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Traffic Operations Study
Tri-Level Ramp

Final Report

May 2008

Prepared for: North Dakota Department of Transportation

Prepared by:
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ENGINEERING CERTIFICATION

This document was originally issued and sealed by Shawn C. Birst, Registration Number PE-5438, on 5/27/2008 and the original document is stored at the Advanced Traffic Analysis Center

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of North Dakota.

Shawn C. Birst	May 27, 2008
Name, P.E.	Date

BACKGROUND

Operational deficiencies along Interstate 94 (I-94) have been developing in recent years within the Fargo-Moorhead metropolitan area. One such area is the section of I-94 between I-29 and 25th Street, which experiences congestion during the afternoon (PM) peak period. This congestion causes the tri-level ramp traffic to significantly queue and operate under stop-and-go conditions. Although the tri-level ramp congestion currently occurs for approximately 20 minutes during the PM peak period, it poses safety issues due to the large disparity in travel speeds between the southbound I-29 mainline and off ramps. In addition, the congested period will likely increase as the traffic levels continue to grow in the Fargo-Moorhead area.

The primary reason for the tri-level ramp congestion relates to the high traffic volume on the ramp which then merges with the southeast ramp (northbound to eastbound) from I-29 (Figure 1). Although the southeast ramp traffic should yield to the tri-level ramp traffic, vehicles traveling on the southeast ramp force their way into the tri-level ramp's traffic stream. This occurrence causes the tri-level ramp traffic to slow down or even stop, causing a significant shock wave for the tri-level traffic.

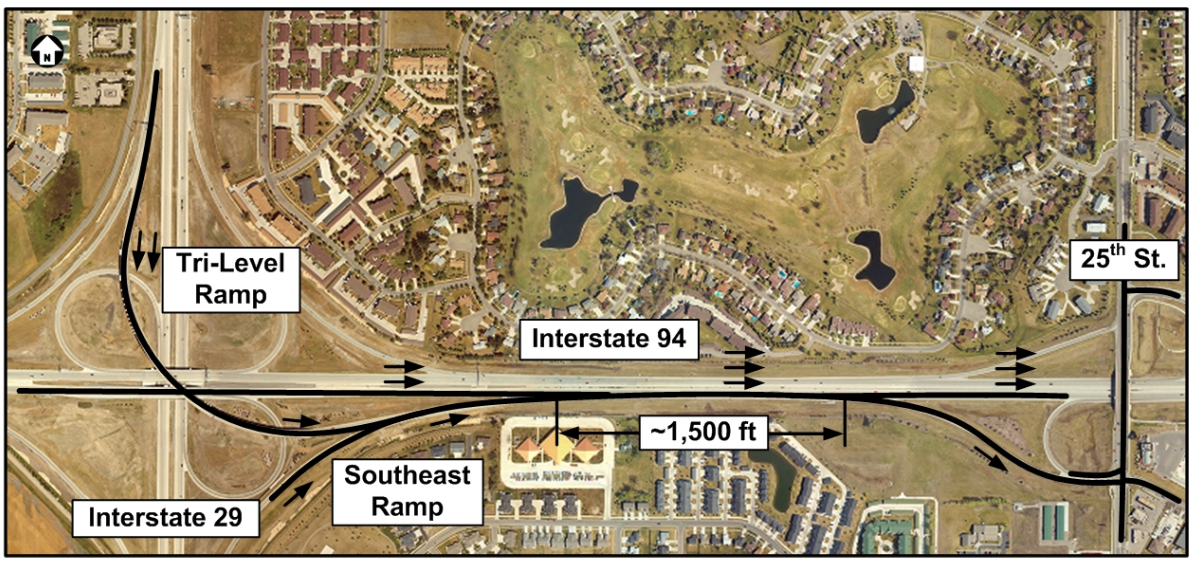

Figure 1. Study Area

OBJECTIVES

This study will assess the operational performance of the existing conditions and various alternative geometric designs between the I-94 & I-29 Interchange and the I-94 & 25th Street Interchange. In addition, this study will provide guidance on selecting the most appropriate design alternative(s) that will accommodate both the existing and future traffic conditions.

METHODOLOGY

Due to the close proximity between the various freeway sections, a significant effort is required to accurately analyze the study area. Once the tri-level and southeast ramp merge together, creating an additional mainline travel lane, a three-lane weaving section of approximately 1,500 feet exists prior to the 25th St. Off-ramp. Therefore, simply adding more capacity may actually reduce operational performance and safety due to increased lane changes (vehicle conflicts) within the weaving section.

Various design alternatives will be evaluated using existing and forecasted traffic. Vehicle paths through the study area will be obtained during the PM peak period to more accurately analyze the weaving section. The design alternatives, traffic volumes, and vehicle paths will be used to construct various simulation scenarios. Key measures of effectiveness (MOE) will be compared among the simulation scenarios, which will provide insight for selecting the most appropriate design alternative(s).

Geometric Design Alternatives

The North Dakota Department of Transportation (NDDOT) provided several geometric design alternatives to analyze. The design alternatives provide combinations of increasing the capacity of either the tri-level ramp or the southeast ramp and the 25th St. Off-ramp. The following geometric alternatives will be analyzed in this study:

- **Base Case (Existing Conditions)**
  Existing geometric conditions of the tri-level, southeast ramp, I-94 eastbound weaving section, and the off-ramp for the 25th Street Interchange.

- **Alternative 1A**
  This alternative will eliminate the merge on the tri-level, creating an additional travel lane (Figure 2). The southeast ramp will merge with the tri-level traffic as it currently does. The additional travel lane from the tri-level will act as an auxiliary lane to the 25th St. Interchange. This auxiliary lane will exit and terminate at the 25th Street Interchange. The approach to 25th Street will be widened to three lanes (one for each turning movement).

- **Alternative 1B**
  This alternative is the same as Alternative 1A, but will include an additional exit lane (double exit) at the 25th Street Interchange (Figure 2).

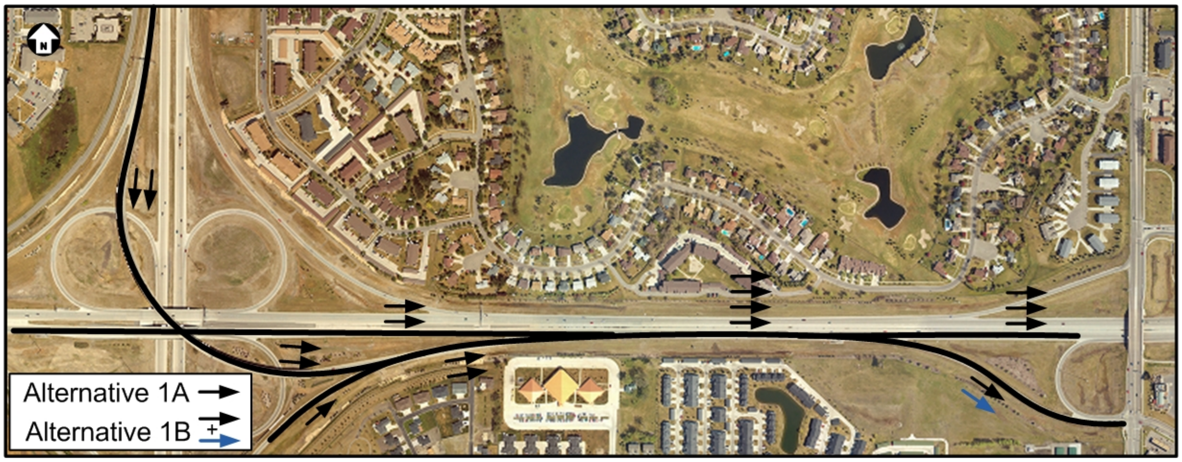

Figure 2. Design Alternatives 1A and 1B

- **Alternative 2A**
  The tri-level merge will remain in its current condition. However, the southeast ramp will have an additional travel lane entering eastbound I-94, which will eliminate the merge with the tri-level ramp (Figure 3). The additional travel lane from the southeast ramp will act as an auxiliary lane to the 25th St. Interchange. This auxiliary lane will exit and terminate at the 25th Street Interchange. The approach to 25th Street will be widened to three lanes (one for each turning movement).

- **Alternative 2B**
  Same as Alternative 2A, but will include an additional exit lane (double exit) at the 25th Street Interchange (Figure 3).

