5.0 Field Evaluation Results

5.1 Travel Performance Data Analysis

This section presents the results of the field data collection and evaluation. Focused data collection efforts were targeted at gathering comprehensive traffic performance data for representative corridors during both the "with" and "without" study periods. Four primary study corridors were selected, as described in Section 4.0, and data was collected for periods corresponding with the times when the corridors were metered. The study corridors were metered in the following directions during the following time periods:

- I-494 Northbound (NB) p.m. peak,
- I-494 Southbound (SB) a.m. peak,
- I-35W Northbound a.m. peak,
- I-94 Eastbound (EB) p.m. peak,
- I-94 Westbound (WB) a.m. and p.m. peaks,
- I-35E Northbound p.m. peak, and
- I-35E Southbound a.m. peak.

Data collection methods included:

- Travel time runs to capture the speed, travel time, and travel time variability on the freeways, ramps, and adjacent parallel arterials;
- Traffic volume counts on freeways, ramps, and arterials; and
- Ramp delay studies to measure the delay imposed by the meters and the queue spillover effects onto the adjacent streets.

Table 5.1 summarizes the corridor travel time, travel time reliability, speed, mainline volume, ramp volume, and ramp travel time observed at the various study corridors during both the "with" and "without" periods.

5.1.1 Statistical Significance Tests

Before studying the impacts observed in the "with" and "without" periods, statistical analysis was conducted on the observed data to:

Table 5.1 Summary of Freeway and Ramp Evaluation Results

	I-494		I-35W	I-94			I-35E		Average Across All Corridors
	NB p.m.	**SB a.m.**	**NB a.m.**	**EB p.m.**	**WB a.m.**	**WB p.m.**	**NB p.m.**	**SB a.m.**	
Freeway Speed Average									
With (mph)	61.44	54.12	52.71	49.81	51.68	54.42	53.87	49.86	53.49
Without (mph)	53.95	42.73	50.66	44.45	44.02	45.45	50.32	37.03	46.08
Difference (%)	-12%	-21%	-4%	-11%	-15%	-16%	-7%	-26%	-14%
Difference (mph)	-7.50	-11.39	-2.05	-5.35	-7.66	-8.97	-3.55	-12.83	-7.41
Freeway Speed Standard Deviation[1]									
With (mph)	4.54	8.90	13.66	7.23	5.76	4.46	9.34	12.20	8.26
Without (mph)	5.99	16.25	16.50	9.70	8.88	8.08	7.53	12.68	10.70
Difference (%)	32%	82%	21%	34%	54%	81%	-19%	4%	36%
Difference (mph)	1.45	7.34	2.85	2.48	3.12	3.63	-1.80	0.47	2.44
Freeway Travel Time Average									
With (min)	8.8	10.4	7.4	14.8	14.1	13.3	8.1	9.1	10.77
Without (min)	10.1	15.3	8.2	17.4	17.1	16.4	8.6	12.7	13.22
Difference (%)	15%	47%	10%	18%	21%	23%	6%	40%	22%
Difference (min)	1.30	4.89	0.78	2.60	2.95	3.04	0.45	3.61	2.45
Freeway Travel Time Standard Deviation[1]									
With (min)	0.7	2.8	2.5	2.5	1.7	1.2	1.9	3.2	2.07
Without (min)	1.2	7.9	3.7	6.3	3.7	3.1	1.5	4.5	3.97
Difference (%)	64%	180%	46%	153%	114%	154%	-23%	41%	91%
Difference (min)	0.47	5.04	1.15	3.78	1.99	1.89	-0.42	1.30	1.90
Freeway Volume Average									
With	11,810	11,010	11,093	18,359	16,082	17,657	14,974	14,552	14,442
Without	11,840	10,047	10,042	17,386	15,284	16,437	12,165	12,140	13,168
Difference (%)	0%	-9%	-9%	-5%	-5%	-7%	-19%	-17%	-9%
Difference (veh)	30	-963	-1,051	-973	-798	-1,220	-2,809	-2,412	-1,275
Ramp Travel Time Average[2]									
Ramp Vol per Corr	6,872	7,659	7,526	23,099	20,898	26,010	7,844	7,486	13,424
With (min/veh)	4.0	3.1	3.3	1.6	1.8	3.3	1.4	2.5	2.6
Without (min/veh)	0.25	0.31	0.24	0.35	0.49	0.49	0.20	0.26	0.33
Difference (min/veh)	-3.7	-2.8	-3.1	-1.3	-1.3	-2.8	-1.2	-2.2	-2.3
Ramp Travel Time Standard Deviation[1,2]									
With (min/veh)	2.4	2.9	2.8	1.1	1.6	1.9	0.9	2.0	1.9
Without (min/veh)	0.03	0.16	0.11	0.13	0.11	0.09	0.03	0.09	0.09
Difference (min/veh)	-2.4	-2.7	-2.7	-1.0	-1.5	-1.8	-0.9	-1.9	-1.8

[1] Standard Deviation is defined as the measure of distribution of travel time around an average value.

[2] Ramp travel time consists of time it takes to travel the length of the ramp, meter delay time, and queue delay time.

- Identify any anomalies in the data that may introduce bias into the analysis of travel conditions; and

- Identify the statistical significance of differences observed in the "with" and "without" study periods.

Statistical Analysis of Field Conditions

Statistical tests were conducted on all data to identify any external factors that might introduce bias to the data. During the data collection for both the "with" and "without" study periods, all data collected on Mondays, Fridays, bad weather days (rain, snow), major incident days, and "dark" versus "light" conditions were flagged. Statistical significance tests ("t-tests") were then applied to the data to determine if these external factors resulted in data that were significantly different from other collected data.

Table 5.2 summarizes the results of the t-tests for all study corridors. Statistically significant data sets are shown in *italics*. In most instances, the variability in days of the week, weather, sunlight, or incidents were not statistically significant from each other to warrant separate analysis of the data. Therefore, all valid observations were grouped and analyzed together throughout this study.

Table 5.2 Field Condition T-Test Results Across All Corridors

Comparison	Travel Time	Speed
Tuesday-Thursday vs. Monday	1.11	1.72
Tuesday-Thursday vs. Friday	1.33	1.26
Monday vs. Friday	0.19	0.37
Light vs. Dark	1.64	0.54
Dry vs. Wet	1.95	*3.35*
Incidents vs. Not	*3.47*	*3.85*

Note: Statistically significant differences in *italics*.

Statistical Analysis Between "With" and "Without" Meter Study Periods

Once the data was categorized and grouped, another t-test procedure was performed on the "with" and "without" data sets to determine whether or not the observed data statistically supports the hypothesis that ramp metering makes a significant impact on travel speeds and traffic volume.

Table 5.3 summarizes the comparisons between "with" and "without" data sets. Except for a few isolated instances, statistically significant differences were observed in speed and volume on all study corridors.

Table 5.3 "With" Versus "Without" T-Test Results

	I-494		I-35W	I-94			I-35E		
With vs. Without t-test	**NB p.m.**	**SB a.m.**	**NB a.m.**	**EB p.m.**	**WB a.m.**	**WB p.m.**	**NB p.m.**	**SB a.m.**	**All Corridors**
Speeds	*8.07*	*4.25*	1.55	*5.86*	*4.65*	*7.14*	*2.47*	*5.94*	*4.99*
Volumes	0.82	*5.69*	*4.62*	*2.71*	*2.33*	*3.99*	*18.33*	*21.16*	*7.46*

Note: Statistically significant differences in *italics*.
EB = Eastbound, NB = Northbound, SB = Southbound, and WB = westbound.

5.2 Travel Performance Results

5.2.1 Travel Time and Travel Speed

Once the statistical significance of the data sets were confirmed, detailed analysis was conducted to identify the impacts (both positive and negative) attributable to the ramp metering system.

Freeway mainline travel times were observed to be lower in the "with metering" study period for all study corridors and directions. On average, mainline travel time was 22 percent or 2.5 minutes less with metering. The highest travel time improvement occurred on I-494 SB in the a.m. peak period, improving from 15.3 minutes (without metering) to 10.4 minutes (with metering).

Without metering, the reliability of travel time was also observed to decrease by an average of 91 percent as reflected by an increase in the range of travel time. This finding was supported by observations of highway patrol personnel who reported an increase in the duration of accidents due to longer time required for emergency personnel to access the scene of the accidents. The highest travel time reliability percentage increase occurred on the I-494 SB a.m. peak period corridor (increasing from 2.8 to 7.9 minutes), I-94 WB p.m. peak period corridor (increasing from 1.2 to 3.1 minutes), and I-94 EB p.m. peak period corridor (increasing from 2.5 to 6.3 minutes).

Similarly, travel speeds on the freeway mainlines improved with metering by an average of 14 percent or 7.4 miles per hour (mph). The largest speed improvement was observed on southbound I-35E and I-494 during the a.m. peak period (26 percent or 12.8 mph, and 21 percent or 11.4 mph, respectively). I-35W NB a.m. and I-35E NB p.m. showed the least amount of speed improvements (only four percent and seven percent, respectively).

