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SR 9, MP 13.80
24TH STREET SE / SOUTH LAKE STEVENS ROAD
INTERSECTION CONTROL EVALUATION
DRAFT REPORT

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Washington State Department of Transportation

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INTRODUCTION

This Intersection Control Evaluation (ICE) Report was prepared to evaluate a full-access intersection improvement project for the SR 9 and 24th Street SE / South Lake Stevens Road intersection. This ICE will also consider the impacts of control changes at the SR 9 and 24th Street SE / South Lake Stevens Road intersection to the nearby intersections of SR 9 and 20th Street SE and 20th Street and 91st Avenue SE.

This analysis included travel time, Level of Service, and queueing analysis for the areas shown in **Figure 1**. Travel time evaluation included SR 9 from US 2 eastbound ramps to 4th Street SE and 20th Street SE from 91st Avenue SE to SR 9. Level of Service and queueing were analyzed at the following intersections:

- SR 9 & South Lake Stevens Road / 24th Street SE
- SR 9 & 20th Street SE
- 20th Street SE and 91st Avenue SE

In order for the traffic simulation model used in this analysis to accurately represent traffic patterns entering and exiting the traffic analysis area, the traffic model was built to extend beyond the analysis area in each direction. The traffic model area included SR 9 from 30th Street/John Jump Road to Market Place and 20th Street SE from 83rd Avenue SE to S Lake Stevens Road.

1. BACKGROUND AND PROJECT NEEDS

Existing Roadways

The intersection of SR 9 and South Lake Stevens Road is in the City of Lake Stevens, near the south City Limit. The east and west legs of the intersection are stop sign controlled. Turn restrictions are shown in **Figure 2**.

SR 9 is a north-south Urban Principal Arterial with a posted speed of 55 mph in the study area. The route is designated by WSDOT as a Highway of Statewide Significance (HSS). SR 9 consists of two lanes from US 2 to the south approach of the S Lake Stevens Road intersection, where it widens to accommodate (1) turn lanes at the S Lake Stevens Road intersection, (2) turn lanes at the 20th Street SE intersection and (3) two northbound and southbound through lanes from S Lake Stevens Road to 1,300 feet north of 20th Street SE. SR 9 includes 8-foot paved shoulder on both sides of the roadway. SR 9 is a Highway of Statewide Significance (HSS), with a minimum Level of Service (LOS) threshold of LOS D. Average Daily Traffic (ADT) on SR 9 is approximately 21,000 with 1 percent trucks.

20th Street SE is an east-west minor arterial with a posted speed of 35 mph in the study area. It consists of a five-lane section from 400 feet west of 91st Avenue SE through the S Lake Stevens Road intersection. ADT on 20th Street SE is approximately 16,000, with 1 percent truck traffic.

South Lake Stevens Road is a two-lane Major Collector which connects 87th Avenue SE to the southwest with 20th Street SE and the Machias Cutoff to the northeast. Posted speed is 35 mph. ADT on S Lake Stevens Road is approximately 2,000 with less than 1 percent trucks.

Turning movement counts were collected in March 2018 at each study intersection. Observed turning movement volumes for are summarized in **Tables 1** and **2**.

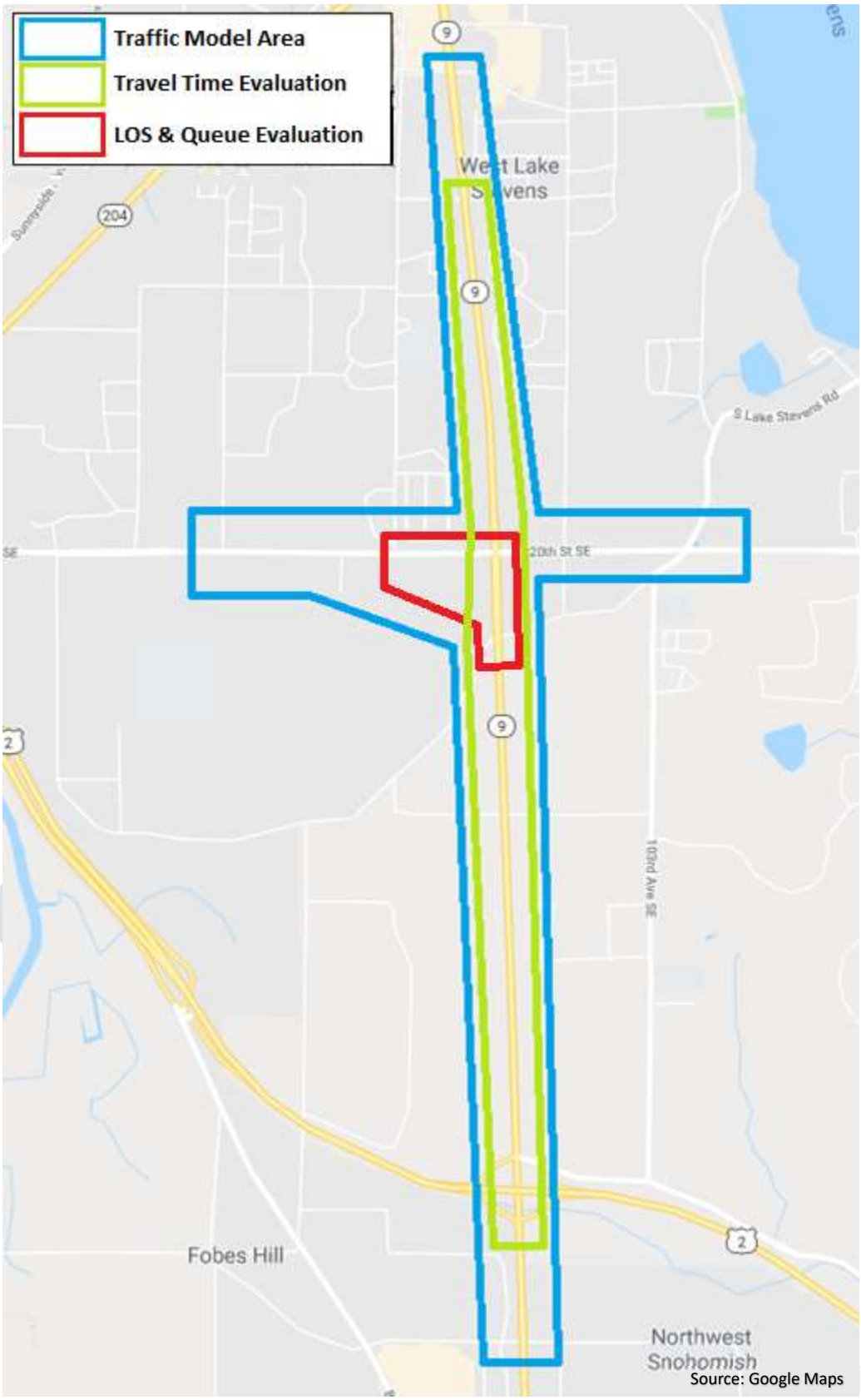

Figure 1. Study Area

Figure 2. Existing Channelization at SR 9 and S Lake Stevens Road

Table 1. 2018 AM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	29	4	1	0	0	12	7	391	29	0	903	524
SR 9 & 20th St SE	122	261	253	415	362	84	45	329	52	63	744	58
20th St SE & 91st Ave SE	0	451	77	0	350	117	0	0	0	157	0	81

Table 2. 2018 PM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	122	3	11	1	0	10	5	888	122	0	741	49
SR 9 & 20th St SE	50	717	126	143	313	69	156	708	156	97	521	54
20th St SE & 91st Ave SE	150	783	0	1	365	157	0	0	1	109	0	96

Project Context

The 2015-2035 City of Lake Stevens Comprehensive Plan identifies a new full access intersection at SR 9 and South Lake Stevens Road to support the planned construction of 24th Street SE, as identified in the City of Lake Stevens 20th Street SE Corridor Subarea Plan. 24th Street SE is planned as a new east-west arterial south of and parallel to 20th Street SE, beginning at Cavalero Road to the west and intersecting SR 9 at the existing South Lake Stevens Road intersection. 24th Street SE is required to support commercial and residential development identified in the 20th Street SE Corridor Subarea Plan.

With the new roadway, South Lake Stevens Road would be realigned to intersect with 24th Street SE west of SR 9. The intersection of SR 9 and S Lake Stevens Road would be maintained as a 4-leg intersection with 24th Street SE forming the west approach leg. The intersection of SR 9 and 24th Street SE / S Lake Stevens Road is identified for future signalization in the 20th Street Corridor SE Subarea Plan.

The 20th Street SE Corridor Subarea Plan identifies the following new roadways in the study area vicinity:

- 24th Street SE (SR 9 to Cavalero Road): New Collector roadway
- 79th Avenue SE (20th Street SE to 24th Street SE): New local street
- 83rd Avenue SE (20th Street SE to 24th Street SE): New local street
- 87th Avenue SE (12th Street SE to 24th Street SE): New local street
- 91st Avenue SE (20th Street SE to 24th Street SE): New local street
- S Lake Stevens Rd: Realign to intersect new 24th Street SE west of SR 9

New roadways are shown in **Figure 3.**

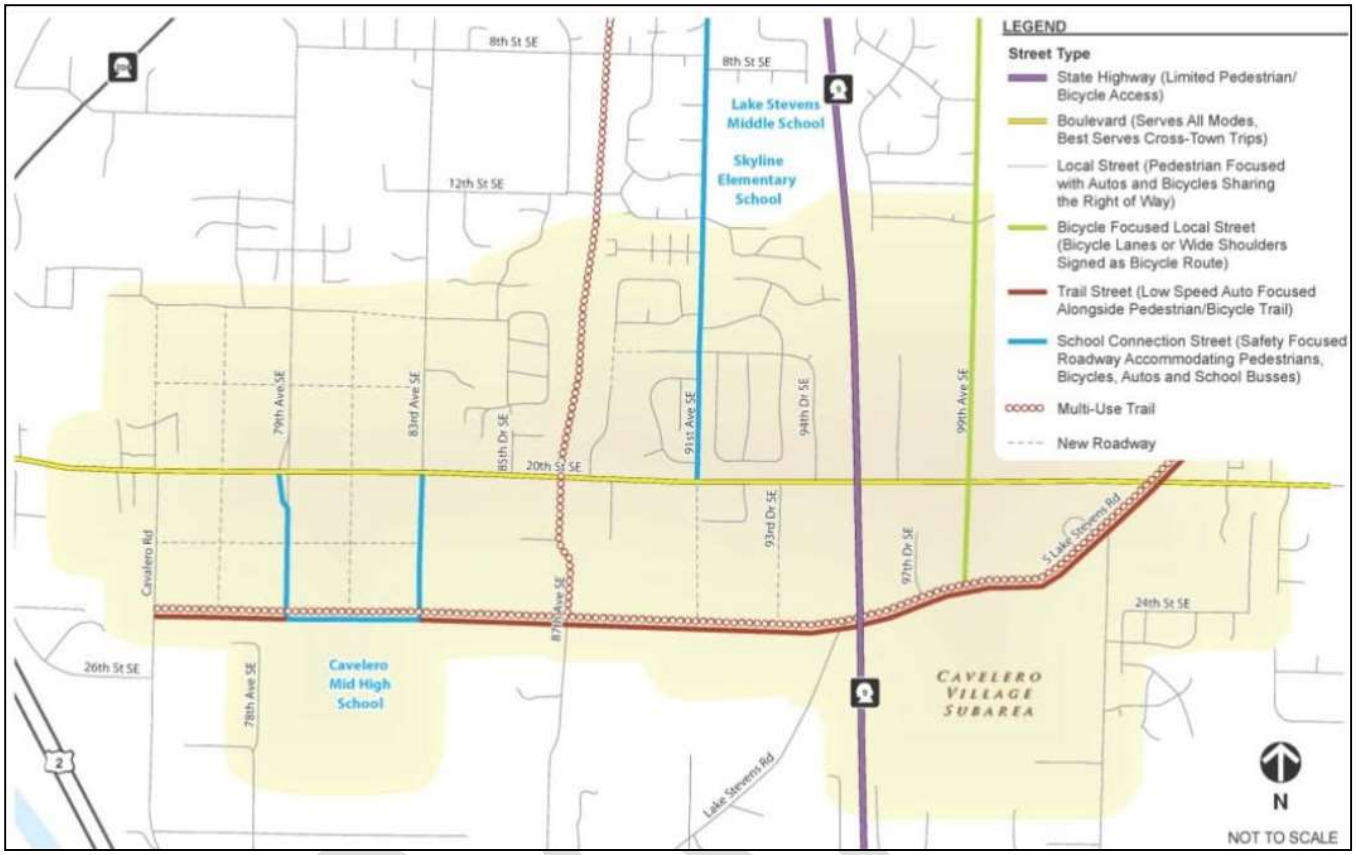

Figure 3. 20th Street Corridor SE Subarea Plan Transportation Network Improvements

The WSDOT State Route 9 Corridor Planning Study identifies a series of three improvement projects which will widen SR 9 from two lanes to four lanes from (1) Bickford Avenue to US 2, (2) from US 2 to 20th Street SE, and (3) from 20th Street SE to Market Place. The SR 9 Corridor Planning Study also identifies intersection improvements at SR 9 and 20th Street SE to include widening of the north and south approaches to accommodate three lanes in each direction and widening of the east and west approaches to accommodate dual westbound left turn lanes and an eastbound right turn pocket. WSDOT staff further requested that the future conditions analysis for this ICE include two-lane roundabouts at the SR 9 / US 2 interchange.

Project Needs and Performance Targets

Project needs and performance targets were developed with consideration for the State Route 9 Corridor Planning Study (WSDOT 2011), the adopted 20th Street SE Corridor Subarea Plan (City of Lake Stevens 2012), the 2015-2035 City of Lake Stevens Comprehensive Plan, and City of Lake Stevens municipal code.

The study intersections must support planned growth, maintain local circulation, and preserve regional mobility. The following baseline Project needs have been identified:

- **Level of Service**: maintain minimum WSDOT and City of Lake Stevens Level of Service (LOS) standards, including:
    - SR 9 and South Lake Stevens Road / 24th Street SE: LOS D
    - SR 9 & 20th Street SE: LOS D
    - 20th Street SE & 91st Avenue SE: LOS E
- **Queue**: Prevent queue stacking on SR 9 between South Lake Stevens Road / 24th Street SE and 20th Street SE.
- **Travel time**: Minimize travel time impacts on SR 9 from the US 2 interchange to 4th Street SE
- **Safety:** Maintain safety for motorized and nonmotorized users

The following contextual Project needs were also identified:

- **Access**: Maintain property access along local routes 24th Street SE and 91st Avenue SE
- **Multimodal transportation**: Improve multimodal safety and operations, consistent with the City of Lake Stevens 20th Street SE Corridor Subarea Plan.

Level of Service

Intersection and approach Level of Service (LOS) were evaluated using Vissim 10 microsimulation software. Simulated vehicle delay was categorized based on Highway Capacity Manual 2010 (HCM2010) Level of Service (LOS) thresholds. Simulation model methods, assumptions, and calibration are documented in the attached "SR 9 / 24th Street SE Vissim Model Methods and Assumptions" memorandum, dated July 14, 2018.

It should be noted that microscopic traffic simulation represents a fundamentally different analysis approach to macroscopic and deterministic tools such as HCM2010 and results are therefore not directly comparable to results from a deterministic analysis. For a more detailed discussion of the differences between macroscopic and microscopic model results see *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (FHWA 2004).

Existing LOS and delay for the AM peak hour and PM peak hour are summarized in **Table 3.**

The intersection of SR 9 and 20th Street SE currently operates at LOS D in the AM and PM peak hours. The intersection of SR 9 and South Lake Stevens Road operates at LOS D in the AM peak hour and LOS C in the PM peak hour.

Table 3. Existing (2018) LOS

Intersection	AM Peak Hour					PM Peak Hour				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & SLS Rd	C (16.0)	A (5.1)	A (0.7)	A (7.2)	D (27.3)	C (15.4)	A (5.1)	A (0.4)	A (4.0)	C (15.9)
SR 9 & 20th St SE	C (33.9)	D (35.4)	D (38.0)	E (63.1)	D (44.1)	E (63.9)	D (37.4)	D (51.6)	D (42.2)	D (50.6)
20th St SE & 91st Ave SE	A (7.4)	A (9.2)	-	B (12.1)	A (9.0)	A (6.3)	A (8.8)	-	B (11.9)	A (7.8)

[1]Approach delay represents average delay for all movements on a given approach
[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average.

95th Percentile Queue

Existing 95th percentile queues for the AM and PM peak hours are summarized in **Table 4**. During the PM peak hour, northbound 95th percentile queue at the intersection of SR 9 and 20th Street SE do not reach the intersection of South Lake Stevens Road. During the AM peak hour, westbound 95th percentile queue at the intersection of SR 9 and 20th Street SE exceeds the left-turn storage length.

Table 4. Existing (2018) 95th Percentile Queue

Intersection	Movement	Storage (feet)	AM Q (feet)	PM Q (feet)
SR 9 & S Lake Stevens Rd	NBL	200	0	0
	EBL	2,600	60	90
	EBR	2,600	15	25
	WBR	1,000	25	30
SR 9 & 20th St SE	NBL	600	115	475
	NBT	1,150	365	660
	NBR	230	65	75
	SBL	360	155	205
	SBT	5,280	3,700	385
	SBR	150	200	25
	EBL	300	150	85
	EBTR	1,370	310	830
	WBL	520	605	210
	WBTR	900	305	285
20th St SE & 91st Ave SE	NB	-	0	0
	SBL	200	125	105
	SBTR	880	40	45
	EBL	430	65	75
	EBTR	930	135	185
	WBL	370	0	0
	WBTR	1,370	315	320

Travel Speed

A floating car travel time survey was conducted by TSI on Wednesday, June 13, 2018. Travel time, speed, and acceleration data were collected using "Travel Time and Delay Study," a smartphone application which records vehicle coordinates in 1-second intervals using a smartphone GPS. For the 2018 base year of analysis, the AM peak hour and PM peak hour microsimulation models were calibrated to match observed travel time in both directions of SR 9 from the US 2 eastbound ramp intersection to 4th Street SE.

The 2018 AM peak hour Vissim model was calibrated to within 1.9 mph of observed travel speeds in the northbound direction of SR 9 and to within 0.4 mph of travel speeds in the southbound direction of SR 9. Calibrated AM peak hour travel times and speeds along SR 9 are shown in **Table 5.**

Table 5. 2018 AM Peak Hour SR 9 Travel Time Summary

Segment	Northbound				Southbound			
	Floating Car		Simulated		Floating Car		Simulated	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:42	15.8	0:30	23.4	0:21	29.7	0:22	32.4
Bunk Foss Rd to 32nd St SE	1:23	41.9	1:16	45.4	5:03	11.7	4:01	14.4
32nd St SE to 24th St SE	0:37	48.5	0:37	49.5	0:54	33.5	1:04	28.4
24th St SE to 20th St SE	0:39	21.6	0:52	15.9	0:22	39.8	0:26	32.3
20th St SE to 4th St SE	1:20	45.3	1:13	49.5	2:44	22.0	3:46	16.2
Total	**4:41**	**37.0**	**4:29**	**38.9**	**9:24**	**18.5**	**9:38**	**18.1**

The 2018 PM peak hour Vissim model was calibrated to within 1.4 mph of observed travel speeds in both northbound and southbound directions of SR 9. Calibrated PM peak hour travel times and speeds along SR 9 are shown in **Table 6.**

Table 6. 2018 PM Peak Hour SR 9 Travel Time Summary

Segment	Northbound				Southbound			
	Floating Car		Simulated		Floating Car		Simulated	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:16	41.0	0:24	29.2	0:19	34.7	0:21	34.1
Bunk Foss Rd to 32nd St SE	1:34	37.2	1:45	33.2	1:35	36.9	1:23	41.6
32nd St SE to 24th St SE	0:42	43.7	0:36	50.1	0:52	34.9	0:42	42.6
24th St SE to 20th St SE	1:11	12.3	0:56	14.8	0:22	41.2	0:22	37.7
20th St SE to 4th St SE	1:27	41.7	1:16	47.6	1:38	36.1	1:47	34.0

Total	**5:10**	**33.8**	**4:57**	**35.2**	**4:45**	**36.5**	**4:36**	**37.9**

2. FEASIBILITY

This ICE evaluated four control alternatives under future (2040) AM and PM peak hour conditions. All future scenarios included the following assumptions:

- **Land use growth** consistent with the 20th Street SE corridor subarea plan, including commercial development to the southwest of the SR 9 and 20th Street SE intersection
- **SR 9**: Widen to four lanes from US 2 interchange through Market Place
- **SR 9 / US 2 interchange**: Two-lane roundabouts at both intersections
- **SR 9 and 20th Street SE**:
    - Widen north and south approaches provide three through lanes each direction
    - Widen west approach to provide eastbound right turn lane
- **20th Street SE**: Widen to five lanes from US 2 to 91st Avenue SE
- **91st Avenue SE**: Extend roadway from 20th Street SE to future 24th Street SE
- **24th Street SE**: New collector roadway from SR 9 to Cavalero Road
- **South Lake Stevens Road**: Realign to create new intersection at 24th Street SE west of SR 9

A future No Build scenario assumed existing access restrictions would be maintained at the intersection of SR 9 and 24th Street SE / S Lake Stevens Road. Alternative scenarios included control changes at the intersection, including:

Alternative A. Right-in right-out access restriction. This alternative includes additional turn restrictions at the study intersection, prohibiting the existing northbound left-turn and eastbound left-turn movements and maintaining existing left-turn restrictions on the southbound and westbound approaches. A conceptual layout is provided in **Figure 4.**

Alternative B. Two-lane roundabout. This alternative includes roundabout with two circulating lanes for north-south movements and single-lane east-west approaches. A conceptual roundabout layout is shown in **Figure 5**.