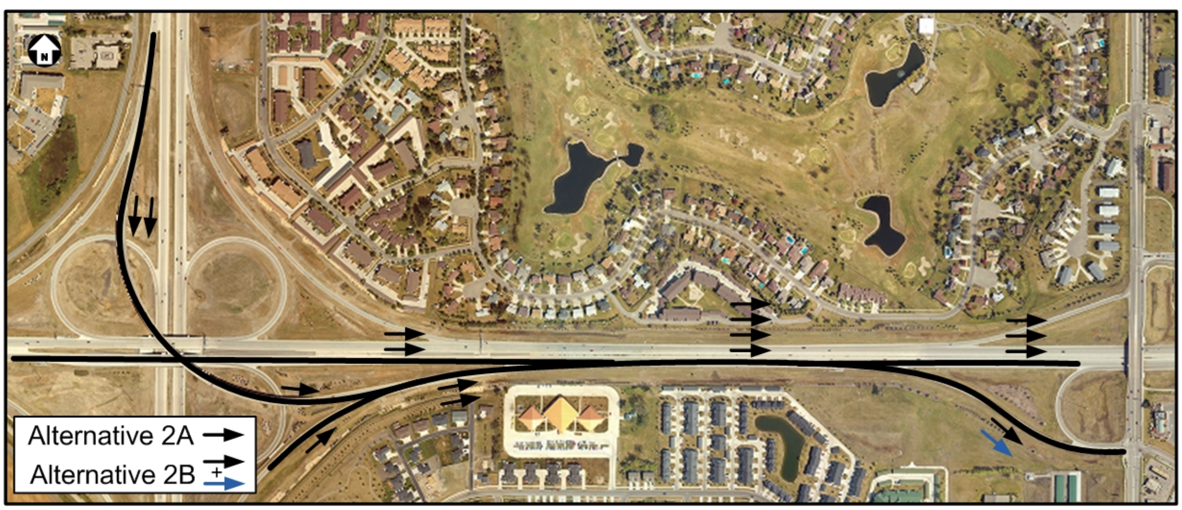

Figure 3. Design Alternatives 2A and 2B

Traffic Volume Data

This analysis will incorporate the existing and forecasted traffic volume data. The existing traffic conditions were observed from 4:00 pm to 6:00 pm on February 21, 2008. Traffic data were obtained using ATAC's Traffic Data Collection System (TDCS) and NDDOT's surveillance camera located on the tri-level ramp. The video data were processed by ATAC staff to obtain traffic counts for the tri-level ramp, southeast ramp, I-94 eastbound prior to the weaving section, and the 25th St. Off-ramp. In addition, turning movement counts were provided by the City of Fargo for the 25th St. Interchange. Since the peak period is rather short, the data were processed using five-minute intervals. In addition, the vehicle counts included two classes: passenger cars and heavy vehicles (more than two axles).

While the data collection was occurring in the field, ATAC staff drove the tri-level ramp several times. It appeared that traffic congestion was significant for about a 20-minute period. On two occasions, ATAC's vehicle stopped briefly on the tri-level ramp and traveled at a low rate of speed (10-15 mph) for several hundred feet until beyond the merge area with the southeast ramp.

After the traffic data was processed, it was determined that the PM peak hour occurred from 4:35 p.m. to 5:35 p.m. (as shown in Appendix A). The tri-level ramp, southeast ramp, and the I-94 eastbound prior to the weaving section observed 1,516; 1,578; and 436 vehicles, respectively (Figure 4). The weaving section observed 3,530 vehicles: 2,930 vehicles (83%) continued eastbound on I-94 while 600 vehicles (17%) exited the freeway at 25th St.

The peak 5-minute interval (5:10 – 5:15 p.m.) was reviewed again to obtain the vehicle origin-destination (O-D) paths. The O-D data consisted of vehicles originating from either the tri-level ramp, southeast ramp, or I-94 eastbound mainline (prior to the weaving section) and arriving at either the 25th St. Off-ramp or I-94 eastbound past the 25th St. Interchange (Figure 4). Traffic exiting at 25th St. from the tri-level ramp, southeast ramp, and I-94 eastbound were 17, 13, and 16 percent, respectively. The O-D demands were slightly factored so the hourly volumes for the mainline and off-ramp replicated those in the field.

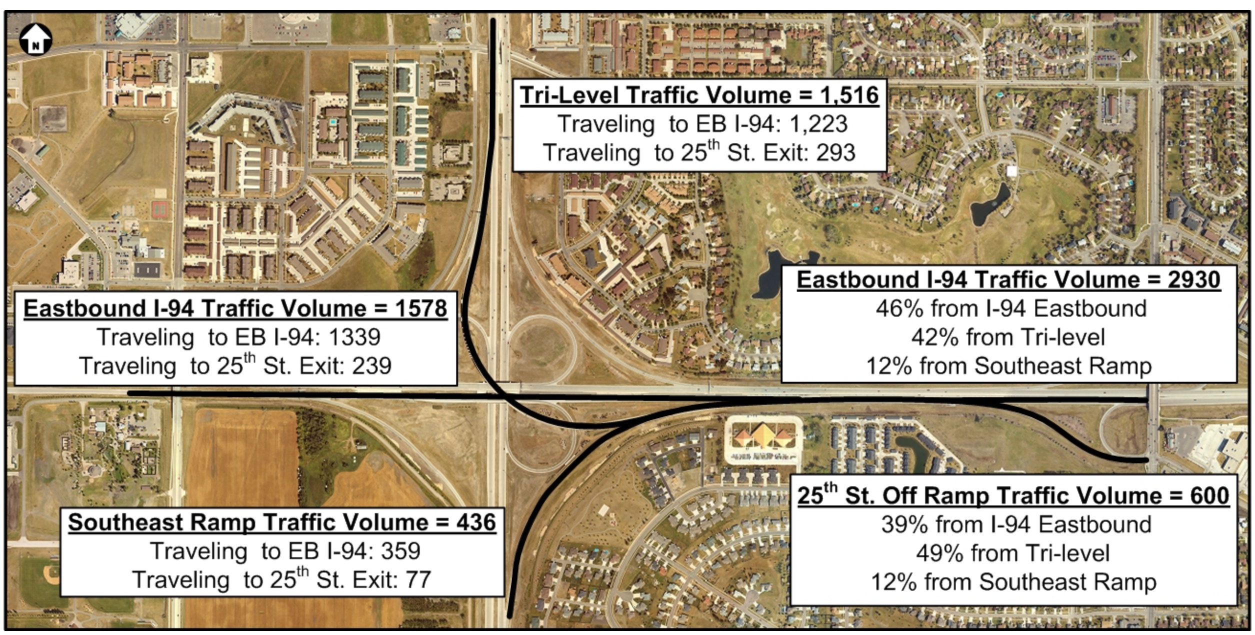

Figure 4. PM Peak-Hour Traffic Volumes

Incorporating forecasted traffic volumes will provide insight on how the design alternatives may perform as the Fargo-Moorhead metro area continues to grow. It is a challenge to accurately forecast traffic volumes 20+ years into the future; however, two methods were available for guiding the study's future traffic scenarios. First, average daily traffic (ADT) volumes can be used to determine the growth over the past several years and project into a future year using an annual growth rate. The second method consists of using the Fargo-Moorhead regional travel demand model, which uses population and employment projections to estimate the future traffic volumes.

Projecting traffic volumes using the interchange's historical count data is difficult since the data contains several inconsistencies and lacks some of the required detail (e.g., directional split). Therefore, the travel demand model seemed more appropriate to use for this study.

Using the modeled 2005 ADT and projected 2030 ADT, growth factors were calculated for the originating traffic entering the I-94 weaving section. This process determined growth factors from 2008 to 2030 for the tri-level ramp, southeast ramp, and the I-94 eastbound mainline to be 1.1, 1.3, and 1.5, respectively. The growth factors for the southeast ramp and the I-94 eastbound mainline seemed realistic; however, the tri-level ramp's growth factor seemed conservative. Due to increased truck traffic (primarily from Canada) and growth along I-94 in Moorhead, which is not accounted for in the travel demand model's 2030 traffic projections, a growth factor of 1.2 for the tri-level ramp was incorporated. In addition, a growth factor of 1.2 was used for the 25th St. corridor.

Traffic Simulation Analysis

Due to the oversaturated conditions and the complexity of the study area, a traffic simulation model was used to analyze the various geometric/traffic scenarios. The simulation model chosen for the study was VISSIM, which is a microscopic traffic simulation model developed by PTV AG. VISSIM is capable of modeling complex network geometry, vehicle interactions, and traffic control devices. The following sections discuss several important components of the simulation analyses.

Simulation Calibration

VISSIM provides various network elements and calibration parameters, creating a more realistic and accurate simulation network. An example of this relates to the lane utilization for the tri-level ramp traffic. Although the ramp initially consists of two travel lanes, the right travel lane terminates as the ramp approaches the merge area with the southeast ramp. Most of the traffic traveling on the tri-level ramp are aware of the merge area and are already traveling in the left travel lane as they approach the interchange. VISSIM can replicate this behavior by modifying the lane change distance, which makes vehicles utilize the appropriate travel lane.

Another powerful feature of VISSIM relates to using priority rules or yield points at locations where vehicles merge together. Although the southeast ramp traffic should yield to the tri-level ramp traffic, this occurrence was not observed in the field. The southeast ramp traffic didn't queue since these vehicles forced their way into the merge area (sometimes by driving on the shoulder for several hundred feet). Therefore, priority rules were incorporated to more accurately reflect this occurrence.

Once the lane utilization and priority rules were incorporated into the base case (2008 traffic), some adjustments were made to the driving behavior to better reflect the vehicle interactions at the merge and weaving sections. Adjustments in the headway time (CC1 of the Wiedemann 99 Car Following Model) for the tri-level ramp, southeast ramp, and the I-94 mainline were made to more accurately reflect the current tri-level queues at the merge area with the southeast ramp. When the appropriate calibration parameters were realized for the existing case, they were incorporated into the remaining simulation scenarios.

Simulation Traffic Data

Traffic data were entered into VISSIM using several O-D matrices. The 5-minute count data for the PM peak hour were used in conjunction with the 5-minute peak O-D data. Therefore, 24 (12 passenger car and 12 heavy vehicle) O-D matrices were used to replicate the peak-hour period.

Simulation Time Periods

The simulation scenarios for the 2008 and 2030 scenarios had slightly different simulation durations. The 2008 scenarios had a simulation duration of 4,800 seconds, which included a 10-minute seed time, 60 minutes of peak-hour traffic, followed by a 10-minute off-peak period. The off-peak period allowed any remaining vehicles to clear the network.

The 2030 scenarios had a simulation duration of 5,700 seconds, which also included a 10-minute seed time, 60 minutes of peak-hour traffic, followed by a 10-minute off-peak period. Since significant traffic congestion was observed during the base case, the off-peak period did not clear the tri-level ramp queue length. Therefore, another 15 minutes was added to the simulation duration, which did not generate any additional traffic, allowing the remaining traffic to complete their trip.