Figures 5.1 through 5.8 illustrate the travel speeds observed on the study corridors for all weekdays. Appendix B contains travel speed results categorized by the different days of the week. The solid lines indicate average speeds, while the dashed lines represent the

Figure 5.1 I-494 NB Afternoon Speed and Speed Variability

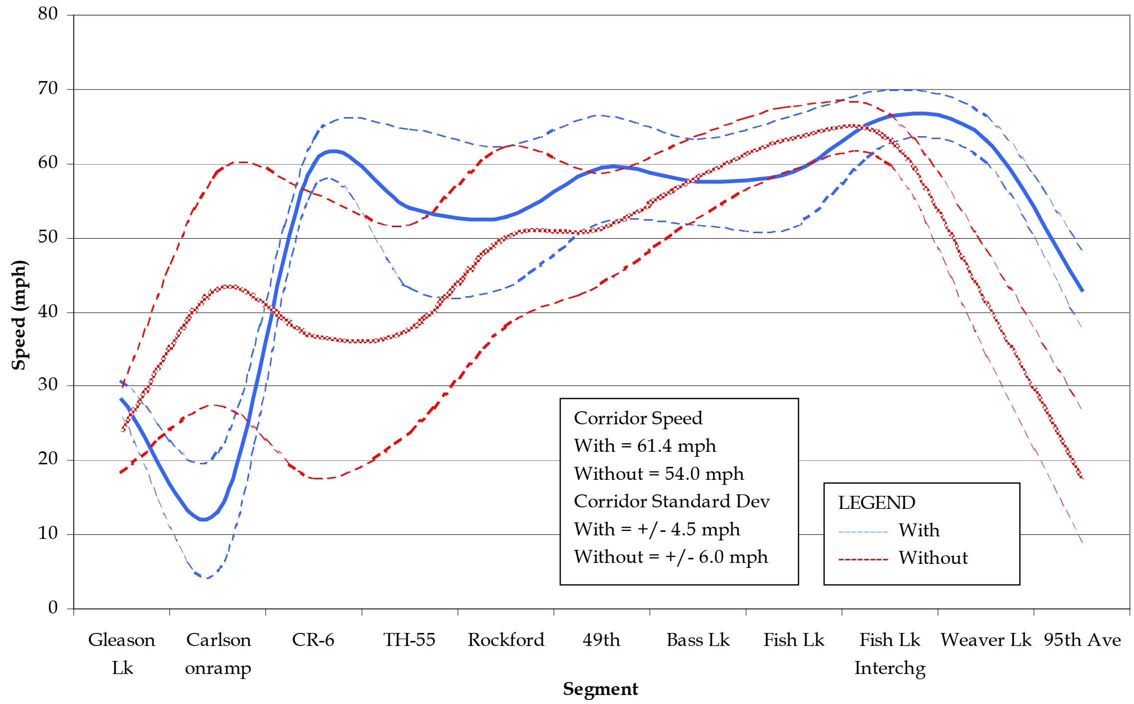


Figure 5.2 I-494 SB Morning Speed and Speed Variability

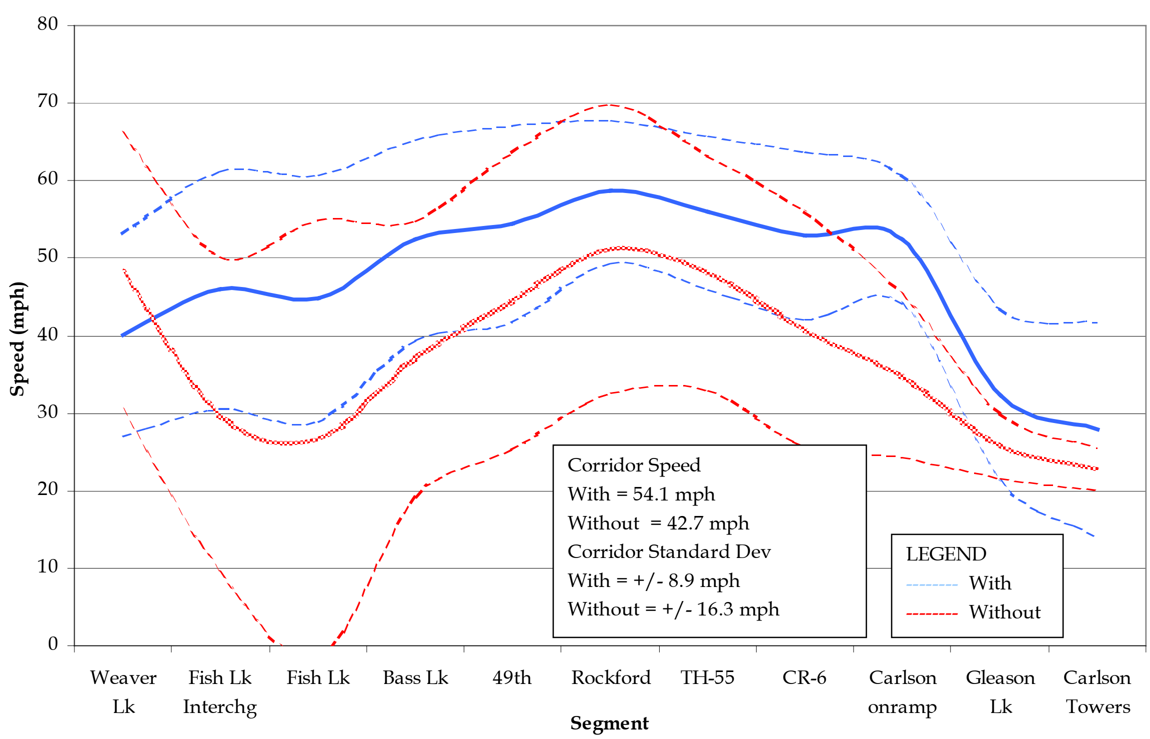


Figure 5.3 I-35W NB Morning Speed and Speed Variability

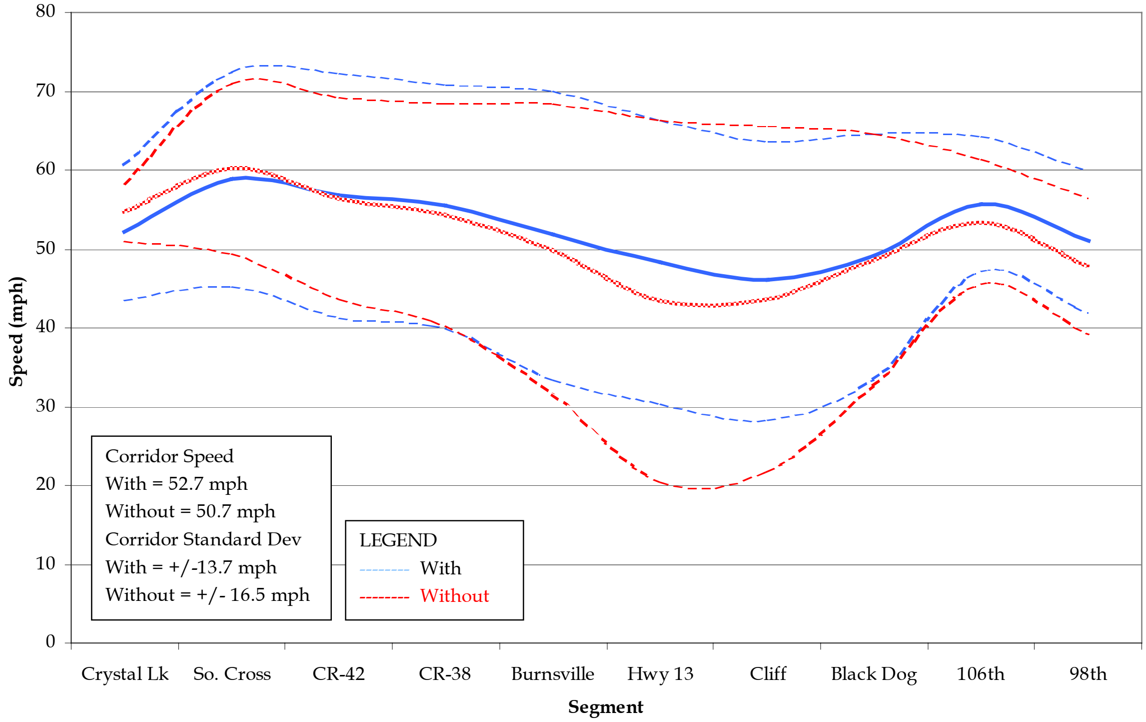


Figure 5.4 I-94 EB Afternoon Speed and Speed Variability

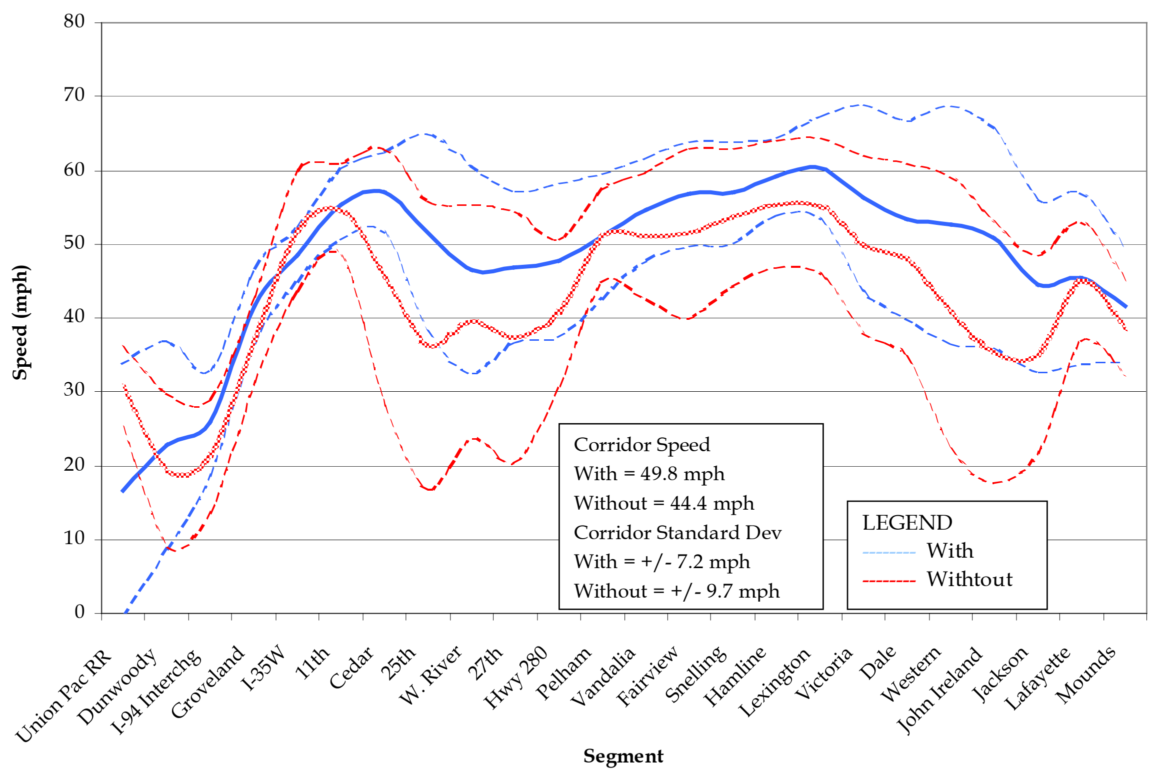


Figure 5.5 I-94 WB Morning Speed and Speed Variability

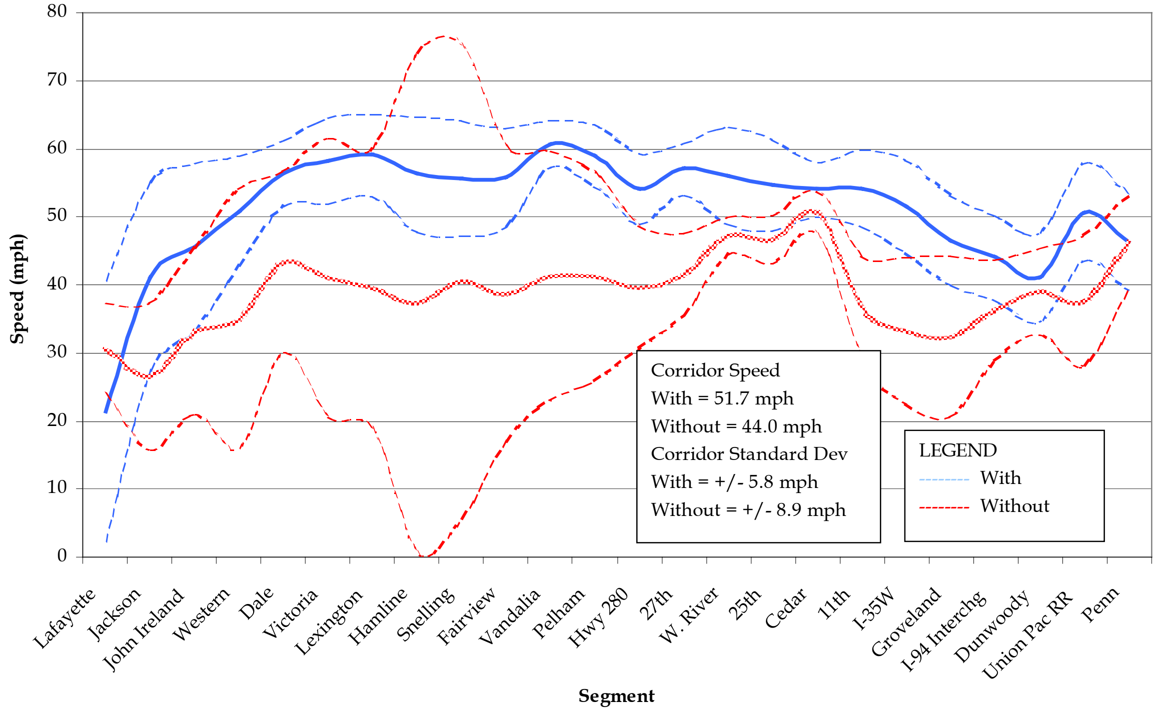


Figure 5.6 I-94 WB Afternoon Speed and Speed Variability

