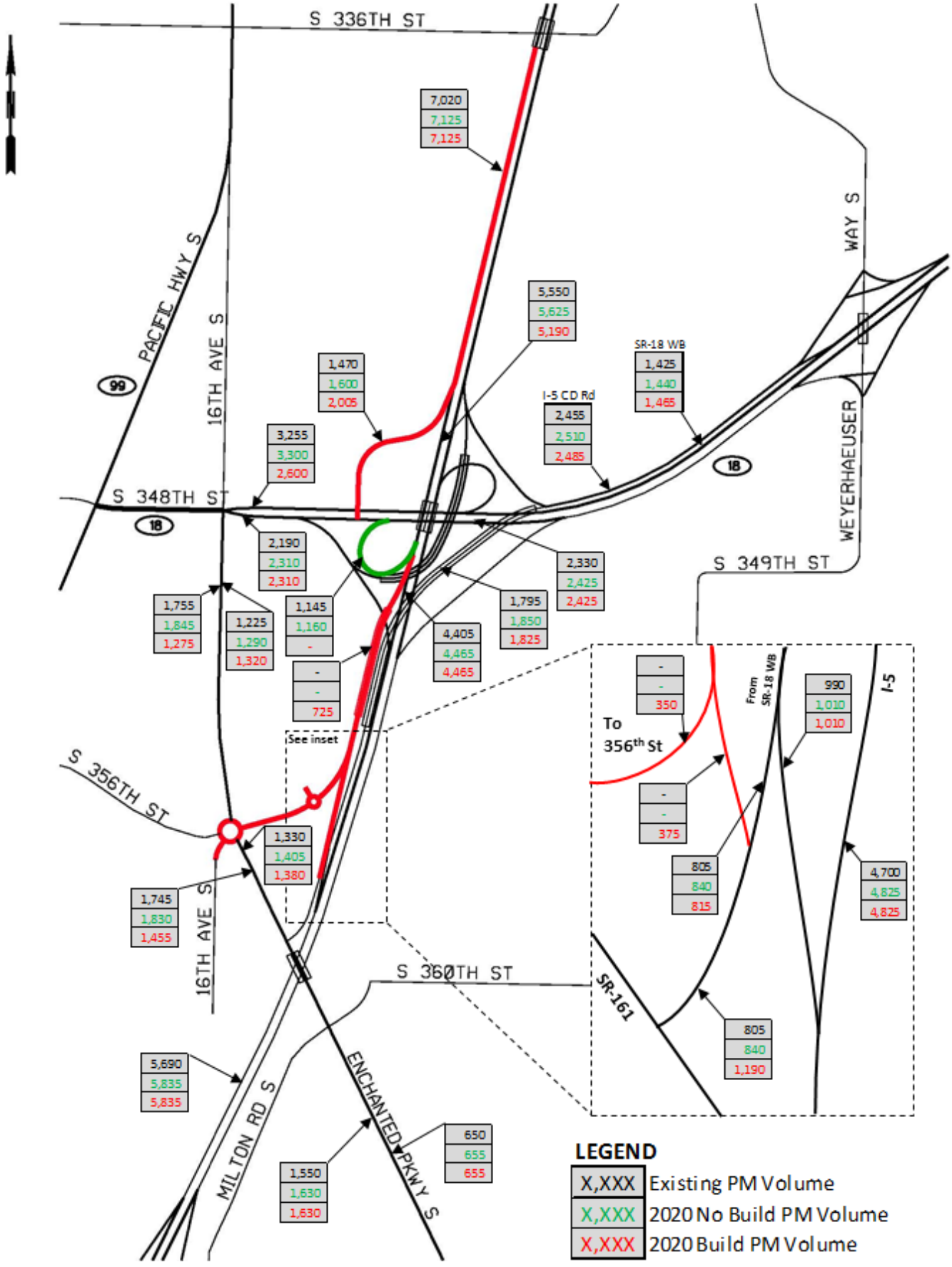


Exhibit 3-6. Existing (2015) and Year of Opening (2020) Forecast Volumes (vph), PM Peak Hour

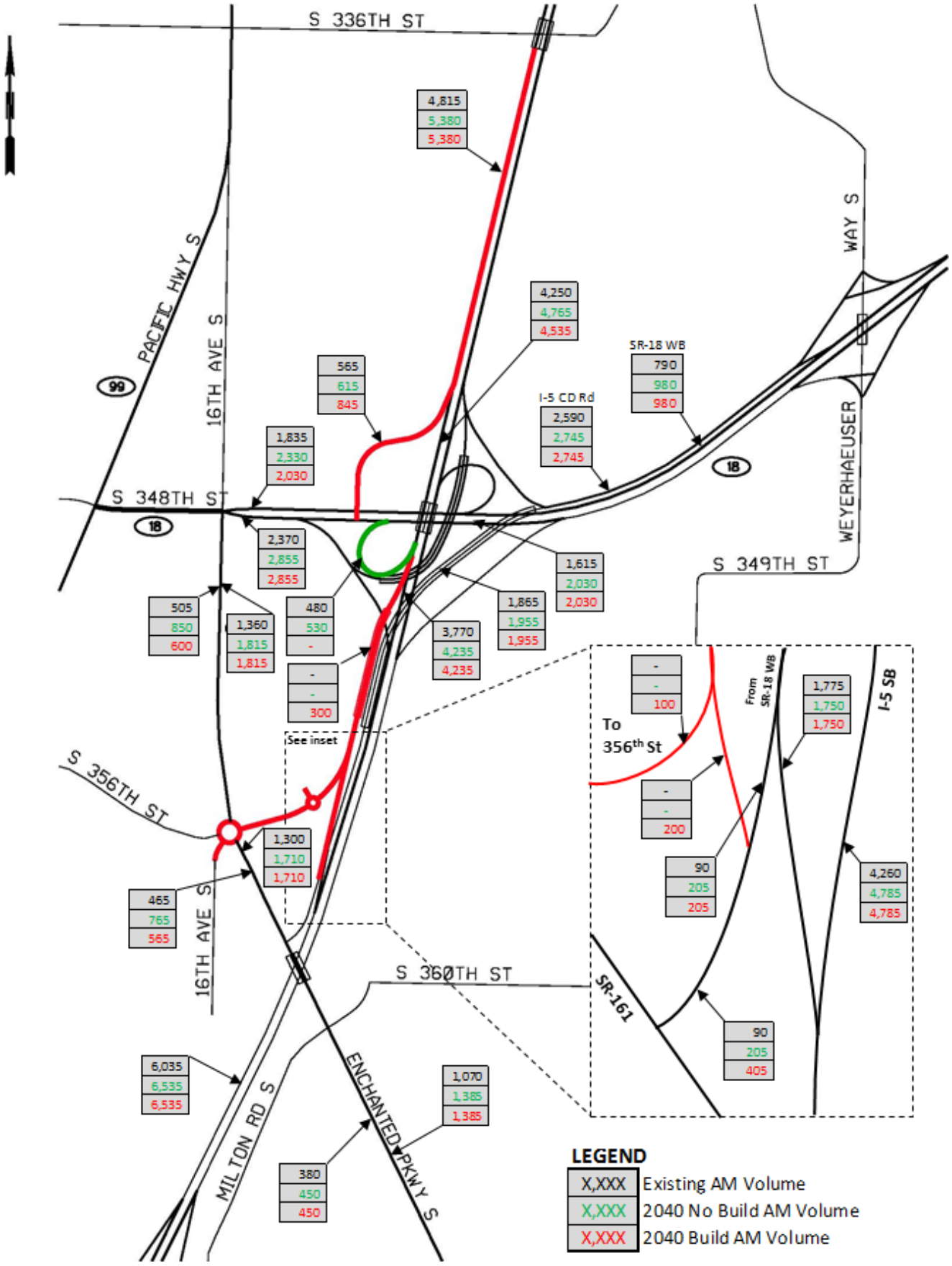


Exhibit 3-7. Existing (2015) and Design Year (2040) Forecast Volumes (vph), AM Peak Hour

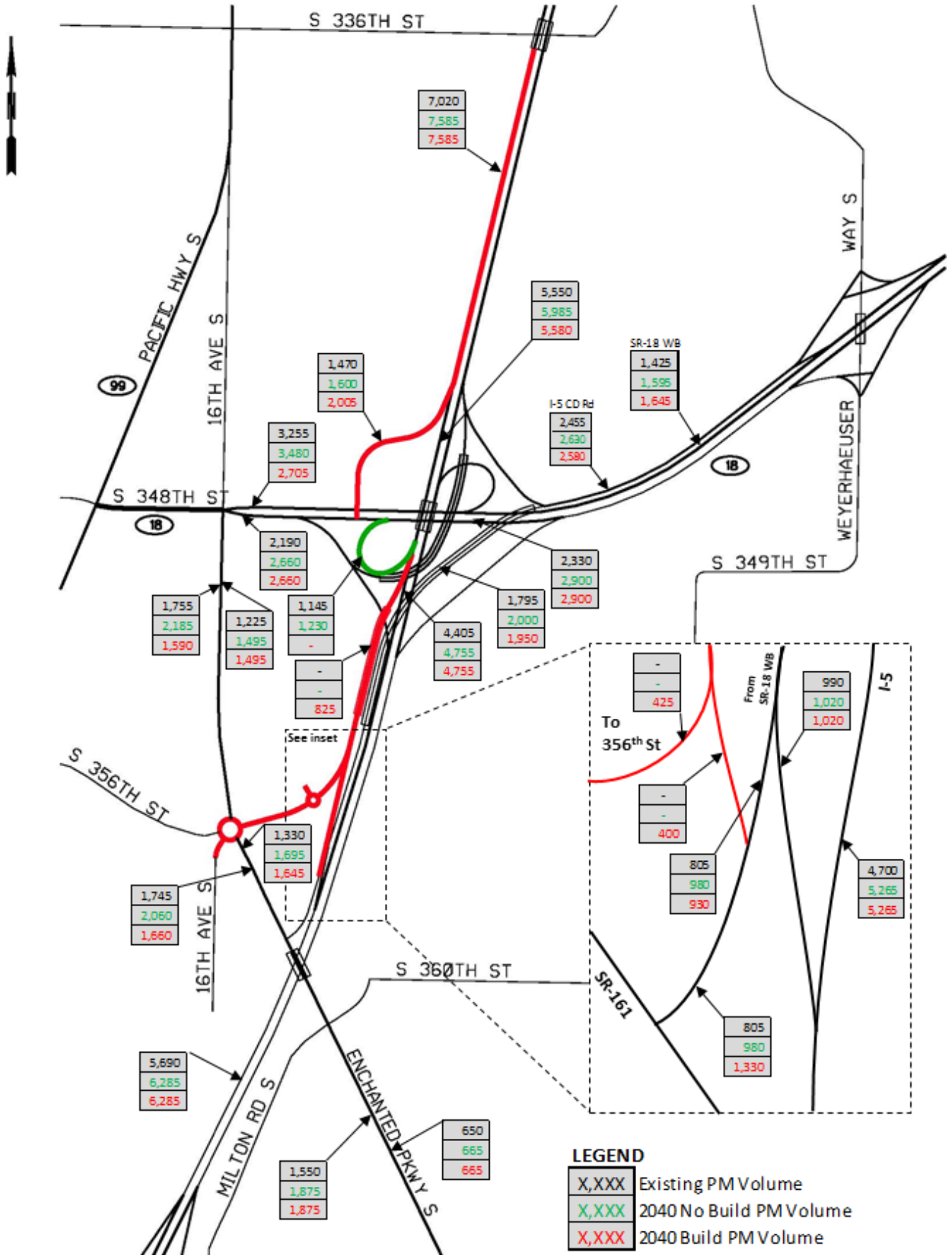


Exhibit 3-8. Existing (2015) and Design Year (2040) Forecast Volumes (vph), PM Peak Hour

The removal of the I-5 southbound loop off-ramp to SR 18 eastbound (SW loop ramp) would shift traffic onto the realigned I-5 southbound off-ramp to SR 18, where a southbound left turn would be provided at the signalized ramp terminal to continue east on SR 18. This would shift slightly more than 500 vehicles in the AM peak hour, while shifting over 1,200 vehicles in the PM peak hour by 2040. This would cause an overall increase in traffic volume on the I-5 southbound off-ramp to SR 18 in the Build condition compared to the No Build condition, although some of this increase in volume is offset by drivers not using this off-ramp in lieu of the new I-5 southbound connection to SR 161 at S 356th Street. Therefore, the I-5 southbound off-ramp to SR 18 would only experience an increase of about 400 vehicles in the 2040 PM peak hour. To accommodate this increase in demand, the I-5 southbound off-ramp to SR 18 is proposed to be widened from a single-lane off-ramp in the No Build alternative to a two-lane off-ramp in the Build alternative.

Traffic volumes on I-5 southbound mainline in the study area would be the same in the No Build and Build conditions, except for the segment between the off-ramp to SR 18 and the off-ramp to S 356th Street/SR 161, which would drop by 200 to 400 vph depending on the year and time period. This drop would occur because trips on the SW loop off-ramp (I-5 southbound to SR 18 eastbound) would exit upstream with the project at the realigned off-ramp to SR 18.

3.7 Future No Build and Build Traffic Conditions

Based on the year 2020 and 2040 travel demand forecasts described in Section 3.6, the future No Build and Build conditions were assessed on the freeway and local street system in the study area. A combination of traffic analysis software packages was used, including VISSIM for the freeway system and for travel times and queue lengths on the local system, Synchro for intersection and ramp terminal LOS and delay, and Sidra for roundabout LOS and delay. This is described in greater detail in Appendix B.

Existing and future freeway and interchange ramp conditions were also assessed by creating predictive crash models using the Interactive Highway Safety Design Model (IHSDM) safety analysis software package. A quantitative assessment of the No Build and the previous and current Phase 2 designs is presented in Section 3.8.

3.7.1 System Throughput

Throughput volumes on all of the road facilities in the VISSIM model, including I-5 southbound, SR 18 eastbound and westbound, and all intersections on SR 161 between S 348th Street and Milton Road S were compared to demand volumes to measure the percent of demand served. This provides a sense of how well the transportation system is able to accommodate the demand and, more specifically, how the project influences the throughput and efficiency of the transportation system. For example, congestion typically occurs when a portion of the demand cannot be served during the peak hour, leading to queues and spillback to adjacent intersections and in heavily congested areas, extending the duration of the peak period. If the percent demand increases with the Build condition, this would indicate that the project is improving the efficiency of the system as more vehicles are able to move through the study area. The throughput results from VISSIM are presented in Table 3-7.

The results show that there is little difference in throughput in the AM peak between the No Build and Build condition for both years 2020 and 2040. This is partially because I-5 southbound in the AM peak is the off-peak direction and does not exhibit noticeable congestion in the No Build or Build conditions. Along SR 161, northbound is the peak direction in the AM peak, but 100 percent of the demand is served in both No Build and Build conditions because there is relatively low delay even in the peak direction.

Table 3-7. Future Year VISSIM System Throughput Results, AM/PM Peak Hour

Road	Type	Dir.	Location	Percent of Demand Volume Served					
				2020 Year of Opening			2040 Design Year		
				No Build	Build	Diff.	No Build	Build	Diff.
AM Peak Hour									
I-5	GP Lanes	SB	S 320th St to SR 161 Overpass	100%	99%	-1%	101%	101%	0%
SR 18	GP Lanes	EB	SR 161 to Weyerhaeuser Way Overpass	99%	100%	+1%	98%	100%	+2%
		WB	Weyerhaeuser Way Overpass to On-Ramp from I-5 NB	99%	99%	0%	99%	99%	0%
	C-D Road	WB	SR 18 WB Mainline to SR 161 Off-Ramp	99%	99%	0%	100%	100%	0%
SR 161	Arterial	All[a]	S 348th Street to Milton Road S	99%	100%	+1%	100%	100%	0%
PM Peak Hour									
I-5	GP Lanes	SB	S 320th St to SR 161 Overpass	99%	101%	+2%	86%	101%	+15%
SR 18	GP Lanes	EB	SR 161 to Weyerhaeuser Way Overpass	98%	99%	+1%	89%	96%	+7%
		WB	Weyerhaeuser Way Overpass to On-Ramp from I-5 NB	100%	100%	0%	76%	90%	+14%
	C-D Road	WB	SR 18 WB Mainline to SR 161 Off-Ramp	100%	100%	0%	88%	98%	+10%
SR 161	Arterial	All[a]	S 348th Street to Milton Road S	96%	99%	+3%	86%	91%	+5%

[a] All entering movements for intersections on SR 161 were measured to compute percent of demand served.
GP = general purpose

In the PM peak, the system throughput in year 2020 is up to 3 percent higher in the Build condition compared to the No Build condition. The proposed I-5 southbound off-ramp to S 356th Street/SR 161 provides another connection to SR 161 and would be used by drivers avoiding the congested S 348th Street (SR 18) and SR 161 area. This would lower vehicle delays in this area and reduce the length of queue that spills back into the I-5 southbound off-ramp terminal at SR 18. As a result, the queue at this off-ramp terminal would no longer extend back onto the I-5 mainline that occurs in the No Build alternative (shown in Exhibit 3-9). As a result, the average throughput on I-5 southbound within the study area would increase by 2 percent. In addition, the throughput along SR 161 would increase by 3 percent as the proposed I-5 southbound off-ramp to S 356th Street/SR 161 in the Build condition alleviates some of the demand and hence congestion at the SR 161/S 348th Street intersection by providing another connection to SR 161 and improving the overall efficiency along the corridor.

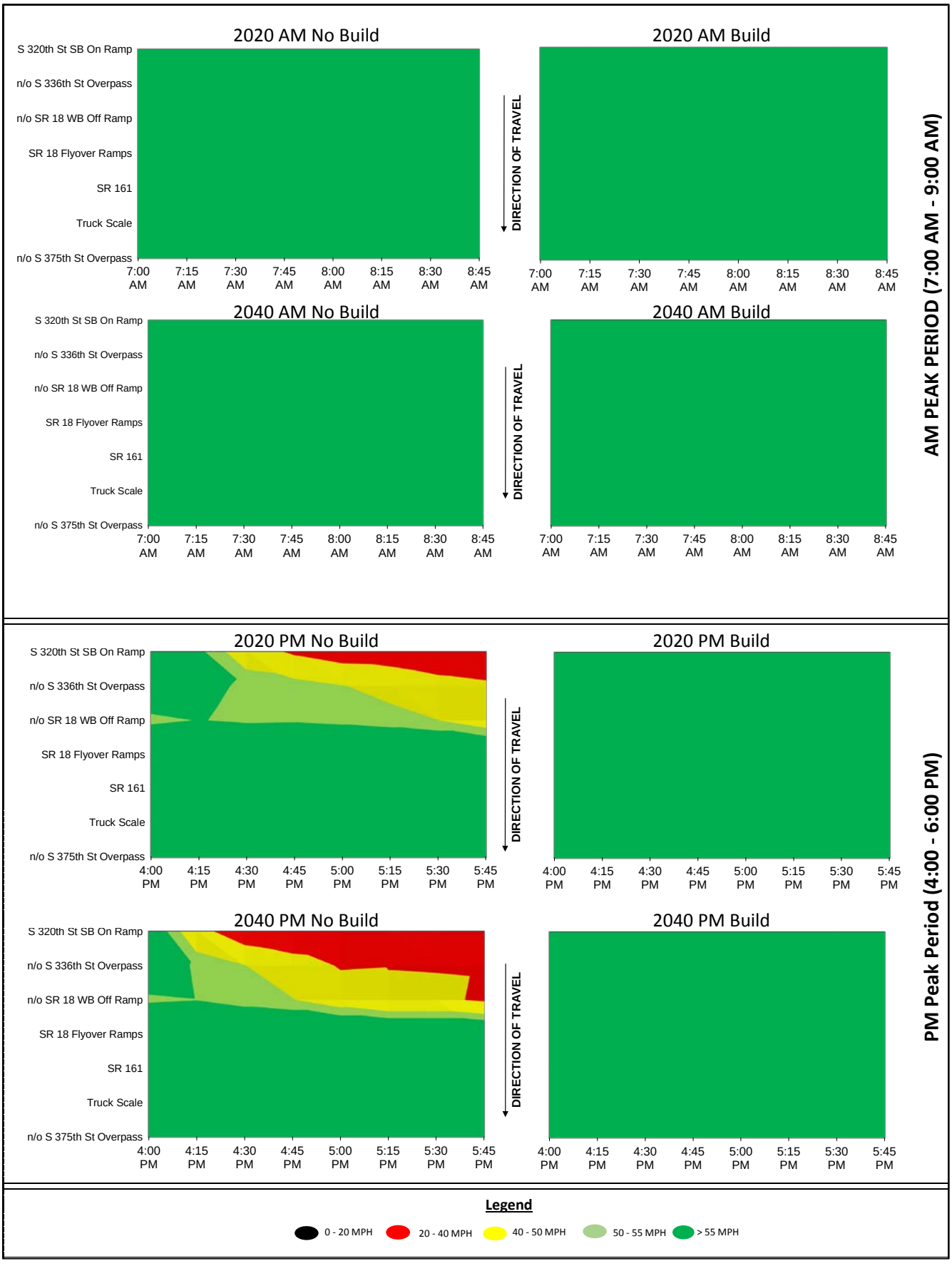


Exhibit 3-9. Future Year VISSIM Freeway Temporal Speed Maps, I-5 Southbound, AM/PM Peak Period

By year 2040, system throughput in the No Build condition would decrease to as low as 76 percent (SR 18 westbound) due to congestion in the study area. The percent of demand served for both I-5 southbound and SR 161 would decrease to 86 percent in year 2040 due to increased traffic demands that create higher vehicle delays and queues at SR 161 and S 348th Street that spill back on I-5 southbound mainline, constraining the ability of drivers to move freely.

With the project, system throughput in year 2040 would improve between 5 and 15 percent compared to the No Build condition. Because of the travel pattern shift with the proposed I-5 southbound off-ramp to S 356th Street connection to SR 161, the project would eliminate the queue from the I-5 southbound off-ramp to SR 18 from spilling back onto I-5 southbound mainline. This would improve throughput on I-5 southbound by 15 percent. With the proposed S 356th Street off-ramp forecasted to shift almost 800 vehicles from the westbound approach of the SR 161/S 348th Street intersection, throughput on SR 18 is also expected to improve from 76 percent to 90 percent with the project. Throughput on SR 161 would also improve by 5 percent as vehicles along SR 161 originating from I-5 southbound would be able to use the proposed S 356th Street connection, and other vehicles along SR 161 would not be impacted as much by the congestion predicted at SR 161/S 348th Street in the No Build condition.

3.7.2 Freeway Operations

Freeway density, speed, and LOS results are provided as a measure to understand freeway operations and should be reviewed in conjunction with the other freeway analytical measures (i.e., travel time and ramp terminal operations) presented in this policy point to understand how the project affects I-5 and SR 18 operations. WSDOT LOS standards for I-5 and SR 18 are presented previously in Table 3-2.

VISSIM freeway results, including demand volume, speed, density, and LOS for future year AM and PM peak hours are shown in Tables 3-8 and 3-9, respectively. Temporal speed charts from VISSIM for I-5 southbound for future year AM and PM peak hours are shown in Exhibit 3-9.

In the AM peak, the difference in traffic operations on I-5 southbound between the No Build and Build conditions is expected to be negligible for both the years 2020 and 2040 as there is minimal congestion in either condition as shown in Table 3-8 and illustrated in Exhibit 3-9. AM peak average speeds on I-5 southbound would be above 60 mph and density would range between 18 to 20 veh/mi/ln for both No Build and Build alternatives. In addition, both directions of SR 18 would operate with average speeds of 60 mph and density between 12 and 21 veh/mi/ln (LOS C or better) in both No Build and Build conditions for years 2020 and 2040 as shown in Table 3-8.

As previously stated in Section 3.5.1, the TPC HOV Program project is scheduled to be completed before this project's year of opening. The TPC HOV Program is predicted to reduce the severity of congestion and queue lengths on I-5 southbound that originate from the Fife/Tacoma area with congestion no longer extending into the Triangle IJR study area. This is accounted for in all future conditions PM peak VISSIM models, and can be seen in the PM peak period speed temporal charts in Exhibit 3-9 where vehicles speeds on I-5 southbound between the Triangle interchange and the southern study limits are over 55 mph for both 2020 and 2040 years and No Build and Build conditions.

In the year 2020 PM No Build condition, average speeds on I-5 southbound in the study area would increase from 16 to 61 mph and density would be reduced from 114 to 22 veh/mi/ln compared to 2015 Existing Conditions. By year 2040, No Build conditions on I-5 southbound operations would be slightly worse than in year 2020 with average speeds of 58 mph and density of 25 veh/mi/ln. However, I-5 southbound between the S 320th Street on-ramp and S 348th Street off-ramp would operate at LOS F in the No Build condition for both years 2020 and 2040 due to queue spillback from the I-5 southbound off-ramp terminal at SR 18. This can also be seen in Exhibit 3-9 with speeds dropping below 40 mph between the S 320th Street on-ramp and S 348th Street off-ramp from about 4:30 p.m. to 6:00 p.m.

Table 3-8. Future Year Freeway Results, AM Peak Hour

Facility	Type	Dir.	Segment Type & Location	2020 AM No Build				2020 AM Build				Difference (2020 Build - 2020 No Build)		2040 AM No Build				2040 AM Build				Difference (2040 Build - 2040 No Build)	
				Demand Volume	Speed	Density	LOS	Demand Volume	Speed	Density	LOS	Speed	Density	Demand Volume	Speed	Density	LOS	Demand Volume	Speed	Density	LOS	Speed	Density
I-5	GP Lanes	SB	Basic - S 320th St On to SR 18 Off	4695	66	18	B	4695	65	18	B	-1	0	5060	65	20	C	5060	65	20	C	0	0
			Build - Diverge to SR 18 EB/WB Off *[Not Applicable to No Build Alternative]*	n/a				4695	66	11	B	n/a		n/a				5060	66	12	B	n/a	
			Build - Diverge - to SR 161/S 356th St Off *No Build* - Diverge - to SR 18 EB Off (SW Loop)	4080	66	15	B	3880	66	14	B	0	-1	4480	66	17	B	4265	66	15	B	0	-2
			Build - Basic - SR 161/S 356th St Off to SR 18 EB On (SW Slip) *No Build* - Basic - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	3600	66	14	B	3600	66	14	B	0	0	3980	66	15	B	3980	66	15	B	0	0
			Merge - from SR 18 EB On (SW Slip)	4090	63	16	B	4090	63	16	B	0	0	4500	63	17	B	4500	63	18	B	0	1
			Merge - from SR 18 WB On (Flyover)	5880	63	26	C	5880	64	25	C	1	-1	6145	63	27	C	6145	63	28	C	0	1
			Basic - SR 18 WB On to Southern Study Area Boundary	5880	65	22	C	5880	65	22	C	0	0	6145	65	24	C	6145	65	24	C	0	0
SR-18	GP Lanes	EB	Basic - I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	1740	64	13	B	1740	63	14	B	-1	1	2030	65	15	B	2030	64	16	B	-1	1
			Weave - I-5 NB On (SE Slip) to Weyerhaeuser Way Off	3310	57	19	B	3310	57	19	B	0	0	3655	57	21	C	3655	56	22	C	-1	1
			Basic - Weyerhaeuser Way off to Eastern Study Area Boundary	2865	63	23	C	2865	63	23	C	0	0	3100	63	24	C	3100	63	25	C	0	1
		WB	Basic - east of Weyerhaeuser Way to I-5/SR 161 CD Off	3125	66	16	B	3125	66	16	B	0	0	3320	66	17	B	3320	66	17	B	0	0
			Basic - I-5/SR 161 CD Off to I-5 NB On (NE Loop)	835	55	8	A	835	55	8	A	0	0	980	55	9	A	980	55	9	A	0	0
	CD Road	WB	Basic - SR 18 WB Mainline to Weyerhaueser Way WB On	2290	56	20	C	2290	56	20	C	0	0	2340	56	21	C	2340	56	21	C	0	0
			CD Weave - Weyerhaeuser Way On to I-5 NB Off (NE Slip)	2610	51	18	B	2610	52	17	B	1	-1	2745	51	18	B	2745	51	18	B	0	0
			Basic - I-5 NB Off (NE Slip) to SR 161 Off	1880	48	20	C	1880	48	20	C	0	0	1955	48	21	C	1955	48	21	C	0	0
	Average of all segments =		**I-5 SB GP =**		**65**	**19**			**65**	**17**		**0**	**-2**		**65**	**20**			**65**	**19**		**0**	**-1**
			SR 18 EB GP =		**61**	**18**			**61**	**19**		**0**	**1**		**61**	**20**			**61**	**21**		**0**	**1**
			SR 18 WB GP =		**61**	**12**			**61**	**12**		**0**	**0**		**60**	**13**			**60**	**13**		**0**	**0**
			SR 18 WB CD =		**52**	**19**			**52**	**19**		**0**	**0**		**52**	**20**			**52**	**20**		**0**	**0**

Notes:
SB = southbound; EB = eastbound; WB = westbound; SW = southwest; SE = southeast; NE = northeast; GP = general purpose; CD = collector-distributor.
Demand volume is in vehicles per hour. Speed is in miles per hour. Density is in vehicles per mile per lane. Yellow shaded values indicate segment is at LOS standard while red shaded values indicate segment is below LOS standard.

Table 3-9. Future Year Freeway Results, PM Peak Hour

Facility	Type	Dir.	Location & Segment Type	2020 PM No Build				2020 PM Build				Difference (2020 Build - 2020 No Build)		2040 PM No Build				2040 PM Build				Difference (2040 Build - 2040 No Build)	
				Demand Volume	Speed	Density	LOS	Demand Volume	Speed	Density	LOS	Speed	Density	Demand Volume	Speed	Density	LOS	Demand Volume	Speed	Density	LOS	Speed	Density
I-5	GP Lanes	SB	Basic - S 320th St On to SR 18 Off	6115	39	57	F	6115	64	25	C	25	-32	6440	26	77	F	6440	63	26	D	37	-51
			Build - Diverge to SR 18 EB/WB Off *[Not Applicable to No Build Alternative]*	n/a				6115	65	18	B	n/a		n/a				6440	66	18	B	n/a	
			Build - Diverge - to SR 161/S 356th St Off *No Build* - Diverge - to SR 18 EB Off (SW Loop)	4640	65	14	B	4255	66	15	B	1	1	4970	63	13	B	4575	65	16	B	2	3
			Build - Basic - SR 161/S 356th St Off to SR 18 EB On (SW Slip) *No Build* - Basic - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	3485	67	13	B	3525	66	13	B	-1	0	3755	67	12	B	3755	66	14	B	-1	2
			Merge - from SR 18 EB On (SW Slip)	3860	63	11	B	3910	63	13	B	0	2	4265	63	11	B	4265	63	15	B	0	4
			Merge - from SR 18 WB On (Flyover)	4785	64	18	B	4845	64	20	B	0	2	5215	65	17	B	5215	64	21	C	-1	4
			Basic - SR 18 WB On to Southern Study Area Boundary	4785	66	19	C	4845	66	20	C	0	1	5215	66	18	C	5215	66	21	C	0	3
SR-18	GP Lanes	EB	Basic - I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	2425	64	19	C	2425	63	19	C	-1	0	2900	62	20	C	2900	63	22	C	1	2
			Weave - I-5 NB On (SE Slip) to Weyerhaeuser Way Off	3845	56	22	C	3845	55	23	C	-1	1	4275	55	24	C	4275	54	26	C	-1	2
			Basic - Weyerhaeuser Way off to Eastern Study Area Boundary	3225	63	25	C	3225	62	26	C	-1	1	3435	62	25	C	3435	62	27	D	0	2
		WB	Basic - east of Weyerhaeuser Way to I-5/SR 161 CD Off	3525	66	18	B	3525	66	18	B	0	0	3600	16	92	F	3600	24	69	F	8	-23
			Basic - I-5/SR 161 CD Off to I-5 NB On (NE Loop)	1440	15	61	F	1465	24	49	F	9	-12	1595	3	191	F	1645	4	183	F	1	-8
	CD Road	WB	Basic - SR 18 WB Mainline to Weyerhaueser Way WB On	2085	57	18	C	2060	57	18	C	0	0	2005	51	23	C	1955	55	17	B	4	-6
			CD Weave - Weyerhaeuser Way On to I-5 NB Off (NE Slip)	2510	53	16	B	2485	53	16	B	0	0	2630	49	22	B	2580	53	16	B	4	-6
			Basic - I-5 NB Off (NE Slip) to SR 161 Off	1850	48	19	C	1825	48	19	C	0	0	2000	42	29	D	1950	48	20	C	6	-9
Average of all segments =			**I-5 SB GP =**		**61**	**22**			**65**	**18**		**4**	**-4**		**58**	**25**			**65**	**19**		**7**	**-6**
			SR 18 EB GP =		**61**	**22**			**60**	**23**		**-1**	**1**		**60**	**23**			**60**	**25**		**0**	**2**
			SR 18 WB GP =		**41**	**40**			**45**	**34**		**4**	**-6**		**10**	**142**			**14**	**126**		**4**	**-16**
			SR 18 WB CD =		**53**	**18**			**53**	**18**		**0**	**0**		**47**	**25**			**52**	**18**		**5**	**-7**

Notes:
SB = southbound; EB = eastbound; WB = westbound; SW = southwest; SE = southeast; NE = northeast; GP = general purpose; CD = collector-distributor.
Demand volume is in vehicles per hour. Speed is in miles per hour. Density is in vehicles per mile per lane. Yellow shaded values indicate segment is at LOS standard while red shaded values indicate segment is below LOS standard.

SR 18 westbound would also improve in the 2020 No Build Condition compared to 2015 Existing Conditions, with average speeds increasing from 32 to 40 mph and density decreasing from 61 to 39 veh/mi/ln. This is because the improved operations on I-5 southbound south of the study area would no longer cause queues to spill back on the SR 18 westbound flyover ramp to I-5 southbound, helping to improve the flow of traffic. By the year 2040, No Build conditions on SR 18 westbound would degrade substantially compared to year 2020 No Build conditions, with average speeds dropping from 40 to 10 mph and density increasing from 39 to 142 veh/mi/ln. This is due to background traffic growth between the years 2020 and 2040.

The Build alternative would improve operations on I-5 southbound and SR 18 westbound in both years 2020 and 2040. In the PM peak hour, I-5 southbound between S 320th Street and S 348th Street would see average speeds increase from 39 to 64 mph (a 25 mph increase) and density decrease from 57 to 25 veh/mi/ln (from LOS F to LOS C) in the year 2020 as a result of the project. In year 2040, average speeds would increase from 26 to 63 mph (a 37 mph increase) and density would decrease from 77 to 26 veh/mi/ln (from LOS F to LOS D). This is due to a reduction in the vehicle queue on the I-5 southbound off-ramp to S 348th Street previously described in Section 3.7.1.

SR 18 westbound between Weyerhaeuser Way S and I-5 would also see the average speed increase by 5 mph and density decrease by 6 veh/mi/ln in the year 2020 with the project compared to the No Build condition. This is because less vehicle demand is travelling on S 348th Street between SR 161 and the I-5 southbound off-ramp terminal with the project as vehicles from I-5 can also use the proposed S 356th Street connection to access SR 161. By the year 2040, SR 18 westbound average speed would increase by 4 mph (from 10 to 14 mph) and density would decrease by 16 veh/mi/ln (from 142 to 126 veh/mi/ln), although this segment would still operate at LOS F in both No Build and Build conditions. Throughput would also increase on SR 18 westbound, as described in Section 3.7.1.

3.7.3 Intersection Operations

Intersections, including I-5 ramp terminals, were analyzed during the AM and PM peak hours for the year 2020 and 2040 No Build and Build conditions. Future year signalized and unsignalized intersection results from Synchro and roundabout intersection results from Sidra for the AM and PM peak hours are presented in Tables 3-10 and 3-11, respectively. The tables include LOS, average delay per vehicle, and v/c ratios. The relevant agencies within the project study area and their intersection LOS standards are presented in Table 3-2. Detailed information on the I-5 southbound ramp terminal intersections, including vehicle queue and VISSIM results, are discussed in Section 3.7.4.

In the AM peak, intersection operations are very similar between the 2015 Existing and 2020 No Build alternatives. Although it is expected there would be additional traffic demand in the area by 2020, the background improvements described in Section 3.5.1, including the third southbound through lane at the SR 161/S 348th Street intersection and the extension of S 352nd Street, would accommodate some of this traffic demand. The two intersections on S 348th Street at SR 99 and SR 161 would operate at LOS D, while all other intersections would operate at LOS C or better.

As shown in Table 3-10, intersection LOS and delay would be very similar between the 2020 AM No Build and Build conditions. Most intersections would have the same LOS in both the No Build and Build alternatives, except for the SR 161/SR 18 westbound off-ramp (which would change from LOS A to B) and the roundabout at SR 161/S 356th Street (from a LOS C to LOS A). The SR 161 and S 356th Street intersection operates as a signalized intersection in the No Build condition. The proposed I-5 southbound roundabout off-ramp terminal with S 356th Street and 18th Avenue S would operate at LOS A. All intersections would operate above the LOS standards in both alternatives in the year 2020 AM peak.

Table 3-10. Future Year Intersection Results, AM Peak Hour

ID#	North-South Street	East-West Street	Traffic Control	2020 No Build LOS	2020 No Build Delay	2020 No Build v/c	2020 Build LOS	2020 Build Delay	2020 Build v/c	2040 No Build LOS	2040 No Build Delay	2040 No Build v/c	2040 Build LOS	2040 Build Delay	2040 Build v/c
1	SR 161 (Enchanted Pkwy S)	SR 18 (S 348th St)	Signal	D	45	0.92	D	41	0.89	E	77	1.08	E	60	1.02
2	I-5 SB Off-Ramp	SR 18	Signal	B	18	0.71	B	15	0.70	C	23	0.84	B	19	0.83
3	SR 161 (Enchanted Pkwy S)	S 352nd St	Signal	C	24	0.69	C	32	0.69	D	37	0.92	D	52	0.92
4	16th Ave S	S 356th St	Signal	C	32	0.26	n/a			C	32	0.29	n/a		
5	SR 161 (Enchanted Pkwy S)	S 356th St	Signal / Roundabout	C	28	0.77	A (A)	6 (7)	0.58 (0.74)	D	43	0.85	A (B)	6 (10)	0.72 (0.9)
6	SR 161 (Enchanted Pkwy S)	SR 18 WB Off-Ramp	Signal	A	7	0.49	B	14	0.57	B	15	0.6	B	19	0.67
7	SR 161 (Enchanted Pkwy S)	Milton Rd S	Signal	C	32	0.63	C	33	0.62	D	52	0.85	D	47	0.83
8	SR 99 (Pacific Hwy S)	SR 18 (S 348th St)	Signal	D	42	0.80	D	45	0.81	E	58	0.99	D	53	0.97
9	18th Ave S	I-5 SB Off-Ramp	Roundabout	n/a			A (A)	4 (4)	0.08 (0.09)	n/a			A (A)	7 (7)	0.1 (0.12)
			AM Average =		*28*	*0.72*		*26*	*0.69*		*44*	*0.88*		*32*	*0.75*

Notes:
Results for signals are from Synchro's HCM 2000 methodology. Results for roundabouts are from a combination of Sidra methodology and HCM 2010 methodology. HCM 2010 results are in parenthesis. Results shaded in yellow are at LOS standards while results shaded in red are below LOS standards. SR 161/S 356th St is signalized in the Existing and No Build alternatives and a roundabout in the Build Alternative.

