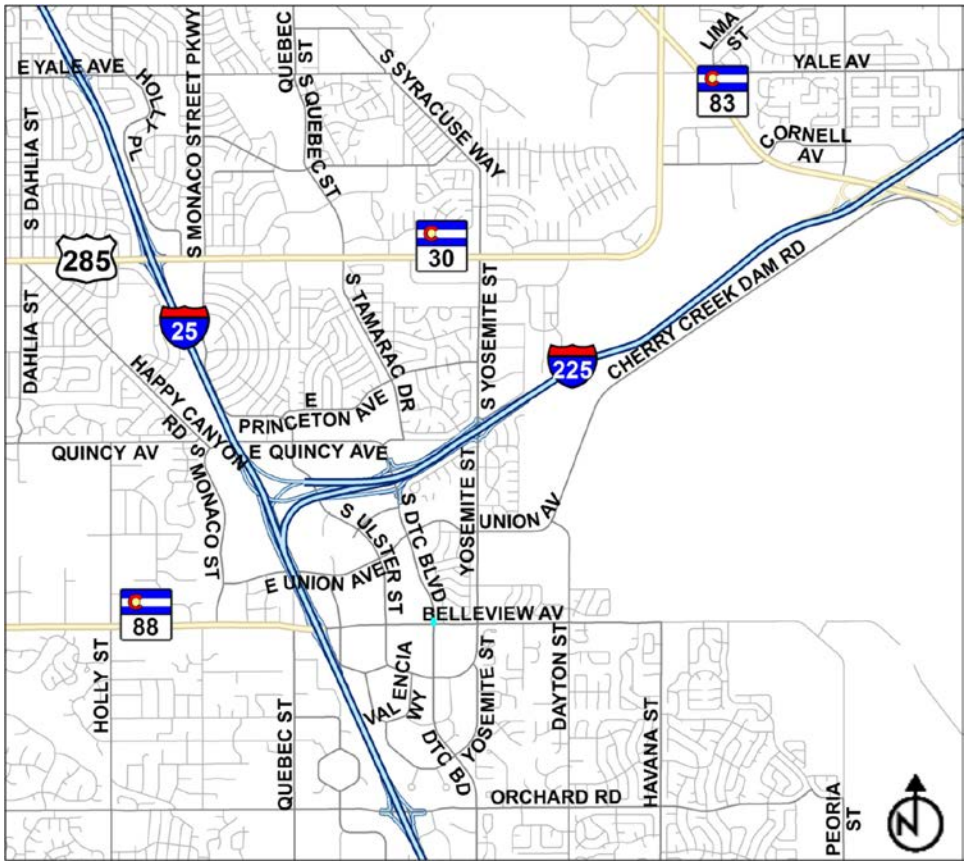
MEMORANDUM

Project:	Southbound I-225 VISSIM Analysis: Parker to I-25
To:	Paul Scherner, PE – Colorado Department of Transportation
From:	Kenneth Ryan, PE, PTOE – Muller Engineering Co. Karl Buchholz, PE, PTOE – Muller Engineering Co.
Date:	July 13, 2017
Subject:	Results Summary

INTRODUCTION

Two scenarios, outlined by CDOT staff, are under consideration to address the recurring congestion problem on southbound I-225 between the Parker Road and I-25 interchanges. An updated VISSIM model was requested as a secondary study, focusing on the freeway modeling, to provide results in accordance with Federal Highway Administration (FHWA) guidelines for microsimulation modeling. A graphic showing the study area is shown in **Figure 1**.

Figure 1 – Study Area



EXISTING CONDITION

Detailed information regarding the data collection efforts including a review of the existing traffic volumes and speeds is provided in the April 17, 2017 *Data Collection and Calibration Data* memorandum. The recurring patterns of congestion along I-225 and I-25 within the study area were in evidence during the data collection phase of the project.

Southbound I-225

Under current conditions, the 2-lane bridge over DTC Boulevard (the bottleneck) results in a recurring queue that extends over three miles in length during the morning peak period, often extending north of Parker Road. Significantly shorter queues often persist throughout the workday before spiking again during the evening peak, though these typically do not extend beyond Parker Road. During the morning peak period, the queue from the bottleneck forms rapidly, and has been observed to take as little as fifteen minutes to reach the three-mile mark from free-flow conditions.