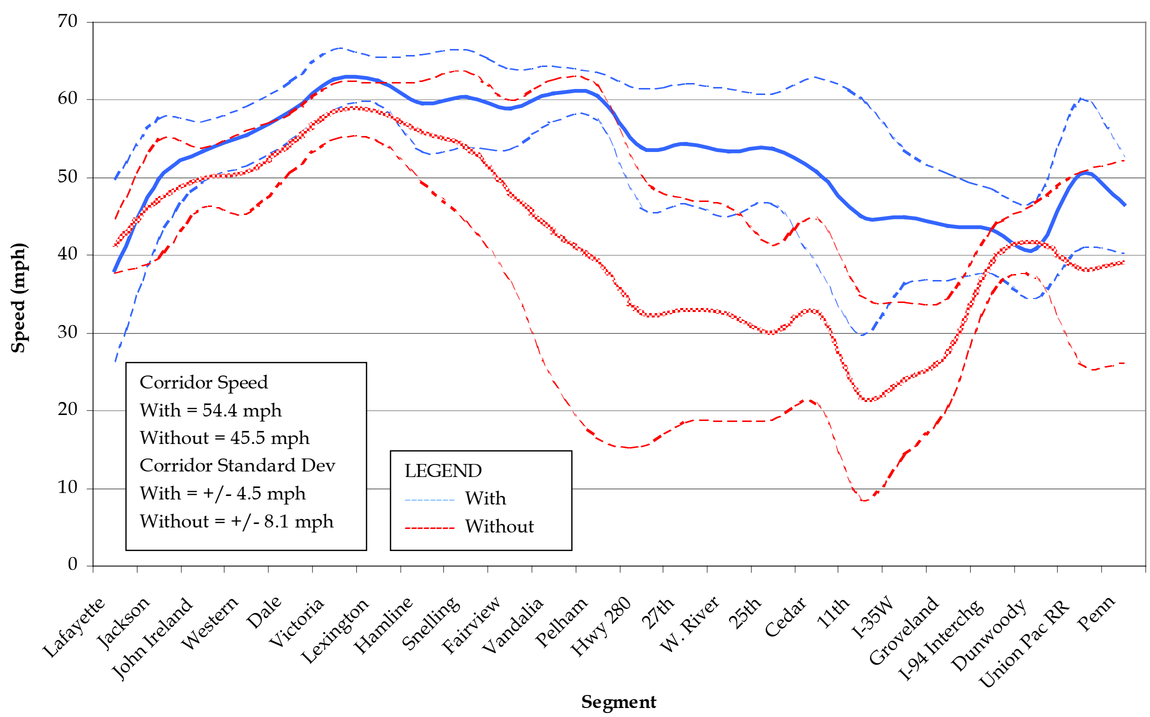


Figure 5.7 I-35E NB Afternoon Speed and Speed Variability

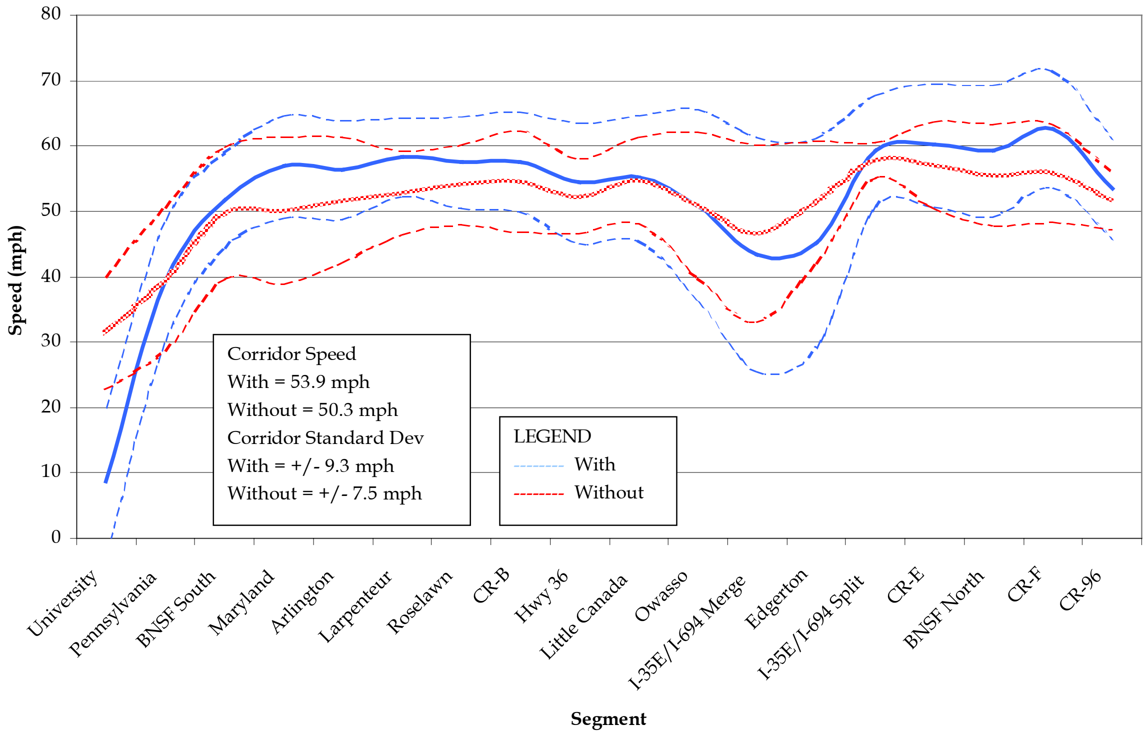
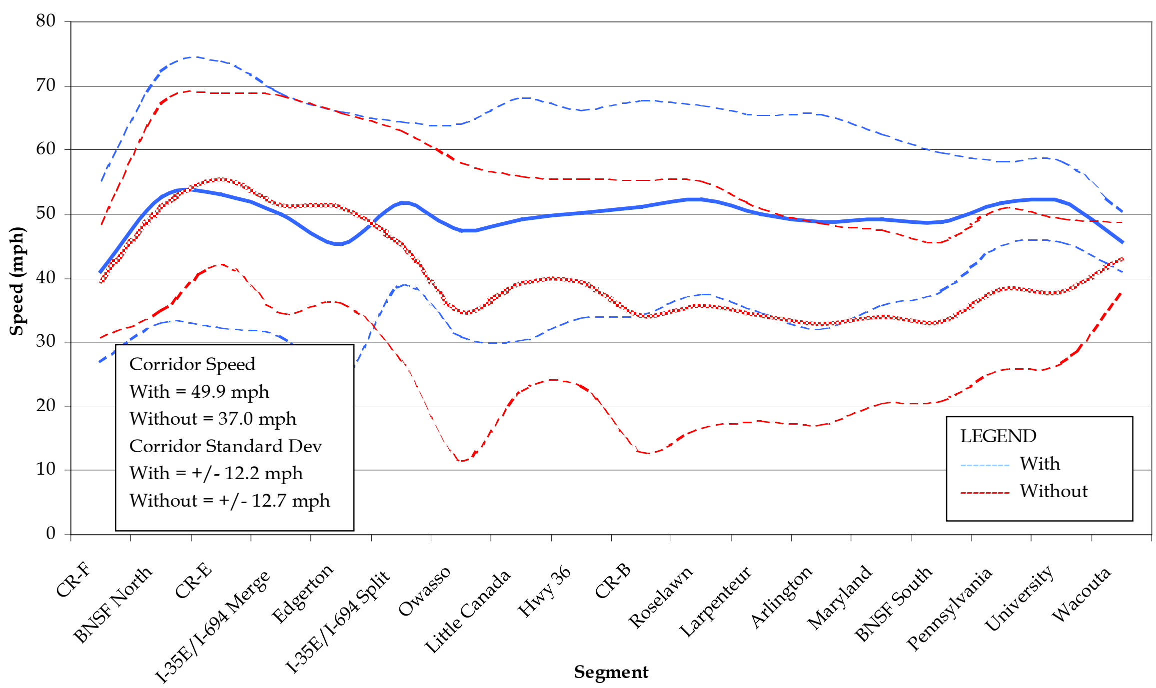


Figure 5.8 I-35E SB Morning Speed



upper and lower ranges of the average speeds. In this report, the range is defined as one standard deviation above and below the average value, which covers approximately 70 percent of all observations (blue lines represent the "with" study period, red lines represent the "without" study period). The larger the distance between a solid line and its corresponding dashed lines, the larger the speed variability observed (i.e., travel time is less reliable). Conversely, tighter sets of lines indicate that the speeds do not deviate as greatly from the average, and travel speed is more predictable.