Alternative C. Signalized control. The southbound drop lane from the SR 9 and 20th Street SE intersection would terminate as a right turn lane at the 24th Street SE intersection. A conceptual layout is shown in **Figure 6.**

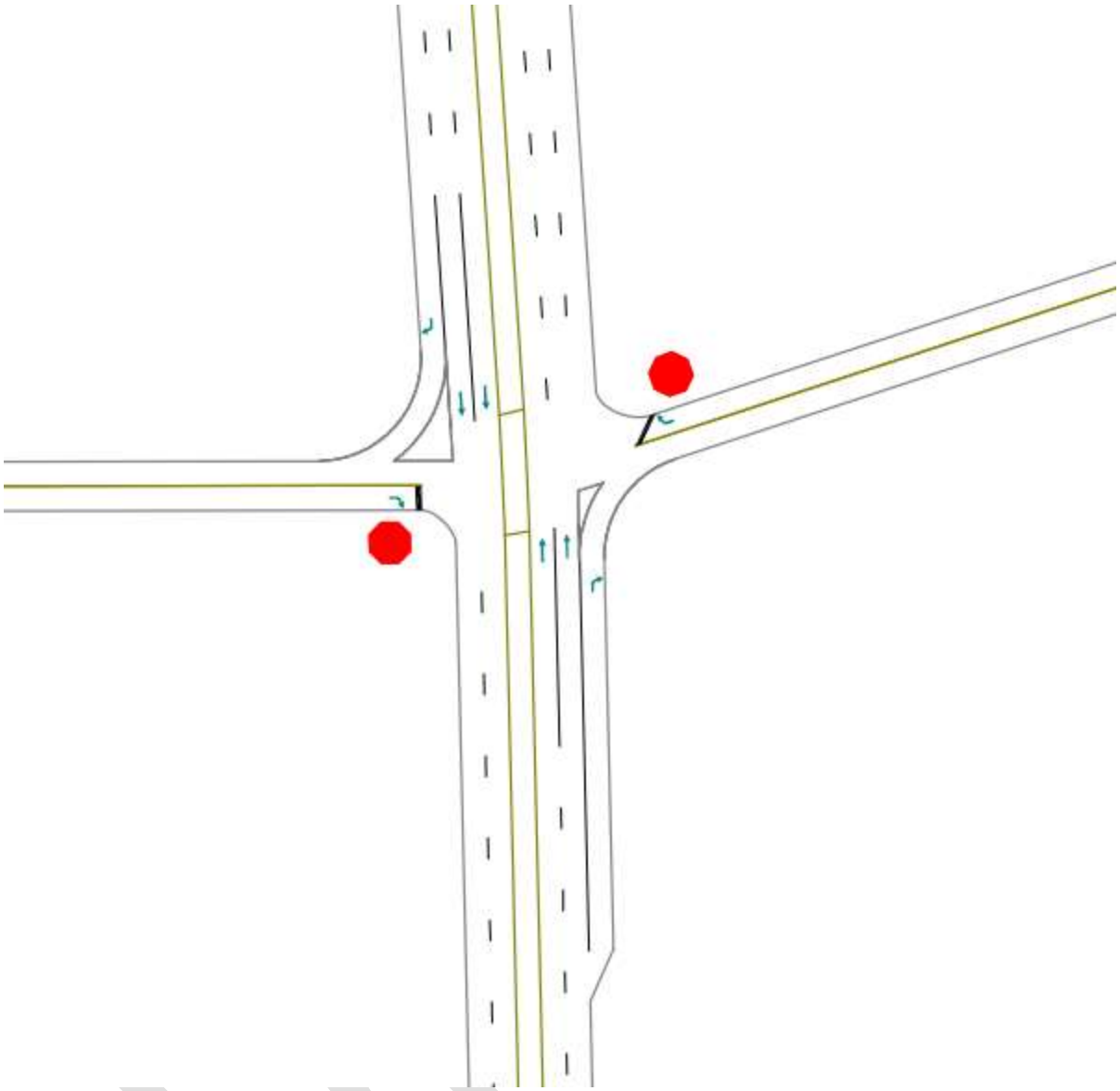

Figure 4. SR 9 & 24th Street SE Alternative A Conceptual Layout

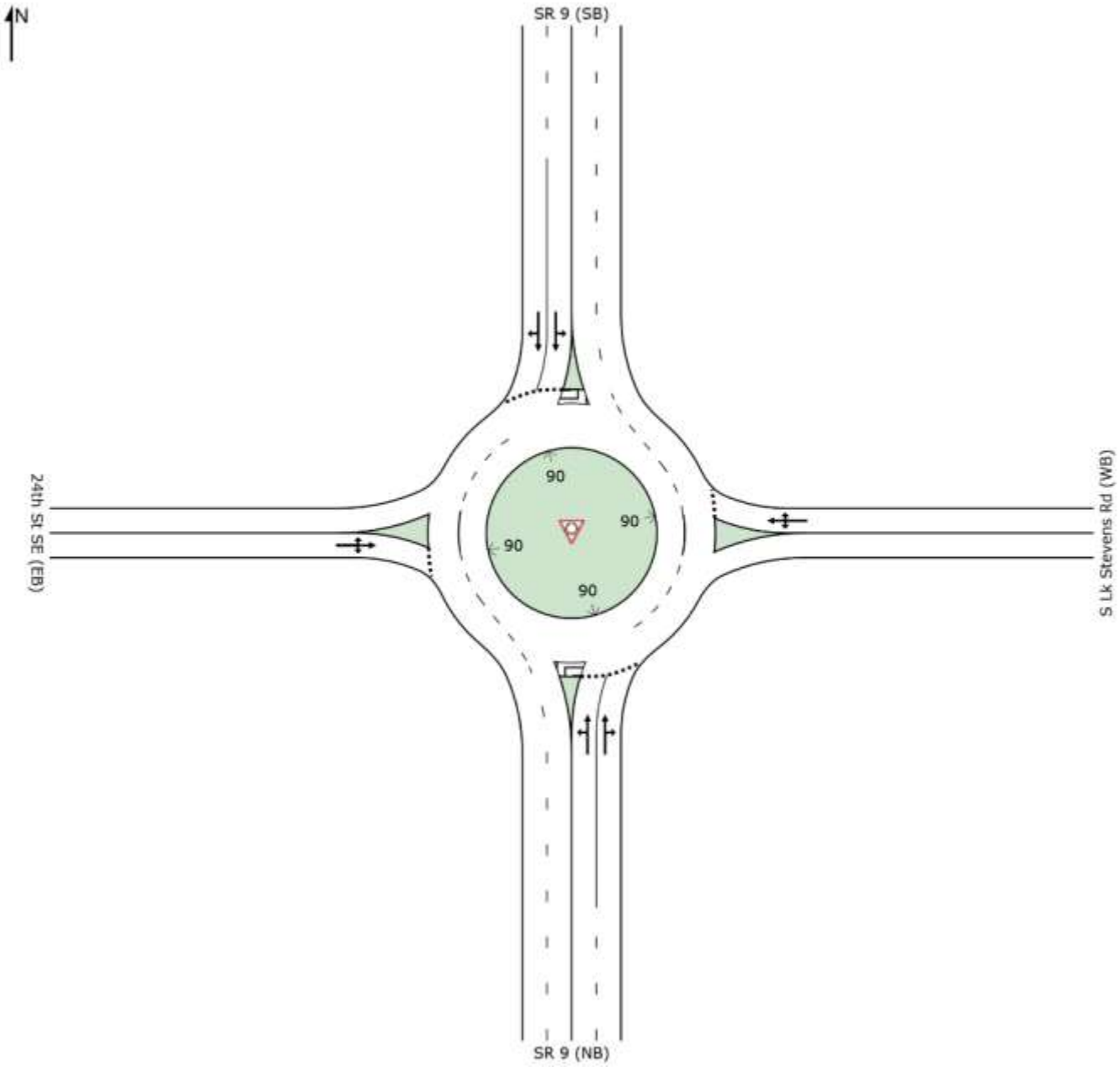

Figure 5. SR 9 & 24th Street SE Alternative B Conceptual Layout

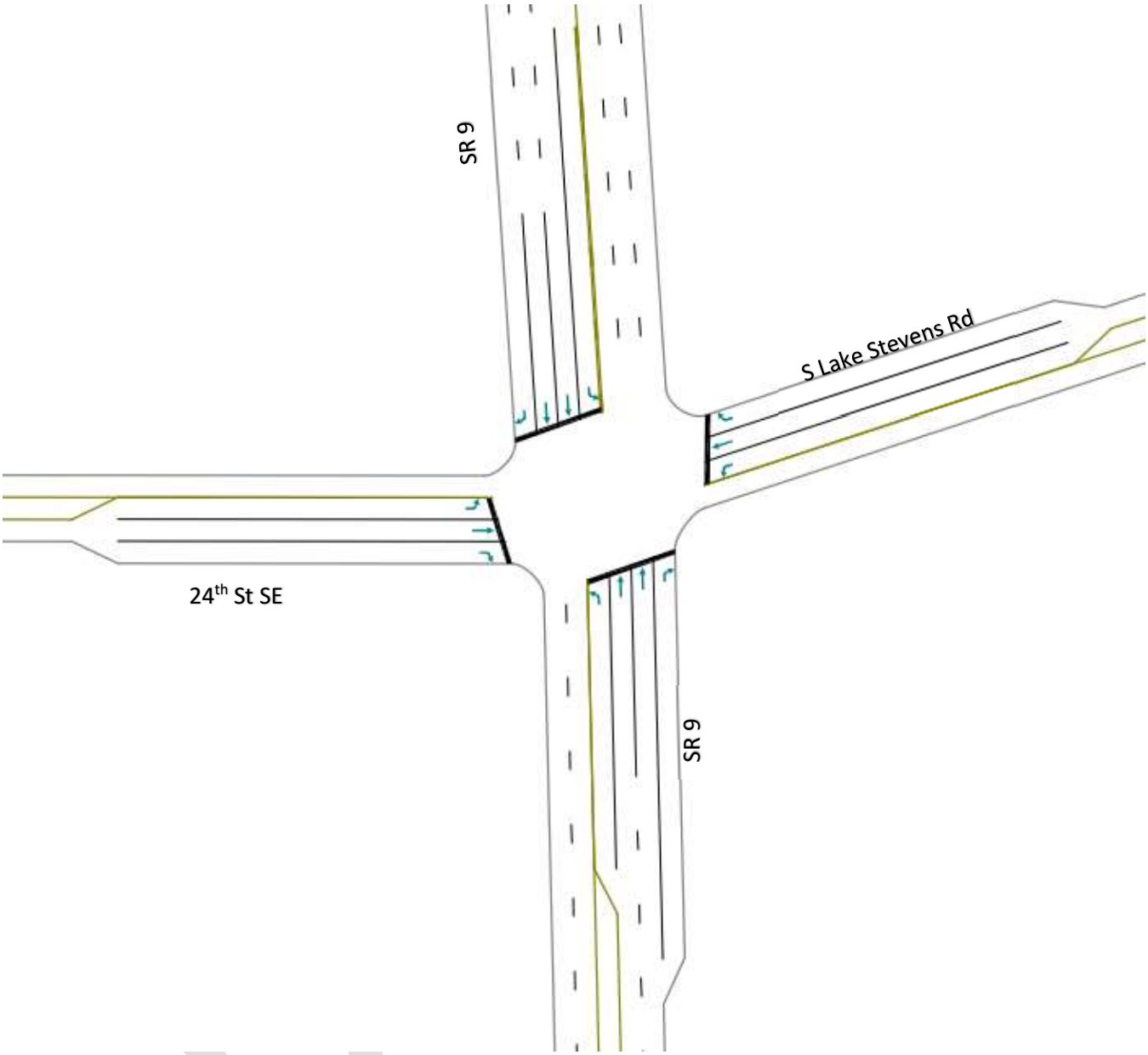

Figure 6. SR 9 & 24th Street SE Alternative C Conceptual Layout

Right of Way

Right of way requirements are summarized below. The intersection's location with respect to surrounding parcels is shown in **Figure 7.** Right of way considerations should accommodate the planned widening of SR 9 to two through lanes in each direction and the realignment of S Lake Stevens Road to intersect the new 24th Street SE to the west of SR 9.

- **Alternative A**: Right-in/right-out control will require no additional right of way beyond the right of way required for reconstruction of SR 9 and 24th Street SE.
- **Alternative B**: A two-lane roundabout may require additional right of way to accommodate the center island and two-lane circulating roadway. Right-of-way requirements would not likely require removal of any structures.
- **Alternative C**: A traffic signal may require additional right of way on the east and west intersection approaches to accommodate necessary turn bays. Right-of-way requirements would not likely require removal of any structures.

Figure 7. Vicinity Parcel Map

Environmental

There are no known environmental risks at the intersection of SR 9 and 24th Street SE that would affect this ICE.

Context Sensitive/Sustainable Design

SR 9 is designated by WSDOT as a Highway of Statewide Significance (HSS) through the study area and serves approximately 21,000 vehicles per day. WSDOT has indicated that regional mobility is a key concern in the study area.

24th Street SE will function as a necessary access route to planned development along the 20th Street SE Corridor Subarea, as indicated by the subarea plan. Future commercial and residential growth on both sides of SR 9 in the study area will increase opportunities for nonmotorized trips at the SR 9 and 24th Street SE intersection. The 20th Street SE Corridor Subarea Plan also identifies a future trail connection along the north side of 24th Street SE across SR 9.

Improvements at the intersection of SR 9 and 24th Street SE should consider both the regional mobility needs of SR 9 and the local mobility, land access and nonmotorized needs of 24th Street SE.

3. Operational and Safety Performance Analysis

Traffic Analysis

No Build

The No Build condition assumes completion of all transportation improvement projects identified above as well as land use growth in the 20th Street SE corridor subarea as identified in the 20th Street SE Corridor Subarea Plan.

Traffic Volumes

Travel demand forecasts for all future scenarios were generated by the Snohomish County travel demand (EMME) model and the US 2/SR 204 IJR dynamic traffic assignment (DYNAMEQ) model. No Build turning movement volumes for are summarized in **Tables 7** and **8.**

Table 7. No Build AM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	40	0	20	0	0	180	120	690	90	0	1440	570
SR 9 & 20th St SE	180	490	280	610	470	110	60	680	170	80	1120	80
20th St SE & 91st Ave SE	100	570	30	100	380	130	10	90	150	230	30	100

Table 8. No Build PM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	210	0	210	0	0	60	180	1200	210	0	950	220
SR 9 & 20th St SE	320	1100	110	340	390	100	210	980	280	120	720	170
20th St SE & 91st Ave SE	170	1180	220	120	480	170	140	60	220	130	30	100

LEVEL OF SERVICE

The intersection of SR 9 and 24th Street SE will operate at LOS E in the PM peak hour due to eastbound left-turn delay. The intersection of SR 9 and 20th Street SE will continue to operate at LOS D in the PM peak hour, assuming widening along SR 9 and 20th Street SE. No Build LOS is summarized in **Table 9.**

Table 9. No Build LOS

Intersection	AM Peak Hour					PM Peak Hour				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	B (11.7)	A (7.2)	A (4.9)	A (2.8)	D (33.4)	D (33.0)	A (5.7)	A (1.6)	A (1.8)	E (36.8)
SR 9 & 20th St SE	C (23.2)	C (29.8)	C (23.5)	C (33.2)	C (28.1)	D (40.6)	C (34.5)	D (39.0)	D (44.8)	D (40.0)
20th St SE & 91st Ave SE	B (16.9)	B (15.0)	B (13.1)	B (12.3)	B (14.9)	C (23.8)	C (22.5)	B (17.6)	C (22.2)	C (22.5)

[1]Approach delay represents average delay for all movements on a given approach

[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average.

QUEUE

In the PM peak hour, eastbound 95th percentile queue at the SR 9 and 24th Street SE intersection will extend through the proposed alignment of the new 24th Street SE and South Lake Stevens Road intersection, approximately 425 feet to the west. 95th percentile queues for the No Build scenario are summarized in **Table 10.**

Table 10. No Build 95th Percentile Queue

Intersection	Movement	Storage (feet)	AM Q (feet)	PM Q (feet)
SR 9 & 24th St SE	NBL	200	135	100
	EBL	400	45	**500**
	EBR	400	45	**500**
	WBR	1,000	100	65
SR 9 & 20th St SE	NBL	600	135	390
	NBT	1,150	180	375
	NBR	230	75	175
	SBL	360	260	265
	SBT	5,280	405	300
	SBR	150	60	115
	EBL	300	165	**380**
	EBT	1,370	225	900
	EBR	150	140	30
	WBL	520	265	185
	WBTR	900	250	305
20th St SE & 91st Ave SE	NBL	200	25	135
	NBT	500	100	80
	NBR	150	75	105
	SBL	200	150	170
	SBTR	880	75	95
	EBL	430	85	115
	EBTR	930	215	825
	WBL	370	110	140
	WBTR	1,370	205	290

TRAVEL TIME

In the southbound direction, average AM peak hour travel time will decrease by 226 seconds, or approximately 39 percent, by 2040, assuming widening of SR 9 and interchange improvements at US 2. AM peak hour travel time is summarized in **Table 11.**

In the northbound direction, average PM peak hour travel time will decrease by 30 seconds by 2040, or approximately 10 percent, assuming widening of SR 9 and two-lane roundabouts at the US 2 interchange. Average travel speed will increase by 4 mph. PM peak hour travel time is summarized in **Table 12.**

Table 11. No Build Travel Time (AM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	2018		2040 No Build		2018		2040 No Build	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:30	23.4	0:27	27.3	0:22	32.4	0:26	28.2
Bunk Foss Rd to 32nd St SE	1:16	45.4	1:18	44.3	4:01	14.4	2:50	20.4
32nd St SE to 24th St SE	0:37	49.5	0:36	49.6	1:04	28.4	0:43	42.0
24th St SE to 20th St SE	0:52	15.9	0:37	22.4	0:26	32.3	0:20	45.2
20th St SE to 4th St SE	1:13	49.5	1:13	49.7	3:46	16.2	1:34	38.6
Total	**4:29**	**38.9**	**4:11**	**41.6**	**9:38**	**18.1**	**5:52**	**29.8**

Table 12. No Build Travel Time (PM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	2018		2040 No Build		2018		2040 No Build	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:24	29.2	0:26	27.9	0:21	34.1	0:26	27.8
Bunk Foss Rd to 32nd St SE	1:45	33.2	1:22	42.4	1:23	41.6	1:23	41.7
32nd St SE to 24th St SE	0:36	50.1	0:36	50.4	0:42	42.6	0:38	46.9
24th St SE to 20th St SE	0:56	14.8	0:48	17.2	0:22	37.7	0:18	45.5
20th St SE to 4th St SE	1:16	47.6	1:15	48.5	1:47	34.0	1:50	33.0
Total	**4:57**	**35.2**	**4:27**	**39.2**	**4:36**	**37.9**	**4:36**	**37.9**

Alternative A. Right-In/Right-Out

Traffic Volume

Alternative A turning movement volumes for are summarized in **Tables 13** and **14.** Turn restrictions at the intersection of SR 9 and 24th Street SE will result in demand redistribution at the intersections of SR 9 & 20th Street and 20th Street SE & 91st Avenue SE.

Table 13. Alternative A AM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	0	0	20	0	0	180	0	810	90	0	1440	570
SR 9 & 20th St SE	200	510	280	610	470	110	160	660	150	80	1120	80
20th St SE & 91st Ave SE	100	570	30	120	480	130	10	90	190	230	30	100

Table 14. Alternative A PM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	0	0	210	0	0	60	0	1310	210	0	950	220
SR 9 & 20th St SE	450	1180	110	340	390	100	320	850	200	120	720	170
20th St SE & 91st Ave SE	170	1180	220	230	480	170	140	60	430	130	30	100

Level of Service

During the AM peak hour, the northbound approach of SR 9 and 20th Street SE intersection will deteriorate to LOS F as a result of increased northbound left-turn demand associated with right-in right-out turn restrictions at 24th Street SE. Northbound delay at 20th Street will cause queue stacking through the SR 9 and 24th Street SE intersection, resulting in LOS E due to northbound queue delay. Alternative A AM peak hour LOS is summarized in **Table 15.**

Table 15. Alternative A LOS (AM Peak Hour)

Intersection	No Build					Alternative A				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	B (11.7)	A (7.2)	A (4.9)	A (2.8)	D (33.4)	A (8.1)	A (7.3)	D (31.8)	A (2.8)	E (35.1)
SR 9 & 20th St SE	C (23.2)	C (29.8)	C (23.5)	C (33.2)	C (28.1)	C (23.8)	C (30.4)	F (139.2)	C (32.1)	D (52.3)
20th St SE & 91st Ave SE	B (16.9)	B (15.0)	B (13.1)	B (12.3)	B (14.9)	B (15.8)	B (15.3)	B (12.4)	B (11.9)	B (14.4)

[1]Approach delay represents average delay for all movements on a given approach

[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average.

In the PM peak hour, Alternative A will improve intersection LOS at SR 9 and 24th Street SE from LOS E to LOS B by removing left-turn delay from the eastbound (24th Street SE) approach. However, the right-in/right-out turn restrictions will cause some redistribution of travel demand, resulting in increased delay at the intersections of SR 9 & 20th Street SE and 20th Street SE & 91st Avenue SE. Average vehicle delay at SR 9 and 20th Street SE will increase by 8 seconds from the No Build condition. At the intersection of 20th Street SE and 91st Avenue SE, average delay will increase by 24.5 seconds per vehicle, resulting in LOS D. PM peak hour LOS is summarized in **Table 16.**

Table 16. Alternative A LOS (PM Peak Hour)

Intersection	No Build					Alternative A				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	D (33.0)	A (5.7)	A (1.6)	A (1.8)	E (36.8)	B (11.4)	A (5.7)	A (0.5)	A (1.8)	B (11.4)
SR 9 & 20th St SE	D (40.6)	C (34.5)	D (39.0)	D (44.8)	D (40.0)	E (61.7)	D (39.2)	D (40)	D (42.9)	D (48.1)
20th St SE & 91st Ave SE	C (23.8)	C (22.5)	B (17.6)	C (22.2)	C (22.5)	E (59.5)	C (34.9)	D (38.5)	C (28.1)	D (46.6)

[1]Approach delay represents average delay for all movements on a given approach
[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average.

QUEUE

In the AM peak hour, northbound (SR 9) left-turn queue at 20th Street SE will extend up to 2,325 feet and through the 24th Street SE intersection to the south. Northbound queue and delay could be reduced by increasing green time on the northbound left-turn phase of the SR 9 and 20th Street SE intersection, however this analysis assumed that future signal timing would be optimized to minimize overall intersection delay.

In the PM peak hour, turn restrictions at the SR 9 & 24th Street SE intersection will reduce 95th percentile queue from 500 feet to 125 feet on the eastbound (24th Street SE) approach, eliminating the potential blockage of the realigned South Lake Stevens Road and 24th Street SE intersection. However, demand redistribution associated with the turn restrictions will cause eastbound queue on 20th Street SE at 91st Avenue SE to extend 1,915 feet, blocking local access streets 85th Drive SE, 87th Avenue SE, 88th Drive SE, and 88th Avenue SE. Northbound right-turn 95th percentile queue will extend 515 feet, potentially blocking future driveway accesses along 91st Avenue SE. 95th percentile queueing is summarized in **Table 17.**

Table 17. Alternative A 95th Percentile Queue

Intersection	Movement	Storage (feet)	AM Q (feet)	PM Q (feet)
SR 9 & 24th St SE	EBR	400	35	120
	WBR	1,000	95	65
SR 9 & 20th St SE	NBL	600	**2,325**	505
	NBT	1,150	185	280
	NBR	230	55	155
	SBL	360	200	220
	SBT	5,280	375	315
	SBR	150	55	145
	EBL	300	195	**670**
	EBT	1,370	230	1,255
	EBR	150	150	40
	WBL	520	265	190
	WBTR	900	250	310
20th St SE & 91st Ave SE	NBL	200	30	145
	NBT	500	90	90
	NBR	150	85	**515**
	SBL	200	140	**225**
	SBTR	880	80	120
	EBL	430	85	**145**
	EBTR	930	210	**1,915**
	WBL	370	125	335
	WBTR	1,370	215	305

TRAVEL TIME

In the southbound direction, average AM peak hour travel time will not change significantly from the No Build scenario to Alternative A. AM peak hour travel time is summarized in **Table 18.**

In the northbound direction, average PM peak hour travel time will decrease by 4 seconds from the 2040 No Build condition. PM peak hour travel time is summarized in **Table 19.**

Table 18. Alternative A Travel Time (AM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	No Build		Alternative A		No Build		Alternative A	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:27	27.3	0:00:27	27.2	0:26	28.2	0:00:26	28.3
Bunk Foss Rd to 32nd St SE	1:18	44.3	0:01:18	44.5	2:50	20.4	0:02:54	20.0
32nd St SE to 24th St SE	0:36	49.6	0:01:08	26.5	0:43	42.0	0:00:43	41.9
24th St SE to 20th St SE	0:37	22.4	0:00:48	17.2	0:20	45.2	0:00:20	45.1
20th St SE to 4th St SE	1:13	49.7	0:01:13	49.8	1:34	38.6	0:01:35	38.1
Total	**4:11**	**41.6**	**0:04:54**	**35.6**	**5:52**	**29.8**	**0:05:57**	**29.4**

Table 19. Alternative A Travel Time (PM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	No Build		Alternative A		No Build		Alternative A	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:26	27.9	0:26	27.9	0:26	27.8	0:26	27.9
Bunk Foss Rd to 32nd St SE	1:22	42.4	1:22	42.2	1:23	41.7	1:25	41.0
32nd St SE to 24th St SE	0:36	50.4	0:36	50.7	0:38	46.9	0:42	43.3
24th St SE to 20th St SE	0:48	17.2	0:46	18.2	0:18	45.5	0:19	45.2
20th St SE to 4th St SE	1:15	48.5	1:14	49.2	1:50	33.0	1:53	32.2
Total	**4:27**	**39.2**	**4:23**	**39.8**	**4:36**	**37.9**	**4:43**	**36.9**

Alternative B. Two-Lane Roundabout

Traffic Volume

Travel demand forecasts for all future scenarios were generated by the Snohomish County travel demand (EMME) model and the US 2/SR 204 IJR dynamic traffic assignment (DYNAMEQ) model. Alternative B turning movement volumes for are summarized in **Tables 20** and **21.**

Table 20. Alternative B AM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	40	20	20	40	20	180	120	690	90	10	1440	530
SR 9 & 20th St SE	180	490	280	570	470	110	60	680	170	70	1130	80
20th St SE & 91st Ave SE	100	570	30	100	380	130	10	90	150	230	30	100

