DKS Associates
TRANSPORTATION SOLUTIONS

MEMORANDUM

TO:	Annette Clark, Caltrans District 10	
FROM:	Paul Menaker, DKS Associates Terry Klim, DKS Associates Kevin Stankiewicz, DKS Associates	
DATE:	December 16, 2009	
SUBJECT:	Corridor System Management Plan (CSMP) for the I-205/I-5 Freeway in San Joaquin County Task Order No. 205-004 – Task 3: Baseline 2009 (Post I-205 6 Lane Widening) Simulation Model Validation Memorandum - Final	08076-041

INTRODUCTION

DKS Associates has successfully developed traffic simulation models using Synchro and CORSIM computer software for Baseline Year 2009 Traffic Conditions as part of the Corridor System Management Plan (CSMP) for the I-205/I-5 freeway in San Joaquin County.

The network used for analysis is illustrated in Figure 1. This network was agreed with the stakeholders and documented in the Software Selection and Network Definition memorandum, dated August 20, 2008. The software used to simulate the operation is CORSIM, version 6. While CORSIM is used for the simulation of both the freeways and the arterial roads, Synchro 6 was used for intermediate steps for the arterial analysis. The traffic volume and coordinated signal timing information was entered into Synchro, and the model run to estimate the traffic signal phase times. The signal timing and volumes were then exported from Synchro into CORSIM. Models were developed for the periods 5-10 AM and 2-7 PM.

The traffic simulation models were developed through a collaborative process, which included valuable contributions from the I-205 CSMP Project Manager and the stakeholder team. This memo summarizes how the new Baseline 2009, with I-205 six lanes wide and post widening volumes, CORSIM model is a validated representation of the traffic conditions observed in the field during June, 2009.