While some delay occurs due to weaving traffic from the DTC on-ramp, vehicles heading southbound on I-25 do not regularly experience major delays within the study area, though incidents and downstream factors do create issues from time to time. Vehicles heading northbound on I-25 run into congested conditions after merging onto I-25 until downstream of the Hampden Avenue bottleneck, as traffic tends to loosen up through the Yale Avenue interchange before running into issues further downstream.

Southbound I-25

The observed traffic conditions along southbound I-25 did not show signs of major congestion during the data collection phase of the project. Further review confirmed that, barring incidents, traffic generally flows well through the study section south of Hampden Avenue, with congested conditions occurring farther north and south rather than in the vicinity of the I-225 interchange.

Northbound I-25

There are several congested areas along northbound I-25 through the study area, in particular the weaving section between the I-225 on-ramp and Hampden Avenue. Other interchanges have negative impacts along this section of I-25, and stop-and-go conditions are common during the peak periods, more significantly during the morning peak period, but generally present at times during the evening peak period.

MODEL CALIBRATION

Detailed information regarding model calibration is provided in the April 17, 2017 *Calibration Report* memorandum. The VISSIM model provides a reasonable approximation of current traffic conditions during the AM and PM peak periods for the purpose of evaluating the proposed construction alternatives with the following caveats:

- While the AM peak period calibration targets were met above the 85% level, there remain some concerns regarding the correlation to the speed data at specific locations.
- The calibration targets were not fully met during the PM peak period on I-225.
  - The model does indicate similar fluctuations in queue length, but due to the nature of unstable flow these do not align consistently with the data collected in the field.
- The calibration targets were not fully met during the PM peak period on northbound I-25.
  - The field conditions responsible for the traffic patterns on northbound I-25 were not observed in the field; the model was therefore calibrated in a conservative manner, showing more congestion near the I-225 merge than was shown in the data.