Table 21. Alternative B PM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	220	30	210	50	20	60	180	1200	210	10	900	210
SR 9 & 20th St SE	280	1100	110	280	380	100	210	1020	250	110	730	170
20th St SE & 91st Ave SE	170	1180	220	110	480	170	140	60	180	130	30	100

Level of Service

In the AM peak hour, overall LOS will improve from LOS D to LOS B at the intersection of SR 9 and 24th Street SE as a result of roundabout control. AM peak hour LOS is summarized in **Table 22.**

Table 22. Alternative B LOS (AM Peak Hour)

Intersection	No Build					Alternative B				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	B (11.7)	A (7.2)	A (4.9)	A (2.8)	D (33.4)	C (20)	A (3.9)	A (1.0)	B (18.8)	B (12.7)
SR 9 & 20th St SE	C (23.2)	C (29.8)	C (23.5)	C (33.2)	C (28.1)	C (21.7)	C (28)	C (23.2)	C (28.7)	C (25.8)
20th St SE & 91st Ave SE	B (16.9)	B (15.0)	B (13.1)	B (12.3)	B (14.9)	B (15.9)	B (14.7)	B (13.0)	B (12.0)	B (14.4)

[1]Approach delay represents average delay for all movements on a given approach

[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average

PM peak hour LOS at the intersection of SR 9 & 24th Street SE will improve from LOS E to LOS B in Alternative B. PM peak hour LOS is summarized in **Table 23.**

Table 23. Alternative B LOS (PM Peak Hour)

Intersection	No Build					Alternative B				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	D (33.0)	A (5.7)	A (1.6)	A (1.8)	E (36.8)	B (15.3)	D (49.3)	B (12.1)	B (14.5)	B (14.8)
SR 9 & 20th St SE	D (40.6)	C (34.5)	D (39.0)	D (44.8)	D (40.0)	D (38.6)	C (30.6)	D (42.1)	D (40.0)	D (38.8)
20th St SE & 91st Ave SE	C (23.8)	C (22.5)	B (17.6)	C (22.2)	C (22.5)	C (21.0)	B (19.9)	B (17.5)	C (22.4)	C (20.4)

[1]Approach delay represents average delay for all movements on a given approach
[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average

QUEUE

In the PM peak hour, eastbound 95th percentile queue at the intersection of SR 9 and 24th Street SE will extend 400 feet and may reach the proposed alignment of the new 24th Street SE and South Lake Stevens intersection, approximately 400 feet to the west, pending final design of the roundabout and future South Lake Stevens Road intersection. 95th percentile queues for Alternative B are summarized in **Table 24.**

Table 24. Alternative B 95th Percentile Queue

Intersection	Movement	Storage (feet)	AM Q (feet)	PM Q (feet)
SR 9 & 24th St SE	NB	2,500	0	565
	SB	1,130	790	375
	EB	400	75	**400**
	WB	1,000	70	325
SR 9 & 20th St SE	NBL	600	130	400
	NBT	1,150	185	365
	NBR	230	70	170
	SBL	360	145	200
	SBT	5,280	360	325
	SBR	150	55	125
	EBL	300	170	260
	EBT	1,370	205	840
	EBR	150	120	35
	WBL	520	240	145
	WBTR	900	245	315
20th St SE & 91st Ave SE	NBL	200	25	135
	NBT	500	95	80
	NBR	150	65	90
	SBL	200	160	175
	SBTR	880	70	115
	EBL	430	95	120
	EBTR	930	210	625
	WBL	370	110	100
	WBTR	1,370	205	280

TRAVEL TIME

In the southbound direction, average AM peak hour travel time will increase by 41 seconds or 11.6 percent from the No Build scenario. AM peak hour travel time is summarized in **Table 25.**

In the northbound direction, average PM peak hour travel time will increase by 14 seconds, or approximately 5 percent, from the 2040 No Build condition. Average travel speed will decrease by approximately 2 mph. PM peak hour travel time is summarized in **Table 26.**

Table 25. Alternative B Travel Time (AM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	No Build		Alternative B		No Build		Alternative B	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:27	27.3	0:00:27	27.2	0:26	28.2	0:00:26	28.1
Bunk Foss Rd to 32nd St SE	1:18	44.3	0:01:18	44.6	2:50	20.4	0:03:06	18.7
32nd St SE to 24th St SE	0:36	49.6	0:00:37	48.9	0:43	42.0	0:00:48	37.9
24th St SE to 20th St SE	0:37	22.4	0:00:38	22.3	0:20	45.2	0:00:39	22.9
20th St SE to 4th St SE	1:13	49.7	0:01:13	49.7	1:34	38.6	0:01:34	38.3
Total	**4:11**	**41.6**	**0:04:12**	**41.5**	**5:52**	**29.8**	**0:06:33**	**26.8**

Table 26. Alternative B Travel Time (PM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	No Build		Alternative B		No Build		Alternative B	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:26	27.9	0:26	28.0	0:26	27.8	0:26	27.7
Bunk Foss Rd to 32nd St SE	1:22	42.4	1:21	43.0	1:23	41.7	1:20	43.3
32nd St SE to 24th St SE	0:36	50.4	0:47	38.5	0:38	46.9	0:43	42.1
24th St SE to 20th St SE	0:48	17.2	0:53	16.1	0:18	45.5	0:36	23.9
20th St SE to 4th St SE	1:15	48.5	1:15	48.6	1:50	33.0	1:49	33.4
Total	**4:27**	**39.2**	**4:41**	**37.3**	**4:36**	**37.9**	**4:54**	**35.7**

Alternative C. Signal

Traffic Volume

Travel demand forecasts for all future scenarios were generated by the Snohomish County travel demand (EMME) model and the US 2/SR 204 IJR dynamic traffic assignment (DYNAMEQ) model. Alternative C turning movement volumes for are summarized in **Tables 7** and **8.**

Table 27. Alternative C AM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	40	20	20	40	20	180	120	690	90	10	1440	530
SR 9 & 20th St SE	180	490	280	570	470	110	60	680	170	70	1130	80
20th St SE & 91st Ave SE	100	570	30	100	380	130	10	90	150	230	30	100

Table 28. Alternative C PM Peak Hour Turning Movement Volumes

Intersection	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
SR 9 & SLS Rd	310	30	210	50	10	60	180	1200	210	10	900	220
SR 9 & 20th St SE	190	1100	110	290	380	100	210	1110	250	110	730	170
20th St SE & 91st Ave SE	170	1180	220	110	480	170	140	60	90	130	30	100

Signal Warrant Analysis

Warrants identified in the Manual on Uniform Traffic Control Devices (MUTCD) are summarized below. A warrant analysis is provided in Appendix C. The intersection meets warrants #1, #2, #3, #6, and #8. Volume warrants were evaluated using 2040 peak hour demand forecasts, with peak hour volumes extrapolated to 4- and 8-hour volumes based on 2018 peaking characteristics.

Table 29. Alternative C Signal Warrant Analysis

Warrant #	Description	Met?	Note
1	Eight-Hour Vehicular Volume	Yes	Scaled 2040 forecast per 2018 peaking factors
2	Four-Hour Vehicular Volume	Yes	Scaled 2040 forecast per 2018 peaking factors
3	Peak Hour	Yes	2040 AM peak hour forecast
4	Pedestrian Volume	No	Limited existing pedestrian volume; No pedestrian forecasts
5	School Crossing	No	
6	Coordinated Signal System	Yes	Signal may be coordinated w/ 20th St SE
7	Crash Experience	No	
8	Roadway Network	Yes	20th St SE Corridor Subarea Plan identifies 24th St SE as a major route
9	Intersection Near a Grade Crossing	No	

LEVEL OF SERVICE

In the AM peak hour, the intersection of SR 9 and 24th Street SE will operate at LOS B under signal control. Alternative C AM peak hour LOS is summarized in **Table 30.**

Table 30. Alternative C LOS (AM Peak Hour)

Intersection	No Build					Alternative C				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	B (11.7)	A (7.2)	A (4.9)	A (2.8)	D (33.4)	D (40.3)	B (19.5)	B (12.3)	B (11.4)	B (13)
SR 9 & 20th St SE	C (23.2)	C (29.8)	C (23.5)	C (33.2)	C (28.1)	C (32.2)	C (33.7)	C (24.8)	C (32.4)	C (31.1)
20th St SE & 91st Ave SE	B (16.9)	B (15.0)	B (13.1)	B (12.3)	B (14.9)	B (15.7)	B (15.2)	B (13.1)	B (12.2)	B (14.6)

[1]Approach delay represents average delay for all movements on a given approach
[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average

PM peak hour LOS at the intersection of SR 9 & 24th Street SE will improve from LOS E to LOS C in Alternative C. PM peak hour LOS is summarized in **Table 31.**

Table 31. Alternative C LOS (PM Peak Hour)

Intersection	No Build					Alternative C				
	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)	EB LOS[1] (Delay)	WB LOS[1] (Delay)	NB LOS[1] (Delay)	SB LOS[1] (Delay)	Overall LOS[2] (Delay)
SR 9 & 24th St SE	D (33.0)	A (5.7)	A (1.6)	A (1.8)	E (36.8)	C (20.4)	C (20.2)	B (17.9)	C (23.9)	C (20.5)
SR 9 & 20th St SE	D (40.6)	C (34.5)	D (39.0)	D (44.8)	D (40.0)	D (47.3)	C (30.4)	D (51.4)	D (47.6)	D (46.1)
20th St SE & 91st Ave SE	C (23.8)	C (22.5)	B (17.6)	C (22.2)	C (22.5)	C (20.9)	C (20.5)	C (21.9)	C (21.2)	C (21.0)

[1]Approach delay represents average delay for all movements on a given approach
[2]Overall delay for stop-controlled intersections represents delay for the worst (i.e. highest-delay) movement. For all other intersections, overall delay represents intersection average

QUEUE

In the PM peak hour, 24th Street SE eastbound 95th percentile queue at SR 9 will extend up to 270 feet. The queue will not reach the new intersection of South Lake Stevens Road and 24th Street SE to the west. No other 95th percentile queues will exceed their storage capacity. 95th percentile queues for Alternative C are summarized in **Table 32.**

Table 32. Alternative C 95th Percentile Queue

Intersection	Movement	Storage (feet)	AM Q (feet)	PM Q (feet)
SR 9 & 24th St SE	NBL	400	185	350
	NBT	2,600	200	560
	NBR	150	60	105
	SBL	150	50	40
	SBT	1,150	570	460
	SBR	1,150	325	390
	EBL	350	85	280
	EBT	425	45	45
	EBR	150	0	75
	WBL	150	65	125
	WBT	1,000	95	35
	WBR	150	80	35
SR 9 & 20th St SE	NBL	600	115	565
	NBT	1,150	190	535
	NBR	230	75	165
	SBL	360	125	250
	SBT	5,280	460	360
	SBR	150	55	145
	EBL	300	205	215
	EBT	1,370	310	980
	EBR	150	150	30
	WBL	520	285	155
	WBTR	900	315	290
20th St SE & 91st Ave SE	NBL	200	25	160
	NBT	500	100	80
	NBR	150	65	55
	SBL	200	155	160
	SBTR	880	75	100
	EBL	430	90	130
	EBTR	930	225	690
	WBL	370	115	135
	WBTR	1,370	245	295

TRAVEL TIME

In the southbound direction, average AM peak hour travel time will increase by 41 seconds or 11.6 percent from the No Build scenario. AM peak hour travel time is summarized in **Table 33.**

In the northbound direction, average PM peak hour travel time will increase by 22 seconds, or 8.2 percent, from the 2040 No Build condition. Average travel speed will decrease by 3.1 mph. PM peak hour travel time is summarized in **Table 34.**

The signal timing plan assumed for this analysis balanced regional mobility needs with local access and mobility. Signal control would provide flexibility to serve different priorities based on demand patterns – for example, emphasizing regional mobility during peak hours and local circulation during off-peak hours.

Table 33. Alternative C Travel Time (AM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	No Build		Alternative C		No Build		Alternative C	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:27	27.3	0:00:27	27.2	0:26	28.2	0:00:26	28.2
Bunk Foss Rd to 32nd St SE	1:18	44.3	0:01:18	44.7	2:50	20.4	0:03:17	17.6
32nd St SE to 24th St SE	0:36	49.6	0:00:42	42.6	0:43	42.0	0:00:46	39.7
24th St SE to 20th St SE	0:37	22.4	0:00:41	20.3	0:20	45.2	0:00:25	36.0
20th St SE to 4th St SE	1:13	49.7	0:01:13	49.9	1:34	38.6	0:01:40	36.2
Total	**4:11**	**41.6**	**0:04:20**	**40.2**	**5:52**	**29.8**	**0:06:33**	**26.7**

Table 34. Alternative C Travel Time (PM Peak Hour)

SR 9 Segment	Northbound				Southbound			
	No Build		Alternative C		No Build		Alternative C	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:26	27.9	0:26	28.0	0:26	27.8	0:26	27.5
Bunk Foss Rd to 32nd St SE	1:22	42.4	1:21	42.8	1:23	41.7	1:26	40.6
32nd St SE to 24th St SE	0:36	50.4	0:50	36.1	0:38	46.9	0:41	43.7
24th St SE to 20th St SE	0:48	17.2	0:56	14.8	0:18	45.5	0:44	19.1
20th St SE to 4th St SE	1:15	48.5	1:16	48.0	1:50	33.0	1:55	31.7
Total	**4:27**	**39.2**	**4:49**	**36.2**	**4:36**	**37.9**	**5:12**	**33.6**

Safety Performance Analysis

CRASH HISTORY

Crash history for the five-year period from 2013 through 2017 indicates 14 total crashes at the intersection of SR 9 and South Lake Stevens Road. The predominant collision types are rear-end and entering at angle, with four of each type in the five-year period. Entering at angle collisions are characteristic of a minor-approach stop controlled intersection.

Collisions at the intersection of SR 9 and 20th Street SE are predominantly rear-end type collisions, with a total of 35 or 7 per year from 2013 through 2017. Rear-end collisions are typically the predominant crash type for signalized intersections.

Crash history by type is summarized in **Table 35.** No crashes involved pedestrians or bicyclists were reported.

Table 35. Crash Type by Year, 2013-2017

Intersection	Year	Fixed Object	Rear-End	Side-swipe	Opposite Direction	Enter at Angle	Other	Total
SR 9 & S Lake Stevens Rd	2013	1	0	0	0	0	0	1
	2014	2	0	0	0	1	1	4
	2015	0	3	1	0	2	0	6
	2016	0	1	0	0	0	1	2
	2017	0	0	0	0	1	0	1
	Total	**3**	**4**	**1**	**0**	**4**	**2**	**14**
	Average	**0.6**	**0.8**	**0.2**	**0.0**	**0.8**	**0.4**	**2.8**
SR 9 & 20th St SE	2013	0	8	0	0	0	1	9
	2014	2	5	2	0	2	0	11
	2015	0	7	2	1	1	0	11
	2016	1	8	1	1	3	0	14
	2017	0	7	1	0	1	0	9
	Total	**3**	**35**	**6**	**2**	**7**	**1**	**54**
	Average	**0.6**	**7.0**	**1.2**	**0.4**	**1.4**	**0.2**	**10.8**
20th St SE & 91st Ave SE	2013	0	0	0	0	0	3	3
	2014	0	1	1	0	0	0	2
	2015	0	2	0	1	0	1	4
	2016	0	1	0	0	0	0	1
	2017	0	0	1	2	0	0	3
	Total	**0**	**4**	**2**	**3**	**0**	**4**	**13**
	Average	**0.0**	**0.8**	**0.4**	**0.6**	**0.0**	**0.8**	**2.6**

Crash severity is summarized in **Table 36**. Of the 14 crashes at the intersection of SR 9 and S Lake Stevens Road, nine involved injury, with two reporting serious injuries.

One fatality occurred at the intersection of SR 9 and 20th Street SE when in 2016 a southbound vehicle failed to yield at a red signal, striking an eastbound vehicle. Alcohol was cited as a factor in this crash.

One fatality occurred at the intersection of 20th Street SE and 91st Avenue SE when in 2017 a left-turning vehicle failed to yield right of way to opposing traffic. Drug use was cited as a factor in the crash.

Table 36. Crash Severity by Year, 2013-2017

Intersection	Year	Property Damage	Possible Injury	Evident Injury	Serious Injury	Fatal	Total
SR 9 & S Lake Stevens Rd	2013	0	0	1	0	0	1
	2014	3	1	0	0	0	4
	2015	2	3	1	0	0	6
	2016	0	1	0	1	0	2
	2017	0	0	0	1	0	1
	Total	**5**	**5**	**2**	**2**	**0**	**14**
SR 9 & 20th St SE	2013	8	1	0	0	0	9
	2014	8	2	0	1	0	11
	2015	9	2	0	0	0	11
	2016	7	4	0	2	1	14
	2017	5	4	0	0	0	9
	Total	**37**	**13**	**0**	**3**	**1**	**54**
20th St SE & 91st Ave SE	2013	3	0	0	0	0	3
	2014	2	0	0	0	0	2
	2015	1	2	1	0	0	4
	2016	1	0	0	0	0	1
	2017	2	0	0	0	1	3
	Total	**9**	**2**	**1**	**0**	**1**	**13**

Serious injury crashes at the SR 9 and South Lake Stevens Road intersection included:

- 12/28/2016: Two vehicles collided, both traveling straight ahead on opposite directions of SR 9. The crash report cites icy road conditions.
- 5/4/2017: Vehicle making eastbound left-turn movement from South Lake Stevens Road to SR 9 failed to yield right-of-way to southbound vehicle on SR 9. The crash occurred in daylight, but weather was rainy.

Serious injury crashes at the SR 9 and 20th Street SE intersection included:

- 9/9/2014: Entering collision occurred when a vehicle making an eastbound through movement along 20th Street SE struck a vehicle traveling southbound along SR 9. The crash occurred during daylight with clear weather and dry road. Driver inattention was cited as a contributing circumstance.

- 5/16/2016: Entering collision occurred when a motorcycle making an eastbound through movement on 20th Street SE struck a pickup or small truck traveling northbound along SR 9. The motorcycle failed to yield to a red traffic signal. The crash occurred during nighttime with rainy weather.
- 9/19/2016: Rear-end collision occurred on the southbound (SR 9) approach. Crash records indicate that the driver was asleep at the time of the crash.

Future Alternatives Analysis

Each improvement alternative was analyzed by applying Crash Modification Factors (CMFs) to the societal cost of the observed crashes in the 2013-2017 period. Societal cost was calculated consistent with values identified in the *Safety Analysis Guide* (WSDOT 2017).

The CMFs applied to each improvement alternative are summarized in **Table 37**. Detailed descriptions of each CMF are provided in Appendix C. CMFs were accessed from the Crash Modification Factors Clearinghouse. All selected CMFs are also included in the Highway Safety Manual.

Table 37. Crash Modification Factors

Alternative	CMF Name	CMF ID	CMF	Crash Type	Crash Severity
A	Prohibit left-turns with "No Left Turn" Sign	391	0.32	All	All
B	Convert intersection with minor-road stop control to modern roundabout	227	0.56	All	All
C	Install a traffic signal	325	0.56	All	All

Expected crashes by severity for each alternative were calculated using the CMFs described above. Expected crash rate and societal costs are summarized in **Table 38.** The crash analysis indicates that Alternative A will yield the lowest societal cost. Alternatives B and C will yield the same societal cost.

Table 38. Crash Analysis Results

Crash Severity	No Build		Alternative A: Right-In/Right-Out		Alternative B: Roundabout		Alternative C: Signal	
	Crash Rate	Societal Cost	Crash Rate	Societal Cost	Crash Rate	Societal Cost	Crash Rate	Societal Cost
Fatal	0.0	$0	0.0	$0	0.0	$0	0.0	$0
Serious Injury	0.4	$1,160,000	0.1	$371,200	0.2	$649,600	0.2	$649,600
Evident Injury	0.4	$62,000	0.1	$19,840	0.2	$34,720	0.2	$34,720
Possible Injury	1.0	$60,000	0.3	$19,200	0.6	$33,600	0.6	$33,600
Property Damage	1.0	$10,000	0.3	$3,200	0.6	$5,600	0.6	$5,600
Total	**2.8**	**$1,292,000**	**0.9**	**$413,440**	**1.6**	**$723,520**	**1.6**	**$723,520**

Multimodal Safety and Operations

The 20th Street SE Corridor Subarea Plan identifies the study area as a target for future commercial, high-density residential, and mixed-use development. The plan identifies several goals and policies which prioritize multimodal transportation options in the 20th Street SE Corridor Subarea. The subarea plan also identifies a future multi-use path along the north side of 24th Street SE crossing SR 9, as shown in **Figure 3.**

The No Build and right-in/right-out (Alternative A) scenarios do not accommodate the planned 24th Street SE path across SR 9. Pedestrians crossing from residentially-zoned parcels to the east of SR 9 to commercial development to the west would be required to cross at the intersection of SR 9 and 20th Street SE located 1,150 feet to the north. This could discourage multimodal transportation in the subarea and encourage unsafe crossing behavior by pedestrians and cyclists.

Roundabout control (Alternative B) at the intersection of SR 9 and 24th Street SE would improve multimodal safety by reducing entering speeds and providing marked pedestrian crossings. Pedestrian warning signs can be supplemented with Rectangular Rapid Flash Beacons (RRFBs) to further improve safety.

Signal control (Alternative C) will facilitate multimodal safety and operations at the intersection of SR 9 and 24th Street SE by providing pedestrian walk phasing.

4. ALTERNATIVES EVALUATION

Level of Service

The intersection of SR 9 and 24th Street SE will operate at LOS E and below the WSDOT minimum LOS standard in the No Build PM peak hour scenario.

Alternative A will mitigate eastbound approach delay at the 24th Street intersection but the demand redistribution associated with right-in/right-out turn restrictions will result in northbound SR 9 delay interaction with the intersection of SR 9 and 20th Street SE to the north. Under Alternative A, the 24th Street SE intersection will operate at LOS E and below the WSDOT minimum LOS standard during the AM peak hour.

Under Alternatives B and C, the three study intersections will operate at LOS D or better, satisfying their respective minimum LOS standards.

Queue

In the No Build scenario PM peak hour, 95th percentile queue on the eastbound (24th Street SE) approach of the SR 9 and 24th Street SE intersection will extend through the planned alignment of the new 24th Street SE and South Lake Stevens Road intersection, approximately 425 feet to the west.

In Alternative A, northbound 95th percentile queue at the intersection of SR 9 and 20th Street SE will extend 2,325 feet and through the 24th Street SE intersection during AM peak hour. Further, 95th percentile queue on 20th Street SE at 91st Avenue SE will extend 1,915 feet, blocking local access streets 85th Drive SE, 87th Avenue SE, 88th Drive SE, and 88th Avenue SE. Northbound right-turn 95th percentile queue at 20th Street SE and 91st Avenue SE will extend 515 feet, potentially blocking future driveway accesses along 91st Avenue SE.

In Alternative B, 95th percentile on the eastbound (24th Street SE) approach of the SR 9 and 24th Street SE intersection will extend 400 feet and may reach the future intersection of 24th Street SE and South Lake Stevens Road to the west.

In Alternative C, no queue blocking will occur in the study area through 2040.

Travel Time

SR 9 peak direction travel time is summarized in **Table 39** for each alternative.

Alternative A will have no significant travel time impact from the No Build scenario.

Alternative B will result in travel time increases of 14 seconds (5 percent) in the northbound direction during PM peak hour and 41 seconds (12 percent) in the southbound direction during AM peak hour.

Alternative C will have similar travel time impacts to Alternative B, with additional travel time of 22 seconds (8 percent) in the northbound direction during PM peak hour and 41 seconds (12 percent) in the southbound direction during AM peak hour.