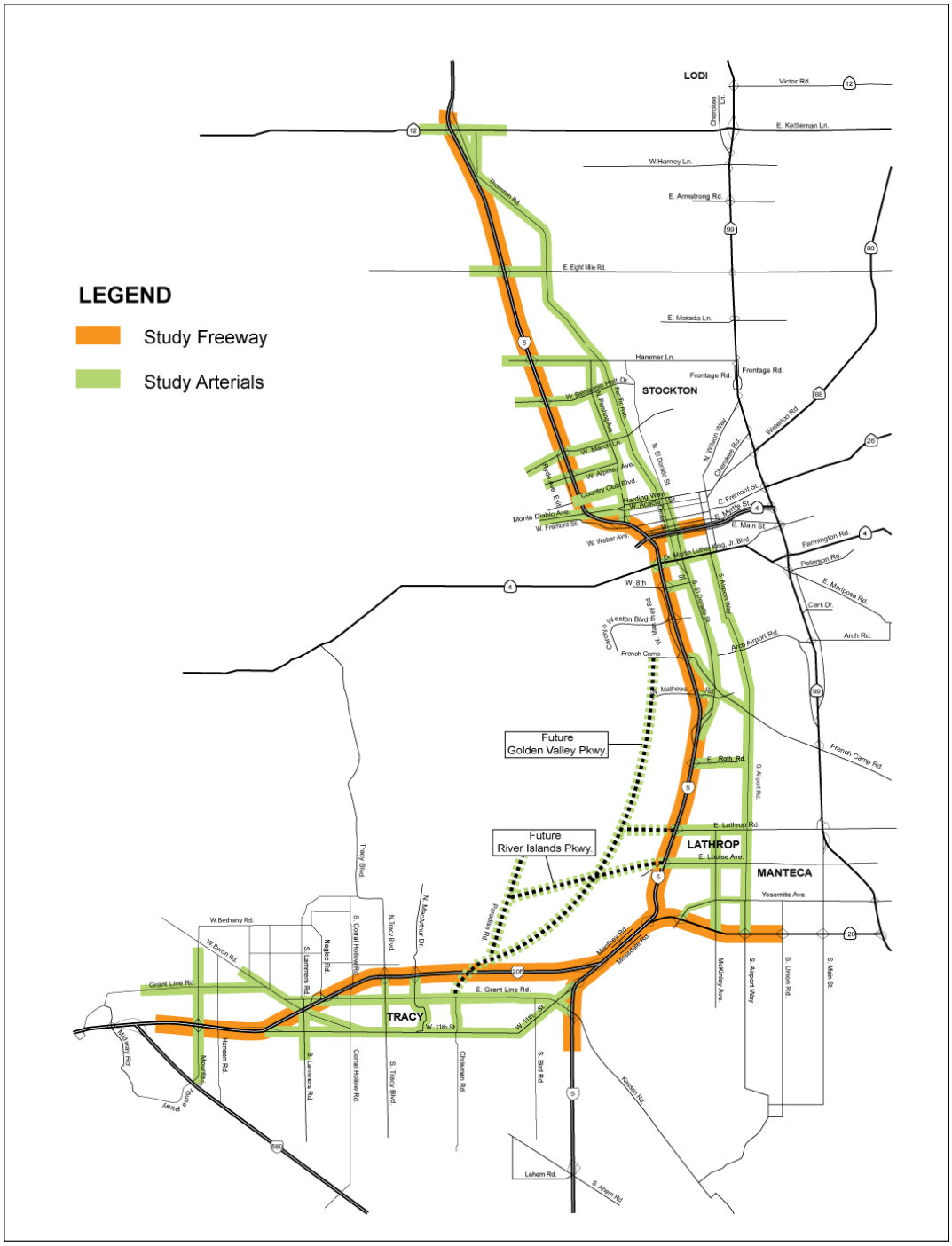

Figure 1 Agreed Study Network

VALIDATION TARGETS

All preliminary Baseline Year AM and PM peak period CORSIM models follow FHWA criteria as described in the Traffic Analysis Toolbox Volume IV: Guidelines for Applying

CORSIM Micro-simulation Modeling Software (Table 11. Wisconsin DOT freeway model validation targets) and were calibrated to match the conditions observed during the data collection effort. This validation focused on the core freeway segments of I-205 from I-580 to I-5 and I-5 from I-205 to SR-12, but also included ramps and arterial roadway segments.

The parameters against which validation is measured are:

- Freeway volumes;
- Ramp volumes;
- Freeway speeds; and
- Bottleneck locations.

Comparison was made with existing measured conditions for each of these parameters during each hour of simulation.

Number of Required Simulation Runs

The minimum number of runs required to achieve a statistically valid median run was calculated. The formula[1] used to calculate the necessary sample size for an unbiased estimate of the population mean is shown below.

$$n = \frac{1}{\left(\frac{d^2}{z^2\sigma^2} + \frac{1}{N}\right)}$$

For the population size (N) we assumed 147, based on the number of Tuesdays, Wednesdays and Thursdays in a year minus three holiday weeks. The maximum allowable difference (d) was calculated by multiplying a relative error of 5% times the mean. The z statistic (z) was calculated based on a 95% confidence interval. The travel time standard deviation during the PM peak hour of variation (4 PM) for the full length of the freeway network was 30 seconds, representing 0.6% of the mean. For the eastbound I-205 section, the standard deviation was 3 seconds, representing 0.3% of the mean. The minimum number of required runs was calculated using these statistics. If the entire freeway system travel time is used then only one run is required. Also if only eastbound I-205 travel time is used, then only one run is required. This low variability is due to the uncongested free flow conditions. Eleven simulation runs were performed because that is what we did for the existing condition. For the AM peak period all eleven runs were used to calculate the median run. In the PM two runs had fatal errors and were ignored, so the median run was calculated based on nine runs.

Freeway Volumes

There are three target values for validation of freeway volumes:

- Model volume on at least 85% of the segments be no more than 400 vehicles per hour different from the adjusted Performance Measurement System (PeMS) based count, or

[1] Hamburg, M, "Statistical Analysis for Decision Making", Harcourt Brace Jovanovich, 1977

within 15% of the adjusted PeMS based count if the counted freeway volume was less than 2700 vehicles per hour.

- The sum of all model freeway link flows be within 5% of the sum of all equivalent link counts.
- The GEH statistic for at least 85% of the freeway segments be no more than 5.

Statistics were calculated for this parameter for each hour of simulation and for the total simulation period.

Ramp Volumes

There are three target values for validation of ramp volumes:

- Model volume on at least 85% of the ramps be within 100 vehicles per hour of the selected counts, or within 15% of the selected counts if the counted ramp volume was more than 700 vehicles per hour.
- The sum of all model ramp link flows be within 5% of the sum of all equivalent link counts.
- The GEH statistic on at least 85% of the ramps be no more than 5.