Figure 5.9 illustrates the relationship between speed and throughput as recorded by a station detector on I-94 EB p.m. The lower chart shows that speed was consistently lower in the "without" period (red line) than the "with" period (green line). The jaggedness of the red line also indicates that the speed variability was increased in the absence of ramp meters. Although not as dramatic as the speed difference, the freeway traffic flow (volume) during the metered condition was also generally higher than its non-metered counterpart.

In general, parallel arterial speeds stayed the same "with" and "without" metering. Table 5.4 summarizes the changes in speeds and their standard deviations at selected arterials paralleling the study corridors. The speed stability in the two study periods may be attributed to the fact that traffic signals control many of the intersections along the arterials; unless there are significant changes in arterial volumes that cause gridlock at intersections, speeds along the arterials would be expected to remain relatively unchanged.

According to the traffic volume analysis presented in the next section, there were no changes in traffic volumes on the arterials segments of sufficient magnitude to cause the failure of arterial signal systems or a significant degradation of travel time. Figures 5.10 and 5.11 illustrate examples of travel speeds along CR-61 NB p.m. and Vicksburg NB p.m., arterials that parallel the I-494 study corridor. Appendix B shows the remainder of the arterial speed figures.

5.2.2 Freeway Traffic Volume and Throughput

With the meters off, a peak period volume traffic reduction of about nine percent was observed for all study corridors, or approximately 1,200 vehicles per corridor. The largest volume reduction was observed on I-35E NB p.m. (2,800 vehicles), while I-494 NB p.m. experienced virtually no changes in traffic volumes. There was minimal traffic diversion onto the studied parallel arterials due to the shutdown. In fact, an average decrease of 56 vehicles per studied parallel arterial was observed in the "without" period (refer to Table 5.4 for details). The observed reduction in traffic volumes in the "without" study period supports the notion that ramp metering results in greater throughput capacity on freeway facilities.

Figures 5.12 through 5.19 show the traffic volume differences at the freeway corridors, as well as their corresponding parallel arterials. Larger circles represent higher volume differences between the metered and non-metered conditions. For the actual traffic volumes at all corridors and arterials, refer to Appendix C.

Figure 5.9 Detector Reading – Example of Changes to Speed and Speed Variability

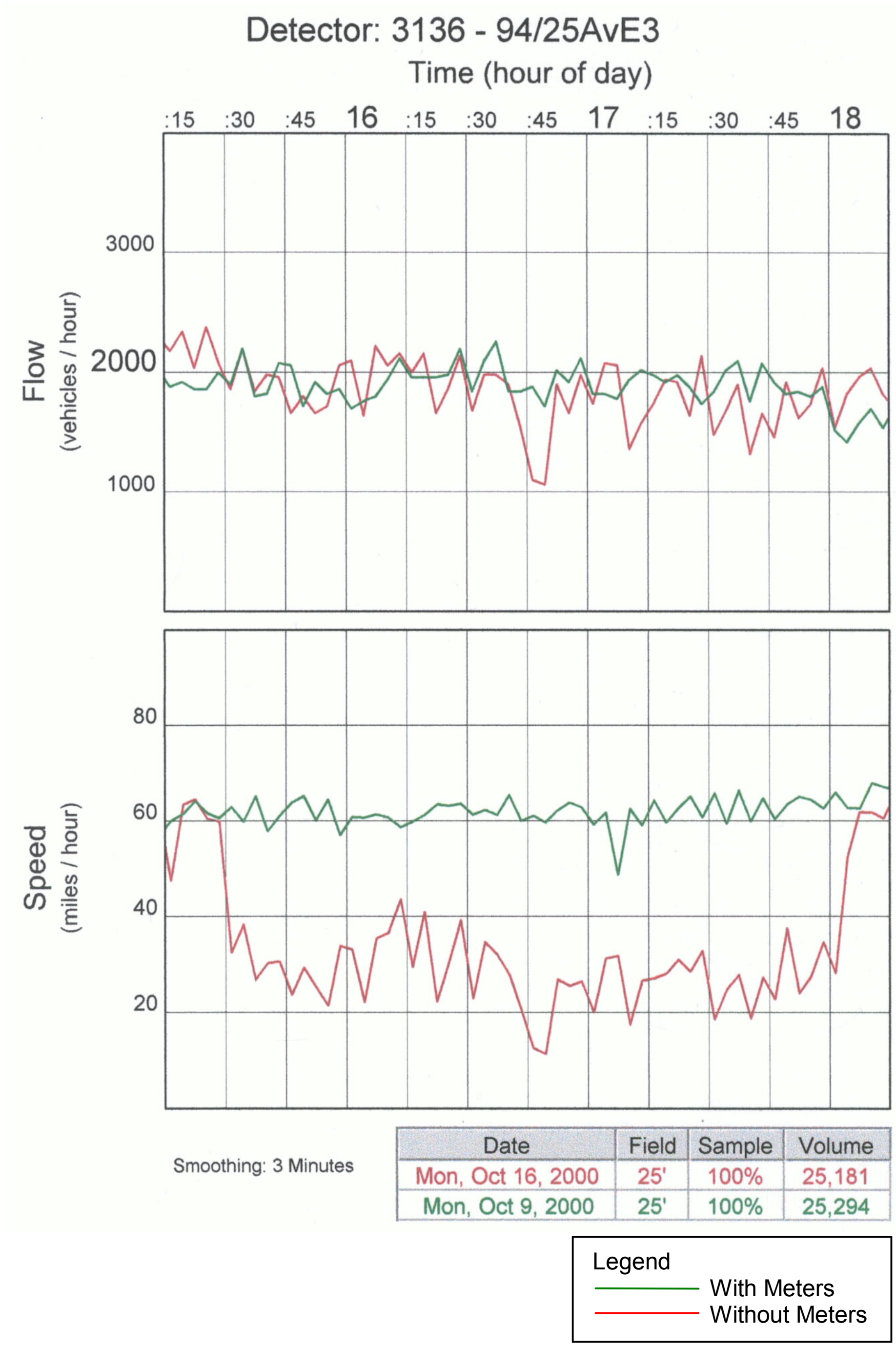


Table 5.4 Summary of Arterial Evaluation Results

	CR-61		Vicksburg		TH-77	University			Marshall			Rice		Edgerton		All Arterials
	NB p.m.	SB a.m.	NB p.m.	SB a.m.	NB a.m.	EB p.m.	WB a.m.	WB p.m.	EB p.m.	WB a.m.	WB p.m.	NB p.m.	SB a.m.	NB p.m.	SB a.m.	
Arterial Speed Average																
With Metering (mph)	31.02	32.48	31.27	32.78	59.88	22.08	25.13	23.81	18.85	22.40	21.30	25.58	18.18	27.84	26.53	27.94
Without Metering (mph)	31.33	31.20	31.92	31.53	60.91	21.47	24.93	23.32	22.12	22.36	23.19	26.76	28.57	28.34	27.61	29.04
Difference (%)	1%	-4%	2%	-4%	2%	-3%	-1%	-2%	17%	0%	9%	5%	57%	2%	4%	6%
Difference (mph)	0.30	-1.28	0.65	-1.24	1.03	-0.61	-0.19	-0.50	3.26	-0.03	1.88	1.18	10.39	0.50	1.08	1.09
Arterial Speed Std Dev																
With Metering (mph)	6.05	6.69	4.00	4.44	8.11	5.51	5.78	6.50	4.95	4.55	4.37	5.87	4.65	3.54	4.41	5.29
Without Metering (mph)	5.38	5.54	3.45	5.04	7.23	5.98	5.84	5.79	4.49	4.67	4.14	5.28	5.46	3.17	6.27	5.18
Difference (%)	-11%	-17%	-14%	13%	-11%	9%	1%	-11%	-9%	3%	-5%	-10%	18%	-10%	42%	-1%
Difference (mph)	-0.68	-1.15	-0.55	0.59	-0.88	0.48	0.06	-0.70	-0.46	0.11	-0.23	-0.59	0.82	-0.36	1.86	-0.11
Arterial Vol Average																
With Metering	2,573	2,138	1,762	1,484	11,092	2,921	1,592	2,299	1,622	1,084	1,312	2,141	1,652	1,811	1,395	2,458.50
Without Metering	2,406	1,913	1,433	1,366	10,141	2,793	2,057	2,521	2,265	646	1,364	2,129	1,538	1,713	1,742	2,401.81
Difference (%)	-6%	-11%	-19%	-8%	-9%	-4%	29%	10%	40%	-40%	4%	-1%	-7%	-5%	25%	0%
Difference (veh)	-166	-225	-329	-118	-951	-128	465	52	-12	-438	222	643	-114	-98	347	-56.69
Arterial With vs. Without T-Test																
Speed	0.71	0.82	0.72	1.49	0.29	0.17	0.14	1.61	6.86	0.62	3.82	2.55	1.52	1.44	0.38	

