Dynamic Traffic Assignment (DTA) – Initial Findings

Date: February 11, 2013

Project #: 11732

To: TSP Public Advisory Committee

From: TSP Project Management Team

Project: Clackamas County Transportation System Plan Update

Subject: Clackamas Regional Center Southwest Access Corridor Dynamic Traffic Assignment (DTA) Initial Findings

This memorandum reports the findings of the Dynamic Traffic Assignment (DTA) analysis performed as part of the Clackamas County Transportation System Plan (TSP) Update. The analysis provides more detailed information about alternative improvements for the Clackamas Regional Center Southwest Access Corridor (Harmony Road/Sunnyside Road/82nd Avenue) area, which is expected to experience significant future congestion and out of direction travel.

This memorandum provides an introduction to DTA and is organized as follows:

BACKGROUND

The Clackamas Regional Center Southwest Access Corridor is a part of the transportation system that supports the future development of the Clackamas Regional Center, which is and will continue to be one of the major employment centers in Clackamas County. As part of the Clackamas County Transportation System Plan (TSP) update, a number of existing and future congestion problems were identified in the area.

The *Existing and Future Conditions Report* assessed operations on the Clackamas County transportation system under a 2035 Low Build Scenario, which assumes projected population and employment growth occurs and only the transportation projects that are currently funded are constructed. This analysis assumed that the Sunnybrook Road extension and Monterey Avenue extension are constructed. However, it does not include additional widening on Harmony or grade-separated improvements at the SE Harmony Road/SE Linwood Avenue intersections. With the Low Build improvements in place, the analysis projected the 2035 operations shown in Table 1 for study intersections within the Clackamas Regional Center Southwest Access Corridor:

Table 1 2035 Low Build Traffic Operations Analysis Results at Study Intersections in the Clackamas Regional Center

ID	Intersection	Jurisdiction	Performance Standard	Currently Meets Standard?	Low Build Project?	Meets Standard in 2035 Low Build?
123	SE Lake Rd/SE International Way	County	v/c = 0.99	Yes	No	No (v/c=1.39)
124	SE Harmony Rd/SE Linwood Ave	County	v/c = 0.99	Yes	No	No (v/c=1.11)
125	SE Harmony Rd/SE Fuller Rd	County	v/c = 1.1	Yes	No	Yes (v/c = 1.0)
126	SE Sunnyside Rd/SE Harmony Rd/SE 82nd Ave	ODOT	v/c = 1.1	Yes	No	Yes (v/c = 1.0)
136	SE Sunnybrook Blvd/ OR 213 (SE 82nd Ave)	ODOT	v/c = 1.1	Yes	Yes (U001)	No (v/c=1.35)

v/c = volume-to-capacity ratio

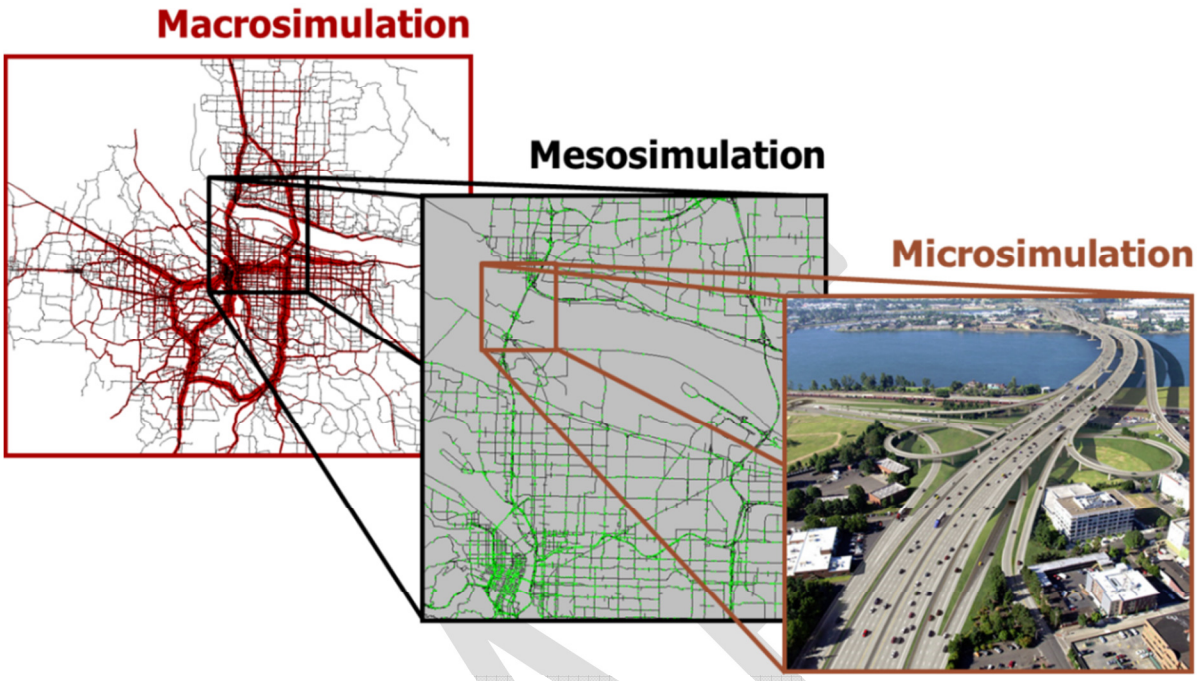
As seen in Table 1, three of the intersections in the Southwest Access Corridor are forecast to not meet the operational standards in 2035. Two additional intersections operate at volume-to-capacity ratios just under the standard. These projected deficiencies could hinder future development in the area. Therefore, a number of potential improvements are being considered for the area. In order to assess the potential impact of these improvements for the area, a Dynamic Traffic Assignment (DTA) analysis was performed.

CLACKAMAS REGIONAL CENTER SOUTHWEST ACCESS CORRIDOR DTA ANALYSIS

Dynamic Traffic Assignment (DTA) is an analysis tool that models individual travel behavior at a system level and takes a mesoscopic simulation approach to travel modeling. This means that DTA is able to provide a higher level of detail than a travel demand model (macrosimulation) by using smaller units of time. It is also able to model a larger network area and more complex route selection, than intersection-based models (microsimulation).

This concept is illustrated below:

Exhibit 1: Mesosimulation Illustration



Source: Metro

DTA can provide more detailed and holistic information than traditional static models and has several unique advantages over static tools, including:

- **Capacity constrained**: Street segments and intersections in a DTA model are capacity constrained, while static models can produce volume/capacity ratios that exceed 1.0 for these same facilities. A DTA model addresses excess demand by either spreading it across the network (using alternate routes) or across a longer period of time (i.e., vehicles spend additional time on the network).
- **Signal Timing**: DTA models take signal timing into account, producing more realistic results compared to macrosimulation models which have a simplified approach to intersection capacity.
- **Variability**: DTA can model multiple hours, days and months; thereby, capturing more variability in roadway conditions (e.g., weather, incidents, construction, etc.). DTA can also model network operations in smaller increments (such a 5 minute intervals) for the entire modeling period, providing a more granular data set.
- **Event Modeling**: DTA can model events such as train crossings, work zones, special events, and crashes.
- **Relatable Measures of Effectiveness (MOE)**: DTA produces results that address travel time, speed, and reliability, which are more relatable to the experience of traveler using the system than traditional outputs like Level of Service (LOS) and volume/capacity ratio (v/c).

DTA is being used for the TSP Update in order to re-evaluate the alternatives for the Clackamas Regional Center Southwest Access Corridor (Harmony Road/Sunnyside Road/82nd Avenue area) that were previously evaluated in the Harmony Road Area Transportation Improvements EIS (*shown in Appendix A*). It is able to provide a more detailed, complete comparison of the potential improvements for the area by modeling the transportation system with each alternative in place. The DTA study area for this analysis is shown in ***Figure 1*** and shows the transportation projects (in blue) assumed to be built in the 2035 Low Build Scenario which were used in the DTA analysis. The figure also includes the study intersections that do not meet standards in the 2035 Low Build Scenario. The majority of the DTA analysis focused on the Harmony Road/Sunnyside Road/82nd Avenue area, as described below.

DTA ALTERNATIVES TESTED

The DTA analysis of the Clackamas Regional Center Southwest Access Corridor was undertaken to test the relative effectiveness of potential improvements for the Harmony Road/Sunnyside Road/82nd Avenue area. Alternatives were originally developed as part of the original Harmony Road Area Transportation Improvement EIS. This analysis tests six alternatives for the area to better understand the operational effectiveness using additional relatable Measures of Effectiveness (MOE) beyond the traditional volume-to-capacity ratio and level-of-service measures used in the EIS. All six alternatives model projected traffic volumes for the year 2035 and assume the other Low-Build transportation projects shown in Figure 1 have been completed.

Each alternative is described below and illustrated in ***Figure 2***.

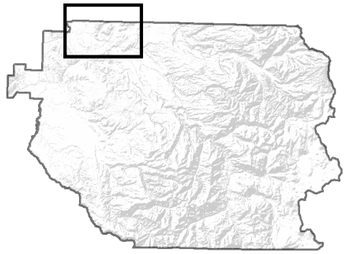
1. **"No-Build" Alternative** (Baseline) – this scenario assumes no additional improvements are made in the area, beyond the projects shown in Figure 1 (i.e. no Sunnybrook Extension).

2. **Alternative 2** (Sunnybrook Extension, Grade-Separated RR Crossing) – this scenario assumes the Sunnybrook Extension is built with a two-lane cross-section and a grade-separated railroad crossing is constructed at the intersection of Harmony Road and Linwood Avenue. It also assumes Harmony Road is widened to three lanes between OR 224 and 82nd Avenue.

3. **Alternative 3** (Harmony Widening from Fuller Road to 82nd, 82nd Widening, Grade-Separated RR Crossing) – this scenario assumes that Harmony Road is widened to 5 lanes between Fuller Road and 82nd Avenue and 3 lanes between OR 224 and Fuller Road, It also assumes 82nd Avenue is widened to 7 lanes between Harmony Road/Sunnyside Road and Sunnybrook Boulevard and a grade-separated railroad crossing is constructed at the intersection of Harmony Road and Linwood Avenue.