Statistics were calculated for this parameter for each hour of simulation and for the total simulation period.

Freeway Travel Time

The travel time was compared to the average floating car travel time for each interchange to interchange segment by hour start time. The target value for validation of travel time was that model freeway hourly segment travel times be within 15% of the average floating cars travel times for at least 85% of segments by hour. Statistics were calculated for this parameter for each hour of simulation and for the total simulation period.

Freeway Speeds

The freeway speed was compared to the average floating car speed for each interchange to interchange segment by hour start time. The target value for validation of freeway speeds was that model freeway hourly segment speeds be within 15% of the average floating car speeds for at least 85% of segments by hour.

Statistics were calculated for this parameter for each hour of simulation and for the total simulation period.

Bottleneck Locations

The fifth basis of validation is the location of bottlenecks and the length of congestion approaching each bottleneck. The location of bottlenecks was determined by examining the speed profiles of the floating car surveys. The bottleneck location was defined as the end of the link at which speed is below 40 MPH and rises above 40 MPH for the downstream link. The floating car surveys had a wide variety of speeds recorded in some links, and some

bottlenecks did not appear every day. The validation approach taken was to confirm that the location of a bottleneck was simulated as occurring at the same location as observed in the field, and the simulated speed profile upstream of the bottleneck lay within the range of speeds measured during the surveys.

Arterial Volumes

After amending the observed arterial volumes to accommodate inconsistencies between count days and count locations, the normalized volumes were coded into the Synchro data files and exported to CORSIM. For each arterial link between major intersections, the normalized observed (Synchro) volume was compared with the modeled (CORSIM) volume. The validation criterion used for acceptance of this part of the simulation is for 85% of the links to be within 15% of the normalized input volume (for volumes greater than 700 vph) or within 100 vph for volumes less than 700 vph.

Statistics were calculated for this parameter for each hour of simulation and for the total simulation period.

CORSIM CALIBRATION ADJUSTMENTS

Freeway (FRESIM) Calibration

The calibration was conducted using the guidance provided by FHWA in Traffic Analysis Toolbox Volume IV: Guidelines for Applying CORSIM Micro-simulation Modeling Software (section 5.5). The only changes made to the existing CORSIM model calibration parameters of the freeway were for those freeway segments of I-205 that were widened and no longer in a confined construction zone. The link specific car following sensitivity multiplier was returned to the default (100) except for those sections I-205 where there is a sound wall close to the right lane. There the link car following sensitivity multiplier factor was changed to 170 as it was done in the existing model for the congested lane drop on Northbound I-5 at the lane drop just north of Country Club Boulevard. Also the anticipatory lane change speed and distance were returned to the default.

Intersection (NETSIM) Calibration

There were no changes made to the previous existing conditions intersection calibration parameters. None were needed to match the new counts.

Geometry Changes

The section of I-205 between the 11th Street interchange and the I-5 was widened to six lanes. The section of northbound I-5 between I-205 and just north of SR 120 off ramp was widened to five lanes northbound. This section was restriped with two lanes entering from I-5, three lanes merging from I-205, one lane and a choice lane exiting to SR 120, and four lanes continuing on I-5. The diverge of I-205 from I-5 was restriped to have two lanes and a choice lane exiting to I-205 and three lanes continuing on I-5.

Table 1 Change in Freeway Volumes Before and After Opening of New Lanes on I-205

Volume Change on I-205 and West 11th Street												
	7 - 8 AM - Westbound			8 - 9 AM - Westbound			4 - 5 PM - Eastbound			5 - 6 PM - Eastbound		
Roadway	Before	After	Change	Before	After	Change	Before	After	Change	Before	After	Change
11th St ramp	1408	869	-540	1179	725	-455	1730	956	-774	1986	1019	-968
I-205 - 11th St to Grant Line	2799	3234	435	2557	2837	280	2595	3759	1164	2703	3520	817
I-205 - Grant Line to Tracy	2714	2692	-22	2555	2441	-113	2530	3884	1354	2609	3733	1124
I-205 - Tracy to MacArthur	2795	3131	337	2663	2871	208	2733	4038	1306	2813	3824	1011
I-205 - MacArthur to I-5	2995	3256	262	2758	2944	186	3094	4195	1100	3165	3979	814
Source: I-205 -PeMS November 2008 and June 2009, 11th Street - Wiltec												