Simulation Measures of Effectiveness

The study will extract key MOE from the simulation scenarios, including travel time, delay time, travel speed, and queue length (when needed) for the overall network, O-D paths, and critical locations. Comparisons will be made among the design alternatives using the MOE data. To extract the selected MOE data from VISSIM, several data collection elements were placed within the simulation scenarios. The data collection started 10 minutes into the simulation and was gathered every 5 minutes until the simulation was complete. In addition, the MOE comparisons among the simulation scenarios will be based on averaging the output of 30 runs for each scenario. It should also be noted that the 25th St. corridor will not undergo any geometric changes for the 2030 scenarios other than having 3 approach lanes for the eastbound approach (which currently has 2 lanes).

Several network-wide MOE are calculated automatically, such as travel time, delay time, number of stops, vehicles simulated, etc. However, several travel time, travel speed, and queue length data collections were incorporated. Travel time and delay time output were collected from traffic originating from the tri-level ramp, southeast ramp, or I-94 eastbound and arriving at either 25th St. or I-94 eastbound at the 25th St. overpass (Figure 5). It should be noted that the travel time and delay data information at 25th St. is based on vehicles traveling past the stopline of the eastbound approach. Speed data were also collected at several locations within the study area, which focused on the tri-level ramp, southeast ramp, and the I-94 weaving section (Figure 6).

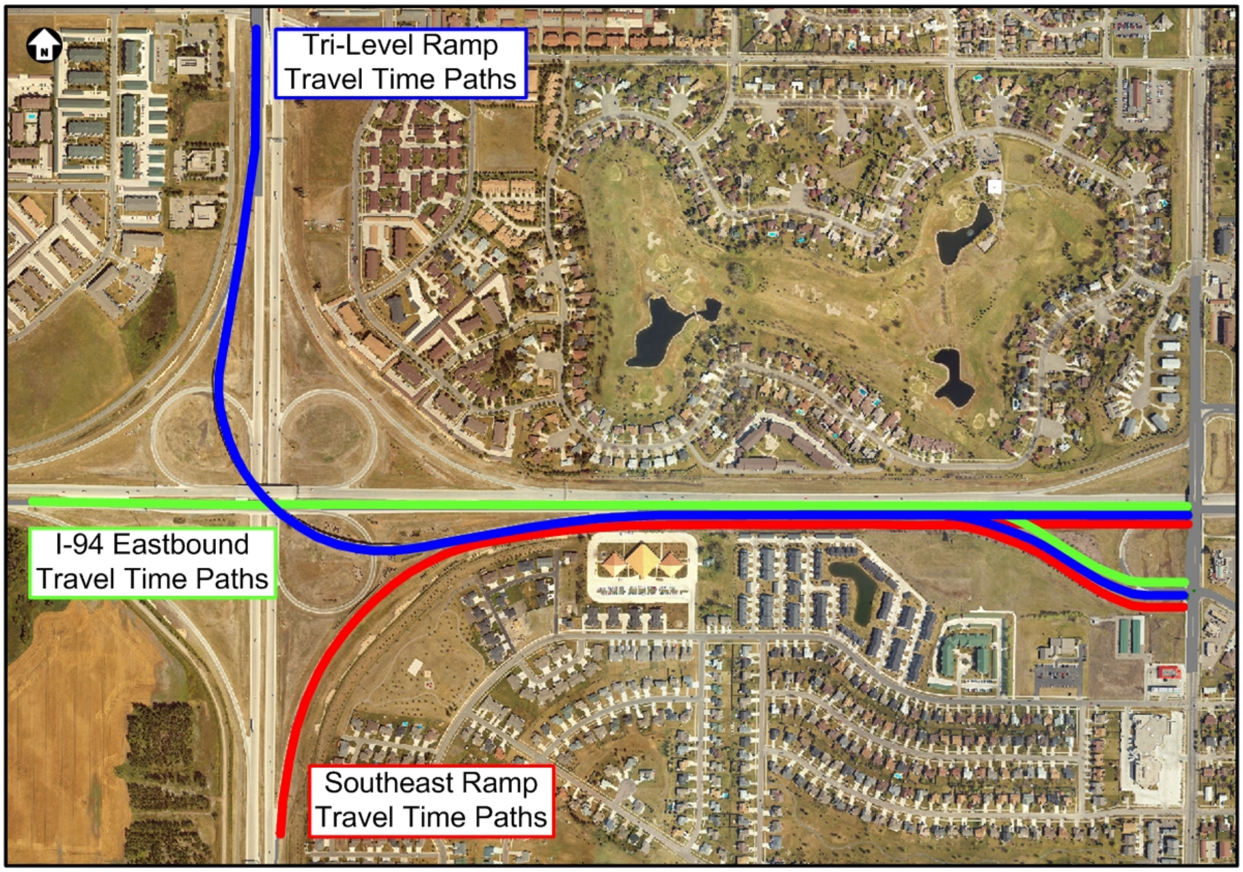

Figure 5. Origin-Destination Travel Time Paths

Queue length data were collected at the tri-level ramp. For the existing case, the queue detector (counter) was located prior to the merge area with the southeast ramp since this is where the queues initially develop. However, the queue detectors for Alternatives 2A and 2B were located where the tri-level ramp merges from two lanes to one lane since this is where queues can develop for these scenarios (Figure 6). VISSIM also allows users to define when a vehicle is in a queued condition. For this study, a vehicle will be considered queued when it starts traveling slower than 15 mph and will remain queued until it travels faster than 30 mph.

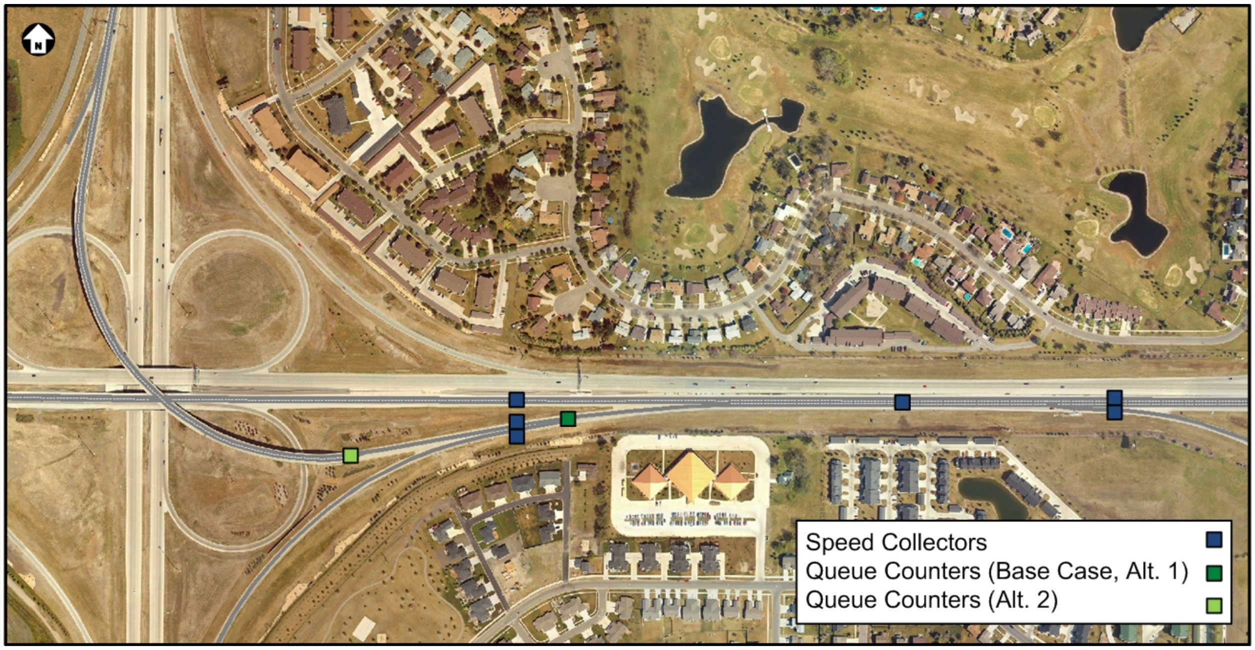

Figure 6. Speed and Queue Length Data Collection Locations in VISSIM Networks

ANALYSIS RESULTS

The simulation results were grouped into three main levels of detail, including network wide, O-D paths, and location specific. The network-wide MOE data provides a more general view of how the scenarios compare to the base case and each other, while travel time, speed, and queue length results provide more detail when comparing the alternative designs.

Network Delay Time

Total delay time data were compared among the alternatives for the existing traffic (2008) and the forecasted traffic (2030). For the existing traffic levels, adding capacity to either the tri-level ramp or southeast ramp provides significant benefits in terms of delay time. Compared to the existing conditions, having two tri-level ramp travel lanes (Alternatives 1A and 1B) reduced network delay by 26%, while incorporating an auxiliary lane for the southeast ramp (Alternatives 2A and 2B) reduced network delay by 23% (Table 1).

The 2030 traffic conditions created significant congestion for the tri-level ramp that often extended past the network link's entry point. Therefore, the delay time for existing geometry at the tri-level ramp will significantly increase the network delay time. Alternatives 1A and 1B reduced network delay by 75% and 76%, respectively. Alternatives 2A and 2B reduced network delay by 70% and 71%, respectively. When comparing Alternative 1A (tri-level ramp capacity increase) to Alternative 2A (southeast ramp auxiliary lane), Alternative 1A had 17% less total delay time (15.0 vehicle-hours).