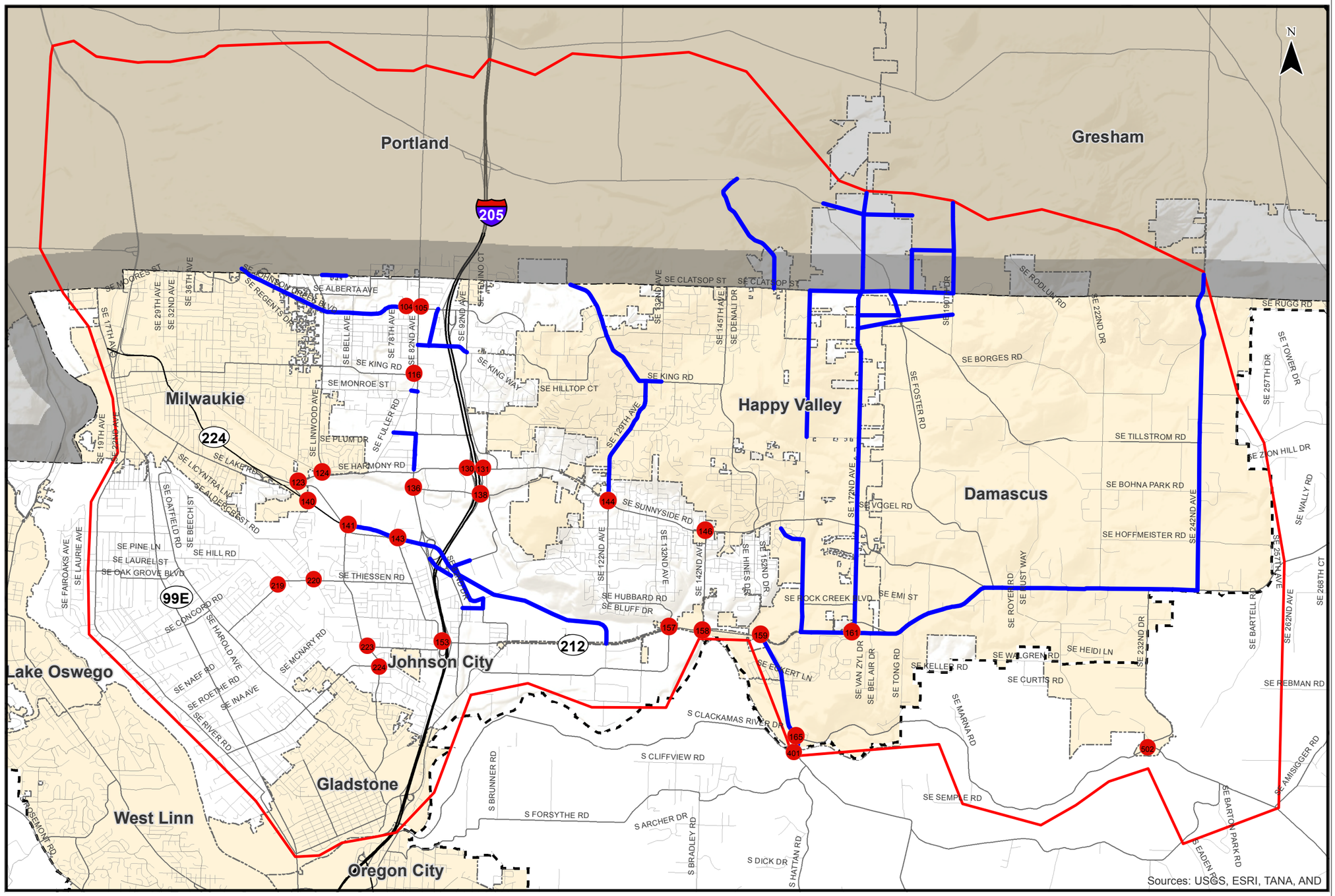
4. **Alternative 4** (Sunnybrook Extension) – this scenario assumes the Sunnybrook extension is built with a two-lane cross-section without any improvements at the Harmony Road/Linwood Avenue railroad crossing (i.e. this intersection is not grade separated).

CLACKAMAS COUNTY TRANSPORTATION SYSTEM PLAN Update



Study Intersection

- Fails under Low Build Scenario
- Project Complete in DTA Analysis
- DTA Boundary
- Incorporated Areas
- County Boundary
- UGB



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Coordinate System:
NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Data Source:
Clackamas County, Metro Data Resouce Center

DTA Study Area

Figure 1

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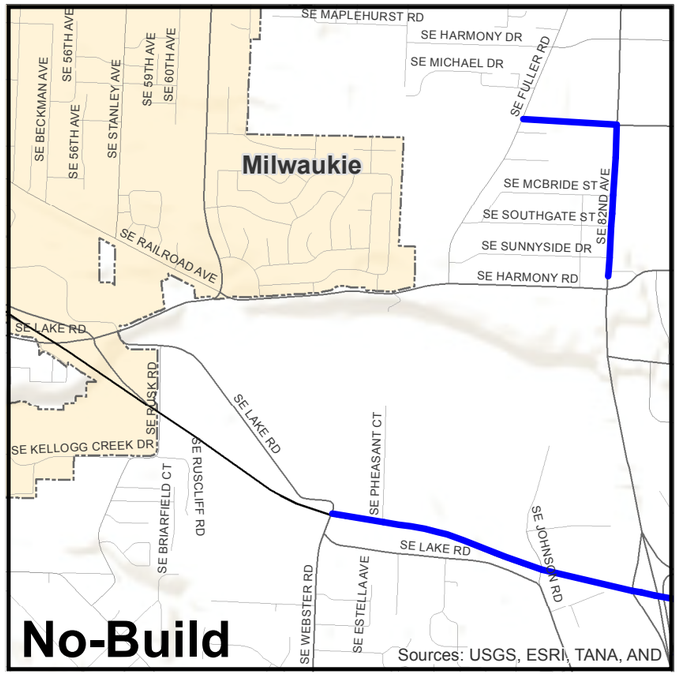
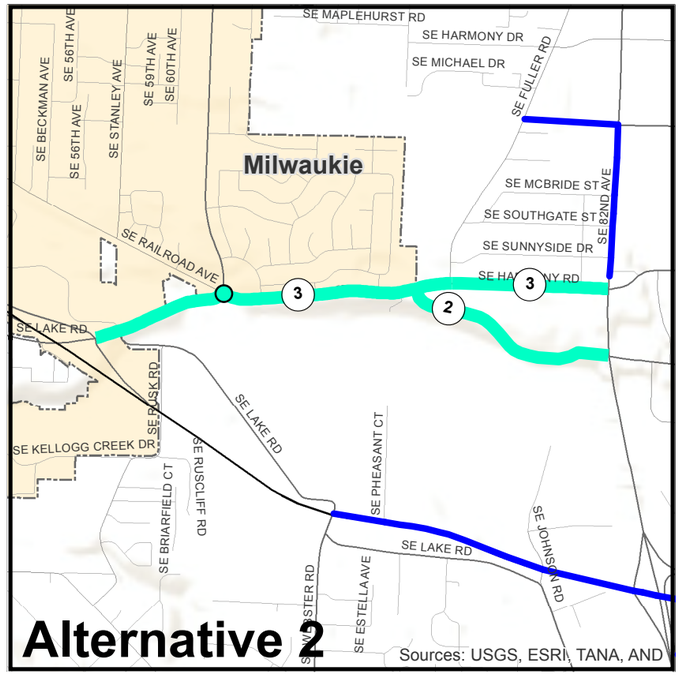
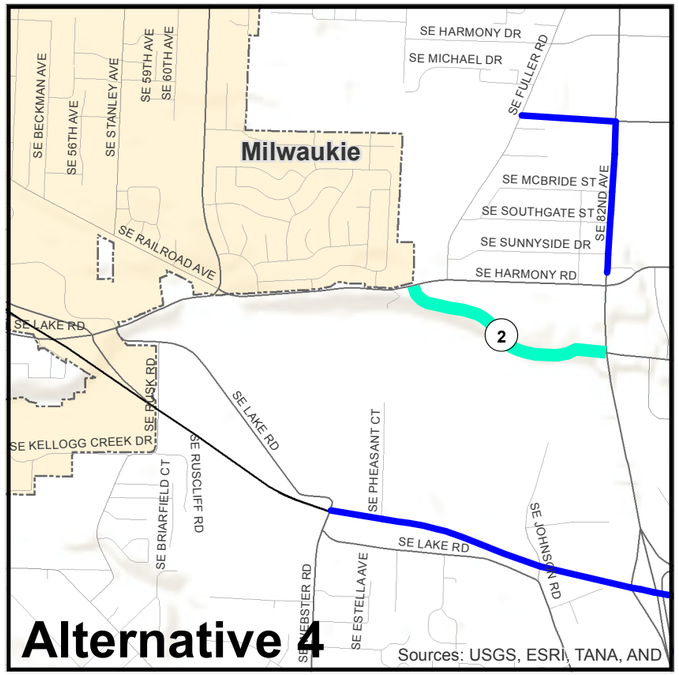
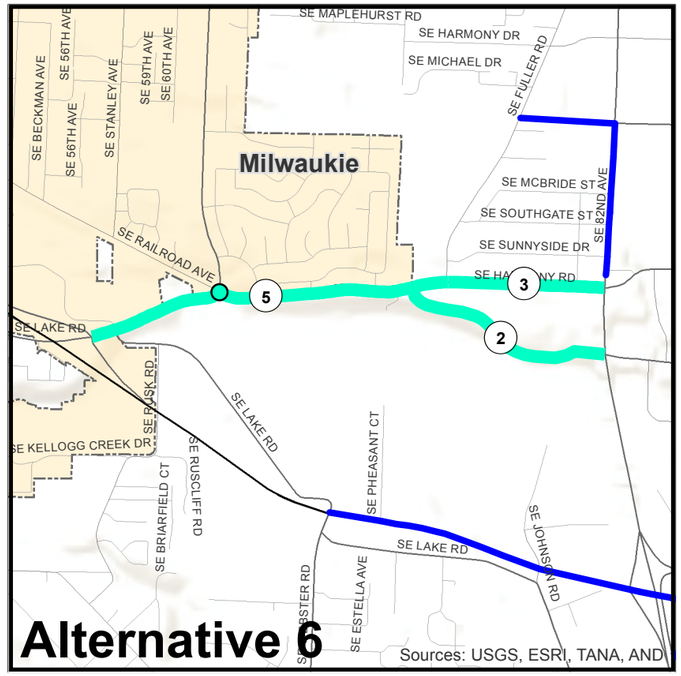
CLACKAMAS COUNTY TRANSPORTATION SYSTEM PLAN Update

- Grade-Separated Railroad Crossing
- Roadway Widening
- (#) Number of Lanes
- Project Complete in DTA Analysis
- Incorporated Areas
- County Boundary
- UGB









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Coordinate System:
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Data Source:
Clackamas County, Metro Data Resouce Center

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DTA: Alternatives Tested

Figure 2

5. **Alternative 5** (Greater Harmony Widening, Grade-Separated RR Crossing) – this scenario assumes that Harmony Road is widened to 5 lanes between 82nd Avenue and OR 224 and a grade-separated railroad crossing is constructed at the intersection of Harmony Road and Linwood Avenue.