Table 2 Change in Freeway Speeds Before and After Opening of New Lanes on I-205

Speed Change (miles per hour) on I-205												
	7 - 8 AM - Westbound			8 - 9 AM - Westbound			4 - 5 PM - Eastbound			5 - 6 PM - Eastbound		
Roadway	Before	After	Change	Before	After	Change	Before	After	Change	Before	After	Change
I-205 - 11th St to Grant Line	64	73	9	61	65	4	37	71	34	60	68	8
I-205 - Grant Line to Tracy	56	72	16	61	67	6	31	70	39	37	68	31
I-205 - Tracy to MacArthur	57	70	13	54	68	14	31	67	36	37	67	30
I-205 - MacArthur to I-5	60	71	11	65	70	5	52	70	18	50	69	20
Source: I-205 -Wiltec January and April 2009 and June 2009												

Volume Changes

A significant amount of traffic has moved from 11th Street onto I-205, after the new lanes on I-205 opened. Without the congestion on I-205 traffic that was previously diverted to parallel 11th Street has now shifted to I-205. This can be seen in Table 1.

Speed Changes

With the widening of I-205 from four to six lanes congestion has been eliminated and speeds have increased to free flow conditions. The speed limit was also raised from 65 miles per hour to 70 miles per hour. This can be seen in Table 2.

VALIDATION RESULTS

Freeway Volume

The volume and GEH statistic validation results for the freeway segments are summarized in Table 3 and Table 4, respectively. The median run of the multiple runs performed for both the Baseline Year AM and PM peak periods met all the volume throughput validation targets. In the AM peak period, 99% of the freeway segments were within volume targets and 94% of the freeway segments were within GEH validation targets. In the PM peak period, 97% of the freeway segments were within the volume validation targets and 92% of the freeway segments were within the GEH validation targets. The sum of all the freeway flows was virtually equal to the sum of the counts in the AM period and within 3% of the sum of the counts in the PM period. The full comparison of freeway volumes is included in Attachment A.

Ramp Volume

The ramp volume and GEH statistic calibration results are summarized in Table 5 and Table 6, respectively. The median run of the multiple runs performed for both the Baseline Year AM and PM peak periods met all the volume throughput validation targets. In the AM peak period, 98% of the ramp segments was within 100 vehicles per hour or 15% if the counted volume was over 700 vehicles per hour, and 97% of the ramp segments had a GEH of 5 or lower. The sum of all the ramp flows over the entire simulation matched the sum of the counts in the AM peak period. In the PM peak period, 95% of the ramp segments were within 100 vehicles per hour or 15% if the counted volume was over 700 vehicles per hour, and 94% of the ramp segments had a GEH of 5 or lower. The sum of all the ramp flows was within 2% of the sum of the counts in the PM period. The full comparison of ramp volumes is included in Attachment B.

Freeway Travel Times and Speeds

Link evaluation

These validation results for freeway travel times and speeds are summarized in Table 7 and Table 8, respectively. In the AM peak period, 74% of the freeway interchange to interchange segments are within 15% of the measured travel time by hour. There are eleven instances, or **"**cases**"** (combination of freeway corridor and hour)**,** where the results fall outside of the

desired validation value of 85% of links within 15% of the measured travel time by hour. Freeway speed validation results show that 86% of the freeway interchange to interchange segments are within 15% of the measured speed by hour. Eight cases fall outside of the desired validation value of 85% of links within 15% of the measured speed by hour.

In the PM peak period, 75% of the freeway interchange to interchange segments are within 15% of the measured travel time by hour. Eleven cases fall outside of the desired validation value of 85% of links within 15% of the measured travel time by hour. Freeway speed validation results show that 84% of the freeway interchange to interchange segments are within 15% of the measured speed by hour. Eight cases fall outside of the desired validation value of 85% of links within 15% of the measured speed by hour. Note that field travel time data is not available between 2 PM and 3PM. The PM model does not meet the original calibration targets.