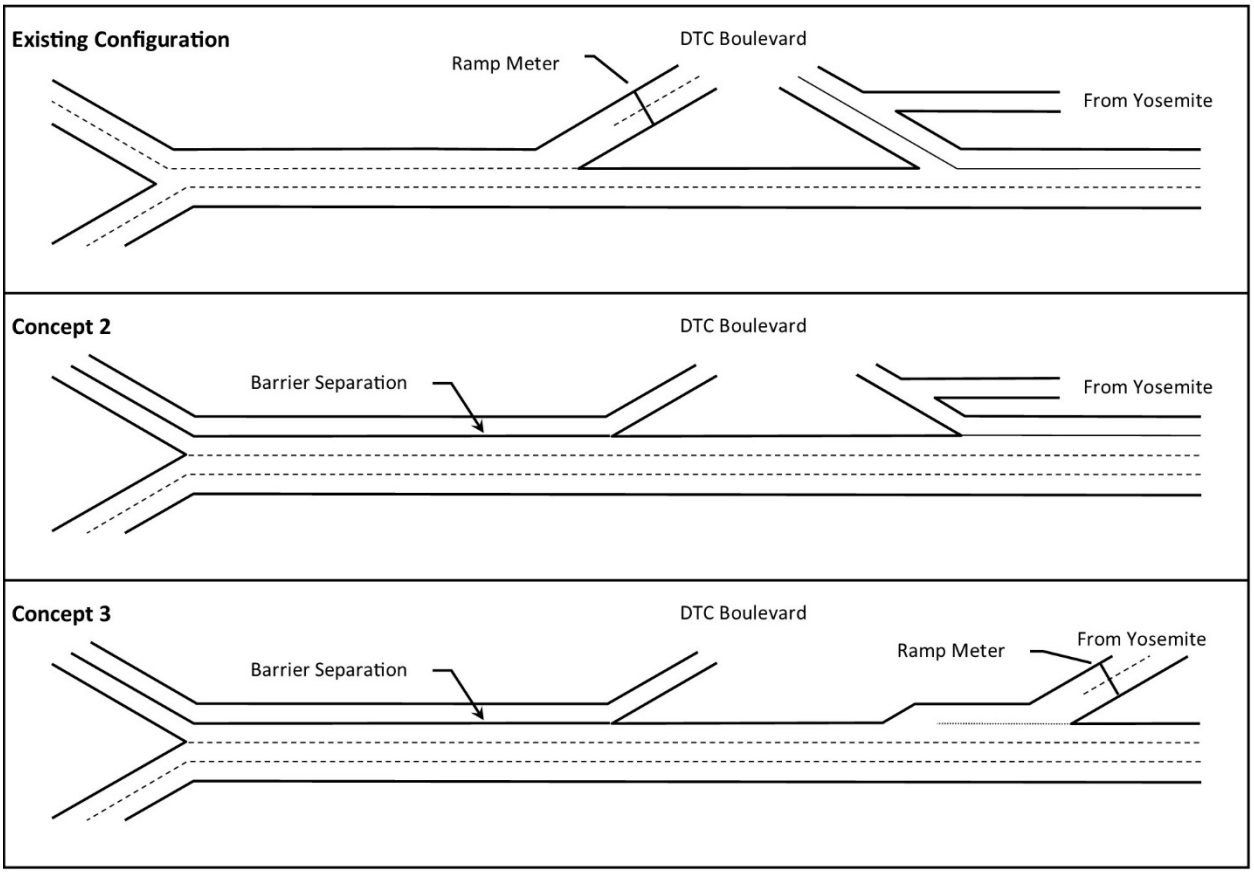
CONCEPT DEVELOPMENT

The two scenarios selected by CDOT staff for modeling are based on conceptual layouts evaluated as a part of previous work efforts. These scenarios are described as follows:

- **Scenario 2**: Southbound I-225 hard shoulder lane starting north of Yosemite; Reconfigure DTC Boulevard on-ramp traffic to provide access to northbound I-25 only. DTC Boulevard travel to SB I-25 would occur via the local street system.
- **Scenario 3**: Southbound I-225 hard shoulder lane starting north of Yosemite; Reconfigure DTC Boulevard on-ramp traffic to provide access to northbound I-25 only; Remove DTC Boulevard off-ramp, add Yosemite on-ramp.

A schematic depiction of the existing roadway configuration and the conceptual layout changes are shown on **Figure 2**.

Figure 2 – Concept Schematics



MODEL DEVELOPMENT

The Concept 2 and Concept 3 scenarios were modeled in VISSIM by altering the calibrated model as necessary to provide the new lane geometry. The analysis results are based on the average results after 11 simulation runs with different random seeds.

Redirected Traffic

Concept 2 will eliminate the connection between the Yosemite Street and DTC Boulevard interchanges with I-225 and southbound I-25 (barrier separation). As a result, this traffic will divert to alternative locations. Due to the significant reduction in congestion along southbound I-225 observed in the initial model runs, some of this traffic was diverted to the Parker Road interchange and therefore accounted for explicitly in the VISSIM model. The remaining traffic was routed through the Denver Tech Center and assumed to split between the Belleview Avenue and Orchard Road interchanges to access I-25.

A macro-level analysis using Synchro and data provided by DRCOG regarding historic peak period travel time through the Denver Tech Center was used to estimate the travel time and delay accrued by this traffic. The travel time and delay estimate was then added back into the network-wide performance evaluation results to account for the delay experienced by the diverted traffic in the Concept 2 scenario.

In Concept 3, while a connection will be provided between the Yosemite Street interchange and southbound I-25 by the reconfigured ramp, similar to Concept 2 some traffic will likely still divert to southbound I-225 at Parker Road in direct response to the reduction in congestion. Therefore, the Yosemite Street on-ramp would not be expected to accommodate all traffic from the combined DTC Boulevard / Yosemite Street interchanges.

Latent Demand on I-225

The recurring congestion on southbound I-225 inevitably leads drivers to seek alternative routes, who may then return to southbound I-225 should conditions improve. This would have a positive benefit on the surrounding arterial street system, at the possible expense of operations on southbound I-225 even after the improvement.