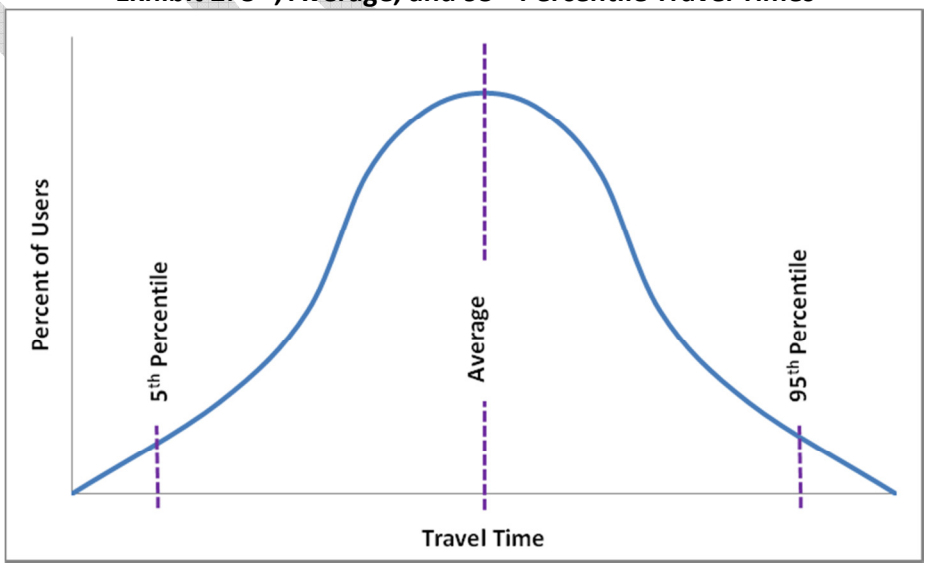
6. **Alternative 6** (Sunnybrook Extension, Harmony Widening from Fuller to OR 224, Grade-Separated RR Crossing) - this scenario assumes Harmony Road is widened to 5 lanes between OR 224 and Fuller Road and 3 lanes between Fuller Road and 82nd Avenue. It also includes the Sunnybrook extension and grade-separated railroad crossing at the intersection of Harmony Road and Linwood Avenue.

MEASURES OF EFFECTIVENESS

DTA provides a variety of different measures of effectiveness (MOE) for assessing the operational results of the alternatives. As noted above, these MOEs provide more realistic and relatable measures than most static models that primarily utilize volume-to-capacity ratios and level-of-service for a specific one-hour period time. For this analysis, the following MOEs were assessed over a three-hour time period:

- **Travel Time (or running speed)**: travel time provides a relatable, easily conceptualized measure of how long it takes to travel from one end of a corridor to the other. Assessing the 5th percentile and 95th percentile travel time accounts for the more exceptional cases. The 5th percentile travel time is the time below which 5% of all travel times fall, meaning it represents the lowest travel times, while the 95th percentile travel time represents the highest travel times. This concept is illustrated in Exhibit 2. Comparing the 95th percentile travel time for different alternatives can help assess how events (such as train crossings) impact travel time.

Exhibit 2: 5th, Average, and 95th Percentile Travel Times



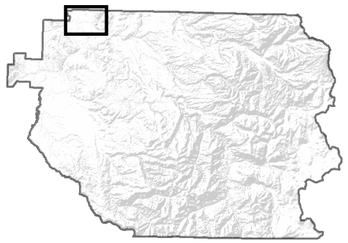
- **Travel Time Reliability:** travel time reliability considers the range of travel times experienced during a given period of time (weekdays from 3:00 to 6:00 PM for this analysis). Drivers typically judge their roadway experience by the predictability of their travel time, and they are most affected by travel times that are far higher than they expect. The smaller the range of travel times, the more reliable the roadway and the better its performance. When drivers are able to more accurately predict the time it takes them to travel a roadway, they can budget their time appropriately. If the travel time is unreliable, drivers have to build in additional travel time as a buffer, which leads to inefficiencies and lost time.
- **Congestion**: the higher the level of congestion, the lower the speeds on the roadway. For the DTA analysis, congestion is based on the speeds on the roadway and is relative, meaning it can be defined by any speed. For this analysis, congestion was defined as speeds less than or equal to 60 percent of the free flow speed (the speed vehicles move in the absence of any congestion).
- **Outflow volume (intersection-level)**: outflow volume reflects how many vehicles an intersection is able to process during a given period of time. The higher the outflow volume, the more vehicles that can pass through the intersection and thus the better its performance.
- **Queuing**: queue lengths (distances occupied by stopped vehicles) provide an easily understandable measure of how well an intersection is performing. Monitoring queue spillback is helpful for assessing potential impacts between intersections as well as impacts on driveways. It can also be used to assess whether left-turn lanes are needed or are adequate at a given storage length [The queuing analysis results are still being extracted from the models at the time of this memorandum's publication and will be provided in the future].

OVERVIEW OF INITIAL FINDINGS

The six alternatives outlined above were compared by modeling traffic on eight different corridors in the DTA study area shown in **Figure 3**, including:

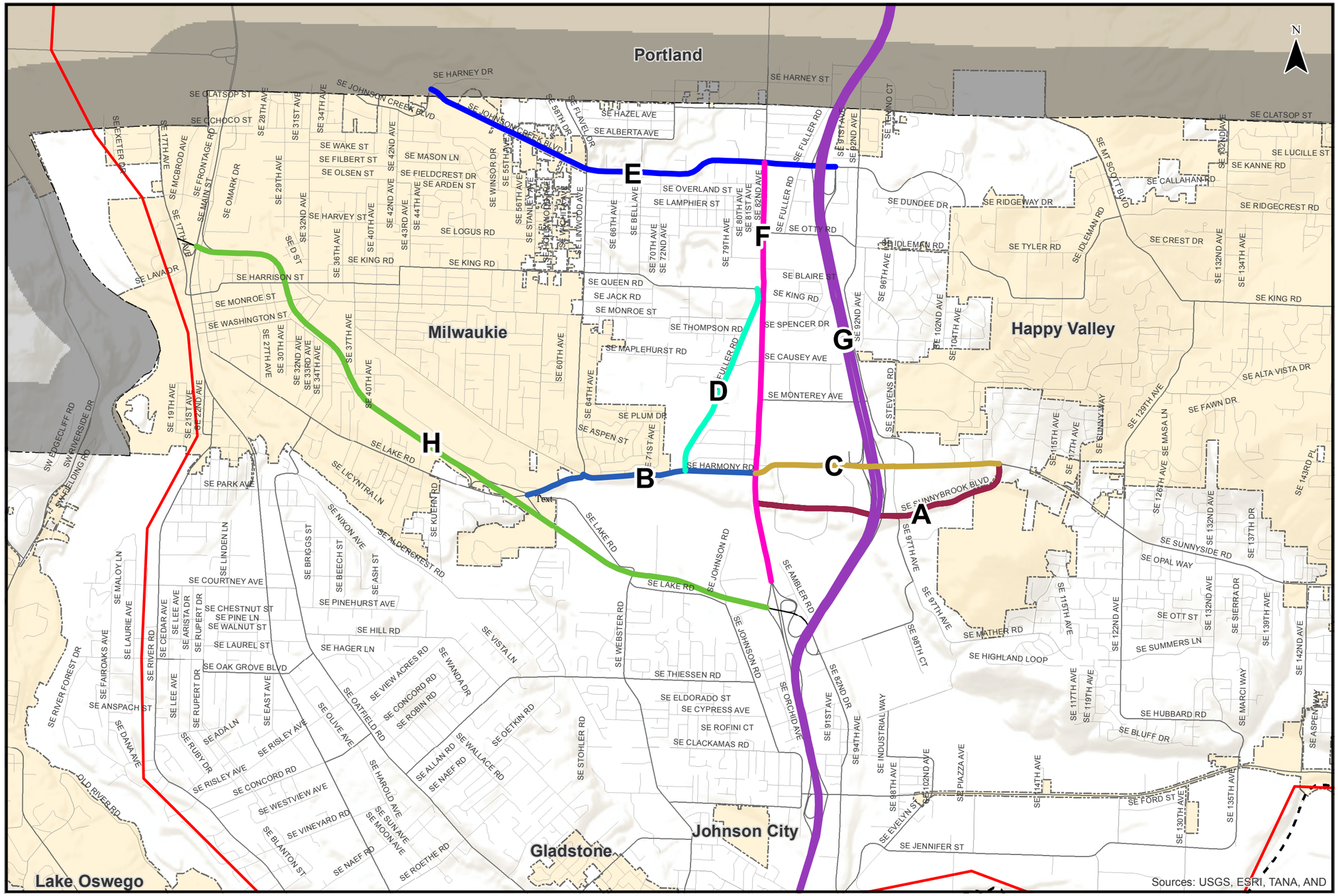
A. SE Sunnybrook Boulevard (between SE 82nd Avenue and SE Sunnyside Road)
B. SE Harmony Road (between OR 224 and SE 82nd Avenue)
C. SE Sunnyside Road (between SE 82nd Avenue and SE Sunnybrook Blvd)
D. SE Fuller Road (between SE King and SE Harmony Road)
E. SE Johnson Creek Boulevard (between SE 45th Place and I-205 Ramps)
F. SE 82nd Avenue (between OR 224 and SE Johnson Creek Boulevard)
G. I-205 (between 82nd Drive on-ramp and SE Foster Road off-ramp)
H. OR 224 (between OR 99E on-ramp and I-205)