Table 3-11. Future Year Intersection Results, PM Peak Hour

ID#	North-South Street	East-West Street	Traffic Control	2020 No Build LOS	2020 No Build Delay	2020 No Build v/c	2020 Build LOS	2020 Build Delay	2020 Build v/c	2040 No Build LOS	2040 No Build Delay	2040 No Build v/c	2040 Build LOS	2040 Build Delay	2040 Build v/c
1	SR 161 (Enchanted Pkwy S)	SR 18 (S 348th St)	Signal	F	88	1.12	E	77	1.08	F	122	1.25	F	94	1.19
2	I-5 SB Off-Ramp	SR 18	Signal	E	57	1.02	D	50	1.02	E	56	1.02	D	52	1.03
3	SR 161 (Enchanted Pkwy S)	S 352nd St	Signal	C	26	0.76	C	33	0.72	C	23	0.81	D	37	0.81
4	16th Ave S	S 356th St	Signal	C	32	0.39	n/a			C	33	0.58	n/a		
5	SR 161 (Enchanted Pkwy S)	S 356th St	Signal / Roundabout	E	64	1.01	A (D)	9 (36)	0.65 (1.14)	F	101	1.45	B (F)	12 (87)	0.83 (1.44)
6	SR 161 (Enchanted Pkwy S)	SR 18 WB Off-Ramp	Signal	C	21	0.82	D	35	0.83	C	30	0.95	D	48	0.94
7	SR 161 (Enchanted Pkwy S)	Milton Rd S	Signal	F	85	1.04	F	81	1.03	F	121	1.16	F	88	1.11
8	SR 99 (Pacific Hwy S)	SR 18 (S 348th St)	Signal	E	63	0.96	D	54	0.94	F	94	1.17	F	86	1.14
9	18th Ave S	I-5 SB Off-Ramp	Roundabout	n/a			A (A)	4 (4)	0.36 (0.4)	n/a			A (A)	6 (6)	0.41 (0.44)
			PM Average =		*58*	*0.96*		*48*	*0.90*		*78*	*1.12*		*60*	*1.01*

Notes:
Results for signals are from Synchro's HCM 2000 methodology. Results for roundabouts are from a combination of Sidra methodology and HCM 2010 methodology. HCM 2010 results are in parenthesis. Results shaded in yellow are at LOS standards while results shaded in red are below LOS standards. SR 161/S 356th St is signalized in the Existing and No Build alternatives and a roundabout in the Build Alternative.

By the year 2040, the two intersections on S 348th Street at SR 99 and SR 161 would degrade to LOS E in the AM No Build condition, and three more intersections on SR 161 would operate at LOS D (at S 352nd Street, at S 356th Street, and at Milton Road S). Average intersection delay would increase 60 percent from 26 to 44 sec/veh from year 2020.

The 2040 AM Build condition would improve the average delay at all study area intersections from 44 to 32 sec/veh (a 27 percent decrease), and only one intersection would operate at LOS E (SR 161/S 348th

Street). The intersection of SR 99/S 348th Street would improve from LOS E to D because of a decrease in the westbound demand along S 348th Street that would occur as the proposed I-5 southbound off-ramp to S 356th Street provides an alternate route to reach SR 99. The roundabout at SR 161/S 356th Street would operate at LOS A compared to the signal in the No Build condition that would operate at LOS D, although the northbound approach of the roundabout would operate near capacity. The proposed I-5 southbound roundabout off-ramp terminal with S 356th Street and 18th Avenue S would operate at LOS A. All intersections would continue to operate above the LOS standards in the year 2040 AM peak for both alternatives.

PM peak intersection operations in 2020 No Build would improve slightly compared to 2015 Existing Conditions due to background improvements previously described in this section. Of the three intersections on SR 161 that currently operate below LOS standards, two would continue to operate below LOS standards in 2020 No Build (at S 348th Street and at Milton Road S) and SR 161/S 356th Street would operate at the LOS standard, as shown in Table 3-11. This intersection would improve to LOS E due to a change in traffic patterns caused by the S 352nd Street Extension project. The other background improvement projects which help improve intersection operations include the third southbound through lane at SR 161/S 348th Street and SR 99 HOV lanes at S 348th Street.

In the 2020 PM Build alternative, average delay at all study intersections would decrease by 16 percent (from 58 to 48 sec/veh) compared to the No Build alternative. Only one intersection would continue to operate below LOS standards, which is the SR 161/Milton Road S intersection. The SR 161/S 348th Street intersection would improve from LOS F and 88 sec/veh of delay to LOS E and 77 sec/veh with the project. All other intersections would operate at LOS D or better in the Build condition. The SR 161/S 356th Street intersection would improve from LOS E and 64 sec/veh to LOS A and 9 sec/veh in the Build condition. This intersection operates as a signal in the No Build condition but is proposed as a roundabout with the project. The proposed I-5 southbound roundabout off-ramp terminal with S 356th Street and 18th Avenue S would operate at LOS A.

Intersection operations would degrade substantially in the 2040 PM No Build condition compared to the 2020 No Build condition due to increased demand volumes. The average delay at all intersections in year 2040 would increase by 36 percent (from 58 to 78 sec/veh) compared to year 2020. Four intersections would operate below LOS standards in the 2040 PM No Build condition, including three intersections along SR 161 (at S 348th Street, at S 356th Street, and at Milton Road S) and the SR 99/S 348th Street intersection. Southbound queues on SR 161 would extend from Milton Road S to the S 348th Street intersection, and westbound queues on S 348th Street would extend from SR 99 past the I-5 southbound off-ramp terminal.

With the project, the average delay at all study intersections in year 2040 would reduce by 24 percent (from 78 to 60 sec/veh) compared to the No Build alternative. Three of the four intersections that operate below LOS standards in the 2040 PM No Build condition would remain below the LOS standard in the Build, although average delay would decrease at all three locations. The proposed I-5 southbound roundabout off-ramp terminal with S 356th Street and 18th Avenue S would operate at LOS A.

The SR 161/S 356th Street intersection would operate above the LOS standard as a roundabout, improving from LOS F in the 2040 PM No Build alternative to LOS B in the Build alternative. However, the southbound approach to the roundabout would be at or near capacity with a v/c ratio of 0.83. Results from Sidra indicate that v/c ratios at or above 0.85 for any leg of a roundabout indicate conditions could become unstable. Additionally, VISSIM results for this intersection, described in Section 3.7.4.2, indicate that southbound queues on SR 161 at the Milton Road S intersection would spill back into and north of the roundabout.

Therefore, to improve southbound operations on SR 161 and limit the queueing through the roundabout at S 356th Street by year 2040, additional improvements would be necessary in either the No Build or Build conditions, but were assumed in only the Build conditions as they have not been previously programmed by any agency. These signal phasing and channelization improvements are in addition to the project elements described in Section 3.5.2, and are focused at the SR 161/Milton Road S intersection. These improvements include:

- Modifying the channelization on the east leg of the SR 161/Milton Road S intersection from the current two-lane approach (that includes a shared left-through lane and separate right-turn lane) to a three-lane approach (that includes separate left, through, and right-turn lanes).
- Modifying the signal phasing at the SR 161/Milton Road S intersection to eliminate the current split-phasing of eastbound and westbound movements and instead have eastbound and westbound left-turn movements operate concurrently.

An analysis was conducted to identify when these additional intersection improvements at SR 161 and Milton Road S would be necessary by analyzing the southbound SR 161 operations between the years 2020 and 2040. This analysis was conducted by interpolating traffic volumes between 2020 and 2040 and assessing them using the project's VISSIM model with the same general assumptions used for the 2020 and 2040 analysis. Based on this analysis, the additional improvements at SR 161 and Milton Road S intersection would be necessary to reduce the vehicle queueing through the S 356th Street roundabout between the years 2025 and 2030. Depending on the timing of construction funds for the Phase 2 improvements, WSDOT could consider adding the SR 161/Milton Road S intersection improvements as part of the overall Phase 2 improvement project. These improvements would need to be coordinated by WSDOT with the City of Federal Way and other key stakeholders prior to implementation.

3.7.4 Ramp Terminal Intersection VISSIM Results

At the current and proposed I-5 ramp terminals, additional MOEs from the VISSIM models, including percent demand served, delay, and queue lengths, are presented below to supplement the LOS, delay, and v/c ratios from Synchro and Sidra. The VISSIM model can capture the effects of oversaturated conditions and queue spillback between closely spaced intersections.

3.7.4.1 I-5 Southbound Off-Ramp and SR 18

2040 PM peak hour intersection results for the ramp terminal with I-5 southbound off-ramp and SR 18 (S 348th Street) are presented in Table 3-12. The 2040 PM peak hour represents the period with the highest demand volume and most congestion in the study area.

Table 3-12. I-5 Southbound Off-Ramp/SR 18 Intersection Results - Year 2040, PM Peak Hour

			VISSIM Results							Synchro Results		
Alternative	Appr.	Lane Group	Demand	Throughput	% Demand Served	Delay	Queue Storage	Average Queue	95% Queue	LOS	Delay	V/C
No Build	SB	RT	1600	1115	70%	303	1650	4888	5318	F	107	1.11
	WB	TH	1880	1371	73%	378	715	4878	5353	D	42	0.97
	All		3480	2486	71%	344				E	56	1.02
Build with 3 SB Lefts	EB	TH	1670	1551	93%	21	1025	340	627	C	24	0.85
	SB	LT	1230	1219	99%	41	2200	674	1570	D	44	0.80
		RT	775	777	100%	133	2200	669	1574	D	54	0.89
	WB	TH	1930	1685	87%	295	715	4898	5351	D	37	0.97
	All		5605	5232	93%	130				D	37	0.94
Build with 2 SB Lefts	EB	TH	1670	1543	92%	20	1025	334	654	C	33	0.92
	SB	LT	1230	1239	101%	71	2200	850	1788	E	71	1.01
		RT	775	785	101%	132	2200	852	1793	D	42	0.77
	WB	TH	1930	1683	87%	294	715	4917	5353	E	61	1.04
	All		5605	5249	94%	137				D	52	1.03

Note:
NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = left; TH - through; RT - right.
Demand and throughput volumes are in vehicles per hour; Delay is in seconds per vehicle. Queue storage and lengths are in feet.
Queue values shaded in red indicate queue length will exceed available storage.

In the 2040 PM No Build condition, the signalized ramp terminal controls two movements; the SR 18 westbound through and I-5 southbound off-ramp right-turn movements. The two other movements at this location, SR 18 eastbound through and I-5 southbound off-ramp to SR 18 eastbound, are free-flow movements. Although the Synchro results show the intersection would operate at LOS E, the results from VISSIM indicate LOS F operations due to the effects of westbound vehicle queues from S 348th Street at SR 99 and SR 161 spilling back through this ramp terminal intersection. When considering this queue into the intersection operations, vehicles on the I-5 southbound off-ramp right turning to S 348th Street would experience delays of 300 sec/veh and only 70 percent of the demand volume would be served with queues that exceed the 1,600 feet of vehicle storage and spill back to I-5 southbound mainline. This would create congestion and lower throughput on I-5 southbound mainline. Vehicles on SR 18 westbound would have delays over 300 sec/veh and only 73 percent of demand would be served with queues over 1 mile in length.

At this location in the 2040 PM Build condition:

- the southbound I-5 off-ramp is widened and lengthened to the north providing for two-lane off-ramp with additional storage,
- some of the demand to SR 161 would utilize the proposed I-5 southbound off-ramp to S 356th Street, and

- the I-5 southbound loop off-ramp to SR 18 eastbound would be removed and those trips would be re-routed through this signalized ramp terminal as a southbound left-turn movement. This would require that the SR 18 eastbound movement be controlled by the traffic signal.

Because of the high demand volume for the southbound left-turn movement (approximately 1,230 vph in 2040 PM Build), a design option was analyzed to determine if two or three southbound left-turn lanes would be necessary to contain the queues within the off-ramp vehicle storage. The VISSIM results show that both the two- and three-lane options would increase overall intersection throughput by 20 percent and lower average delay by over 200 sec/veh. The I-5 southbound off-ramp throughput would increase to 100 percent, and queues would be contained on the off-ramp in both options. The SR 18 westbound through movement would serve 14 percent more demand and delays would be reduced by 22 percent.

The comparison of the two- and three-lane options shows similar results (demand served, delay and queues) from the VISSIM models. The Synchro results show the intersection would operate at LOS D under both options, although the two-lane option would have a higher v/c ratio for the southbound left-turn movement. However, with the three-lane option, vehicles using the right-most lane of the three left-turn lanes would be forced to merge to the left approximately 1,000 feet downstream of the intersection. Because of this merge, fewer vehicles would choose to use the third lane, leading to lower lane utilization compared to the other two lanes. Based on these results, the two-lane option was recommended but not precluding WSDOT's ability to widen for a third lane in the future if necessary.

3.7.4.2 SR 161/S 356th Street/16th Avenue S

Results for the SR 161/S 356th Street/16th Avenue S intersection are provided for the 2040 AM peak in Table 3-13. Table 3-14 presents Year 2040 No Build and Build results for the PM peak hour, as well as 2020 PM Build conditions. Both 2020 and 2040 Build results are provided to indicate the roundabout operations for the near and long-term conditions. This 5-leg intersection is signalized in the No Build alternative but is proposed to be a roundabout with the Proposal.

The 2040 AM peak Synchro and Sidra results show the signal in the No Build condition would operate at LOS D and 43 sec/veh of average delay, while the roundabout in the Build condition would operate at LOS A and 6 sec/veh. However, VISSIM results show the intersection would have similar vehicle throughput and delays between the No Build and Build conditions. 100 percent of demand would be served and overall intersection delay would be between 23 and 25 sec/veh in both alternatives. No queues would exceed vehicle storage in the Build condition, although the northbound left would exceed the available storage in the No Build condition.

In the 2040 PM No Build condition, both Synchro and VISSIM results show the SR 161/S 356th Street intersection would operate poorly. The southbound through and northbound left movements would experience high delays, and long queues would occur on the northbound, southbound, and westbound approaches. The intersection would only serve 88 percent of the demand volume and queues would extend beyond the next intersection on SR 161. The poor operations are caused by the fifth leg (16th Avenue S) requiring an exclusive signal phase to operate safely. This limits the amount of signal time that can be provided on SR 161 and vehicle queues originating from the SR 161/Milton Road S intersection spill back into this intersection prohibiting vehicle movements and therefore adding delay.

Table 3-13. SR 161/S 356th Street/16th Avenue S Intersection Results - Year 2040, AM Peak Hour

				VISSIM Results							Synchro/Sidra Results		
Alternative	Traffic Control	Appr.	Lane Group	Demand	Throughput	% Demand Served	Delay	Queue Storage	Average Queue	95% Queue	LOS	Delay	V/C
2040 No Build	Signal	NB	LT	275	277	101%	73	250	244	423	E	78	0.79
			TH-RT	1435	1449	101%	14	925	205	464	D	43	0.88
		NEB	LT-RT	100	100	100%	68	850	75	185	D	45	0.15
		EB	LT-TH-RT	285	285	100%	66	1400	175	326	E	60	0.59
		SB	LT	5	5	104%	83	300	7	22	F	90	0.38
			TH	520	502	97%	32	1250	145	295	C	29	0.51
			RT	155	154	99%	18	380	41	130	D	35	0.13
		WB	LT	10	10	102%	60	100	10	40	D	53	0.07
			TH-RT	90	90	99%	51	300	70	191	E	56	0.35
		All		2875	2872	100%	23				D	43	0.85
2040 Build	Round about	NB	LT-TH-RT	1710	1671	98%	24	890	174	626	A (B)	6 (11)	0.72 (0.90)
		NEB	LT-TH-RT	100	97	97%	3	640	25	72	A (A)	6 (6)	0.07 (0.11)
		EB	LT-TH-RT	285	304	107%	3	700	31	70	A (A)	7 (7)	0.16 (0.21)
		SB	LT-TH	385	401	104%	5	1100	49	107	A (A)	5 (5)	0.18 (0.29)
			RT	45	45	101%	2	420	10	28			
		WB	LT-TH-RT	195	213	109%	117	450	31	70	B (B)	11 (19)	0.26 (0.45)
		All		2720	2732	100%	25				A (B)	6 (10)	0.72 (0.90)

Note:
NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = left; TH - through; RT - right.
Demand and throughput volumes are in vehicles per hour; Delay is in seconds per vehicle. Queue storage and lengths are in feet. Sidra results not in parentheses are from Sidra methodology; Sidra results in parentheses are from HCM 2010 methodology. Roundabout approach legs with V/C ratios over 0.85 in Sidra methodology could indicate unstable conditions. Queue values shaded in red indicate queue length will exceed available storage.

In the 2040 PM Build condition, Sidra results indicate the overall intersection would operate at LOS B, although the southbound approach would be at capacity with a v/c ratio of 0.83. VISSIM results indicate the overall delay at this intersection would be similar to the No Build condition. Northbound and westbound queue lengths at the roundabout would be shorter with the project, although queues on 16th Avenue would be longer. However, the southbound queues from the SR 161/Milton Road S intersection would occasionally spill back into the roundabout similar to the No Build condition. This spill-back contributes to the high delay on the 16th Avenue S approach and long queues on the southbound SR 161 approach. The channelization and signal-phasing improvements at the SR 161/Milton Road intersection, described in Section 3.6.3, are assumed as part of the 2040 Build condition. By contrast, both Sidra and VISSIM results show the roundabout would operate under capacity with lower vehicle delay and shorter queues in the year 2020 compared to the year 2040.

Table 3-14. SR 161/S 356th Street/16th Avenue S Intersection Results – Year 2020 & 2040, PM Peak Hour

				VISSIM Results							Synchro/Sidra Results		
Alternative	Traffic Control	Appr.	Lane Group	Demand	Throughput	% Demand Served	Delay	Queue Storage	Average Queue	95% Queue	LOS	Delay	V/C
2040 No Build	Signal	NB	LT	430	396	92%	166	250	2009	5298	F	161	1.18
			TH-RT	1265	1235	98%	29	925	661	4424	C	21	0.70
		NEB	LT-RT	140	139	99%	38	850	60	146	D	41	0.60
		EB	LT-TH-RT	425	411	97%	79	1400	264	422	D	51	0.61
		SB	LT	25	19	75%	95	300	19	65	F	109	0.74
			TH	1510	1132	75%	109	1250	1292	1540	F	159	1.24
			RT	395	306	78%	53	380	150	344	D	39	0.25
		WB	LT	175	175	100%	62	100	172	437	D	51	0.60
			TH-RT	225	221	98%	65	300	213	439	D	52	0.64
		All		4590	4034	88%	69				F	101	1.45
2040 Build	Round about	NB	LT-TH-RT	1645	1633	99%	16	890	146	498	A (B)	6 (11)	0.70 (0.88)
		NEB	LT-TH-RT	140	138	99%	536	640	626	1037	B (B)	14 (13)	0.46 (0.43)
		EB	LT-TH-RT	425	407	96%	46	700	144	354	C (B)	24 (16)	0.70 (0.61)
		SB	LT-TH	1425	1107	78%	91	1100	1181	1471	B (F)	12 (198)	0.83 (1.44)
			RT	95	74	78%	37	420	21	62			
		WB	LT-TH-RT	480	418	87%	193	450	144	354	B (E)	18 (76)	0.64 (1.07)
		All		4210	3777	90%	80				B (F)	12 (87)	0.83 (1.44)
2020 Build	Round about	NB	LT-TH-RT	1380	1377	100%	11	890	133	382	A (A)	6 (9)	0.60 (0.79)
		NEB	LT-TH-RT	140	137	98%	59	640	130	460	B (B)	12 (14)	0.38 (0.45)
		EB	LT-TH-RT	390	385	99%	14	700	73	167	B (B)	12 (14)	0.44 (0.53)
		SB	LT-TH	1225	1207	99%	45	1100	469	1175	A (E)	8 (77)	0.65 (1.14)
			RT				12	420	23	55			
		WB	LT-TH-RT	490	412	84%	38	450	73	167	B (C)	13 (33)	0.54 (0.91)
		All		3625	3518	97%	27				A (D)	9 (36)	0.65 (1.14)

Note:
NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = left; TH - through; RT - right.
Demand and throughput volumes are in vehicles per hour; Delay is in seconds per vehicle. Queue storage and lengths are in feet. Sidra results not in parentheses are from Sidra methodology; Sidra results in parentheses are from HCM 2010 methodology. Roundabout approach legs with V/C ratios over 0.85 in Sidra methodology could indicate unstable conditions. Queue values shaded in red indicate queue length will exceed available storage.

3.7.4.3 I-5 Southbound Off-Ramp at S 356th Street

Results for proposed teardrop roundabout at the I-5 southbound off-ramp at S 356th Street ramp terminal intersection are presented in Table 3-15 for the 2040 AM, 2040 PM and 2020 PM conditions. In the 2020 year of opening, this roundabout would only have two approaches (eastbound U-turn movement from driveways on S 356th Street and westbound through movement from I-5 southbound). In the year 2040, the City of Federal Way's 18th Avenue S Extension project would create a third leg (southbound right-turn movement) to the roundabout.

The 2040 AM results from both Sidra and VISSIM show the roundabout would operate well (LOS A) with short queue lengths. In the 2040 PM peak, Sidra results show the roundabout would operate at LOS A. However, results from VISSIM show that the intersection would experience average delay of 80 sec/veh with most of the delay experienced on the southbound (18th Avenue S) approach. This would be caused by queue spill-back from the adjacent roundabout at SR 161/S 356th Street/16th Avenue S. This congestion and queue spill-back would not occur in the year 2020 as average delay would be 4 sec/veh.

In both the 2020 and 2040 conditions, the vehicle queue on the I-5 off-ramp would be contained within the storage as less than 100 feet of vehicle queues are experienced on this approach.

Table 3-15. I-5 Southbound Off-Ramp/S 356th Street Intersection Results - Year 2040, AM/PM Peak Hour

			VISSIM Results							Sidra Results		
Alternative	Appr.	Lane Group	Demand	Throughput	% Demand Served	Delay	Queue Storage	Avg. Queue	95% Queue	LOS	Delay	V/C
2040 AM Build	EB	U Turn-LT	105	108	103%	9				B (B)	11 (11)	0.09 (0.07)
	SB	RT	35	28	79%	24	1000	9	71	A (A)	5 (5)	0.04 (0.04)
	WB	TH-RT	100	100	100%	9	440	1	14	A (A)	4 (4)	0.10 (0.12)
	All		240	236	98%	11				A (A)	7 (7)	0.10 (0.12)
2040 PM Build	EB	U Turn-LT	95	90	95%	65				B (B)	12 (12)	0.08 (0.07)
	SB	RT	40	37	92%	261	1000	97	364	A (A)	6 (6)	0.05 (0.07)
	WB	TH-RT	425	421	99%	68	440	9	34	A (A)	4 (4)	0..41 (0.44)
	All		560	548	98%	80				A (A)	6 (6)	0.41 (0.44)
2020 PM Build	EB	U Turn	105	84	80%	4				A (A)	3 (3)	0.10 (0.10)
	WB	TH	350	352	100%	3	440	1	5	A (A)	5 (4)	0.36 (0.40)
	All		455	435	96%	4				A (A)	4 (4)	0.36 (0.40)

Note:
NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = left; TH - through; RT - right.
Demand and throughput volumes are in vehicles per hour; Delay is in seconds per vehicle. Queue storage and lengths are in feet. Sidra results not in parentheses are from Sidra methodology; Sidra results in parentheses are from HCM 2010 methodology. Roundabout approach legs with V/C ratios over 0.85 could indicate unstable conditions. Queue values shaded in red indicate queue length will exceed

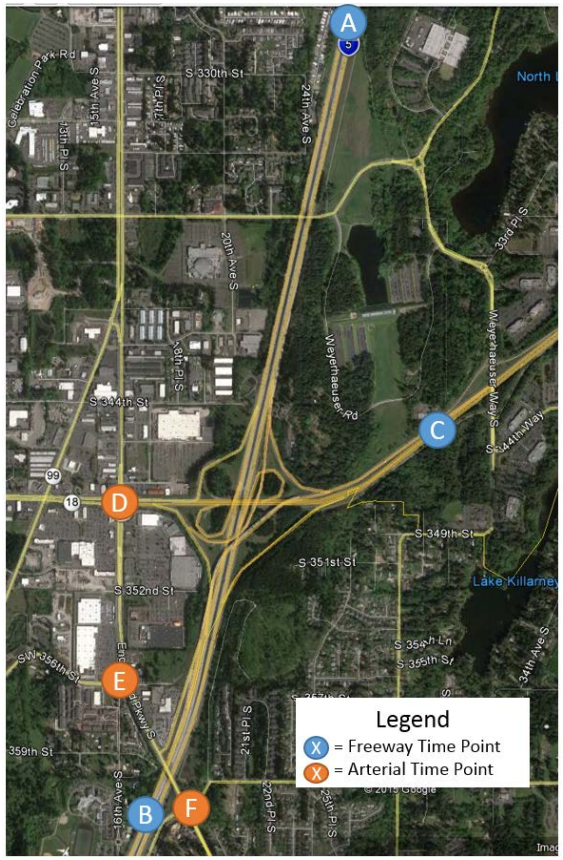
3.7.5 Travel Times

Travel times are provided for various paths to assess the future travel conditions and are a key measure in understanding how the project may affect travel within the study area. Future year travel times from the VISSIM model for AM and PM peak hours are presented in Exhibits 3-10 and 3-11, respectively. Beginning and ending points within the study area were chosen to create travel time paths to compare between No Build and Build conditions. The key locations for these paths are listed below and also previously described in Section 3.4.4:

- Point A: I-5 Southbound Mainline at the S 320th Street On-ramp
- Point B: I-5 Southbound Mainline at the SR 161 Overpass
- Point C: SR 18 (both directions) just west of Weyerhaeuser Way S
- Point D: SR 161/S 348th Street Intersection
- Point E: SR 161/S 356th Street Intersection
- Point F: SR 161/Milton Road S Intersection

In the AM peak, travel times within the study area are similar between 2015 Existing Conditions and 2020, with less than one minute of additional travel time along any path. With the project, all of the travel time paths remain similar (less than a 0.5-minute difference) to the No Build condition. Both the 2020 AM No Build and Build conditions are relatively uncongested with speeds near free-flow conditions.

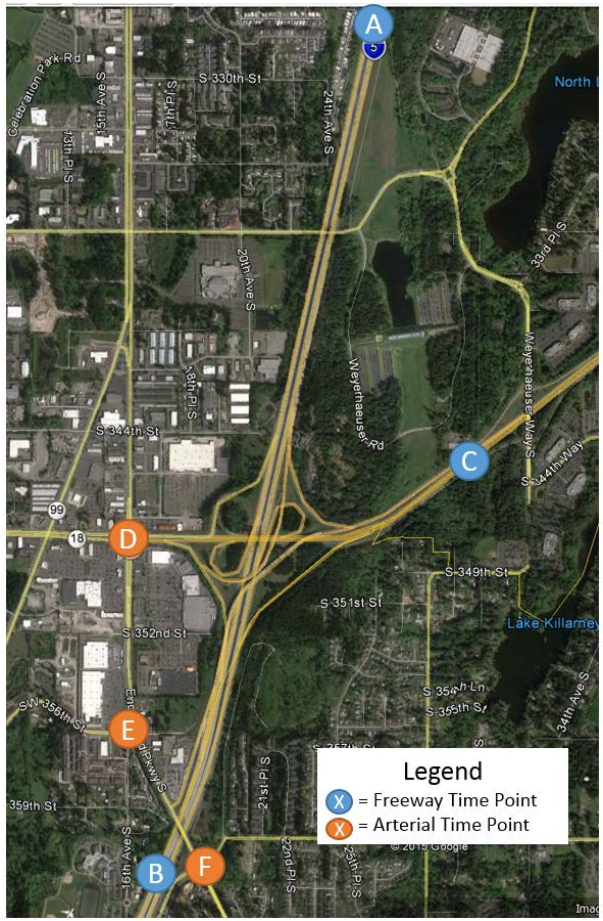
Path Description	From - To	2015 Existing	2020 Year of Opening			2040 Design Year		
			No Build	Build	Diff.	No Build	Build	Diff.
I-5 SB Mainline: S 320th St to SR 161 Overpass	**A - B**	2.0	2.0	2.0	0.0	2.0	2.0	0.0
I-5 SB at S 320th St to SR 18 EB at Weyerhaeuser Way	**A - C**	2.3	2.3	2.7	0.4	2.3	2.8	0.5
I-5 SB at S 320th St to SR 161/S 348th St	**A - D**	2.5	2.7	2.7	0.0	3.0	2.9	-0.1
I-5 SB at S 320th St to SR 161/S 356th St *No Build via SR 161/S 348th St; Build via New Phase 2 Off Ramp*	**A - E**	4.2	4.4	4.7	0.3	5.3	4.7	-0.6
I-5 SB at S 320th St to SR 161/Milton Rd *No Build via SR 161/S 348th St; Build via New Phase 2 Off Ramp*	**A - F**	4.9	5.6	5.3	-0.3	6.3	3.8	-2.5
SR 18 WB: Weyerhaueser Way to SR 161/S 348th St	**C - D**	2.3	2.3	2.4	0.1	2.5	2.5	0.0
SR 18 WB at Weyerhaueser Way to SR 161/S 356th St via SR 18 WB Flyover Ramp	**C - E**	2.0	2.1	2.5	0.4	2.3	2.7	0.4
SR 18 WB at Weyerhaueser Way to SR 161/Milton Rd via SR 18 WB Flyover Ramp	**C - F**	2.0	2.8	2.8	0.0	2.9	2.9	0.0
SR 161/S 348th St to I-5 SB Mainline at SR 161 overpass	**D - B**	1.1	1.8	1.8	0.0	1.6	1.5	-0.1
SR 18 EB: SR 161 to Weyerhauser Way Exit	**D - C**	1.0	1.0	1.1	0.1	1.0	1.1	0.1
SR 161 SB: S 348th St to Milton Rd	**D - F**	1.5	2.0	1.9	-0.1	2.7	2.2	-0.5
SR 161 NB: Milton Rd to S 348th St	**F - D**	2.6	2.1	2.6	0.5	2.6	3.3	0.7



Note:
Results are from VISSIM. Travel time is reported in minutes and speed is in miles per hour.

Exhibit 3-10. 2015 Existing and Future Year Travel Time Results, AM Peak Hour

Path Description	From - To	2015 Existing	2020 Year of Opening			2040 Design Year		
			No Build	Build	Diff.	No Build	Build	Diff.
I-5 SB Mainline: S 320th St to SR 161 Overpass	**A - B**	9.2	2.2	2.0	-0.2	2.7	2.0	-0.7
I-5 SB at S 320th St to SR 18 EB at Weyerhauser Way Exit	**A - C**	3.2	2.5	3.5	1.0	3.2	3.6	0.4
I-5 SB at S 320th St to SR 161/S 348th St	**A - D**	8.0	12.4	5.0	-7.4	16.5	5.6	-10.9
I-5 SB at S 320th St to SR 161/S 356th St (A - E) *No Build via SR 161/S 348th St; Build via New Phase 2 Off Ramp*	**A - E**	14.4	16.9	7.0	-9.9	25.5	6.9	-18.6
I-5 SB at S 320th St to SR 161/Milton Rd (A - F) *No Build via SR 161/S 348th St; Build via New Phase 2 Off Ramp*	**A - F**	16.2	18.3	8.7	-9.6	26.8	4.9	-21.9
SR 18 WB: Weyerhaueser Way to SR 161/S 348th St	**C - D**	11.7	7.2	5.7	-1.5	15.5	10.0	-5.5
SR 18 WB at Weyerhaueser to SR 161/S 356th St via SR 18 WB Flyover Ramp	**C - E**	3.8	2.7	2.6	-0.1	6.0	2.9	-3.1
SR 18 WB at Weyerhaueser to SR 161/Milton Rd via SR 18 WB Flyover Ramp	**C - F**	4.1	3.4	3.3	-0.1	5.8	3.5	-2.3
SR 161/S 348th St to I-5 SB Mainline at SR 161 overpass	**D - B**	6.2	2.1	2.2	0.1	1.9	2.3	0.4
SR 18 EB: SR 161 to Weyerhauser Way Exit	**D - C**	1.0	0.9	1.2	0.3	0.9	1.3	0.4
SR 161 SB: S 348th St to Milton Rd	**D - F**	6.8	4.8	3.7	-1.1	7.4	9.3	1.9
SR 161 NB: Milton Rd to S 348th St	**F - D**	3.6	3.5	3.9	0.4	5.1	4.2	-0.9



Note:
NB = northbound; EB = eastbound; SB = southbound; WB = westbound.
Results are from VISSIM. Travel time is in minutes.

Exhibit 3-11. 2015 Existing and Future Year Travel Time Results, PM Peak Hour

By year 2040, AM peak hour travel times in the No Build alternative would remain similar to a 1.4-minute increase compared to 2015 Existing Conditions. Travel from I-5 southbound at S 320th Street to SR 161/Milton Road S (path A to F) would experience the largest increase in travel time (1.4 minutes) due to increases in traffic volumes. The project would reduce the travel time on this path by up to 2.5 minutes (a 40 percent reduction) as drivers would be able to use the proposed I-5 southbound off-ramp at S 356th Street to access SR 161. However, drivers on SR 161 northbound between Milton Road S and S 348th Street (path F to D) would experience a slight increase in travel time (0.7 minute) in the Build alternative due to some additional delay to travel through the S 356th Street roundabout. This is because the roundabout would balance the vehicle priority such that northbound vehicles on SR 161 would be required to yield to circulating traffic from the other street legs, while in the No Build condition, northbound travel was provided the majority of the signal phasing time in the morning.

In the PM peak, some paths along I-5 southbound and SR 18 westbound would have lower travel time in the 2020 No Build condition compared to the 2015 Existing Condition due to background improvement projects previously described in Section 3.5.1. Travel on I-5 southbound in the study area (path A to F) would see a 7-minute decrease in travel time as a result of the TPC HOV Program improvements. Improvements on the local streets, including the third southbound through lane at SR 161/S 348th Street and the S 352nd Street extension would reduce travel times on SR 161 southbound (path D to F) by 2 minutes. However, paths from I-5 southbound to locations on SR 161 (including A to D, A to E, and A to F) would increase between 2 and 4 minutes due to increased demand volumes and congestion along S 348th Street and specifically at the SR 161/S 348th Street intersection.

The project would reduce travel times in the 2020 PM peak between I-5 southbound and SR 161 by up to 10 minutes compared to the No Build alternative. Travel time on SR 18 westbound (path C to D) would decrease by 1.5 minutes, and travel time on SR 161 southbound (path D to F) would decrease by 1 minute. The only path that would have an increase in travel time in the 2020 PM with the project would be from I-5 southbound to SR 18 eastbound at Weyerhaeuser Way S (path A to C). This path would increase by 1 minute as the SW loop ramp in the No Build condition would be removed with the project and traffic would be relocated onto the I-5 southbound off-ramp and turn left at the signalized SR 18 intersection.

No Build travel time during the PM peak hour would increase between 1 and 8 minutes by year 2040 compared to year 2020. The paths that would see the highest travel time increase would be from I-5 southbound to SR 161 at S 356th Street (path A to E) and Milton Road S (path A to F). It is expected to take between 25 and 27 minutes (an average speed of approximately 5 mph) to travel along these paths by year 2040.

The 2040 PM Build condition would lower the travel time from I-5 southbound to SR 161 at S 356th Street (path A to E) and Milton Road S (path A to F) by 18 to 22 minutes, resulting in average speeds between 18 and 22 mph. This is more than an 80 percent reduction in travel time as drivers are able to use the proposed I-5 southbound off-ramp at S 356th Street to access SR 161, avoiding congestion along S 348th Street and through the SR 161 intersection. Travel time from SR 18 westbound at Weyerhaeuser Way S to the SR 161 intersection (path C to D) would also decrease by over 5 minutes. As described previously, the project provides an additional off-ramp connection between I-5 southbound and SR 161, which relieves congestion at the SR 161/S 348th Street intersection.

A few paths, most noticeably SR 161 southbound (path D to F), would see small travel time increases in the 2040 PM Build condition compared to the No Build condition. The southbound travel time on SR 161 (path D to F) would increase by 1.9 minutes compared to the No Build alternative. This would occur because as the project increases the vehicle throughput in the study area, more vehicles are able to travel on SR 161, causing longer queues on SR 161 southbound. As previously described in Section 3.7.3,

improvements at the SR 161/Milton Road S intersection would help reduce the amount of congestion and queues on SR 161.

3.8 Safety Conditions

3.8.1 Observed Crash History

Collision data were collected from WSDOT for the 3-year period after the construction of Phase 1 between July 2012 and July 2015 in the study area. Crash rates were calculated for the roadway segments within the study area as the number of crashes per million vehicle miles traveled (MVMT) and are summarized in Table 3-16 along with the observed crash frequencies. No crash rates were calculated for segments less than one (1) mile as short segments can artificially inflate the crash rate.

Crash rates were also calculated for the arterial intersections and ramp terminal intersections within the study area. These are presented as the number of crashes per million entering vehicles (MEV) and summarized in Table 3-17. The intersection of SR 161 and SR 18 (S 348th Street) has the highest crash frequency with 89 crashes and the highest crash rate with 0.81 crashes/MEV.

There are no collision analysis corridors, collision analysis locations, or intersection analysis locations within the study area.

Table 3-16. Existing Road Segment Observed Crash Summary (2012-2015)

Road Segment	Length (mi)	Total ADT[a]	2012-2015 Crash Frequency (# of crashes)				Crash Rate (crashes/ MVMT)
			Fatal	Injury	PDO	Total	
Mainline							
M1: I-5 (S 320th St to SR 161 Overpass)	2.4	141,300	1	149	294	444	0.91
M2: SR 18 (SR 161 to I-5 NB/SB Slip Ramps)	1.3	53,900	0	23	40	63	0.60
M3: SR 161 (S 356th St to WB SR 18 Off-Ramp)	0.6	28,500	0	9	10	19	N/A[b]
Ramps							
R1: SB I-5 Off-Ramp to WB SR 18 (NW Slip)	0.3	13,900	0	9	34	43	N/A[b]
R2: SB I-5 Off-Ramp to EB SR 18 (SW Loop)	0.3	10,800	0	3	3	6	N/A[b]
R3: WB SR 18 to SB I-5/SR 161 Flyover Ramp	0.8	23,600	0	16	22	38	N/A[b]
R4: EB SR 18 On-Ramp to SB I-5 (SW Slip)	0.3	6,500	0	0	6	6	N/A[b]
R6: WB SR 18 Off-Ramp to SR 161	0.3	4,500	0	0	2	2	N/A[b]

PDO = property damage only

[a] Average daily traffic (ADT) volumes (veh/day) were developed using the existing 2015 PM peak hour volumes (k=0.10) and averaged for segments with multiple volume sections.

[b] Crash rates were not calculated for segments shorter than 1 mile as the short length can artificially inflate the crash rate.