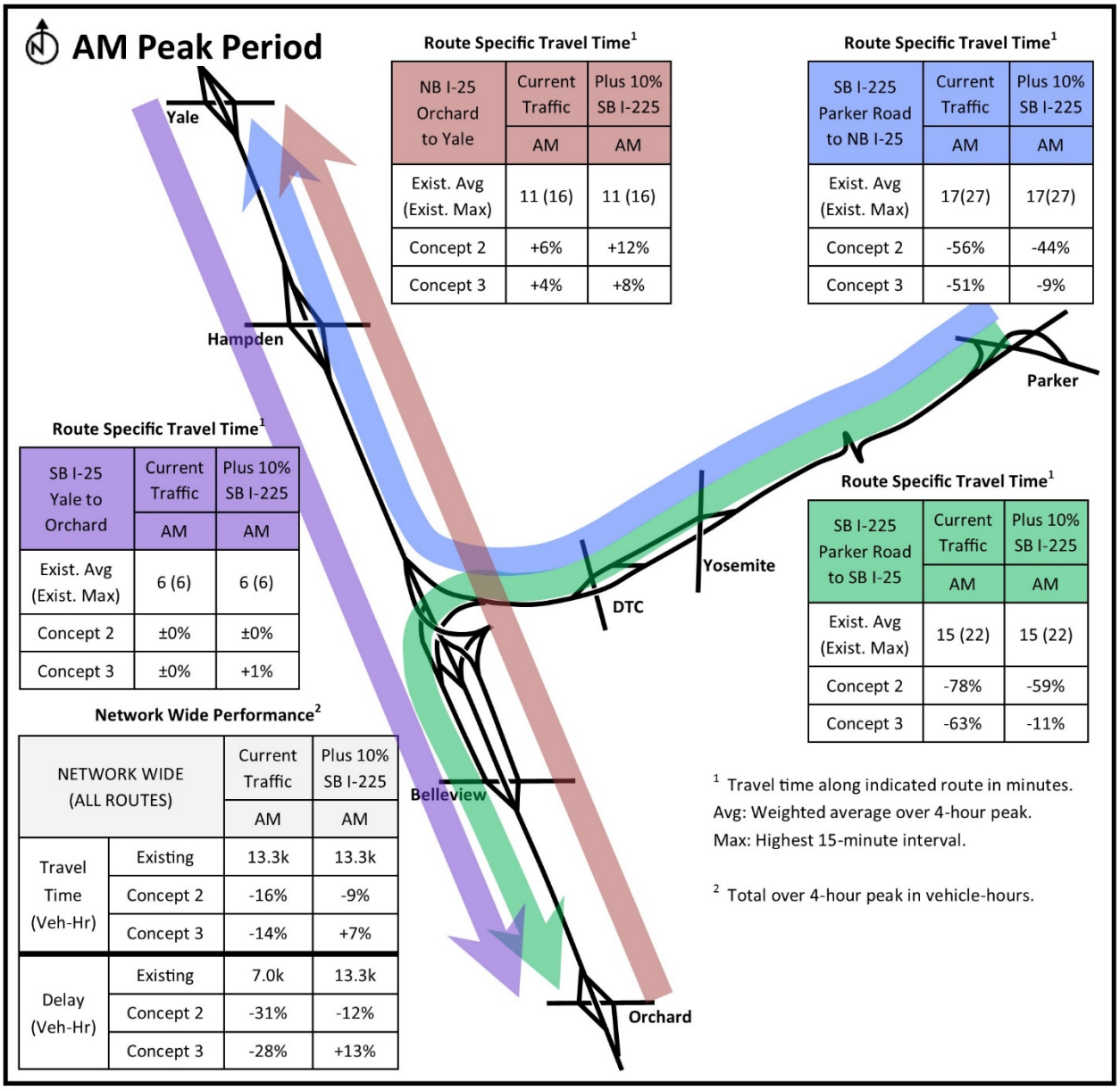
The effect of this potential latent demand is uncertain, but for the purpose of this analysis a sensitivity analysis was performed to evaluate the impact of this additional traffic at several levels. At this preliminary stage, this includes a scenario where an additional 10% traffic is added to the volume inputs from Parker Road and southbound I-225 (from Iliff).

ANALYSIS RESULTS

Several performance measures were evaluated for analysis, including vehicle speeds, number of stops, travel time, and delay. The primary measures selected for comparison were travel time and delay. The travel time is measured as vehicles travel through the network, and delay is the difference between the measured travel time and the free-flow (no traffic) travel time. The travel time and delay for the redirected traffic through DTC in Concept 2 was also included in the analysis. The Concept 2 and Concept 3 results, with and without the additional I-225 traffic, were compared to the current conditions results.

These results are summarized in **Figure 3** for the AM peak period, and **Figure 4** for the PM peak period. A more detailed discussion of the comparative results follows the graphics.