To examine the sensitivity of the above travel time and speed assessments, the target for travel time or speed comparison was relaxed to be within 20% of the floating car average for at least 80% of segments by hour. Using this criterion, 89% of the freeway interchange to interchange segments meet the relaxed travel time calibration target while three cases fall outside of the desired validation value of 80% of links within 20% of the measured travel time by hour. With respect to speed, 97% of the freeway interchange to interchange segments are within 20% of the target speed by hour, and all AM cases meet the desired validation value of 80% of links within 20% of the measured speed by hour. These results show that the Baseline AM Model meets the relaxed calibration target travel time and speed.

In the PM peak period, 87% of the freeway interchange to interchange segments are within 20% of the target travel time by hour while five cases fall outside of the desired validation value of 80% of links within 20% of the measured travel time by hour. With respect to speed, 92% of the freeway interchange to interchange segments are within 20% of the target speed by hour, and two PM cases do not meet the desired validation value of 80% of links within 20% of the measured speed by hour. These results show that the Baseline PM Model also meets the relaxed calibration target travel time and speed.

Table 9 and Table 10 summarize the freeway travel time and speed results based on the relaxed targets. The full comparison of freeway segment speeds is included in Attachment C and D.

The full set of AM period speed profiles is illustrated in Attachment E, and the PM period profiles are included in Attachment F. The green line indicates the maximum speed measured on that segment in that hour, blue line indicates the minimum speed measured on that segment in that hour, the black line indicates the average speed measured on that segment in that hour and the red line indicates the median simulated speed on that segment in that hour. The average is calculated from all the runs in that time period.

Bottleneck Locations

As illustrated by the speed profiles discussed above, the consistently recurring bottleneck was observed on I-5 northbound at Country Club during the PM peak. This bottleneck is

accurately located in the CORSIM simulations, and is illustrated in Figure 2. The extent of queuing illustrated in that figure is for the median simulation run. The consistently recurring bottleneck that was observed on I-205 eastbound at MacArthur during the PM peak before the new lanes opened no longer exists with the new I-205 lanes open. While congestion is sometimes observed in other locations and during other periods, it is not evident for the average travel times nor does it appear in the median simulation run.

Arterial Volumes

The arterial volume comparison is documented in Attachment G. In the AM peak period 68% of the arterial roadway segments were within 100 vehicles per hour or 15% if the counted volume was over 700 vehicles per hour, and 87% of the arterial roadway segments had a GEH of 5 or lower. In the PM peak period 80% of the arterial roadway segments were within 100 vehicles per hour or 15% if the counted volume was over 700 vehicles per hour, and 78% of the arterial roadway segments had a GEH of 5 or lower.

INTERSECTION LOS

In addition to the calibration described above, the level of service (LOS) was calculated for each signalized intersection based on the CORSIM simulation median run results to confirm that the phase splits being used in the simulation are reasonable. No existing condition LOS is available for direct comparison, so each intersection was checked for reasonableness, based on the study team's field observations. The calculated LOS for each signalized intersection for each hour during the AM and PM peak periods is documented in Attachment H.

CONCLUSION

It is concluded that the I-205 and I-5 corridor baseline conditions simulation model is accurately calibrated to the conditions observed during June 2009, after the new lanes on I-205 were opened to traffic.

Table 3 Validation Results of Freeway Volumes

TARGET: 85% of links with model volume within 400 vehicles per hour of measured value if measured value is more than 2700 vehicles per hour, or within 15% of measured value if measured value is less than 2700 vehicles per hour

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Westbound I-205	100%	100%	100%	73%	100%	95%	100%	100%	100%	100%	100%	100%
Northbound I-5	100%	100%	100%	100%	100%	100%	100%	100%	100%	92%	58%	90%
Southbound I-5	100%	100%	97%	100%	100%	99%	100%	100%	100%	97%	84%	96%

Source: DKS Associates, 2009

Table 4 Validation Results of Freeway Volumes – GEH Statistic

TARGET: 85% of links with GEH statistic of 5 or lower

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Westbound I-205	100%	100%	100%	18%	91%	82%	100%	100%	100%	100%	100%	100%
Northbound I-5	100%	100%	87%	100%	100%	97%	100%	100%	100%	66%	5%	74%
Southbound I-5	100%	100%	95%	87%	97%	96%	100%	100%	100%	89%	71%	92%