Table 3-17. Existing Intersection Observed Crash Summary (2012-2015)

Intersection	Entering ADT[a]	2012-2015 Crash Frequency (# of crashes)				Crash Rate (crashes/ MEV)
		Fatal	Injury	PDO	Total	
I1: SB I-5 Off-Ramp/SR 18 (S 348th Street)	44,400	0	11	37	48	0.74
I2: SR 161/SR 18 (S 348th Street)	75,450	0	28	61	89	0.81
I3: SR 161/ S 352nd Street	34,700	0	8	21	29	0.57
I4: SR 161/S 356th Street	34,150	0	13	25	38	0.76
I5: SR 161/WB SR 18 Off-Ramp	35,100	0	4	4	8	0.16

MEV = million entering vehicles; PDO = property damage only

[a] Average daily traffic (ADT) volumes (veh/day) were developed using the 2015 existing PM peak hour volumes (k=0.10).

3.8.2 Future Safety Conditions

3.8.2.1 Safety Analysis Methodology and Assumptions

A *Highway Safety Manual* (HSM; http://www.highwaysafetymanual.org/Pages/default.aspx, AASHTO, 2010) predictive analysis was conducted to assess the change in average predicted crash frequency in the study area between three conditions in year 2040: No Build, the previously proposed Phase 2 design, and the currently proposed Phase 2 design. The IHSDM software (2015 release) was used to perform this analysis. In addition, two of the arterial intersections along SR 161 were analyzed using the National Cooperative Highway Research Program 17-38 Enhanced HSM Analysis spreadsheets to capture the change in safety performance due to the volume changes that occurred at these intersections. These were the SR 161/SR 18 (S 348th Street) intersection and the SR 161/S 352nd Street intersection.

Design files for each of the alternatives analyzed were obtained from WSDOT and used to collect all of the relevant geometric data necessary for the analysis. The data include attributes such as lane and shoulder width, barrier length and offset, horizontal curve data, and median treatments for all corresponding station locations within the study area.

In addition, volume data (ADT) are required for all analyzed roads and were developed from the corresponding PM peak hour volumes from the operations analysis using a k-factor determined from field counts and *2014 Ramp and Roadway* (http://www.wsdot.wa.gov/Northwest/TrafficVolume/, WSDOT, 2014) data for each facility. Since the ramp configurations differ between the previous and current Phase 2 designs, the specific ramps carrying the forecasted 2040 volumes are not the same between the two conditions, but the total volumes in the study area and the specific origin and destination trip patterns were assumed to be consistent between the previous and current Phase 2 conditions.

Both the northbound and southbound directions of the I-5 mainline were analyzed even though there are no changes occurring to northbound I-5. The HSM models do not allow for a directional analysis of a freeway facility; therefore, both directions need to be included in the analysis. Because of the nature of the Phase 2 design improvements, any safety performance changes shown for the I-5 mainline can be solely attributed to the changes occurring in the southbound direction. Since the alternatives analyzed are for the 2040 design year and contain volume changes as well as geometric changes, the existing

crash data do not apply and therefore were not incorporated into the analysis. In addition, no results are shown for any ramps that did not have a geometric or volume change between the alternatives.

The safety performance functions in the HSM are models that have been developed using research from a selected number of states. Therefore, there is the potential that when they are applied to other states, the results are skewed. To account for this, the HSM encourages the development of calibration factors that will (linearly) adjust the models to a particular area by incorporating local data. Without this calibration, the magnitude of the output from the models is unreliable. WSDOT has not developed calibration factors for freeways and interchange facilities; thus, none were available for this analysis. The analysis is therefore focused on how the safety performance changes between each alternative and calibration is not required. Because of this, only the difference in predicted crash frequencies between the alternatives is reported.

3.8.2.2 2040 Safety Performance Results

Table 3-18 summarizes the change in average predicted crash frequency between both the previous and current Phase 2 configurations as compared to the No Build (same as existing) condition in the year 2040. The results are shown in terms of existing road facilities and new road facilities, where the new facilities (illustrated in Exhibit Intro-3) are:

- I-5 southbound off-ramp to SR 161/S 356th Street ramp terminal (R5)
- I-5 southbound connection between the I-5 southbound-to-SR 161 ramp and the SR 18 westbound-to-SR 161 ramp (R7)

Table 3-18. Phase 2 IHSDM Results Compared to No Build – Year 2040

	Change from 2040 No Build							
	2040 Previous Phase 2				**2040 Current Phase 2**			
	Fatal/Injury Crashes		**Total Crashes[a]**		**Fatal/Injury Crashes**		**Total Crashes[a]**	
Analysis Facilities	**Change in Frequency**	**Percent Change**	**Change in Frequency**	**Percent Change**	**Change in Frequency**	**Percent Change**	**Change in Frequency**	**Percent Change**
Existing Facilities	-2.6	-4%	-0.4	0%	-0.7	-1%	-4.3	-2%
New Facilities	0.9	-	2.1	-	2.5	-	5.0	-
Total	**-1.7**	**-2%**	**1.7**	**1%**	**1.8**	**3%**	**0.7**	**0%**

[a] Total includes both fatal/injury and PDO crashes.

The number of predicted crashes on existing road facilities in the study area is predicted to decrease for both previous and current Phase 2 designs as compared to the No Build condition. Although, there would be a larger decrease in predicted crash frequency on the existing facilities with the current Phase 2 design (4.3 crashes/year) than with the previous Phase 2 design (0.4 crash/year) when compared to No Build. Compared to the previous Phase 2 design, the current Phase 2 design would have a 2 percent reduction in crashes on existing facilities (3.9 crashes/year). The new facilities, previously listed, would be predicted to have 5 crashes per year with the current design and 2.1 crashes per year with the previous design. Overall, the current Phase 2 design would have a similar crash frequency as the No Build condition (0.7 crash/year increase or a 0 percent change). Therefore, the current Phase 2 design does show a safety performance improvement over the previous Phase 2 design, which predicts slightly

less than 2 more crashes per year than in the No Build condition (a 1 percent increase). A detailed summary table of the IHSDM analysis results can be found in Appendix F.

Exhibit 3-12 also shows both previous and current Phase 2 configuration results as compared to the 2040 No Build configuration for all of the facilities with a non-zero change in predicted crash frequency. The change in the horizontal alignment of the southbound I-5 SW loop ramp (R2) in the previous Phase 2 design would reduce crashes by about 1 crash/year, whereas removal of the SW loop ramp in the current Phase 2 design would decrease crashes by over 7 crashes/year.

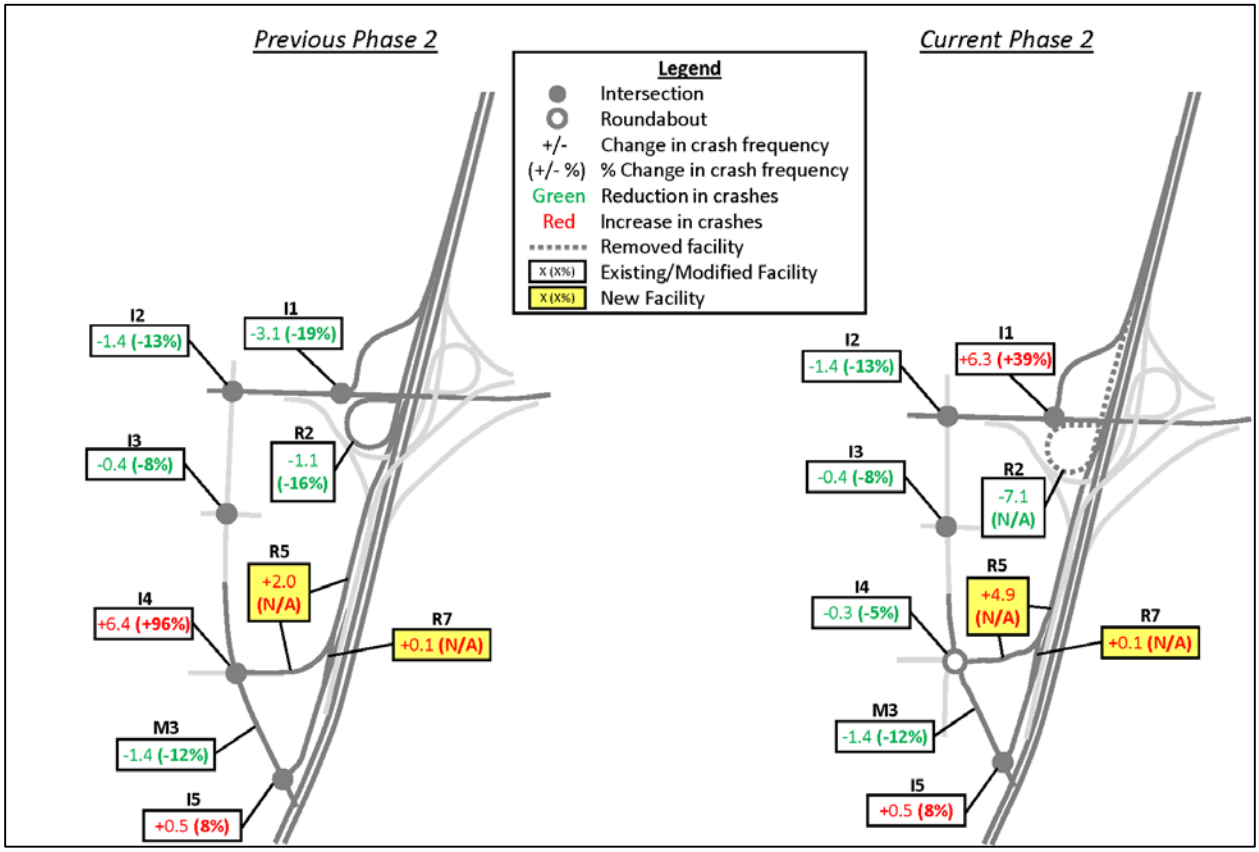


Exhibit 3-12. Change in Total Predicted Crash Frequency Compared to No Build – Year 2040

The I-5 southbound off-ramp/SR 18 (S 348th Street) intersection (I1) is predicted to have more crashes in the current Phase 2 condition than the No Build and previous Phase 2 design. This is due to a volume increase on the ramp resulting from the removal of the southwest loop ramp (R2) and the consolidation of the volumes onto the one off-ramp. Collectively, there would be a net reduction in crashes when considering both the elimination of the R2 ramp and the increases in volume on I1 ramp due to the elimination of the R2 ramp with the current Phase 2 design.

The current Phase 2 design of the new I-5 southbound off-ramp to S 356th Street/SR 161 (R5) is predicted to have slightly more crashes than the previous Phase 2 design. This is largely due to the horizontal alignment curvature in the current Phase 2 design that accommodates and prepares drivers to enter the teardrop roundabout intersection. Overall, the current Phase 2 design would reduce the total predicted crash frequency on all ramps within the interchange by about 2 crashes/year over the No Build; the previous design predicted an increase of over 1 crash/year (see Table F-1 in Appendix F).

Predicted crashes on SR 161 road segments between S 348th Street and S 356th Street (excluding intersections) would decrease with less volume travelling along the corridor in both the previous and current Phase 2 designs (M3). This projected decrease in volume would also decrease the predicted crash frequency of the intersections along SR 161 at SR 18 (S 348th Street) (I2) and S 352nd Street (I3) for both previous and current Phase 2 designs. The southbound I-5 ramp to SR 161/S 356th Street ramp terminal (I4) shows an increase in predicted crashes for the previous Phase 2 design compared to the current design due to an increase in volume on the minor leg (off-ramp). This volume increase occurs in the current Phase 2 condition as well; however, the proposed roundabout at the intersection would reduce the total crashes compared to the signal in the previous Phase 2 configuration.

Policy Point 4: Access Connections and Design

Will the Proposed Alternative provide fully directional interchanges connected to public streets or roads, spaced appropriately, and designed to meet the identified performance needs?

4.1 Design Summary

Policy Point 4 documents the project's Phase 2 design complete to date. Specific information provided includes lane channelization, design decisions, and documentation of any design variances. As summarized in Policy Point 1, the purpose of this project is to improve mobility and safety at the Triangle interchange. The intent of this IJR Amendment is to document only the proposed modifications to the Phase 2 design from the original IJR. The proposed Phase 2 design includes the following interchange access improvements:

- Widen and realign the southbound I-5 off-ramp to westbound SR 18 to accommodate eastbound and westbound SR 18 traffic.
- Close the southbound I-5 loop ramp to eastbound SR 18.
- Provide a new one lane C-D ramp from southbound I-5 with access to SR 161 at S 356th Street.
- Replace the S 356th Street/SR 161 and S 356th Street/16th Avenue S intersections with a two-lane roundabout.
- Provide access from the new southbound I-5 C-D to the existing directional ramp to SR 161 from westbound SR 18.

These improvements are described to provide an integrated documentation of all roadway improvements within WSDOT's permitting authority.

4.2 Existing Conditions

I-5 is a National Highway System (NHS) route with a state functional classification of U5 (Urban, Interstate). SR 18 and SR 161 are both NHS routes with a state functional classification of U1 (Urban, Principal Arterial). The terrain is rolling within the project limits for all three NHS routes. A base map was created by topographical survey of the existing roadways and surrounding areas. This base map and aerial photography were used in the design of the proposed roadway improvements.

4.2.1 I-5 - SR 161/SR 18 Interchange

The Triangle interchange is a semi-directional interchange with full access between I-5 and SR 18 as well as direct access from westbound SR 18 to SR 161 as shown in Exhibit 4-1.

The southbound I-5 off-ramp to westbound SR 18 is a one-lane off-ramp that ends in a westbound-only signalized ramp terminal intersection with two GP right-turn lanes and one HOV free right-turn lane. Eastbound SR 18 at this ramp terminal is uncontrolled and contains two through lanes. The southbound I-5 off-ramp to eastbound SR 18 is a one-lane loop ramp that merges with eastbound SR 18 with a 650-foot acceleration lane. As seen in Exhibit 4-1, the completed Phase 1 improvements as part of this project included a flyover ramp from SR 18 westbound to I-5 southbound and SR 161 (at S 359th Street) and an SR 18 eastbound flyover ramp to I-5 northbound.

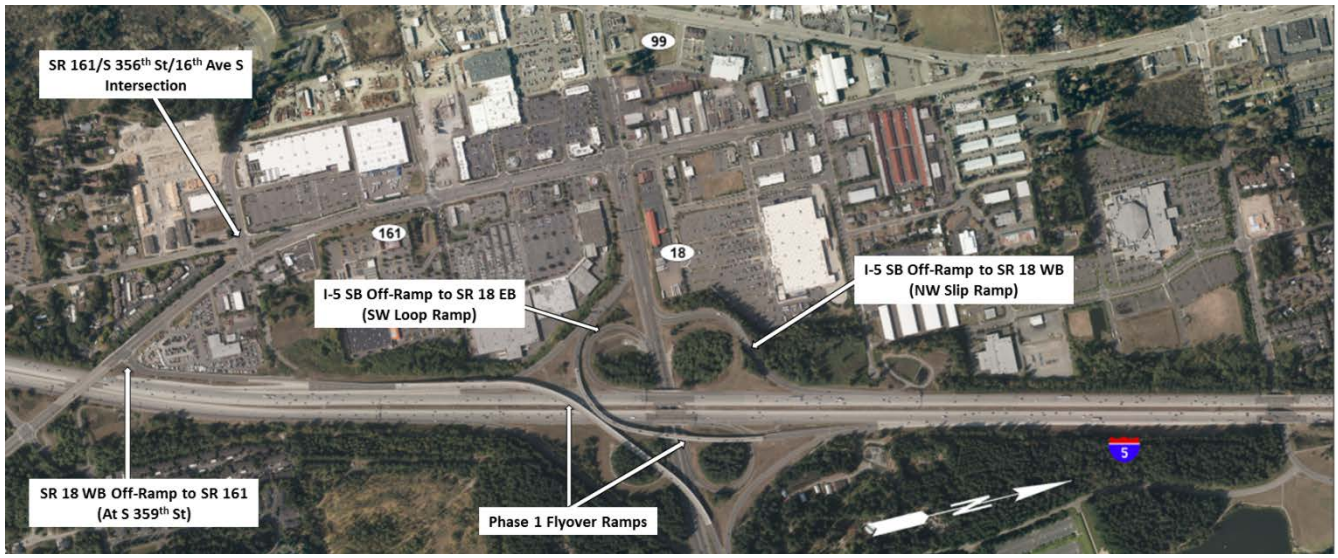


Exhibit 4-1. Existing Conditions Map – Entire Study Area

4.2.1.1 SR 161/S 356th Street/16th Avenue S Intersection

The intersection of SR 161 with S 356th Street is a signalized intersection located south of the SR 18 (S 348th Street) intersection with SR 161 and north of the SR 18 westbound flyover ramp to SR 161 at S 359th Street. The SR 161 and S 356th Street intersection is located adjacent to the signalized intersection of S 356th Street and 16th Avenue S. Only 120 feet separate the intersection centers as shown in Exhibit 4-2. Therefore, these two signalized intersections operate with coordinated signal phasing and one signal controller to accommodate all traffic movements at the two intersections.

SR 99 is the next signalized intersection to the west of SR 161/S 356th Street/16th Avenue S intersection and is approximately ½ mile from SR 161. To the north, there is approximately ¼ mile of separation from S 352nd Street, which is the next signalized intersection. South on SR 161, the next signalized intersection is the westbound SR 18 flyover off-ramp (equivalent to S 359th Street) to SR 161. This intersection is a little over 1,000 feet from S 356th Street. South of this location, SR 161 crosses over I-5, and east of I-5 there is a signalized intersection with Milton Road S. This intersection with Milton Road S is approximately 850 feet from the SR 18 flyover off-ramp intersection. East of SR 161, S 356th Street provides some commercial access to properties on both north and south sides but dead ends approximately 600 feet east of SR 161.

There are numerous commercial accesses on SR 161 and S 356th Street in the vicinity of the intersection. There are also several residential accesses on 16th Avenue S in the vicinity of the intersection. These accesses are shown in Exhibit 4-2.

Exhibit 4-2. Existing Conditions Map – SR 161/S 356th Street/16th Avenue S Intersection

4.3 Project Phasing

Due to funding constraints, the I-5 - SR 161/SR 18 Interchange Project was separated into phases as shown in Exhibit 4-3. Phase 1, which included the two flyover ramps from SR 18 to I-5 along with other associated improvements, was completed in September 2012. This IJR Amendment only considers the current Phase 2 design as future phases are not funded at this time with no timeframe for construction. In 2015, the Connecting Washington Transportation Revenue Package included full funding for construction of Phase 2 between the years 2023 and 2027.

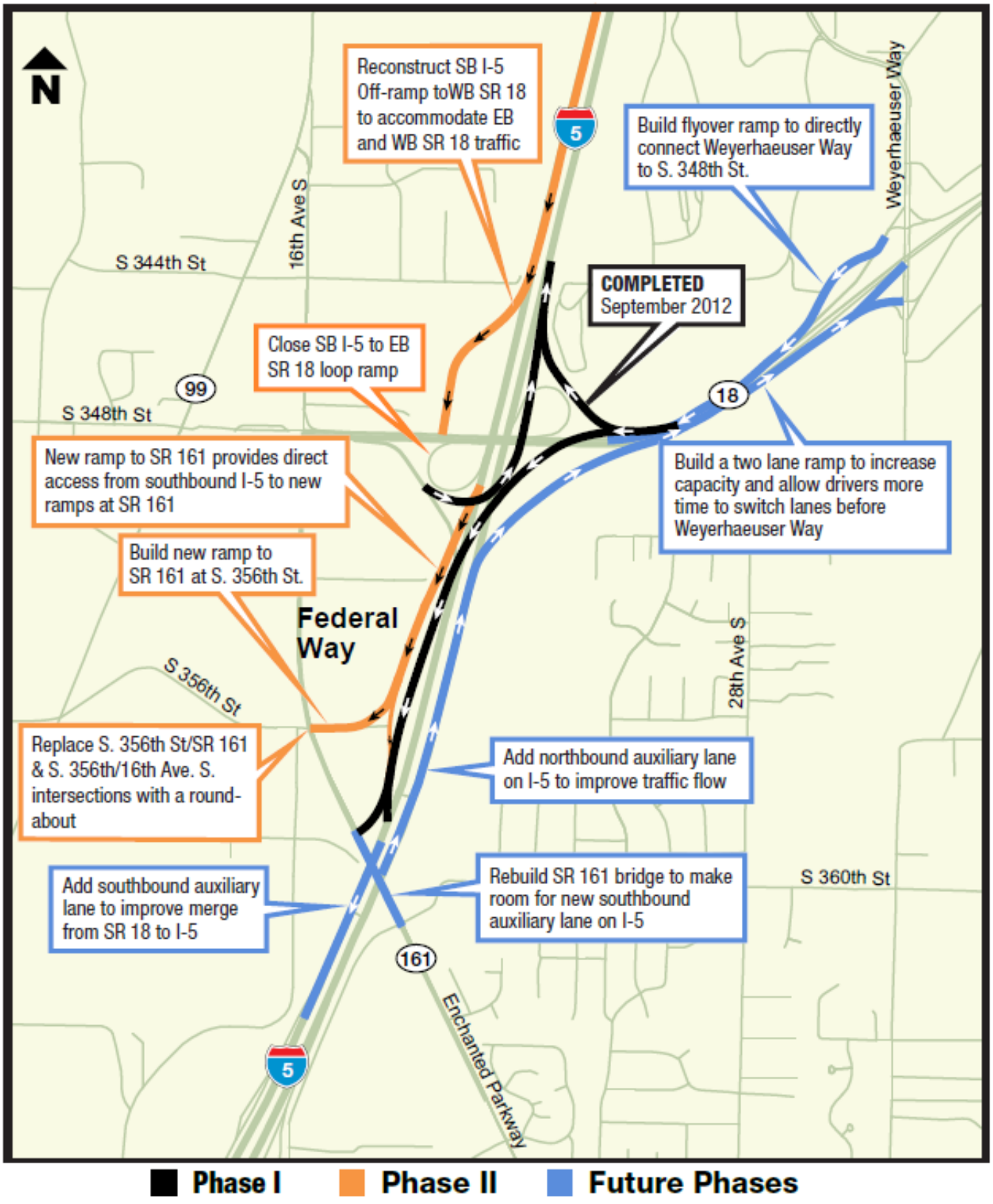


Exhibit 4-3. Triangle Interchange Improvement Project Phasing Map

4.4 Geometric Design Decisions

The geometric design uses the current version of the WSDOT *Design Manual* (DM), M 22-01.12 (November 2015; http://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm). The design elements documented in this section are based on the information known as of this IJR Amendment publication date. Through subsequent design efforts, design elements may be modified but would be coordinated with the appropriate agencies.

4.4.1 I-5 Southbound Off-Ramp to SR 18 (S 348th Street)

As shown in Exhibit 4-4, the I-5 southbound off-ramp to SR 18 (S 348th Street) would be widened and realigned to accommodate both eastbound and westbound SR 18 traffic. The existing south-to-east (SE) loop ramp within the interchange area would be removed as a result of the construction of this new off-ramp and would also provide the necessary area to build the proposed I-5 southbound off-ramp to S 356th Street/SR 161 while still maintaining desirable ramp spacing. The proposed off-ramp to SR 18 would be constructed as a two-lane diamond off-ramp. An auxiliary lane on I-5 southbound would be added between the S 336th Street overpass and the proposed off-ramp to create the second lane of the off-ramp. The lengthened horizontal alignment of the two-lane off-ramp would also provide one additional lane and 550 feet of vehicle queue storage on the off-ramp (measured from ramp terminal stop bar to off-ramp painted gore). The signalized intersection at the off-ramp terminal with SR 18 would be widened and the traffic operations would be modified to allow left and right turn movements from southbound I-5 to both directions of SR 18.

In accordance with the WSDOT DM 1103.05 (November 2015), design speed of the auxiliary lane and the proposed off-ramp is the same as the posted speed of 60 mph which is the targeted operating speed of the I-5 facility.

The I-5 southbound auxiliary lane would begin on the south side of the S 336th Street overpass with a 300-foot taper and a total length of 1,670 feet to the realigned I-5 southbound off-ramp to SR 18. Per Section 4.3 of the Green Book, auxiliary lanes should be as wide as the through-traffic lanes but not less than 10 feet; as such, existing through lane widths are 12 feet wide, while the proposed auxiliary lane is 11 feet wide. The existing right shoulder width in this segment is 10 feet wide, while the proposed right shoulder width along the auxiliary lane would be 8 feet wide. Both the auxiliary lane and shoulder widths were dimensioned using quantitative analysis (see Section 4.6 for the safety evaluation results).

The proposed I-5 southbound off-ramp to SR 18 is a two-lane tapered off-connection and meets WSDOT's guidelines per DM Exhibit 1360-14d (November 2015) criteria with a 25:1 taper rate. Beyond the off-connection, the ramp is targeted for a 25-mph design speed. The ramp lane widths are 12.5 feet with a 4-foot left shoulder and an 8-foot right shoulder, which meet WSDOT's guidelines per DM Exhibit 1360-6 (November 2015).

The ramp provides 1,138 feet of deceleration to the first curve in the ramp, which is greater than the 460-foot minimum length per WSDOT DM Exhibit 1360-10 (November 2015) for grades flatter than 3 percent. The minimum deceleration rate was calculated with a highway design/posted speed of 60 mph to a ramp design speed of 25 mph. All grades on the ramp are less than 3 percent. Both horizontal curves on the ramp have a centerline radius of 290 feet. In the first curve, the 14.5-foot lane width through the curvature for a two-lane, one-way ramp meets WSDOT's guidelines per DM Exhibit 1240-2a (November 2015).

The ramp then widens from two 14.5-foot lanes to four 14-foot lanes, and the right shoulder narrows from 8 feet to 4 feet between the first and second curves, which meet WSDOT's guidelines per DM Exhibit 1360-6 (November 2015). In the second curve, the 14-foot lane width through the curvature for a four-lane, one-way ramp exceeds WSDOT's guidelines for an 290' radius curve per DM 1240.02(4) and DM Exhibit 1240-2a (November 2015). The ramp would intersect SR 18 at a full signalized intersection with two right-turn lanes and two left-turn lanes. The ramp provides 260 feet of deceleration to the signalized intersection, which is greater than the 235-foot minimum per WSDOT DM Exhibit 1360-10 (November 2015). The minimum deceleration rate was calculated with a design speed of 30 mph to a stopped condition at the intersection.

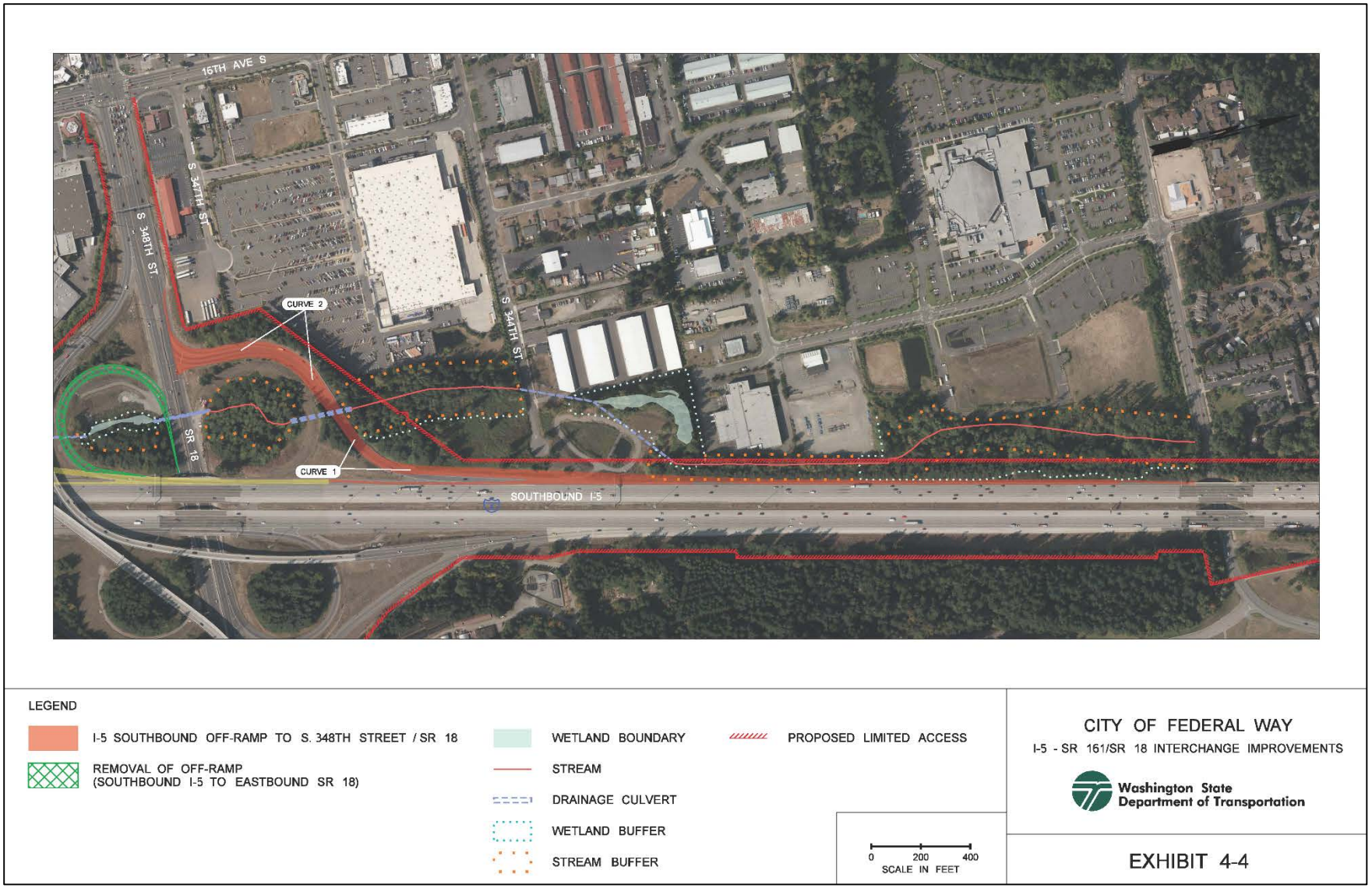


Exhibit 4-4. Triangle Interchange Project Phase 2 Design – S 348th Street to S 336th Street

4.4.2 I-5 Southbound C-D Ramp to S 356th Street/SR 161

As shown in Exhibit 4-5, a C-D ramp would be constructed to provide access from southbound I-5 to S 356th Street and SR 161. The C-D ramp would provide access to a new off-ramp to SR 161 at S 356th Street (see Section 4.4.3) and would merge with the westbound SR 18 ramp to SR 161. The C-D ramp and connection to S 356th Street would provide an alternative path for southbound I-5 traffic destined to the commercial businesses on SR 161 as well as traffic traveling to destinations west of the project area and south on SR 161. This proposed off-ramp from southbound I-5 is intended to reduce traffic volume on the southbound I-5 to SR 18 off-ramp and at the intersection of SR 18 and SR 161, both of which currently have very high traffic volumes in the PM Peak hour.

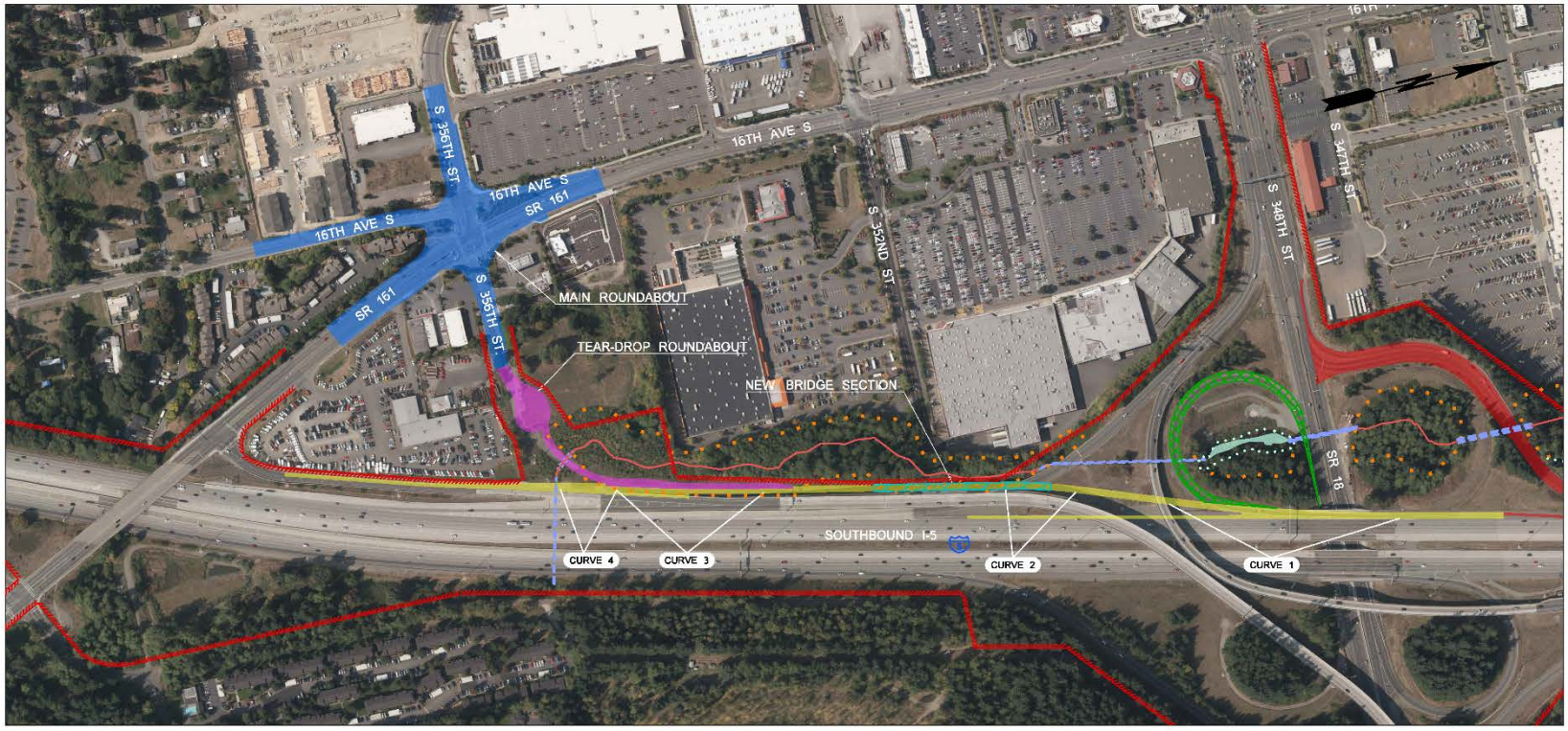
The proposed C-D ramp is a single-lane, parallel off-connection and meets WSDOT's guidelines per DM Exhibit 1360-14b (November 2015) criteria. The off-connection is designed for a design/posted speed of 50 mph. The ramp width of a 12-foot lane with a 2-foot left shoulder and an 8-foot right shoulder, which were dimensioned using quantitative analysis, meet WSDOT's guidelines per DM Exhibit 1360-6 (November 2015) for tangent portions of the ramp. The deceleration lane for the ramp starts north of the SR 18 overpass after the 250-foot taper and a total length of 590 feet to the start of the first horizontal curve. This provides 340 feet of deceleration to the first horizontal curve, which has a design speed of 50 mph. This length exceeds the 240-foot minimum per WSDOT DM Exhibit 1360-10 (November 2015) for grades flatter than 3 percent. The minimum deceleration rate is calculated with a highway design/posted speed of 60 mph to a ramp design speed of 50 mph.

The remaining discussion in this section describes design details regarding horizontal curvature and lane and shoulder width for the proposed I-5 southbound C-D ramp to S 356th Street/SR 161. Some segments of this C-D ramp propose lane and shoulder widths that do not meet WSDOT guidelines. A design justification for lane and shoulder widths on this C-D ramp is provided in Section 4.6.2.

The first horizontal curve has a left edge-line radius of 6,000 feet. The 12-foot lane width through the curvature for a one-lane ramp does not meet WSDOT's guidelines (14 feet) per DM Exhibit 1240-3a (November 2015). The ramp would pass under the bridge for the eastbound SR 18 flyover to northbound I-5 with a minimum vertical clearance of 16 feet 9 inches, which is greater than the 16-foot-6-inch minimum per WSDOT DM 720.03(5)(b)(1) (November 2015).

The second horizontal curve has a left edge-line radius of 1,600 feet. The 12-foot lane width through the curvature for a one-lane ramp does not meet WSDOT's guidelines (14 feet) per DM Exhibit 1240-3a (November 2015). There is 1,065 feet of deceleration to the second horizontal curve, which is greater than the 225-foot minimum per WSDOT DM Exhibit 1360-10 (November 2015) for grades flatter than 3 percent. The minimum deceleration rate is calculated with a ramp design/posted speed of 50 mph to a ramp design speed of 40 mph. The ramp would pass over the eastbound SR 18 on-ramp to southbound I-5 on a bridge with a minimum vertical clearance of 16 feet 9 inches, which is greater than the 16-foot-6-inch minimum per WSDOT DM 720.03(5)(b)(1) (November 2015). The ramp widens to two 12-foot lanes at the parallel off-ramp to SR 161 at S 356th Street (see Section 4.4.3), which meets WSDOT's guidelines per DM Exhibit 1360-6 (November 2015).

The third horizontal curve has a left edge-line radius of 6,800 feet. The 12-foot lane width through the curvature for a two-lane, one-way ramp meets WSDOT's guidelines per DM Exhibit 1240-2a (November 2015). Once the off-ramp diverges from the C-D, the 12-foot lane width through the remaining curvature on the C-D for a one-lane ramp does not meet WSDOT's guidelines (14 feet) per DM Exhibit 1240-3a (November 2015).



LEGEND

- I-5 SOUTHBOUND COLLECTOR-DISTRIBUTOR TO SR 161
- NEW BRIDGE SECTION
- I-5 SOUTHBOUND OFF-RAMP TO S. 356TH STREET / SR 161
- S. 356TH STREET ROUNDABOUT
- REMOVAL OF OFF-RAMP (SOUTHBOUND I-5 TO EASTBOUND SR 18)
- WETLAND BOUNDARY
- STREAM
- DRAINAGE CULVERT
- WETLAND BUFFER
- STREAM BUFFER
- PROPOSED LIMITED ACCESS

0 200 400
SCALE IN FEET

CITY OF FEDERAL WAY
I-5 - SR 161/SR 18 INTERCHANGE IMPROVEMENTS
Washington State Department of Transportation

EXHIBIT 4-5

Exhibit 4-5. Triangle Interchange Project Phase 2 Design – S 360th Street to S 348th Street

The fourth horizontal curve has a left edge-line radius of 3,200 feet, the 12-foot lane width through the curvature for a one-lane ramp does not meet WSDOT's guidelines (14 feet) per DM Exhibit 1240-3a (November 2015). There is 1,340 feet of deceleration to the fourth horizontal curve, which is greater than the 282-foot minimum per WSDOT DM Exhibit 1360-10 (November 2015) for downgrades between 3 percent and 5 percent. The minimum deceleration rate is calculated with a ramp design/posted speed of 40 mph to a ramp design speed of 25 mph.