Table 39. Travel Time Summary

SR 9 Segment	Northbound (PM Peak Hour)				Southbound (AM Peak Hour)			
	No Build	Alt. A RIRO	Alt. B RAB	Alt. C Signal	No Build	Alt. A RIRO	Alt. B RAB	Alt. C Signal
US 2 EB to Bunk Foss Rd	0:26	0:26	0:26	0:26	0:26	0:26	0:26	0:26
Bunk Foss Rd to 32nd St SE	1:22	1:22	1:21	1:21	0:50	2:54	3:06	3:17
32nd St SE to 24th St SE	0:36	0:36	0:47	0:50	0:43	0:43	0:48	0:46
24th St SE to 20th St SE	0:48	0:46	0:53	0:56	0:20	0:20	0:39	0:25
20th St SE to 4th St SE	1:15	1:14	1:15	1:16	1:34	1:35	1:34	1:40
Total (m:ss)	**4:27**	**4:23**	**4:41**	**4:49**	**5:52**	**5:57**	**6:33**	**6:33**
Difference (m:ss)	-	**-0:04**	**+0:14**	**+0:22**	-	**+0:05**	**+0:41**	**+0:41**
Difference (%)	-	**-1.5%**	**+5.2%**	**+8.2%**	-	**+1.4%**	**+11.6%**	**+11.6%**

Safety

The crash analysis described above indicates that Alternative A will yield the lowest societal cost, at $413,440 per year. This represents a cost reduction of 68 percent from the No Build scenario. Alternatives B and C will yield the same societal cost, at $723,520 per year, representing a societal cost reduction of 44 percent from the No Build scenario.

Access

Right-in right-out access (Alternative A) will restrict access to future development along the 20th Street SE Corridor Subarea. The demand redistribution associated with turn restrictions at the SR 9 and 24th Street SE intersection will increase queue lengths on 91st Avenue SE at 20th Street SE, indirectly impacting access to parcels along 91st Avenue SE. These access impacts conflict with the goals and policies identified in the City of Lake Stevens 20th Street SE Corridor Subarea Plan.

Under roundabout control (Alternative B), queuing on the eastbound (24th Street SE) approach of the SR 9 and 24th Street SE intersection will extend through the proposed commercial driveway and the proposed realigned South Lake Stevens Road intersection to the west of the intersection.

Signal control (Alternative C) will provide full access to parcels east and west of SR 9 at 24th Street SE. Queues along 24th Street SE will not impact driveways or adjacent intersections along 24th Street SE.

Multimodal Facilities

Alternatives B and C will provide the greatest benefit to multimodal operations and safety at the intersection of SR 9 and 24th Street SE. Alternative A will not accommodate the planned multi-use trail crossing identified in the 20th Street SE Corridor Subarea Plan.

Table 40 summarizes the performance of each alternative with regard to the identified baseline and contextual needs.

Table 40. Alternatives Comparison

Category	Project Need	Alternative A: Right-In/Right-Out	Alternative B: Roundabout	Alternative C: Signal
Baseline	LOS	SR 9 & 20th St SE will fall to LOS E during AM peak hr	LOS D or better	LOS D or better
	Queue	SR 9 northbound queue at 20th St SE will block 24th St SE	24th St SE eastbound queue may reach future S Lk Stevens Rd alignment	No queue blocking
	Travel Time	No travel time impact	SR 9 NB PM: +5%; SR 9 SB AM: +12%	SR 9 NB PM: +8%; SR 9 SB AM: +12%; Timing may emphasize regional mobility during peak hours
	Safety	68% crash reduction; $413,440 societal cost	44% crash reduction; $723,520 societal cost	44% crash reduction; $723,520 societal cost
Contextual	Access	Limits access to local commercial and residential development	24th St SE queues may impact land access during peak hours	Provides full access
	Multimodal	Does not provide multimodal crossing of SR 9 at 24th St SE	Provides signed crossing and RRFB to improve multimodal safety, operations	Provides signal phasing to improve multimodal safety and operations

5. SELECTION

Based on the analysis described above, signal control (Alternative C) is the recommended intersection control at the intersection of SR 9 and 24th Street SE. Signal control satisfies all identified performance targets while allowing flexibility to emphasize either regional or local mobility according to time-of-day timing plans.

Appendix A. ICE Methods and Assumptions

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July 14, 2018

TO: Miguel Gavino, PE
Traffic Engineer
Washington State Department of Transportation, Northwest Region

COPY: Cory Nau, PE
Senior Engineer
Department of Public Works
City of Lake Stevens

FROM: Andrew Bratlien, PE, TSI

SUBJECT: SR 9, MP 13.80
24th Street SE / South Lake Stevens Road
Intersection Control Analysis Methods and Assumptions

This memorandum documents the methods and assumptions that will be used to develop the Intersection Control Analysis (ICA) for the intersection of SR 9 and SE 24th Street in Lake Stevens, Washington. This ICA represents an update and a refinement of the analysis documented in the City of Lake Stevens 20th Street Corridor Subarea Plan EIS.

1. Overview

The intersection of SR 9 and S Lake Stevens Road is currently a two-way stop-controlled intersection with partial access restrictions. The intersection is identified in the 20th Street Corridor Subarea Plan as a future signalized intersection. The Washington State Department of Transportation (WSDOT) State Route 9 Corridor Planning Study does not identify improvements at the intersection.

Costco Wholesale is proposing a new 170,000 square foot wholesale warehouse and up to 30-pump membership fueling station at the northwest corner of State Route 9 and S Lake Stevens Road in Lake Stevens, Washington. Site access is proposed off a planned extension of 91st Avenue SE south of 20th Street SE, and a planned new 24th Street SE between the 91st Avenue SE extension and a revised intersection at SR 9 and S Lake Stevens Road. S Lake Stevens Road will be realigned to connect with the new 24th Street SE west of its current intersection with SR 9.

This ICA will evaluate several control alternatives at the future intersection of SR 9 and 24th Street SE. The analysis will maintain consistency with the future roadways identified in the 20th Street Corridor Subarea Plan while incorporating updated and refined land use growth forecasts per the Snohomish County Comprehensive Plan and TSI's Costco Wholesale trip generation analysis.

2. Study Area

The ICA will focus on the intersection of SR 9 with the future 24th Street SE in Lake Stevens and will also evaluate the impacts of access revisions at SR 9 and 24th Street SE on the intersection of SR 9 and 20th Street SE to the north and the intersection of 20th Street SE and 91st Avenue SE to the northwest. A map of the study area is provided in **Figure 1**.

3. Analysis Period

Both the AM and PM peak one-hour periods will be evaluated.

The Future model scenarios will represent a 2040 horizon year. Traffic volumes and routing will be generated from the Snohomish County 2040 DYNAMEQ model for each future year scenario.

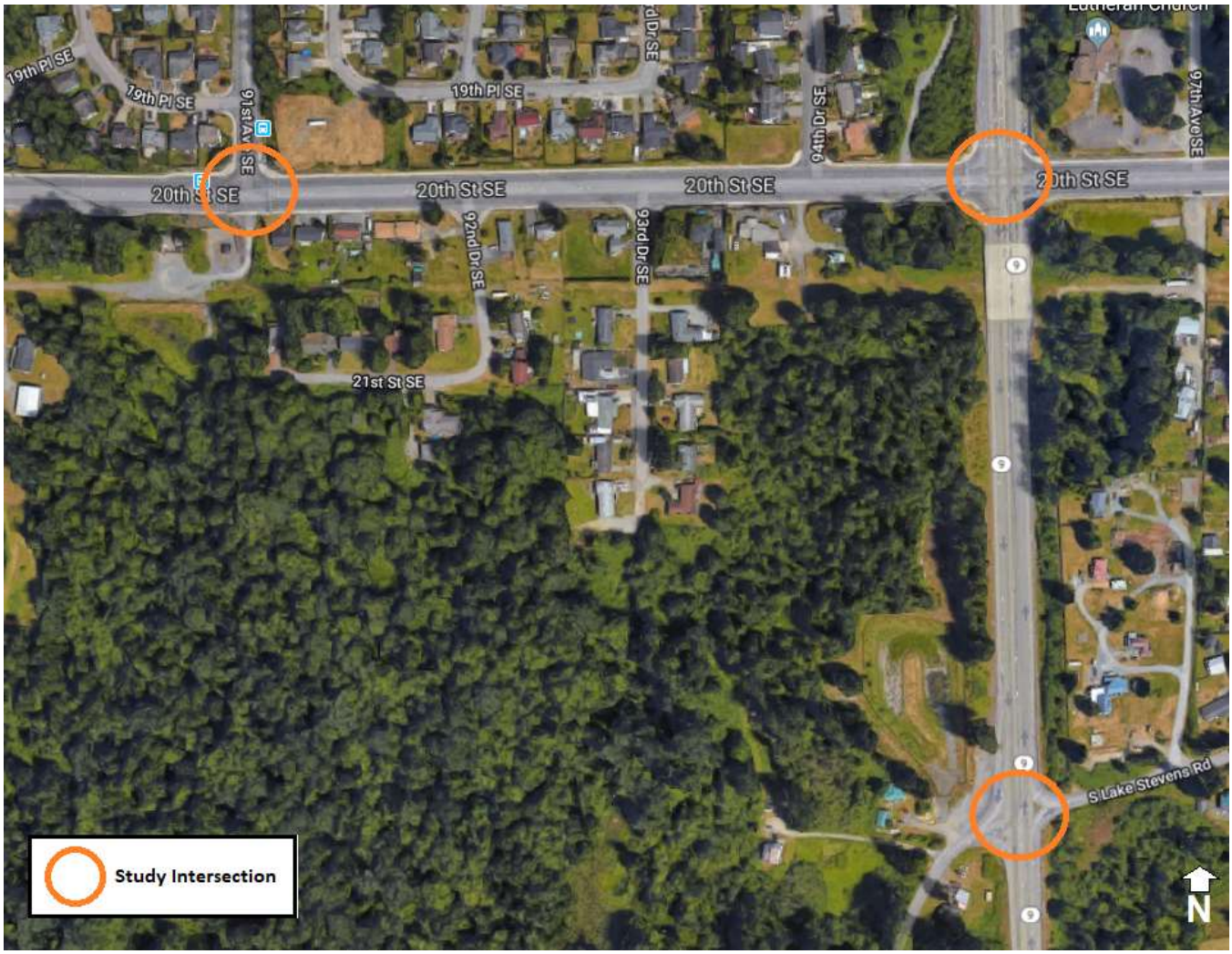


Figure 1. Study Intersections

4. Intersection Control Alternatives

Up to three Alternative scenarios will be evaluated for the Future (2040) AM and PM peak hour. All Future scenarios will include the proposed Costco warehouse and fueling station, extension of 91st Avenue SE south of 20th Street SE, and a new 24th Street SE between the Cavelero Rd and intersection at SR 9 and S Lake Stevens Road.

Alternative scenarios will evaluate control changes at the intersection of SR 9 and the proposed 24th Street SE (existing S Lake Stevens Rd) and will include:

Scenario 1. Right-in right-out access restriction.

Scenario 2. Two-lane roundabout.

Scenario 3. Signalized control (Optional). Based on the findings of Scenario 2, signal control may be evaluated as an alternative to a roundabout.

5. Data Collection

Data collection will include:

- Intersection turning movement counts collected in March and May 2018 at the study area intersections
- Maximum queue observations recorded from turning movement count videos or field observations
- Floating car travel time data collected along SR 9 in the study area
- Unserved PM peak hour demand observed during intersection turning movement counts

6. Travel Demand Forecasting

Travel demand forecasts for the 2040 AM and PM peak hours will be generated by Fehr & Peers using the Snohomish County travel demand (EMME) model and the US 2/SR 204 IJR dynamic traffic assignment (DYNAMEQ) model. The Fehr & Peers scope of work is attached.

The trip generation forecasts and connector loading points will be modeled consistent with Snohomish County long-range land use forecasts. Trip generation associated with the Costco Wholesale development will be refined using a trip generation forecast developed by TSI and approved by WSDOT staff.

Trips will be assigned to the transportation network using the DYNAMEQ model. A plot showing the DYNAMEQ network and zone connectors is attached.

The future roadway network in the EMME and DYNAMEQ traffic models will be refined with the following changes to provide consistency with the 20th Street Corridor Subarea Plan:

- SR 9 (20th Street SE to Bunk Foss Road / US 2 WB on-ramp): Widen to four lanes
- 24th Street SE (SR 9 to Cavalero Road): New Collector roadway
- 79th Avenue SE (20th Street SE to 24th Street SE): New local street
- 83rd Avenue SE (20th Street SE to 24th Street SE): New local street
- 87th Avenue SE (12th Street SE to 24th Street SE): New local street
- 91st Avenue SE (20th Street SE to 24th Street SE): New local street
- S Lake Stevens Rd: Realign to intersect new 24th Street SE west of SR 9

7. Level of Service Analysis

Intersection Levels of Service (LOS) will be evaluated using Vissim 10 microsimulation software. Vissim-based Level of Service will be assigned based on Highway Capacity Manual 2010 (HCM2010) intersection LOS thresholds. Conceptual roundabout layout and channelization will be calculated in Sidra Intersection 7 software using parameter settings identified in the April 2018 WSDOT Sidra policy guidelines.

8. Queueing Analysis

Queueing will be modeled using Vissim microsimulation software, consistent with the Vissim Methods & Assumptions document.

Queues will be evaluated at the intersections of SR 9 with 20th Street SE and with 24th Street SE / S Lake Stevens Road.

9. Travel Time Analysis

Travel time will be calculated along SR 9 from US 2 eastbound ramps to 4th Street SE using the calibrated Vissim microsimulation model.

Attachment 1: Fehr & Peers Scope of Work

Attachment 2: Snohomish County DYNAMEQ Network Plot

FEHR PEERS

DRAFT SCOPE OF SERVICES
SR 9/20TH ST SE DEVELOPMENT PROJECT
CITY OF LAKE STEVENS, WA

The following draft scope of work has been prepared to provide traffic forecasting and trip distribution information for a proposed development project in Lake Stevens, WA.

SCOPE OF SERVICES

Fehr & Peers will provide AM and PM peak hour intersection forecasts change in travel time along SR 9 for future year 2045 scenarios using the travel demand modeling tools developed for the US 2/SR 204 IJR project. These tools include the Snohomish County travel demand model and the IJR dynamic traffic assignment (DTA) model.

This scope assumes that no land use or network adjustments will be made to the travel demand model. Minor adjustments to the DTA model will be coordinated with the project team, as necessary, to ensure a reasonable increase in vehicle trip growth is included at the project site and that the network assumptions within the study area on SR 9, 20th St SE, and 24th St SE are consistent with the project team's expectations.

Intersection forecasts will be provided at the following three (3) locations:

- SR 9 / 20th Street SE
- SR 9 / 24th Street SE
- 91st Avenue SE / 20th Street SE

Forecasts will be provided for up to four (4) analysis scenarios looking at changes in traffic control at each of the study intersections. The DTA model will provide changes in traffic distribution at the project site due to the changes in driveway access. The DTA will also be used to estimate changes in travel time along SR 9 between the US 2 interchange and Market Place.

Existing traffic counts at each of the study locations will be provided.

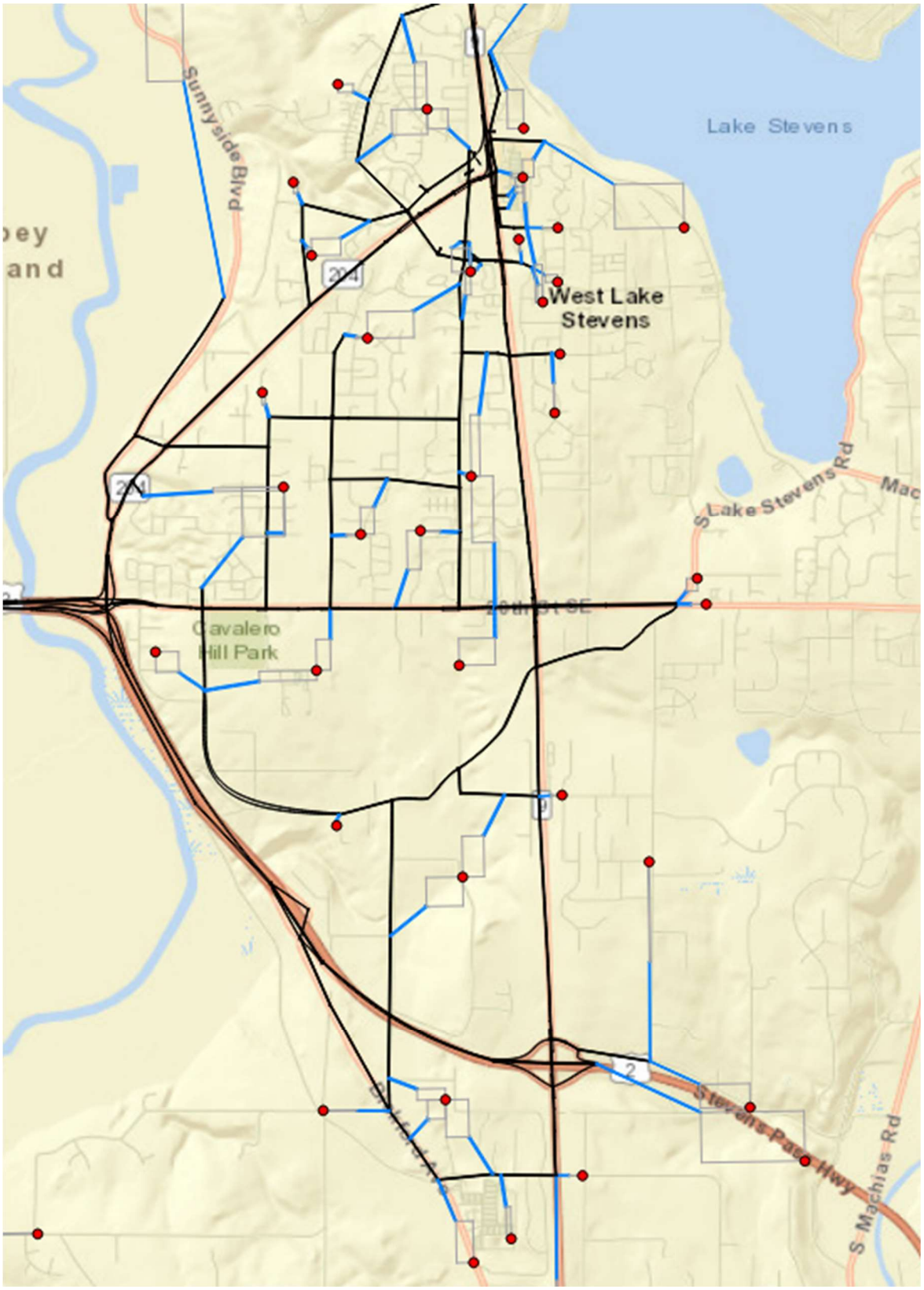
The intersection forecasts, traffic distribution for the project site, and relative travel time differences under each of the scenarios will be summarized in a brief technical memo. Trip distribution plots will be included.

The schedule for delivery will be determined in consultation with the project team after the exact descriptions of the access scenarios are defined.

BUDGET

This scope of work can be completed on a time and materials basis for an amount not to exceed $16,500.

Snohomish County DYNAMEQ Network



Appendix B. Vissim Calibration and Analysis Methods

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August 28, 2018

TO: Miguel Gavino, PE
Traffic Engineer – Snohomish/Mt. Baker Area
WSDOT Northwest Region

FROM: Andrew Bratlien, PE, TSI

SUBJECT: SR 9 / 24th Street SE Intersection Control Evaluation
Vissim Calibration and Analysis Methods

This memorandum documents the calibration of the SR 9 / 24th Street SE Intersection Control Evaluation (ICE) Vissim Existing AM and PM peak hour Vissim models.

MODEL DEVELOPMENT

The Washington State Department of Transportation (WSDOT) Protocol for Vissim Simulation and the Federal Highway Administration's (FHWA's) Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software were used as guidelines for the development of the Vissim model. As outlined in both documents, Vissim model development includes four steps:

1. Project Scoping
2. Data Collection / Data Development
3. Base Model Development
4. Error Correction

The following sections outline the details of how those four steps were applied to the Existing Conditions PM peak hour Vissim model developed for this project.

Project Scope

The ICE analysis included travel time, Level of Service, and queueing analysis for the areas shown in **Figure 1**. Travel time evaluation includes SR 9 from US 2 eastbound ramps to 4th Street SE and 20th Street SE from 91st Avenue SE to SR 9. Level of Service and queueing were analyzed at the following intersections:

- SR 9 & South Lake Stevens Road / 24th Street SE
- SR 9 & 20th Street SE
- 20th Street SE and 91st Avenue SE

In order for the traffic simulation model used in this analysis to accurately represent traffic patterns entering and exiting the traffic analysis area, the traffic model was built to extend beyond the analysis area in each direction. The traffic model area included SR 9 from 30th Street/John Jump Road to Market Place and 20th Street SE from 83rd Avenue SE to S Lake Stevens Road.

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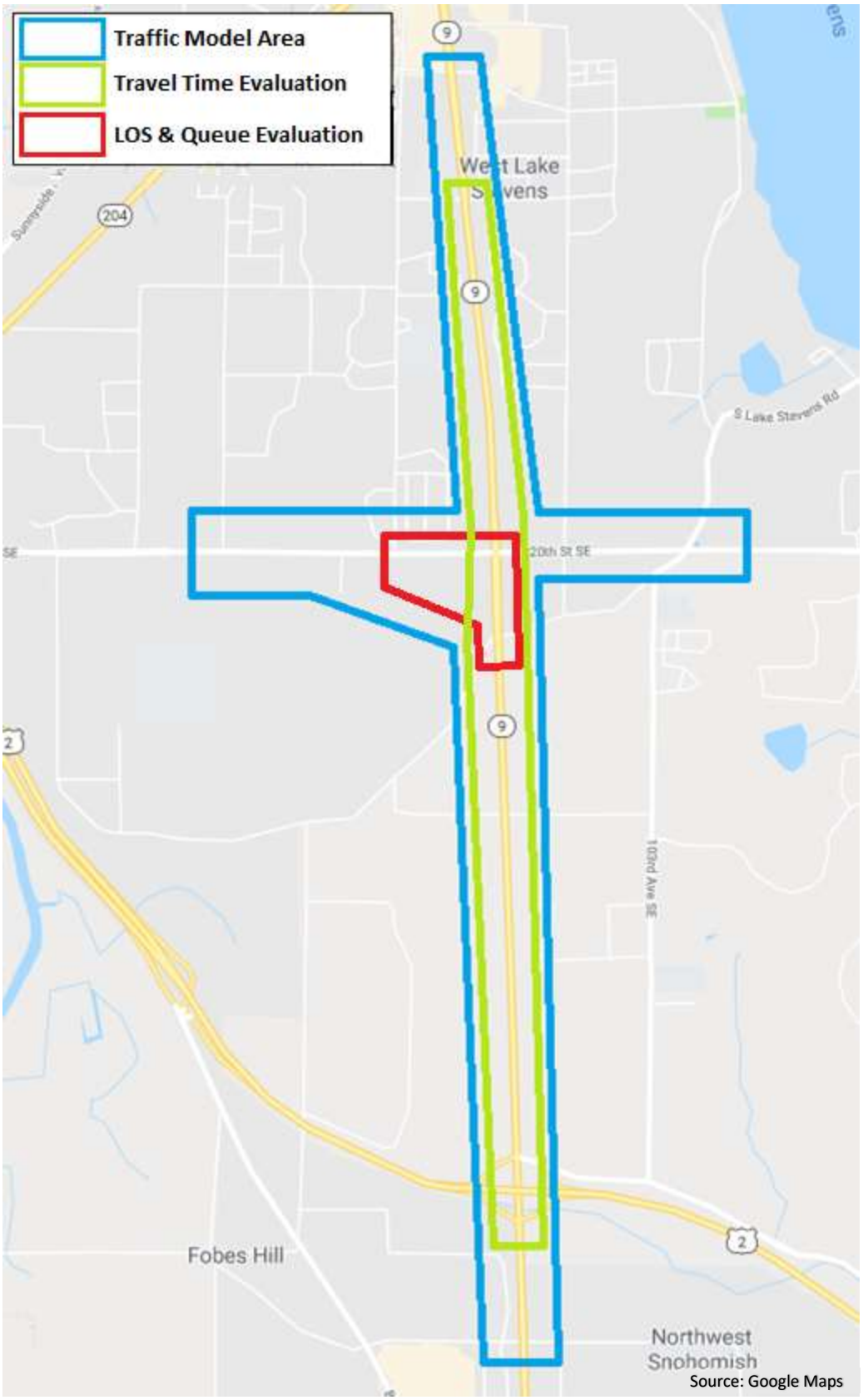


Figure 1. SR 9 / 24th St SE Traffic Evaluation Area and Model Area

Data Collection

Data for Vissim model development and calibration were collected from several sources:

- Peak period intersection turning movement and vehicle classification counts collected Thursday, May 10, 2018 at:
    - SR 9 and 20th Street SE
    - SR 9 and S Lake Stevens Road
    - 20th Street SE and 91st Avenue SE
- Peak period intersection turning movement counts collected Tuesday, March 6, 2018 at:
    - SR 9 and 32nd Street SE
    - SR 9 and 4th Street SE
    - 20th Street SE and 83rd Avenue SE
    - 20th Street SE and 99th Avenue SE
    - 20th Street SE and S Lake Stevens Road
- Peak period queues observed along SR 9 on Thursday, May 10, 2018.
- Floating car travel time surveys conducted on Wednesday, June 13, 2018.