Source: DKS Associates, 2009

Table 5 Validation Results of Ramp Traffic Volumes

TARGET: 85% of links with model volume within 100 vehicles per hour of measured value if measured value is less than 700 vehicles per hour, or within 15% of measured value if measured value is more than 700 vehicles per hour

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	100%	100%	100%	100%	89%	98%	89%	89%	89%	100%	78%	89%
Westbound I-205	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Northbound I-5	97%	97%	97%	97%	100%	98%	100%	100%	97%	95%	84%	95%
Southbound I-5	100%	97%	95%	97%	97%	97%	97%	100%	95%	97%	95%	97%

Source: DKS Associates, 2009

Table 6 Validation Results of Ramp Traffic Volumes – GEH Statistic

TARGET: 85% of links with a GEH statistic of 5 or lower

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	78%	100%	100%	100%	89%	93%	89%	89%	89%	100%	78%	89%
Westbound I-205	100%	100%	100%	100%	100%	100%	90%	100%	100%	100%	100%	98%
Northbound I-5	97%	100%	97%	97%	100%	98%	100%	100%	97%	95%	86%	96%
Southbound I-5	100%	95%	92%	92%	97%	95%	95%	100%	92%	92%	92%	94%

Source: DKS Associates, 2009

Table 7 Validation Results of Freeway Travel Time (85% criterion)

TARGET: 85% of interchange-to-interchange segments with CORSIM model corridor output within 15% of measured value for period

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	86%	86%	71%	86%	86%	83%	NA	43%	71%	86%	71%	68%
Westbound I-205	86%	43%	29%	71%	86%	63%	NA	100%	100%	100%	100%	100%
Northbound I-5	89%	68%	58%	58%	63%	67%	NA	74%	74%	63%	63%	68%
Southbound I-5	95%	90%	70%	80%	80%	83%	NA	75%	60%	60%	55%	63%

Source: DKS Associates, 2009

Table 8 Validation Results of Freeway Speed (85% criterion)

TARGET: 85% of interchange-to-interchange segments with CORSIM model corridor output within 15% of measured value for period

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	100%	100%	100%	100%	100%	100%	NA	86%	100%	86%	86%	89%
Westbound I-205	86%	57%	43%	86%	100%	74%	NA	100%	100%	100%	100%	100%
Northbound I-5	95%	95%	80%	80%	90%	88%	NA	80%	65%	70%	65%	70%
Southbound I-5	95%	84%	74%	68%	79%	80%	NA	84%	79%	79%	68%	78%

Source: DKS Associates, 2009

Table 9 Validation Results of Freeway Travel Time (80% criterion)

TARGET: 80% of interchange-to-interchange segments with CORSIM model corridor output within 20% of measured value for period

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	100%	100%	100%	100%	100%	100%	NA	86%	100%	100%	86%	93%
Westbound I-205	100%	86%	71%	86%	0%	69%	NA	100%	100%	100%	100%	100%
Northbound I-5	95%	95%	85%	90%	90%	91%	NA	80%	70%	70%	65%	71%
Southbound I-5	95%	95%	79%	79%	84%	86%	NA	95%	79%	84%	74%	83%

Source: DKS Associates, 2009

Table 10 Validation Results of Freeway Speed (80% criterion)

TARGET: 80% of interchange-to-interchange segments with CORSIM model corridor output within 20% of measured value for period

	AM						PM					
Freeway Segment	**5 AM**	**6 AM**	**7 AM**	**8 AM**	**9 AM**	**Period**	**2 PM**	**3 PM**	**4 PM**	**5 PM**	**6 PM**	**Period**
Eastbound I-205	100%	100%	100%	100%	100%	100%	NA	100%	100%	100%	86%	96%
Westbound I-205	100%	100%	100%	100%	100%	100%	NA	100%	100%	100%	100%	100%
Northbound I-5	95%	95%	90%	90%	90%	92%	NA	85%	80%	75%	70%	78%
Southbound I-5	100%	100%	95%	95%	100%	98%	NA	95%	95%	95%	100%	96%