Figure 3 – Change in Performance Measures AM Peak Period



Route Specific Travel Time[1]

NB I-25 Orchard to Yale	Current Traffic	Plus 10% SB I-225
	AM	AM
Exist. Avg (Exist. Max)	11 (16)	11 (16)
Concept 2	+6%	+12%
Concept 3	+4%	+8%

Route Specific Travel Time[1]

SB I-225 Parker Road to NB I-25	Current Traffic	Plus 10% SB I-225
	AM	AM
Exist. Avg (Exist. Max)	17(27)	17(27)
Concept 2	-56%	-44%
Concept 3	-51%	-9%

Route Specific Travel Time[1]

SB I-25 Yale to Orchard	Current Traffic	Plus 10% SB I-225
	AM	AM
Exist. Avg (Exist. Max)	6 (6)	6 (6)
Concept 2	±0%	±0%
Concept 3	±0%	+1%

Route Specific Travel Time[1]

SB I-225 Parker Road to SB I-25	Current Traffic	Plus 10% SB I-225
	AM	AM
Exist. Avg (Exist. Max)	15 (22)	15 (22)
Concept 2	-78%	-59%
Concept 3	-63%	-11%

Network Wide Performance[2]

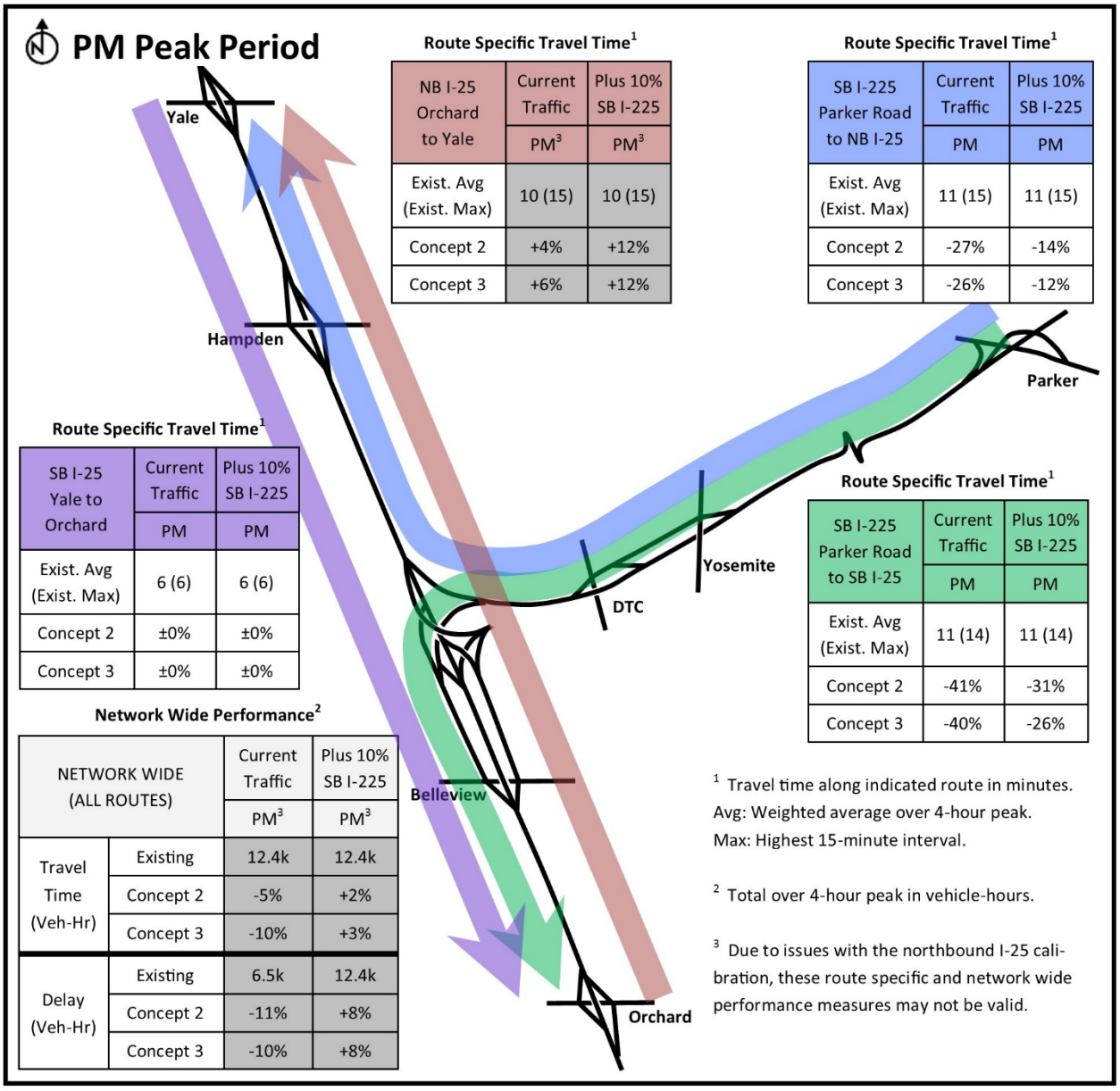
NETWORK WIDE (ALL ROUTES)		Current Traffic	Plus 10% SB I-225
		AM	AM
Travel Time (Veh-Hr)	Existing	13.3k	13.3k
	Concept 2	-16%	-9%
	Concept 3	-14%	+7%
Delay (Veh-Hr)	Existing	7.0k	13.3k
	Concept 2	-31%	-12%
	Concept 3	-28%	+13%