Base Model Development

Base model development began with coding link geometry (shape, length, and number of lanes) over ortho-rectified Bing Maps satellite photography of the study area.

Network links were assigned Vissim's "Urban" driver behavior model, with corresponding Wiedemann 74 car following model.

Desired speed distributions were defined based on posted speed for local streets. Detailed speed profiles were not available, so desired speed distributions were defined linearly as plus or minus 5 miles per hour from posted speeds.

Reduced speed areas were coded for all left- and right-turn movements at intersections. Reduced speeds areas were assigned separate desired speed distributions for cars and trucks, consistent with WSDOT *Vissim Protocol* guidance. For left-turn movements, desired speeds of 15 mph (+/-) 2 mph were used for cars, and desired speeds of 10 mph (+/-) 2 mph were used for trucks. For right-turn movements, desired speeds of 9 mph (+/-) 2 mph were used for cars, and desired speeds of 5 mph (+/-) 2 mph were used for trucks.

Intersection control was coded for all study area intersections based on current signal timing plans provided by WSDOT. Signal timing plans were coded using the Vissim Ring-Barrier Controller interface. Detectors were coded at each stop bar. Right-turns on red (RTOR) were coded where allowed in the field using Vissim's RTOR feature.

Conflict areas were coded in locations where links/connectors cross and have the potential for vehicles to cross paths. The default conflict area parameters were maintained in the base models.

Vehicle inputs and vehicle compositions were coded with volumes identified in 2018 peak hour intersection turning movement counts at study area boundary intersections.

Static routing decisions were used to assign paths traffic through the network. Route volumes were defined based on 2018 intersection turning movement counts. Routes were developed based on the assumptions that (1) drivers will not take unrealistic or unnecessarily circuitous routes through the study area, and (2) routes will be assigned proportional to turning movement volumes at each intersection approach. Routing for cars and trucks were assumed to be similar.

A 15-minute (900-second) seeding period was used for model evaluation, as described in the Methods and Assumptions memorandum. Seeding period volumes were modeled as 90 percent of peak hour volumes.

Error Checking

Error checking involves the correction of model coding errors before beginning the calibration process. Error checking includes review of coded data and a review of the animation. All coded data (geometry, speeds, signal timing data, and traffic volumes) was reviewed by the model developer.

Review of the simulation animation was conducted to identify any locations where signal controllers may not be operating correctly, where lane changing behavior may be causing unrealistic queuing, and any other locations where coding errors may exist. Model parameters were adjusted as necessary, for example, correcting detector channel coding or adjusting static routing decision placement.

No errors or warning messages were produced during the AM peak hour and PM peak hour simulations.

CONFIDENCE

Given the variation in results that inherently exist between individual simulation runs due to the stochastic nature of microsimulation, it is important to evaluate model results to ensure that the evaluation sample is representative of the true model mean and not skewed toward a statistical outlier.

Initial Sample Size

To determine the level of confidence in the reported model results, an initial sample of model outputs was generated using an 11-run simulation. Eleven runs represent the recommended minimum per WSDOT *Vissim Protocol*. The random seed values used in the initial sampling were 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11.

Confidence Level

Confidence level represents the probability that the true model mean exists within the target confidence interval. A 95 percent confidence level was selected for this project. This is consistent with the WSDOT *Vissim Protocol and* FHWA *Traffic Analysis Toolbox*.

Confidence Interval

The confidence interval is the range of values within which the true mean may lie. To have confidence that the true mean lies within the calibration targets, defined below, the allowable variation between field observations and model outputs were used as the basis for the initial confidence interval.

Traffic throughput volumes were selected as the measure of effectiveness (MOE) to justify the confidence in the model results. The Confidence Report Template spreadsheets developed by WSDOT were updated for use in the development of the Confidence Interval.

Required Number of Simulation Runs

To ensure that the reported results are representative of the model average, the following formula was applied, per the FHWA *Traffic Analysis Toolbox*:

$$N = (2 * t_{0.025,N-1} \frac{s}{R})^2$$

R = Confidence interval for the true mean

$t_{0.025, N-1}$ = Student's t-statistic for two-sided error of 2.5 percent (total 5 percent with N-1 degrees of freedom (this is related to a 95% confidence level)

s = Standard deviation for selected MOE

N = number of required simulation runs

The standard deviation for the vehicle throughput MOE was determined from the preliminary set of 11 simulation runs.

Based on the number of runs calculation using the preliminary model results, it was determined that 11 simulation runs are sufficient to obtain the desired 95 percent confidence level. Detailed calculations are provided in Attachment B.

CALIBRATION

The calibration process involved reviewing and identifying model parameters and adjustments to allow the model to more closely represent observed field conditions. The calibration process involves comparison of simulation model outputs to field collected data.

Simulation parameters and model geometry were adjusted as necessary to reflect field observations. A list of adjustments in provided in Attachment A.

Notable adjustments to driving behavior parameters included:

- Desired acceleration and desired deceleration functions were modified for vehicles traveling SR 9. Modified curves were developed based on GPS traces from TSI's floating car travel time survey on Wednesday, June 13, 2018. Modified acceleration and deceleration functions are attached.

  The modified acceleration and deceleration functions were generally more conservative than the default Vissim functions. Field observations indicated that these behaviors may be related to driver expectations of congestion along southbound SR 9 during the AM peak hour.

  Future model scenarios assumed widening of SR 9 to a four-lane section. Future models further assumed that, based on travel time improvements associated with SR 9 widening, drivers would revert to "normal" or software default acceleration and deceleration behavior. Therefore the modified curves were applied to the 2018 AM peak hour calibrated Vissim model but were not applied to any of the 2040 Vissim models.

- Additive part of safety distance increased from 2.00 to 2.50 to reflect queue lengths along SR 9 and SE 20th Street

- Mulitplicative part of safety distance increased from 3.00 to 3.50 to reflect queue lengths along SR 9 and SE 20th Street

- Standstill distance increased from 6.56 feet to 7.50 feet to reflect queue lengths along SR 9 and SE 20th Street

Connector lane change distances were also adjusted on an approach-by-approach basis in order to reflect observed lane utilization and queueing at the intersection of SR 9 and 20th Street SE.

Base Model Calibration Results

Model outputs were compared to field observations and model parameters were adjusted iteratively until calibration targets were met. This section summarizes the calibration targets, the calibration results, and documents the calibrated model outputs.

To ensure that results representative of the true average of the model were used, confidence tests (as described above) were performed throughout the iterative calibration process.

Calibration targets included vehicle throughput volumes and queue length observations. Vehicle throughput volume targets included all turning movement volumes in the model area. Queue lengths were observed to reflect qualitative field observations.

The GEH statistic is an empirical formula used to compare a model output to a real-world observation, with smaller GEH values representing smaller variation between modeled and real-world conditions. The models were calibrated to within a GEH of 3 for throughput volumes and for per-lane speeds. Additionally, the total network volumes fell within the calibration target of 5 percent from total observed throughput volumes. All WSDOT and FHWA calibration targets were satisfied. Detailed calibration reports are provided in Attachment C and Attachment D.

Base Model Travel Time Check

As a supplemental calibration check, simulated travel times were compared to observed travel speeds along the SR 9 corridor. Travel time data was collected by TSI on Wednesday June 13, 2018 suing a smartphone-based GPS tracking application. For the 2018 base year of analysis, the AM peak hour and PM peak hour microsimulation models were calibrated to match observed travel time in both directions of SR 9 from the US 2 eastbound ramp intersection to 4th Street SE.

The 2018 AM peak hour Vissim model was calibrated to within 1.9 mph of observed travel speeds in the northbound direction of SR 9 and to within 0.4 mph of travel speeds in the southbound direction of SR 9. Calibrated AM peak hour travel times and speeds along SR 9 are shown in **Table 1.**

Table 1. 2018 AM Peak Hour SR 9 Travel Time Summary

Segment	Northbound				Southbound			
	Floating Car		Simulated		Floating Car		Simulated	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:42	15.8	0:30	23.4	0:21	29.7	0:22	32.4
Bunk Foss Rd to 32nd St SE	1:23	41.9	1:16	45.4	5:03	11.7	4:01	14.4
32nd St SE to 24th St SE	0:37	48.5	0:37	49.5	0:54	33.5	1:04	28.4
24th St SE to 20th St SE	0:39	21.6	0:52	15.9	0:22	39.8	0:26	32.3
20th St SE to 4th St SE	1:20	45.3	1:13	49.5	2:44	22.0	3:46	16.2
Total	**4:41**	**37.0**	**4:29**	**38.9**	**9:24**	**18.5**	**9:38**	**18.1**

The 2018 PM peak hour Vissim model was calibrated to within 1.4 mph of observed travel speeds in both northbound and southbound directions of SR 9. Calibrated PM peak hour travel times and speeds along SR 9 are shown in **Table 2.**

Table 2. 2018 PM Peak Hour SR 9 Travel Time Summary

Segment	Northbound				Southbound			
	Floating Car		Simulated		Floating Car		Simulated	
	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed
US 2 EB to Bunk Foss Rd	0:16	41.0	0:24	29.2	0:19	34.7	0:21	34.1
Bunk Foss Rd to 32nd St SE	1:34	37.2	1:45	33.2	1:35	36.9	1:23	41.6
32nd St SE to 24th St SE	0:42	43.7	0:36	50.1	0:52	34.9	0:42	42.6
24th St SE to 20th St SE	1:11	12.3	0:56	14.8	0:22	41.2	0:22	37.7
20th St SE to 4th St SE	1:27	41.7	1:16	47.6	1:38	36.1	1:47	34.0
Total	**5:10**	**33.8**	**4:57**	**35.2**	**4:45**	**36.5**	**4:36**	**37.9**

CONCLUSION

Based on the calibration targets and visual inspections of the field in comparison with the AM peak hour and PM peak hour Vissim models, it was determined that the base models are adequately calibrated. These base models will be used as the foundation for other Vissim models developed for this project.

Attachment A: Model Assumptions and Adjustments from Default Parameters

Attachment B: Vehicle Throughput Confidence Reports

Attachment C: Vehicle Throughput Calibration Reports

Attachment D: Modified Desired Acceleration and Deceleration Functions

Project: SR 9 / 24th Street SE / S Lake Stevens Rd ICE
Scenario: Existing Conditions
Prepared By: Andrew L. Bratlien, PE - TSI
Date: Tuesday, August 28, 2018

Type	Category	Setting	Assumption	Reason
Base Data	Distribution	Desired Speed	Linear distribution	No sufficient speed data to develop curves
	Driving Behavior	Urban	5 max observed vehicles (default is 4 for Urban; 2 for Freeway)	Enhances interaction between vehicles
			Average standstill distance: PM Peak Hour = 7.50 ft; AM peak hour = 6.50 ft	Adjusted standstil distance to match queueing observations at SR 9 & 20th St
			Additive part of safety distance = 2.50 (default is 2)	Increased to match queueing observations at SR 9 & 20th St
			Multiplicative part of safety distance = 3.50 (default is 3)	Increased to match queueing observations at SR 9 & 20th St
	Acceleration Functions	Desired Acceleration	Modified functions for cars and HV along SR 9	Developed acceleration function based on SR 9 floating car GPS traces
		Desired Deceleration	Modified functions for cars and HV along SR 9	Developed deceleration function based on SR 9 floating car GPS traces
Traffic	Vehicle Compositions	Arterial	SR 9 NB: 99.2% cars; 0.8% trucks (50-60 mph) SR 9 SB: 98.1% cars; 1.9% trucks (50-60 mph) 20th St SE EB: 98.9% cars; 1.1% trucks (25-35 mph) 20th St SE WB: 97.9% cars; 2.1% trucks (25-35 mph)	Truck percentage based on 2018 intersection turning movement counts; speeds based on posted speeds. Free flow speeds were not available; therefore speed distributions were coded as +/- 5mph of posted speed
Signal Control	Controllers	Controller Type	RBC controller type	Existing signal timing plans were applied for both signals
Links & Connectors	Lane Change	Lane Change Distance	Adjusted by location (default is 656 ft)	Lane change distance adjusted by location to account for observed lane utilization along SR 9 upstream of existing land drops. extended and applied per lane to account for more realistic lane changing behavior
			Per lane box checked (default is unchecked)	
Vehicle Inputs	All Inputs	Start Up Time	0-900: Applied 90% of peak hour vehicle volumes for 15 mintues prior to peak hour	Network seed volume was based on off-peak demand for 2 15-minute intervals prior to peak hour, per turning movement counts
		Input Volumes	900-4500: Applied peak hour volumes in 15-minute intervals, per turning movement counts.	Vehicle volumes were input based on 2018 turning movement counts. Peak Hour Factor was simulated by adjusted the third volume interval by the observed peak hour factor.
Routing Decisions	Static	All locations	Cars and trucks have same routes	No sufficient routing data to develop separate routes for cars and trucks
Priority Rules & Conflict Areas	Location	All Intersections	Conflict areas were used	No problems were observed with conflict area behavior
Detectors	Location	All Signalized Intersections	Detectors place at stop bars	Existing detector locations were unavailable. For consistency, detectors were placed just before the stop bar

WSDOT Vissim Throughput Volume Confidence Report

Project: SR 9 / 24th St SE / S Lake Stevens Rd ICA
Scenario: Existing Conditions - PM Peak Hour
Prepared By: Andrew L. Bratlien, PE - TSI
Date: Tuesday, July 3, 2018

Select Confidence Level for analysis (typically 95% is used)	95%
Select Confidence Interval Target **Acceptable variation in results based on the selected GEH statistic**	3
Number of Sample Runs	11
Number of sites failing to meet the Confidence Interval Target	1

Location Description					Model Results				Confidence Interval Target		Model Results Confidence Test	
Vissim Model Data Measurement	Route	Direction of Travel	Number of Lanes	Additional Description	Average Model Volume (vph)	Std Deviation (Model)	Confidence Interval based on a 95% Confidence Level (Volume Range)	Confidence Interval based on a 95% Confidence Level (%)	Confidence Interval based on GEH = 3 (Volume Range)	Confidence interval based on GEH = 3 (%)	TEST - Model results meet the following criteria. Selected Confidence Level = 95% Uniquiely defined desired confidence interval	Number of runs required to meet desired confidence criteria
1040101	20th St @ 91st Ave	EBL	1	20th St & 91st Ave	146	9	6.0	4.1%	34.1	23.3%	PASS	11
1040102	20th St @ 91st Ave	EBT	2	20th St & 91st Ave	761	12	8.1	1.1%	80.6	10.6%	PASS	11
1040103	20th St @ 91st Ave	EBR	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040201	20th St @ 91st Ave	WBL	1	20th St & 91st Ave	1	1	0.7	67.2%	-6.0	-600.3%	FAIL	11
1040202	20th St @ 91st Ave	WBT	2	20th St & 91st Ave	350	15	10.1	2.9%	54.0	15.4%	PASS	11
1040203	20th St @ 91st Ave	WBR	1	20th St & 91st Ave	155	11	7.4	4.8%	35.2	22.7%	PASS	11
1040301	91st Ave @ 20th St	NBL	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040302	91st Ave @ 20th St	NBT	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040303	91st Ave @ 20th St	NBR	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040401	91st Ave @ 20th St	SBL	1	20th St & 91st Ave	110	8	5.4	4.9%	29.3	26.6%	PASS	11
1040402	91st Ave @ 20th St	SBT	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040403	91st Ave @ 20th St	SBR	1	20th St & 91st Ave	93	9	6.0	6.5%	26.8	28.8%	PASS	11
1050101	20th St @ SR 9	EBL	1	SR 9 & 20th St	49	7	4.7	9.6%	18.9	38.5%	PASS	11
1050102	20th St @ SR 9	EBT	2	SR 9 & 20th St	697	15	10.1	1.4%	77.0	11.0%	PASS	11
1050103	20th St @ SR 9	EBR	1	SR 9 & 20th St	122	8	5.4	4.4%	31.0	25.4%	PASS	11
1050201	20th St @ SR 9	WBL	1	SR 9 & 20th St	143	11	7.4	5.2%	33.7	23.6%	PASS	11
1050202	20th St @ SR 9	WBT	2	SR 9 & 20th St	305	7	4.7	1.5%	50.2	16.5%	PASS	11
1050203	20th St @ SR 9	WBR	1	SR 9 & 20th St	64	4	2.7	4.2%	21.9	34.2%	PASS	11
1050301	SR 9 @ 20th St	NBL	1	SR 9 & 20th St	152	8	5.4	3.5%	34.8	22.9%	PASS	11
1050302	SR 9 @ 20th St	NBT	2	SR 9 & 20th St	694	17	11.4	1.6%	76.8	11.1%	PASS	11
1050303	SR 9 @ 20th St	NBR	1	SR 9 & 20th St	152	15	10.1	6.6%	34.8	22.9%	PASS	11
1050401	SR 9 @ 20th St	SBL	1	SR 9 & 20th St	98	7	4.7	4.8%	27.5	28.1%	PASS	11
1050402	SR 9 @ 20th St	SBT	2	SR 9 & 20th St	517	14	9.4	1.8%	66.0	12.8%	PASS	11
1050403	SR 9 @ 20th St	SBR	1	SR 9 & 20th St	52	6	4.0	7.8%	19.5	37.5%	PASS	11
1100101	S Lk Stevens Rd @ SR 9	EBL	1	SR 9 & 24th St/S Lk Stevens Rd	120	4	2.7	2.2%	30.7	25.6%	PASS	11
1100102	S Lk Stevens Rd @ SR 9	EBT	1	SR 9 & 24th St/S Lk Stevens Rd	3	1	0.7	22.4%	3.4	113.8%	PASS	11
1100103	S Lk Stevens Rd @ SR 9	EBR	1	SR 9 & 24th St/S Lk Stevens Rd	13	3	2.0	15.5%	8.8	67.7%	PASS	11
1100201	[reserved]			[reserved]	0	0	0.0	#DIV/0!				11
1100202	[reserved]			[reserved]	0	0	0.0	#DIV/0!				11
1100203	S Lk Stevens Rd @ SR 9	WBR	1	SR 9 & 24th St/S Lk Stevens Rd	11	1	0.7	6.1%	8.0	72.3%	PASS	11
1100301	SR 9 @ S Lk Stevens Rd	NBL	1	SR 9 & 24th St/S Lk Stevens Rd	5	2	1.3	26.9%	4.8	96.5%	PASS	11
1100302	SR 9 @ S Lk Stevens Rd	NBT	1	SR 9 & 24th St/S Lk Stevens Rd	878	18	12.1	1.4%	86.7	9.9%	PASS	11
1100303	SR 9 @ S Lk Stevens Rd	NBR	1	SR 9 & 24th St/S Lk Stevens Rd	118	13	8.7	7.4%	30.4	25.8%	PASS	11
1100401	[reserved]			[reserved]	0	0	0.0	#DIV/0!				11
1100402	SR 9 @ S Lk Stevens Rd	SBT	1	SR 9 & 24th St/S Lk Stevens Rd	733	19	12.8	1.7%	79.0	10.8%	PASS	11

1100403	SR 9 @ S Lk Stevens Rd	SBR	1	SR 9 & 24th St/S Lk Stevens Rd	48	6	4.0	8.4%	18.7	38.9%	PASS	11
1100404	SR 9 @ US 2 EB	NBT	1	SR 9 & US 2 EB	885	8	5.4	0.6%	87.1	9.8%	PASS	11
1100405	SR 9 @ US 2 EB	NBR	1	SR 9 & US 2 EB	42	4	2.7	6.4%	17.3	41.3%	PASS	11
1100406	SR 9 @ US 2 EB	SBL	1	SR 9 & US 2 EB	141	10	7	0	33	0	PASS	11
1100407	SR 9 @ US 2 EB	SBT	1	SR 9 & US 2 EB	741	25	17	0	79	0	PASS	11
1100408	US 2 EB off-ramp	EBL	1	SR 9 & US 2 EB	222	11	7	0	43	0	PASS	11
1100409	US 2 EB off-ramp	EBR	1	SR 9 & US 2 EB	326	11	7	0	52	0	PASS	11
1100410	SR 9 @ US 2 WB	NBL	1	SR 9 & US2 WB	73	10	7	0	23	0	PASS	11
1100411	SR 9 @ US 2 WB	NBT	1	SR 9 & US2 WB	722	22	15	0	78	0	PASS	11
1100412	SR 9 @ US 2 WB	NBR	1	SR 9 & US2 WB	307	16	11	0	50	0	PASS	11
1100413	SR 9 @ US 2 WB	SBL	1	SR 9 & US2 WB	25	4	3	0	13	1	PASS	11
1100414	SR 9 @ US 2 WB	SBT	1	SR 9 & US2 WB	650	20	13	0	74	0	PASS	11
1100415	SR 9 @ US 2 WB	SBR	1	SR 9 & US2 WB	9	3	2	0	7	1	PASS	11
1100416	Bunk Foss Rd @ SR 9	WBL	1	SR 9 & US2 WB	237	6	4	0	44	0	PASS	11
1100417	Bunk Foss Rd @ SR 9	WBT	1	SR 9 & US2 WB	68	10	7	0	23	0	PASS	11
1100418	Bunk Foss Rd @ SR 9	WBR	1	SR 9 & US2 WB	234	11	7	0	44	0	PASS	11
1100419	SR 9 @ Market Pl	NBL	1	SR 9 & Market Pl	79	8	5	0	25	0	PASS	11
1100420	SR 9 @ Market Pl	NBT	1	SR 9 & Market Pl	635	17	11	0	73	0	PASS	11
1100421	SR 9 @ Market Pl	NBR	1	SR 9 & Market Pl	68	9	6	0	23	0	PASS	11
1100422	SR 9 @ Market Pl	SBL	2	SR 9 & Market Pl	77	9	6	0	24	0	PASS	11
1100423	SR 9 @ Market Pl	SBT	2	SR 9 & Market Pl	474	10	7	0	63	0	PASS	11
1100424	SR 9 @ Market Pl	SBR	2	SR 9 & Market Pl	149	9	6	0	34	0	PASS	11
1100425	Market Pl @ SR 9	EBL	1	SR 9 & Market Pl	129	11	7	0	32	0	PASS	11
1100426	Market Pl @ SR 9	EBT	1	SR 9 & Market Pl	288	10	7	0	49	0	PASS	11
1100427	Market Pl @ SR 9	EBR	1	SR 9 & Market Pl	106	7	5	0	29	0	PASS	11
1100428	Market Pl @ SR 9	WBL	1	SR 9 & Market Pl	112	9	6	0	30	0	PASS	11
1100429	Market Pl @ SR 9	WBT	1	SR 9 & Market Pl	219	13	9	0	42	0	PASS	11
1100430	Market Pl @ SR 9	WBR	1	SR 9 & Market Pl	98	6	4	0	28	0	PASS	11

WSDOT Vissim Throughput Volume Confidence Report

Project: SR 9 / 24th St SE / S Lake Stevens Rd ICE
Scenario: Existing Conditions - AM Peak Hour
Prepared By: Andrew L. Bratlien, PE - TSI
Date: Wednesday, August 15, 2018

Select Confidence Level for analysis (typically 95% is used)	95%
Select Confidence Interval Target **Acceptable variation in results based on the selected GEH statistic**	3
Number of Sample Runs	11
Number of sites failing to meet the Confidence Interval Target	0