Incorporating a double off-ramp at 25th St. created additional benefits for alternative groups 1 and 2. Alternative 1B had 4.3 hours less delay time than Alternative 1A, which is a reduction of

6%. Alternative 2B had 3.1 hours less delay time than Alternative 2A, which is a reduction of approximately 4%.

Table 1. Total Network Delay Time Results.

		2008 Traffic	2030 Traffic
Simulation Scenario		**Total delay Time [h]**	**Total delay Time [h]**
Base Case	Value	46.9	283.1
	% Change	-	-
Alternative 1A	Value	34.8	71.1
	% Change	-26%	-75%
Alternative 1B	Value	34.7	66.8
	% Change	-26%	-76%
Alternative 2A	Value	36.2	86.1
	% Change	-23%	-70%
Alternative 2B	Value	36.3	83.0
	% Change	-23%	-71%

Travel Time: Tri-Level Ramp Vehicle Paths

Travel time results were obtained from the three originating locations, which include the tri-level ramp, southeast ramp, and the I-94 eastbound mainline (prior to the weaving section). The destination of the travel time measurements were located at both 25th St. and the I-94 eastbound mainline at the 25th St. overpass. The tri-level ramp travel times for the existing geometry (2008 traffic) experience significantly higher values for about 30 minutes (Figure 7). Travel times to 25th St. for the uncongested periods were as low as 134 seconds, while the congested periods created travel times as high as 205 seconds. The existing geometry (2008 traffic) to I-94 eastbound followed a similar pattern but reported lower travel times since it is a shorter trip and doesn't have any traffic control devices (such as a traffic signal). Alternative 2A had the highest travel time results to 25th St. during the peak period, while Alternative 1B reported the lowest travel time results.

Since the tri-level ramp currently experiences traffic congestion, the 2030 traffic creates significant travel time increases for trips originating from this ramp. Travel times to 25th St. started at 198 seconds and increased to 575 seconds before subsiding to some degree (Figure 8). Alternative 2A generally reported the highest travel time results, while Alternative 1B reported the lowest travel time results.

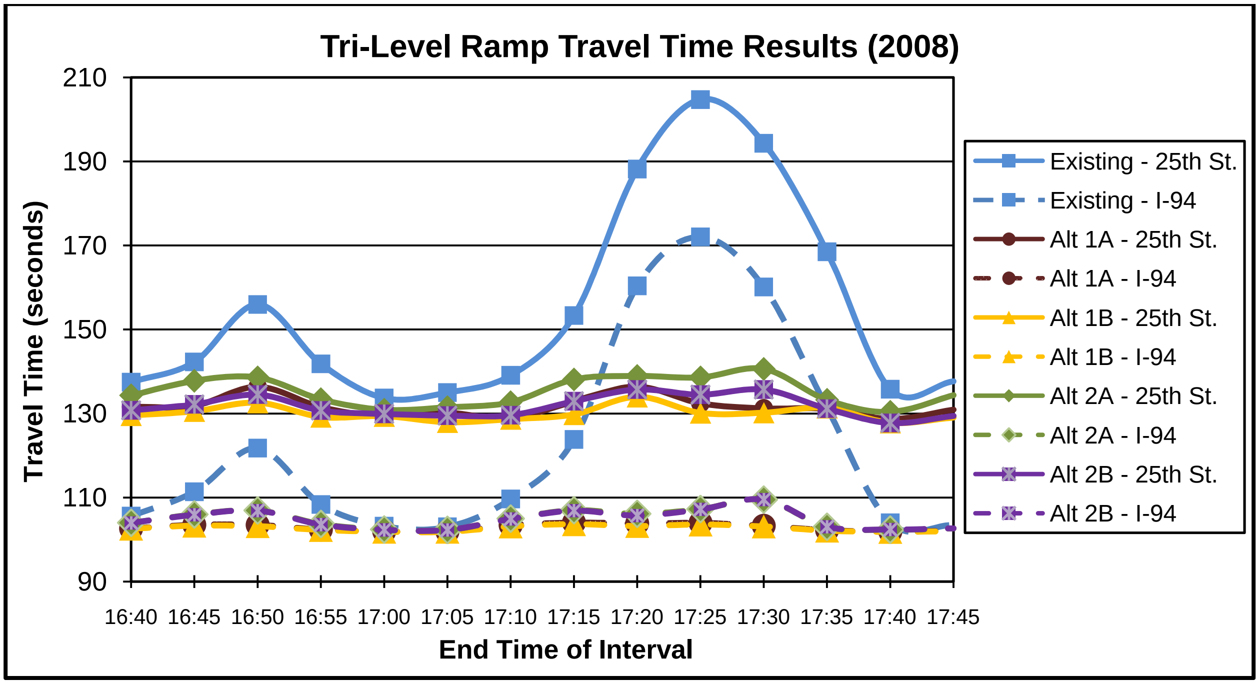

Figure 7. Travel Time Results from Tri-Level Ramp to 25th St. and I-94 Eastbound (2008)

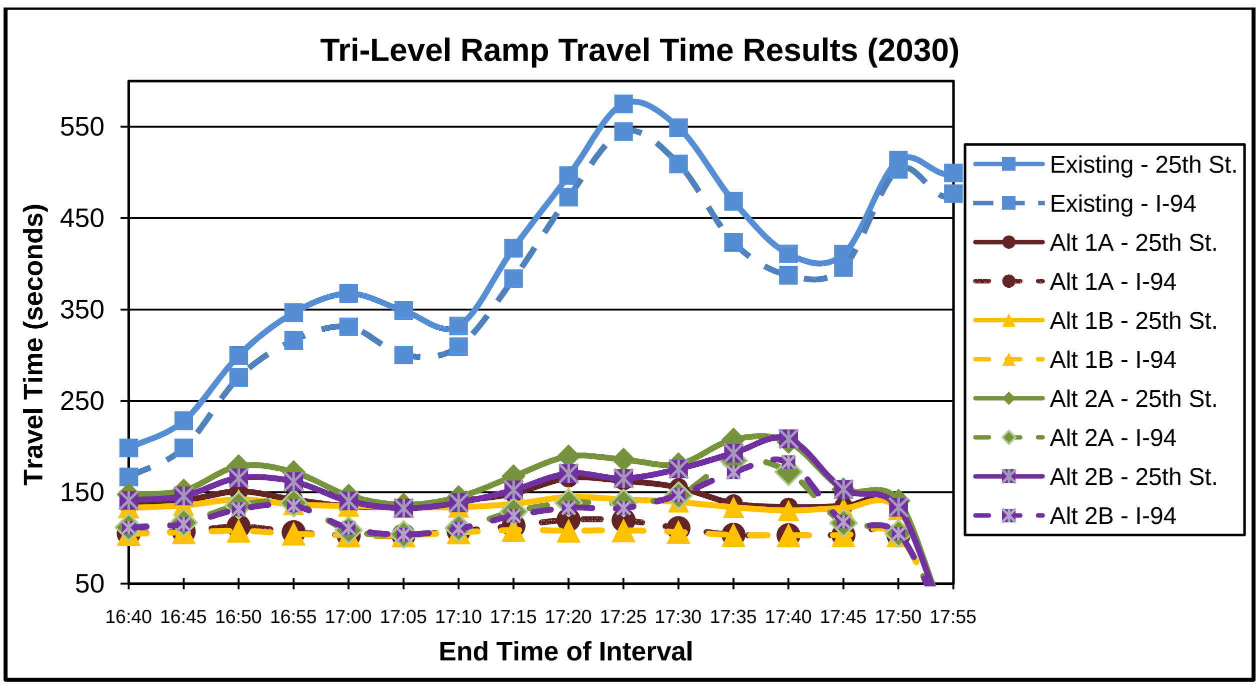

Figure 8. Travel Time Results from Tri-Level Ramp to 25th St. and I-94 Eastbound (2030)

Travel Time: Southeast Ramp Vehicle Paths

The southeast ramp travel time results displayed more variability among the time intervals. Since the existing traffic conditions and driving behavior don't create any significant queue lengths, the existing geometry is much closer to the alternative scenarios compared to the tri-level ramp travel time results (Figure 9). Alternative 2B performed slightly better than Alternative 1B for trips arriving at 25th St. All of the design alternatives provided very similar travel time results for trips continuing eastbound on I-94.

As expected, the 2030 traffic created higher travel time results for the southeast ramp. A somewhat unexpected result was observed with regards to Alternatives 1A and 2A having higher travel times than the existing geometry during the peak intervals within the peak hour (25th St. destination), as shown in Figure 10. This can be explained by the additional congestion within the weaving section created by the additional auxiliary lane while not having a double off-ramp at 25th St.   Alternative 1B and 2B generally reported the lowest travel time results for vehicles traveling to 25th St. and eastbound on I-94.