Figure 5.10 CR-61 NB Afternoon Speed and Speed Variability

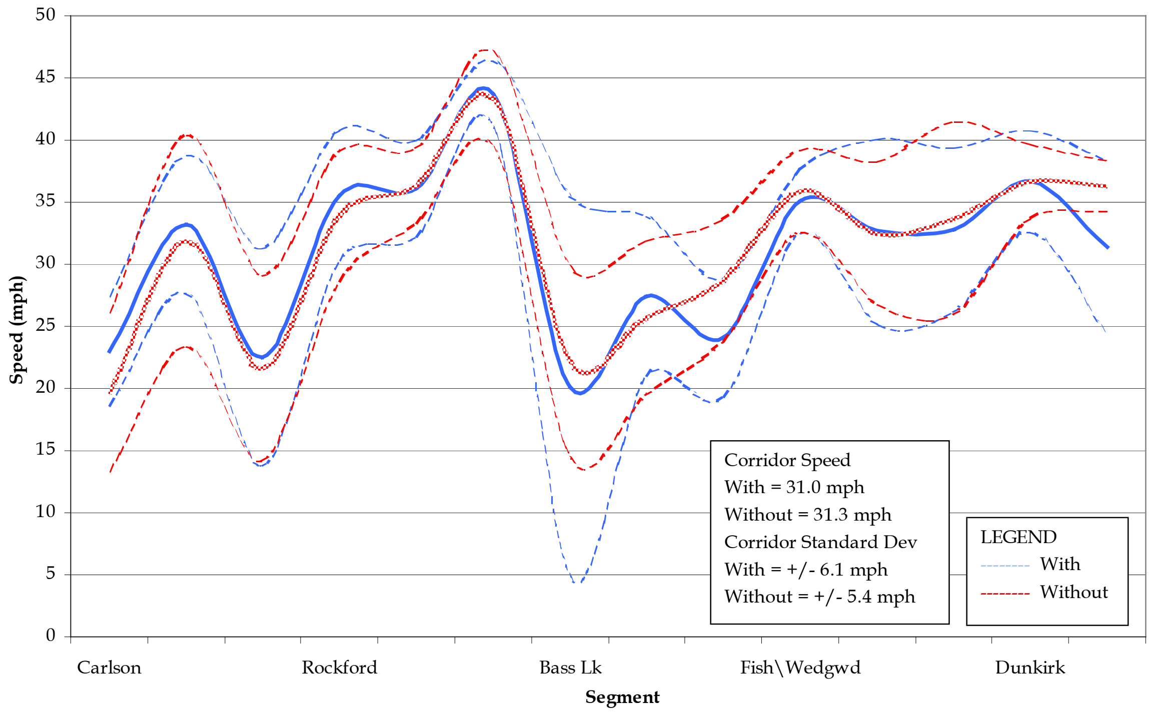


Figure 5.11 Vicksburg Avenue NB Afternoon Speed and Speed Variability

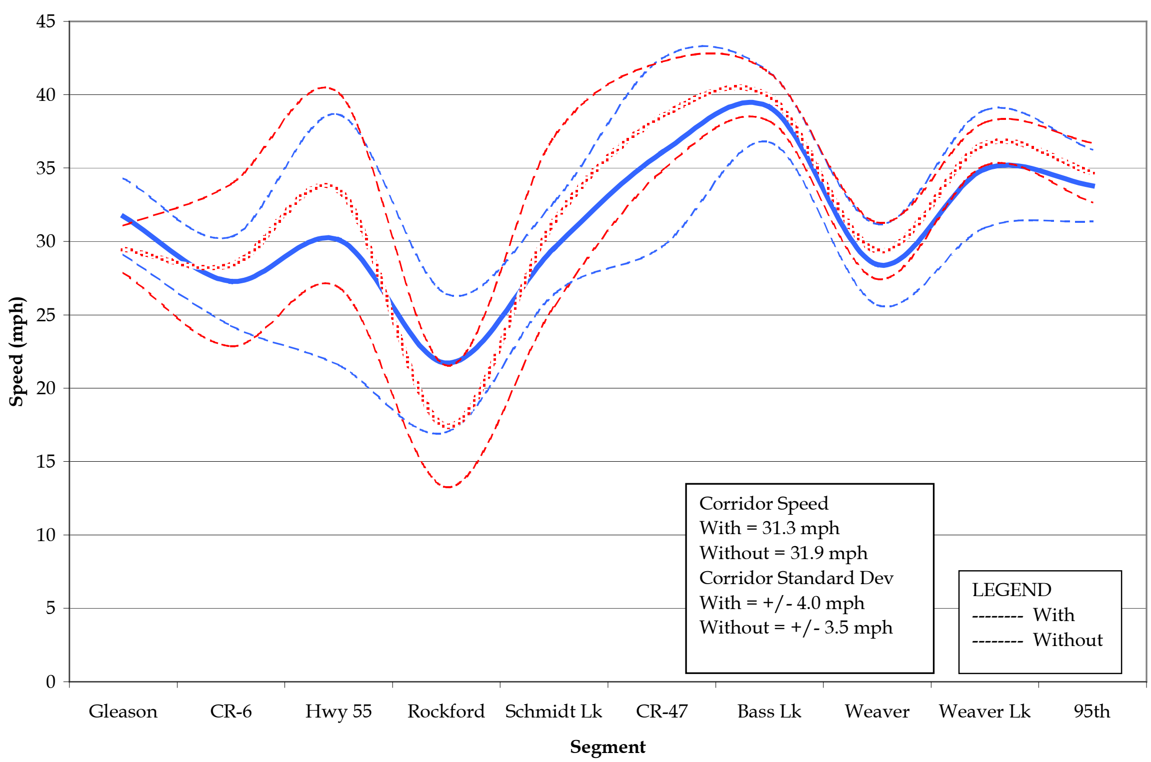
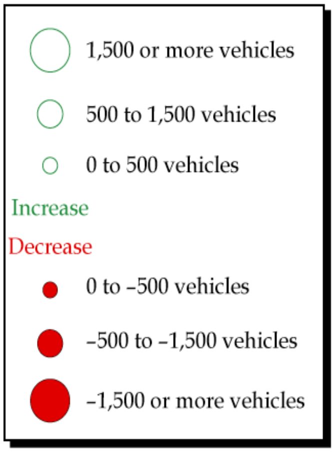


Figure 5.12



Average Volumes	I-494	CR-61	Vicksburg
With Metering	11,810	2,573	1,762
Without Metering	11,840	2,406	1,433

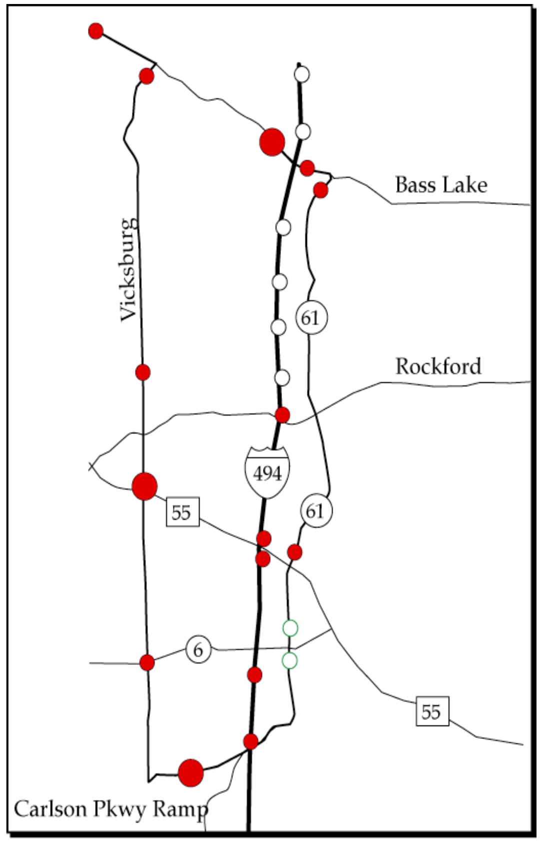
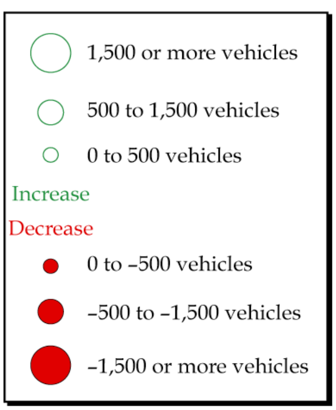


Figure 5.13 I-494 SB A.M. Traffic Volume Differences



Average Volumes	I-494	CR-61	Vicksburg
With Metering	11,010	2,138	1,484
Without Metering	10,047	1,913	1,366

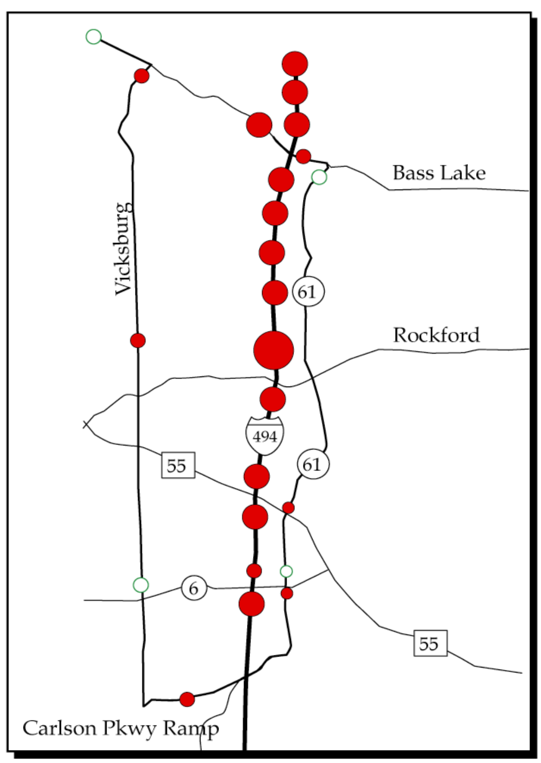
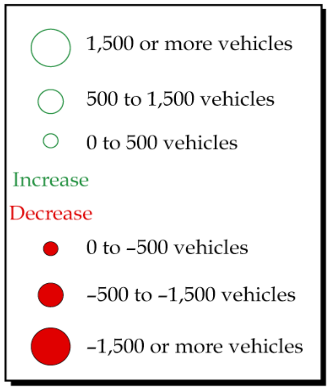
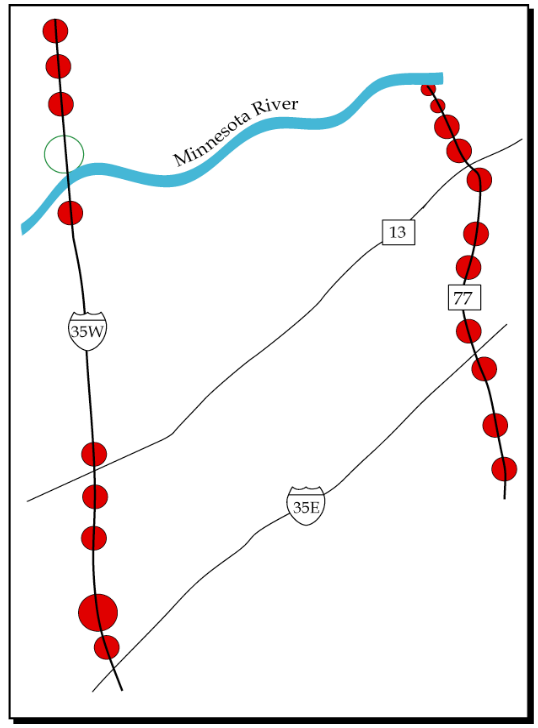


Figure 5.14 I-35W NB A.M. Traffic Volume Differences



Average Volumes	I-35W	TH-77
With Metering	11,093	11,092
Without Metering	10,042	10,141



Analysis on the temporal distribution of traffic showed limited peak spreading outside the peak periods (6:00 to 9:00 a.m. or 3:00 to 6:00 p.m.). In some cases, slight shifts were observed in traffic volumes away from the peak period towards earlier or later departure times in the off-peak period.