Location Description					Model Results				Confidence Interval Target		Model Results Confidence Test	
Vissim Model Data Measurement	Route	Direction of Travel	Number of Lanes	Additional Description	Average Model Volume (vph)	Std Deviation (Model)	Confidence Interval based on a 95% Confidence Level (Volume Range)	Confidence Interval based on a 95% Confidence Level (%)	Confidence Interval based on GEH = 3 (Volume Range)	Confidence interval based on GEH = 3 (%)	TEST - Model results meet the following criteria. Selected Confidence Level = 95% Uniquiely defined desired confidence interval	Number of runs required to meet desired confidence criteria
1040101	20th St @ 91st Ave	EBL	1	20th St & 91st Ave	76	7	4.7	6.2%	24.0	31.6%	PASS	11
1040102	20th St @ 91st Ave	EBT	2	20th St & 91st Ave	466	8	5.4	1.2%	62.6	13.4%	PASS	11
1040103	20th St @ 91st Ave	EBR	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040201	20th St @ 91st Ave	WBL	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040202	20th St @ 91st Ave	WBT	2	20th St & 91st Ave	342	13	8.7	2.6%	53.3	15.6%	PASS	11
1040203	20th St @ 91st Ave	WBR	1	20th St & 91st Ave	119	13	8.7	7.3%	30.6	25.7%	PASS	11
1040301	91st Ave @ 20th St	NBL	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040302	91st Ave @ 20th St	NBT	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040303	91st Ave @ 20th St	NBR	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040401	91st Ave @ 20th St	SBL	1	20th St & 91st Ave	168	6	4.0	2.4%	36.7	21.9%	PASS	11
1040402	91st Ave @ 20th St	SBT	1	20th St & 91st Ave	0	0	0.0	#DIV/0!				11
1040403	91st Ave @ 20th St	SBR	1	20th St & 91st Ave	75	6	4.0	5.4%	23.8	31.8%	PASS	11
1050101	20th St @ SR 9	EBL	1	SR 9 & 20th St	120	7	4.7	3.9%	30.7	25.6%	PASS	11
1050102	20th St @ SR 9	EBT	2	SR 9 & 20th St	258	11	7.4	2.9%	46.0	17.8%	PASS	11
1050103	20th St @ SR 9	EBR	1	SR 9 & 20th St	254	7	4.7	1.9%	45.6	18.0%	PASS	11
1050201	20th St @ SR 9	WBL	1	SR 9 & 20th St	414	13	8.7	2.1%	58.9	14.2%	PASS	11
1050202	20th St @ SR 9	WBT	2	SR 9 & 20th St	361	11	7.4	2.0%	54.8	15.2%	PASS	11
1050203	20th St @ SR 9	WBR	1	SR 9 & 20th St	81	4	2.7	3.3%	24.9	30.7%	PASS	11
1050301	SR 9 @ 20th St	NBL	1	SR 9 & 20th St	41	7	4.7	11.5%	17.1	41.7%	PASS	11
1050302	SR 9 @ 20th St	NBT	2	SR 9 & 20th St	337	19	12.8	3.8%	52.9	15.7%	PASS	11
1050303	SR 9 @ 20th St	NBR	1	SR 9 & 20th St	56	7	4.7	8.4%	20.3	36.3%	PASS	11
1050401	SR 9 @ 20th St	SBL	1	SR 9 & 20th St	61	8	5.4	8.8%	21.3	34.9%	PASS	11
1050402	SR 9 @ 20th St	SBT	2	SR 9 & 20th St	758	17	11.4	1.5%	80.4	10.6%	PASS	11
1050403	SR 9 @ 20th St	SBR	1	SR 9 & 20th St	56	7	4.7	8.4%	20.3	36.3%	PASS	11
1100101	S Lk Stevens Rd @ SR 9	EBL	1	SR 9 & 24th St/S Lk Stevens Rd	32	2	1.3	4.2%	14.9	46.5%	PASS	11
1100102	S Lk Stevens Rd @ SR 9	EBT	1	SR 9 & 24th St/S Lk Stevens Rd	0	0	0.0	#DIV/0!				11
1100103	S Lk Stevens Rd @ SR 9	EBR	1	SR 9 & 24th St/S Lk Stevens Rd	2	1	0.7	33.6%	2.6	127.6%	PASS	11
1100201	[reserved]			[reserved]	0	0	0.0	#DIV/0!				11
1100202	[reserved]			[reserved]	0	0	0.0	#DIV/0!				11
1100203	S Lk Stevens Rd @ SR 9	WBR	1	SR 9 & 24th St/S Lk Stevens Rd	11	0	0.0	0.0%	8.0	72.3%	PASS	11
1100301	SR 9 @ S Lk Stevens Rd	NBL	1	SR 9 & 24th St/S Lk Stevens Rd	7	3	2.0	28.8%	6.0	85.7%	PASS	11
1100302	SR 9 @ S Lk Stevens Rd	NBT	1	SR 9 & 24th St/S Lk Stevens Rd	385	21	14.1	3.7%	56.7	14.7%	PASS	11
1100303	SR 9 @ S Lk Stevens Rd	NBR	1	SR 9 & 24th St/S Lk Stevens Rd	27	6	4.0	14.9%	13.5	50.0%	PASS	11
1100401	[reserved]			[reserved]	0	0	0.0	#DIV/0!				11
1100402	SR 9 @ S Lk Stevens Rd	SBT	1	SR 9 & 24th St/S Lk Stevens Rd	913	17	11.4	1.3%	88.5	9.7%	PASS	11

1100403	SR 9 @ S Lk Stevens Rd	SBR	1	SR 9 & 24th St/S Lk Stevens Rd	514	15	10.1	2.0%	65.8	12.8%	PASS	11
1100404	SR 9 @ US 2 EB	NBT	1	SR 9 & US 2 EB	482	9	6.0	1.3%	63.7	13.2%	PASS	11
1100405	SR 9 @ US 2 EB	NBR	1	SR 9 & US 2 EB	36	7	4.7	13.1%	15.9	44.2%	PASS	11
1100406	SR 9 @ US 2 EB	SBL	1	SR 9 & US 2 EB	202	12	8	0	40	0	PASS	11
1100407	SR 9 @ US 2 EB	SBT	1	SR 9 & US 2 EB	866	21	14	0	86	0	PASS	11
1100408	US 2 EB off-ramp	EBL	1	SR 9 & US 2 EB	42	6	4	0	17	0	PASS	11
1100409	US 2 EB off-ramp	EBR	1	SR 9 & US 2 EB	166	6	4	0	36	0	PASS	11
1100410	SR 9 @ US 2 WB	NBL	1	SR 9 & US2 WB	118	9	6	0	30	0	PASS	11
1100411	SR 9 @ US 2 WB	NBT	1	SR 9 & US2 WB	325	16	11	0	52	0	PASS	11
1100412	SR 9 @ US 2 WB	NBR	1	SR 9 & US2 WB	89	9	6	0	26	0	PASS	11
1100413	SR 9 @ US 2 WB	SBL	1	SR 9 & US2 WB	4	2	1	0	4	1	PASS	11
1100414	SR 9 @ US 2 WB	SBT	1	SR 9 & US2 WB	822	19	13	0	84	0	PASS	11
1100415	SR 9 @ US 2 WB	SBR	1	SR 9 & US2 WB	45	6	4	0	18	0	PASS	11
1100416	Bunk Foss Rd @ SR 9	WBL	1	SR 9 & US2 WB	247	12	8	0	45	0	PASS	11
1100417	Bunk Foss Rd @ SR 9	WBT	1	SR 9 & US2 WB	307	8	5	0	50	0	PASS	11
1100418	Bunk Foss Rd @ SR 9	WBR	1	SR 9 & US2 WB	64	6	4	0	22	0	PASS	11
1100419	SR 9 @ Market Pl	NBL	1	SR 9 & Market Pl	30	7	5	0	14	0	PASS	11
1100420	SR 9 @ Market Pl	NBT	1	SR 9 & Market Pl	483	24	16	0	64	0	PASS	11
1100421	SR 9 @ Market Pl	NBR	1	SR 9 & Market Pl	34	7	5	0	15	0	PASS	11
1100422	SR 9 @ Market Pl	SBL	2	SR 9 & Market Pl	61	10	7	0	21	0	PASS	11
1100423	SR 9 @ Market Pl	SBT	2	SR 9 & Market Pl	691	9	6	0	77	0	PASS	11
1100424	SR 9 @ Market Pl	SBR	2	SR 9 & Market Pl	63	5	3	0	22	0	PASS	11
1100425	Market Pl @ SR 9	EBL	1	SR 9 & Market Pl	47	4	3	0	18	0	PASS	11
1100426	Market Pl @ SR 9	EBT	1	SR 9 & Market Pl	71	6	4	0	23	0	PASS	11
1100427	Market Pl @ SR 9	EBR	1	SR 9 & Market Pl	98	7	5	0	28	0	PASS	11
1100428	Market Pl @ SR 9	WBL	1	SR 9 & Market Pl	58	6	4	0	21	0	PASS	11
1100429	Market Pl @ SR 9	WBT	1	SR 9 & Market Pl	81	8	5	0	25	0	PASS	11
1100430	Market Pl @ SR 9	WBR	1	SR 9 & Market Pl	42	3	2	0	17	0	PASS	11

WSDOT Vissim Throughput Volume Calibration Test

Project: SR 9 / 24th St SE / S Lake Stevens Rd ICA
Scenario: Existing Conditions - PM Peak Hour
Prepared By: Andrew L. Bratlien, PE - TSI
Date: Tuesday, July 3, 2018

Calibration Targets	
Criteria	**Target Details**
GEH < 3.0	All state facility segments within the calibration area
GEH < 3.0	All entry and exist 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%

Sum of All Segment Flows Calibration Test	
Total "Field" Volumes	13,927
Total Model Volumes	13,706
Percent Difference	-1.6%

Number of Sample Runs	11
Number of Sites Failing to Meet the Calibration Target	0

Location Description						"Field" Volumes		Model Volume		Calibration Test		
Vissim Model Data Measurement	**Route**	**Direction of Travel**	**Number of Lanes**	**Additional Description**	**Facility Type**	**Total Volume (vph)**	**Vehicles per Lane (vphpl)**	**Average Total Volume (vph)**	**Average Vehicles Per Lane (vphpl)**	**GEH Target**	**GEH**	**Calibration Test**
1040101	20th St @ 91st Ave	EBL	1	20th St & 91st Ave	Local	150	150	146	146	5.0	0.3	PASS
1040102	20th St @ 91st Ave	EBT	2	20th St & 91st Ave	Local	783	392	761	381	5.0	0.6	PASS
1040103	20th St @ 91st Ave	EBR	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040201	20th St @ 91st Ave	WBL	1	20th St & 91st Ave	Local	1	1	1	1	5.0	0.0	PASS
1040202	20th St @ 91st Ave	WBT	2	20th St & 91st Ave	Local	365	183	350	175	5.0	0.6	PASS
1040203	20th St @ 91st Ave	WBR	1	20th St & 91st Ave	Local	157	157	155	155	5.0	0.2	PASS
1040301	91st Ave @ 20th St	NBL	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040302	91st Ave @ 20th St	NBT	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040303	91st Ave @ 20th St	NBR	1	20th St & 91st Ave	Local	1	1	0	0	5.0	1.4	PASS
1040401	91st Ave @ 20th St	SBL	1	20th St & 91st Ave	Local	109	109	110	110	5.0	0.1	PASS
1040402	91st Ave @ 20th St	SBT	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040403	91st Ave @ 20th St	SBR	1	20th St & 91st Ave	Local	96	96	93	93	5.0	0.3	PASS
1050101	20th St @ SR 9	EBL	1	SR 9 & 20th St	Local	50	50	49	49	5.0	0.1	PASS
1050102	20th St @ SR 9	EBT	2	SR 9 & 20th St	Local	717	359	697	349	5.0	0.5	PASS
1050103	20th St @ SR 9	EBR	1	SR 9 & 20th St	Local	126	126	122	122	5.0	0.4	PASS
1050201	20th St @ SR 9	WBL	1	SR 9 & 20th St	Local	143	143	143	143	5.0	0.0	PASS
1050202	20th St @ SR 9	WBT	2	SR 9 & 20th St	Local	313	157	305	153	5.0	0.3	PASS
1050203	20th St @ SR 9	WBR	1	SR 9 & 20th St	Local	69	69	64	64	5.0	0.6	PASS
1050301	SR 9 @ 20th St	NBL	1	SR 9 & 20th St	State	156	156	152	152	3.0	0.3	PASS
1050302	SR 9 @ 20th St	NBT	2	SR 9 & 20th St	State	708	354	694	347	3.0	0.4	PASS
1050303	SR 9 @ 20th St	NBR	1	SR 9 & 20th St	State	156	156	152	152	3.0	0.3	PASS
1050401	SR 9 @ 20th St	SBL	1	SR 9 & 20th St	State	97	97	98	98	3.0	0.1	PASS
1050402	SR 9 @ 20th St	SBT	2	SR 9 & 20th St	State	521	261	517	259	3.0	0.1	PASS
1050403	SR 9 @ 20th St	SBR	1	SR 9 & 20th St	State	54	54	52	52	3.0	0.3	PASS
1100101	S Lk Stevens Rd @ SR 9	EBL	1	SR 9 & 24th St/S Lk Stevens Rd	Local	122	122	120	120	5.0	0.2	PASS

1100102	S Lk Stevens Rd @ SR 9	EBT	1	SR 9 & 24th St/S Lk Stevens Rd	Local	3	3	3	3	5.0	0.0	PASS
1100103	S Lk Stevens Rd @ SR 9	EBR	1	SR 9 & 24th St/S Lk Stevens Rd	Local	11	11	13	13	5.0	0.6	PASS
1100201	[reserved]			[reserved]		1	#VALUE!	0	#VALUE!	3.0	#VALUE!	#VALUE!
1100202	[reserved]			[reserved]			#VALUE!	0	#VALUE!	3.0	#VALUE!	#VALUE!
1100203	S Lk Stevens Rd @ SR 9	WBR	1	SR 9 & 24th St/S Lk Stevens Rd	Local	10	10	11	11	5.0	0.3	PASS
1100301	SR 9 @ S Lk Stevens Rd	NBL	1	SR 9 & 24th St/S Lk Stevens Rd	State	5	5	5	5	3.0	0.0	PASS
1100302	SR 9 @ S Lk Stevens Rd	NBT	1	SR 9 & 24th St/S Lk Stevens Rd	State	888	888	878	878	3.0	0.3	PASS
1100303	SR 9 @ S Lk Stevens Rd	NBR	1	SR 9 & 24th St/S Lk Stevens Rd	State	122	122	118	118	3.0	0.4	PASS
1100401	[reserved]			[reserved]			#VALUE!	0	#VALUE!	3.0	#VALUE!	#VALUE!
1100402	SR 9 @ S Lk Stevens Rd	SBT	1	SR 9 & 24th St/S Lk Stevens Rd	State	741	741	733	733	3.0	0.3	PASS
1100403	SR 9 @ S Lk Stevens Rd	SBR	1	SR 9 & 24th St/S Lk Stevens Rd	State	49	49	48	48	3.0	0.1	PASS
1100404	SR 9 @ US 2 EB	NBT	1	SR 9 & US 2 EB	State	891	891	885	885	3.0	0.2	PASS
1100405	SR 9 @ US 2 EB	NBR	1	SR 9 & US 2 EB	State	44	44	42	42	3.0	0.3	PASS
1100406	SR 9 @ US 2 EB	SBL	1	SR 9 & US 2 EB	State	146	146	141	141	3.0	0.4	PASS
1100407	SR 9 @ US 2 EB	SBT	1	SR 9 & US 2 EB	State	747	747	741	741	3.0	0.2	PASS
1100408	US 2 EB off-ramp	EBL	1	SR 9 & US 2 EB	State	223	223	222	222	3.0	0.1	PASS
1100409	US 2 EB off-ramp	EBR	1	SR 9 & US 2 EB	State	324	324	326	326	3.0	0.1	PASS
1100410	SR 9 @ US 2 WB	NBL	1	SR 9 & US2 WB	State	69	69	73	73	3.0	0.5	PASS
1100411	SR 9 @ US 2 WB	NBT	1	SR 9 & US2 WB	State	733	733	722	722	3.0	0.4	PASS
1100412	SR 9 @ US 2 WB	NBR	1	SR 9 & US2 WB	State	312	312	307	307	3.0	0.3	PASS
1100413	SR 9 @ US 2 WB	SBL	1	SR 9 & US2 WB	State	24	24	25	25	3.0	0.2	PASS
1100414	SR 9 @ US 2 WB	SBT	1	SR 9 & US2 WB	State	660	660	650	650	3.0	0.4	PASS
1100415	SR 9 @ US 2 WB	SBR	1	SR 9 & US2 WB	State	11	11	9	9	3.0	0.6	PASS
1100416	Bunk Foss Rd @ SR 9	WBL	1	SR 9 & US2 WB	State	233	233	237	237	3.0	0.3	PASS
1100417	Bunk Foss Rd @ SR 9	WBT	1	SR 9 & US2 WB	State	69	69	68	68	3.0	0.1	PASS
1100418	Bunk Foss Rd @ SR 9	WBR	1	SR 9 & US2 WB	State	233	233	234	234	3.0	0.1	PASS
1100419	SR 9 @ Market Pl	NBL	1	SR 9 & Market Pl	State	81	81	79	79	3.0	0.2	PASS
1100420	SR 9 @ Market Pl	NBT	1	SR 9 & Market Pl	State	660	660	635	635	3.0	1.0	PASS
1100421	SR 9 @ Market Pl	NBR	1	SR 9 & Market Pl	State	68	68	68	68	3.0	0.0	PASS
1100422	SR 9 @ Market Pl	SBL	2	SR 9 & Market Pl	State	77	39	77	39	3.0	0.0	PASS
1100423	SR 9 @ Market Pl	SBT	2	SR 9 & Market Pl	State	469	235	474	237	3.0	0.2	PASS
1100424	SR 9 @ Market Pl	SBR	2	SR 9 & Market Pl	State	159	80	149	75	3.0	0.6	PASS
1100425	Market Pl @ SR 9	EBL	1	SR 9 & Market Pl	Local	138	138	129	129	5.0	0.8	PASS
1100426	Market Pl @ SR 9	EBT	1	SR 9 & Market Pl	Local	290	290	288	288	5.0	0.1	PASS
1100427	Market Pl @ SR 9	EBR	1	SR 9 & Market Pl	Local	109	109	106	106	5.0	0.3	PASS
1100428	Market Pl @ SR 9	WBL	1	SR 9 & Market Pl	Local	111	111	112	112	5.0	0.1	PASS
1100429	Market Pl @ SR 9	WBT	1	SR 9 & Market Pl	Local	220	220	219	219	5.0	0.1	PASS
1100430	Market Pl @ SR 9	WBR	1	SR 9 & Market Pl	Local	102	102	98	98	5.0	0.4	PASS

WSDOT Vissim Throughput Volume Calibration Test

Project: SR 9 / 24th St SE / S Lake Stevens Rd ICE
Scenario: Existing Conditions - AM Peak Hour
Prepared By: Andrew L. Bratlien, PE - TSI
Date: Wednesday, August 15, 2018

Calibration Targets	
Criteria	**Target Details**
GEH < 3.0	All state facility segments within the calibration area
GEH < 3.0	All entry and exist 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%

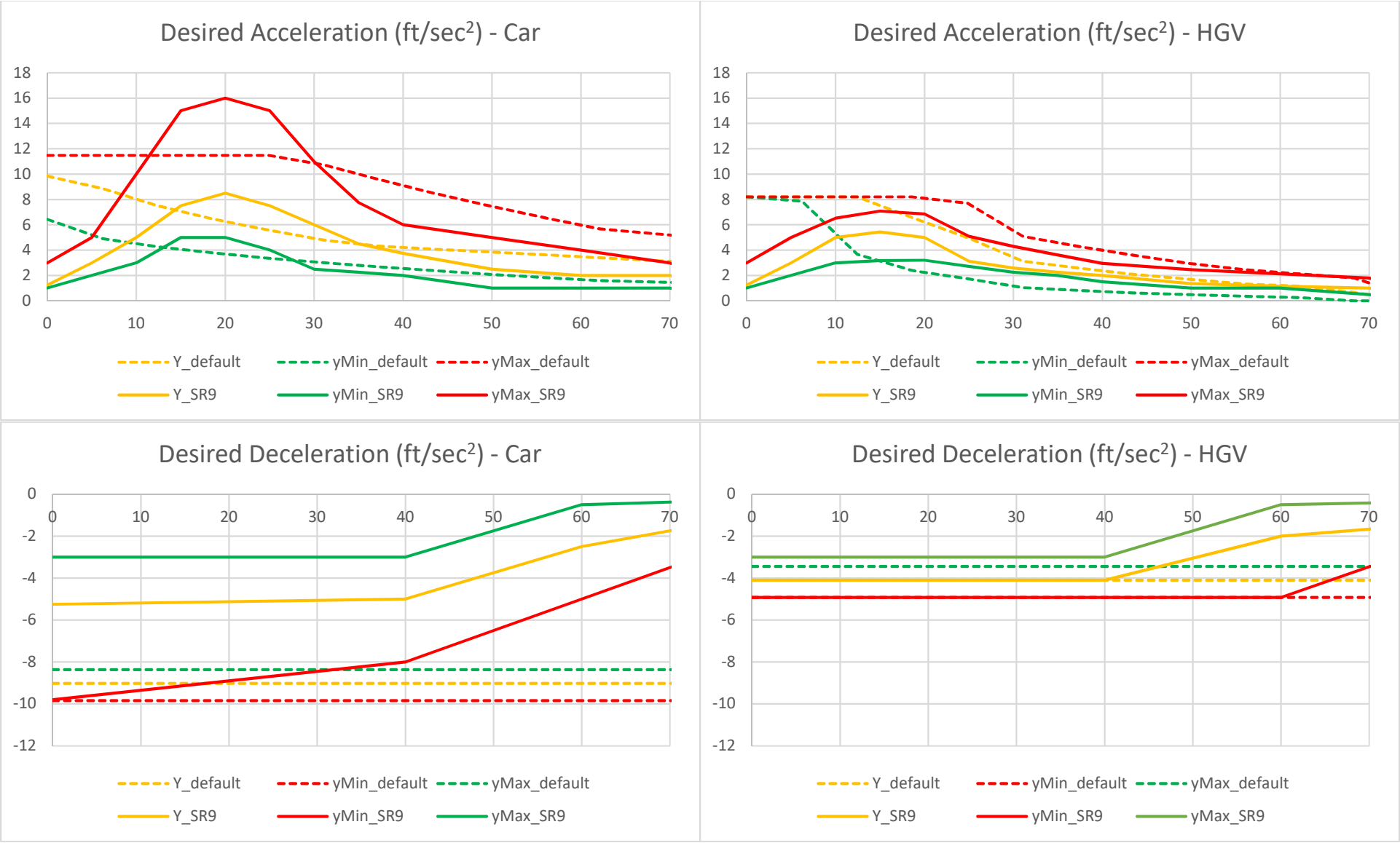
Sum of All Segment Flows Calibration Test	
Total "Field" Volumes	11,560
Total Model Volumes	11,508
Percent Difference	-0.4%

Number of Sample Runs	11
Number of Sites Failing to Meet the Calibration Target	0