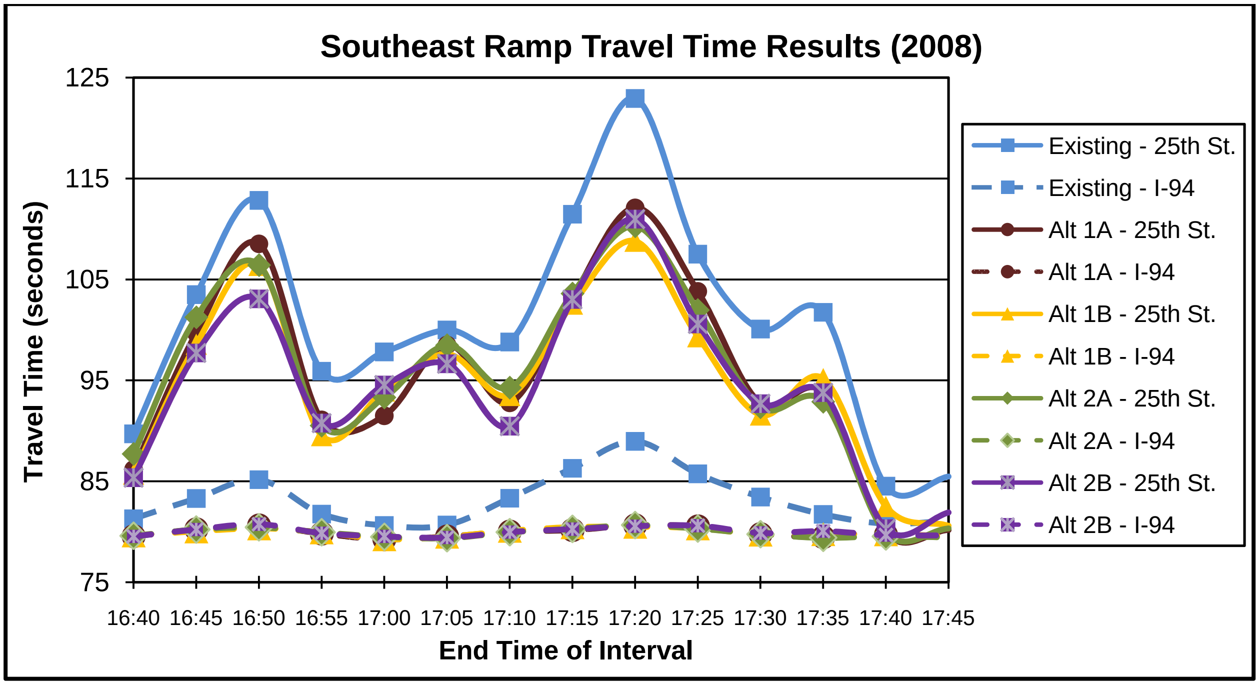

Figure 9. Travel Time Results from Southeast Ramp to 25th St. and I-94 Eastbound (2008)

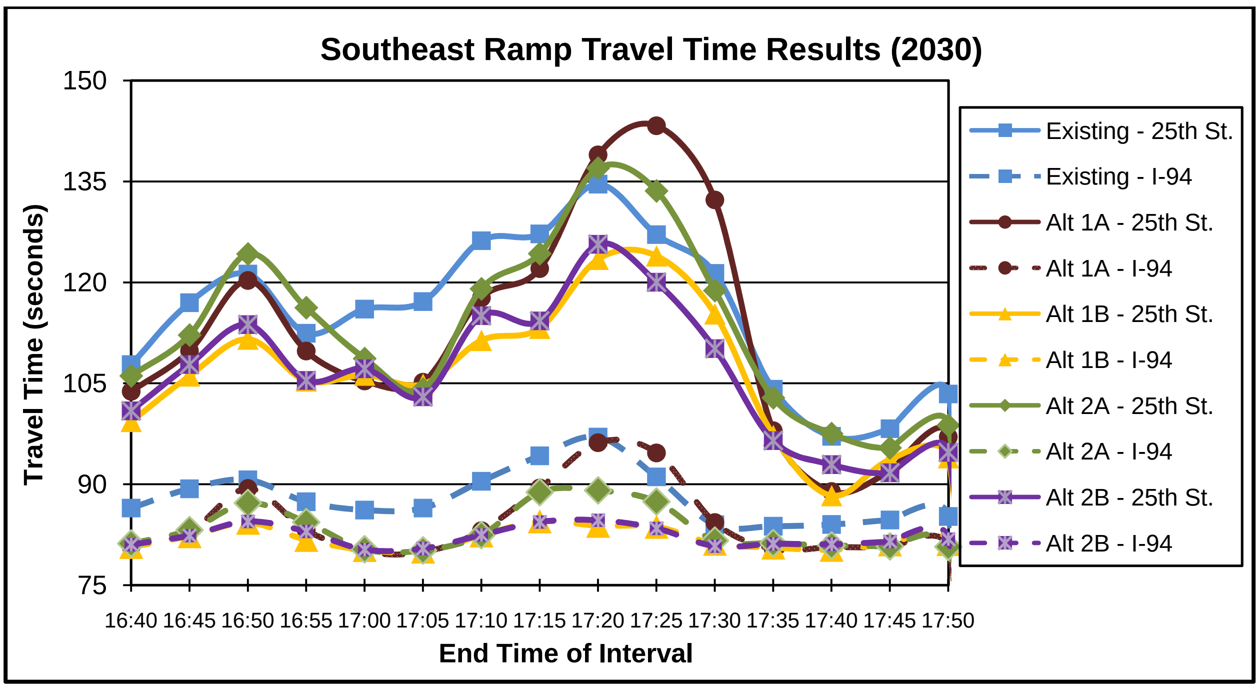

Figure 10. Travel Time Results from Southeast Ramp to 25th St. and I-94 Eastbound (2030)

Travel Time: I-94 Eastbound Vehicle Paths

The I-94 eastbound travel time results were similar for all of the alternatives using the 2008 traffic. Vehicles traveling from the west on I-94 to 25th St. reported travel times ranging from 104 seconds to 117 seconds (Figure 11). Alternatives 1B and 2B reported the lowest travel time results for vehicles traveling to 25th St. Vehicles proceeding on I-94 eastbound for all of the scenarios reported a travel time of approximately 79 seconds.

Similar to the southeast ramp travel time results using the 2030 traffic, Alternative 1A and 2A reported the highest travel times during the peak 15-20 minutes within the peak hour due to congestion that developed within the weaving section (Figure 12). In addition, Alternative 1B and 2B provided the lowest travel times for vehicles traveling to 25th St. and continuing eastbound on I-94.

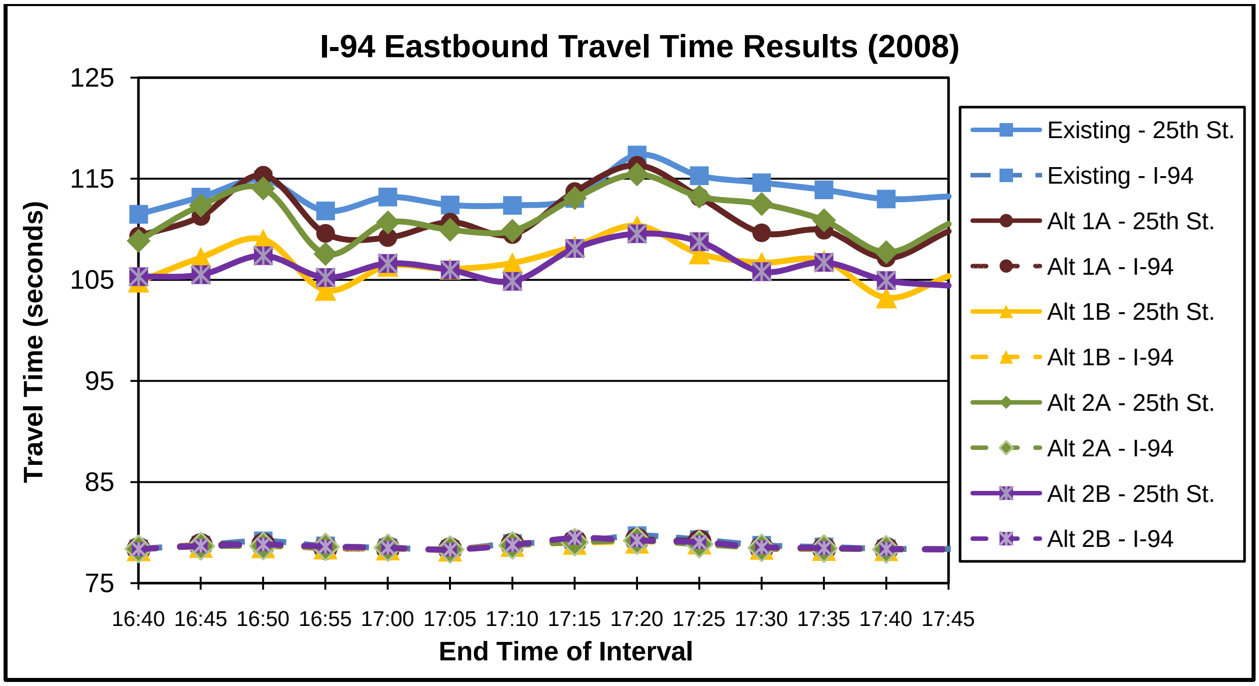

Figure 11. Travel Time Results from I-94 Eastbound to 25th St. and I-94 Eastbound (2008)