CLACKAMAS COUNTY TRANSPORTATION SYSTEM PLAN Update



DTA Study Corridors

- SE Sunnybrook Boulevard
- SE Harmony Road
- SE Sunnyside Road
- SE Fuller Road
- SE Johnson Creek Boulevard
- SE 82nd Avenue
- I-205
- OR 224
- DTA Boundary
- Incorporated Areas
- County Boundary
- UGB



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Coordinate System:
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Data Source:
Clackamas County, Metro Data Resouce Center

DTA Study Corridors

Figure 3

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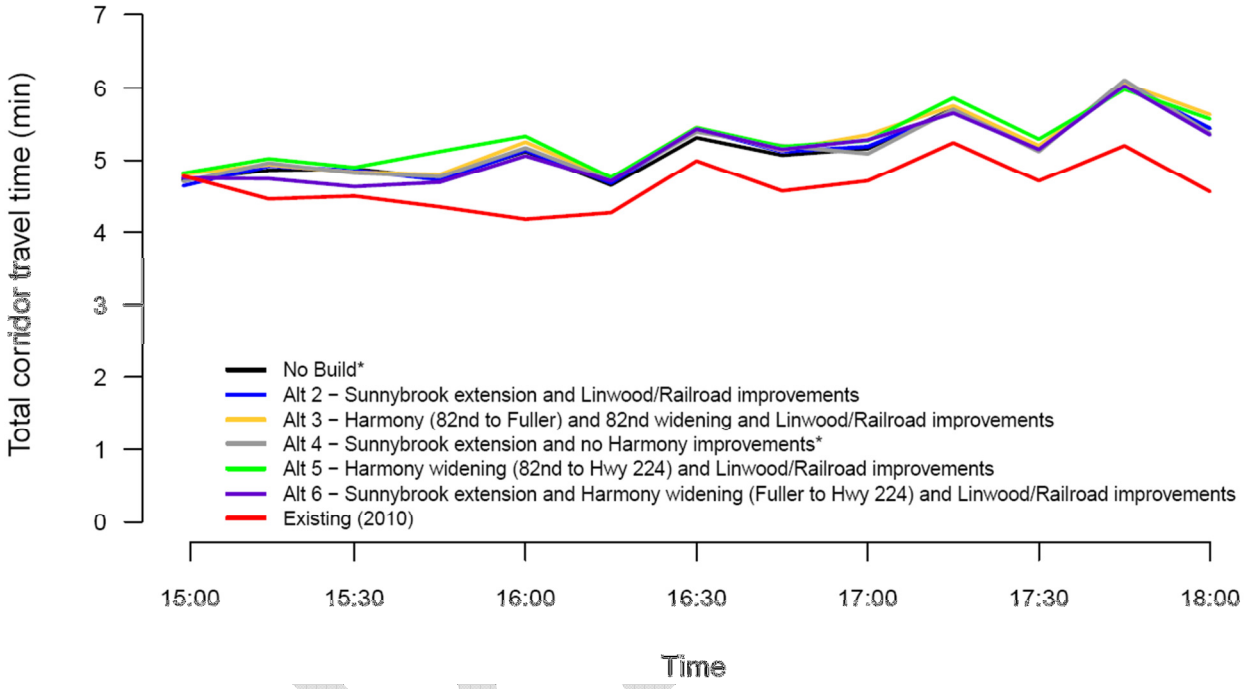
Overall, the differences in operational performance between the alternatives were minimal on the majority of the corridors. On most corridors, the analysis showed less than a half-minute difference in travel time between each alternative (e.g., Exhibit 3 compares the average travel time on the SE Sunnyside Road corridor for vehicles traveling eastbound between SE 82nd Avenue and SE Sunnybrook Boulevard between 3:00 and 6:00 PM).

Exhibit 3: 2035 Average 15-minute Peak Hour Travel Time on SE Sunnyside Road Eastbound



* indicates at-grade railroad crossing (not modeled in this analysis)

The only significant differences in performance were observed on the SE Harmony Road and SE Fuller Road corridors, which makes sense given that these corridors are the closest to the transportation improvements modeled under the different alternatives. Alternative 5 (Greater Harmony Widening, Grade-Separated RR Crossing) and Alternative 6 (Sunnybrook Extension, Harmony Widening from Fuller to OR 224, Grade-Separated RR Crossing) produced the best operations on both corridors when compared to the other alternatives, as shown below in Exhibit 4. Alternatives 2, 3 and 4 produced operations similar in year 2035 to what vehicles experience today on SE Harmony Road and SE Fuller Road. The remainder of this analysis focuses on the Harmony Road and Fuller Road corridor findings. (*Additional graphs showing the travel time on each corridor under each alternative are provided in Appendix B*).

HARMONY ROAD FINDINGS

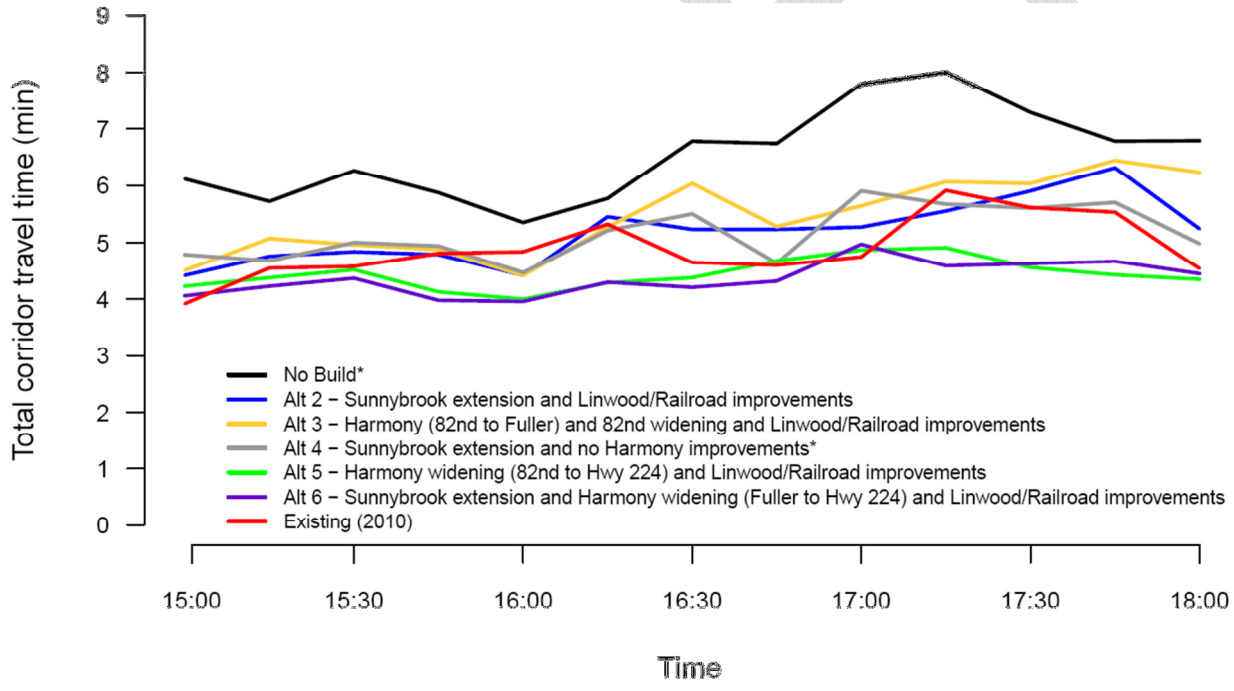
The DTA analysis revealed significant differences in performance on SE Harmony Road between OR 224 and SE 82nd Avenue for the five build alternatives. Overall, Alternatives 5 and 6 performed the best on the corridor and produced the most significant operational benefits. While not as high performing,

Alternatives 2, 3 and 4 showed advantages over the 2035 no build alternative. The findings for the corridor are reported below for the previously identified MOEs. It should be noted that MOE results for each alternative are provided in the appendix, while the information below highlights key findings and illustrates the MOEs using select alternatives to demonstrate how the graphics should be interpreted.

Travel Time

According to the DTA analysis, Alternatives 5 and 6 produce the most travel time savings on the Harmony Road corridor. For the 1.3-mile segment of Harmony Road between OR 224 and 82nd Avenue, Alternatives 5 and 6 both reduce peak hour travel times in the eastbound direction by up to 3 minutes per trip compared to the 2035 no build alternative. In comparison, Alternatives 2, 3, and 4 reduces travel times by about 2 minutes per trip compared to the no build alternative and operate similarly to the existing conditions. The average travel times for the Harmony Road corridor in the eastbound direction between 3:00 – 6:00 PM are shown in Exhibit 4.