Following the fourth horizontal curve, the ramp matches into the outside lane of the westbound SR 18 ramp to SR 161 with a deflection angle of 1 degree 55 minutes, which meets WSDOT guidelines for a roadway design speed of 25 mph per DM Exhibit 1210-1 (November 2015).

4.4.3 I-5 Southbound Off-Ramp to S 356th Street

As shown in Exhibit 4-5, an off-ramp would be constructed to provide access from the southbound I-5 C-D ramp to S 356th Street east of SR 161. The off-ramp would terminate into a tear-drop roundabout intersection at the end of S 356th Street. Due to the ramp length prior to the roundabout, a painted chicane is proposed at the beginning of the ramp divergence as a traffic calming measure. The chicane, the diameter of the roundabout, and the lane widths were dimensioned quantitatively using the AutoTURN software application in MicroStation using a 30-foot single-unit truck (AASHTO 2011 SU-30) design vehicle. The chicane and roundabout were also checked to ensure they would accommodate a semi-truck with a 53-foot trailer (AASHTO 2011 WB-67) with encroachment into the paved shoulders and center-island. The legs of the roundabout have a grade of 4 percent or flatter for at least 100 feet from the roundabout to improve sight distance and speed control entering the roundabout. Sight distances have yet to be evaluated.

The proposed off-ramp is a single-lane, parallel off-connection based on WSDOT's guidelines per DM Exhibit 1360-14b (November 2015) criteria. The off connection is designed to a target speed of 40 mph. The deceleration lane for the off-ramp to S 356th Street begins approximately 250 feet south of the C-D ramp bridge structure and provides 302 feet of deceleration distance to the painted chicane, which is greater than the 282-foot minimum per WSDOT DM Exhibit 1360-10 (November 2015) for downgrades between 3 percent and 5 percent. The minimum deceleration rate is calculated with a ramp design/posted speed of 40 mph to a ramp design speed of 25 mph. The lane and shoulder widths for the deceleration lane meet WSDOT guidelines (see Section 4.4.2).

4.4.4 SR 161/S 356th Street/16th Avenue S Roundabout

As shown in Exhibit 4-5, the two-lane roundabout intersection would replace the two intersections of S 356th Street with 16th Avenue S and SR 161. The diameter of the roundabout and the lane widths were dimensioned quantitatively using the AutoTURN software application in MicroStation. As 16th Avenue S is the main access to Todd Beamer High School, a 36-foot school bus (AASHTO 2011 S-BUS-36) was used as the design vehicle to ensure there were no encroachments on adjacent lanes. The roundabout was also designed to ensure it accommodates a semi-truck with a 53-foot trailer (AASHTO 2011 WB-67) with encroachments on adjacent lanes allowed. All legs of the roundabout have a grade of 4 percent or flatter for at least 100 feet from the roundabout to improve sight distance and speed control entering the roundabout. The approach speeds for the legs of the roundabout are 45 mph on SR 161, 35 mph on S 356th Street, and 30 mph for 16th Avenue S. Sight distances have not been evaluated.

Residential and commercial driveway accesses adjacent to the roundabout will primarily be restricted to right-in right-out access only (as described in Section 4.7) with the exception of the Lowe's driveway to S 356th Street, which is located on the north side of the west leg to the roundabout. The Lowe's driveway

would maintain the existing left-in movement with the project. WSDOT is coordinating with the City of Federal Way to ensure pedestrian and bicycle access meet federal, state, and local guidelines.

The roundabout has an inscribed diameter of 210 feet, which is greater than the 135-foot diameter suggested in WSDOT DM Exhibit 1320-1 (July 2013). The circulating roadway uses two 15-foot lanes, which is greater than the 29-foot width suggested in WSDOT DM Exhibit 1320-1 (July 2013). The circulatory roadway would have a short one-lane segment on the south leg (see Exhibit 3-3) as one lane is sufficient to accommodate the forecasted turn movement volumes. Specifically, the outside lane of the roundabout would be dropped at the southbound SR 161 exiting leg and the inside lane would shift to the outside at the SR 161 northbound entering leg.

The SR 161 (north and south) legs have two lanes entering and exiting the roundabout. The entry width is 28 feet for the northbound entrance and 33 feet for the southbound entrance, which are both greater than the 25-foot width suggested in WSDOT DM Exhibit 1320-1 (July 2013). Chicanes were used on the entry lanes of the roundabout due to high operating speeds during off-peak hours as suggested in DM 1320.05(3)a (July 2013). The legal speed on SR 161 in the project vicinity is listed as a 45 mph legal speed in the 2014 Washington State Highway Log. A slip lane was provided for southbound SR 161 to westbound S 356th Street due to high turn volumes. Exiting the roundabout, the travel lanes were matched to the existing 11-foot lanes.

The west S 356th Street leg has two lanes entering and exiting the roundabout. The entry width is 26 feet, which is greater than the 25-foot width suggested in WSDOT DM Exhibit 1320-1 (July 2013). Exiting the roundabout, the travel lanes were matched to the existing 11-foot lanes.

The east S 356th Street leg has two lanes entering and one leg exiting the roundabout. The second westbound leg was added to accommodate forecasted traffic from the off-ramp. The entry width is 29 feet, which is greater than the 25-foot width suggested in WSDOT DM Exhibit 1320-1 (July 2013). Entrance and exit lanes outside of the roundabout are designed with 11-foot wide lanes which are consistent with the existing lane widths.

The southwest 16th Avenue S leg has one lane entering and exiting the roundabout. The entry width is 16 feet, which is meets the 16-foot to 18-foot width suggested in WSDOT DM Exhibit 1320-1 (July 2013). Entrance and exit lanes outside of the roundabout are designed with 12-foot wide lanes which are consistent with the existing lane widths.

4.4.5 Interchange and Ramp Spacing Criteria

The I-5 southbound project area is between the S 320th Street interchange to the north and the SR 18 westbound fly-over on-ramp to the south. The interchange and ramp spacing along I-5 for the proposed Phase 2 improvements was designed per WSDOT Design Manual (DM) 1360.02(3) (November 2015) and 1360.02(6), respectively. All of the proposed interchange and ramp spacing distances exceed WSDOT guidelines for minimum spacing as shown in Table 4-1. Interchange spacing was not affected with the current Phase 2 design but is shown in the table to illustrate that the WSDOT design manual guidelines are met. The proposed SR 161 C-D off-ramp would be 1,800 feet south of the SR 18 southbound off-ramp and would be 2,000 feet upstream of the SR 18 eastbound on-ramp. Both of these distances meet WSDOT guidelines.

Table 4-1. I-5 Southbound Interchange and Ramp Spacing Summary

I-5 Southbound Interchange and Ramps	Connection Type	WSDOT Design Manual Spacing Guidelines	Proposed Design Spacing
S 320th Street Interchange to SR 18 Interchange	Interchange	1 mile	1.8 miles
SR 18 Interchange to 54th Avenue E Interchange	Interchange	1 mile	4.6 miles
S 320th Street SB On-Ramp to SR 18 SB Off-Ramp	On-Off Type A	2,000 ft	5,170 ft
SR 18 SB Off-Ramp to SR 161 C-D Road Off-Ramp	Off-Off Freeway	1,000 ft	1,800 ft
SR 161 C-D Road Off-Ramp to EB SR 18 On-Ramp	Off-On Freeway	500 ft	2,000 ft

4.5 Conceptual Signing Plan

A conceptual signing plan of the proposed Phase 2 improvements is presented in Appendix G. The location of freeway guide signs for I-5 southbound exits 142A and B would remain the same with the Phase 2 improvements, although the destinations for each of these exits would change. The sign for Exit 142B that currently serves SR 18 West (S 348th Street) would be modified to serve SR 18 East/West and S 348th Street, while the sign for Exit 142A that currently serves SR 18 East would be modified to serve SR 161 and S 356th Street. There would also be additional guide signs on the I-5 southbound C-D ramp to S 356th Street and SR 161.

All new and relocated signs would meet current WSDOT and *Manual on Uniform Traffic Control Devices* (http://mutcd.fhwa.dot.gov/) standards. In addition, all signing would be placed on breakaway bases to meet WSDOT and AASHTO clear zone requirements. If breakaway bases are not feasible, the sign posts and sign bridge foundations located within the clear zone would be mitigated with concrete barrier or guardrail traffic barrier per the WSDOT DM standards.

4.6 Design Analysis Justifications

4.6.1 I-5 Southbound Off-Ramp to SR 18 (S 348th Street)

Auxiliary Lane and Shoulder Width: Per WSDOT DM Exhibit 1230-5b (November 2015), minimum lane widths are 12 feet and outside shoulder widths are 10 feet for high-speed corridors when using the criteria-based dimensioning method. In order to minimize impacts on wetland and stream buffers along the west side of I-5, this project uses quantitative analysis to evaluate the use of an 11-foot lane and 8-foot outside shoulder for the proposed auxiliary lane.

Safety Analysis: An IHSDM safety analysis was performed to compare the predicted crash frequency for the current Phase 2 design proposal of 11-foot lane and 8-foot outside shoulder to the WSDOT auxiliary lane design minimums of a 12-foot lane and a 10-foot outside shoulder. This IHSDM analysis used the same assumptions and was consistent with the safety analysis described in Section 3.8.2. Overall, the 11-foot lane and 8-foot shoulder results in an increase of less than 0.1 total crash/year over the design guidelines. The increase in fatal and injury crashes is also predicted to be less than 0.1 crash/year.

4.6.2 I-5 Southbound Off-Ramp to S 356th Street/ SR 161

Barrier Shy Distance: Per WSDOT DM 1610.05(2) (November 2015), 2 feet of shy distance should be provided where shoulder width would be less than 8 feet when using the criteria-based dimensioning

method. In order to minimize impacts on the stream buffer along the west side of I-5, this project used quantitative analysis to evaluate the use of a 2-foot inside shoulder for the proposed C-D ramp.

Ramp Lane and Shoulder Width: Per WSDOT DM Exhibit 1240-3a (November 2015), minimum lane width for the single-lane portions of the collector-distributor is 14 feet for turning roadway width and 4 feet for outside shoulder width when using the criteria-based dimensioning method. In order to minimize impacts on the stream buffer along the west side of I-5, this project used quantitative analysis to evaluate the use of a 12-foot lane and 8-foot outside shoulder for the proposed C-D ramp. A semi-truck with a 53-foot trailer (AASHTO 2011 WB-67) was used as the design vehicle to ensure there were no encroachments on the shoulders and sight distances were confirmed for each horizontal curve. The overall width of the ramp is 22 feet (2-foot inside shoulder, 12-foot lane, 8-foot outside shoulder). This provides the recommended width for passing a stalled vehicle on single-lane, one-way operations (Case II) with heavy combination truck traffic (Traffic Condition C) with barrier on both sides of the roadway, per Table 3-29 of the Green Book (AASHTO, 2011).

Safety Analysis: An IHSDM safety analysis was performed to compare the predicted crash frequency for the current Phase 2 design proposal for the southbound I-5 off-ramp to SR 161 with a 12-foot lane width and an 8-foot outside shoulder width to the WSDOT ramp design minimums of a 14-foot lane width and a 4-foot outside shoulder width. This IHSDM analysis used the same assumptions and was consistent with the safety analysis described in Section 3.8.2. Both designs assumed a barrier would be present along the inside of the ramp. Overall, the 12-foot lane width and 8-foot outside shoulder width would result in a decrease of 0.1 total crash/year over the DM guidelines. The decrease in fatal and injury crashes is predicted to be less than 0.1 crash/year.

Overall, even with these slight decreases in predicted crashes with the design analysis justifications, the current Phase 2 improvements would have a similar predicted crash frequency to the No Build Alternative and fewer predicted crashes than the previous Phase 2 configuration, as described previously in Section 3.8.

4.7 Access Control

The Triangle interchange is full access control within the limits of the Phase 2 design as defined by WSDOT DM 530.03(3)(c) (November 2015). Full access control would be maintained with the current Phase 2 design except at the I-5 southbound off-ramp terminus to S 356th Street/SR 161.

In order to minimize property acquisition and right-of-way impacts, it is proposed to allow an access within 300 feet of the end of this ramp. The potential access would be approximately 130 feet beyond the end of the off-ramp and only allow right-in and right-out movements. Modified limited access control would be acquired for the remainder of the 300 feet in accordance with the WSDOT DM 530.03(3)(d) (November 2015) as shown on Exhibit 4-6.

SR 161 is Managed Access Class 4 within the limits of the Phase 2 design. As this portion of the route falls within the corporate boundaries of the City of Federal Way, WSDOT would coordinate access with the City of Federal Way. All existing driveways in the vicinity of the SR 161/S 356th Street/16th Avenue S intersection are shown on Exhibit 4-7.

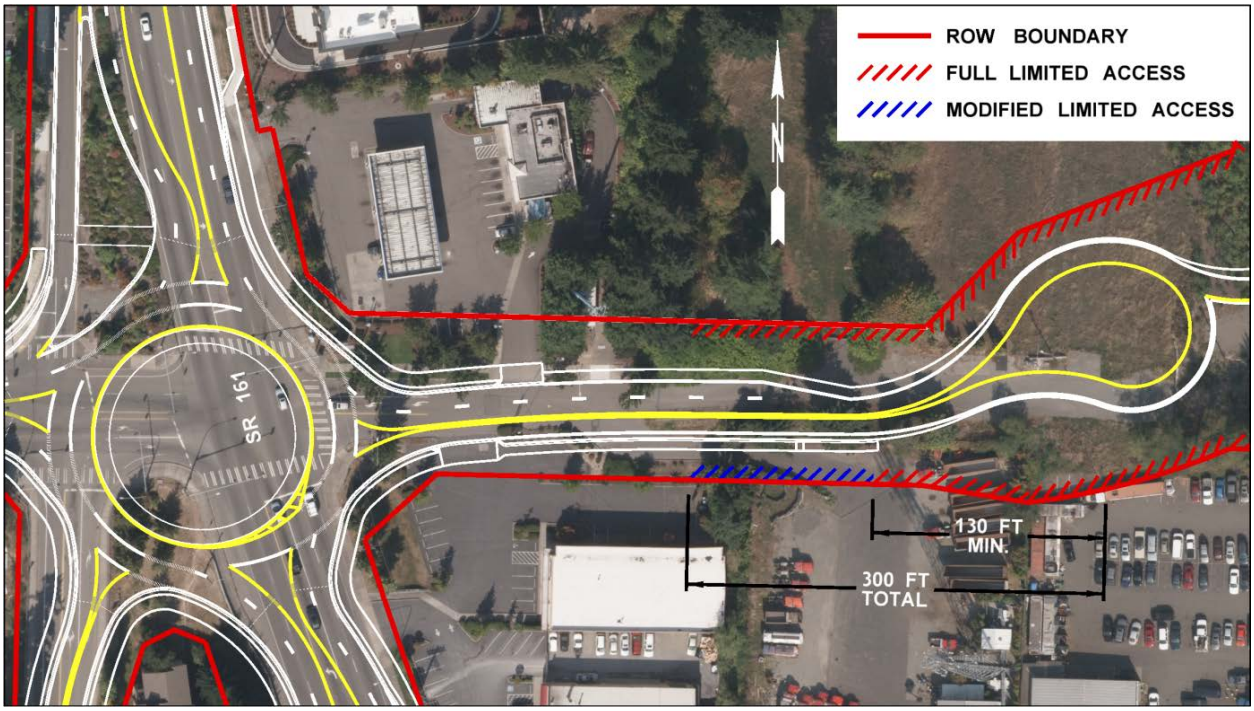


Exhibit 4-6. Proposed Modified Limited Access on the I-5 Southbound Off-Ramp to S 356th Street/SR 161

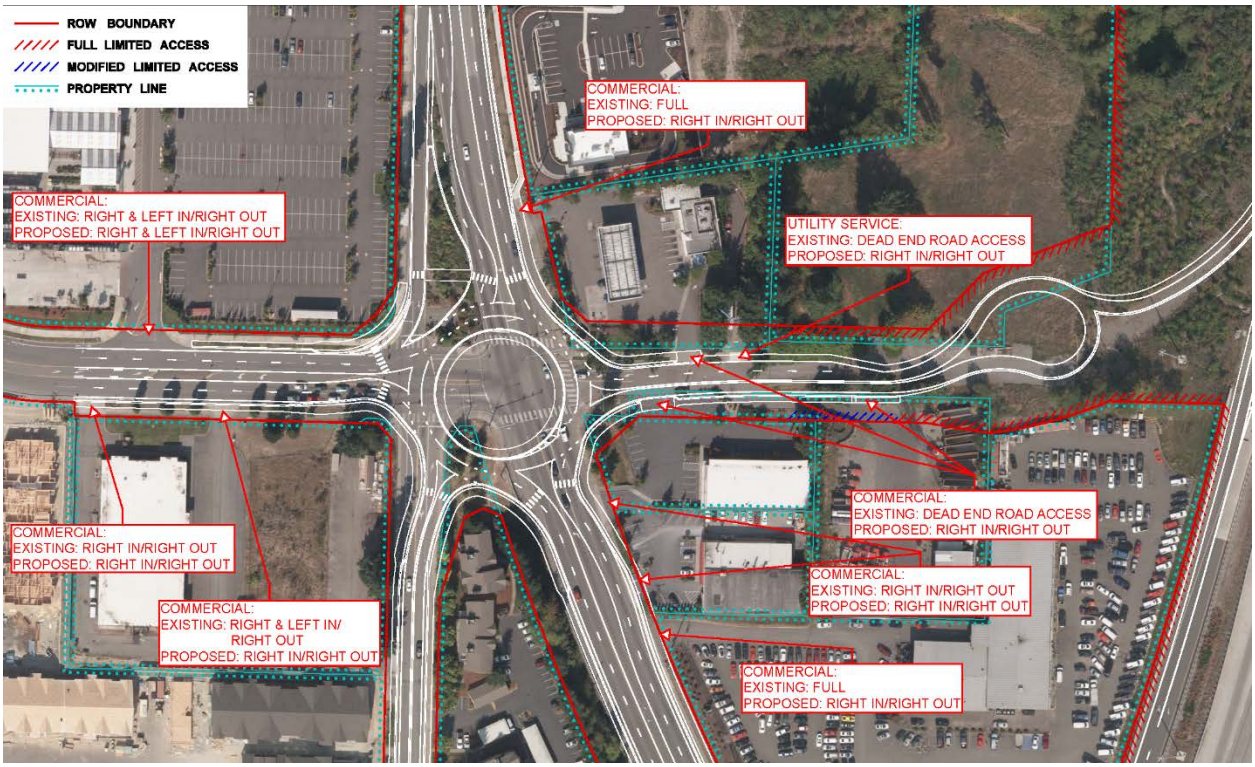


Exhibit 4-7. Existing Driveways near the SR 161/S 356th Street/16th Avenue S Intersection

Policy Point 5: Consistency with Land Use and Transportation Plans

Is the proposed access point revision compatible with all land use and transportation plans for the area?

5.1 Summary

There are multiple regional and state documents that establish the framework for land use and transportation system planning for the region, including:

- PSRC's *Transportation 2040* (http://www.psrc.org/transportation/t2040/t2040-pubs/final-draft-transportation-2040/)
- *Washington Transportation Plan* (http://www.wsdot.wa.gov/planning/wtp)
- Connecting Washington Transportation Revenue Package (http://leap.leg.wa.gov/leap/budget/detail/2015/ht1517p.asp)
- City of Federal Way Comprehensive Plan (http://www.cityoffederalway.com/index.aspx?NID=356)
- City of Milton Comprehensive Plan (http://www.cityofmilton.net/departments/planning-and-community-development/2015-comprehensive-plan-update/)
- Sound Transit 2 Plan (http://www.soundtransit.org/About-Sound-Transit/News-and-events/Reports/ST2-project-details)
- Pierce County Transit Development Plan (http://www.piercetransit.org/documents/)

This section describes how the Triangle Interchange Project is consistent with those documents.

5.2 PSRC *Transportation 2040*

5.2.1 Plan Summary

Transportation 2040 is an action plan for transportation in the central Puget Sound region for the next 30 years. *Transportation 2040* identifies investments to support our expected growth and improve the service transportation provides to people and businesses. It lays out a financing plan that suggests a long-term shift in how we fund transportation improvements, with more reliance on users paying for transportation improvements. *Transportation 2040* also proposes a strategy for reducing transportation's contribution to climate change and its impact on important regional concerns such as air pollution and the health of Puget Sound.

5.2.2 Project Consistency

The Triangle Interchange Project has been adopted and identified in *Transportation 2040*. Specifically, Phase 2 improvements are listed as project #5535.

5.3 State of Washington Transportation Plan

5.3.1 Plan Summary

The WTP is the state's blueprint for implementation programs and budget development to be pursued in future years. The 2007-2026 WTP contains an overview of the current conditions facing the statewide transportation system, an assessment of the state's transportation investment needs for the next 20 years, and a statewide

policy for transportation. The Washington State Transportation Commission (WSTC) developed an update of the plan dated January 2015 (https://wtp2035.files.wordpress.com/2015/01/ wtp2035_final_21-jan-2015.pdf).

The Washington State Highway System Plan (HSP) is the element of the WTP that addresses the state's highway system. The HSP includes a comprehensive assessment of existing and projected 20-year deficiencies on the state's highway system. It also lists potential solutions that address these deficiencies. The WTP also fulfills the requirements of state and federal law.

The WTP is the result of a WSTC and WSDOT collaborative effort to create a statewide policy and an inventory of potential investments to sustain a desirable transportation future in our state. The plan is designed to identify the top transportation investment priorities for the entire state in the areas of (1) preservation, (2) safety, (3) economic vitality, (4) mobility, (5) environmental, and (6) stewardship.

5.3.2 Project Consistency

WSDOT has not publically released an updated HSP project list since its original 2007 publish date. At that time, this project was included in PSRC's submittal to the WSTC in late 2010.

5.4 Connecting Washington Transportation Revenue Package

5.4.1 Summary

The Washington State legislature passed a transportation package in the summer of 2015 that would generate $16 billion for multimodal transportation projects across the state over 16 years (2015 through 2031).

5.4.2 Project Consistency

The I-5 Triangle Interchange Project is identified in the Connecting Washington Transportation Revenue Package as project ID T20400R with $85 million programmed from 2021 through 2027.

5.5 City of Federal Way Comprehensive Plan Transportation Plan

5.5.1 Plan Summary

The City of Federal Way Comprehensive Plan Transportation Plan, updated in 2015, includes several important goals for the city's transportation network. To achieve City and regional goals, the City emphasizes providing integrated and balanced mobility opportunities for all modes. The goals include:

- Goal 1: Maintain mobility through a safe, balanced, and integrated transportation system.
- Goal 2: Be fiscally and environmentally sustainable
- Goal 3: Enhance community health, livability, and transportation by providing a connected system of pedestrian, bicycle, and transit ways that are integrated into a coordinated regional network.
- Goal 4: Support the City's land use vision and plan.
- Goal 5: Develop and implement transportation systems management strategies and programs that contribute to the overall effectiveness of the multimodal transportation system.
- Goal 6: Be an active partner by coordinating with a broad range of groups to help meet Federal Way's transportation goals.

5.5.2 Project Consistency

The City of Federal Way's transportation plan is consistent with the Triangle Interchange Project and identifies this project as a State action that the City supports. In addition, the City's transportation plan is in compliance with WSDOT's direction and vision. The transportation plan for Federal Way relies on WSDOT in the following action areas:

- HOV system completion on I-5 and other freeways.
- Implementation of the HSP. This plan identifies, in priority order, the need for WSDOT maintenance, preservation, safety, economic initiatives, environmental retrofit, and mobility (capacity) improvements. Projects include:
  - HOV access improvements, primarily at I-5 medians
  - Interchange improvements for I-5 from SR 18 to SR 161
  - SR 509 Completion from Burien along the western and southern sections of SeaTac Airport south to I-5
  - The SR 509 extension north from the Port of Tacoma to the new SR 167 connection on I-5 at Fife
- SR 18 improvements east of SR 99.

In addition, the SR 161/356th intersection is identified in the City's 2016 to 2040 Capital Improvement Plan (CIP) as an improvement project (#92-18b) consistent with this Proposal.

5.6 City of Milton Transportation Plan

5.6.1 Plan Summary

The City of Milton is outside the project's study area but through a review of their transportation plan in the 2015 Comprehensive Plan Update their goals would be consistent with the purpose and need for the Triangle Interchange Project. These include:

- The City shall ensure that transportation facilities and services, needed to support development, are available concurrently with the impacts of such development in order to protect investments in existing transportation facilities and services, maximize the use of the facilities and services, and promote orderly compact growth.
- Coordinate with regional transportation entities to ensure maximum connectivity between regional transportation systems and the City of Milton.
- Maintain an environmentally sustainable transportation system that preserves sensitive habitat, protects natural resources and meets air quality requirements.

5.6.2 Project Consistency

The City of Milton Transportation Element of the Comprehensive Plan does not specifically mention the Triangle Interchange Project, but the City has incorporated PSRC land use targets and worked with WSDOT, Sound Transit, Pierce County, King County, and adjacent cities to plan for future regional improvements to the transportation system. The relevant projects include:

- SR 167 Completion
- Meridian Avenue E (SR 161) Widening
- Interstate 5 HOV Lanes

5.7 Sound Transit Long-Range Plan

5.7.1 Plan Summary

On November 4, 2008, voters of the Central Puget Sound region approved the Sound Transit 2 (ST2) ballot measure. The plan adds regional express bus and commuter rail service while building 36 additional miles of Link light rail to form a 55-mile regional system

The ST2 Plan builds on the Link light rail lines and the region's investment in Sounder commuter rail and Sound Transit Express bus service. ST2 proposes a future where light rail train extends to the Overlake Transit Center

area of Redmond, the University of Washington, Lynnwood, and to the Redondo/Star Lake area near Federal Way.

A Sound Transit 3 (ST3) plan is currently being prepared by Sound Transit. At this time candidate projects have only been developed and the plan has yet to be adopted by the Sound Transit Board. As part of this plan, there could be high capacity transit (HCT) studies from Federal Way to Tacoma, but the mode and alignment would not be determined until those studies are completed and a decision made by the Sound Transit Board.

5.7.2 Project Consistency

The ST2 Plan only adopted HCT to the Redondo/Star Lake area near Federal Way. Therefore, the Triangle Interchange Project would not conflict with the ST2 plan. HCT is being considered as a candidate project as part of the update to ST long range plan (ST3) but that would not be approved until late 2016. Furthermore, any alignment and station options would be considered in a separate planning study that has not be identified by Sound Transit at this time.

5.8 Pierce County Transit Development Plan

5.8.1 Plan Summary

The 2015 to 2020 Pierce County Transit Development Plan contains goals that would be consistent with the purpose and need for the Triangle Interchange Project. These include:

- Pierce Transit will continue and expand a growing number of cooperative projects involving local communities, Pierce County, King County Metro Transit, Sound Transit, and WSDOT.
- Pierce Transit will continue to work with local jurisdictions to implement transit-supportive improvements to the built environment wherever practicable.
- Pierce Transit will continue its strong partnerships with other transit agencies, municipalities, and the PSRC MPO to address transportation demand issues, both locally and throughout the region, to promote active transportation and transit usage as viable alternatives to the automobile.

5.8.2 Project Consistency

Pierce Transit connects with other public transit providers, including King County Metro. Pierce Transit route 402, which runs along SR 161 within the study area, makes connections with King County Metro services at the Federal Way Transit Center. The Triangle Interchange Project would support this plan by helping to reduce congestion and lower travel time for all modes along SR 161, including bus transit.

Policy Point 6 – Future Interchanges

Is the proposed access point revision compatible with a comprehensive network plan? Is the proposal compatible with other known new access points and known revisions to existing points?

6.1 Introduction

Phase 2 of the Triangle Interchange Project proposes to continue completing the interchange improvements approved in 2008. The state routes within this IJR Amendment's project area include:

- I-5 southbound: From just south of the S 320th Street southbound on-ramp to 1 mile south of the SR 18 westbound to I-5 southbound flyover ramp merge point (approximately 3 miles of I-5); I-5 northbound is not included in this study area because there are no proposed changes in Phase 2.
- SR 18 westbound: East of the I-5 northbound loop off-ramp with SR 18 westbound to SR 99.
- SR 18 eastbound: From SR 99 to the eastbound off-ramp to Weyerhaeuser Way S.
- SR 161: All signalized intersections and major driveways between S 348th Street and Milton Road S, including the intersection of 16th Avenue S/S 356th Street.

Within the project's study area, there are currently no new interchanges or modifications programmed by either the state, regional or local jurisdictions with the exception of completing the remaining phases of this project.

Even though there are no programmed improvements in the study area, the following plans and projects have been reviewed and incorporated into the project analysis, where appropriate, because they could influence travel patterns on I-5, SR 18, and SR 161:

- WSDOT Tacoma/Pierce County (TPC) HOV Program
- WSDOT Puget Sound Gateway Program, which includes the SR 509 Corridor Completion and SR 167 Completion projects.

6.2 Tacoma/Pierce County HOV Program

The TPC HOV Program is a series of projects that build HOV lanes on I-5, SR 16, and SR 167 in Pierce County. Through 2020, six funded projects are being designed and constructed in Tacoma from the Nalley Valley to the King County line. This program extends north to the King/Pierce county line, which is just under 2 miles south of the Triangle Interchange Project study area. The project would connect with the HOV lanes in King County to complete the HOV system between Tacoma and Seattle.

6.3 Puget Sound Gateway Program

The Puget Sound Gateway Program was developed by WSDOT to integrate the project development of two corridor completion projects, the SR 509 Corridor Completion and SR 167 Completion, which would relieve congestion and improve mobility between Tacoma and Seattle. While both projects are outside of this project's study area, the Puget Sound Gateway Program would affect travel patterns within the study area; therefore, this project was incorporated into the travel demand forecasting. The details of each project are included in the following sub sections.

6.3.1 SR 509 Corridor Completion Project

This project was previously known as the I-5/SR 509 Congestion and Freight Relief Project prior to being incorporated into the Puget Sound Gateway Program. An Environmental Impact Statement (EIS) and Record of Decision (ROD) were issued for the project in 2003, and the Connecting Washington Transportation Revenue Package includes funding for the first phase of the project. However, WSDOT is currently conducting a practical

design review process and re-evaluation of previously completed environmental documentation. The project elements assumed for this study in the 2040 Design Year are consistent with the SR 509 EIS 2003 ROD and the PSRC Transportation 2040 plan. This is consistent with the assumptions in the original 2008 Triangle Interchange Project IJR and would provide a conservative estimate of traffic demand in the Triangle IJR Amendment study area as it provides the full buildout to the SR 509 and I-5 systems. Project elements assumed for this study include:

- Complete the missing section of SR 509 by building two GP lanes and one HOV lane in each direction between South 188th Street and I-5
- Complete the interchange at South 188th Street and SR 509
- Replace the interchange at SR 516 to include new I-5 collector-distributor lanes between SR 509 and SR 516
- Add six miles of new lanes on I-5 from SeaTac to S 320th Street Interchange
- Construct new interchanges:
    - SR 509 and I-5
    - To/from the east at 28th and 24th avenues south
    - To South 231st Way and the Kent Valley

6.3.2 SR 167 Completion Project

This project was previously known as the SR 167 Tacoma to Edgewood New Freeway Construction project. A Tier II EIS was completed in 2006 and the Connecting Washington Transportation Revenue Package includes funding to build the initial phase of the SR 167 Completion Project. The project elements assumed for this study in the 2040 Design Year are consistent with the full buildout of the project described in the PSRC Transportation 2040 plan. This is consistent with the assumptions of the original 2008 Triangle Interchange Project IJR and would provide a conservative estimate of traffic demand in the Triangle IJR Amendment study area. Project elements assumed for this study include:

- Complete the missing section of SR 167 by building two GP lanes and one HOV lane in each direction between SR 509 (Port of Tacoma) to the Meridian Interchange (SR 161) in Puyallup
- Complete the interchange at SR 161
- Construct new interchanges:
    - at SR 509 (Port of Tacoma)
    - at 54th Avenue East
    - at I-5
    - at Valley Avenue East (to and from west)
    - at Freeman Road East (to and from east)

6.4 Other Projects

Other possible improvements on either I-5 or SR 18 are not located near the study area and as a result, they have not been included in the Proposal's analysis.

Policy Point 7 – Coordination

Are all coordinating projects and actions programmed and funded?

7.1 Introduction

Regional highway and local projects that are within the Triangle Project IJR Amendment study area were given consideration and coordination because they could influence the project's design, schedule, and performance. Ongoing and close coordination between the City of Federal Way and WSDOT (including presentations to the City of Federal Way Council as well as Project public open houses) have helped to integrate the planning and design of the Proposal with other relevant project schedules.

This policy point discusses projects within the Proposal's study area that have been considered, coordinated, and included in the Proposal's analysis and design. These projects are described in the following subsections.

7.2 Project Coordination

All reasonably foreseeable and funded projects in the study area that are documented in relevant local and state plans were included in the future No Build and Build conditions and are listed in Table 7-1. These projects came from the following sources:

- PSRC's Transportation 2040
- Washington Transportation Plan (WTP) and Washington Highway System Plan (HSP)
- Connecting Washington Transportation Revenue Package
- City of Federal Way 2016-2021 Transportation Improvement Plan (TIP)
- City of Milton Comprehensive Plan Transportation Element
- Sound Transit Long Range Plan
- Pierce County Transit Development Plan

The Tacoma Pierce County (TPC) HOV Program, Puget Sound Gateway Program, Sound Transit 2 Plan, and City of Federal Way TIP are likely to have the most relevant impacts on the project analysis and are, therefore, described in more detail in the following subsections.

7.2.1 Tacoma/Pierce County HOV Program

While the TPC HOV Program and any of its associated highway improvements would occur outside of this project's study area, the project could affect travel patterns within the study area. The TPC HOV was included in the travel demand forecast modeling for this project. The TPC HOV Program is a series of projects that build HOV lanes on I-5, SR 16 and SR 167 in Pierce County. Through 2020, six funded projects are being designed and constructed in Tacoma from the Nalley Valley to the King County line. This program extends north to the King/Pierce County Line, which is just under 2 miles south of the Triangle Project study area. The project would connect with the HOV lanes in King County to complete the I-5 HOV system between Tacoma and Seattle.

7.2.2 Puget Sound Gateway Program

The Puget Sound Gateway Program is comprised of two unique projects, the SR 509 Corridor Completion project and the SR 167 Completion project, which together make major improvements to complete the long-planned corridor connections to I-5. Both projects were included as background projects in the original Triangle Interchange Project IJR. Although both projects of the Puget Sound Gateway Program are outside of the Triangle IJR Amendment study area, this program would affect travel patterns within the study area.
The SR 509 Completion project completed environmental documentation in 2003, while the SR 167 Completion project completed environmental documentation in 2006. The Connecting Washington Transportation Package allocated the Puget Sound Gateway Program a total of $1.875 Billion (Project ID M00600R) between the years

2015 and 2031 to build the initial phases for both projects. However, WSDOT is currently conducting a practical design review process and re-evaluation of previously completed environmental documentation for SR 509.

This IJR Amendment assumed in year 2040, Puget Sound Gateway project elements consistent with the full buildouts of both projects as described in the PSRC Transportation 2040 plan. This is consistent with the assumptions in the original 2008 Triangle Interchange Project IJR and would provide a conservative estimate of traffic demand in the Triangle IJR Amendment study area as it provides the full buildout to the SR 509, SR 167 and I-5 systems.

7.2.3 Sound Transit 2 Long Range Plan

The Sound Transit (ST) 2 Long Range Plan includes adding regional express bus and commuter rail service while building 36 additional miles of light rail to form a 55-mile regional system. The ST2 Plan currently funds the construction of light rail service to the Redondo/Star Lake area near Federal Way.

A Sound Transit 3 plan is currently being prepared by Sound Transit. At this time candidate projects have only been developed and the plan has yet to be adopted by the Sound Transit Board. As part of this plan, there could be high capacity transit (HCT) studies from Federal Way to Tacoma, but the mode and alignment would not be determined until those studies are completed and a decision made by the Sound Transit Board. Therefore, light rail service beyond the Redondo/Star Lake area near Federal Way was not included in the project's background assumptions.

7.2.4 City of Federal Way TIP and CIP

The City of Federal Way 2016-2021 TIP includes several projects that would affect the travel patterns within the Triangle IJR Amendment study area. These projects are funded and would be in place by the year 2020. Specifically, the projects that would have the most effect on travel patterns and congestion within the study area in the 2020 Year of Opening include:

- S 352nd Street Extension – Provide a new 3-lane east-west road segment from SR 99 to SR 161
- 16th Avenue S: S 344th Street to S 348th Street - Adds a 3rd southbound auxiliary lane to the congested SR 161/S 348th Street intersection
- SR 99 HOV Lanes Stage 5: S 340th Street to S 356th Street – Provides northbound and southbound HOV lanes on SR 99
- S 356th Street: SR 99 to SR 161 – Widen to a 5-lane section

The City of Federal Way 2016-2040 CIP includes one local project that would affect travel patterns in the study area which is the 18th Avenue S Extension between S 352nd Street and S 356th Street. This project would provide an additional access between SR 161 and the commercial and retail development properties along the eastside of SR 161. This road extension would also provide another route from the proposed I-5 southbound off-ramp to SR 161. This project was considered reasonable and foreseeable to be completed by the 2040 Design Year.

7.3 Background Project List

Table 7-1 includes all projects that are currently listed in the Financially Constrained portion of PSRC's *Transportation 2040* in the vicinity of I-5, SR 18, and SR 161. It also lists any local improvements included in the current TIPs for the cities of Federal Way and Milton. These projects were included, where appropriate, in the project analysis for the years indicated.