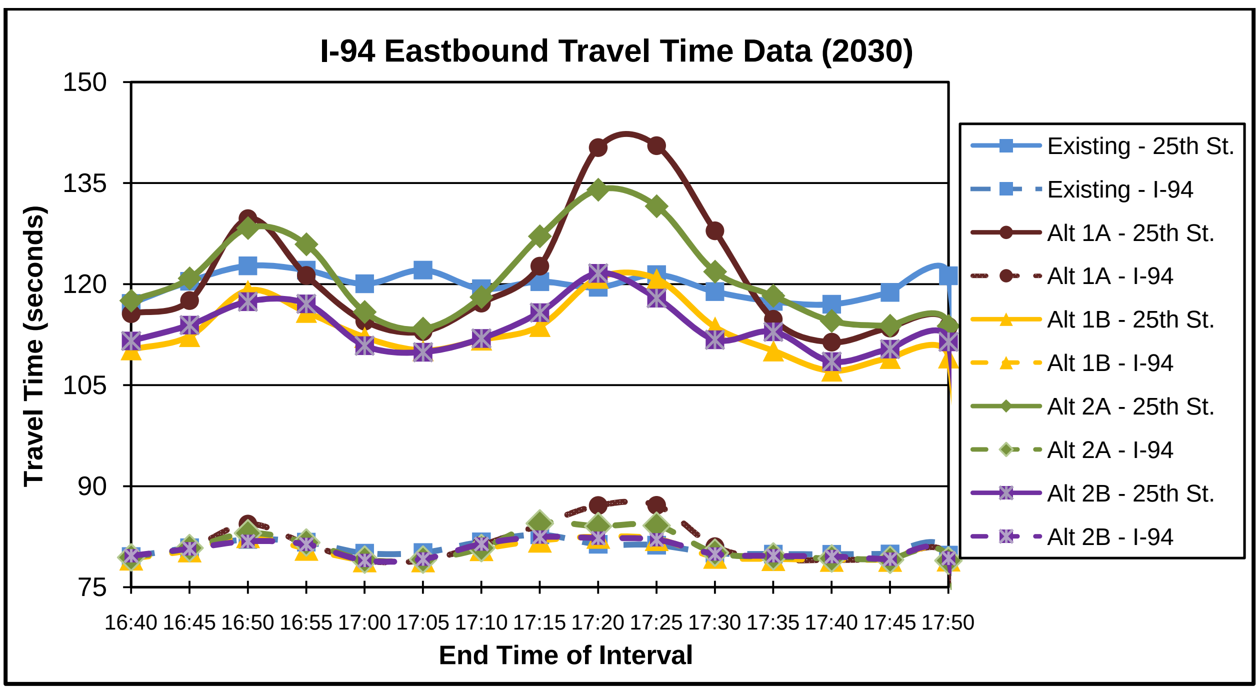

Figure 12. Time Results from I-94 Eastbound to 25th St. and I-94 Eastbound (2030)

Travel Speed: Tri-Level Ramp

Travel speeds were obtained at key locations within the simulation networks. Locations of the speed sensors included the tri-level ramp, southeast ramp, and the I-94 weaving section. Since the off ramp geometry at 25th St. should not impact travel speed at this location, the speed comparisons for the tri-level ramp and southeast ramp were based on Alternatives 1A and 2A. It should be noted that the speed sensor for the tri-level ramp was at the merge area of the southeast ramp. Therefore, speed reductions from the tri-level ramp merge (2 travel lanes to 1 travel lane) occurred several hundred feet upstream from this sensor.

The congestion currently occurring at the merge area of the tri-level ramp and the southeast ramp is reflected in the speed data. During the PM peak period, travel speeds are below 35 mph for about 15 minutes and drop below 25 mph for one 5-minute interval (Figure 13). Since all of the design alternatives provide additional capacity at this location, the travel speeds at the merge area should be close to the free-flow speed. Alternative 2A reported travel speeds that were approximately 2 mph lower than Alternative 1A.

The 2030 traffic conditions adversely affected the existing geometry for most of the simulation duration. Travel speeds were below 30 mph for a significant portion of the analysis period and never reached the free-flow speed (Figure 14). Alternative 2A reported lower speeds than Alternative 1A for most of the analysis period. Alternative 1A observed speed decreases for a 10-minute period, which is primarily based on congestion created at the downstream weaving section.

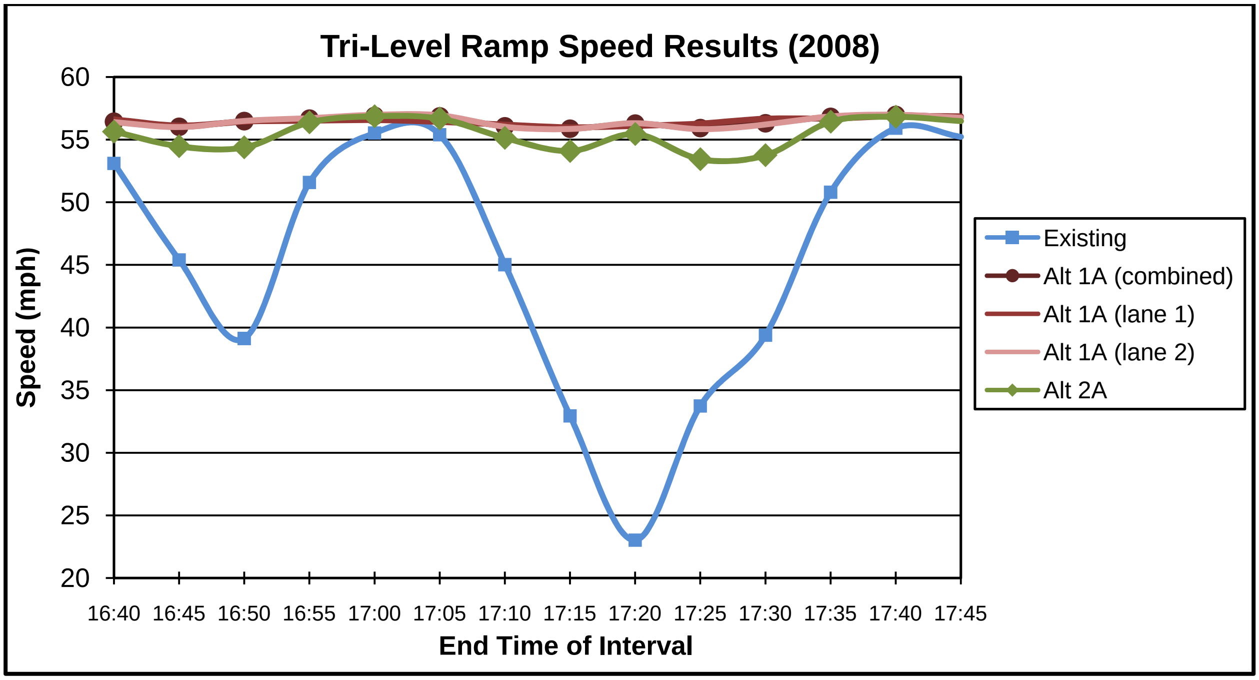

Figure 13. Tri-Level Ramp Speed Results (2008)

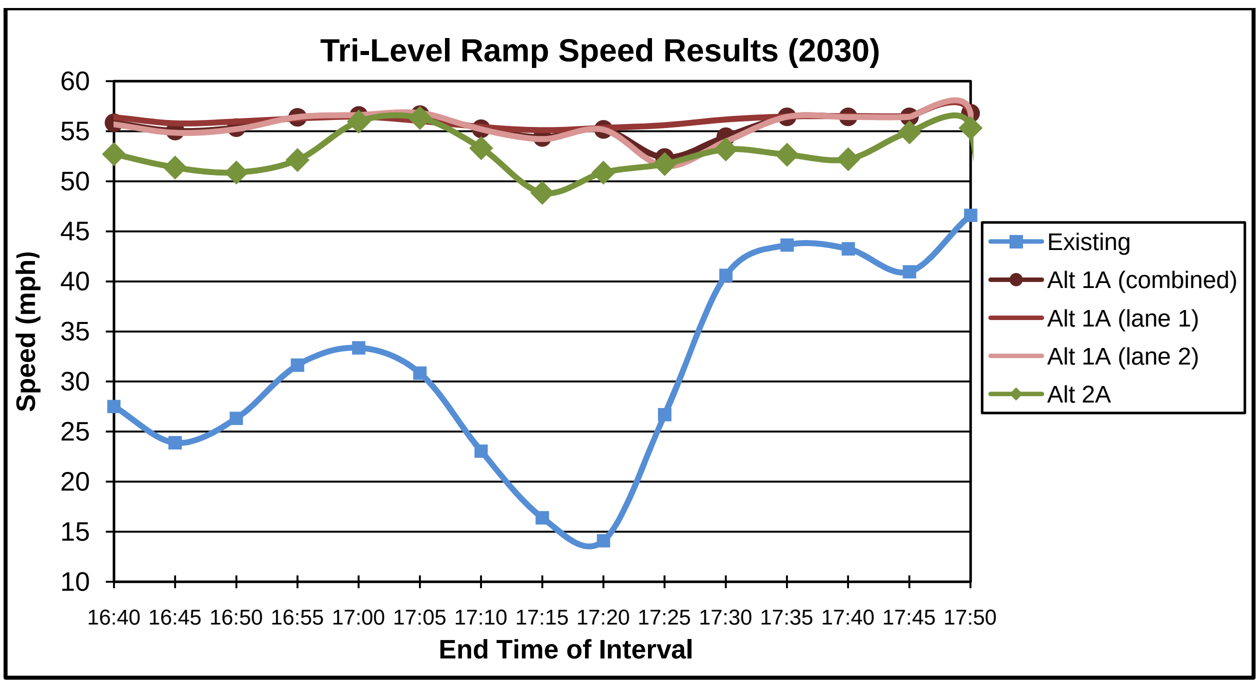

Figure 14. Tri-Level Ramp Speed Results (2030)

Travel Speed: Southeast Ramp

Travel speeds for the southeast ramp under the existing geometric conditions (2008 traffic) were somewhat lower than the free-flow speed due to the merge area with the tri-level ramp. Both Alternative 1A and 2A produced speed output that replicated the free-flow conditions (Figure 15). Alternative 2A achieved slightly higher speeds since this alternative does not require the southeast ramp traffic to merge with the tri-level ramp traffic.

The existing geometric conditions reported additional decreases in travel speed when using the forecasted traffic (2030). Travel speed decreased below 40 mph for about a 10-minute period within the peak hour (Figure 16). No decrease in travel speed was observed for Alternative 1A or 2A.