[1] Travel time along indicated route in minutes.
Avg: Weighted average over 4-hour peak.
Max: Highest 15-minute interval.

[2] Total over 4-hour peak in vehicle-hours.

- **Route Specific Travel Time –** These four color coded tables detail the change in travel time for specific routes, showing the change in travel time expected along each route compared to existing conditions.
- **Network Wide Performance** – This table represents the total of all vehicles within the network, on all routes, showing the change in travel time and delay when compared to existing conditions.

Figure 4 – Change in Performance Measures PM Peak Period



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Impacts to I-25 and southbound I-225

The differences in travel time and delay for shown in **Figure 3** and **Figure 4** for the morning and evening peak periods (respectively) are intended to aid in assessing the impact of the Concept 2 and Concept 3 improvements to the roadway network. This section discusses the impacts to the specific routes through the network as well as the overall network performance.

Southbound I-225 Impacts

Both alternatives remove the critical bottleneck over DTC Boulevard by providing 3-lanes of travel, albeit with narrower lanes and narrower shoulders. In addition, the weaving traffic from the DTC Boulevard on-ramp is also removed in either scenario. This results in a reduction in travel time for southbound I-225 traffic heading in either direction on I-25.

Travel time reductions during the morning peak period range between 51-percent and 78-percent under current traffic conditions, with Concept 2 reductions around 5-percent to 15-percent greater than Concept 3. The expected travel time reductions are very similar for both Concept 2 and Concept 3 during the evening peak period, in the range of 25-percent to 40-percent. Concept 2 shows greater benefits than Concept 3 in large part due to the additional (or re-introduced) traffic from the Yosemite Street on-ramp that is added in Concept 3.

As mentioned previously, the improved conditions have the potential to draw additional traffic (latent demand) to southbound I-225. This additional traffic reduces the benefits for southbound I-225 traffic, in particular for Concept 3 due to the Yosemite Street on-ramp traffic. This is, in part, due to over-capacity conditions that would likely occur on the southbound I-25 on-ramp, as traffic merges down to 1-lane prior to merging with I-25. Travel times during the morning peak period for Concept 2 are still expected to drop by around 50-percent on average, while in Concept 3 travel times may only drop by around 10-percent.

Southbound I-25 Impacts

Due to the minimal congestion observed in the vicinity of the I-225 merge with I-25, the difference between Concept 2 and Concept 3 versus current conditions was 1-percent or less during either peak period, with and without the latent southbound I-225 demand.

Northbound I-25 Impacts

Without the southbound I-225 bottleneck, vehicles reach I-25 at an increased rate, earlier in the peak periods. As a result, travel times and delay increased on northbound I-25 under both scenarios. Additional traffic from southbound I-225 because of the improvement (latent demand) would naturally result in additional congestion. It is important to note that traffic volumes are significantly higher on northbound I-25 than on I-225, which means that impacts to I-25 will affect more vehicles overall.

Under current traffic volumes, both Concept 2 and Concept 3 perform similarly during both the morning and evening peak period, increasing travel times along northbound I-25 by approximately 5-percent. With the additional southbound I-225 traffic (latent demand), the increase in travel time on northbound I-25 is greater for Concept 2 than Concept 3 (12-percent versus 8-percent).

As mentioned previously, there were issues encountered during the model calibration on northbound I-25 during the evening peak period. While the results may still provide insight into the relative impacts of the Concept 2 and Concept 3 improvements, the northbound I-25 model output may not be accurate.