Table 7-1. Future No Build (Baseline) Projects

#	Project	Description	Source	2020	2040
1	City Center Access Phase 2	Add HOV lanes on S 320th St, realign ramps in SE quadrant	Federal Way TIP	✓	✓
2	10th Ave SW/SW Campus Dr	Add SB right-turn lane	Federal Way TIP	✓	✓
3	SW 344th St (12th Ave SW to 21st Ave SW)	Extend 3 lane principal collector	Federal Way TIP	✓	✓
4	SR 99/S 312th St	Add 2nd left-turn lane NB	Federal Way TIP	✓	✓
5	S 304th St/28th Ave S	Add NB right-turn lane, signal	Federal Way TIP	✓	✓
6	S 352nd St (SR 99 to SR 161)	Extend 3 lane principal collector	Federal Way TIP	✓	✓
7	SW 320th St/21st Ave SW	Add 2nd WB left-turn lane, Interconnect to 26th Ave SW	Federal Way TIP	✓	✓
8	S 312th St/28th Ave S	Add SB right-turn lane	Federal Way TIP	✓	✓
9	SW 336th Wy/SW 340th St (26th Pl SW to Hoyt Rd SW)	Widen to 5 lanes, add signal at 26th Pl SW	Federal Way TIP	✓	✓
10	S 356th St (SR 99 to SR 161)	Widen to 5 lanes	Federal Way TIP	✓	✓
11	S 320th St/1 Ave South	Add EBL, WBL, WBR, NBT, SBR; widen to 5 lanes N to S 316th St	Federal Way TIP	✓	✓
12	SR 99 HOV Lane Phase 5: S 340th St to S 356th St	Add HOV Lanes on SR 99, turn lanes at S 348th St	Federal Way TIP	✓	✓
13	16th Ave S: S 344th St – S 348th St	Add SB auxiliary lane	Federal Way TIP	✓	✓
14	Tacoma/Pierce County HOV Program	Extend HOV lanes on I-5 from King/Pierce County Line to SR 16 and associated interchange improvements.	WSDOT	✓	✓
15	New 18th Ave S: S 352nd St - S 356th St	New north-south road connection between S 352nd St and S 356th St that connects to new I-5 SB off-ramp at S 356th St	Federal Way CIP		✓
16	SR 167 Completion Phase 1 - SR 509 to I-5	One lane each direction from existing SR167 terminus at Meridian interchange in Puyallup to I-5, and a single lane each direction continues to connection at SR 509 in Tacoma. Full interchanges at N Meridian and Valley Avenue in Puyallup and freeway-to-freeway interchange connections with I-5.	WSDOT		✓
17	SR 167 Completion Phases 2 and 3 - SR 509 to SR 161	Widen SR 167 Extension Project, complete 2 GP lanes each direction from SR 509 (Port of Tacoma) to the Meridian Interchange (SR 161) in Puyallup. Phase 3 will add HOV lanes each direction between I-5 and Meridian Interchange.	WSDOT		✓
18	SR 167 HOV lane completion - SR 410 to 15th St SW	Extend HOV/HOT Lanes from current termini to SR 410 in Sumner.	WSDOT		✓
19	SR 509 Corridor Completion	Completes SR 509 as 6-lane freeway (including HOV lanes) from S. 188th St.to I-5 in SeaTac. Adds six miles of new lanes on I-5 from SeaTac to S 320th. Improve I-5/SR 516 interchange and add a new interchange between I-5 and S. 228th St. Add a new interchange on SR 509 that will connect with	WSDOT		✓

Table 7-1. Future No Build (Baseline) Projects

#	Project	Description	Source	2020	2040
		a new South Access roadway serving Sea-Tac International Airport.			
20	Federal Way Link Extension	Extend Link light rail from S 200th St to Kent-Des Moines area.	Sound Transit		✓
21	I-5 HOV lane designation	Modify the lane designation to only allow vehicles with 3 or more people.	WSDOT		✓

Policy Point 8 – Environmental Processes

What is the status of the proposal's environmental processes?

A NEPA DCE was issued in August 2007 and a SEPA DNS was issued in May 2007 for the full buildout (all project phases) Triangle Interchange Project. All of the environmental impacts were previously permitted and disclosed in the NEPA document issued in 2007.These environmental approvals were for all the phases of the project.

Specific to the Phase 2 elements, the design modifications proposed with the current Phase 2 design are related to changes in the impact to the stream and wetland buffer areas. The total net impacts with the current Phase 2 are expected to be similar to the previous Phase 2, with less permanent impacts and more temporary impacts in the buffer areas. Due to modifications in the current Phase 2 design, permanent and temporary wetland impacts in the area of the SR 18 ramps and the auxiliary lane were reduced or eliminated. In both the previous and current Phase 2 elements there are no direct wetland or stream impacts.

Due to the current project staging, access from I-5 to construct the proposed I-5 Southbound C-D Ramp to S 356th Street/SR 161 is not feasible, therefore temporary construction impacts are expected to increase along the west side of the proposed C-D ramp. Temporary construction impacts associated with building the C-D ramp are for a short (approximately 400') segment and within the stream and stream buffer area. Permanent impacts are associated with the I-5 southbound off-ramp approach to S 356th Street entering into the tear-drop roundabout ramp terminal as this crosses through a stream buffer area.

As the design progresses, the permitted impacts and mitigation strategy will be reevaluated to see if the original permits are still applicable. WSDOT will engage with the appropriate environmental agencies for concurrence and may need to apply for a new permit. If necessary, WSDOT expects the permit application to be submitted closer to project implementation.

Appendix A
Conceptual Design Drawings of Proposed Phase 2 Improvements

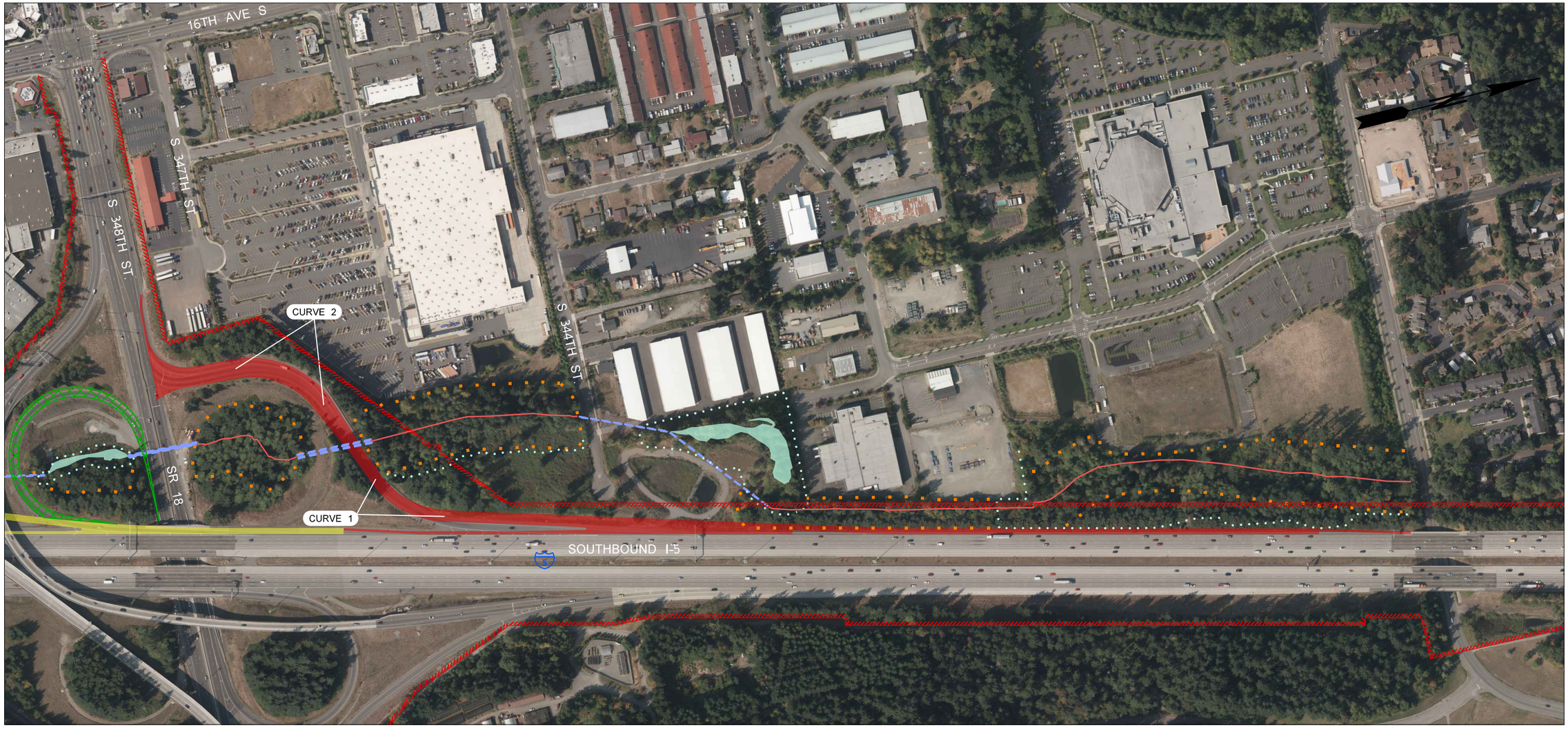
Triangle Interchange IJR Amendment
Exhibit A-1
Proposed Phase 2 Improvements
Channelization - S 336th Street to S 348th Street

Triangle Interchange IJR Amendment

Exhibit A-2

Proposed Phase 2 Improvements

Channelization - S 348th Street to S 359th Street



LEGEND

- I-5 SOUTHBOUND OFF-RAMP TO S. 348TH STREET / SR 18
- REMOVAL OF OFF-RAMP (SOUTHBOUND I-5 TO EASTBOUND SR 18)
- WETLAND BOUNDARY
- STREAM
- DRAINAGE CULVERT
- WETLAND BUFFER
- STREAM BUFFER
- PROPOSED LIMITED ACCESS

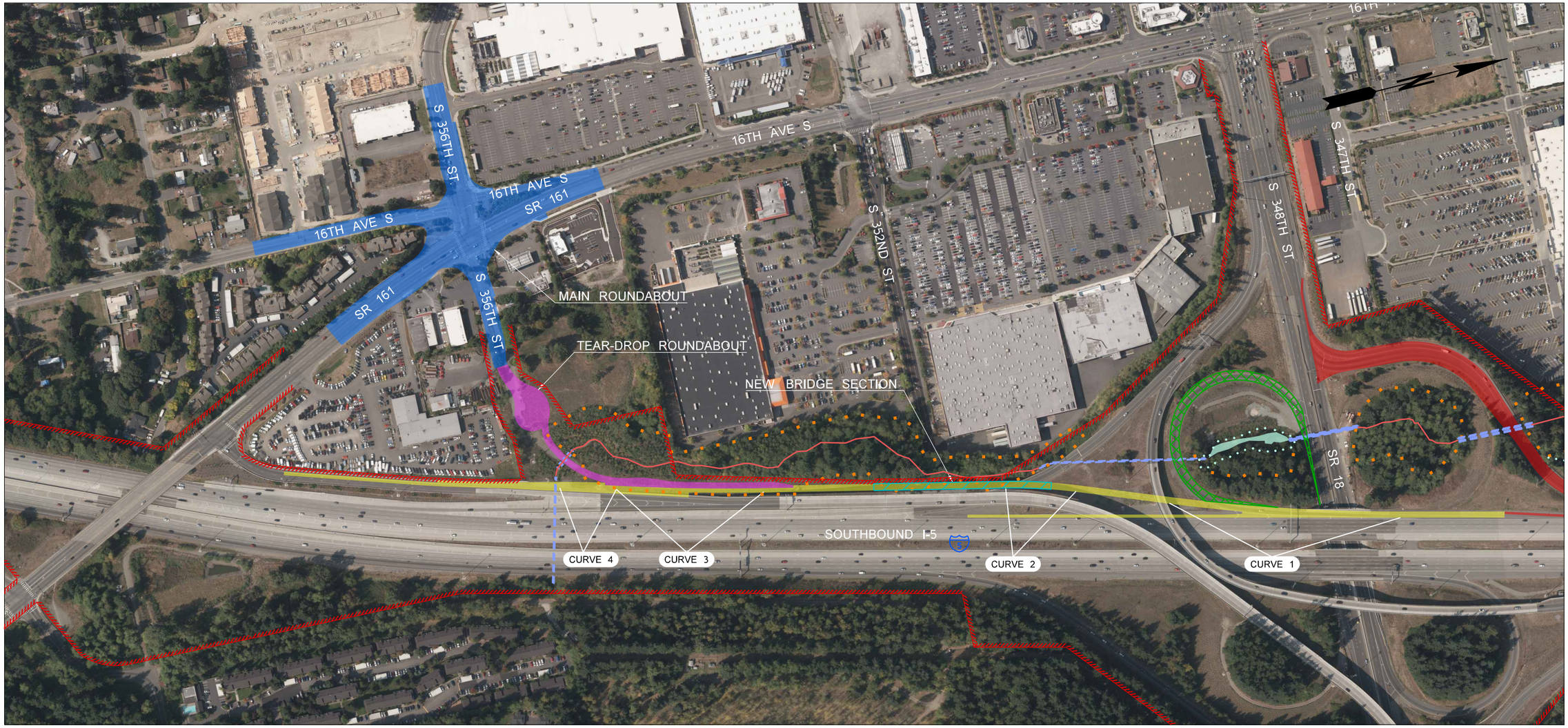
0 200 400
SCALE IN FEET

CITY OF FEDERAL WAY

I-5 - SR 161/SR 18 INTERCHANGE IMPROVEMENTS

Washington State Department of Transportation

Exhibit A-3
Proposed Phase 2 Design
S 336th Street to S 348th Street



LEGEND

- I-5 SOUTHBOUND COLLECTOR-DISTRIBUTOR TO SR 161
- NEW BRIDGE SECTION
- I-5 SOUTHBOUND OFF-RAMP TO S. 356TH STREET / SR 161
- S. 356TH STREET ROUNDABOUT
- REMOVAL OF OFF-RAMP (SOUTHBOUND I-5 TO EASTBOUND SR 18)
- WETLAND BOUNDARY
- STREAM
- DRAINAGE CULVERT
- WETLAND BUFFER
- STREAM BUFFER
- PROPOSED LIMITED ACCESS

0 200 400
SCALE IN FEET

CITY OF FEDERAL WAY

I-5 - SR 161/SR 18 INTERCHANGE IMPROVEMENTS

Washington State Department of Transportation

Exhibit A-4
Proposed Phase 2 Improvements
S 348th Street to S 360th Street

Appendix B
IJR Amendment Methods and Assumptions Document

I-5 - SR 161/SR 18 (Triangle) Interchange IJR Amendment

DRAFT Interchange Justification Report Methods and Assumptions Document

Prepared By: CH2M

September 2015

Stakeholder Acceptance

The undersigned parties, including all members of the support team from WSDOT, FHWA and the Local Agencies, concur with the Interchange Justification Report Amendment - Methods and Assumptions Document for the I-5 – SR 161/SR 18 (Triangle) Interchange Improvements Project as presented in this document.

WSDOT – HQ Access – Barb De Ste. Croix

Barb DeSte Croix
Signature

Dev Svcs & Access Mgr
Title

Sept 17, 2015
Date

WSDOT – HQ Design - Greg Lippincott

Signature

Asst State Design Engr
Title

9/16/15
Date

WSDOT – NW Region - Cathy George

Signature

Engineering Manager
Title

9/16/15
Date

FHWA – Don Petersen

Signature

SAFETEY / GEOMETRIC DESIGN ENGR.
Title

9/18/2015
Date

WSDOT Traffic Representative - Mark Leth

Signature

ARA - Traffic Operations
Title

9/16/15
Date

(1) Participation on the Stakeholders Committee and/or signing of this document does not constitute approval of the I-5 – SR 161/SR 18 Interchange Improvements Project IJR.

(2) All members of the Stakeholder Committee will accept this document as a guide and reference as the study progresses through the various stages of project development. If there are any agreed upon changes to the methods or assumptions in this document a revision will be created, endorsed and signed by all the stakeholders.

(3) At the time this methods and Assumptions document was signed, the latest and controlling version of the WSDOT Design Manual Chapter 550 was dated July 2014.

1.0 Introduction

1.1 *Project Description and Background*

The I-5 - SR 161/SR 18 (Triangle) interchange project is a regional priority designed to reduce congestion, improve safety, and increase freight mobility in the south King County area. In 2008, an IJR was completed for the project. As part of the IJR, several interchange improvements and configurations were analyzed in an effort to improve safety and mobility in the triangle area formed by I-5, SR 161 (also known as Enchanted Parkway), and SR 18. The IJR identified a preferred alternative that is being constructed in multiple stages. Phase 1 of the Triangle Interchange Project was completed in July of 2012 and included the following improvements:

- A new collector-distributor (C-D) roadway for SR 18 westbound to I-5 northbound and southbound between Weyerhaeuser Way and I-5
- A new two-lane flyover ramp for SR 18 westbound to I-5 southbound (eliminated northwest loop ramp at the interchange)
- A new direct access flyover ramp for eastbound SR 18/S 348th Street to I-5 northbound (eliminated southeast loop ramp at the interchange)
- A direct access for SR 18 westbound to SR 161 via a new ramp
- Added ramp meters to the I-5 northbound on-ramps from SR 18 eastbound and westbound and the I-5 southbound on-ramp from SR 18 eastbound

Elements of the previously approved Phase 2 design from the original IJR are described below and illustrated in Exhibit 1:

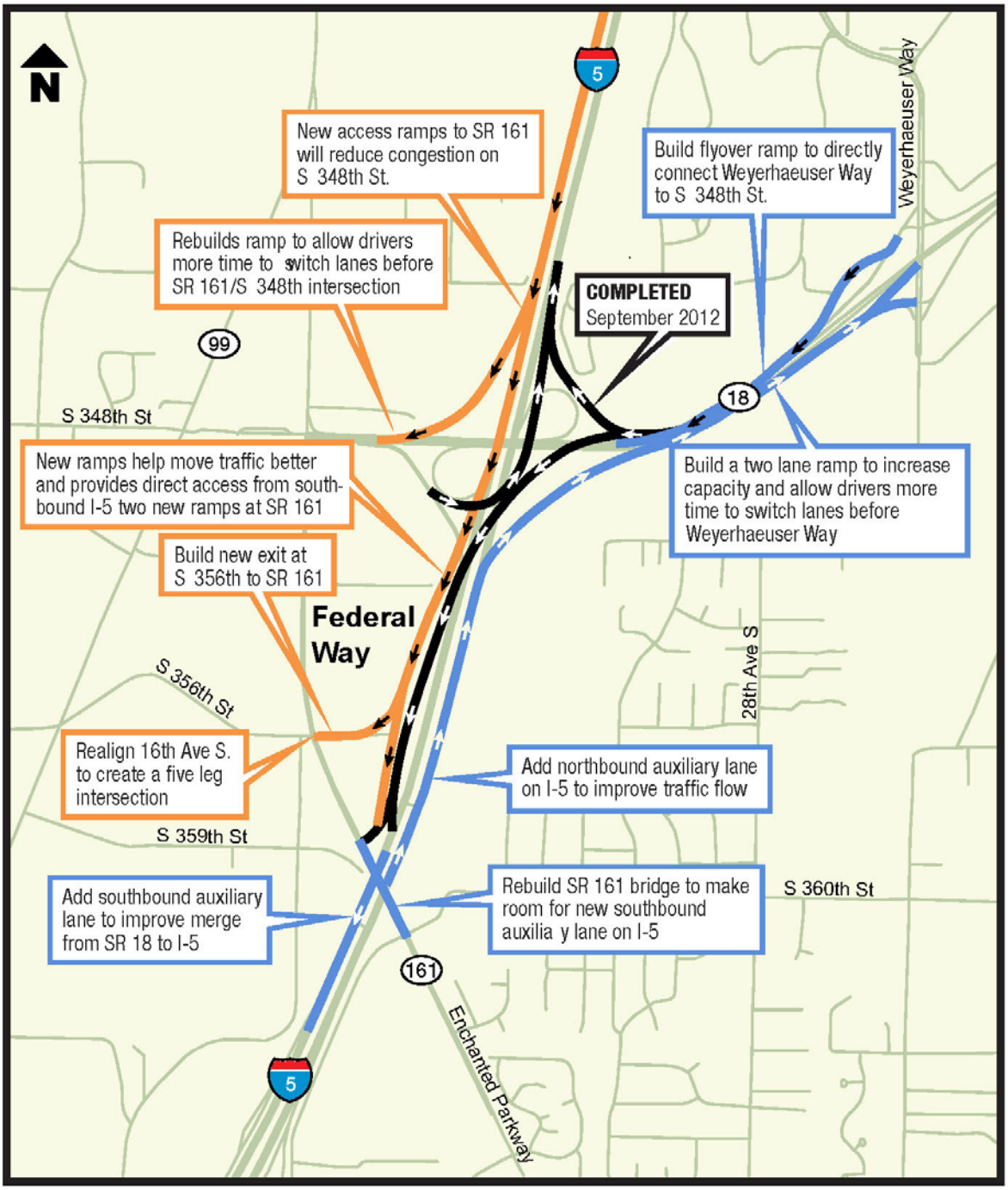
- Provide a new two-lane off-ramp for I-5 southbound that connects to a C-D roadway that provides access to SR 18 eastbound and westbound and SR 161
- Realign the off-ramps from I-5 southbound to SR 18 westbound and eastbound to connect to the new C-D roadway
- A new access from the C-D roadway to SR 161 via S 356th Street and the SR 18 westbound off-ramp to SR 161
- Provide a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street that realigns 16th Avenue S to create a five-leg signalized intersection.

The current Phase 2 design elements are described below and shown in Exhibit 2:

- Provide a new two-lane off-ramp for I-5 southbound to SR 18 eastbound and westbound and extend the off-ramp further north on I-5
- Eliminate the I-5 southbound off-ramp to SR 18 eastbound (southwest loop ramp at the interchange). Southbound left and right turn movements will be accommodated by the new two-lane southbound off-ramp.
- Provide a new single-lane off-ramp from I-5 southbound to SR 161 that provides access to both S 356th Street and the SR 18 westbound off-ramp to SR 161
- Provide a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street and provide improvements to the intersection of S 356th Street/SR 161/16th Avenue S.

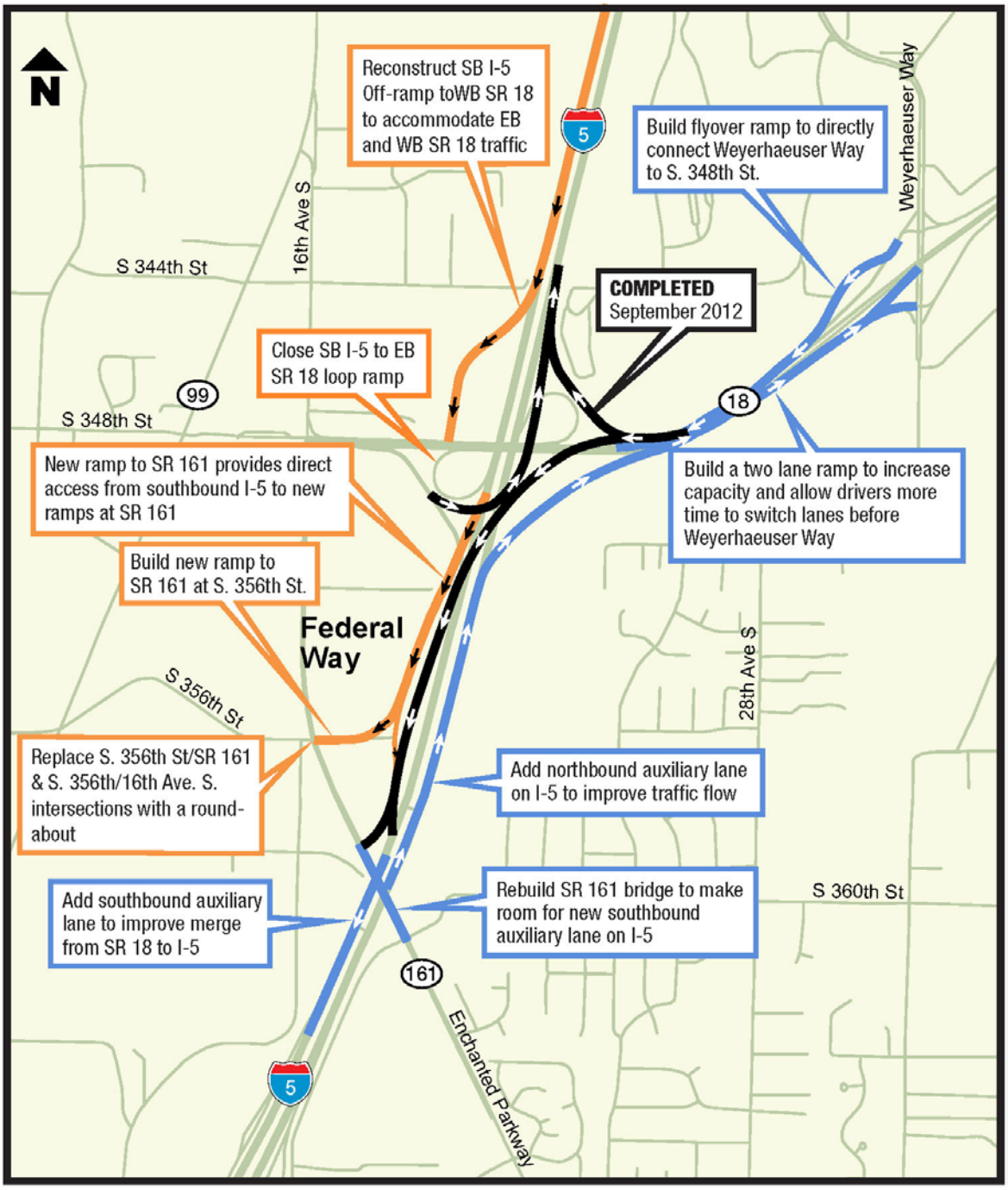
The general connections were addressed in the original I-5 - SR 161/SR 18 IJR but the specific treatments have been modified since the original IJR. Improvements beyond this Phase 2 are not included in this IJR amendment. Exhibit 3 shows the project study area.

EXHIBIT 1. I-5 - SR 161/SR 18 INTERCHANGE IMPROVEMENT PROJECT PHASES WITH PREVIOUS PHASE 2



Note: Black lines show Phase 1, orange lines show the previously approved Phase 2, and blue lines show future phases.

EXHIBIT 2. I-5 - SR 161/SR 18 INTERCHANGE IMPROVEMENT PROJECT PHASES WITH CURRENT PHASE 2



Note: Black lines show Phase 1, orange lines show the current Phase 2 design, and blue lines show future phases.

2.0 IJR Team and Approvals

The IJR team members include staff from WSDOT, the City of Federal Way, FHWA, and CH2M. The IJR will be reviewed and approved by WSDOT and FHWA. The following individuals will be responsible for signing the IJR:

- Greg Lippincott: WSDOT Headquarters Assistant State Design Engineer
- Barb De Ste. Croix: WSDOT Headquarters Development Services & Access Manager
- Mark Leth: WSDOT Northwest Region King County Traffic Engineer
- Cathy George: Northwest Region Engineering Sno-King Area
- Don Petersen: FHWA Design and Safety Engineer

3.0 Interchange Justification Report Content and Assumptions

The I-5 - SR 161/SR 18 IJR Amendment will address, in detail, Policy Points 3, 4, 7, and 8 as outlined in Chapter 550 of the WSDOT Design Manual. The IJR will also include brief statements for Policy Points 1, 2, 5, and 6. A brief preliminary description of policy points will be addressed as shown below. These will be continually refined throughout the IJR process as information and data becomes more available.

Policy Point 1 – Need For the Access Point Revision

What are the current and projected needs? Why are the existing access points and the existing or improved local system unable to meet the proposal needs? Is the anticipated demand short or long trip?

The IJR amendment does not change the basic needs of the I-5 - SR 161/SR 18 (Triangle) project. In part, it reads: "The needs of the Triangle project include improving safety, increasing capacity, meeting transportation demand, and eliminating roadway deficiencies. Triangle project improvements will improve safety and traffic circulation, in an effort to reduce congestion for freight and people in the vicinity of the interchange and local intersections." The project needs, and how the implementation of Phase 2 will complete or satisfy those needs, will be discussed.

Policy Point 2- Reasonable Alternatives

Describe the reasonable alternatives that have been evaluated.

The preferred alternative documented in the original I-5 - SR 161/SR 18 IJR is still considered the ultimate built-out but the Phase 2 elements have been modified since the original IJR was signed. The alternatives considered, as well as the preferred alternative, as part of the original Triangle IJR are still relevant and will be summarized.

Policy Point 3 – Operational and Collision Analysis

How will the proposal affect safety and traffic operations at year of opening and design year?

3.1 Study Area and Project Limits

The freeway study limits and proposed study intersections are displayed in Exhibit 3. A total of 9 intersections will be included in the study and are listed in Table 1. The IJR study area

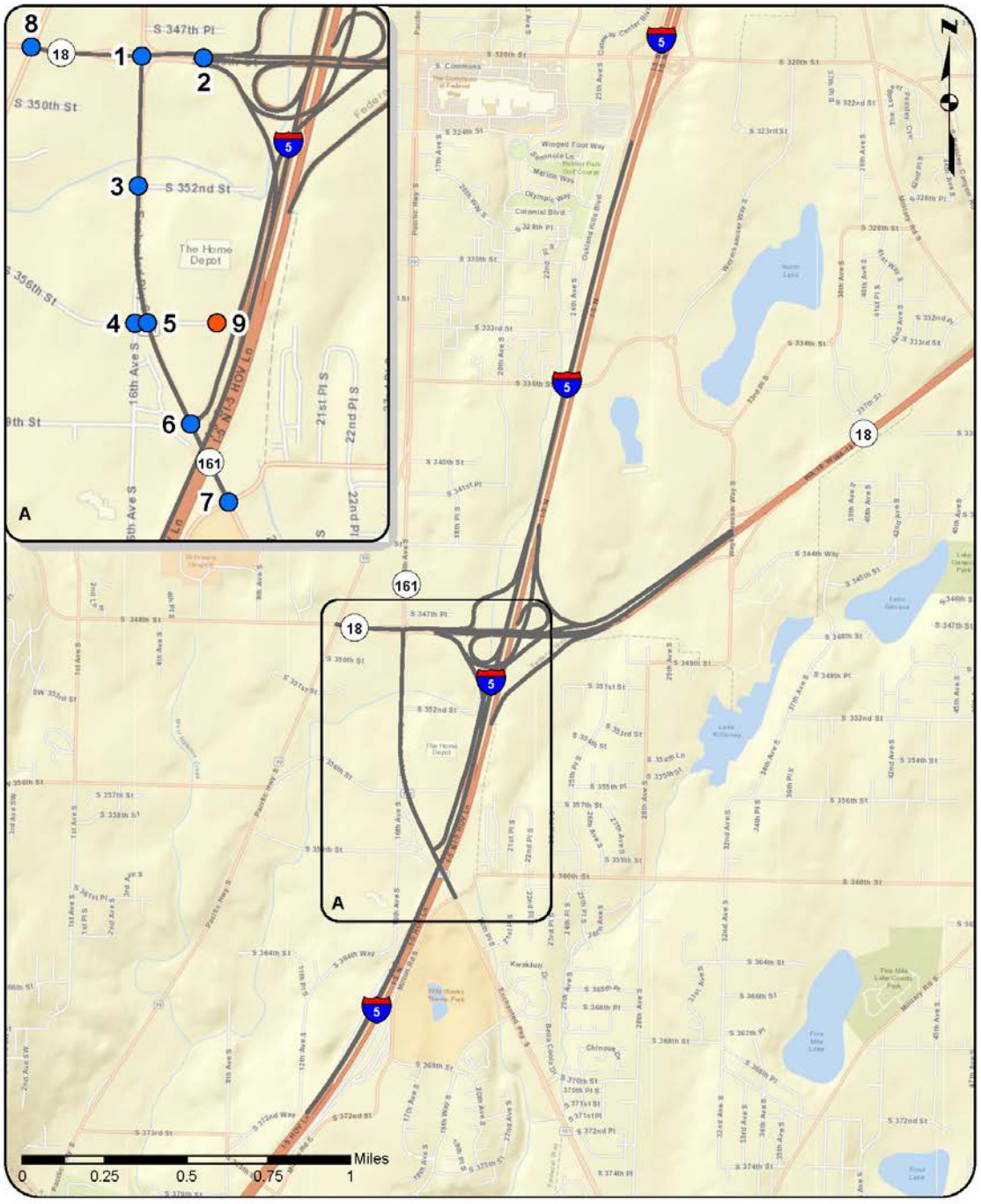
includes freeway mainline, ramps, and ramp terminal intersections along the following corridors:

I-5 southbound: from just south of the S 320th Street southbound on-ramp to 1 mile south of the SR 18 westbound to I-5 southbound flyover ramp merge point (approximately 3 miles of I-5); also includes a new ramp terminal intersection with the I-5 southbound off-ramp and S 356th Street and a proposed north-south road connection between the off-ramp and S 352nd Street in the Build alternative.

I-5 northbound: not to be included in this study as there are no proposed changes in Phase 2.

SR 18 westbound: east of the I-5 northbound loop off-ramp with SR 18 westbound to SR 99

SR 18 eastbound: SR 99 to the eastbound off-ramp to Weyerhaeuser Way



Legend

- Study Intersections
- Future Study Intersections
- Study Roads

EXHIBIT 3
Study Area and Proposed Study Intersections
Triangle IJR Update

SR 161: all signalized intersections between SR 18/S 348th Street and Milton Road S, including the intersection of 16th Avenue S/S 356th Street. Major driveways on SR 161 will also be included in the VISSIM model to account for volume differences between intersections.

S 356th Street: from the signalized intersection with 16th Avenue S to the new ramp terminal with the I-5 southbound off-ramp

TABLE 1
Triangle IJR Amendment Study Intersections

No.	Intersection	Existing Control
1	SR 161/16th Avenue S/SR 18/S 348th Street	Signalized
2	I-5 Southbound Off-ramp/SR 18	Signalized
3	SR 161/S 352nd Street	Signalized
4	16th Avenue S/S 356th Street	Signalized
5	SR 161/S 356th Street	Signalized
6	SR 18 Westbound Off-ramp/SR 161	Signalized
7	SR 161/Milton Road S	Signalized
8	SR 99 (Pacific Highway S)/SR 18/S 348th Street	Signalized
9	I-5 Southbound Off-ramp/S 356th Street/Proposed road connection to S 352nd Street	Not Applicable

3.2 Analysis Years and Periods

The IJR will analyze both AM and PM peak periods. The existing year to serve as a basis of analysis is 2015. An approximate opening year for the project has been identified as 2020. For the purposes of this IJR amendment, 2040 will be assumed as the future design year. This meets a 20-year design horizon and is consistent with PSRC's 2040 "Local Targets" land use forecasts.

3.3 Project Conditions and Alternatives

The alternatives that will be analyzed in this IJR Amendment include 2015 Existing, 2020 and 2040 No Build and Build Alternatives. The No-Build Alternative includes all funded background projects in the study area and only Phase 1 of the I-5 - SR 161/SR 18 (Triangle) Project. The Build Alternative includes all of the background projects assumed in the No Build condition plus Phase 2 of the I-5 - SR 161/SR 18 (Triangle) Project.

Analysis of the full build-out condition of the I-5 - SR 161/SR 18 (Triangle) Project will not be part of this Amendment, as this has already been analyzed in the previously approved IJR. Table 2 summarizes the analysis peaks and years.

TABLE 2
Analysis Peaks and Years

Analysis Peak Hours	2015 Existing	2020 Year of Opening		2040 Design Year	
		No Build	Build	No Build	Build
A.M. Peak	✓	✓	✓	✓	✓
P.M. Peak	✓	✓	✓	✓	✓

Note: ✓ Indicates peak hour will be analyzed.

3.3.1 Future Network Assumptions

All environmentally approved and partial/fully funded projects in the study area that are included in relevant local, regional and state plans are assumed for the No Build (baseline) and Build conditions. Depending on their planned implementation schedule, the background projects are assumed for either the year of opening (2020) and design year (2040) conditions or only the design year (2040) conditions. Projects to be included have been developed from the following sources:

- WSDOT Highway System Plan and PSRC's Transportation 2040
- Sound Transit 2 Plan
- City of Federal Way 2016-2021 Transportation Improvement Plan (TIP)
- Other local relevant agency TIP's within the study area.

Table 3 below includes all of the assumed future projects for this IJR Amendment. These projects will be included in the travel demand and traffic analysis models, where appropriate.

TABLE 3
Future No-Build (Baseline) Projects

#	Project	Description	Source	2020	2040
1	City Center Access Phase 2	Add HOV lanes on S 320th St, realign ramps in SE quadrant	Federal Way TIP	✓	✓
2	10th Ave SW @ SW Campus Dr	Add SB right-turn lane	Federal Way TIP	✓	✓
3	SW 344th St (12th Ave SW to 21st Ave SW)	Extend 3 lane principal collector	Federal Way TIP	✓	✓
4	SR 99 @ S 312th St	Add 2nd left-turn lane NB	Federal Way TIP	✓	✓
5	S 304th St @ 28th Ave S	Add NB right-turn lane, signal	Federal Way TIP	✓	✓
6	S 352nd St (SR 99 to SR 161)	Extend 3 lane principal collector	Federal Way TIP	✓	✓
7	SW 320th St @ 21st Ave SW	Add 2nd WB left-turn lane, Interconnect to 26th Ave SW	Federal Way TIP	✓	✓
8	S 312th St @ 28th Ave S	Add SB right-turn lane	Federal Way TIP	✓	✓
9	SW 336th Wy/SW 340th St (26th Pl SW to Hoyt Rd SW)	Widen to 5 lanes, add signal at 26th Pl SW	Federal Way TIP	✓	✓

TABLE 3
Future No-Build (Baseline) Projects

#	Project	Description	Source	2020	2040
10	S 356th St (SR 99 to SR 161)	Widen to 5 lanes	Federal Way TIP	✓	✓
11	S 320th St @ 1 Ave South	Add EBL, WBL, WBR, NBT, SBR; widen to 5 lanes N to S 316th St	Federal Way TIP	✓	✓
12	SR 99 HOV Lane Phase 5: S 340th St to S 356th St	Add HOV Lanes on SR 99, turn lanes at S 348th St	Federal Way TIP	✓	✓
13	16th Ave S: S 344th St – S 348th St	Add SB auxiliary lane	Federal Way TIP	✓	✓
14	New 18th Ave S: S 352nd St - S 356th St	New north-south road connection between S 352nd St and S 356th St that connects to new I-5 southbound off-ramp at S 356th St	Federal Way CIP		✓
15	SR 167 Extension Phase 1 - SR 509 to I-5	One lane in each direction from the existing SR167 terminus at the Meridian interchange in Puyallup to I-5, and a single lane in each direction would continue to a connection at SR 509 in Tacoma. Full interchanges at N Meridian and Valley Avenue in Puyallup as well as a freeway-to-freeway interchange connections with I-5.	WSDOT		✓
16	SR 167 Extension Phases 2 and 3 - SR 509 to SR 161	Widen the SR 167 Extension Project, competing 2 general purpose lanes in each direction from SR 509 (Port of Tacoma) to the Meridian Interchange (SR 161) in Puyallup. Phase 3 will add HOV lanes each direction between I-5 and the Meridian Interchange.	WSDOT		✓
17	SR 167 HOV lane completion - SR 410 to 15th St SW	Extend HOV/HOT Lanes from current termini to SR 410 in Sumner.	WSDOT		✓
18	I-5/SR 509 Congestion and Freight Relief Project	Completes SR 509 as a six-lane freeway (including HOV lanes) from S. 188th St.to I-5 in SeaTac. Adds six miles of new lanes on I-5 from S 320th in Federal Way to SeaTac. Improves the I-5/SR 516 interchange and adds a new interchange between I-5 and S. 228th St. in Kent. Adds a new interchange on SR 509 that will connect to a new South Access roadway serving Sea-Tac International Airport.	WSDOT		✓
19	Federal Way Link Extension	Extend LRT from S 200th St to Kent-Des Moines area.	Sound Transit		✓

3.4 Travel Demand Forecasting and Post Processing

Travel demand models for No-Build and Build AM and PM peak periods (assumed 3 hour volume set with 2 hours reported) will be developed for Years 2020 and 2040. The City of Federal Way's EMME Travel Demand Model will be used to develop models for this IJR Amendment. This model had traffic forecasts developed for year 2019 and 2040. The Federal Way EMME model was based off of the latest version of the PSRC EMME model and has the same model extents, land use, and road network outside of the City of Federal Way. Within the City of Federal Way area, the land use and road network have been modified based on the City of Federal Way's recent transportation plan update.