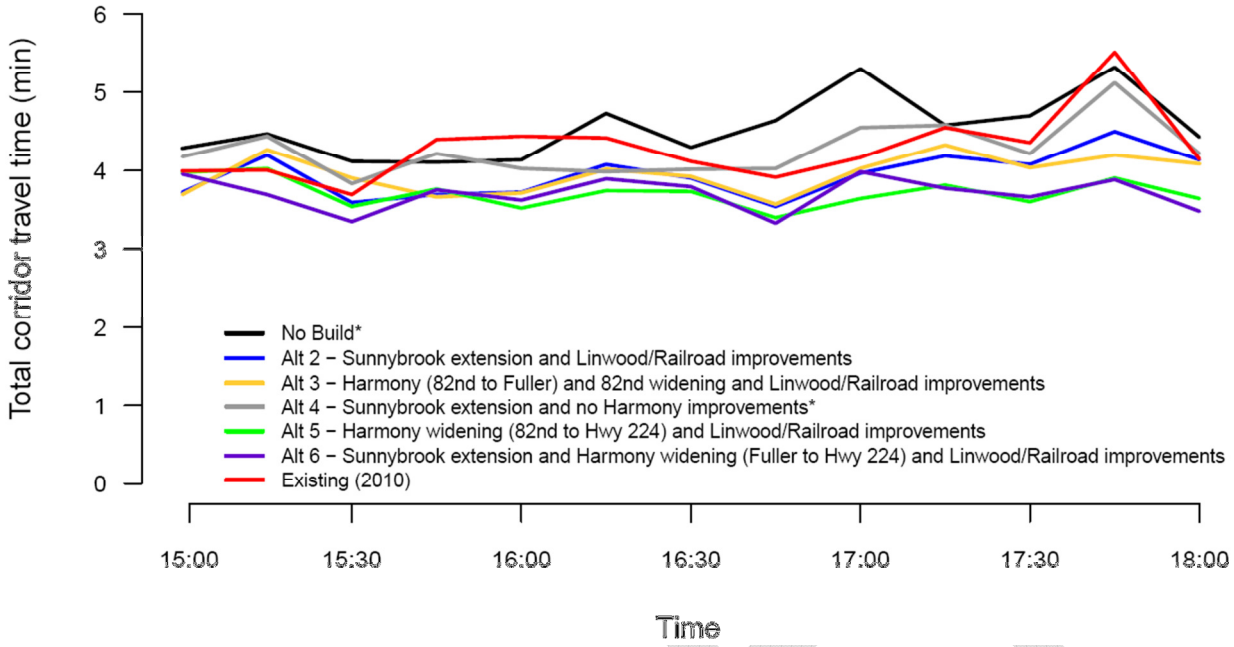
Exhibit 4: 2035 Average 15-minute Peak Hour Travel Time on SE Harmony Road (Eastbound)



* indicates at-grade railroad crossing (not modeled in this analysis)

As seen in Exhibit 4, the difference in travel times for the alternatives is most pronounced between 5:00 and 6:00 PM. The alternatives performed similarly in the westbound direction, although with less acute differences in travel times between the alternatives. Exhibit 5 shows the average travel times for the Harmony Road corridor in the westbound direction between 3:00 – 6:00 PM.

Exhibit 5: 2035 Average 15-minute Peak Hour Travel Time on SE Harmony Road (Westbound)



* indicates at-grade railroad crossing (not modeled in this analysis)

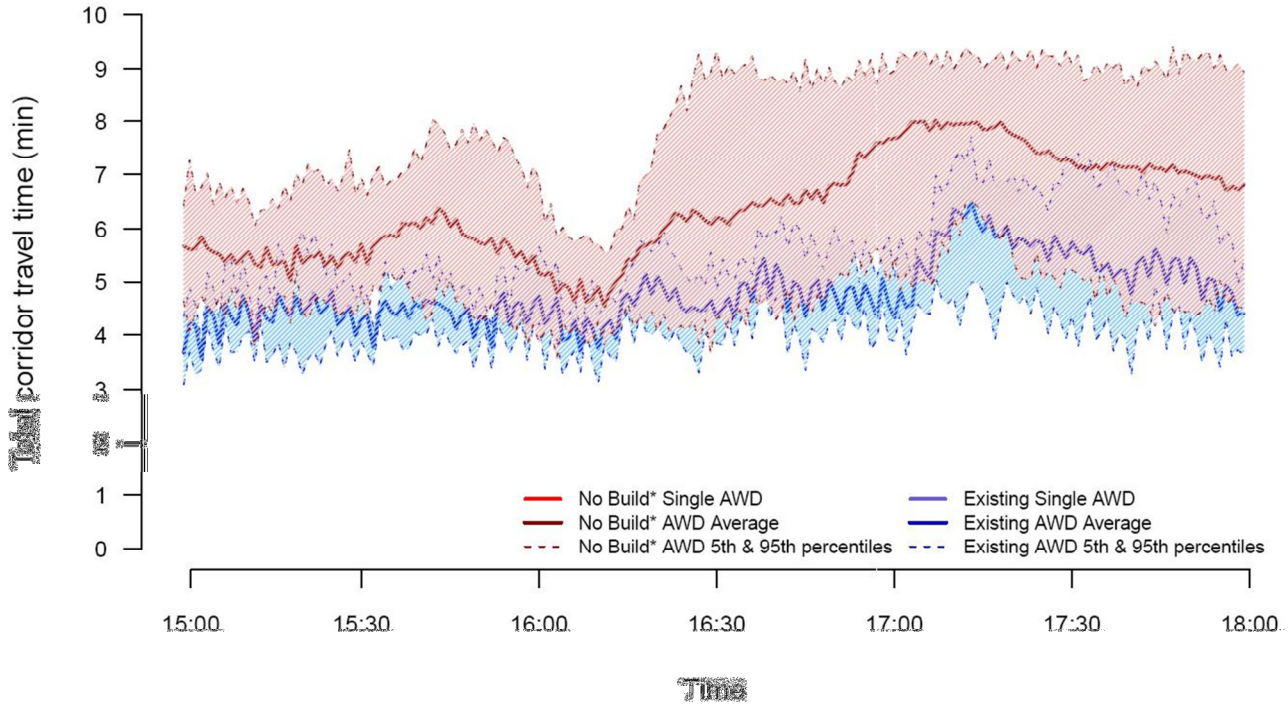
As seen in Exhibit 5, the differences in travel times for vehicles traveling westbound on SE Harmony Road are substantially less between alternatives than in the eastbound direction. The DTA analysis only assessed PM peak hour travel times, so greater differences may be observed during other periods of the day (i.e., AM peak hour as motorists are commuting westbound to the downtown Portland area).

Travel Time Reliability

The DTA analysis showed significantly less variability in travel times for all the alternatives than in the no build alternative. By far the most significant gains in reliability were seen with Alternatives 5 and 6, although improvements were also observed with Alternatives 2, 3 and 4. *Graphs illustrating the travel time reliability for each alterative are provided in Appendix C.*

The "buffer" time (time between the 95th percentile and 5th percentile travel times) under the existing conditions (2010) and no build alternative (2035) for eastbound travel on the SE Harmony Road corridor are shown in Exhibit 6.

Exhibit 6: Existing vs. 2035 No-Build Travel Time Reliability on SE Harmony Road (Eastbound)

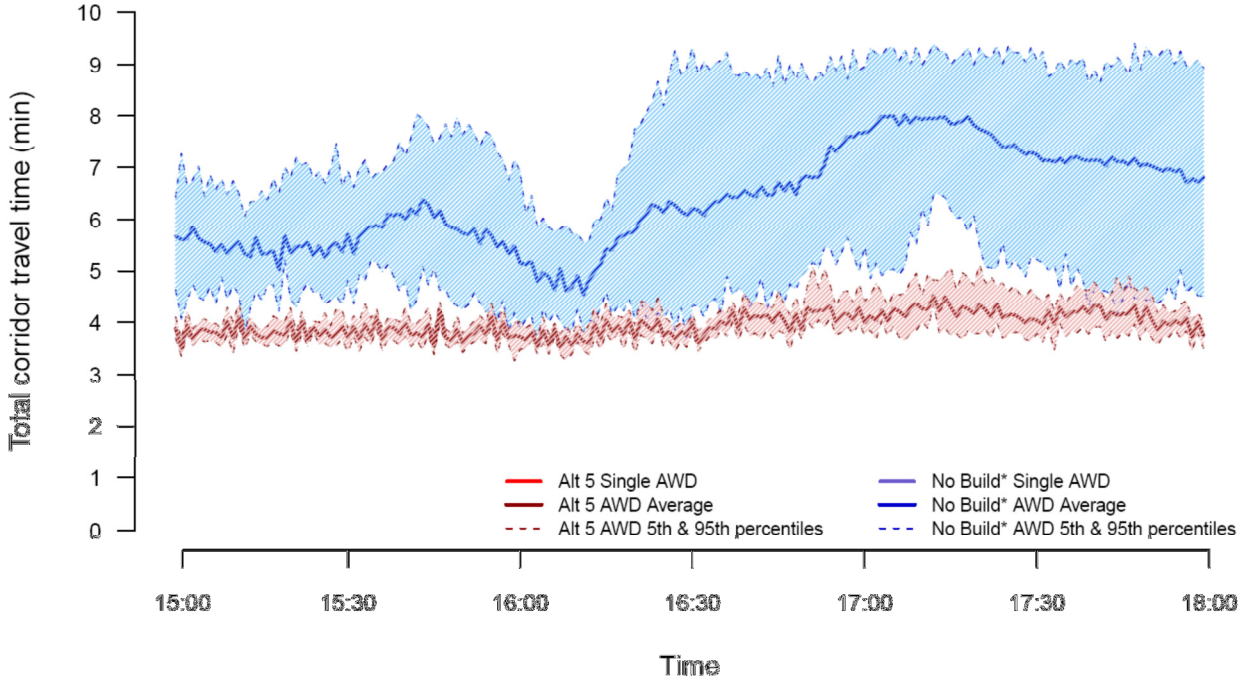


* indicates at-grade railroad crossing (not modeled in this analysis)

As seen in the exhibit, the range of travel times experienced on the corridor is anticipated to increase significantly in the future. The blue ban illustrates the range of travel times observed between the 5th and 95th percentile travel times (roughly 2 to 3 minutes in variation) on the corridor under existing conditions (2010). The red ban is for the no build alternative (2035) and reflects a larger range (roughly 4 to 6 minutes) of travel times. When travel times are unreliable, roadway users have to allot additional buffer time to their expected travel time, which leads to inefficiencies and wasted time.

As noted above, all five build alternatives improve travel time reliability on the SE Harmony Road corridor in the eastbound direction, with Alternative 5 producing the most significant gains, followed by Alternative 6. Alternative 5 reduce the range of travel times experienced to approximately 1 minute, resulting in more consistent, reliable travel times. Exhibit 7 shows the span of travel times observed for both Alternative 5 and the No-Build alternative during the PM peak hour, for the eastbound direction.

Exhibit 7: 2035 No-Build vs. Alternative 5 Travel Time Reliability on SE Harmony Road (Eastbound)



* indicates at-grade railroad crossing (not modeled in this analysis)

In order to compare the gains in travel time reliability across the alternatives, the average buffer time between 3:00 and 6:00 PM was calculated for each alternative. This represents the average difference between the slowest and fastest moving vehicles on the corridor. Therefore, the larger the buffer time, the wider the range of travel times on the corridor and the lower the reliability. The results are shown in Table 2.