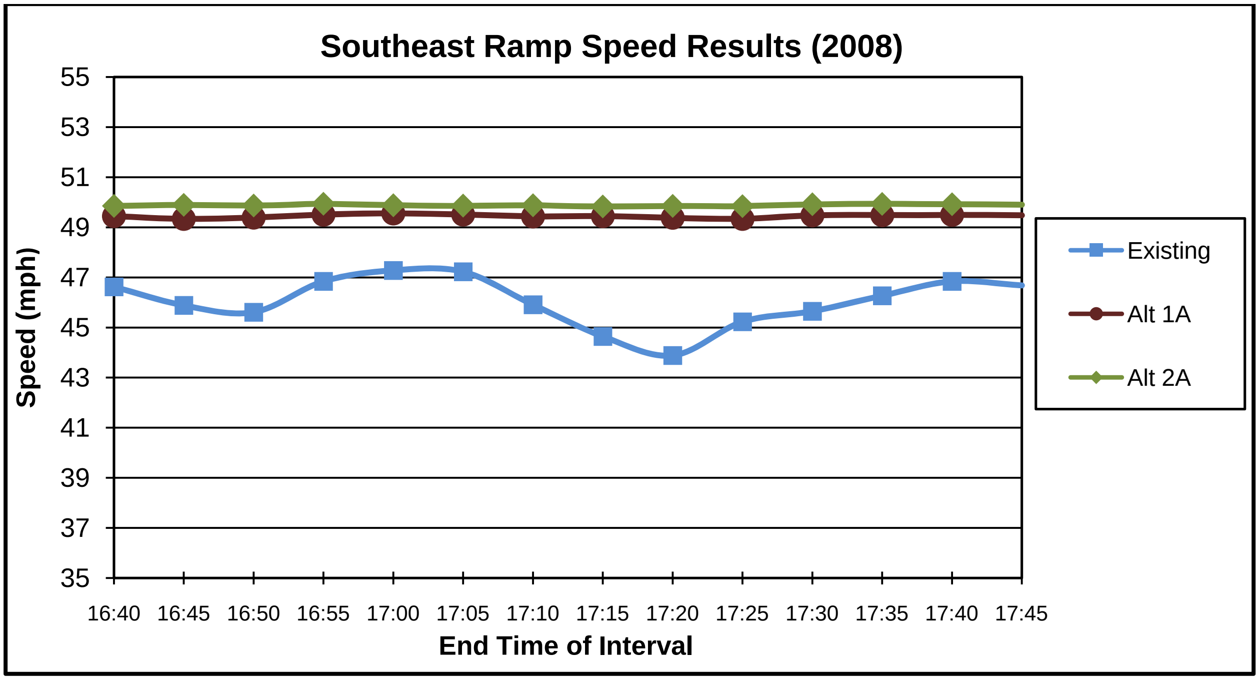

Figure 15. Southeast Ramp Speed Results (2008)

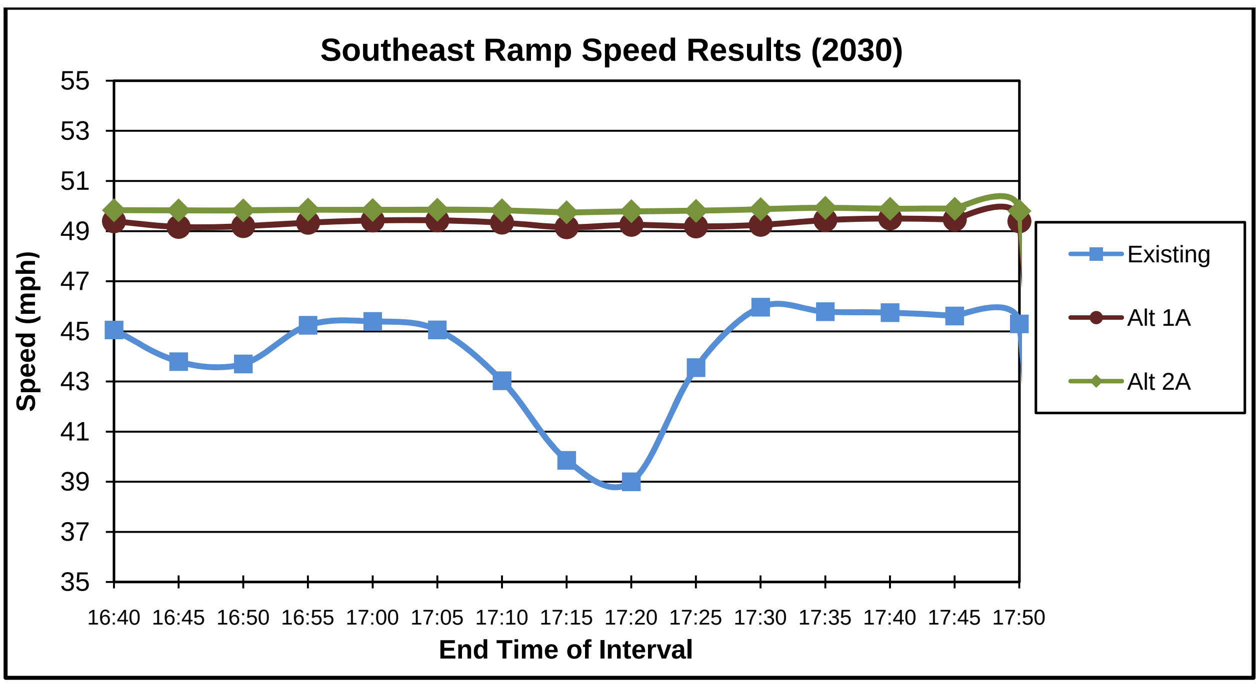

Figure 16. Southeast Ramp Speed Results (2030)

Travel Speed: I-94 Weaving Section

The weaving section of I-94 reported some slight speed decreases for all of the alternatives during the peak intervals within the peak-hour period using the 2008 traffic (Figure 17). The design alternatives reported higher speed data than the existing geometric conditions; however, all of the scenarios report speeds that were very close to the free-flow speed.

The 2030 traffic conditions reported significant speed reductions for a few of the design alternatives. Alternative 1A and 2A reported travel speed as low as 46 mph and 51 mph, respectively (Figure 18). This occurrence points out the benefit of having a double off-ramp at 25th St. (when incorporating an auxiliary lane) to reduce some of the weaving within this freeway section. During the peak intervals within the peak hour, the existing geometry reported slightly higher travel speed than the design alternatives. Alternatives 1B and 2B provided the highest travel speeds of the design alternatives.

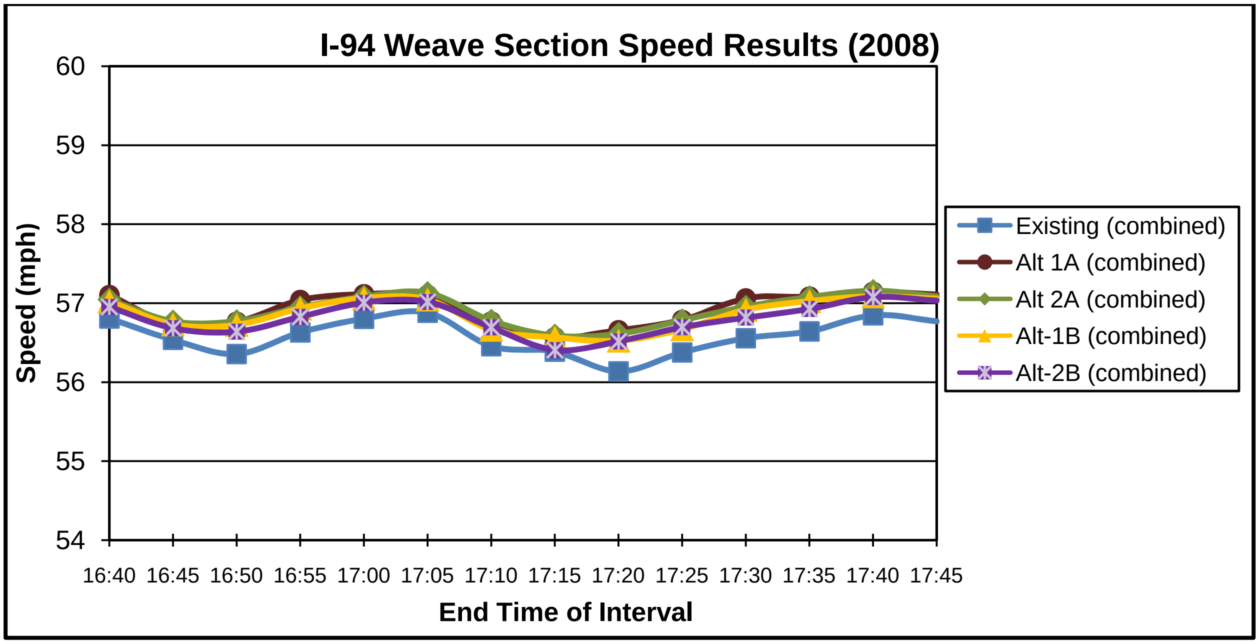

Figure 17. I-94 Weaving Section Speed Results (2008)