Table 4 provides a comparison of 3-hour PM period volume projections between the City of Federal Way and PSRC EMME models at key roadways within the project's study area. The overall magnitude of traffic growth is similar between the two models while the annual growth is slightly higher in the City of Federal Way EMME model on I-5 and SR 18. The growth seen from the City of Federal Way EMME model is consistent with historical trends in travel patterns, is consistent with future land use forecasts which predict that growth will occur in the area and ultimately would result in slightly higher traffic forecasts.

TABLE 4
Comparison of City of Federal Way and PSRC Forecast Models, PM Period 3-Hour Volumes

			City of Federal Way Model			PSRC Model		
Road	**Location**	**Dir.**	**2012**	**2040**	**Annual Growth Rate**	**2010**	**2040**	**Annual Growth Rate**
I-5	North of S 336th St	SB	20,630	21,320	0.1%	21,320	21,400	0.0%
I-5	South of SR 161	SB	22,360	24,240	0.3%	21,840	22,860	0.2%
SR 18	East of Weyerhaeuser Way	EB	7,230	8,350	0.5%	9,690	8,260	-0.5%
		WB	10,960	11,720	0.2%	11,670	11,350	-0.1%
		Total	18,190	20,070	0.4%	21,360	19,610	-0.3%
SR 161	South of S 348th St	NB	3,660	4,340	0.6%	2,800	3,240	0.5%
		SB	5,680	6,630	0.6%	3,970	4,670	0.5%
		Total	9,340	10,970	0.6%	6,770	7,910	0.5%

Notes: NB = northbound; SB = southbound; EB = eastbound; WB = westbound.

Minor network edits will be made to the immediate study area of the IJR, including adjustments to lane, speed and capacity based on the baseline projects listed in Table 3. To develop traffic forecasts for the project's year of opening 2020 conditions, a year of growth will be determined between the 2019 and 2040 forecasts and added to year 2019 to forecast year 2020 conditions.

Both the freeway system and the study intersections will be analyzed for the same peak hour, which will be determined on a system wide basis.

The traffic volumes will be developed based on procedures described in NCHRP 755. Volume imbalances between intersections will be addressed through manual adjustments of individual

turning movements, or through balancing at mid-block access points. Volumes will be rounded to the nearest five for each intersection movement value.

3.5 Traffic Operations Analysis

3.5.1 Existing Data Collection

The City of Federal Way has provided recent PM peak period (4:00 to 6:00 p.m.) traffic counts at most study intersections within the city's jurisdiction. Any missing intersection counts for the AM peak period (7:00 to 9:00 a.m.) and PM peak period will be collected during midweek days (Tuesday, Wednesday, and Thursday). These peak periods generally coincide with typical commute periods. No weekend data or midday volumes will be collected. In addition, any major driveways along SR 161 between the study intersections will also be counted to account for volume differences between study intersections.

WSDOT will provide I-5 and SR 18 traffic count data (SOV and HOV data) for peak and off-peak periods. Any data collected between July 2012 and July 2014 will be factored up by a 1 percent annual growth rate to represent 2015 conditions. Traffic volume data before July 2012 will not be used in the traffic analysis as construction of the Triangle Phase 1 improvements was on-going.

The City of Federal Way and WSDOT will provide existing signal timing data for study intersections.

3.5.2 Tools and Operations Parameters

For the traffic analysis portion of the IJR, Synchro (version 8 build 805, revision 881) will be used for study intersections operations analysis, SIDRA (version 6.1) for roundabouts operations, and VISSIM (version 7.00-09) for freeway mainline/ramp/study intersections operations.

Operational parameters for VISSIM analysis are detailed in Table 5, while Synchro parameters for local intersection operations are detailed in Table 6.

TABLE 5
VISSIM Parameters/Assumptions

VISSIM Parameters	Analysis Year		
	2015 Existing	**2020 Year of Opening**	**2040 Horizon Year**
VISSIM Version	7.00-09		
Time Steps/Second	10 time steps/second		
Seeding Time	Will vary based on matching queue lengths and congestion patterns observed in Existing Conditions at start of recording period	No Build and Build: Same as Existing	
Recording Time	2 hours (could be reevaluated per WSDOT VISSIM Protocol)		
# Random Seeds	11 (could be reevaluated per WSDOT VISSIM Protocol)		
Vehicle Models, Types and Classes	Vehicle Models: Car (mix of car, SUV, pickup, and van); Truck (mix of 75% single-unit and 25% tractor trailer) Vehicle Types: SOV, HOV2, HOV3+, Truck Vehicle Classes: SOV, HOV2, HOV3+, Truck		
Vehicle Acceleration & Deceleration	VISSIM default parameters		
Traffic Composition	Truck %: from existing counts, otherwise assume 3% for arterials and 10% for freeways (consistent with previous IJR) HOV %: from existing I-5 Mainline counts	Truck %: same as existing HOV %: Based on mode split from travel demand forecasts (assumes I-5 HOV lane designation is HOV2+)	Truck %: same as existing HOV %: Based on mode split from travel demand forecasts (assumes I-5 HOV lane designation is HOV3+)
Driving Behavior and Car Following	Freeway: Wiedemann 99 default values Arterial: Wiedemann 74 default values Note: Parameters that change during calibration will be documented	No Build: Same as existing, except if baseline projects are implemented that change freeway conditions, some parameters may differ from those modified as part of existing calibration. Build: If proposed changes modify geometry, calibration changes may be rolled back to default based on engineering judgment, otherwise same as existing.	
Free-Flow Speed	Based on field data, otherwise, based on posted speed limits	No Build: Same as existing Build: New ramps will be based on design speed, otherwise same as existing	
Reduced-Speed Areas	Ramps: From speed advisory signs and field data Intersection turning speeds: 11-13 mph for right turns; 13-17 mph for left turns (speeds that change during calibration will be documented)	No Build: Same as existing; Build: New ramps or intersections based on new design speed, otherwise same as existing	
Off-Ramp Lane Change Distance	Based on location of exit-signs and upstream ramps, locations may be modified as part of network calibration	No Build: Same as existing Build: New off-ramps or weaving area, based on engineering judgment, otherwise same as existing	

TABLE 5
VISSIM Parameters/Assumptions

VISSIM Parameters	**Analysis Year**		
	2015 Existing	**2020 Year of Opening**	**2040 Horizon Year**
Freeway Grades	From As-built plans and WSDOT vertical grade report, otherwise assume 0	No Build: same as existing Build: New ramps based on proposed alignment, otherwise same as existing	
Ramp Meter Rates	1-lane meter rates: 450-800 vphpl; 2-lane meter rates: 300-800 vphpl	No Build and Build: Same as existing	
Intersection signal phasing and coordination	From agency signal phasing sheets/City Synchro files, otherwise from field observation.	No Build: same as existing Build: If proposed design necessitates phasing change, use engineering judgment; will assume coordination where practical.	

TABLE 6
Synchro Intersection Operations Parameters/Assumptions

Synchro Parameters	Analysis Year		
	2015 Existing	**2020 Year of Opening**	**2040 Horizon Year**
Peak Hour Factor (PHF)	From count and for entire intersection, otherwise assume 0.92	No Build & Build: Same as existing	No Build & Build: If existing PHF is greater than 0.95, use existing; otherwise use 0.95
Conflicting Bikes and Pedestrian per Hour	From traffic count, otherwise assume 10 pedestrians/cyclists	No Build and Build: Apply area-wide growth rate from travel demand model to existing count.	
Area Type	"Other" for all areas		
Ideal Saturation Flow (for all movements)	1,900 vehicles per hour		
Lane Utilization	Based on field observations, otherwise use default software assumptions	No Build: same as existing Build: for design changes based on engineering judgment; otherwise same as existing	
Lane Width	From as-built plans, otherwise assume 12'	No Build: Based on improvement plans from background projects, otherwise same as existing. Build: Based on project plans, otherwise same as existing	
Percent Heavy Vehicles	From count, otherwise 3%	No Build and Build: same as existing	
Percent Grade	From As-Built plans and WSDOT vertical grade report, otherwise 0%	No Build and Build: same as existing	
Parking Maneuvers per hour	Assume zero		
Bus Blockages per hour	Headway data from transit agencies	No Build and Build: same as existing	
Intersection signal phasing and coordination	From agency signal phasing sheets/City Synchro files, otherwise from field observation.	No Build: based on planned improvements from background projects, otherwise same as existing Build: If proposed design necessitates phasing change, use engineering judgment; will assume coordination where practical.	
Intersection signal timing optimization limits	From agency information, otherwise from field observation.	No Build and Build: Optimize cycle lengths, splits, and offsets to account for changing demand volumes and intersection configuration (between 60 and 160 seconds)	
Minimum Green time	From agency information, otherwise based on MUTCD min pedestrian times (min of 7 seconds walk time and 3.5 feet per second for Flash-Don't-Walk [FDW] clearance). If no crosswalk: 10 seconds.	No Build and Build: same as existing	
Yellow and all-red time	From agency information, otherwise (Y) = 4 sec. and (R) = 1 sec.	No Build and Build: same as existing	
Right Turn on Red	Allow unless prohibited	No Build and Build: same as existing	

3.5.3 VISSIM Calibration

The 2015 Existing VISSIM model will be calibrated based on guidelines from the WSDOT VISSIM Protocol. The two primary measures of effectiveness (MOE's) used to calibrate the VISSIM model will be:

- Throughput volume (traffic counts vs. model throughput volumes)
- Travel time (field measured vs. model)

Throughput volume calibration will be conducted on all freeway and arterial links in the study area. The GEH statistic will be used to measure field measured volumes to model volumes to ensure the model matches field conditions well.

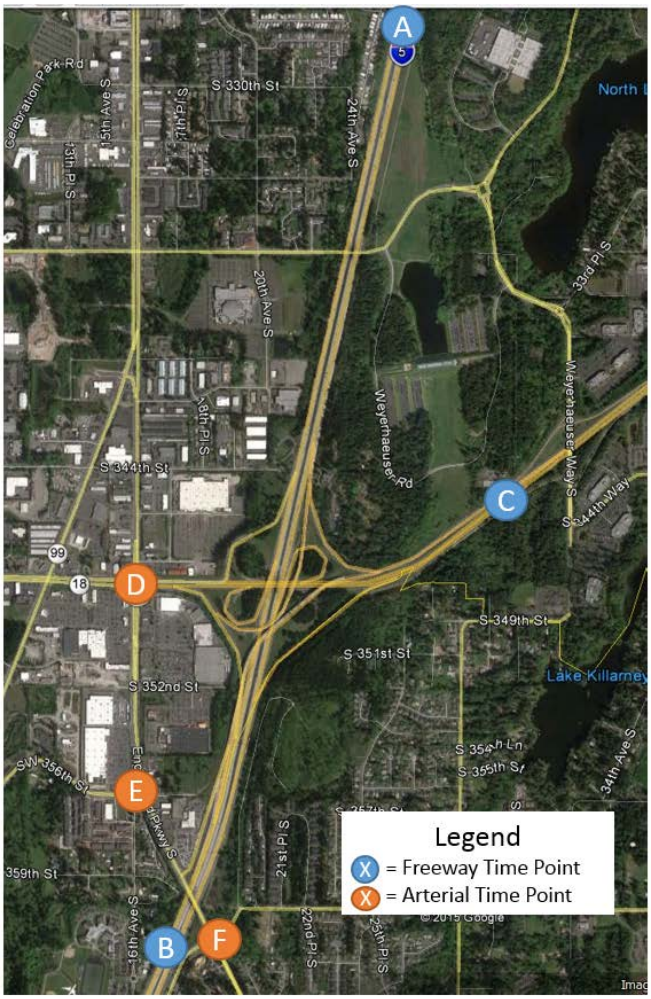
Travel times for certain key destination points in the study area will also be calibrated. The key travel time segments are shown below in Exhibit 4.

EXHIBIT 4. TRAVEL TIME SEGMENTS

Travel Time Points

- A = I-5 Southbound Mainline just south of S 320th St
- B = I-5 Southbound Mainline at SR 161 Overpass
- C = SR 18 Mainline just west of Weyerhauser Way
- D = SR 18/SR 161 intersection
- E = SR 161/S 356th St intersection
- F = SR 161/Milton Rd intersection

Travel Time Matrix		Destination				
		B	C	D	E	F
Origin	A	✓	✓	✓	✓	✓
	C			✓	✓	✓
	D	✓	✓			✓
	F			✓		



3.5.4 Traffic Analysis Measures of Effectiveness

In order to evaluate the I-5 - SR 161/SR 18 Phase 2 elements, VISSIM performance data will be collected and reported on freeway segments and arterials within the study area. The VISSIM model will include a seeding period long enough to replicate queue lengths and congestion patterns observed at the start of the recording period followed by a 2-hour recording period to capture traffic conditions from 7-9 a.m. and 4-6 p.m. The length of the seeding period for the Existing Conditions model will be held constant for all future year models. MOE's will be reported only for the highest single peak-hour within those two-hour periods. The following data will be summarized from VISSIM for the peak hour:

- Freeway and arterial volume (Throughput vs demand)
- Freeway density (and corresponding LOS)
- Freeway and arterial travel times (shown in Exhibit 3)
- Intersection and off-ramp queues

Directional temporal speed charts for I-5 southbound will be developed for the AM and PM peak 2-hour period based on 15-minute VISSIM output data.

The evaluation of intersection performance will be based on Synchro output for signalized/unsignalized intersections and will be based on SIDRA output for roundabouts. The following data will be summarized for intersections/roundabouts from the Synchro/Sidra models for the peak hour:

- LOS
- Delay
- Volume-to-capacity ratio

All results are based on latest HCM methodologies (or an equivalent) with the exception of any roundabout analysis which will be based on SIDRA's methodology. The level of service thresholds for this IJR will be as shown in Table 7.

TABLE 7
Level of Service Standards

Facility	**Level of Service Threshold**
SR 161/SR 18	LOS E/Mitigated
I-5	LOS D
Signalized Intersections (City of Federal Way)	v/c ratio of 1.2
Unsignalized Intersections (City of Federal Way)	v/c ratio of 1.0
Intersections (WSDOT)	LOS E/Mitigated

3.6 Collision Analysis

Three years of crash data between July 1, 2012 and June 30, 2015 will be collected from WSDOT. Data previous to July 1, 2012 before the construction of Phase 1 improvements were completed is not being evaluated as the configuration of I-5 and SR 18 in the Triangle Interchange area was either under construction or in a different configuration; therefore this data has limited benefit

to understanding how the existing conditions performs. Data compiled within 6 months of the completion of the Phase 1 improvements (between July 1, 2012 and January 1, 2013) will also be evaluated to ensure driver behavior patterns are similar to more recent trends.

The future predictive safety models will have a modified study area than what is being conducted for the traffic analysis as the safety focus will be on understanding the changes in I-5 mainline and ramp conditions between the previous Phase 2 elements and the current Phase 2 elements. This is because it is expected that the change in potential collisions would most likely occur along I-5 between these Phase 2 conditions. Therefore the predictive collision analysis will be prepared for I-5 (mainline and ramps) between south of the S 320th Street interchange and south of the SR 18 westbound to the I-5 southbound flyover ramp merge point. Crash statistics will be compiled and summarized to identify any current safety deficiencies.

Forecasted safety conditions on the I-5/SR 161/SR 18 interchange will be assessed using the Highway Safety Manual (HSM) predictive method. The IHSDM software package will be used to conduct the predictive safety analysis. The predictive methodology for interchanges includes two primary components: the crossroad ramp terminals and the ramp segments. Specific data required for analysis of the ramp segments include, but are not limited to, area type, ramp length, shoulder widths, average daily traffic volumes, and other design/geometric elements.

To analyze the ramp terminals using the HSM predictive method, the current and proposed configurations must align with specific sets of defined ramp site types/configurations outlined in the HSM. Ramp terminal intersection analysis incorporates specific information on known characteristics, including but not limited to, design/geometric elements, average daily traffic volumes, signal control, skew angles, and the presence of adjacent intersections or access points.

The HSM predictive method uses this data to estimate the expected average crash frequency for each component of the planned improvement, as well as the potential for safety improvements that could be implemented at the interchange. All ramp terminal and ramp segment data required for application of the HSM predictive method will be collected from WSDOT as-built drawings or field observations. Any locations that cannot be analyzed using the HSM predictive method due to model limitations will be assessed using a qualitative comparative analysis.

The configurations that will be analyzed include the previously approved Phase 2 configuration, and the current proposed Phase 2 configuration. The existing 2015 configuration (assuming only Phase 1 improvements) may be examined as well to provide a baseline to compare the previous and current Phase 2 configurations. Table 8 illustrates the years and alternatives will be analyzed using the IHSDM software package.

TABLE 8
HSM Safety Analysis Years and Configurations

Condition	2015 Existing	2020 Year of Opening	2040 Design Year
Existing Configuration (Phase 1 Only)	✓*	✓	✓
Previous Phase 2 Configuration		✓	✓
Current Phase 2 Configuration		✓	✓

Note: ✓ Indicates condition will be analyzed for that year.
* may be analyzed depending on results from previous and current phase 2 conditions.

Policy Point 4 – Access Connections and Design

Will the proposal provide fully directional interchanges connected to public streets or roads, spaced appropriately, and designed to full design level geometric control criteria?

- The project will maintain or enhance fully directional access between I-5, SR 161, SR 18, S 356th Street, and S 359th Street through phased implementation.
- Potential design deviations (spacing requirements and geometric standards) will be identified in the IJR Amendment.

Policy Point 5 –Land Use and Transportation Plans

Is the proposed access point revision compatible with all land use and transportation plans for the area?

- The project shall be compatible with all land use and transportation plans for the area including Washington Transportation Plan (WTP), the WSDOT State Highway System Plan (HSP), the Puget Sound Regional Council (PSRC) Metropolitan Transportation Plan, the King County Comprehensive Plan, the King County Transit Development Plan, the Pierce Transit Development Plan, and the City of Federal Way Comprehensive Plan.
- The City of Federal Way updated their Comprehensive Plan in 2015.
- Any changes from the previous IJR will be identified and incorporated into the land use and traffic forecasts for this amendment.

Policy Point 6 – Future Interchanges

Is the proposed access point revision compatible with a comprehensive network plan? Is the proposal compatible with other known new access points and known revisions to existing points?

- No interchanges beyond what was already documented in the original IJR are expected by the design year within the project study area. This amendment will summarize and reference the interchanges documented in the original IJR

Policy Point 7 – Coordination

Are all coordinating projects and actions programmed and funded?

- Coordination with stakeholders (City of Federal Way, WSDOT, and PSRC) will occur regarding other funded projects. This amendment will summarize and reference the programmed/funded projects from the original IJR.

Policy Point 8 – Environmental Processing

What is the status of the proposal's environmental processes? This section should be something more than just a status report of the environmental process; it should be a brief summary of the environmental process.

- Environmental documentation will be reviewed and confirmed by WSDOT. The project area will occur within WSDOT right-of-way with the exception of the area around the I-5 Southbound Off-ramp terminal intersection with S 356th Street, which would require right-of-way to be acquired.
- A NEPA DCE was completed for the full build-out design in 2007. The elements included within Phase 2 will be reviewed and confirmed by WSDOT to see if there is a need for further environmental documentation.

Appendix C
Existing VISSIM Calibration and Validation Results

Triangle IJR Amendment

Table C-1

Existing VISSIM Calibration - Changes to Default Driving Behavior

Arterial Links

		Car Following Parameters			Lane Changing Parameters			
Location	**Driver Behavior Name**	**Avg. Standstill Distance (ft)**	**Additive part of safety distance**	**Multipicative part of safety distance**	**Safety distance reduction factor**	**Advanced Merging**	**Consider subsequent static routing decisions**	**Cooperative Lane Change**
Default	Urban (motorized)	6.56	2.00	3.00	0.60	Yes	Yes	No
All Arterial Links except SR 161 SB	Urban - Add/Mult 2.5/3.5	6.56	***2.50***	***3.50***	***0.40***	Yes	Yes	No
SR 161 SB between SR 18 & Milton Rd	Urban - Add/Mult 2.75/3.75	6.56	***2.75***	***3.75***	***0.40***	Yes	Yes	No

Note: Bold italicized indicates change from default value

Freeway Links

		Car Following Parameters			Lane Changing Parameters					
Location	**Driver Behavior Name**	**CC0 Standstill Distance (ft)**	**CC1 Headway (sec)**	**CC2 Following Variation (ft)**	**Safety distance reduction factor**	**Advanced Merging**	**Consider subsequent static routing decisions**	**Cooperative Lane Change**	**Max Decel. Rate (ft/s^2)**	**Accepted Decel. Rate (ft/s^2)**
Default	Freeway (free lane selection)	4.92	0.90	13.12	0.60	Yes	Yes	No	-13.12/-9.84	-3.28/-1.64
SR 18 WB west of Weyerhauser SR 18 WB-to-I-5 CD	Freeway Weave	4.92	***1.10***	13.12	***0.10***	Yes	Yes	No	***-26.00/-20.00***	***-14.00/-9.00***
I-5 SB Diverge to SR 18 WB I-5 SB Merge from SR 18 EB I-5 SB Merge from SR 18 WB SR 18 WB Merge from I-5 NB	Freeway Aggressive Merge	4.92	***1.10***	13.12	***0.10***	Yes	Yes	***Yes***	***-13.12/-18.00***	***-3.28/-3.28***

Note: Bold italicized indicates change from default value

Triangle IJR Update

FHWA Validation Criteria

Table C-2

2015 Existing AM Peak Hour - VISSIM Validation Results

Volume Validation (GEH Criteria)				
Lane Type	**Total Links**	**# Links that meet criteria**	**Results**	**Calibration Metric Achieved**
Freeway Mainline	9	9	100%	Yes
Ramps	13	13	100%	Yes
Arterials	55	53	96%	Yes
All Links	77	75	97%	Yes

Volume Validation (FHWA Volume Criteria)				
Lane Type	**Total Links**	**# Links that meet criteria**	**Results**	**Calibration Metric Achieved**
Freeway Mainline	9	9	100%	Yes
Ramps	13	13	100%	Yes
Arterials	55	53	96%	Yes
All Links	77	75	97%	Yes
Difference in sum of all link flows =			0%	Yes

FHWA Performance Criteria and Measures	**Validation Acceptance Target**
Individual link flows	
Flow < 700 veh/h, Within 100 veh/h	> 85% of cases
700 veh/h < Flow < 2700 veh/h, Within 15%	> 85% of cases
Flow > 2700 veh/h, Within 400 veh/h	> 85% of cases
Difference in sum of all link flows	Within 5%
GEH Statistic Value	
GEH Statistic Value < 5, for individual link flows	> 85% cases
GEH Statistic Value for Sum of All Link Flows	< 4
Travel Times, Model versus Observed	
Within 15% (or 1 min, if higher)	> 85% cases

Network Travel Time Validation: PM Peak Period								
Origin	**Destination**	**Description**	**Field Travel Time (Minutes)**	**VISSIM Travel Time (Minutes)**	**Abs Diff (Minutes)**	**Diff.%**	**Within 1 minute?**	**Travel Time Calibration Result Achieved**
A	B	A to B (I-5 SB Mainline: S 320th St On Ramp to SR 161 Overpass)	1.9	2.0	0.1	3%	Yes	Yes
A	C	A to C (I-5 SB to SR 18 EB Weyerhauser Way Exit)	2.3	2.3	-0.1	-4%	Yes	Yes
A	D	A to D (I-5 SB to SR 18/SR 161 Intersection)	2.9	2.5	-0.4	-12%	Yes	Yes
C	D	C to D (SR 18 WB Mainline from Weyerhauser Way to SR 18/SR 161)	2.6	2.3	-0.3	-12%	Yes	Yes
C	E	C to E via Fly-over (SR 18 WB at Weyerhauser to SR 161/S 356th St)	3.0	2.0	-1.0	-34%	Yes	Yes
C	F	C to F via Fly-over (SR 18 WB at Weyerhauser to SR 161/Milton Rd)	2.9	2.0	-0.9	-32%	Yes	Yes
D	C	D to C (SR 18 EB from SR 161 to Weyerhauser Way EB Off Ramp)	1.0	1.0	-0.1	-7%	Yes	Yes
D	E	D to E (SR 161 SB from SR 18 to S 356th St)	1.5	0.8	-0.6	-43%	Yes	Yes
D	F	D to F (SR 161 SB from SR 18 to Milton Rd)	2.3	1.5	-0.8	-34%	Yes	Yes
E	D	E to D (SR 161 NB from S 356th St to SR 18)	1.4	1.6	0.2	13%	Yes	Yes
E	F	E to F (SR 161 SB from S 356th St to Milton Rd)	0.9	0.7	-0.2	-18%	Yes	Yes
F	D	F to D (SR 161 NB from Milton Rd to SR 18)	2.6	2.6	0.0	0%	Yes	Yes
F	E	F to E (SR 161 NB from Milton Rd to S 356th St)	1.2	0.8	-0.4	-32%	Yes	Yes

# of travel time routes measured =	13
# of travel time routes that meet criteria =	13
% of routes that meet criteria =	100%

Triangle IJR Amendment

WSDOT VISSIM Protocol Criteria

Table C-3

VISSIM Validation Results, 2015 Existing AM Peak Hour

Throughput Volumes					
VISSIM Link #	Roadway Description	Count (vphpl)	VISSIM Model (vphpl)	GEH Statistic Calibration Score 7:30-8:30 AM	Pass/Fail Calibration Criteria
211	I-5 SB - Mainline Entry/Exit between S 320th St On-ramp and SR 18 WB Off-Ramp (Northern Study Area bounda	953	983	1.0	PASS
188	I-5 SB - Off-Ramp to SR 18 WB (NW Slip)	563	572	0.4	PASS
187	I-5 SB - Mainline between SR 18 WB Off-Ramp (NW Slip) and SR 18 EB Off-Ramp (SW Loop)	813	869	1.9	PASS
185	I-5 SB - Off-Ramp to SR 18 EB Off-Ramp (SW Loop)	499	483	0.7	PASS
189	I-5 SB - Mainline between SR 18 EB Off-Ramp (SW Loop) & SR 18 EB On-Ramp (SW Slip)	734	773	1.4	PASS
195	I-5 SB - On-Ramp from SR 18 EB On-Ramp (SW Slip)	466	479	0.6	PASS
177	I-5 SB - On-Ramp from SR 18 WB On-Ramp (E-to-S Flyover)	1796	1791	0.1	PASS
200	I-5 SB - Mainline between SR 18 WB On-Ramp & HOV Lane Rejoining Mainline	1219	1227	0.2	PASS
202	I-5 SB - Mainline Entry/Exit south of HOV Lane Rejoining Mainline (Southern Study Area Boundary)	1219	1228	0.2	PASS
194	SR 18 EB - Off-Ramp to I-5 NB (flyover)	726	713	0.5	PASS
184	SR 18 EB - Mainline between I-5 SB On-Ramp (SW Loop) & I-5 NB On-Ramp (SE Slip)	527	524	0.1	PASS
215	SR 18 EB - On-Ramp from I-5 NB (SE Slip)	1581	1519	1.6	PASS
217	SR 18 EB - Off-Ramp to Weyerhaueser Way	346	339	0.4	PASS
216	SR 18 EB - Mainline east of Weyerhaeuser Way (Eastern Study Area Boundary)	1391	1377	0.4	PASS
186	SR 18 WB - Mainline east of Weyerhaeuser Way (Eastern Study Area Boundary)	1025	1022	0.1	PASS
182	SR 18 WB - Off-Ramp to I-5/SR 161 CD	1144	1141	0.1	PASS
190	SR 18 WB - Mainline between I-5/SR 161 CD Off-Ramp & I-5 NB On-Ramp (NE Loop)	393	393	0.0	PASS
192	SR 18 WB - On-Ramp from I-5 NB (NE Loop)	482	488	0.3	PASS
181	SR 18 WB - On-Ramp from Weyerhauser Way (to I-5 CD)	298	308	0.6	PASS
183	SR 18 WB - Off-Ramp to I-5 NB (NE Slip)	726	723	0.1	PASS
179	SR 18 WB - CD between I-5 NB Off-Ramp & SR 161 Off-Ramp (WB-to-SB Flyover)	943	938	0.2	PASS
176	SR 18 WB - Off-Ramp to SR 161	90	85	0.5	PASS
	Sum of All Segment Flows within Calibration Area	**17934**	**17975**	**0.2%**	**PASS**

Criteria	Acceptable Targets
GEH < 3.0	All state facility segments within the calibration area
GEH < 3.0	All entry and exit locations within the calibration area
GEH < 3.0	All entrance and exit ramps within the calibration area
GEH < 5.0	At least 85% of applicable local roadway segments
Sum of all segment flows within the calibration area	Within 5%

Summary	
# of Freeway Mainline Links with Counts =	7
# of Freeway Mainline links with GEH <= 3	7
% of freeway mainline links with GEH <=3	100%
# of Freeway Mainline Entry/Exit Links with Counts:	2
# of Freeway Mainline Entry/Exit Links with GEH <=3:	2
% of Freeway Mainline Entry/Exit Links with GEH <=3:	100%
# of Freeway Ramp Links with Counts:	13
# of Freeway Ramp links with GEH <= 3:	13
% of ramp links with GEH <=3:	100%
# of Arterial Links with Counts:	55
# of Arterial Links with GEH <= 5:	53
% of Arterial Links with GEH <= 5:	96%

Triangle IJR Amendment

FHWA Validation Criteria

Table C-4

2015 Existing PM Peak Hour, VISSIM Validation Results

Volume Validation (GEH Criteria)				
Lane Type	**Total Links**	**# Links that meet criteria**	**Results**	**Validation Metric Achieved**
Freeway Mainline	9	9	100%	Yes
Ramps	13	13	100%	Yes
Arterials	55	53	96%	Yes
All Links	77	75	97%	Yes

Volume Validation (FHWA Volume Criteria)				
Lane Type	**Total Links**	**# Links that meet criteria**	**Results**	**Validation Metric Achieved**
Freeway Mainline	9	9	100%	Yes
Ramps	13	13	100%	Yes
Arterials	55	54	98%	Yes
All Links	77	76	99%	Yes
Difference in sum of all link flows =			-3%	Yes

FHWA Performance Criteria and Measures	**Validation Acceptance Target**
Individual link flows	
Flow < 700 veh/h, Within 100 veh/h	> 85% of cases
700 veh/h < Flow < 2700 veh/h, Within 15%	> 85% of cases
Flow > 2700 veh/h, Within 400 veh/h	> 85% of cases
Difference in sum of all link flows	Within 5%
GEH Statistic Value	
GEH Statistic Value < 5, for individual link flows	> 85% cases
GEH Statistic Value for Sum of All Link Flows	< 4
Travel Times, Model versus Observed	
Within 15% (or 1 min, if higher)	> 85% cases

Network Travel Time Validation: PM Peak Period								
Origin	**Destination**	**Description**	**Field Travel Time (Minutes)**	**VISSIM Travel Time (Minutes)**	**Abs Diff (Minutes)**	**Diff.%**	**Within 1 minute?**	**Travel Time Calibration Result Achieved**
A	B	A to B (I-5 SB Mainline)	8.9	9.2	0.3	3%	Yes	Yes
A	C	A to C (I-5 SB to SR 18 EB Weyerhauser Way Exit)	3.3	3.2	-0.1	-4%	Yes	Yes
A	D	A to D (I-5 SB to SR 161/Enchanted Pkwy)	8.0	8.0	0.0	0%	Yes	Yes
C	D	C to D (SR 18 WB to SR 161/Enchanted Pkwy)	10.6	11.7	1.1	10%	No	Yes
C	E	C to E via Fly-over (SR 18 WB to S 356th St)	3.5	3.8	0.2	6%	Yes	Yes
C	F	C to F via SR 18 WB Fly-over (SR 18 WB to Milton Rd)	3.9	4.1	0.2	6%	Yes	Yes
D	C	D to C (SR 161/Enchanted Pkwy to SR 18 EB Weyerhauser Way Exit)	1.1	1.0	-0.1	-9%	Yes	Yes
D	E	D to E (SR 18 to S 356th St)	4.0	4.8	0.8	21%	Yes	Yes
D	F	D to F (SR 18 to Milton Rd)	6.6	6.8	0.2	3%	Yes	Yes
E	D	E to D (S. 356th St to SR 18)	1.5	2.0	0.5	30%	Yes	Yes
E	F	E to F (S. 356th St to Milton Rd)	2.6	2.1	-0.5	-20%	Yes	Yes
F	D	F to D (Milton Rd to SR 18)	3.1	3.6	0.5	14%	Yes	Yes
F	E	F to E (Milton Rd to S. 356th St)	1.6	1.2	-0.4	-26%	Yes	Yes

# of travel time routes measured =	13
# of travel time routes that meet criteria =	13
% of routes that meet criteria =	100%

Triangle IJR Amendment

Table C-5

2015 Existing PM Peak Hour - VISSIM Validation Results

WSDOT VISSIM Protocol Criteria

WSDOT VISSIM Protocol Validation Results - Throughput Volumes

VISSIM Link #	Roadway Description	Count (vphpl)	VISSIM Model (vphpl)	GEH Statistic Calibration Score 4:30-5:30 PM	Pass/Fail Calibration Criteria
211	I-5 SB - Mainline Enter/Exit between S 320th St On-ramp and SR 18 WB Off-Ramp (Northern Study Area boundary)	1404	1411	0.2	PASS
188	I-5 SB - Off-Ramp to SR 18 WB (NW Slip)	1470	1352	3.1	FAIL
187	I-5 SB - Mainline between SR 18 WB Off-Ramp (NW Slip) and SR 18 EB Off-Ramp (SW Loop)	1098	1123	0.7	PASS
185	I-5 SB - Off-Ramp to SR 18 EB Off-Ramp (SW Loop)	1147	1157	0.3	PASS
189	I-5 SB - Mainline between SR 18 EB Off-Ramp (SW Loop) & SR 18 EB On-Ramp (SW Slip)	876	868	0.3	PASS
195	I-5 SB - On-Ramp from SR 18 EB On-Ramp (SW Slip)	239	270	1.9	PASS
177	I-5 SB - On-Ramp from SR 18 WB On-Ramp (E-to-S Flyover)	974	985	0.3	PASS
200	I-5 SB - Mainline between SR 18 WB On-Ramp & HOV Lane Rejoining Mainline	1114	1112	0.1	PASS
202	I-5 SB - Mainline Enter/Exit south of HOV Lane Rejoining Mainline (Southern Study Area Boundary)	1114	1108	0.2	PASS
194	SR 18 EB - Off-Ramp to I-5 NB (flyover)	659	690	1.2	PASS
184	SR 18 EB - Mainline between I-5 SB On-Ramp (SW Loop) & I-5 NB On-Ramp (SE Slip)	744	764	0.7	PASS
215	SR 18 EB - On-Ramp from I-5 NB (SE Slip)	1422	1391	0.8	PASS
217	SR 18 EB - Off-Ramp to Weyerhaueser Way	567	552	0.7	PASS
216	SR 18 EB - Mainline east of Weyerhaeuser Way (Eastern Study Area Boundary)	1533	1567	0.9	PASS
186	SR 18 WB - Mainline east of Weyerhaeuser Way (Eastern Study Area Boundary)	1037	1071	1.1	PASS
182	SR 18 WB - Off-Ramp to I-5/SR 161 CD	1043	1030	0.4	PASS
190	SR 18 WB - Mainline between I-5/SR 161 CD Off-Ramp & I-5 NB On-Ramp (NE Loop)	511	549	1.7	PASS
192	SR 18 WB - On-Ramp from I-5 NB (NE Loop)	361	364	0.2	PASS
181	SR 18 WB - On-Ramp from Weyerhauser Way (to I-5 CD)	369	376	0.4	PASS
183	SR 18 WB - Off-Ramp to I-5 NB (NE Slip)	659	654	0.2	PASS
179	SR 18 WB - CD between I-5 NB Off-Ramp & SR 161 Off-Ramp (WB-to-SB Flyover)	891	895	0.2	PASS
176	SR 18 WB - Off-Ramp to SR 161	807	793	0.5	PASS
	Sum of All Segment Flows within Calibration Area	**20037**	**20080**	**0.2%**	**PASS**

Criteria	Acceptable Targets
GEH < 3.0	All state facility segments within the calibration area
GEH < 3.0	All entry and exit locations within the calibration area
GEH < 3.0	All entrance and exit ramps within the calibration area
GEH < 5.0	At least 85% of applicable local roadway segments
Sum of all segment flows within the calibration area	Within 5%

PM Peak Summary	
# of Freeway Mainline Links with Counts	7
# of Freeway Mainline Links with GEH <= 3:	7
% of Freeway Mainline Links with GEH <=3:	100%
# of Freeway Mainline Entry/Exit Links with Counts	2
# of Freeway Mainline Entry/Exit Links with GEH <=3	2
% of Freeway Mainline Entry/Exit Links with GEH <=3	100%
# of Freeway Ramp Links with Counts:	13
# of Freeway Ramp Links with GEH <= 3:	12
% of Freeway Ramp Links with GEH <= 3:	92%
# of Arterial Links with Counts:	55
# of Arterial Links with GEH <= 5:	53
% of Arterial Links with GEH <= 5:	96%

Appendix D
VISSIM Freeway Results

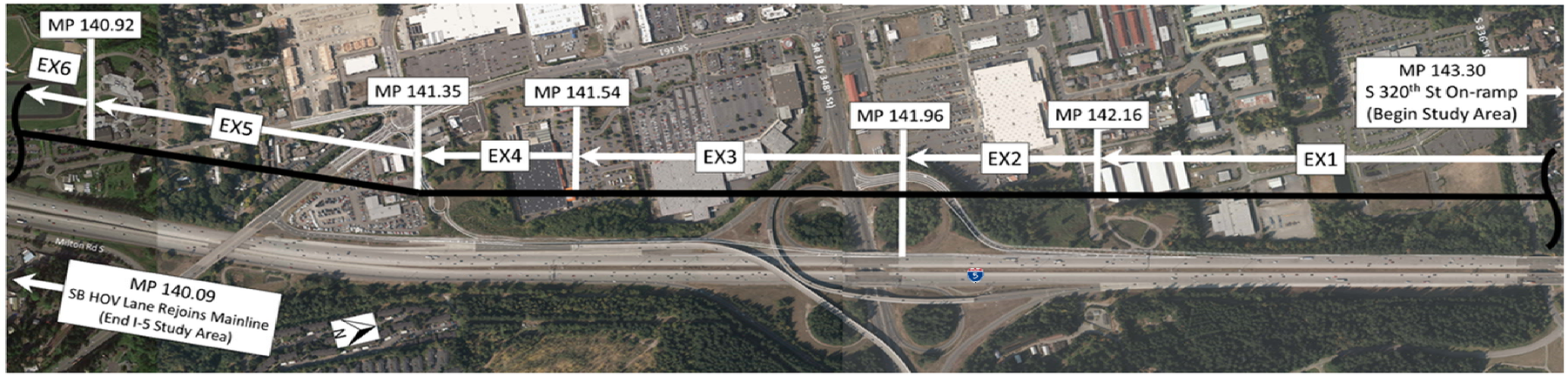
Triangle IJR Amendment

Table D-1

2015 Existing VISSIM Freeway Results, AM/PM Peak Hour

					Geometric Input Data					2015 Existing - AM Peak Hour								2015 Existing - PM Peak Hour							
										Volume Input Data			Results					Volume Input Data			Results				
Facility	Type	Dir.	I-5 Segment ID	Segment Location	HCM Segment Type	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput	% Mainline Demand Served	Speed	Density	LOS	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS
I-5	GP Lanes	SB	EX1	between S 320th St On-ramp and SR 18 WB Off-Ramp (Northern Study Area boundary)	Basic	6020	143.30	142.16	4	4540	n/a	n/a	4582	101%	66	17	B	6050	n/a	n/a	5949	98%	47	40	E
			EX2	to SR 18 EB Off Ramp (SW Loop)	Diverge	1065	142.16	141.96	4	3950	n/a	480	3980	101%	66	15	B	4605	n/a	1145	4478	97%	23	60	F
			EX3	between SR 18 EB Off-Ramp (SW Loop) & SR 18 EB On-Ramp (SW Slip)	Basic	2210	141.96	141.54	4	3470	n/a	n/a	3553	102%	66	13	B	3435	n/a	n/a	3354	98%	6	140	F
			EX4	from SR 18 EB On Ramp (SW Slip)	Merge	980	141.54	141.35	5	3960	490	n/a	4034	102%	63	15	B	3760	295	n/a	3598	96%	5	178	F
			EX5	from SR 18 WB On Ramp (Flyover)	Merge	2280	141.35	140.92	5	5765	1775	n/a	5832	101%	63	25	C	4665	990	n/a	4561	98%	8	143	F
			EX6	south of HOV Lane Rejoining Mainline (Southern Study Area Boundary)	Basic	4405	140.92	140.09	4	5765	n/a	n/a	5825	101%	65	22	C	4665	n/a	n/a	4455	95%	9	123	F
SR-18	GP Lanes	EB		between I-5 SB On-Ramp (SW Loop) & I-5 NB On-Ramp (SE Slip)	Basic	530	0.18	0.28	2	1615	n/a	n/a	1561	97%	55	11	A	2330	n/a	n/a	2273	98%	63	18	B
				between I-5 NB On-Ramp (SE Slip) & Weyerhaeuser Way Off-Ramp	Weave	725	0.28	0.42	3	3165	1615	345	3074	97%	52	20	B	3750	1420	565	3660	98%	41	30	D
				east of Weyerhaeuser Way (EB Eastern Study Area Boundary)	Basic	1790	0.42	0.76	2	2820	n/a	1615	2748	97%	62	22	C	3185	n/a	1420	3125	98%	59	26	D
		WB		east of Weyerhaeuser Way (WB Eastern Study Area Boundary)	Basic	5250	1.76	0.77	3	3080	n/a	1775	3055	99%	66	16	B	3510	n/a	990	3253	93%	55	23	C
				between I-5/SR 161 CD Off-Ramp & I-5 NB On-Ramp (NE Loop)	Basic	3785	0.77	0.05	2	790	n/a	90	783	99%	55	7	A	1425	n/a	805	1104	78%	9	99	F
	CD Road	WB		between SR 18 WB Mainline & Weyerhaueser Way WB On Ramp	Basic	960	0.12	0.30	2	2290	n/a	345	2263	99%	57	20	C	2085	n/a	565	2041	98%	43	39	E
				between Weyerhaeuser Way On-Ramp & I-5 NB Off-Ramp (NE Slip)	CD Weave	1715	0.30	0.62	3	2590	300	725	2585	100%	48	19	B	2455	370	660	2433	99%	41	36	E
				between I-5 NB Off-Ramp (NE Slip) & SR 161 Off Ramp	Basic	3055	0.62	1.20	2	1865	n/a	n/a	1869	100%	48	20	C	1795	n/a	n/a	1781	99%	24	66	F

Notes:
Volumes are in vehicles per hour (vph). Speed is in miles per hour (mph). Density is in vehicles per mile per lane (vpmpl). Segment length is in feet. MP = Milepost.
For Merge/Diverge/Weave segments, upstream and downstream ramp volumes are provided.
Basic segments do not require upstream/downstream ramp volumes and therefore are not applicable.
LOS shaded in yellow is at agency LOS standard while LOS shaded in red is below agency LOS standard. Standard for I-5 is LOS D, while SR 18 is LOS E/mitigated.