Network Wide Impacts

The impact of the Concept 2 and Concept 3 improvements was evaluated on the network, as a whole, accounting for vehicles on all routes through the network. Including the estimated impact for vehicles redirected through the DTC in Concept 2. As such, the benefits to southbound I-225 travel time and delay as well as the impacts on I-25 (negative northbound, more-or-less neutral southbound) are combined, weighted by the number of vehicles affected. This analysis indicated an overall positive impact during both peak periods with the current traffic volumes in either scenario. However, additional traffic on southbound I-225 could result in an overall increase in travel time and delay when compared to current traffic conditions. Only the morning peak period showed an overall positive impact with the additional 10-percent added to southbound I-225, but it would likely take only a little more traffic to tip the other way.

It is important to note that due to the issues with model calibration during the PM peak period for northbound I-25, the magnitude of the impacts during the evening peak may not be accurately represented. However, general trend shown may still be representative of how the Concept 2 and Concept 3 improvements will affect the network.

Impacts to Local Streets

Both Concept 2 and Concept 3 improvements restrict access to southbound I-25 from the DTC Boulevard interchange, requiring some degree of traffic to re-direct. This is expected to be much more significant for the Concept 2 conditions, as traffic will still have access to southbound I-25 via the proximate Yosemite Street interchange with Concept 3.

For Concept 2, traffic will need to redirect to different interchanges, which may require out-of-direction travel (such as Hampden Avenue) and much of the traffic may choose to cut through the DTC heading for the Belleview Avenue or Orchard Road interchanges. Based on the macro-level analysis, this could increase travel time by 5-minues to 10-minutes for vehicles that would access southbound I-25 via the DTC Boulevard interchange with I-225 compared to current conditions. It is also likely that the increased volume would exacerbate already congested conditions through the DTC during peak periods, resulting in additional travel time and delay for existing road users that is not accounted for in this analysis.

CONCLUSION

The preliminary results indicate that both Concept 2 and Concept 3 are expected to provide an overall reduction in congestion within the study network when compared to existing conditions. However, both Concepts show an increase in I-25 travel time compared to existing conditions (Concept 2 in the PM peak period and Concept 3 in the AM and PM peak periods) when traffic volumes on southbound I-225 are increased by 10% to account for potential latent demand traffic diversion. It's worth noting that this increase in travel time for Concepts 2 and 3 is relative to the existing traffic conditions which do not include the 10% increase in traffic volumes. The increase due to latent demand on I-225 will very likely draw traffic from the adjacent street network, which is expected to have an overall positive benefit to the street system and is not reflected in the above analysis due to the limited scope of this modeling effort. Also, it is likely that an equilibrium will occur whereby the latent demand increase is less than 10% because the improvements on I-225 will only draw new traffic to the corridor up to a point where traffic flow does not degrade beyond existing conditions.

Concept 2 provides a greater benefit to southbound I-225 traffic operations than Concept 3. However, Concept 2 also results in more traffic diversion to the local street system due to the removal of the connection between the Yosemite Street / DTC Boulevard interchange and southbound I-25 (barrier separation). As such, Concept 2 may need to be vetted more fully with local jurisdictions. Since traffic will still be able to access southbound I-25 via the Yosemite Street interchange, the impacts to the local street network are expected to be significantly less for the Concept 3 improvements.

APPENDICES

- **Appendix A:** Summary Tables and Charts – By Peak Period
  - *Global Network Performance Results*: Based on the Network Performance output from VISSIM comparing the travel time, delay, and stops for Existing Conditions to Concept 2 and Concept 3 results.
  - *Travel Time Segment Analysis Charts*: Based on the Travel Time and Delay output from VISSIM for key origin-destination pairs through the network comparing the travel time, delay, and stops for Existing Conditions to Concept 2 and Concept 3 results.
  - *Heat Maps*: Based on the Link Segment Evaluation output from VISSIM showing the link speed along southbound I-225 and northbound I-25 in 5 minute intervals for segments approximately 0.25 miles in length for Existing, Concept 2, and Concept 3.
- **Appendix B:** Traffic Volumes – By Link
  - Reports the traffic volumes at each of the field data collection locations and select COGNOS data locations are provided for each of the 11 simulation runs.
- **Appendix C:** Speeds – By Link
  - Reports the vehicle speeds at the 20 COGNOS locations for each of the 11 simulation runs.