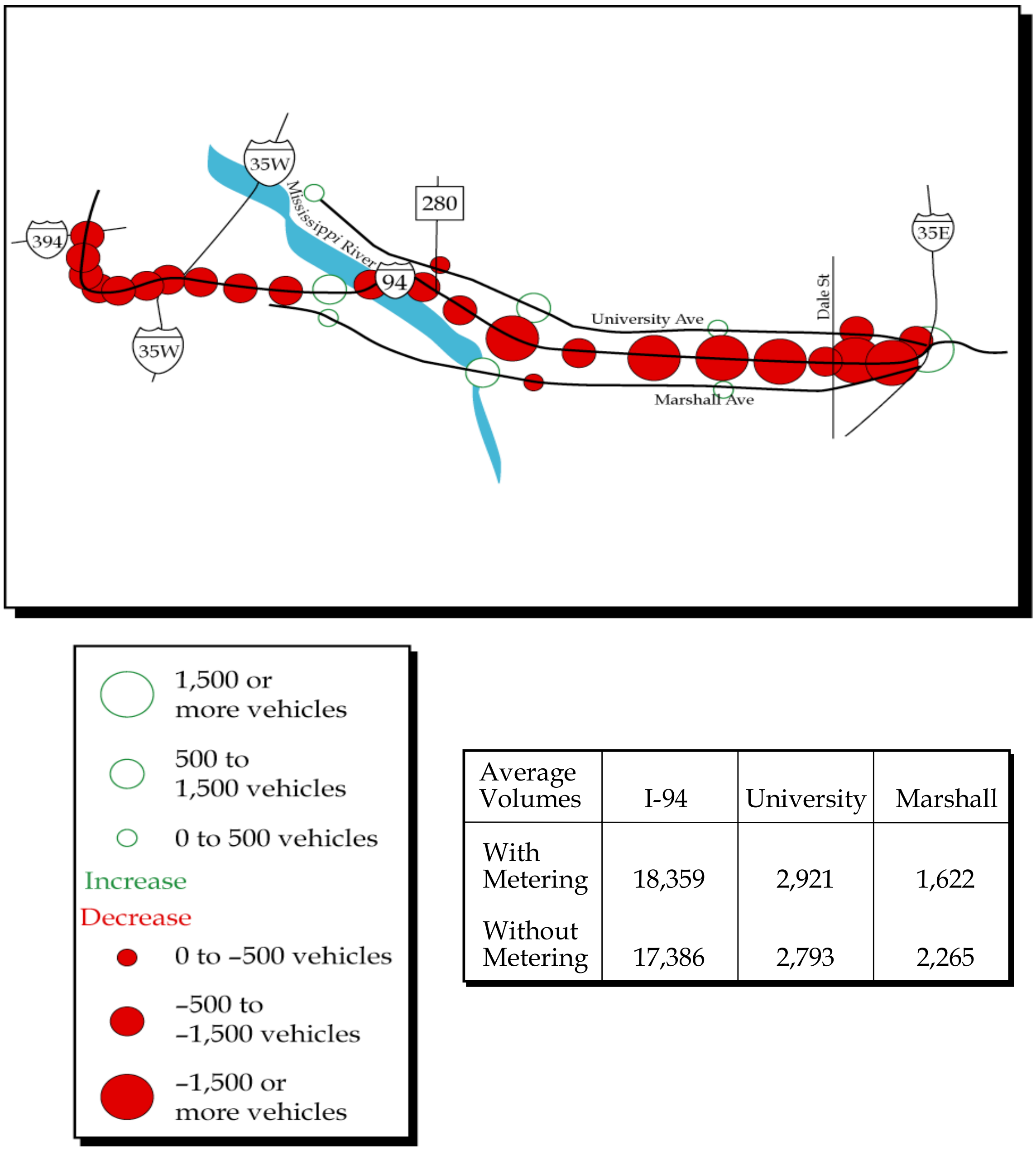
Figure 5.20 illustrates an example of this peak period shift observed on I-94 EB p.m. Between 2:30 and 3:15 p.m., higher traffic volumes were observed in the "without" case than in the "with" case, indicating that some commuters were leaving earlier to avoid peak period congestion.

The studied parallel arterials experience virtually no volume changes between the two study periods, indicating that the remaining volume reductions from the freeways may have diverted to arterials that were not included in this study, or shifted out of the peak periods entirely. This could also suggest that the increased freeway congestion resulted in some travelers foregoing their normal trips.

5.2.3 Ramp Traffic Volume and Ramp Travel Time

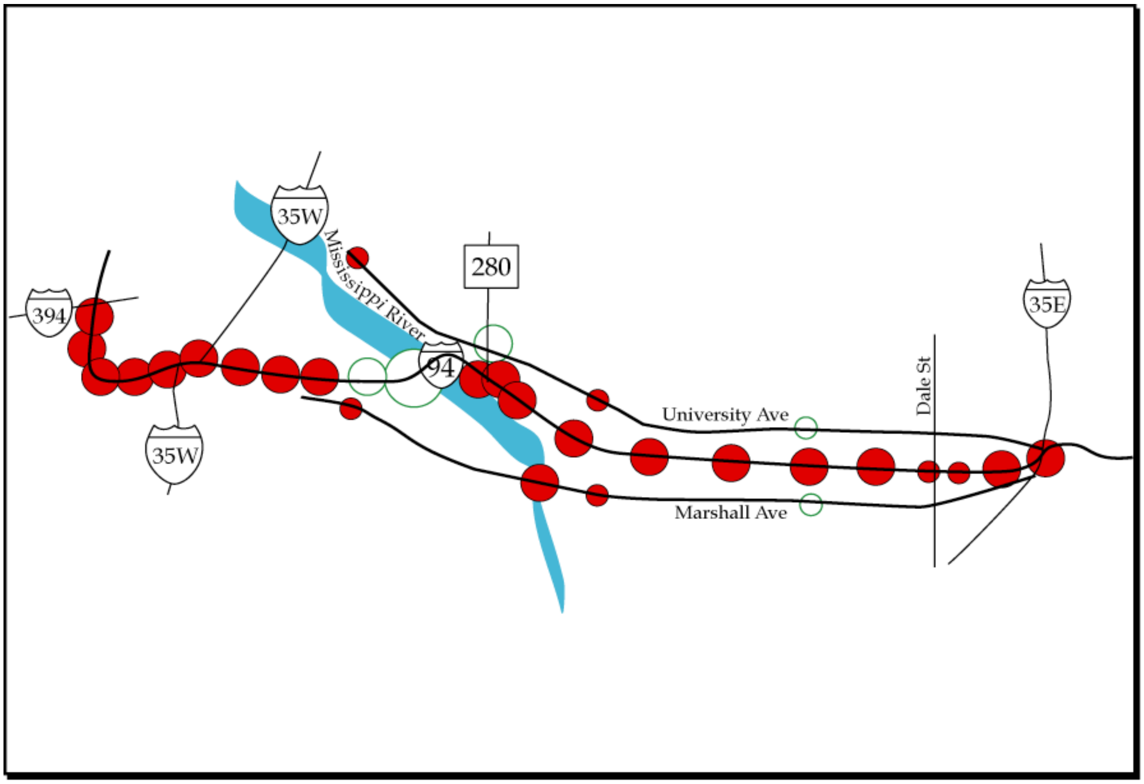
While the meters were on, each ramp carried an average of 1,500 vehicles per peak period, ranging from 1,121 vehicles per ramp on I-35E NB p.m. to 2,001 vehicles per ramp on I-94 WB p.m.

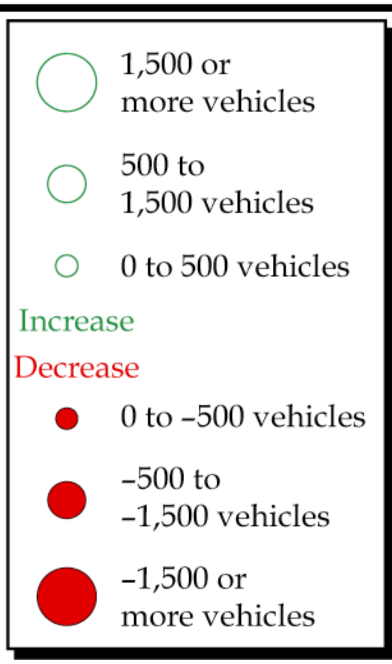
Figure 5.15 I-94 EB P.M. Traffic Volume Differences



Average Volumes	I-94	University	Marshall
With Metering	18,359	2,921	1,622
Without Metering	17,386	2,793	2,265