Table 2 2035 Average Buffer Time on Harmony Road Corridor (82nd to OR 224)

Scenario	Eastbound	Westbound
Existing (2012)*	2.2	2.0
No Build*	**4.6**	**3.1**
2	3.1	1.7
3	2.4	1.5
4*	3.1	2.2
5	1.1	0.7
6	1.8	0.9

* indicates an at-grade railroad crossing (not modeled in this analysis)

As seen in the table, Alternative 5 produces the most significant gains in reliability, followed closely by Alternative 6. Alternatives 2, 3, and 4 also provide more reliable travel times than the no build alternative. The buffer times for westbound travel on the corridor are lower than for the eastbound travel for all alternatives, indicating greater reliability.

Travel Speed

The DTA analysis assessed travel speeds on the Harmony Road corridor for each alternative. This analysis evaluated speeds on the corridor overall, but also took a closer look at speeds along each segment of the corridor to identify where speeds are slower. For example, Exhibit 8 compares the average speeds on Harmony Road eastbound along the corridor from OR 224 to 82nd Avenue in the baseline scenario with speeds in Alternative 2. The lowest speeds in the baseline scenario are observed just east of SE Railroad Avenue/SE Linwood Avenue up to SE 82nd Avenue. Speeds increase noticeably between the baseline scenario and Alternative 2, particularly on the approach to the SE Harmony Road/SE Fuller Road/SE Sunnybrook Boulevard intersection. *Similar plots for all alternatives are provided in Appendix D.*

Exhibit 8: Speeds on SE Harmony Road Eastbound (No-Build versus Alternative 2)

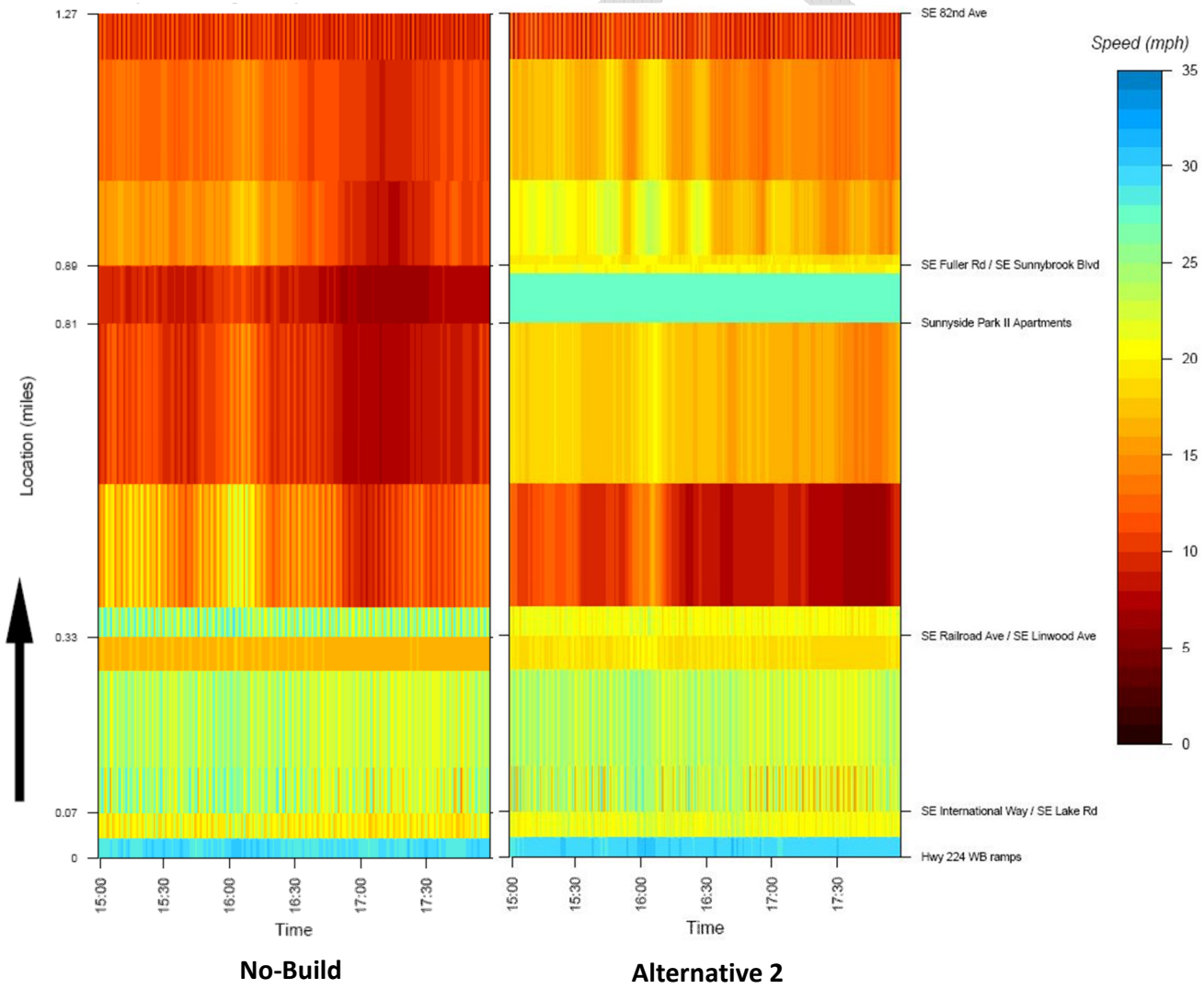


Table 3 provides a comparison of the 5th percentile, average, and 95th percentile speeds along the Harmony Road corridor for each alternative in both the eastbound and westbound directions. These speeds are representative of the entire corridor.

Table 3 2035 Average 5:00-6:00 PM Speed (mph) along Harmony Road Corridor (82nd to OR 224)

	Eastbound			Westbound		
Alternative	5th Percentile	Average	95th Percentile	5th Percentile	Average	95th Percentile
Existing (2010)*	10.3	14.0	17.2	12.5	16.4	20.7
No Build*	**7.7**	**10.2**	**14.9**	**11.1**	**15.3**	**20.4**
2	9.5	13.2	17.7	13.4	18.2	22.0
3	10.4	12.6	15.1	14.5	18.4	21.9
4*	9.8	13.3	17.9	12.4	16.5	21.0
5	14.1	16.2	19.3	18.3	20.3	22.1
6	12.5	16.2	20.0	17.2	19.9	22.3

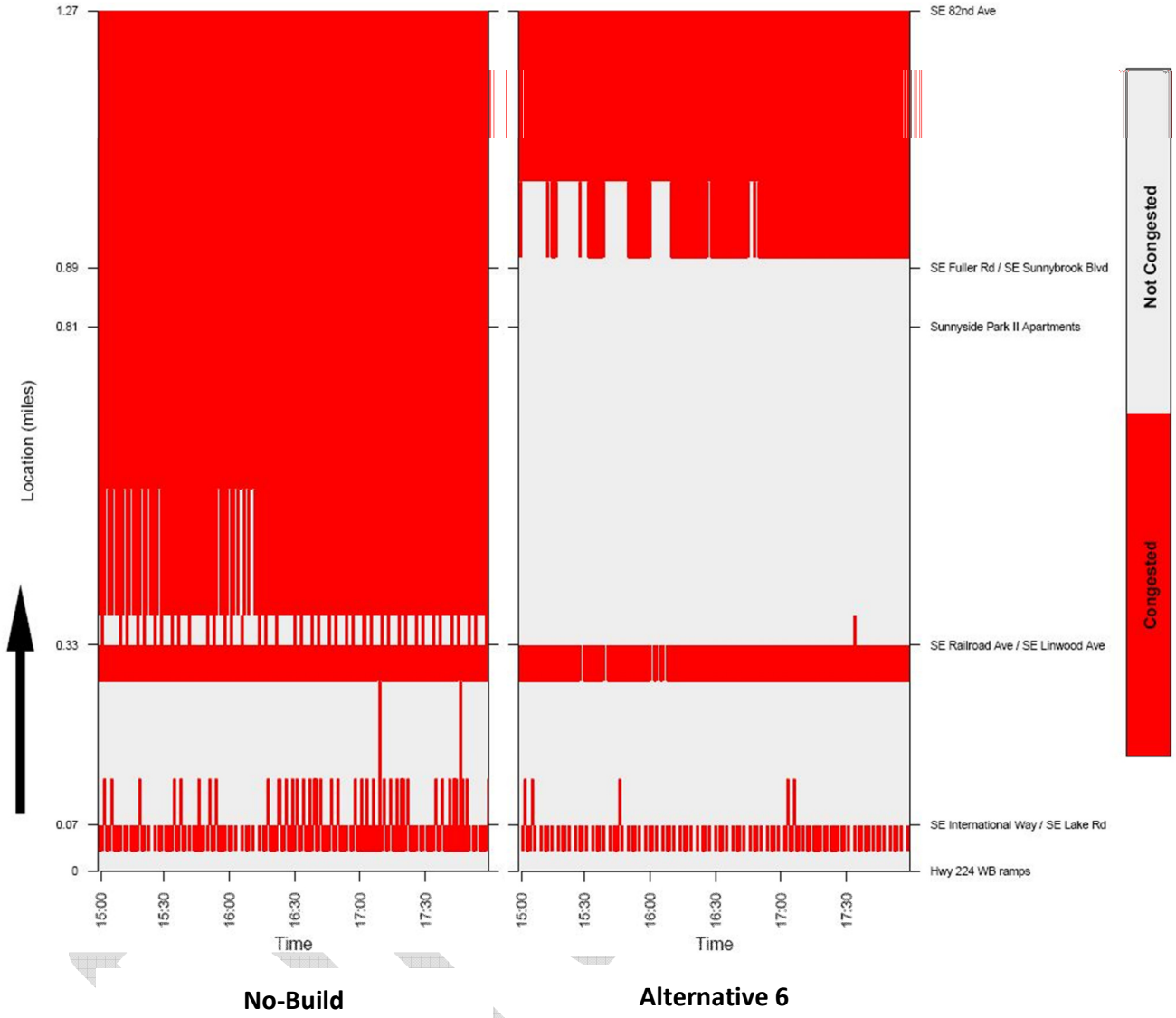
* indicates at-grade railroad crossing (not modeled in this analysis)

As seen in Table 3, the observed speeds on the corridor are substantially higher with Alternatives 5 and 6, particularly in the eastbound direction. Average speeds are about 6 mph higher than the 2035 no build alternative in the eastbound direction and about 5 mph higher in the westbound direction with both Alternative 5 or 6. In order to produce significant gains in speeds on Harmony Road, the roadway needs to be widened to 5 lanes between OR 224 and Fuller Road to support the high volume of through movements (as in Alternative 5 and 6). It should be noted that Alternatives 2 and 4 provides similar operating speeds in 2035 compared to what exists today along Harmony Road because the railroad crossing events meter traffic into the corridor.