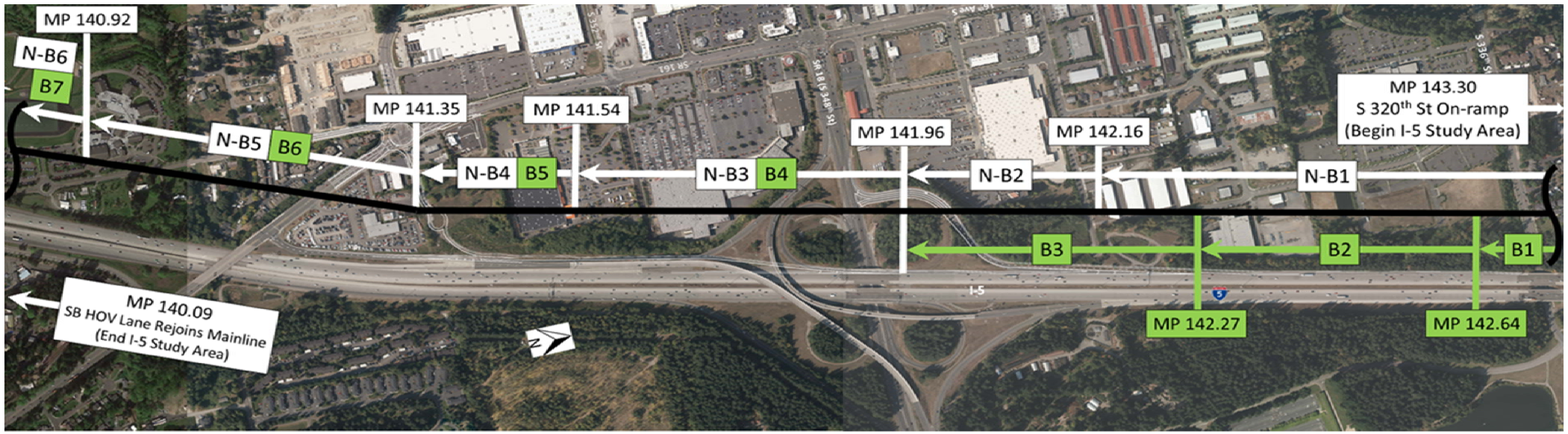
Triangle IJR Amendment

Table D-2

2020 AM Peak Hour - VISSIM Freeway Results, No Build and Build

Facility	Type	Dir.	Segment Location	HCM Segment Type	2020 AM - No Build													2020 AM - Build												
					Geometric & Volume Input Data								Results					Geometric & Volume Input Data								Results				
					I-5 Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS	I-5 Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS
I-5	GP Lanes	SB	S 320th St On to SR 18 Off	Basic	N-B1	6020	143.30	142.16	4	4695	n/a	n/a	4641	99%	66	18	B	B1	3460	143.30	142.64	4	4695	n/a	n/a	4647	99%	65	18	B
			Build - to SR 18 EB/WB Off *[Not Applicable to No Build Alternative]*	Diverge	n/a													B2	1950	142.64	142.27	5	4695	n/a	790	4624	98%	66	11	B
			Build - to SR 161/S 356th St Off *No Build* - to SR 18 EB Off (SW Loop)	Diverge	N-B2	1065	142.16	141.96	4	4080	n/a	490	4048	99%	66	15	B	B3	1620	142.27	141.96	4	3880	n/a	275	3826	99%	66	14	B
			Build - SR 161/S 356th St Off to SR 18 EB On (SW Slip) *No Build* - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	Basic	N-B3	2210	141.96	141.54	4	3600	n/a	n/a	3618	100%	66	14	B	B4	2235	141.96	141.54	4	3600	n/a	n/a	3610	100%	66	14	B
			from SR 18 EB On (SW Slip)	Merge	N-B4	980	141.54	141.35	5	4090	500	n/a	4125	101%	63	16	B	B5	980	141.54	141.35	5	4090	500	n/a	4130	101%	63	16	B
			from SR 18 WB On (Flyover)	Merge	N-B5	2280	141.35	140.92	5	5880	1770	n/a	5903	100%	63	26	C	B6	2280	141.35	140.92	5	5880	1770	n/a	5818	99%	64	25	C
			SR 18 WB On to Southern Study Area Boundary	Basic	N-B6	4405	140.92	140.09	4	5880	n/a	n/a	5883	100%	65	22	C	B7	4405	140.92	140.09	4	5880	n/a	n/a	5808	99%	65	22	C
SR-18	GP Lanes	EB	I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	Basic		530	0.18	0.28	2	1740	n/a	n/a	1715	99%	64	13	B		530	0.00	0.10	2	1740	n/a	n/a	1730	99%	63	14	B
			I-5 NB On (SE Slip) to Weyerhaeuser Way Off	Weave		725	0.28	0.42	3	3310	1570	445	3276	99%	57	19	B		725	0.10	0.24	3	3310	1570	445	3290	99%	57	19	B
			Weyerhaeuser Way off to Eastern Study Area Boundary	Basic		1790	0.42	0.76	2	2865	n/a	1570	2848	99%	63	23	C		1790	0.24	0.58	2	2865	n/a	1570	2860	100%	63	23	C
		WB	east of Weyerhaeuser Way to I-5/SR 161 CD Off	Basic		5250	1.76	0.77	3	3125	n/a	1770	3117	100%	66	16	B		5250	1.21	0.22	3	3125	n/a	1770	3117	100%	66	16	B
			I-5/SR 161 CD Off to I-5 NB On (NE Loop)	Basic		3785	0.77	0.05	2	835	n/a	110	828	99%	55	8	A		3785	0.22	-0.50	2	835	n/a	110	828	99%	55	8	A
	CD Road	WB	SR 18 WB Mainline to Weyerhaueser Way WB On	Basic		960	0.12	0.30	2	2290	n/a	445	2270	99%	56	20	C		960	0.10	0.28	2	2290	n/a	445	2270	99%	56	20	C
			Weyerhaeuser Way On to I-5 NB Off (NE Slip)	CD Weave		1715	0.30	0.62	3	2610	320	730	2598	100%	51	18	B		1715	0.28	0.60	3	2610	320	730	2598	100%	52	17	B
			I-5 NB Off (NE Slip) to SR 161 Off	Basic		3055	0.62	1.20	2	1880	n/a	n/a	1874	100%	48	20	C		3055	0.60	1.18	2	1880	n/a	n/a	1875	100%	48	20	C

Notes:
Volumes are in vehicles per hour (vph). Speed is in miles per hour (mph). Density is in vehicles per mile per lane (vpmpl). Segment Length is in feet. MP = Milepost.
For Merge/Diverge/Weave segments, upstream and downstream ramp volumes are provided.
Basic segments do not require upstream/downstream ramp volumes and therefore are not applicable.



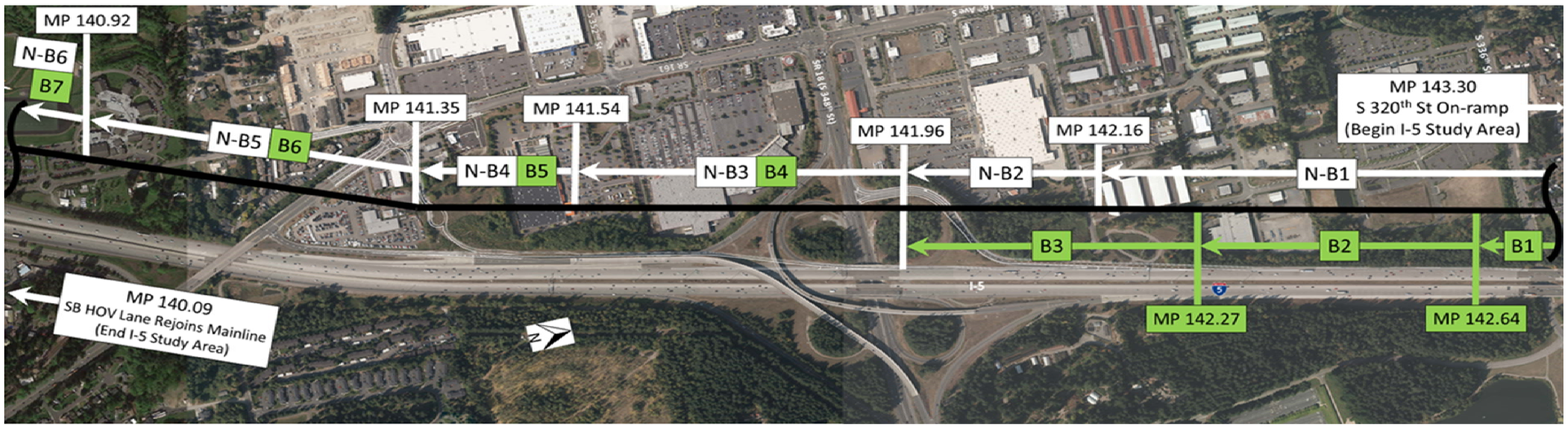
Triangle IJR Amendment

Table D-3

2040 AM Peak Hour - VISSIM Freeway Results, No Build and Build

					2040 AM - No Build														2040 AM - Build											
					Geometric & Volume Input Data								Results						Geometric & Volume Input Data								Results				
Facility	Type	Dir.	Segment Location	HCM Segment Type	I-5 Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS	I-5 Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS
I-5	GP Lanes	SB	S 320th St On to SR 18 Off	Basic	N-B1	6020	143.30	142.16	4	5060	n/a	n/a	5107	101%	65	20	C	B1	3460	143.30	142.64	4	4695	n/a	n/a	4647	99%	65	18	B
			Build - to SR 18 EB/WB Off *[Not Applicable to No Build Alternative]*	Diverge	n/a													B2	1950	142.64	142.27	5	4695	n/a	790	4624	98%	66	11	B
			Build - to SR 161/S 356th St Off *No Build* - to SR 18 EB Off (SW Loop)	Diverge	N-B2	1065	142.16	141.96	4	4480	n/a	530	4465	100%	66	17	B	B3	1620	142.27	141.96	4	3880	n/a	275	3826	99%	66	14	B
			Build - SR 161/S 356th St Off to SR 18 EB On (SW Slip) *No Build* - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	Basic	N-B3	2210	141.96	141.54	4	3980	n/a	n/a	4006	101%	66	15	B	B4	2200	141.96	141.54	4	3600	n/a	n/a	3610	100%	66	14	B
			from SR 18 EB On (SW Slip)	Merge	N-B4	980	141.54	141.35	5	4500	550	n/a	4553	101%	63	17	B	B5	980	141.54	141.35	5	4090	500	n/a	4130	101%	63	16	B
			from SR 18 WB On (Flyover)	Merge	N-B5	2280	141.35	140.92	5	6145	1750	n/a	6307	103%	63	27	C	B6	2280	141.35	140.92	5	5880	1770	n/a	5818	99%	64	25	C
			SR 18 WB On to Southern Study Area Boundary	Basic	N-B6	4405	140.92	140.09	4	6145	n/a	n/a	6264	102%	65	24	C	B7	4405	140.92	140.09	4	5880	n/a	n/a	5808	99%	65	22	C
SR-18	GP Lanes	EB	I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	Basic		530	0.18	0.28	2	2030	n/a	n/a	1979	97%	65	15	B		530	0.00	0.10	2	1740	n/a	n/a	1730	99%	63	14	B
			I-5 NB On (SE Slip) to Weyerhaeuser Way Off	Weave		725	0.28	0.42	3	3655	1625	555	3595	98%	57	21	C		725	0.10	0.24	3	3310	1570	445	3290	99%	57	19	B
			Weyerhaeuser Way off to Eastern Study Area Boundary	Basic		1790	0.42	0.76	2	3100	n/a	1625	3067	99%	63	24	C		1790	0.24	0.58	2	2865	n/a	1570	2860	100%	63	23	C
		WB	east of Weyerhaeuser Way to I-5/SR 161 CD Off	Basic		5250	1.76	0.77	3	3320	n/a	1750	3313	100%	66	17	B		5250	1.21	0.22	3	3125	n/a	1770	3117	100%	66	16	B
			I-5/SR 161 CD Off to I-5 NB On (NE Loop)	Basic		3785	0.77	0.05	2	980	n/a	205	968	99%	55	9	A		3785	0.22	-0.50	2	835	n/a	110	828	99%	55	8	A
	CD Road	WB	SR 18 WB Mainline to Weyerhaueser Way WB On	Basic		960	0.12	0.30	2	2340	n/a	555	2326	99%	56	21	C		960	0.10	0.28	2	2290	n/a	445	2270	99%	56	20	C
			Weyerhaeuser Way On to I-5 NB Off (NE Slip)	CD Weave		1715	0.30	0.62	3	2745	405	790	2738	100%	51	18	B		1715	0.28	0.60	3	2610	320	730	2598	100%	52	17	B
			I-5 NB Off (NE Slip) to SR 161 Off	Basic		3055	0.62	1.20	2	1955	n/a	n/a	1952	100%	48	21	C		3055	0.60	1.18	2	1880	n/a	n/a	1875	100%	48	20	C

Notes:
Volumes are in vehicles per hour (vph). Speed is in miles per hour (mph). Density is in vehicles per mile per lane (vpmpl). Segment Length is in feet. MP = Milepost.
For Merge/Diverge/Weave segments, upstream and downstream ramp volumes are provided.
Basic segments do not require upstream/downstream ramp volumes and therefore are not applicable.



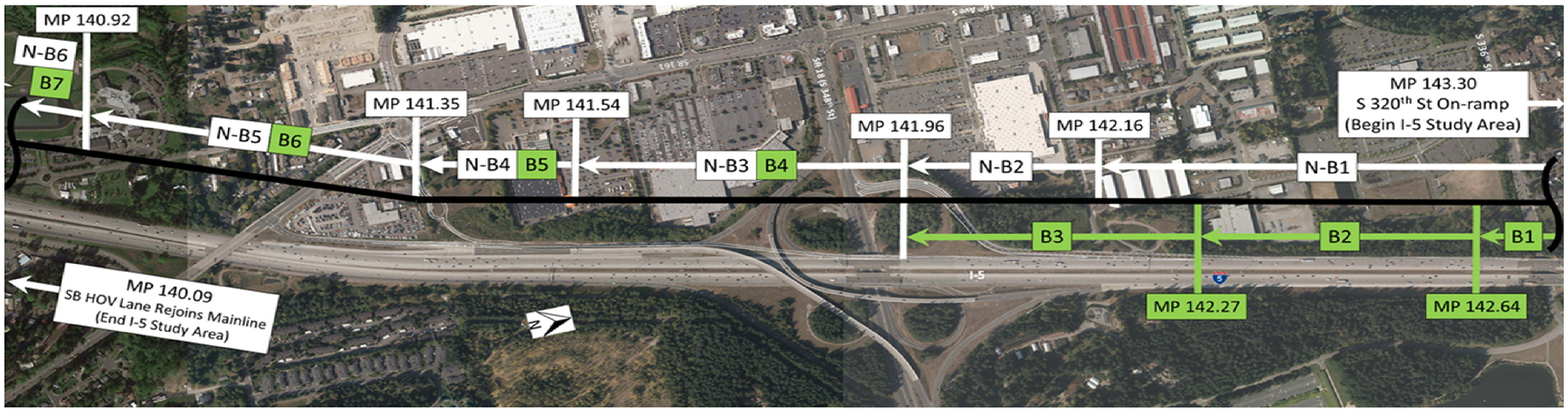
Triangle IJR Amendment

Table D-4

2020 PM Peak Hour - VISSIM Freeway Results, No Build and Build

Facility	Type	Dir.	Segment Location	HCM Segment Type	2020 PM - No Build													2020 PM - Build												
					Geometric & Volume Input Data								Results					Geometric & Volume Input Data								Results				
					I-5 Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS	Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS
I-5	GP Lanes	SB	S 320th St On to SR 18 Off	Basic	N-B1	6020	143.30	142.16	4	6115	n/a	n/a	5787	95%	39	57	F	B1	3460	143.30	142.64	4	6115	n/a	n/a	6148	101%	64	25	C
			Build - to SR 18 EB/WB Off *[Not Applicable to No Build Alternative]*	Diverge	n/a													B2	1950	142.64	142.27	5	6115	n/a	1935	6097	100%	65	18	B
			Build - to SR 161/S 356th St Off *No Build* - to SR 18 EB Off (SW Loop)	Diverge	N-B2	1065	142.16	141.96	4	4640	n/a	1160	4456	96%	65	14	B	B3	1620	142.27	141.96	4	4255	n/a	725	4150	98%	66	15	B
			Build - SR 161/S 356th St Off to SR 18 EB On (SW Slip) *No Build* - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	Basic	N-B3	2210	141.96	141.54	4	3485	n/a	n/a	3436	99%	67	13	B	B4	2235	141.96	141.54	4	3525	n/a	n/a	3534	100%	66	13	B
			from SR 18 EB On (SW Slip)	Merge	N-B4	980	141.54	141.35	5	3860	360	n/a	3795	98%	63	11	B	B5	980	141.54	141.35	5	3910	360	n/a	3898	100%	63	13	B
			from SR 18 WB On (Flyover)	Merge	N-B5	2280	141.35	140.92	5	4785	1010	n/a	4820	101%	64	18	B	B6	2280	141.35	140.92	5	4845	1010	n/a	4922	102%	64	20	B
			SR 18 WB On to Southern Study Area Boundary	Basic	N-B6	4405	140.92	140.09	4	4785	n/a	n/a	5057	106%	66	19	C	B7	4405	140.92	140.09	4	4845	n/a	n/a	5164	107%	66	20	C
SR-18	GP Lanes	EB	I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	Basic		530	0.18	0.28	2	2425	n/a	n/a	2369	98%	64	19	C		530	0.00	0.10	2	2425	n/a	n/a	2384	98%	63	19	C
			I-5 NB On (SE Slip) to Weyerhaeuser Way Off	Weave		725	0.28	0.42	3	3845	1420	620	3782	98%	56	22	C		725	0.10	0.24	3	3845	1420	620	3797	99%	55	23	C
			Weyerhaeuser Way off to Eastern Study Area Boundary	Basic		1790	0.42	0.76	2	3225	n/a	1420	3182	99%	63	25	C		1790	0.24	0.58	2	3225	n/a	1420	3196	99%	62	26	C
		WB	east of Weyerhaeuser Way to I-5/SR 161 CD Off	Basic		5250	1.76	0.77	3	3525	n/a	1010	3518	100%	66	18	B		5250	1.21	0.22	3	3525	n/a	1010	3518	100%	66	18	B
			I-5/SR 161 CD Off to I-5 NB On (NE Loop)	Basic		3785	0.77	0.05	2	1440	n/a	840	1443	100%	15	61	F		3785	0.22	-0.50	2	1465	n/a	815	1469	100%	24	49	F
	CD Road	WB	SR 18 WB Mainline to Weyerhaueser Way WB On	Basic		960	0.12	0.30	2	2085	n/a	620	2070	99%	57	18	C		960	0.10	0.28	2	2060	n/a	620	2047	99%	57	18	C
			Weyerhaeuser Way On to I-5 NB Off (NE Slip)	CD Weave		1715	0.30	0.62	3	2510	425	660	2501	100%	53	16	B		1715	0.28	0.60	3	2485	425	660	2477	100%	53	16	B
			I-5 NB Off (NE Slip) to SR 161 Off	Basic		3055	0.62	1.20	2	1850	n/a	n/a	1846	100%	48	19	C		3055	0.60	1.18	2	1825	n/a	n/a	1822	100%	48	19	C

Notes:
Volumes are in vehicles per hour (vph). Speed is in miles per hour (mph). Density is in vehicles per mile per lane (vpmpl). Segment Length is in feet. MP = Milepost.
For Merge/Diverge/Weave segments, upstream and downstream ramp volumes are provided.
Basic segments do not require upstream/downstream ramp volumes and therefore are not applicable.



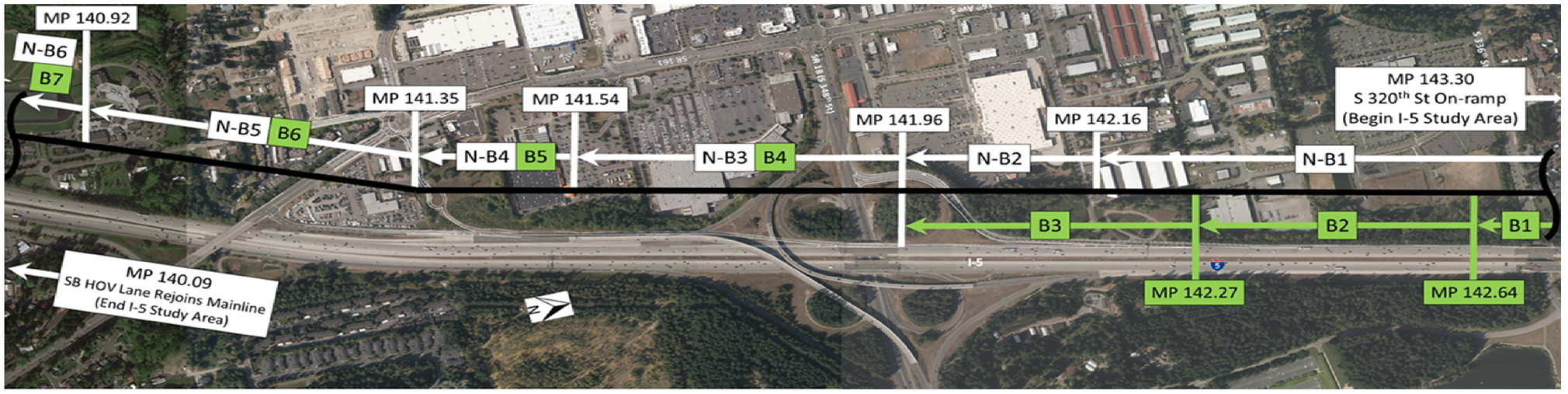
Triangle IJR Amendment

Table D-5

2040 PM Peak Hour - VISSIM Freeway Results, No Build and Build

Facility	Type	Dir.	Segment Location	HCM Segment Type	2040 PM - No Build													2040 PM - Build												
					Geometric & Volume Input Data								Results					Geometric & Volume Input Data								Results				
					I-5 Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS	Segment ID	Segment Length	Begin MP	End MP	# GP Lanes	Mainline Demand	Up stream Ramp Demand	Down stream Ramp Demand	Mainline Thruput Volume	% Mainline Demand Served	Speed	Density	LOS
I-5	GP Lanes	SB	S 320th St On to SR 18 Off	Basic	N-B1	6020	143.30	142.16	4	6440	n/a	n/a	5286	82%	26	77	F	B1	3460	143.30	142.64	4	6440	n/a	n/a	6534	101%	63	26	D
			Build - to SR 18 EB/WB Off *[Not Applicable to No Build Alternative]*	Diverge	n/a													B2	1950	142.64	142.27	5	6440	n/a	2005	6481	101%	66	18	B
			Build - to SR 161/S 356th St Off *No Build* - to SR 18 EB Off (SW Loop)	Diverge	N-B2	1065	142.16	141.96	4	4970	n/a	1230	4112	83%	63	13	B	B3	1620	142.27	141.96	4	4575	n/a	825	4452	97%	65	16	B
			Build - SR 161/S 356th St Off to SR 18 EB On (SW Slip) *No Build* - SR 18 EB Off (SW Loop) to SR 18 EB On (SW Slip)	Basic	N-B3	2210	141.96	141.54	4	3755	n/a	n/a	3183	85%	67	12	B	B4	2235	141.96	141.54	4	3755	n/a	n/a	3757	100%	66	14	B
			from SR 18 EB On (SW Slip)	Merge	N-B4	980	141.54	141.35	5	4265	510	n/a	3643	85%	63	11	B	B5	980	141.54	141.35	5	4265	510	n/a	4237	99%	63	15	B
			from SR 18 WB On (Flyover)	Merge	N-B5	2280	141.35	140.92	5	5215	1020	n/a	4572	88%	65	17	B	B6	2280	141.35	140.92	5	5215	1020	n/a	5255	101%	64	21	C
			SR 18 WB On to Southern Study Area Boundary	Basic	N-B6	4405	140.92	140.09	4	5215	n/a	n/a	4799	92%	66	18	C	B7	4405	140.92	140.09	4	5215	n/a	n/a	5522	106%	66	21	C
SR-18	GP Lanes	EB	I-5 SB On (SW Loop) to I-5 NB On (SE Slip)	Basic		530	0.18	0.28	2	2900	n/a	n/a	2495	86%	62	20	C		530	0.00	0.10	2	2900	n/a	n/a	2764	95%	63	22	C
			I-5 NB On (SE Slip) to Weyerhaeuser Way Off	Weave		725	0.28	0.42	3	4275	1375	840	3867	90%	55	24	C		725	0.10	0.24	3	4275	1375	840	4134	97%	54	26	C
			Weyerhaeuser Way off to Eastern Study Area Boundary	Basic		1790	0.42	0.76	2	3435	n/a	1375	3099	90%	62	25	C		1790	0.24	0.58	2	3435	n/a	1375	3328	97%	62	27	D
		WB	east of Weyerhaeuser Way to I-5/SR 161 CD Off	Basic		5250	1.76	0.77	3	3600	n/a	1020	3002	83%	16	92	F		5250	1.21	0.22	3	3600	n/a	1020	3442	96%	24	69	F
			I-5/SR 161 CD Off to I-5 NB On (NE Loop)	Basic		3785	0.77	0.05	2	1595	n/a	980	1098	69%	3	191	F		3785	0.22	-0.50	2	1645	n/a	930	1399	85%	4	183	F
	CD Road	WB	SR 18 WB Mainline to Weyerhaeuser Way WB On	Basic		960	0.12	0.30	2	2005	n/a	840	1715	86%	51	23	C		960	0.10	0.28	2	1955	n/a	840	1893	97%	55	17	B
			Weyerhaeuser Way On to I-5 NB Off (NE Slip)	CD Weave		1715	0.30	0.62	3	2630	625	630	2338	89%	49	22	B		1715	0.28	0.60	3	2580	625	630	2523	98%	53	16	B
			I-5 NB Off (NE Slip) to SR 161 Off	Basic		3055	0.62	1.20	2	2000	n/a	n/a	1776	89%	42	29	D		3055	0.60	1.18	2	1950	n/a	n/a	1910	98%	48	20	C

Notes:
Volumes are in vehicles per hour (vph). Speed is in miles per hour (mph). Density is in vehicles per mile per lane (vpmpl). Segment Length is in feet. MP = Milepost.
For Merge/Diverge/Weave segments, upstream and downstream ramp volumes are provided.
Basic segments do not require upstream/downstream ramp volumes and therefore are not applicable.



Appendix E
Intersection Volumes, Delay and Queue Results

Triangle IJR Amendment

Table E-1

Intersection Turn Movement Volumes - AM Peak Hour

		Existing/No Build						Build					
Int #	Int Name	Traffic Control	Appr	Turn Mvmt	2015 Existing	2020 No Build	2040 No Build	Traffic Control	Appr	Turn Mvmt	2020 Build	2040 Build
1	Enchanted Pkwy S & S 348th St	Signal	NB	U-Turn	50	50	50	Signal	NB	U-Turn	50	50
				LT	260	275	375			LT	275	375
				TH	405	465	620			TH	465	620
				RT	705	755	840			RT	755	840
				Total	1420	1545	1885			Total	1545	1885
			EB	LT	60	80	140		EB	LT	80	140
				TH	1485	1575	1845			TH	1575	1845
				RT	120	145	245			RT	145	245
				Total	1665	1800	2230			Total	1800	2230
			SB	LT	180	180	170		SB	LT	180	170
				TH	165	195	250			TH	195	250
				RT	35	60	50			RT	60	50
				Total	380	435	470			Total	435	470
			WB	LT	360	375	460		WB	LT	145	210
				TH	930	965	1175			TH	920	1125
				TH-HOV	85	100	100			TH-HOV	100	100
				RT	460	500	595			RT	500	595
				Total	1835	1940	2330			Total	1665	2030
			Int	Total	5300	5720	6915		Int	Total	5445	6615
2	I-5 SB Off-Ramp & SR 18	Signal	n/a					Signal	EB	TH	1250	1500
										Total	1250	1500
			SB	RT	475	485	520		SB	LT	490	530
				RT-HOV	90	90	95			RT	300	315
				Total	565	575	615			Total	790	845
			WB	TH	1270	1365	1715		WB	TH	1365	1715
				Total	1270	1365	1715			Total	1365	1715
			Int	Total	1835	1940	2330		Int	Total	3405	4060
3	Enchanted Pkwy S & S 352nd St	Signal	NB	LT	10	10	10	Signal	NB	LT	10	10
				TH	1230	1290	1465			TH	1290	1465
				RT	130	75	65			RT	75	65
				Total	1370	1375	1540			Total	1375	1540
			EB	LT	20	90	250		EB	LT	90	250
				TH	0	45	25			TH	45	25
				RT	5	10	20			RT	10	20
				Total	25	145	295			Total	145	295
			SB	LT	120	125	125		SB	LT	125	125
				TH	370	440	655			TH	210	405
				RT	15	20	70			RT	20	70
				Total	505	585	850			Total	355	600
			WB	LT	60	65	60		WB	LT	65	60
				TH	0	5	0			TH	5	0
				RT	110	110	100			RT	110	100
				Total	170	180	160			Total	180	160
			Int	Total	2070	2285	2845		Int	Total	2055	2595
4	16th Ave S & S 356th St	Signal	NB	LT	5	15	10	n/a				
				RT	50	75	90					
				Total	55	90	100					
			EB	TH	300	225	280					
				RT	5	5	5					
				Total	305	230	285					
			SB	TH	25	35	70					
				RT	95	100	85					
				Total	120	135	155					
			WB	LT	20	20	15					
				TH	165	225	325					
				Total	185	245	340					
			Int	Total	665	700	880					
5	Enchanted Pkwy S & S 356th St	Signal	NB	LT	150	205	275	Roundabout	NB	n/a		
				TH	1120	1185	1375			RT	1425	1710
				RT	30	35	60			Total	1425	1710
				Total	1300	1425	1710		NEB[1]	RT	90	100
			n/a							Total	90	100
			EB	LT	165	100	100		EB	n/a		
				TH	15	15	35			RT	230	285
				RT	170	185	235			Total	230	285
				Total	350	300	370					
			SB	LT	5	5	5		SB	n/a		
				TH	290	350	520			TH	195	385
				n/a						RT	65	45
				Total	295	355	525			Total	260	430
			WB	LT	5	5	10		WB	n/a		
				TH	35	40	65			RT	160	195
				RT	25	25	25			Total	160	195
				Total	65	70	100					
			Int	Total	2010	2150	2705		Int	Total	2165	2720

Triangle IJR Amendment

Table E-1

Intersection Turn Movement Volumes - AM Peak Hour

		Existing/No Build						Build					
Int #	Int Name	Traffic Control	Appr	Turn Mvmt	2015 Existing	2020 No Build	2040 No Build	Traffic Control	Appr	Turn Mvmt	2020 Build	2040 Build
6	Enchanted Pkwy S & SR 18 WB Off-Ramp	Signal	NB	TH	1260	1385	1640	Signal	NB	TH	1385	1640
				Total	1260	1385	1640			Total	1385	1640
			SB	TH	465	540	765		SB	TH	355	565
				Total	465	540	765			Total	355	565
			WB	LT	50	70	135		WB	LT	255	335
				RT	40	40	70			RT	40	70
				Total	90	110	205			Total	295	405
			Int	Total	1815	2035	2610		Int	Total	2035	2610
7	Enchanted Pkwy S & Milton Rd/20th Ave S	Signal	NB	LT	10	15	25	Signal	NB	LT	15	25
				TH	1040	1100	1255			TH	1100	1255
				RT	20	40	105			RT	40	105
				Total	1070	1155	1385			Total	1155	1385
			EB	LT	60	75	115		EB	LT	75	115
				TH	20	45	145			TH	45	145
				RT	0	0	0			RT	0	0
				Total	80	120	260			Total	120	260
			SB	LT	70	115	230		SB	LT	115	230
				TH	375	390	440			TH	390	440
				RT	70	105	230			RT	105	230
				Total	515	610	900			Total	610	900
			WB	LT	5	10	10		WB	LT	10	10
				TH	20	35	75			TH	35	75
				RT	160	210	270			RT	210	270
				Total	185	255	355			Total	255	355
			Int	Total	1850	2140	2900		Int	Total	2140	2900
8	SR 99 & S 348th St	Signal	NB	LT	185	190	210	Signal	NB	LT	190	210
				TH	310	365	690			TH	365	690
				TH-HOV	n/a	30	50			TH-HOV	30	50
				RT	425	480	645			RT	480	645
				Total	920	1065	1595			Total	1065	1595
			EB	LT	40	50	75		EB	LT	50	75
				TH	1050	1095	1230			TH	1095	1230
				TH-HOV	120	135	195			TH-HOV	135	195
				RT	75	80	90			RT	80	90
				Total	1285	1360	1590			Total	1360	1590
			SB	LT	70	90	160		SB	LT	90	160
				TH	190	215	375			TH	215	375
				TH-HOV	n/a	30	75			TH-HOV	30	75
				RT	40	50	70			RT	50	70
				Total	300	385	680			Total	385	680
			WB	LT	305	340	460		WB	LT	295	410
				TH	830	850	945			TH	850	945
				TH-HOV	90	100	100			TH-HOV	100	100
				RT	85	110	195			RT	110	195
				Total	1310	1400	1700			Total	1355	1650
			Int	Total	3815	4210	5565		Int	Total	4165	5515
9	I-5 SB Off-Ramp & S 356th St & 18th Ave S	n/a						Roundabout	EB	U-Turn	60	55
										LT (18th Ave)	n/a	50
										Total	60	105
									SB	RT	n/a	35
										Total		35
									WB	TH	90	95
										RT	n/a	5
										Total	90	100
									Int	Total	150	240

Notes:

NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = Left; TH = Through; RT = Right; Appr = Approach; Mvmt = Movement; n/a = not applicable. Volume are in vehicles per hour.

[1] NEB approach to #5 SR 161/S 356th Street/16th Avenue S roundabout is the 16th Avenue approach.