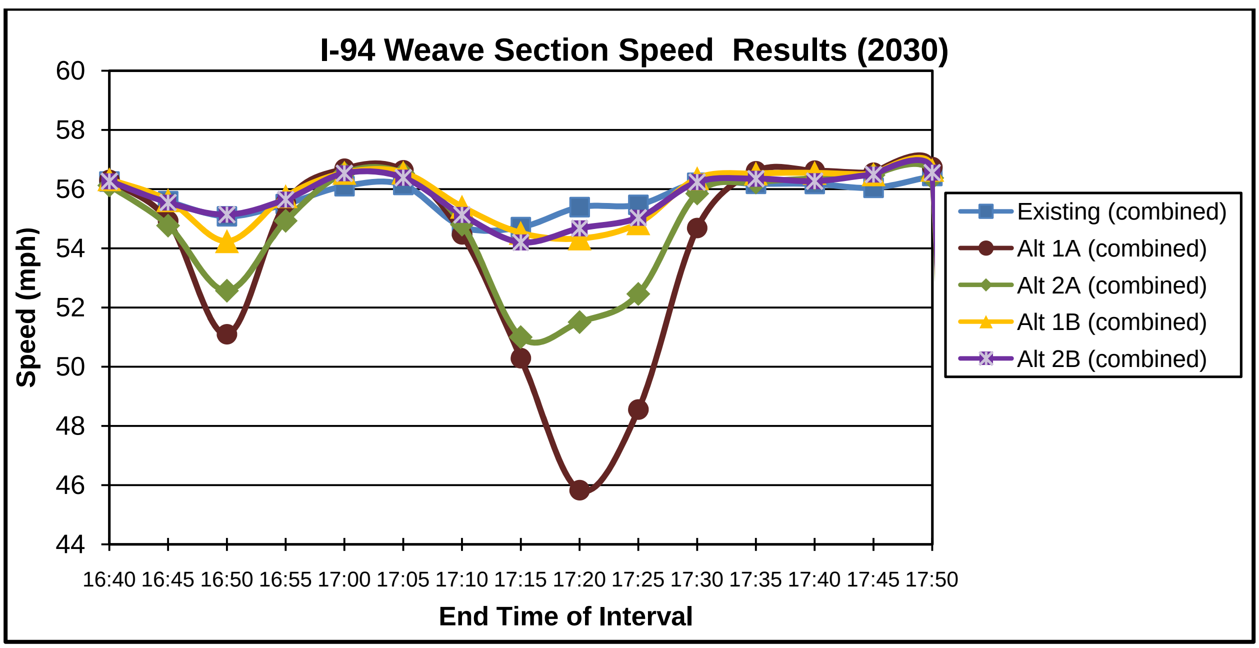

Figure 18. I-94 Weaving Section Speed Results (2030)

Delay Time: Origin-Destination Paths

To summarize the travel time and speed data, the delay time from the traffic originating at the tri-level ramp, southeast ramp, and I-94 eastbound (prior to the weaving section) and travel to 25th St. or I-94 eastbound at 25th St. were summarized for both the 2008 and 2030 traffic conditions. The base case (2008 traffic) has significantly more delay time for trips originating from the tri-level ramp compared to the other design alternatives, while having only slightly higher delay time for the southeast ramp and I-94 eastbound origins (Table 2). The design alternatives significantly reduce the delay time for the tri-level ramp and southeast ramp. Alternative 1B produced the lowest total delay time of the design alternatives.

Table 2. Delay Time from Origins to 25th St./I-94 Eastbound (2008 Traffic).

Network Scenario	Tri-Level Ramp (hr)	Southeast Ramp (hr)	I-94 Eastbound (hr)	Total Delay Time (hr)
Base Case	14.0	1.1	2.3	17.4
Alternative 1A	3.3	0.7	2.2	6.1
Alternative 1B	3.1	0.6	2.1	5.8
Alternative 2A	4.4	0.6	2.2	7.2
Alternative 2B	4.3	0.6	2.1	7.0

The 2030 traffic conditions using the existing geometry observed significant traffic congestion at the tri-level ramp (Table 3). Alternatives 1A and 1B provide significant delay time improvements over Alternatives 2A and 2B, while also providing comparable delay time for the southeast ramp and I-94 eastbound. Alternative 1B provided the lowest total delay time for the three origins, which had 27% lower total delay than the next closest alternative (Alternative 1A).

Table 3. Delay Time from Origins to 25th St./I-94 Eastbound (2030 Traffic).

Network Scenario	Tri-Level Ramp (hr)	Southeast Ramp (hr)	I-94 Eastbound (hr)	Total Delay Time (hr)
Base Case	169.0	2.6	5.6	177.2
Alternative 1A	8.2	2.1	6.7	17.1
Alternative 1B	5.8	1.4	5.2	12.4
Alternative 2A	22.3	1.9	6.3	30.5
Alternative 2B	20.5	1.5	5.3	27.3

Queue Lengths: Tri-Level Ramp

The queue lengths were analyzed for the various geometric alternatives. Since Alternatives 1A and 1B provided increased capacity to the tri-level ramp, no queues developed for this facility. As previously discussed, vehicles were considered to be in a queue when their travel speed dropped below 15 mph and remained queued until it traveled faster than 30 mph. The maximum queue value represents the largest queue that occurred within the previous 5-minute period. Significant queues were observed for the base case for approximately a 25-minute period (Table 4). During this period, queue lengths ranged from 1,228 to 4,025 feet. Alternatives 2A and 2B reported almost identical queue lengths, ranging from 5 to 90 feet.

The 2030 traffic for the existing geometric conditions created significant queue lengths for the entire simulation duration (Table 4). The queue length continuously grew to the point where the tri-level link started (~6,300 feet from the queue counter). The traffic generation stopped at 5:45 p.m. for the 2030 traffic scenarios; however, another 15 minutes was required to clear the tri-level ramp queue for the existing geometry. Alternative 2A and 2B reported queue lengths as high as 2,392 and 2,548 feet, respectively.

Table 4. Tri-level Ramp Maximum Queue Length (2008 and 2030 Traffic).

	2008 Traffic			2030 Traffic		
	Existing	**Alt 2A**	**Alt 2B**	**Existing**	**Alt 2A**	**Alt 2B**
Interval End Time	Max Queue (ft)	Max Queue (ft)	Max Queue (ft)	Max Queue (ft)	Max Queue (ft)	Max Queue (ft)
4:40 PM	34	34	34	3,607	61	61
4:45 PM	470	49	49	5,119	462	407
4:50 PM	1,091	48	47	5,519	1,307	1,273
4:55 PM	183	19	19	5,416	821	735
5:00 PM	0	5	5	5,210	41	64
5:05 PM	3	20	20	5,076	21	21
5:10 PM	444	31	31	5,312	113	113
5:15 PM	1,318	56	56	5,689	891	915
5:20 PM	2,794	29	29	5,868	1,383	1,402
5:25 PM	4,025	74	74	6,237	1,990	1,881
5:30 PM	4,015	90	90	6,232	2,392	2,548
5:35 PM	1,228	21	21	6,228	1,522	1,146
5:40 PM	0	12	12	6,238	640	700
5:45 PM	4	31	31	6,233	126	99
5:50 PM	-	-	-	6,210	7	7
5:55 PM	-	-	-	4,835	0	0
6:00 PM	-	-	-	1,501	0	0

RECOMMENDATIONS

This study assessed the operational performance of several design alternatives using the existing PM peak-hour conditions (2008) and projected peak-hour conditions (2030). The analysis used the VISSIM traffic simulation model to evaluate network-wide, O-D path, and location-specific performance measures. The base case displays significant traffic congestion for a 20-25 minute portion of the peak period. Any of the design alternatives should alleviate this congestion; however, some of the alternatives performed worse than the existing geometry using the 2030 traffic.

Alternative 1B provided the greatest benefits to the analysis network and is recommended for implementation. If funding is an issue, a staged approach could be implemented. The key components of Alternative 1A (2 lane tri-level ramp and auxiliary lane to 25th St.) could be implemented in the near future, while the double exit at 25th St. and additional turning lane at the 25th St. approach could be implemented at a later date to satisfy Alternative 1B.

APPENDIX A:
Traffic Volume Data

PM Peak Hour Traffic Volume Data
Thursday, February 21, 2008

Peak Hr	Tri-level Ramp			SE Ramp			Tri-level & SE Ramp			I-94 EB @ Tri-level			25th St. Off Ramp			I-94 EB @ 25th St.		
Start time	**PC**	**TR**	**Total**	**PC**	**TR**	**Total**	**PC**	**TR**	**Total**	**PC**	**TR**	**Total**	**PC**	**TR**	**Total**	**PC**	**TR**	**Total**
4:35 PM	123	5	128	34	0	34	157	5	162	103	7	110	34	1	35	226	11	237
4:40 PM	142	7	149	35	5	40	177	12	189	149	5	154	53	1	54	273	16	289
4:45 PM	127	5	132	35	1	36	162	6	168	130	8	138	43	0	43	249	14	263
4:50 PM	99	3	102	30	2	32	129	5	134	113	3	116	38	2	40	204	6	210
4:55 PM	91	4	95	32	1	33	123	5	128	106	5	111	40	1	41	189	9	198
5:00 PM	103	3	106	36	1	37	139	4	143	118	1	119	47	0	47	210	5	215
5:05 PM	135	7	142	41	1	42	176	8	184	156	5	161	56	0	56	276	13	289
5:10 PM	132	7	139	53	0	53	185	7	192	145	7	152	48	0	48	282	14	296
5:15 PM	133	5	138	45	1	46	178	6	184	153	4	157	59	0	59	272	10	282
5:20 PM	149	7	156	30	0	30	179	7	186	122	5	127	65	0	65	236	12	248
5:25 PM	119	3	122	28	0	28	147	3	150	113	5	118	66	0	66	194	8	202
5:30 PM	103	4	107	21	4	25	124	8	132	108	7	115	46	0	46	186	15	201
Total	**1456**	**60**	**1516**	**420**	**16**	**436**	**1876**	**76**	**1952**	**1516**	**62**	**1578**	**595**	**5**	**600**	**2797**	**133**	**2930**

Highlighted cells represent peak 15-minute volume for tri-level ramp. PC = passenger cars, TR = vehicles with more than 2 axles