Location Description						"Field" Volumes		Model Volume		Calibration Test		
Vissim Model Data Measurement	**Route**	**Direction of Travel**	**Number of Lanes**	**Additional Description**	**Facility Type**	**Total Volume (vph)**	**Vehicles per Lane (vphpl)**	**Average Total Volume (vph)**	**Average Vehicles Per Lane (vphpl)**	**GEH Target**	**GEH**	**Calibration Test**
1040101	20th St @ 91st Ave	EBL	1	20th St & 91st Ave	Local	77	77	76	76	5.0	0.1	PASS
1040102	20th St @ 91st Ave	EBT	2	20th St & 91st Ave	Local	472	236	466	233	5.0	0.2	PASS
1040103	20th St @ 91st Ave	EBR	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040201	20th St @ 91st Ave	WBL	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040202	20th St @ 91st Ave	WBT	2	20th St & 91st Ave	Local	350	175	342	171	5.0	0.3	PASS
1040203	20th St @ 91st Ave	WBR	1	20th St & 91st Ave	Local	117	117	119	119	5.0	0.2	PASS
1040301	91st Ave @ 20th St	NBL	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040302	91st Ave @ 20th St	NBT	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040303	91st Ave @ 20th St	NBR	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040401	91st Ave @ 20th St	SBL	1	20th St & 91st Ave	Local	164	164	168	168	5.0	0.3	PASS
1040402	91st Ave @ 20th St	SBT	1	20th St & 91st Ave	Local	0	0	0	0	5.0	#DIV/0!	#DIV/0!
1040403	91st Ave @ 20th St	SBR	1	20th St & 91st Ave	Local	81	81	75	75	5.0	0.7	PASS
1050101	20th St @ SR 9	EBL	1	SR 9 & 20th St	Local	122	122	120	120	5.0	0.2	PASS
1050102	20th St @ SR 9	EBT	2	SR 9 & 20th St	Local	261	131	258	129	5.0	0.1	PASS
1050103	20th St @ SR 9	EBR	1	SR 9 & 20th St	Local	253	253	254	254	5.0	0.1	PASS
1050201	20th St @ SR 9	WBL	1	SR 9 & 20th St	Local	421	421	414	414	5.0	0.3	PASS
1050202	20th St @ SR 9	WBT	2	SR 9 & 20th St	Local	364	182	361	181	5.0	0.1	PASS
1050203	20th St @ SR 9	WBR	1	SR 9 & 20th St	Local	84	84	81	81	5.0	0.3	PASS
1050301	SR 9 @ 20th St	NBL	1	SR 9 & 20th St	State	45	45	41	41	3.0	0.6	PASS
1050302	SR 9 @ 20th St	NBT	2	SR 9 & 20th St	State	335	168	337	169	3.0	0.1	PASS
1050303	SR 9 @ 20th St	NBR	1	SR 9 & 20th St	State	52	52	56	56	3.0	0.5	PASS
1050401	SR 9 @ 20th St	SBL	1	SR 9 & 20th St	State	63	63	61	61	3.0	0.3	PASS
1050402	SR 9 @ 20th St	SBT	2	SR 9 & 20th St	State	753	377	758	379	3.0	0.1	PASS
1050403	SR 9 @ 20th St	SBR	1	SR 9 & 20th St	State	58	58	56	56	3.0	0.3	PASS
1100101	S Lk Stevens Rd @ SR 9	EBL	1	SR 9 & 24th St/S Lk Stevens Rd	Local	29	29	32	32	5.0	0.5	PASS

1100102	S Lk Stevens Rd @ SR 9	EBT	1	SR 9 & 24th St/S Lk Stevens Rd	Local	4	4	0	0	5.0	2.8	PASS
1100103	S Lk Stevens Rd @ SR 9	EBR	1	SR 9 & 24th St/S Lk Stevens Rd	Local	1	1	2	2	5.0	0.8	PASS
1100201	[reserved]			[reserved]			#VALUE!	0	#VALUE!	3.0	#VALUE!	#VALUE!
1100202	[reserved]			[reserved]			#VALUE!	0	#VALUE!	3.0	#VALUE!	#VALUE!
1100203	S Lk Stevens Rd @ SR 9	WBR	1	SR 9 & 24th St/S Lk Stevens Rd	Local	12	12	11	11	5.0	0.3	PASS
1100301	SR 9 @ S Lk Stevens Rd	NBL	1	SR 9 & 24th St/S Lk Stevens Rd	State	7	7	7	7	3.0	0.0	PASS
1100302	SR 9 @ S Lk Stevens Rd	NBT	1	SR 9 & 24th St/S Lk Stevens Rd	State	391	391	385	385	3.0	0.3	PASS
1100303	SR 9 @ S Lk Stevens Rd	NBR	1	SR 9 & 24th St/S Lk Stevens Rd	State	29	29	27	27	3.0	0.4	PASS
1100401	SR 9 @ S Lk Stevens Rd	SBL	1	SR 9 & 24th St/S Lk Stevens Rd	State	0	0	0	0	3.0	#DIV/0!	#DIV/0!
1100402	SR 9 @ S Lk Stevens Rd	SBT	1	SR 9 & 24th St/S Lk Stevens Rd	State	903	903	913	913	3.0	0.3	PASS
1100403	SR 9 @ S Lk Stevens Rd	SBR	1	SR 9 & 24th St/S Lk Stevens Rd	State	524	524	514	514	3.0	0.4	PASS
1100404	SR 9 @ US 2 EB	NBT	1	SR 9 & US 2 EB	State	483	483	482	482	3.0	0.0	PASS
1100405	SR 9 @ US 2 EB	NBR	1	SR 9 & US 2 EB	State	34	34	36	36	3.0	0.3	PASS
1100406	SR 9 @ US 2 EB	SBL	1	SR 9 & US 2 EB	State	207	207	202	202	3.0	0.3	PASS
1100407	SR 9 @ US 2 EB	SBT	1	SR 9 & US 2 EB	State	860	860	866	866	3.0	0.2	PASS
1100408	US 2 EB off-ramp	EBL	1	SR 9 & US 2 EB	State	41	41	42	42	3.0	0.2	PASS
1100409	US 2 EB off-ramp	EBR	1	SR 9 & US 2 EB	State	167	167	166	166	3.0	0.1	PASS
1100410	SR 9 @ US 2 WB	NBL	1	SR 9 & US2 WB	State	120	120	118	118	3.0	0.2	PASS
1100411	SR 9 @ US 2 WB	NBT	1	SR 9 & US2 WB	State	318	318	325	325	3.0	0.4	PASS
1100412	SR 9 @ US 2 WB	NBR	1	SR 9 & US2 WB	State	86	86	89	89	3.0	0.3	PASS
1100413	SR 9 @ US 2 WB	SBL	1	SR 9 & US2 WB	State	4	4	4	4	3.0	0.0	PASS
1100414	SR 9 @ US 2 WB	SBT	1	SR 9 & US2 WB	State	814	814	822	822	3.0	0.3	PASS
1100415	SR 9 @ US 2 WB	SBR	1	SR 9 & US2 WB	State	44	44	45	45	3.0	0.1	PASS
1100416	Bunk Foss Rd @ SR 9	WBL	1	SR 9 & US2 WB	State	253	253	247	247	3.0	0.4	PASS
1100417	Bunk Foss Rd @ SR 9	WBT	1	SR 9 & US2 WB	State	316	316	307	307	3.0	0.5	PASS
1100418	Bunk Foss Rd @ SR 9	WBR	1	SR 9 & US2 WB	State	66	66	64	64	3.0	0.2	PASS
1100419	SR 9 @ Market Pl	NBL	1	SR 9 & Market Pl	State	30	30	30	30	3.0	0.0	PASS
1100420	SR 9 @ Market Pl	NBT	1	SR 9 & Market Pl	State	494	494	483	483	3.0	0.5	PASS
1100421	SR 9 @ Market Pl	NBR	1	SR 9 & Market Pl	State	34	34	34	34	3.0	0.0	PASS
1100422	SR 9 @ Market Pl	SBL	2	SR 9 & Market Pl	State	61	31	61	31	3.0	0.0	PASS
1100423	SR 9 @ Market Pl	SBT	2	SR 9 & Market Pl	State	692	346	691	346	3.0	0.0	PASS
1100424	SR 9 @ Market Pl	SBR	2	SR 9 & Market Pl	State	63	32	63	32	3.0	0.0	PASS
1100425	Market Pl @ SR 9	EBL	1	SR 9 & Market Pl	Local	52	52	47	47	5.0	0.7	PASS
1100426	Market Pl @ SR 9	EBT	1	SR 9 & Market Pl	Local	70	70	71	71	5.0	0.1	PASS
1100427	Market Pl @ SR 9	EBR	1	SR 9 & Market Pl	Local	96	96	98	98	5.0	0.2	PASS
1100428	Market Pl @ SR 9	WBL	1	SR 9 & Market Pl	Local	58	58	58	58	5.0	0.0	PASS
1100429	Market Pl @ SR 9	WBT	1	SR 9 & Market Pl	Local	78	78	81	81	5.0	0.3	PASS
1100430	Market Pl @ SR 9	WBR	1	SR 9 & Market Pl	Local	47	47	42	42	5.0	0.7	PASS

Desired Acceleration and Deceleration Functions – Vissim Default vs. SR 9 Calibrated (SR 9 – 24th St SE ICE, AM peak hour)



Appendix C. Signal Warrant Analysis

TRAFFIC SIGNAL WARRANTS

City/Town:	Lake Stevens, WA	Analysis Performed By:	Andrew L. Bratlien
County:	WSDOT	Date Analysis Performed:	8/17/2018
Division:		Project Number if Applicable:	218002
Data Date:	2040 DYNAMEQ forecast	Weather Conditions:	

Major Route:	SR 9	Appr. Lanes:	4	Critical Approach Speed (mph):	55
Minor Route:	24th St SE	Appr. Lanes:	2		

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph) ? [X] Yes [ ] No
2. Is the intersection in a built-up area or isolated community of <10,000 population? [ ] Yes [ ] No

If Question 1 or 2 above is answered "Yes", then use "70%" volume level [X] 70% [ ] 100%

WARRANT 1 - EIGHT-HOUR VEHICULAR VOLUME

Warrant 1 is satisfied if Condition A or Condition B is "100%" satisfied.

Warrant is also satisfied if both Condition A and Condition B are "80%" satisfied, given adequate trials of other remedial measures have been tried.

Satisfied: [X] Yes [ ] No

Adequate trial(s) of other remedial measures tried: [ ] Yes [X] No

List Remedial Measures Tried (Required for 80% Combination of A & B)

Condition A - Minimum Vehicular Volume & Condition B - Interruption of Continuous Traffic

100% Satisfied: [X] Yes [ ] No

(Used if neither Condition A or B is satisfied) 80% Satisfied: [ ] Yes [ ] No

	(volumes in veh/hr)	Minimum Requirements				Eight Highest Hours							
	Approach Lanes	1		2 or more									
	Volume Level	100%	70%	100%	70%	4 PM	5 PM	7 AM	8 AM	76% pk	68% pk	63% pk	60% pk
W - 1A 100%	Both Approaches on Major Street	500	350	600	420	2,760	2,510	2,010	1,616	2,098	1,877	1,739	1,656
	Highest Approach on Minor Street	150	105	200	140	420	516	180	246	319	286	265	252
	(volumes in veh/hr)	Minimum Requirements				4 PM	5 PM	7 AM	8 AM	76% pk	68% pk	63% pk	60% pk
	Approach Lanes	1		2 or more									
	Volume Level	100%	70%	100%	70%								
W - 1B 100%	Both Approaches on Major Street	750	525	900	630	2,760	2,510	2,010	1,616	2,098	1,877	1,739	1,656
	Highest Approach on Minor Street	75	53	100	70	420	516	180	246	319	286	265	252
	(volumes in veh/hr)	Minimum Requirements				4 PM	5 PM	7 AM	8 AM	76% pk	68% pk	63% pk	60% pk
	Approach Lanes	1		2 or more									
	Volume Level	100%	70%	100%	70%								
W - 1A 80%	Both Approaches on Major Street	400	280	480	336	2,760	2,510	2,010	1,616	2,098	1,877	1,739	1,656
	Highest Approach on Minor Street	120	84	160	112	420	516	180	246	319	286	265	252
	(volumes in veh/hr)	Minimum Requirements				4 PM	5 PM	7 AM	8 AM	76% pk	68% pk	63% pk	60% pk
	Approach Lanes	1		2 or more									
	Volume Level	100%	70%	100%	70%								
W - 1B 80%	Both Approaches on Major Street	600	420	720	504	2,760	2,510	2,010	1,616	2,098	1,877	1,739	1,656
	Highest Approach on Minor Street	60	42	80	56	420	516	180	246	319	286	265	252

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal*

TRAFFIC SIGNAL WARRANTS

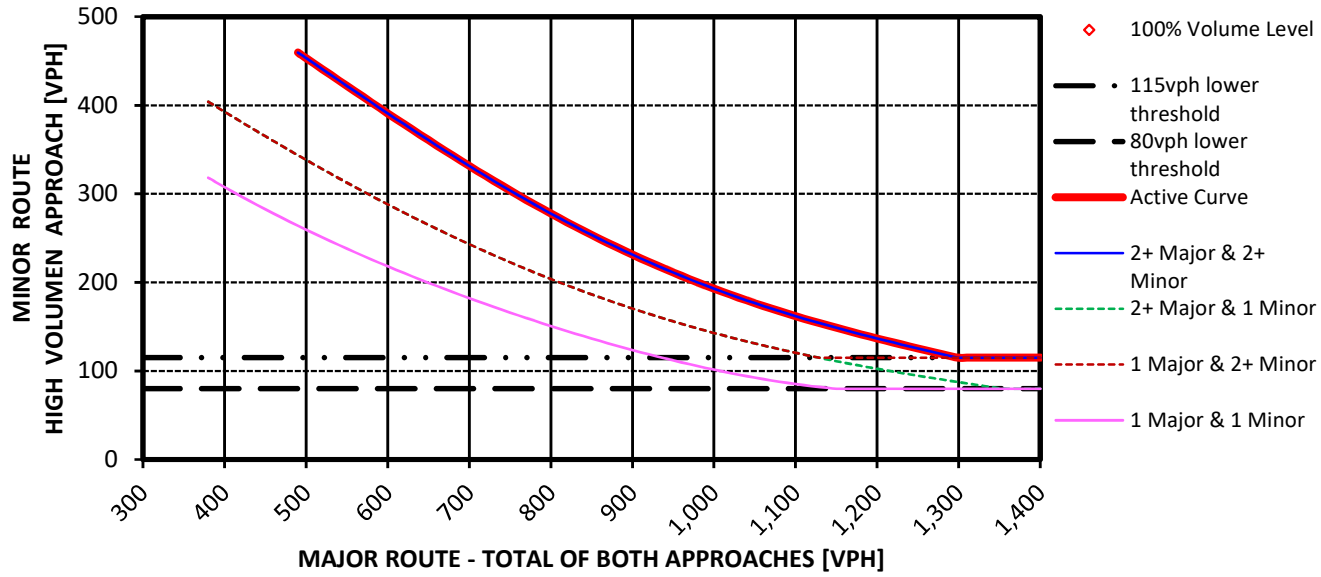
WARRANT 2 - FOUR-HOUR VEHICULAR VOLUME

Satisfied: [X] Yes [ ] No

If all four points lie above the appropriate line, then this warrant is satisfied.

(Volumes in veh/hr)	Four Highest Hours			
	4 PM	5 PM	7 AM	8 AM
SUM of Both Approaches on Major Street	2,760	2,510	2,010	1,616
Highest Minor Street Approach	420	516	180	246

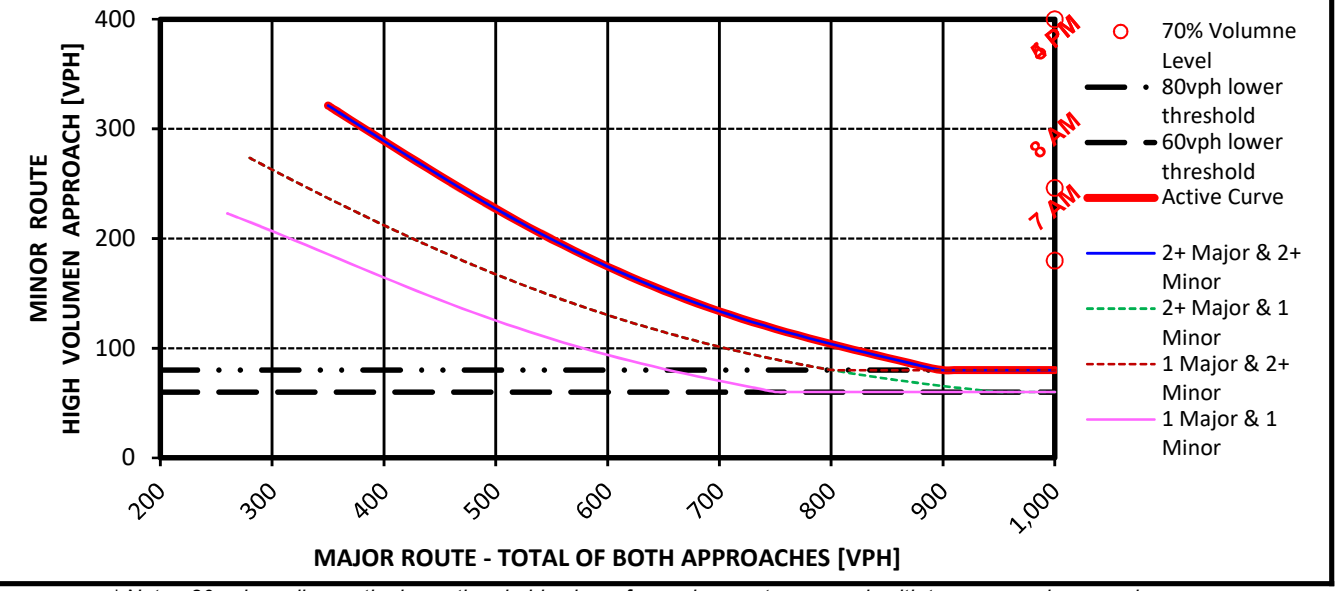
FIGURE W-2: Criteria for "100%" Volume Level



** Note: 115 vph applies as the lower threshold volume for a minor route approach with two or more lanes and 80 vph applies as the lower threshold volume threshold for a minor route approach with one lane.*

FIGURE W-2: Criteria for "70%" Volume Level

(Community less-than 10,000 population or speeds greater-than 70 km/hr [40 mph] on Major Street)



** Note: 80 vph applies as the lower threshold volume for a minor route approach with two or more lanes and 60 vph applies as the lower threshold volume threshold for a minor route approach with one lane.*

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal.*

TRAFFIC SIGNAL WARRANTS

WARRANT 3 - PEAK HOUR VEHICULAR VOLUME

Applicable: [X] Yes [ ] No

Satisfied: [X] Yes [ ] No

This signal warrant sahll be applied only in unsual cases, such as office complexes, manufacturing plants, industrial complexes, or high-ocupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time period.

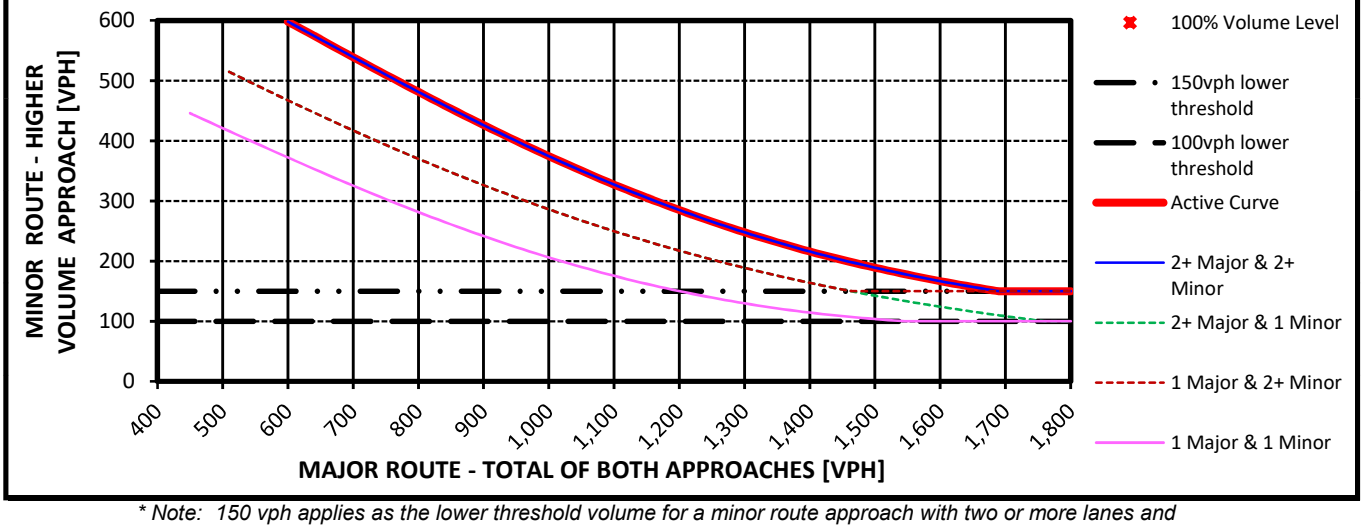
Signalization shall be considered if a point lies above the appropriate line or the Delay criteria is met.

Unusual case(s) justifying this Warrant:

ICE

Peak Hour Data		
Peak Hour	*Major Route*	*Minor Route*
4 PM	***2,760***	***420***

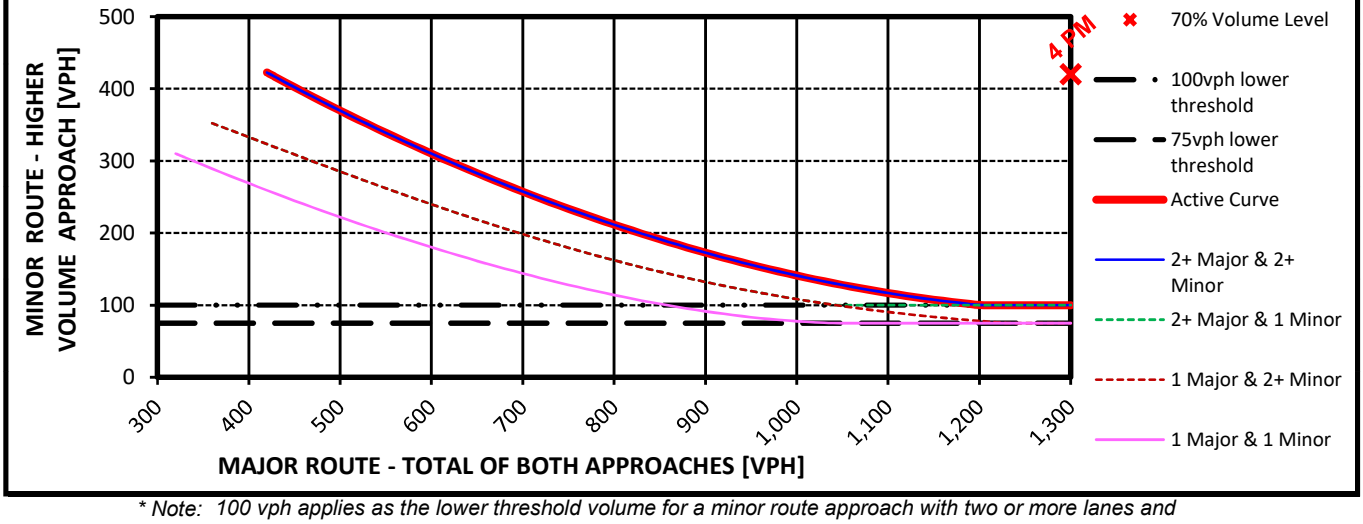
FIGURE W-3: Criteria for "100%" Volume Level



** Note: 150 vph applies as the lower threshold volume for a minor route approach with two or more lanes and 100 vph applies as the lower threshold volume threshold for a minor route approach with one lane.*

FIGURE W-3: Criteria for "70%" Volume Level

(Community less-than 10,000 population or speeds greater-than 70 km/hr [40 mph] on Major Street)



** Note: 100 vph applies as the lower threshold volume for a minor route approach with two or more lanes and 75 vph applies as the lower threshold volume threshold for a minor route approach with one lane.*

DELAY CRITERIA

1. Delay on Minor Approach (vehicle-hours)		
Approaches Lanes:	1	2
Delay Criteria:	4.0	5.0
Delay:		
Fullfilled? [ ] Yes	[X] NO	

2. Volume on Minor Approach (veh/hr)		
Approaches Lanes	1	2
Volume Criteria	100	150
Volume :		
Fullfilled? [ ] Yes	[X] NO	

3. Total Entering Volume (veh/hr)		
Number of Approaches: [ ] *3* [X] *4 or more*		
No. of Approaches	3	4
Volume Criteria	650	800
Volume :		***3,240***
Fullfilled? [X] Yes	[ ] NO	