Source: DKS Associates, 2009

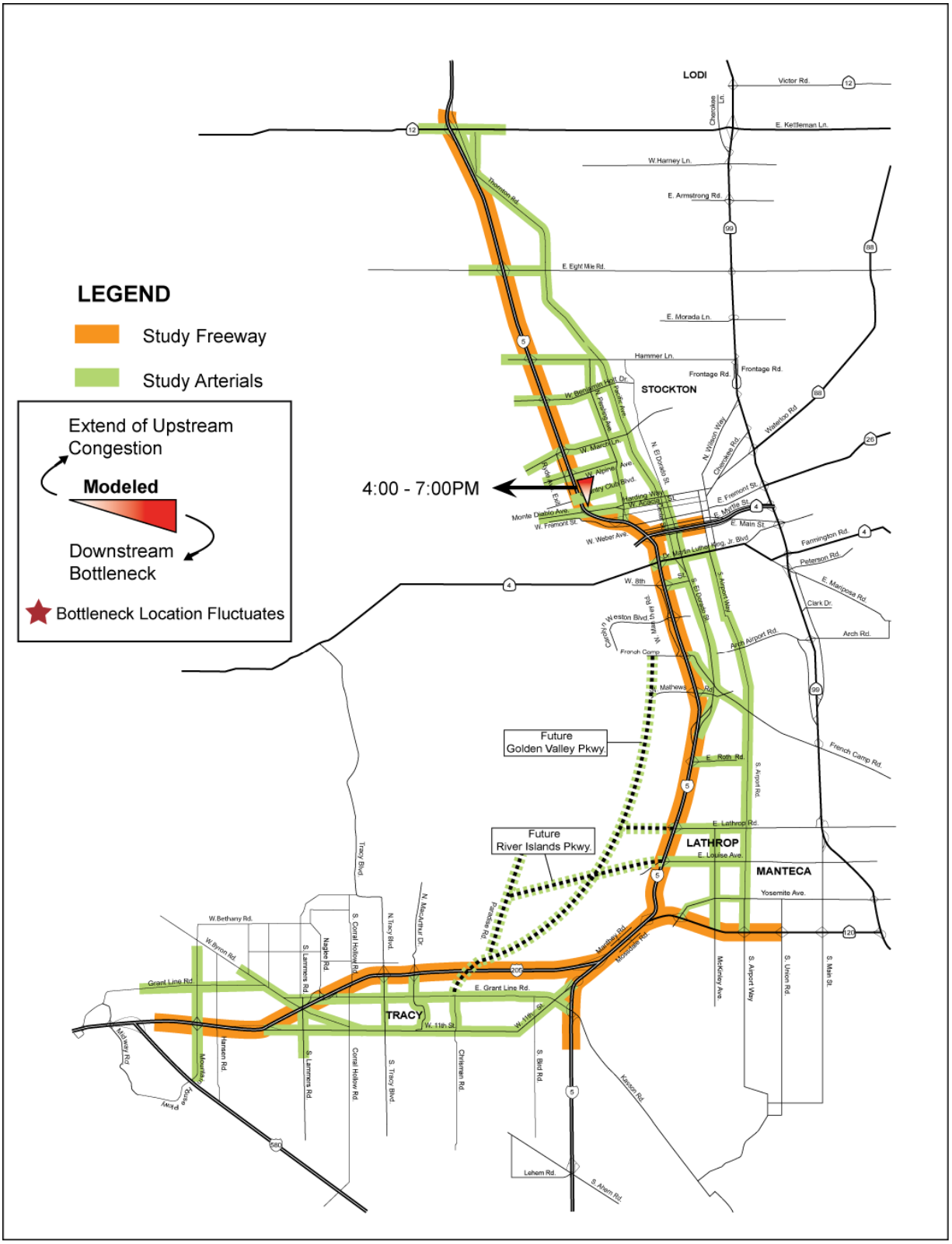

Figure 2 Baseline PM Peak Period Congestion

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Attachment A
Freeway Mainline Volume Comparison

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Attachment B
Ramp Volume Comparison

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Attachment C
Freeway Segment Travel Time Comparison

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Attachment D
Freeway Segment Speed Comparison

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Attachment E
Freeway AM Speed Profiles

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Attachment F
Freeway PM Speed Profiles

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Attachment G
Arterial Volume Comparison

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Attachment H
Intersection LOS