Congestion

Congestion on the SE Harmony Road corridor was also assessed for each alternative. For this analysis, roadway segments are considered congested if the average speeds are less than or equal to 60% of the free flow speed. Like travel speeds, congestion was assessed along each segment of the corridor to identify where congestion is most severe. Exhibit 9 compares the congestion on the corridor in the eastbound direction for the no build alternative and Alternative 6. As seen in the exhibit, Alternative 6 reduces congestion most significantly between the intersection of SE Harmony Road/SE Railroad Avenue/ SE Linwood Avenue and SE Harmony Road/SE Fuller Road/SE Sunnybrook Boulevard. *Similar plots for all alternatives are provided in Appendix E.*

Exhibit 9: 2035 Congestion on SE Harmony Road Eastbound (No-Build versus Alternative 6)



No-Build **Alternative 6**

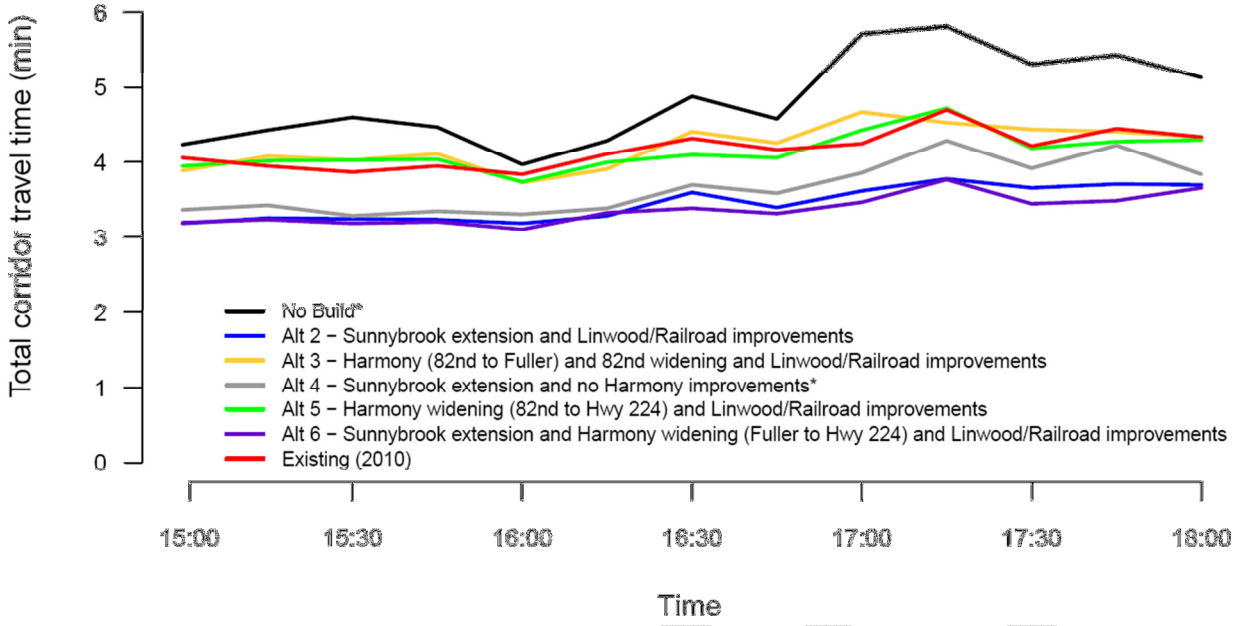
Queuing

[The queuing analysis results are still being extracted from the models at the time of this memorandum's publication and will be provided in the future]

FULLER ROAD FINDINGS

The Fuller Road corridor study corridor showed notable differences in the alternatives assessed for travel time in the southbound direction. The alternatives including the Sunnybrook Extension (Alternatives 2, 4 and 6) improved travel times compared to the other alternatives, with up to a minute in travel time savings during the PM peak hour. Exhibit 10 compares the travel times for the southbound direction of travel along Fuller Road between SE King Road and SE Harmony Road.

Exhibit 10: 2035 Average 15-minute Peak Hour Travel Time on SE Fuller Road Corridor (Southbound)



* indicates at-grade railroad crossing (not modeled in this analysis)

As seen in the exhibit, the savings in travel time are most significant during the hour between 5:00 and 6:00 PM. The average travel times on the corridor in the northbound direction differed negligibly between the alternatives during the PM peak hour (*graph of travel times on SE Fuller Road in the northbound direction provided in Appendix A*).

The other metrics assessed on the Fuller Road corridor (i.e. travel time reliability, travel speed, congestion) showed similar trends between the alternatives. *Full results for operations in the southbound direction are provided in Appendix F.*

GRADE-SEPARATION AT HARMONY ROAD/LINWOOD AVENUE

Grade-separating the railroad crossing at the Harmony Road/Linwood Avenue intersection would eliminate the influence of rail on vehicular traffic and also provide opportunities for improving the Harmony Road/Linwood Avenue intersection and surrounding roadways (which are currently constrained by the railroad). The expected delays from railroad crossings were calculated and the results are presented in Table 4.

Table 4 Estimated 2035 Railroad Crossing Closures at Harmony Road/Linwood Avenue (5:00-6:00 PM)

Performance Element	Value
Average number of crossings (per hour)	1.24
Maximum number of crossings (per hour)	2
5th percentile railroad closure time (minutes)	1.00
Average railroad closure time (minutes)	1.93
95th percentile railroad closure time (minutes)	4.00
Maximum railroad closure time (minutes)	6.00

As seen in the table, the average closure time during the peak hour is just under 2 minutes, with a 95th percentile closing time of 4 minutes. Therefore, a railroad crossing has the potential to add 2 to 4 minutes of additional travel time for vehicles that encounter a train crossing under the No-Build and Alternative 4. The MOEs presented above for the Harmony Road and Fuller Road corridors do not include the influence of railroad closures for the 2035 No-Build alternative and Alternative 4 (which do not include a grade-separated crossing). Delay associated with railroad crossing closure is in addition to the travel times reported in the plots and tables. *Therefore, while Alternative 4 and Alternative 2 (Sunnybrook extension and grade-separated crossing) perform similarly based on the speeds on the Harmony Road corridor (see Table 3), these times do not include the railroad crossing delay.*

The delay results presented in Table 4 were used to adjust the average travel times on the corridor for the No Build alternative and Alternative 2, assuming that 5% of vehicles encounter a train crossing (based on the frequency of trains and average crossing time). The results are shown in Table 5.

Table 5 Average Travel Times (minutes) along Harmony Corridor (82nd to Hwy 224)

Alternative	Eastbound		Westbound	
	Average Travel Time (without railroad crossing adjustment)	Adjusted Average Travel Time (includes railroad crossing delay)	Average Travel Time (without railroad crossing adjustment)	Adjusted Average Travel Time (includes railroad crossing delay)
Existing	5.5	5.5	4.6	4.6
No Build*	7.5	7.6	5.0	5.1
2	5.8	5.8	3.7	3.7
3	6.0	6.0	3.8	3.8
4*	5.7	5.8	4.6	4.7
5	5.8	5.8	3.7	3.7
6	6.0	6.0	3.8	3.8

* indicates at-grade railroad crossing

As seen in the table, rail crossings are not likely to significantly affect average travel time on the corridor, although they could substantially increase travel times for users that encounter a train crossing. These results are based on the assumption that rail use increases about 25% by 2035. If rail use increases more significantly, the anticipated delays and average travel times could increase significantly. Also, these results do not account for additional delays due to queues or congestion that result from the train crossing. Therefore, the adjusted average travel times may underestimate the influence of the at-grade railroad crossings in the Bo Build alternative and Alternative 4.

In addition to eliminating delays from railroad crossings, grade-separating the crossing at Harmony Road/Linwood Avenue provides opportunities for improving the intersection, which is anticipated to operate over capacity and at a LOS F in the future without improvements (see Table 1). Without the grade-separation, the intersection of Harmony Road/Linwood Avenue acts as a valve that blocks vehicles from passing through the intersection. Table 6 compares the volume of vehicles that the intersection is able to serve between Alternatives 2 and 4.

Table 6 2035 Total Exiting Volume at Harmony Road/Linwood Avenue Intersection

Time Period	Alt 2	Alt 4*	Delta
3:00 – 4:00 PM	2572	2262	310
4:00 – 5:00 PM	2640	2303	337
5:00 – 6:00 PM	2914	2549	365
Total	**8126**	**7114**	**1012**

* indicates at-grade railroad crossing

As seen in the table, the intersection is able to serve approximately 14 percent more vehicles with the grade-separation over the peak hour period. In addition, grade-separating the intersection is necessary to widen Harmony Road and construct the improvements included in Alternatives 2, 3, 5 and 6.

ALTERNATIVE COST ESTIMATES AND ESTIMATED PEAK HOUR SAVINGS

In order to more fully conceptualize the findings presented above, the cost estimate and 2035 weekday PM peak hour travel time savings were calculated for each alternative. The cost estimate and travel time saved during the PM peak period was monetized for the average motorist under each alternative is shown in Table 7. The travel time savings was determined by multiplying the number of motorists on the corridor under each alternative and a set time value of money to extrapolate the value of time saved during the PM peak period each day.