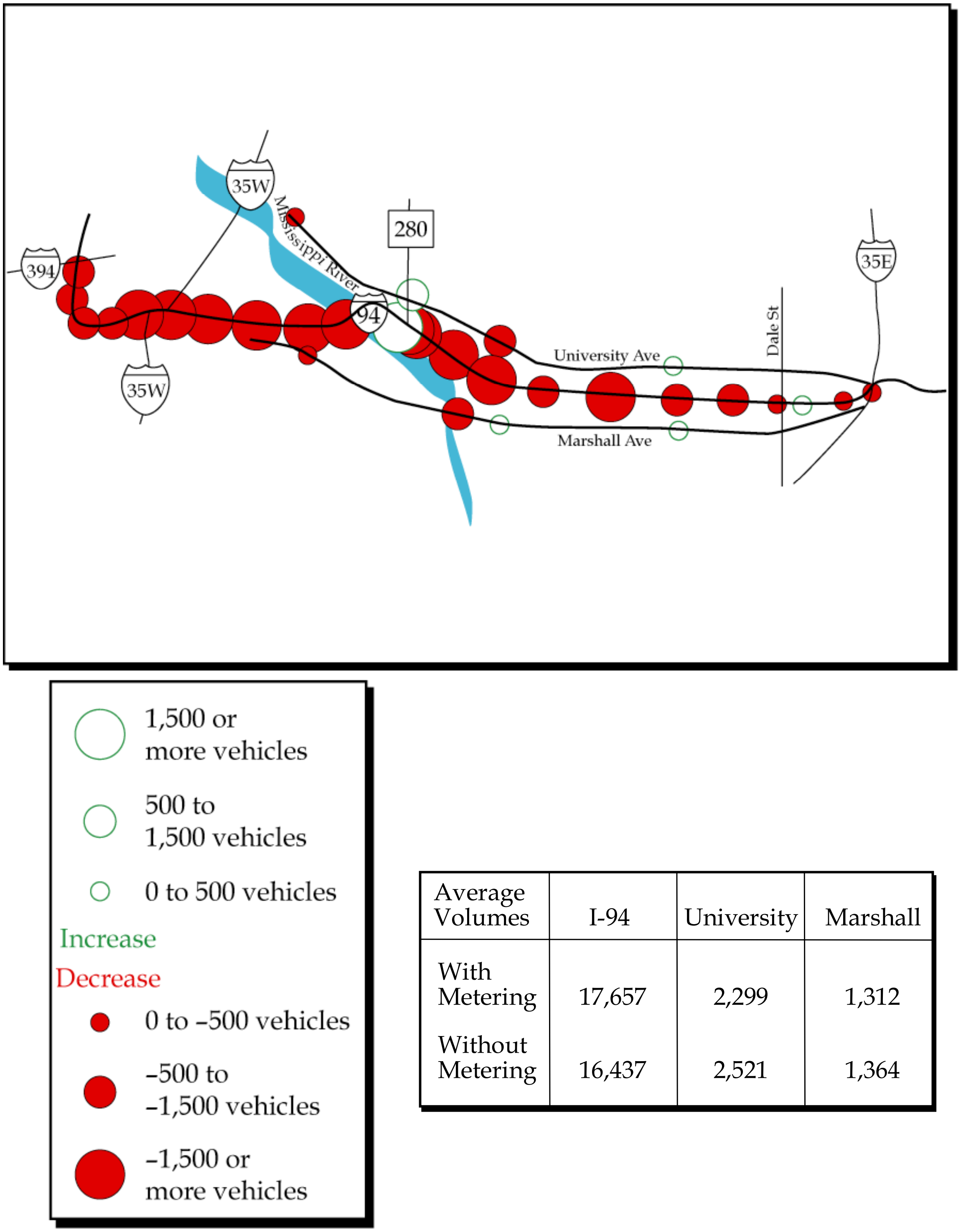
Figure 5.16 I-94 WB A.M. Traffic Volume Differences





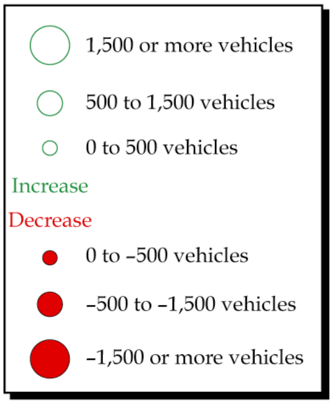
Average Volumes	I-94	University	Marshall
With Metering	16,082	1,592	1,084
Without Metering	15,284	2,057	646

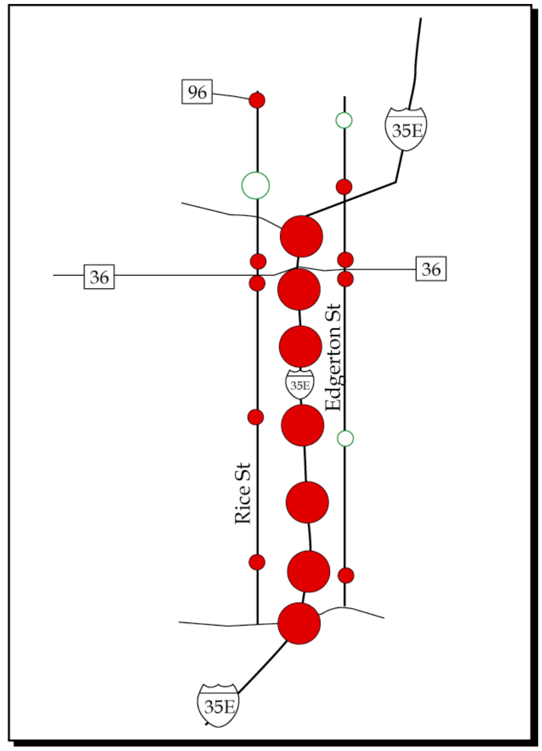
Figure 5.17 I-94 WB P.M. Traffic Volume Differences



Average Volumes	I-94	University	Marshall
With Metering	17,657	2,299	1,312
Without Metering	16,437	2,521	1,364

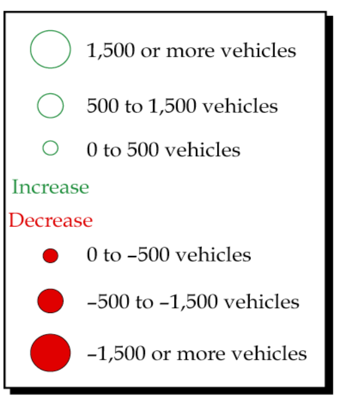
Figure 5.18 I-35E NB P.M. Traffic Volume Differences

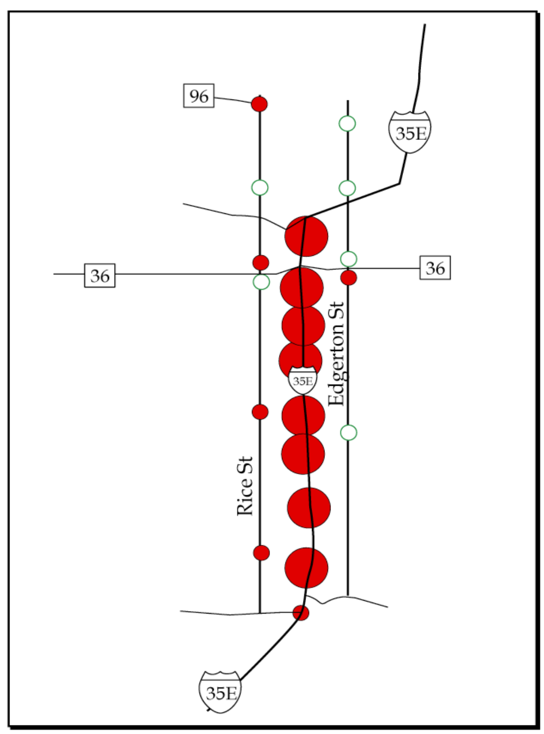




Average Volumes	I-35E	Rice	Edgerton
With Metering	14,974	2,141	1,811
Without Metering	12,165	2,129	1,713

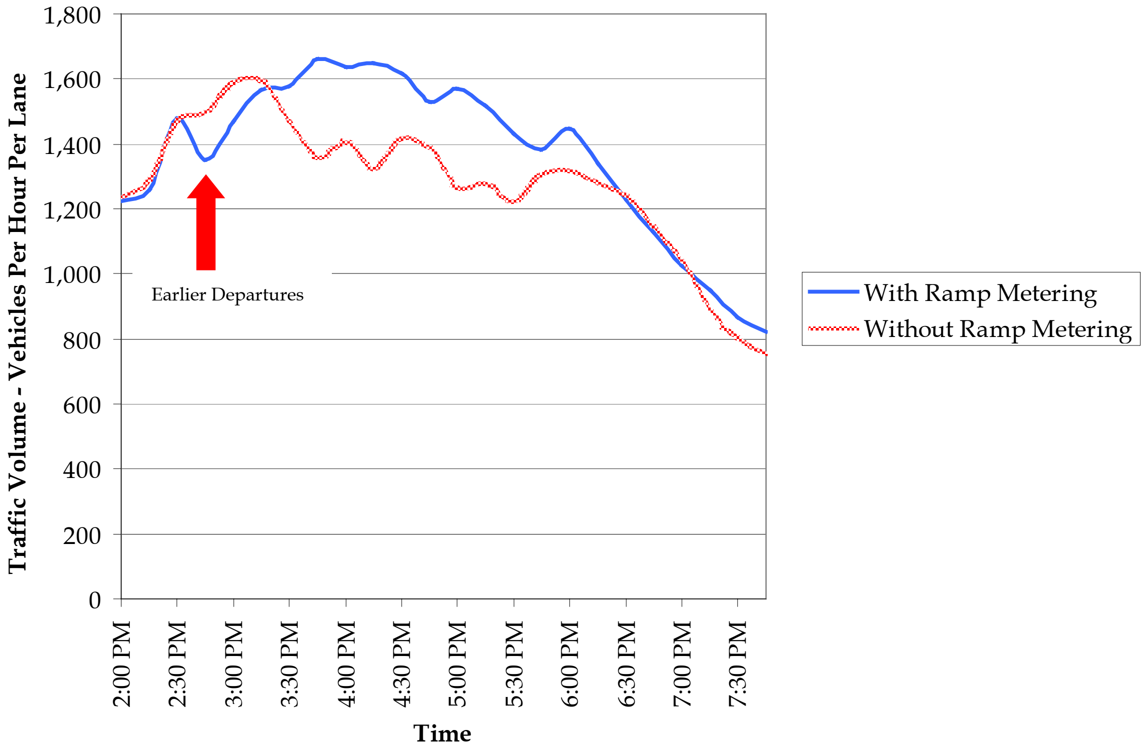
Figure 5.19 I-35E SB A.M. Traffic Volume Differences





Average Volumes	I-35E	Rice	Edgerton
With Metering	14,552	1,652	1,395
Without Metering	12,140	1,538	1,742