Triangle IJR Amendment

Table E-2

Intersection Turn Movement Volumes, PM Peak Hour

		Existing/No Build						Build				
Int #	Int Name	Traffic Control	Appr	Mvmt	2015 Existing	2020 No Build	2040 No Build	Traffic Control	Appr	Mvmt	2020 Build	2040 Build
1	Enchanted Pkwy S & S 348th St	Signal	NB	U-Turn	100	90	100	Signal	NB	U-Turn	90	100
				LT	305	300	300			LT	300	300
				TH	540	580	760			TH	580	760
				RT	575	595	550			RT	595	550
				Total	1520	1565	1710			Total	1565	1710
			EB	LT	115	135	200		EB	LT	135	200
				TH	1220	1305	1640			TH	1305	1640
				RT	285	315	435			RT	315	435
				Total	1620	1755	2275			Total	1755	2275
			SB	LT	395	410	470		SB	LT	410	470
				TH	635	700	885			TH	740	935
				RT	120	160	225			RT	160	225
				Total	1150	1270	1580			Total	1310	1630
			WB	LT	1150	1135	1100		WB	LT	510	425
				TH	1495	1520	1625			TH	1445	1525
				TH-HOV	240	265	325			TH-HOV	265	325
				RT	370	380	430			RT	380	430
				Total	3255	3300	3480			Total	2600	2705
			Int	Total	7545	7890	9045		Int	Total	7230	8320
2	I-5 SB Off-Ramp & SR 18	Signal	n/a					Signal	EB	TH	1265	1670
										Total	1265	1670
			SB	RT	1035	1065	1095		SB	LT	1160	1230
				RT-HOV	435	435	505			RT	775	775
				Total	1470	1500	1600			Total	1935	2005
			WB	TH	1785	1800	1880		WB	TH	1825	1930
				Total	1785	1800	1880			Total	1825	1930
			Int	Total	3255	3300	3480		Int	Total	5025	5605
3	Enchanted Pkwy S & S 352nd St	Signal	NB	LT	10	15	30	Signal	NB	LT	15	30
				TH	940	1000	1210			TH	1030	1210
				RT	195	115	115			RT	130	115
				Total	1145	1130	1355			Total	1175	1355
			EB	LT	20	30	75		EB	LT	30	75
				TH	5	90	90			TH	90	90
				RT	25	30	25			RT	30	25
				Total	50	150	190			Total	150	190
			SB	LT	185	190	190		SB	LT	185	180
				TH	1530	1480	1745			TH	985	1105
				RT	40	175	250			RT	105	305
				Total	1755	1845	2185			Total	1275	1590
			WB	LT	250	225	140		WB	LT	225	360
				TH	5	10	10			TH	10	85
				RT	265	260	210			RT	260	210
				Total	520	495	360			Total	495	655
			Int	Total	3470	3620	4090		Int	Total	3095	3790
4	16th Ave S & S 356th St	Signal	NB	LT	20	20	20	n/a				
				RT	90	120	120					
				Total	110	140	140					
			EB	TH	395	365	375					
				RT	15	25	50					
				Total	410	390	425					
			SB	TH	70	90	155					
				RT	250	150	240					
				Total	320	240	395					
			WB	LT	30	45	135					
				TH	410	410	460					
				Total	440	455	595					
			Int	Total	1280	1225	1555					
5	Enchanted Pkwy S & S 356th St	Signal	NB	LT	355	370	430	Round-about	NB	n/a		
				TH	930	985	1200			RT	1380	1645
				RT	45	50	65			Total	1380	1645
				Total	1330	1405	1695		NEB[1]	RT	140	140
			n/a							Total	140	140
			EB	LT	210	140	110		EB	n/a		
				TH	5	10	10			RT	390	425
				RT	270	335	375			Total	390	425
				Total	485	485	495		SB	n/a		
			SB	LT	20	20	25			TH	1135	1425
				TH	1445	1460	1510			RT	90	95
				n/a						Total	1225	1520
				Total	1465	1480	1535		WB	n/a		
			WB	LT	30	35	175			RT	490	480
				TH	85	85	165			Total	490	480
				RT	20	20	60					
				Total	135	140	400					
			Int	Total	3415	3510	4125		Int	Total	3485	4070

Triangle IJR Amendment

Table E-2

Intersection Turn Movement Volumes, PM Peak Hour

Int #	Int Name	Existing/No Build						Build				
		Traffic Control	Appr	Mvmt	2015 Existing	2020 No Build	2040 No Build	Traffic Control	Appr	Mvmt	2020 Build	2040 Build
6	Enchanted Pkwy S & SR 18 WB Off-Ramp	Signal	NB	TH	960	1025	1275	Signal	NB	TH	1025	1275
				Total	960	1025	1275			Total	1025	1275
			SB	TH	1745	1830	2060		SB	TH	1455	1660
				Total	1745	1830	2060			Total	1455	1660
			WB	LT	435	460	560		WB	LT	835	960
				RT	370	380	420			RT	355	370
				Total	805	840	980			Total	1190	1330
			Int	Total	3510	3695	4315		Int	Total	3670	4265
7	Enchanted Pkwy S & Milton Rd/20th Ave S	Signal	NB	LT	20	20	10	Signal	NB	LT	20	10
				TH	610	610	630			TH	610	630
				RT	20	25	25			RT	25	25
				Total	650	655	665			Total	655	665
			EB	LT	175	195	255		EB	LT	195	255
				TH	45	55	85			TH	55	85
				RT	45	50	55			RT	50	55
				Total	265	300	395			Total	300	395
			SB	LT	175	215	365		SB	LT	215	365
				TH	1475	1545	1765			TH	1545	1765
				RT	530	530	490			RT	530	490
				Total	2180	2290	2620			Total	2290	2620
			WB	LT	30	35	55		WB	LT	35	55
				TH	95	100	110			TH	100	110
				RT	175	220	390			RT	220	390
				Total	300	355	555			Total	355	555
			Int	Total	3395	3600	4235		Int	Total	3600	4235
8	SR 99 & S 348th St	Signal	NB	LT	185	195	220	Signal	NB	LT	195	220
				TH	400	340	485			TH	340	485
				TH-HOV	n/a	100	100			TH-HOV	100	100
				RT	450	480	585			RT	480	585
				Total	1035	1115	1390			Total	1115	1390
			EB	LT	80	90	125		EB	LT	90	125
				TH	875	950	1190			TH	950	1190
				TH-HOV	150	160	260			TH-HOV	160	260
				RT	230	245	290			RT	245	290
				Total	1335	1445	1865			Total	1445	1865
			SB	LT	145	165	240		SB	LT	165	240
				TH	735	630	1000			TH	630	1000
				TH-HOV	n/a	200	200			TH-HOV	200	200
				RT	165	190	285			RT	190	285
				Total	1045	1185	1725			Total	1185	1725
			WB	LT	765	790	870		WB	LT	715	770
				TH	1150	1190	1240			TH	1190	1240
				TH-HOV	185	205	275			TH-HOV	205	275
				RT	60	60	90			RT	60	90
				Total	2160	2245	2475			Total	2170	2375
			Int	Total	5575	5990	7455		Int	Total	5915	7355
9	I-5 SB Off-Ramp & S 356th St (Future)	n/a						Round-about	EB	U-Turn	105	85
										LT (18th Ave)	n/a	10
										Total	105	95
									SB	RT	n/a	40
										Total		40
									WB	TH	350	300
										RT	n/a	125
										Total	350	425
									Int	Total	455	560

Notes:

NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = Left; TH = Through; RT = Right; Appr = Approach; Mvmt = Movement; n/a = not applicable. Volume are in vehicles per hour.

[1] NEB approach to #5 SR 161/S 356th Street/16th Avenue S roundabout is the 16th Avenue approach.

Table E-3

VISSIM Intersection Results, AM Peak Hour

				2015 PM Existing			2020 AM Year of Opening								2040 AM Design Year							
							No Build			Build			Difference		No Build			Build			Difference	
Int #	North-South Street	East-West Street	Traffic Control	Delay	LOS	% Demand Served	Delay	LOS	% Demand Served	Delay	LOS	% Demand Served	Delay	% Demand Served	Delay	LOS	% Demand Served	Delay	LOS	% Demand Served	Delay	% Demand Served
1	SR 161 (Enchanted Pkwy S)	SR 18 (S 348th St)	Signal	33	C	100%	33	C	100%	29	C	100%	-3	0%	45	D	99%	38	D	100%	-7	1%
2	I-5 SB Off-Ramp	SR 18	Signal	8	A	100%	8	A	100%	12	B	100%	3	0%	9	A	100%	14	B	100%	5	0%
3	SR 161 (Enchanted Pkwy S)	S 352nd St	Signal	8	A	94%	13	B	100%	20	C	100%	7	0%	23	C	100%	28	C	100%	5	0%
4	16th Ave S	S 356th St	Signal	37	D	97%	35	C	100%	n/a			n/a	n/a	33	C	100%	n/a			n/a	n/a
5	SR 161 (Enchanted Pkwy S)	S 356th St	Signal / Roundabout	15	B	100%	16	B	100%	12	B	99%	-4	0%	23	C	100%	25	C	100%	2	0%
6	SR 161 (Enchanted Pkwy S)	SR 18 WB Off-Ramp	Signal	4	A	98%	5	A	99%	14	B	100%	9	1%	6	A	100%	14	B	99%	9	-1%
7	SR 161 (Enchanted Pkwy S)	Milton Rd S	Signal	15	B	98%	26	C	99%	27	C	100%	1	1%	38	D	100%	34	C	99%	-4	0%
8	SR 99 (Pacific Hwy S)	SR 18 (S 348th St)	Signal	33	C	100%	33	C	100%	32	C	100%	-1	0%	59	E	98%	45	D	100%	-14	2%
9	18th Ave S	I-5 SB Off-Ramp	Roundabout	n/a			n/a			3	A	100%	n/a	n/a	n/a			11	B	98%	n/a	n/a
			AM Average =	***17***		***98%***	***19***		***100%***	***21***		***100%***	***2***	***0%***	***29***		***99%***	***28***		***100%***	***-1***	***1%***

Table E-4

VISSIM Intersection Results, PM Peak Hour

				2015 PM Existing			2020 PM Year of Opening								2040 PM Design Year							
							No Build			Build			Difference		No Build			Build			Difference	
Int #	North-South Street	East-West Street	Traffic Control	Delay	LOS	% Demand Served	Delay	LOS	% Demand Served	Delay	LOS	% Demand Served	Delay	% Demand Served	Delay	LOS	% Demand Served	Delay	LOS	% Demand Served	Delay	% Demand Served
1	SR 161 (Enchanted Pkwy S)	SR 18 (S 348th St)	Signal	90	F	98%	57	E	97%	53	D	99%	-4	3%	107	F	82%	72	E	92%	-35	10%
2	I-5 SB Off-Ramp	SR 18	Signal	242	F	100%	216	F	95%	95	F	100%	-121	5%	344	F	71%	137	F	94%	-208	22%
3	SR 161 (Enchanted Pkwy S)	S 352nd St	Signal	44	D	100%	36	D	95%	21	C	99%	-14	4%	48	D	84%	70	E	87%	22	3%
4	16th Ave S	S 356th St	Signal	39	D	100%	33	C	97%	n/a			n/a		41	D	91%	n/a			n/a	n/a
5	SR 161 (Enchanted Pkwy S)	S 356th St	Signal / Roundabout	52	D	100%	45	D	96%	27	C	100%	-18	4%	69	E	89%	80	F	93%	11	4%
6	SR 161 (Enchanted Pkwy S)	SR 18 WB Off-Ramp	Signal	52	D	100%	27	C	96%	41	D	98%	14	3%	66	E	88%	61	E	92%	-5	4%
7	SR 161 (Enchanted Pkwy S)	Milton Rd S	Signal	38	D	100%	35	C	95%	35	C	98%	0	2%	41	D	89%	42	D	92%	1	3%
8	SR 99 (Pacific Hwy S)	SR 18 (S 348th St)	Signal	47	D	98%	44	D	99%	45	D	100%	1	1%	136	F	80%	117	F	89%	-19	10%
9	18th Ave S	I-5 SB Off-Ramp	Roundabout	n/a			n/a			4	A	96%	n/a	n/a	n/a			80	F	98%	n/a	n/a
			PM Average =	***81***		***99%***	***66***		***96%***	***45***		***99%***	***-21***	***3%***	***116***		***84%***	***83***		***91%***	***-33***	***7%***

Notes:

Delay is in seconds per vehicle. HCM 2010 intersection LOS thresholds have been applied to delay from VISSIM for comparison purposes.

Results shaded in yellow are at agency LOS standards while results shaded in red are below agency LOS standards.

SR 161/S 356th St is signalized in the Existing and No Build alternatives and a roundabout in the Build Alternative.

Triangle IJR Amendment

Table E-5

VISSIM Intersection Queue Results - AM Peak Hour

		Existing / No Build										Build							
						2015		2020		2040						2020		2040	
Int. #	Intersection Name	Control Type	Appr. Dir.	Lane Group	Storage Length	Avg. Queue	95th Perc. Queue	Avg. Queue	95th Perc. Queue	Avg. Queue	95th Perc. Queue	Control Type	Appr. Dir.	Lane Group	Storage Length	Avg. Queue	95th Perc. Queue	Avg. Queue	95th Perc. Queue
1	Enchanted Pkwy S & S 348th St	Signal	NB	LT	360	270	793	164	312	199	327	Signal	NB	LT	360	148	255	234	459
				TH	1130	350	729	317	561	340	609			TH	1130	313	492	433	912
				RT	640	344	723	312	555	335	603			RT	640	307	486	428	906
			EB	LT	385	57	146	78	166	127	256		EB	LT	385	76	164	133	272
				TH	940	214	436	319	582	687	1061			TH	940	320	587	494	996
				RT	450	8	44	15	65	47	130			RT	450	11	55	30	95
			SB	LT	460	111	197	118	213	107	207		SB	LT	460	121	229	98	178
				TH/RT	760	89	168	91	172	88	149			TH/RT	760	95	168	95	162
			WB	LT	600	131	214	134	213	169	263		WB	LT	600	76	135	90	146
				TH	1000	257	451	331	568	500	1086			TH	1000	308	555	419	727
				RT	240	45	185	51	195	91	349			RT	240	62	222	123	466
2	I-5 SB Off-Ramp & SR 18	Signal	EB	n/a								Signal	EB	TH	1025	159	375	196	447
			SB	RT	1650	44	95	56	123	62	149		SB	LT	2200	116	215	131	237
				n/a										RT	2200	56	107	65	124
			WB	TH	715	127	222	133	266	152	304		WB	TH	715	157	277	224	387
3	Enchanted Pkwy S & S 352nd St	Signal	NB	LT	150	1	2	1	1	3	21	Signal	NB	LT	150	3	20	3	20
				TH/RT	1250	81	238	121	321	371	1030			TH/RT	1250	279	550	414	782
			EB	LT	85	22	64	95	242	258	566		EB	LT	85	102	257	267	566
				TH/RT	500	0	0	55	169	19	64			TH/RT	500	53	169	17	63
			SB	LT	400	42	131	50	134	79	179		SB	LT	400	61	149	78	178
				TH	1130	35	107	49	127	144	279			TH	1130	33	90	81	179
				RT	1130	2	19	7	23	15	45			RT	1130	4	20	14	44
			WB	LT	150	62	127	66	132	56	107		WB	LT	150	72	146	66	115
				TH	450	63	128	67	133	57	108			TH	450	73	147	67	116
				RT	150	60	125	65	130	54	104			RT	150	70	144	64	113
4	16th Ave S & S 356th St	Signal	NB	LT/RT	850	42	105	81	235	75	185	n/a							
			EB	TH/RT	1400	169	292	149	275	175	326								
			SB	TH	380	10	42	18	64	41	130								
				RT	55	4	41	6	43	10	67								
			WB	TH/LT	90	7	26	12	44	8	38								
5	Enchanted Pkwy S & S 356th St	Signal	NB	LT	250	127	255	192	356	244	423	Round about	NB	n/a					
				TH/RT	925	175	449	106	237	205	464			RT	890	141	535	174	626
			n/a										NEB	RT	640	17	64	25	72
			EB	TH/LT	90	36	112	33	95	32	95		EB	n/a					
				RT	90	40	112	32	75	34	77			RT	700	23	67	31	70
			SB	LT	300	8	23	9	38	7	22		SB	n/a					
				TH	1250	54	127	81	187	145	295			TH	1100	27	81	49	107
				n/a										RT	420	12	44	10	28
			WB	LT	100	5	22	6	34	10	40		WB	n/a					
				TH/RT	300	42	128	52	147	70	191			RT	450	23	67	31	70
6	Enchanted Pkwy S & SR 18 WB Off-Ramp	Signal	NB	TH	750	81	290	80	317	52	111	Signal	NB	TH	750	58	124	105	258
			SB	TH	945	30	88	18	79	17	48		SB	TH	945	34	100	54	127
			WB	LT/RT	1500	21	57	42	98	74	143		WB	LT/RT	1500	166	298	165	274
7	Enchanted Pkwy S & Milton Rd/20th Ave S	Signal	NB	LT	225	9	39	17	60	28	85	Signal	NB	LT	225	17	57	25	83
				TH/RT	2000	162	336	258	524	507	1002			TH/RT	2000	260	513	434	827
			EB	LT	370	60	146	69	153	101	211		EB	LT	370	84	184	127	253
				TH/RT	1500	22	74	43	117	119	238			TH/RT	1500	49	123	128	264
			SB	LT	260	64	165	167	323	181	325		SB	LT	260	195	412	193	420
				TH/RT	750	56	157	80	201	141	334			TH/RT	750	42	110	85	211
			WB	TH/LT	1200	19	63	45	110	85	254		WB	TH/LT	1200	40	102	9	39
				RT	130	16	71	79	191	112	257			RT	130	68	168	62	166
8	SR 99 & S 348th St	Signal	NB	LT	230	93	172	93	176	92	164	Signal	NB	LT	230	96	177	92	168
				TH	1800	188	549	151	257	265	472			TH	1800	164	278	306	517
				RT	185	192	572	109	207	180	346			RT	185	121	218	212	478
			EB	LT	180	43	112	89	198	279	1685		EB	LT	180	59	127	94	171
				TH	1100	285	502	339	624	986	1798			TH	1100	338	615	598	1251
				RT	1100	78	193	80	174	572	1781			RT	1100	100	210	271	798
			SB	LT	250	68	152	57	121	82	160		SB	LT	250	53	117	86	168
				TH	2000	95	192	107	195	142	237			TH	2000	104	188	165	256
				RT	160	2	12	48	134	83	197			RT	160	49	157	103	237
			WB	LT	380	146	234	157	255	187	318		WB	LT	380	143	240	166	264
				TH	915	107	221	117	242	150	317			TH	915	110	195	173	371
				RT	650	41	107	12	58	29	108			RT	650	12	60	55	222
9	I-5 SB Off-Ramp & S 356th St & 18th Ave S	n/a										Round about	SB	RT	1000	n/a		9	71
													WB	RT	440	0	0	1	14

Notes

NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = Left; TH = Through; RT = Right; Appr. Dir. = Approach Direction; Mvmt = Movement;
n/a = not applicable. Storage and queue lengths are in feet. Red shaded values indicate queue length would exceed storage length.

Triangle IJR Amendment

Table E-6

VISSIM Intersection Queue Results - PM Peak Hour

		Existing / No Build										Build							
						2015		2020		2040						2020		2040	
Int. #	Intersection Name	Control Type	Appr. Dir.	Lane Group	Storage Length	Avg. Queue	95th Perc. Queue	Avg. Queue	95th Perc. Queue	Avg. Queue	95th Perc. Queue	Control Type	Appr. Dir.	Lane Group	Storage Length	Avg. Queue	95th Perc. Queue	Avg. Queue	95th Perc. Queue
1	Enchanted Pkwy S & S 348th St	Signal	NB	LT	360	484	1227	358	804	758	1240	Signal	NB	LT	360	311	841	248	487
				TH	1130	538	1230	451	821	919	1259			TH	1130	499	1033	595	1120
				RT	640	534	1224	445	815	913	1253			RT	640	493	1027	590	1114
			EB	LT	385	86	198	134	277	233	611		EB	LT	385	142	276	229	457
				TH	940	177	288	227	411	769	1102			TH	940	278	443	443	1059
				RT	450	83	231	109	325	751	1104			RT	450	85	221	430	1102
			SB	LT	460	255	397	230	424	477	1137		SB	LT	460	237	431	308	795
				TH/RT	760	992	1419	230	341	464	1079			TH/RT	760	245	377	568	1386
			WB	LT	600	3347	5298	4213	5313	4441	5313		WB	LT	600	159	239	149	280
				TH	1000	3401	5302	4910	5313	4873	5313			TH	1000	949	1163	1015	1166
				RT	240	37	135	1031	5296	1839	5303			RT	240	58	199	126	881
2	I-5 SB Off-Ramp & SR 18	Signal	EB	n/a								Signal	EB	TH	1025	239	476	334	654
			SB	RT	1650	2964	5298	4890	5313	4888	5318		SB	LT	2200	716	1615	850	1788
				n/a										RT	2200	710	1620	852	1793
			WB	TH	715	2757	5298	1996	3562	4878	5353		WB	TH	715	1679	3558	4917	5353
3	Enchanted Pkwy S & S 352nd St	Signal	NB	LT	150	4	21	7	31	11	48	Signal	NB	LT	150	6	24	13	45
				TH/RT	1250	286	538	238	391	478	1242			TH/RT	1250	265	465	357	640
			EB	LT	85	22	59	29	92	72	213		EB	LT	85	31	103	71	214
				TH/RT	500	12	62	96	233	108	258			TH/RT	500	106	230	109	254
			SB	LT	400	83	199	83	190	62	145		SB	LT	400	67	157	103	242
				TH	1130	754	1366	602	1372	1718	2278			TH	1130	101	210	1223	2275
				RT	1130	8	25	140	648	19	72			RT	1130	13	41	539	2235
			WB	LT	150	235	508	159	373	90	150		WB	LT	150	135	247	470	526
				TH	450	236	509	159	374	91	151			TH	450	136	248	470	527
				RT	150	233	506	156	371	88	147			RT	150	133	245	467	524
4	16th Ave S & S 356th St	Signal	NB	LT/RT	850	60	151	63	163	60	146								
			EB	TH/RT	1400	223	386	208	340	264	422								
			SB	TH	380	68	237	71	212	150	344								
				RT	55	57	185	17	61	48	191								
			WB	TH/LT	90	30	88	24	72	64	151								
5	Enchanted Pkwy S & S 356th St	Signal	NB	LT	250	314	611	312	525	2009	5298	Round about	NB	n/a					
				TH/RT	925	217	440	224	371	661	4424			RT	890	133	382	146	498
			n/a										NEB	RT	640	130	460	626	1037
			EB	TH/LT	90	70	155	61	148	85	157		EB	n/a					
				RT	90	73	155	66	148	87	157			RT	700	73	167	144	354
			SB	LT	300	19	64	18	61	19	65		SB	n/a					
				TH	1250	1240	1363	1088	1468	1292	1540			TH	1100	469	1175	1181	1471
				n/a										RT	420	23	55	21	62
			WB	LT	100	22	63	28	84	172	437		WB	n/a					
				TH/RT	300	62	160	81	192	213	439			RT	450	73	167	144	354
6	Enchanted Pkwy S & SR 18 WB Off-Ramp	Signal	NB	TH	750	208	416	94	175	177	369	Signal	NB	TH	750	152	279	275	535
			SB	TH	945	682	1076	439	1008	682	1074		SB	TH	945	674	1452	1757	2559
			WB	LT/RT	1500	1035	5295	283	454	1544	5296		WB	LT/RT	1500	415	618	521	904
7	Enchanted Pkwy S & Milton Rd/20th Ave S	Signal	NB	LT	225	19	51	22	67	10	41	Signal	NB	LT	225	21	62	10	42
				TH/RT	2000	156	262	174	294	214	349			TH/RT	2000	172	291	208	362
			EB	LT	370	138	278	166	306	225	417		EB	LT	370	174	325	307	696
				TH/RT	1500	51	141	70	172	99	223			TH/RT	1500	67	171	104	232
			SB	LT	260	142	248	253	767	464	789		SB	LT	260	298	766	550	793
				TH/RT	750	669	856	586	784	632	852			TH/RT	750	627	790	665	853
			WB	TH/LT	1200	101	214	122	280	169	469		WB	TH/LT	1200	141	309	59	134
				RT	130	20	62	53	113	123	298			RT	130	58	128	121	339
8	SR 99 & S 348th St	Signal	NB	LT	230	92	165	96	167	119	214	Signal	NB	LT	230	97	174	121	212
				TH	1800	189	438	133	219	263	934			TH	1800	136	233	263	1173
				RT	185	169	477	104	197	376	1017			RT	185	120	240	309	1218
			EB	LT	180	78	154	107	342	772	1854		EB	LT	180	98	207	369	1811
				TH	1100	291	465	381	631	1212	1850			TH	1100	370	606	1018	1811
				RT	1100	228	458	290	577	1194	1843			RT	1100	282	567	990	1805
			SB	LT	250	220	612	85	150	1486	2062		SB	LT	250	85	155	971	2053
				TH	2000	417	717	309	478	1778	2075			TH	2000	306	505	1790	2071
				RT	160	39	126	287	483	1782	2080			RT	160	290	510	1795	2076
			WB	LT	380	260	419	353	742	322	701		WB	LT	380	305	448	278	434
				TH	915	238	428	260	452	206	391			TH	915	280	436	296	434
				RT	650	95	210	95	262	31	114			RT	650	16	64	15	60
9	I-5 SB Off-Ramp & S 356th St & 18th Ave S	n/a										Round about	SB	RT	1000	n/a		97	364
													WB	RT	440	1	5	9	34

Notes

NB = northbound; EB = eastbound; SB = southbound; WB = westbound; NEB = northeastbound; LT = Left; TH = Through; RT = Right; Appr. Dir. = Approach Direction; Mvmt = Movement; n/a = not applicable. Storage and queue lengths are in feet. Red shaded values indicate queue length would exceed storage length.

Appendix F
IHSDM Analysis Results

Triangle IJR Amendment

Table F-1

Summary of 2040 Phase 2 IHSDM Results Compared to 2040 No Build

	Analysis Section	Change from 2040 No Build									
		2040 Previous Phase 2					*2040 Current Phase 2*				
		Change in F.I. Crash Frequency	Percent Change: F.I.	Change in Total Crash Frequency	Percent Change: Total	Cause of Change[3]	Change in F.I. Crash Frequency	Percent Change: F.I.	Change in Total Crash Frequency	Percent Change: Total	Cause of Change[3]
	Mainline/Arterial										
M1	I-5 (S 320th to SR 161 Overpass)	0.1	0%	0.0	0%	-	**-0.1**	0%	**-0.7**	0%	Remove Connection
M2	SR 18 (SR 161 to I-5 NB/SB Slip Ramps)	0.0	0%	0.0	0%	-	0.0	0%	**-0.1**	0%	Volume Decr.
M3	SR 161 (S 356th to WB SR 18 Off Ramp)	**-0.4**	**-13%**	**-1.4**	**-12%**	Volume Decr.	**-0.4**	**-13%**	**-1.4**	**-12%**	Volume Decr.
Subtotal		***-0.3***	***-12%***	***-1.4***	***-1%***	-	***-0.5***	***-13%***	***-2.2***	***-1%***	-
	Ramps										
SB I-5											
R1	SB I-5 to SR 18 Ramp (NW Slip)[1]	0.5	26%	0.1	2%	Length Incr.	0.7	36%	0.4	7%	Length Incr.
R2	SB I-5 to EB SR 18 Ramp (SW Loop)	**-0.4**	**-13%**	**-1.1**	**-16%**	Improved Deceleration	**-3.0**	-	**-7.1**	-	Removed
R3	WB SR 18 to SB I-5/SR 161 Flyover Ramp	0.0	0%	0.0	0%	-	0.0	0%	0.0	0%	-
R4	EB SR 18 to SB I-5 Ramp (SW Slip)	0.0	0%	0.0	0%	-	0.0	0%	0.0	0%	-
R5	SB I-5 to S 356th St[2]	0.9	-	2.0	-	New Facility	2.4	-	4.9	-	New Facility, Curvature
SR 161/SR 18											
R6	WB SR 18 to SR 161 Ramp	0.1	21%	0.1	10%	Volume Incr., New Connection	0.1	21%	0.1	10%	Volume Incr., New Connection
R7	SB I-5 to SR 161 SB Ramp[2]	0.0	0%	0.1	-	New Facility	0.1	10%	0.1	-	New Facility
Subtotal		*1.1*	*33%*	*1.1*	*5%*	-	*0.3*	*67%*	***-1.7***	***-7%***	-
	Intersections										
I1	SB I-5 Off Ramp/SR 18 (S 348th St)	**-1.5**	**-23%**	**-3.1**	**-19%**	Volume Decr.	1.9	29%	6.3	39%	Volume Incr.
I2	SR 161/SR 18 (S 348th St)	**-0.5**	**-13%**	**-1.4**	**-13%**	Volume Decr.	**-0.5**	**-13%**	**-1.4**	**-13%**	Volume Decr.
I3	SR 161/S 352nd St	**-0.2**	**-11%**	**-0.4**	**-8%**	Volume Decr.	**-0.2**	**-11%**	**-0.4**	**-8%**	Volume Decr.
I4	SR 161/S 356th St	**-0.7**	**-30%**	6.4	96%	Minor Leg Volume Incr.	0.4	17%	**-0.3**	**-5%**	Minor Leg Volume Incr., Roundabout
I5	WB SR 18 Off Ramp/SR 161	0.4	17%	0.5	8%	Minor Leg Volume Incr.	0.4	17%	0.5	8%	Minor Leg Volume Incr.
Subtotal		***-2.5***	***-60%***	2.0	5%	-	*2.0*	39%	4.6	10%	-
Total/Average		***-1.7***	***-2%***	*1.7*	*1%*	-	*1.8*	*3%*	*0.7*	*0%*	-
	Existing Facilities	**-2.6**	**-4%**	**-0.4**	0%		**-0.7**	**-1%**	**-4.3**	**-2%**	
	New Facilities[2]	0.9	-	2.1	-		2.5	-	5.0	-	

Note: F.I. = Fatal and Injury

[1]Ramp connects to SR 18 WB only for 2040 No Build and 2040 Previous Phase 2. Ramp connects to WB and EB SR 18 for 2040 Current Phase 2.

[2]New facilities include the SB I-5 to SR 161/S 356th Ramp and the connection between the SB I-5 to SR 161 Ramp and the WB SR 18 to SR 161 Ramp

[3]Cause of Change Definitions:

New Facility = Proposed ramp

New Connection = Proposed ramp connection to mainline/ramp

Remove Connection = Removed ramp

Length Incr. = Increase in length/exposure

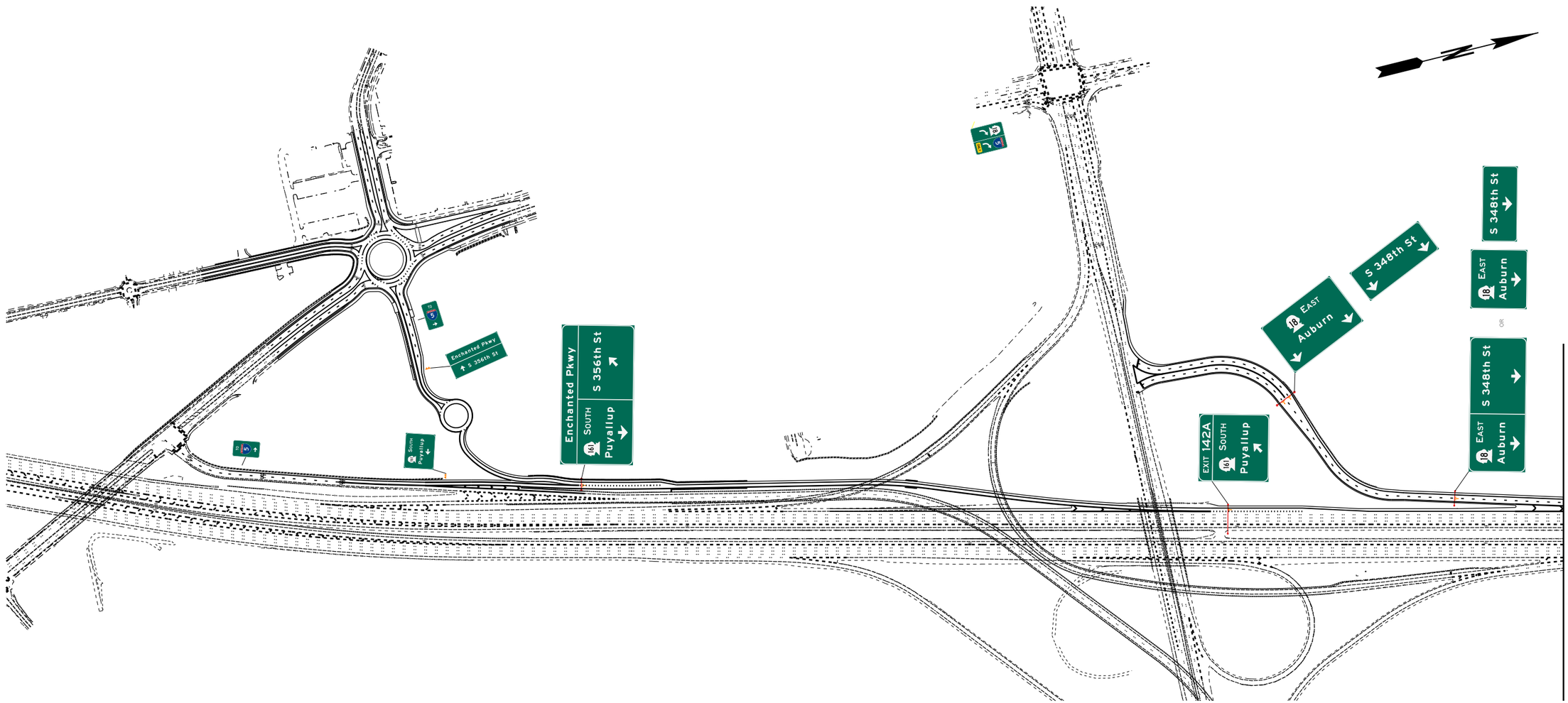
Improved Deceleration = Increased length of deceleration before low speed horizontal curve

Curvature = Increase in horizontal curvature

Roundabout = Proposed roundabout at intersection

Volume Incr./Decr. = Increase/Decrease in Total ADT

Appendix G
Conceptual Signing Plan for Proposed Phase 2 Improvements



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DATE	3/16/2016						
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DESIGNED BY							
ENTERED BY							
CHECKED BY					CONTRACT NO.	LOCATION NO.	
PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

DATE
P.E. STAMP BOX

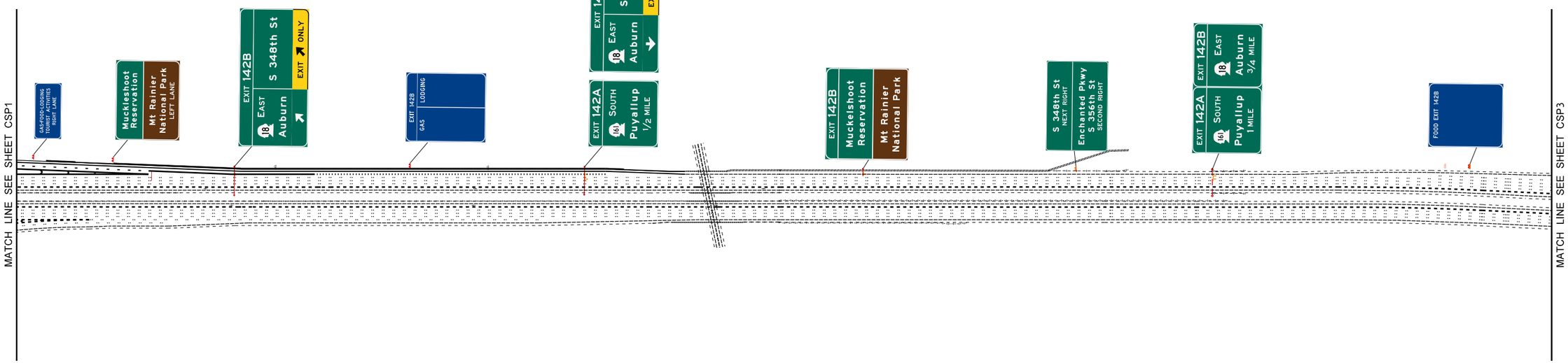
DATE
P.E. STAMP BOX

Washington State
Department of Transportation

I-5
SR 161/SR 18 (TRIANGLE) I/C PROJECT
IJR AMENDMENT

CONCEPTUAL SIGNING PLAN

Plot 1
PLAN REF NO
CSP1
SHEET 1 OF 3 SHEETS



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DESIGNED BY							
ENTERED BY							
CHECKED BY							
PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

REGION NO.	STATE
10	WASH

JOB NUMBER

CONTRACT NO.

FED.AID PROJ.NO.

LOCATION NO.

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

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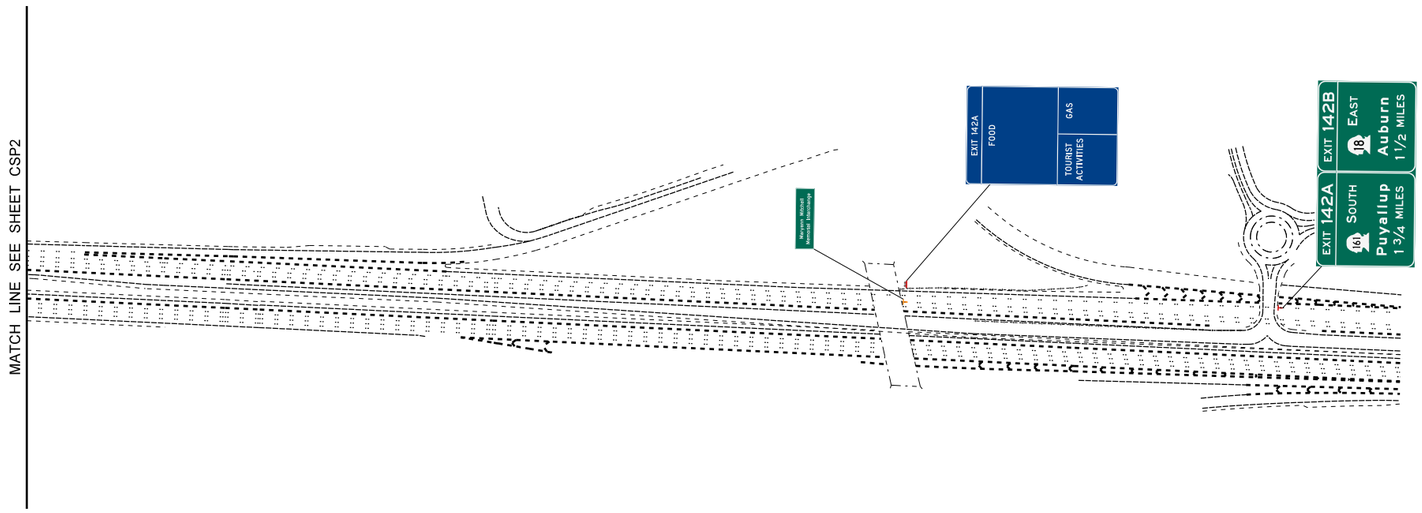
SR 161/SR 18 (TRIANGLE) I/C PROJECT
IJR AMENDMENT

CONCEPTUAL SIGNING PLAN

Plot 2

PLAN REF NO
CSP2

SHEET 2 OF 3 SHEETS



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PLOTTED BY	labollt								SHEET 3 OF 3 SHEETS
DESIGNED BY					CONTRACT NO.		LOCATION NO.		
ENTERED BY									
CHECKED BY									
PROJ. ENGR.									
REGIONAL ADM.		REVISION	DATE	BY					

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

I-5
SR 161/SR 18 (TRIANGLE) I/C PROJECT
IJR AMENDMENT

CONCEPTUAL SIGNING PLAN