Table 7 Time Savings for Alternatives – Harmony Road (OR 224 to 82nd Avenue)

Alt	Projects	Cost Estimate[1] by Project	Total Cost Estimate	Travel Time Saved During PM Peak Period (3-6 PM)[1] (minutes)	Value of Time[1] Saved During PM Peak Period (3-6 PM)[3]
2	Sunnybrook Extension (U001)	$10,600,000	$30,600,000	2.69	$2,910
	Grade-Separated RR Crossing (U103)	$20,000,000			
3	Harmony Widening to 5 lanes from Fuller Road to 82nd (partial TSP ID U104)	$7,067,000	$29,847,000	2.44	$2,400
	82nd Widening (TSP ID U109)	$2,780,000			
	Grade-Separated RR Crossing (U103)	$20,000,000			
4*	Sunnybrook Extension (U001)	$10,600,000	$10,600,000	2.11	$2,010
5	Greater Harmony Widening to 5 Lanes (TSP ID U104)	$34,130,000	$54,130,000	4.19	$4,760
	Grade-Separated RR Crossing(U103)	$20,000,000			
6	Harmony Widening to 5 lanes from OR 224 to Fuller (partial TSP ID U104)	$22,753,000	$53,353,000	4.09	$4,910
	Sunnybrook Extension (U001)	$10,600,000			
	Grade-Separated RR Crossing (U103)	$20,000,000			

[1] Cost Estimates developed for Clackamas County TSP Updated
[2] Value of time = $20.35 per hour based on Portland Travel Demand Model Stated Preference Value of Time Survey, adjusted for 2012 dollars
[3] Travel time savings only capture weekday PM peak hour, but weekday AM, weekend and holiday periods are likely to also experience TT benefits
* indicates at-grade railroad crossing (travel time saved adjusted to account for rail crossings)

As seen in Table 7, Alternative 6 produces the most significant travel time savings, followed closely by Alternative 5. Alternative 2 produces about half the travel time savings of Alternative 5 or 6, followed by Alternatives 3 and 4. The DTA analysis suggests that both widening Harmony Road to 5 lanes between OR 224 and Fuller Road (as in Alternative 5 and 6) and creating additional capacity between Fuller Road and 82nd, either by widening Harmony Road (Alternative 5) or with the Sunnybrook Extension (Alternative 6), are necessary to create these increased operational benefits.

For the most part, the relationships between the cost estimate and travel time savings are proportional for all the alternatives. For example, Alternative 5 and 6 cost about twice as much as Alternative 2 and 3, and produce about twice the travel time savings. Alternative 4 is the exception, as it costs significantly less than Alternative 2 or 3 and produces approximately the same travel time savings. However, it is important to note that Alternative 4 does not address the operational deficiency at the Harmony Road/Linwood Avenue intersection.

Benefit-Cost Comparison

While Alternatives 5 and 6 provide the best overall operational results and reliability, it is important to also evaluate the alternatives from both a benefit-cost standpoint and relative to what motorists experience without improvements to the corridor. Thus, the benefit-cost of the alternatives as well as the average travel time was compared to the no build alternative to provide an additional perspective. Table 8 provides the benefit cost of the alternatives based on the weekday 3:00 – 6:00 PM period travel time savings over the 20-year forecast period.

Table 8 Benefit/Cost Ratio for Alternatives Based on 20-year Weekday PM (3 to 6 PM) Travel Time Savings

Alternative	Cost Estimate	Savings per Day[1]	Savings per Year[2]	20 Year Savings	B/C Ratio (20 years)
2	$30,600,000	$2,910	$1,062,150	$21,243,000	0.49
3	$29,847,000	$2,400	$876,000	$17,520,000	0.42
4*	$10,600,000	$2,010	$733,650	$14,673,000	0.99
5	$54,130,000	$4,760	$1,737,400	$34,748,000	0.46
6	$53,353,000	$4,910	$1,792,150	$35,843,000	0.48

[1] Travel time savings only capture weekday PM peak hour, but weekday AM, weekend and holiday periods are likely to also experience TT benefits
[2] Savings per year extrapolated by multiplying savings per day times 260; savings do not account for AM, weekend, or holiday time savings
* indicates at-grade railroad crossing (travel time saved adjusted to account for rail crossings)

As shown in the table, Alternative 4 provide the highest benefit cost over the forecast period based on travel time savings, followed by Alternative 2. However, it should be noted that Alternative 4 does not address the identified operational deficiencies at the SE Harmony/SE Linwood intersection. Alternative 2 does address this deficiency as provides an increased benefit-to-cost ratio compared to the remaining alternatives.

FINDINGS AND CONCLUSIONS

The following findings are based on the DTA analysis:

- The different alternatives for the Clackamas Regional Center Southwest Access Corridor (Harmony Road/Sunnyside Road/82nd Avenue area) perform similarly from an operations perspective on most study corridors. Significant differences between the alternatives were observed on the Harmony Road (eastbound and westbound travel) and Fuller Road (southbound travel) corridors.
- Alternatives 5 and 6 provide the most substantial operational benefits on Harmony Road from a motorist perspective, resulting in significant travel time savings compared to the no build alternative (and existing conditions).
- Alternatives 2, 3 and 4 produce year 2035 travel times on the Harmony Road corridor similar to what motorists experience today (2010 existing conditions), while Alternatives 5 and 6 improve operations in 2035 compared to today.
- All alternatives reduce variability in travel times (reflecting greater travel time reliability) from hour-to-hour and day-to-day on the Harmony Road Corridor. Alternative 5 produces the most reliable travel times, followed by Alternative 6.
- Alternatives 2, 4 and 6 (all include Sunnybrook Extension) provide the greatest savings in travel time on Fuller Road for motorists traveling in the southbound direction, although the differences are not as significant as on Harmony Road.
- Grade-separating the intersection at Harmony Road/Linwood Avenue (Alternatives 2, 3, 5, and 6) is not likely to significantly reduce the average travel times on the SE Harmony Road corridor. However, it allows for improvements to the Harmony Road/Linwood Avenue intersection, which is projected to fail in the future and also facilitates approximately 14 percent more vehicles during the peak hour time period.
- In order to meet current Metro RTP requirements and County zoning and concurrency requirements and address the identified deficiencies within the Clackamas Regional Center Southwest Access Corridor, Alternatives 2, 3, 5 or 6 would need to be included in the County's TSP.
- Alternative 2 provides the highest benefit/cost ratio compared to the alternatives that address the existing and future deficiencies within the Clackamas Regional Center Southwest Access Corridor.

These findings will be used to inform the selection of alternatives and prioritization of projects on the Clackamas County TSP Master List.

NEXT STEPS -- ECONOMIC DEVELOPMENT, TRANSPORTATION INVESTMENT AND REGULATORY CONSIDERATIONS

The above findings and conclusions can be used to consider how to best encourage economic development in the Clackamas Regional Center and meet the overall goals and objectives of the County's Transportation System Plan. The current and projected congestion and intersection failures within the Clackamas Regional Center Southwest Access Corridor directly impact future development as well as the velocity of County investment in transportation infrastructure.

The existing County concurrency requirements set out in the Zoning and Development Ordinance establish level-of-service and v/c ratio standards for intersections in the Regional Center that new development must maintain at day of opening. Due to the congestion projected in this area, new development would be required to make substantial, expensive and potentially unattainable (where public right-of-way is not available) improvements to resolve transportation impacts. Thus, new development under current regulations would become increasingly economically infeasible without the County investing in the immediate near-term to implement transportation improvements in the area.

Therefore, in order to allow continued economic development in the Clackamas Regional Center, meet Metro's RTP requirements and the goals and objectives of the TSP, the County would need select one of the following framework options as part of the TSP:

- **Framework Option #1:** Select and implement Alternative 2, 3, 5, or 6 along with other transportation improvements in the Clackamas Regional Center and increase the velocity of investment within this area to allow for future development to continue to meet and maintain the current zoning and concurrency measures of effectiveness (level of service and v/c ratios) standards; or
- **Framework Option #2:** Modify the current zoning and concurrency measures of effectiveness standards to reduce the velocity and needed level of investments in this area and allow motorists to experience longer periods of congestion.

To help inform this decision, the DTA analysis contained herein provides the operational benefits and costs associated with the transportation improvement alternatives as well as how they perform in 2035 compared to today. Alternatives 2 and 4 effectively generally maintain existing operations in the area through 2035, while Alternatives 3, 5 and 6 improve the transportation system beyond how it operates today. Alternative 4 is significantly less expensive than the other options, but doesn't address congestion at the Harmony Road/Linwood Avenue intersection. Therefore, to allow economic development to move forward under the current zoning and concurrency requirements, Alternative 2 at a minimum would need to be implemented at a minimum to meet Metro's RTP requirements and the goals and objectives of the TSP.

In order to assess how Alternative 2 relates to the intersection operations reported in Table 1 and current concurrency standards, the intersections that did not meet standards under the Low Build

Scenario were reanalyzed with the improvements and projected traffic volumes for Alternative 2. The results are reported in Table 9.

Table 9 2035 Low Build Traffic Operations Analysis Results at Study Intersections in the Clackamas Regional Center

ID	Intersection	Jurisdiction	Performance Standard	Meets Standard with Alternative 2?
123	SE Lake Rd/SE International Way	County	v/c = 0.99	Yes (v/c = 0.97)
124	SE Harmony Rd/SE Linwood Ave[1]	County	v/c = 0.99	Yes (v/c = 0.94)
136	SE Sunnybrook Blvd/ OR 213 (SE 82nd Ave)	ODOT	v/c = 1.1	Yes (v/c = 0.98)

v/c = volume-to-capacity ratio
1 Assumes additional turn lanes at intersection are included with grade-separation improvement

As seen in the table, with the improvements included in Alternative 2, the three intersections that do not meet standards under the Low Build Scenario operate acceptably.

Based on the information contained herein and developed to date through the development of the TSP, the consultant team has provided the following recommendations for both framework options for consideration by the County:

Framework Option #1 Recommendations: The County includes Alternative 2 in the TSP project list as it provides the best return of investment from a travel time perspective, allows for continued economic development in the vicinity of the Clackamas Regional Center with accelerated County funding, and meets the requirements of the existing County Zoning and Concurrency Ordinances as well as the Regional Transportation Plan.

Framework Option #2 Recommendations: The County modifies it operational measures of effectiveness standards to include travel time in lieu of, or in addition to volume-to-capacity ratio and level of service and sets the new standards to tolerate a level of increased congestion. This approach allows for continued development without making it economically infeasible, the County to either delay or completely eliminate the improvement alternatives in the Harmony Road/Sunnyside Road/82nd Avenue area and comply with the Regional Transportation Plan.