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal*

TRAFFIC SIGNAL WARRANTS

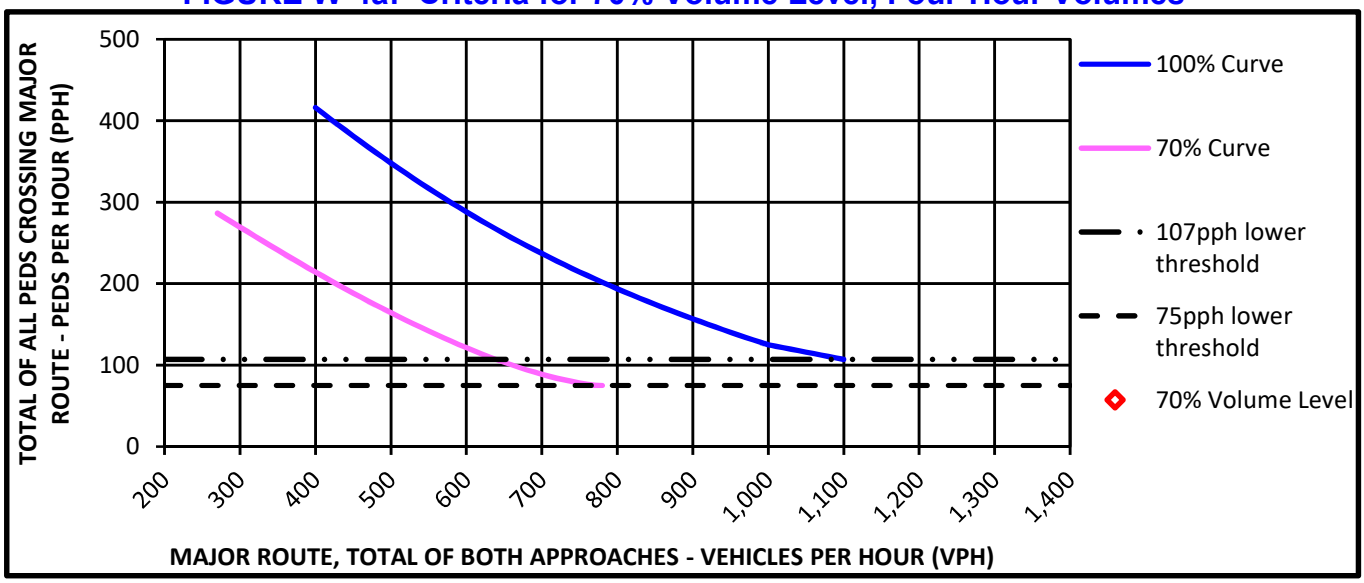
WARRANT 4 - PEDESTRIAN VOLUME

Satisfied: [ ] Yes [X] No

Pedestrian Signal Location Criteria			Fulfilled? Yes	No
The nearest traffic control device (signal or STOP sign) controlling traffic on the major route is more than 90m (300 ft) away:	[X] Yes	[ ] No	X	
If no above, will this proposed signal restrict the progrssive movement of traffic?	[ ] Yes	[X] No		

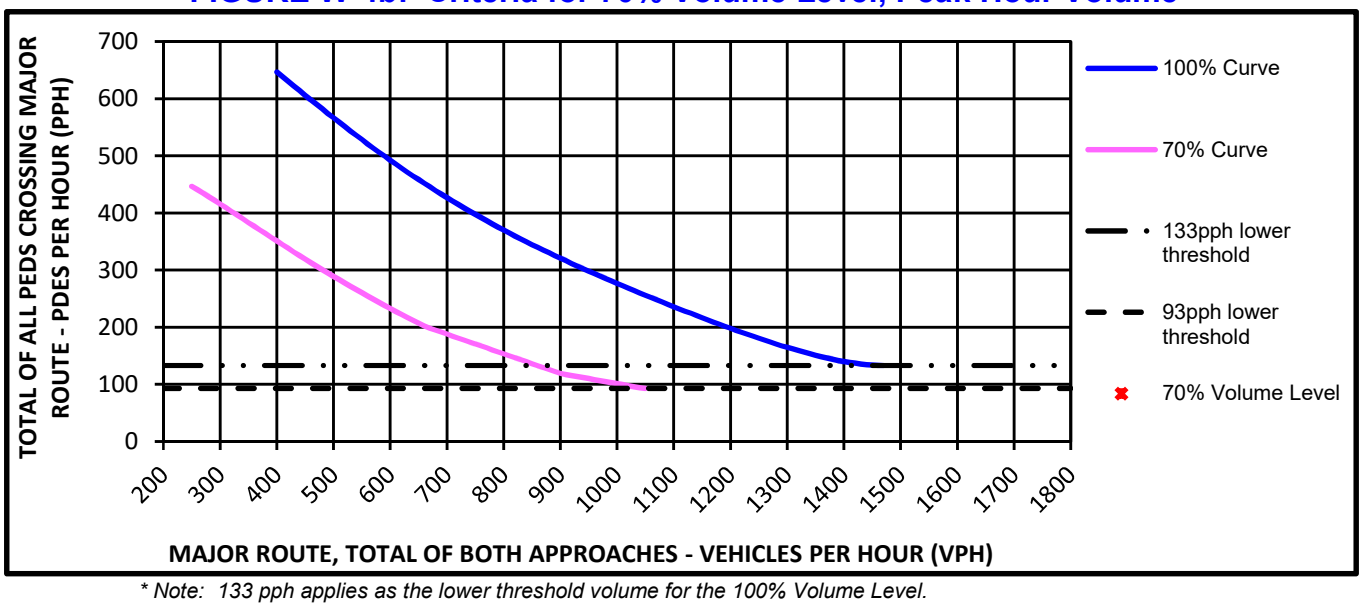
Vehicle volumes in veh/hr and Pedestrian volumnes in ped/hr	*Four Greatest Hours*				Peak Hour
SUM of Both Approaches on Major Route					
Pedestrians crossing the Major Route					

FIGURE W-4a: Criteria for 70% Volume Level, Four-Hour Volumes



** Note: 107 pph applies as the lower threshold volume for the 100% Volume Level.*
75 pph applies as the lower threshold volume for the 70% Volume Level.

FIGURE W-4b: Criteria for 70% Volume Level, Peak Hour Volume



** Note: 133 pph applies as the lower threshold volume for the 100% Volume Level.*
93 pph applies as the lower threshold volume for the 70% Volume Level.

NOTE: *The Satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal.*

TRAFFIC SIGNAL WARRANTS

WARRANT 5 - SCHOOL CROSSING

Satisfied: ☐ Yes ☒ No

This warrant is intended for application where the fact that schoolchildren crossing the major route is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "schoolchildren" includes elementary through high school students. This warrant is satisfied if all three of the criteria below are fulfilled after remedial measures have been considered.

Any remedial measures implemented in or around the intersection to improve the safety of the students as noted in Section **4C.06 Warrant 5, School Crossing** in the MUTCD:

Criteria			Fulfilled? Yes	Fulfilled? No
1. *Enter the number of schoolchildren crossing the major route along with the hour this occurs. The hour can be any 60 minute interval (ex 2:15 PM - 3:15 PM enter 2:15 - 3:15). Requires a minimum of 20 schoolchildren durning the any hour.*	*Num. of Students*	*Highest Crossing Hour Period*		X
		-		
2. *For both the morning (AM) and afternoon (PM) periods of operation, enter the number of adequate gaps observed for each period and the number of minutes each period lasted. Requires one period to operate with fewer gaps than the number of minutes in the period.*		*Period*		X
		Minutes / *Gaps*		
	AM			
	PM			
3. *Is the nearest traffic signal along the major route more than 90m (300 ft) from this crossing?*	☐ Yes	☒ No		X
If the signal is within 90m (300 ft) of an existing signalize intersection, will it restrict progressive movement of traffic?	☒ Yes	☐ No		

WARRANT 6 - COORDINATED SIGNAL SYSTEM

Satisfied: ☒ Yes ☐ No

Progressive movement in a coordinated signal system sometimes necessitates the installtion of traffic control signals at intersections that would not otherwise be considered in order to maintain proper paltooning of vehicles. This warrant is satisfied if the below criteria is satified as follows: criteria 1 is satisfied and either criteria 2 or 3 is satisfied.

Criteria		Fulfilled? Yes	Fulfilled? No
1. *The inclusion of this proposed signal, into the coordinated system, does not result in a signal spacing of less than 305m (1,000 ft)?*		x	
2. a. *On a one-way street or a street that has traffic predominantly in one direction, are the adjacent traffic control signals so far apart that they do not provide the necessary degree of vehiclular platooning?*			X
b. *On a two-way street, do adjacent traffic control signals **not** provide the necessary degree of platooning and will the proposed and adjacent traffic control signals collectively provide a progressive operation?*		x	

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal.*

TRAFFIC SIGNAL WARRANTS

WARRANT 7 - CRASH EXPERIENCE

Satisfied: ☐ Yes ☒ No

This warrant is intended for application where the severity and frequency of crashes are the principal reasons to consider the installation of a traffic control signal. The need for a traffic control signal shall be considered if an engineering study finds that criteria 1, 2, and 3 are met.

Criteria			Fulfilled? Yes	Fulfilled? No
1. *Adequate trial of alternatives with satisfactory observance and enforcement has fialed to reduce the crash frequency as shown below:*				
				X
2. ***How many crashes within the past 12 months?*** *For this criteria to be met, five or more reported crashes, of types suseptible to correction by the installation of a traffic control signal, must have occurred.*	2			X
3. *If Warrant 1A or Warrant 1B are 80 percent satisfied of the current values or if Warrant 4, 4-hour or peak, is met at the 80 percent values.*	Met? Yes	Met? No		
Warrant 1, Condition A, Minimum Vehicular Volume (80 percent satisfied):	X		X	
Warrant 1, Condition B, Interruption of Continuous Traffic (80 percent satisfied):	X			
Warrant 4, Four-Hour Volume (80 percent satisfied):		X		
Warrant 4, Peak Hour Volume (80 percent satisfied):		X		

WARRANT 8 - ROADWAY NETWORK

Satisfied: ☒ Yes ☐ No

This warrant is used to encourage the concentration and organization of traffic flow on a roadway network. This warrant is satisfied if one of the following 2 criteria is met and both routes meet at least on of the characteristics of a Major Route below.

Criteria			Met? Yes	Met? No	Fulfilled? Yes	Fulfilled? No
1. *Both of the criteria to the right are required in order to be met.*	a. *Please enter the total existing, or immediately projected, entering traffic volume during the peak hour of a typical weekday. Requires a minumum of 1,000 vehicles to be met.*	Volume 3,240	X		X	
	b. *Based on an engineering study, does the 5 year projected traffic volumes, for this location, meet one or more of Warrants 1, 2, or 3 during an average weekday? **		X			
2. *Enter the total existing, or immediately projected, entering volume for each of any 5 hours of a non-normal business day.* ***(Saturday or Sunday).*** *1,000 vph for each hour required.*		← Hour				X
		← Volume				

**** Supporting data required for verification of the projected 5 year traffic Warrants.***

A major route, as used in this signal warrant, shall have at least one of the following characteristics:		Met? Yes	Met? No	Fulfilled? Yes	Fulfilled? No
Characteristics of Major Routes					
1. *Is it a part of the street or highway system that serves as the principal roadway network for through traffic flow?*	*Major Route*	X		X	
	** Minor Route*		X		
2. *Does it include rural or suburban highways outside, entering, or traversing a city?*	*Major Route*	X			
	** Minor Route*	X			
3. *Does it appear as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study?*	*Major Route*	X			
	** Minor Route*		X		

**** This is a minor route, but for the purposes of this Warrant, shall be considered as the other major route.***

Note: ***Supporting data shall be required to verify the routes meet one of the characteristics of a major route.***

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal.*

TRAFFIC SIGNAL WARRANTS

WARRANT 9 - INTERSECTION NEAR A GRADE CROSSING

Applicable ☐ Yes ☐ No

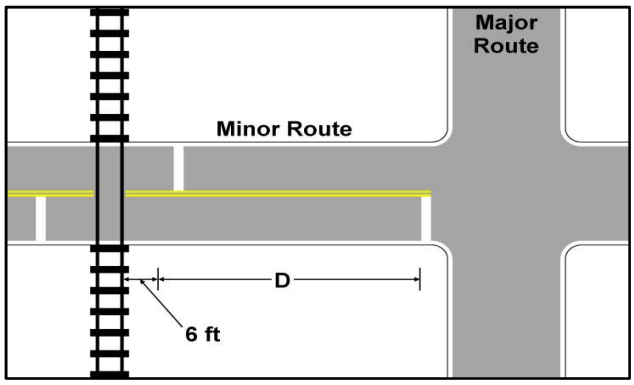
The need for a traffic control signal may be considered if an intersection that is controlled by a STOP or YIELD sign has a rail crossing within 140 feet of the stop/yield line and the highest Equivalent Minor Approach Traffic value lies above the curve represented on the graph below.

Minor Route Adjustment Factors - Enter the following:	
1. The number of occurrances of rail traffic/day:	
2. The percentage of "High-Occupancy Buses" crossing the track/day: (A high-occupancy bus is defined as a bus occupied by at least 20 people)	
3. The percentage of Tractor-trailer Trucks crossing the track/day:	

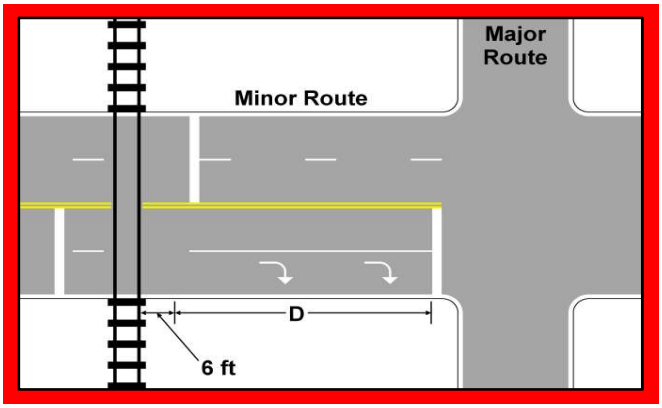
Satisfied: ☐ Yes ☐ No

Peak Hour Data		
Peak Hour	Major Route	Minor Route

Enter the distance value "D" from the STOP/YIELD bar to the track as shown below:

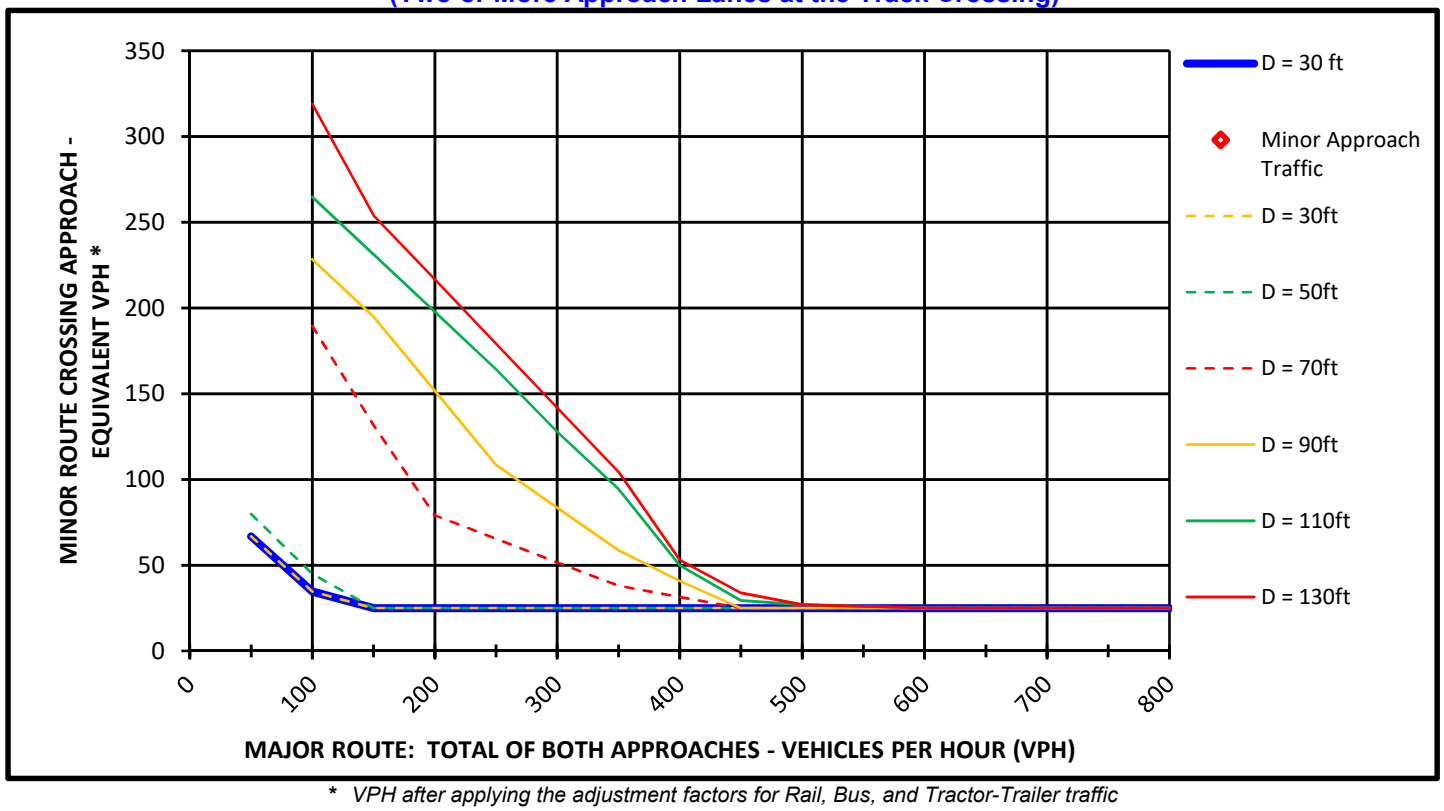


(One Approach Lane at the Track Crossing)



(Two or More Approach Lanes at the Track Crossing)

FIGURE W-9: Intersection Near a Grade Crossing
(Two or More Approach Lanes at the Track Crossing)



* *VPH after applying the adjustment factors for Rail, Bus, and Tractor-Trailer traffic*

25 vph applies as the lower threshold volume

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal.*

TRAFFIC SIGNAL WARRANT SUMMARY

City/Town: Lake Stevens, WA
County: WSDOT
Division:
Data Date: 2040 DYNAMEQ forecast

Analysis Performed By: Andrew L. Bratlien
Date Analysis Performed: 8/17/2018
Project Number if Applicable: 218002
Weather Conditions:

Major Route: SR 9 — Appr. Lanes: 4
Minor Route: 24th St SE — Appr. Lanes: 2
Critical Approach Speed (mph): 55

	SATISFIED		80% Satisfied		100% Satisfied	
Warrant #1: Eight-Hour Vehicular Volume	[X] Yes	[ ] No				
1A - Minimum Vehicular Volume:			[X] Yes	[ ] No	[X] Yes	[ ] No
1B - Interruption of Continuous Traffic:			[X] Yes	[ ] No	[X] Yes	[ ] No

Any Remedial Measures Tried and their Outcome.

Warrant #2: Four-Hour Vehicular Volume [X] Yes [ ] No

Warrant #3: Peak Hour [X] Yes [ ] No

The Unusual Case(s) that Justifies the use of this Warrant.

ICE

Warrant #4: Pedestrian Volume [ ] Yes [X] No

Warrant #5: School Crossing [ ] Yes [X] No

Any Remedial Measures Implemented to improve the Safety of the Students.

Warrant #6: Coordinated Signal System [X] Yes [ ] No

Warrant #7: Crash Experience [ ] Yes [X] No

Other Alternatives that have failed to reduce crashes.

Warrant #8: Roadway Network [X] Yes [ ] No

Warrant #9: Intersection Near a Grade Crossing [ ] Yes [X] No

CONCLUSIONS

Warrants Satisfied: 1 2 3 6 8

Remarks: This analysis based on 2040 AM & PM peak hr DYNAMEQ volume forecasts
Four-hour and eight-hour volume forecasts were calculated by factoring peak hr vol.

NOTE: *The satisfaction of a warrant or warrants shall not in itself require the installation of a traffic control signal.*

Appendix D. Crash Modification Factors

CMF / CRF Details

CMF ID: 391

Prohibit left-turns with "No Left Turn" sign

Description:

Prior Condition: ***No Prior Condition(s)***

Category: Intersection traffic control

Study: ***Guidelines for the Use of No U-Turn and No-Left Turn Signs*****, Brich and Cottrell, 1994**

Star Quality Rating:	★★★★☆

Crash Modification Factor (CMF)	
Value:	0.32
Adjusted Standard Error:	0.13
Unadjusted Standard Error:	0.06

Crash Reduction Factor (CRF)	
Value:	68 *(This value indicates a **decrease** in crashes)*
Adjusted Standard Error:	13

Unadjusted Standard Error:	6

Applicability

Crash Type:	All
Crash Severity:	All
Roadway Types:	Minor Arterial
Number of Lanes:	
Road Division Type:	
Speed Limit:	
Area Type:	Urban and Suburban
Traffic Volume:	
Time of Day:	

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	3-leg,4-leg
Traffic Control:	Stop-controlled
Major Road Traffic Volume:	19435 to 42000 Average Daily Traffic (ADT)
Minor Road Traffic Volume:	

Development Details

Date Range of Data Used:	
Municipality:	
State:	

Country:	
Type of Methodology Used:	Simple before/after
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	Yes. HSM lists this CMF in **bold** font to indicate that it has the highest reliability since it has an adjusted standard error of 0.1 or less.
Date Added to Clearinghouse:	Dec-01-2009
Comments:	

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CMF / CRF Details

CMF ID: 227

Convert intersection with minor-road stop control to modern roundabout

Description:

Prior Condition: ***No Prior Condition(s)***

Category: Intersection geometry

Study: ***NCHRP Report 572: Applying Roundabouts in the United States,*** **Rodegerdts et al., 2007**

Star Quality Rating:	★★★★★

Crash Modification Factor (CMF)	
Value:	0.56
Adjusted Standard Error:	0.05
Unadjusted Standard Error:	0.04

Crash Reduction Factor (CRF)	
Value:	44 *(This value indicates a* ***decrease*** *in crashes)*
Adjusted Standard Error:	5

Unadjusted Standard Error:	4

Applicability

Crash Type:	All
Crash Severity:	All
Roadway Types:	Not Specified
Number of Lanes:	1 or 2
Road Division Type:	
Speed Limit:	
Area Type:	All
Traffic Volume:	
Time of Day:	

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	4-leg
Traffic Control:	Stop-controlled
Major Road Traffic Volume:	
Minor Road Traffic Volume:	

Development Details

Date Range of Data Used:	
Municipality:	
State:	

Country:	
Type of Methodology Used:	Before/after using empirical Bayes or full Bayes
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	Yes. HSM lists this CMF in **bold** font to indicate that it has the highest reliability since it has an adjusted standard error of 0.1 or less.
Date Added to Clearinghouse:	Dec-01-2009
Comments:	Countermeasure name changed from "convert two-way stop-controlled intersection to roundabout" to match HSM

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CMF / CRF Details

CMF ID: 325

Install a traffic signal

Description:

Prior Condition: Stop controlled

Category: Intersection traffic control

Study: *Accident Modification Factors for Traffic Engineering and ITS Improvements*, Harkey et al., 2008

Star Quality Rating:	★★★★★

Crash Modification Factor (CMF)	
Value:	0.56
Adjusted Standard Error:	0.03
Unadjusted Standard Error:	

Crash Reduction Factor (CRF)	
Value:	44 *(This value indicates a **decrease** in crashes)*
Adjusted Standard Error:	3

Unadjusted Standard Error:	

Applicability

Crash Type:	All
Crash Severity:	All
Roadway Types:	Not specified
Number of Lanes:	
Road Division Type:	
Speed Limit:	
Area Type:	Rural
Traffic Volume:	
Time of Day:	

If countermeasure is intersection-based

Intersection Type:	Roadway/roadway (not interchange related)
Intersection Geometry:	3-leg,4-leg
Traffic Control:	Stop-controlled
Major Road Traffic Volume:	3261 to 29926 Annual Average Daily Traffic (AADT)
Minor Road Traffic Volume:	101 to 10300 Annual Average Daily Traffic (AADT)

Development Details

Date Range of Data Used:	
Municipality:	
State:	

Country:	
Type of Methodology Used:	Before/after using empirical Bayes or full Bayes
Sample Size Used:	

Other Details

Included in Highway Safety Manual?	Yes. HSM lists this CMF in **bold** font to indicate that it has the highest reliability since it has an adjusted standard error of 0.1 or less.
Date Added to Clearinghouse:	Dec-01-2009
Comments:	Countermeasure name has been slightly modified for consistency across Clearinghouse

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