Figure 5.20 I-94 EB Afternoon Volume Spread



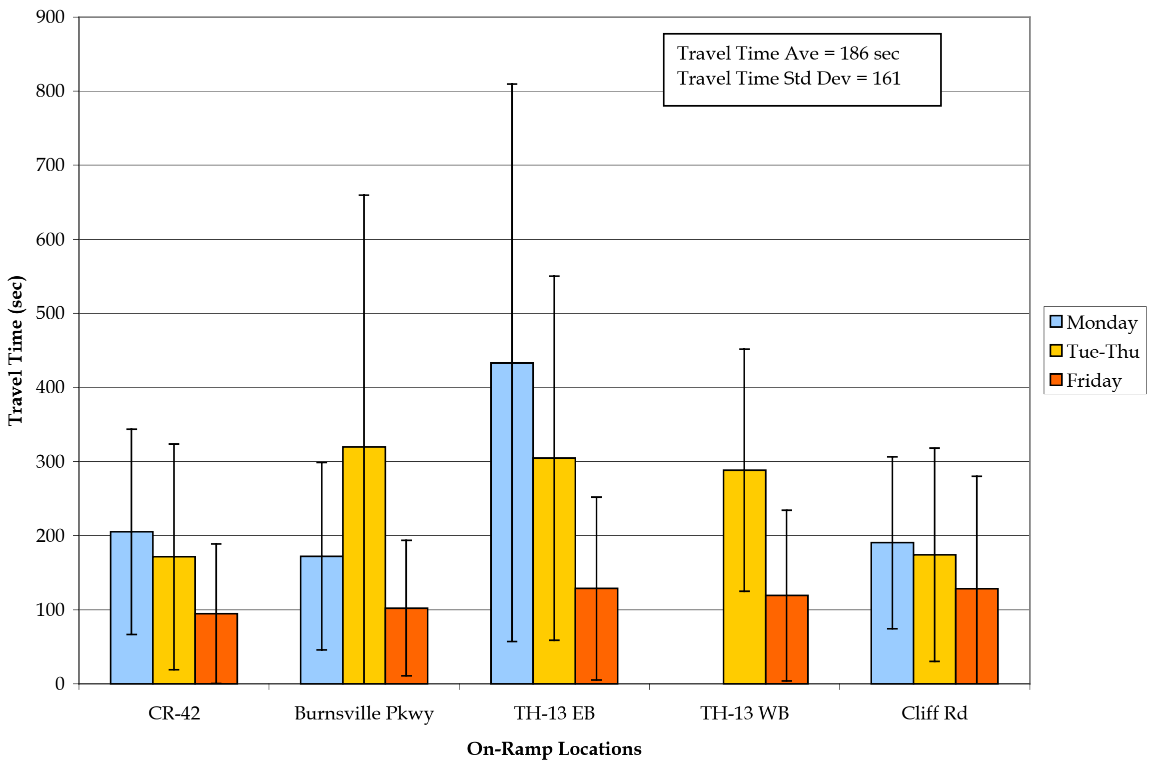
Without metering, vehicles may enter the freeway without delay at the meter. The ramp travel time in the absence of metering was calculated based on the time it takes to travel the length of the ramp, assuming that the average speed on the ramp is approximately the same as the mainline right lane speed).

With metering, ramp travel time includes the meter delay and the queue delay, in addition to the distance travel time. With meters on, the average ramp travel time in all studied corridors was 158 seconds or 2.6 minutes.

Metering also resulted in increased travel time variability at the ramps. Based on the collected data, ramp travel time variability was about 117 seconds (almost two minutes) when the meters were on, compared to only six seconds without the meters.

Figure 5.21 illustrates the ramp travel times observed at I-35W NB a.m. with the meters on. The travel times are categorized into three different sets according to the day of the week (e.g., Mondays, Tuesdays through Thursdays, and Fridays). The vertical lines indicate the variability in the travel times. At this particular corridor, the average ramp travel time was 200 seconds (3.3 minutes), with an average variability of 168 seconds (2.8 minutes). The remainder of the ramp travel time figures categorized by different days of the week can be found in Appendix D.

Figure 5.21 I-35W NB Morning Ramp Travel Time



Figures 5.22 through 5.30 illustrate the comparison of ramp travel times between the "with" and "without" study periods. For simplicity, data from different days of the week were grouped together. Overall, the observed data indicate that ramp travel time was reduced by 139 seconds (2.3 minutes), and travel time reliability was improved by 111 seconds (1.9 minutes) in the "without" study period.

5.2.4 Freeway Mainline Versus Ramp Travel Times

From the freeway mainline perspective, ramp metering was shown to improve travel time by an average of 2.5 minutes and improve travel time reliability by 1.9 minutes for the average nine-mile segment observed by the evaluation team. These improvements on the freeway mainline are balanced against a worsening of conditions at the ramp facilities. Metering imposed an average of 2.3 minutes of additional delay at the ramps and reduced the ramp travel time reliability by an average of 1.85 minutes.

Direct comparison of the observed impacts suggests that ramp metering results in a net travel time benefit for the study corridors. The corridor mainline freeways carried an average of 14,400 vehicles during the peak period, which translated to about 590 hours of time savings on average per peak period. The ramps for each corridor carried an average

Figure 5.22 I-494 NB Afternoon Ramp Travel Time

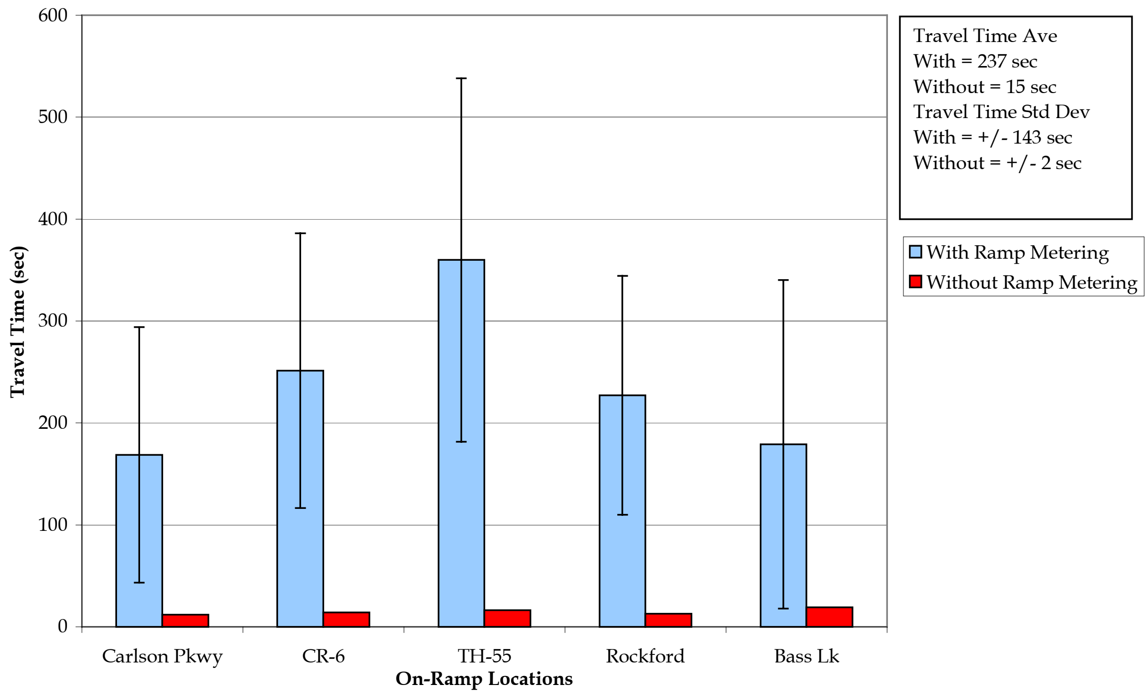


Figure 5.23 I-494 SB Morning Ramp Travel Time

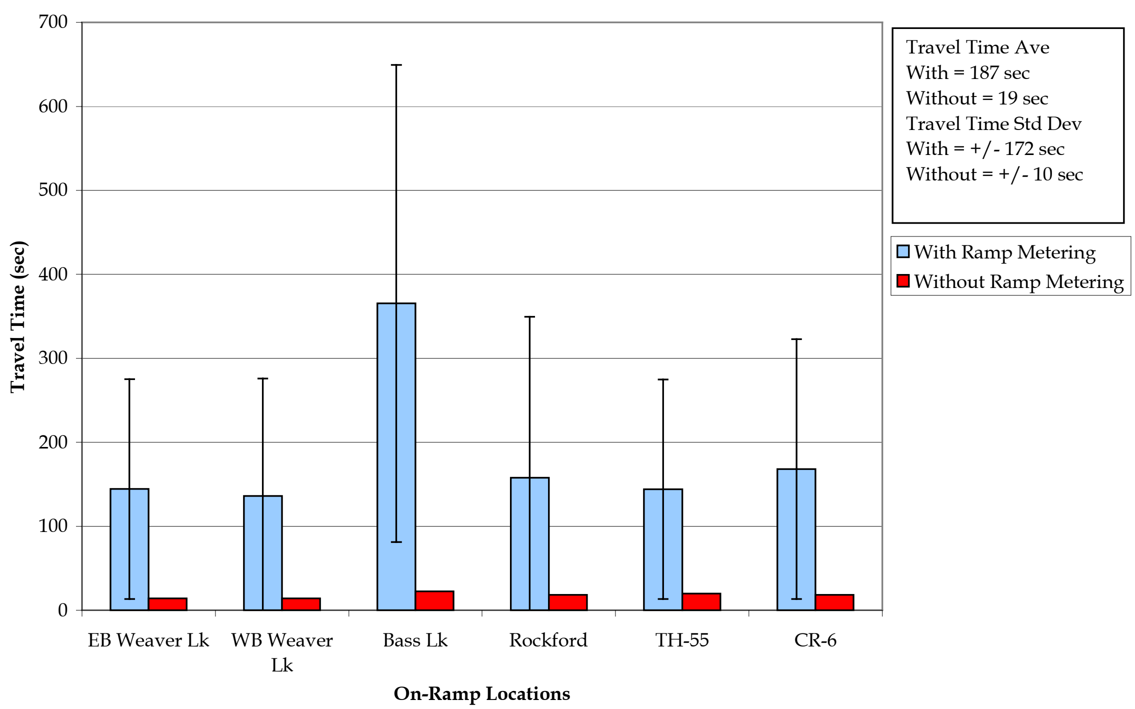


Figure 5.24 I-35W NB Morning Ramp Travel Time

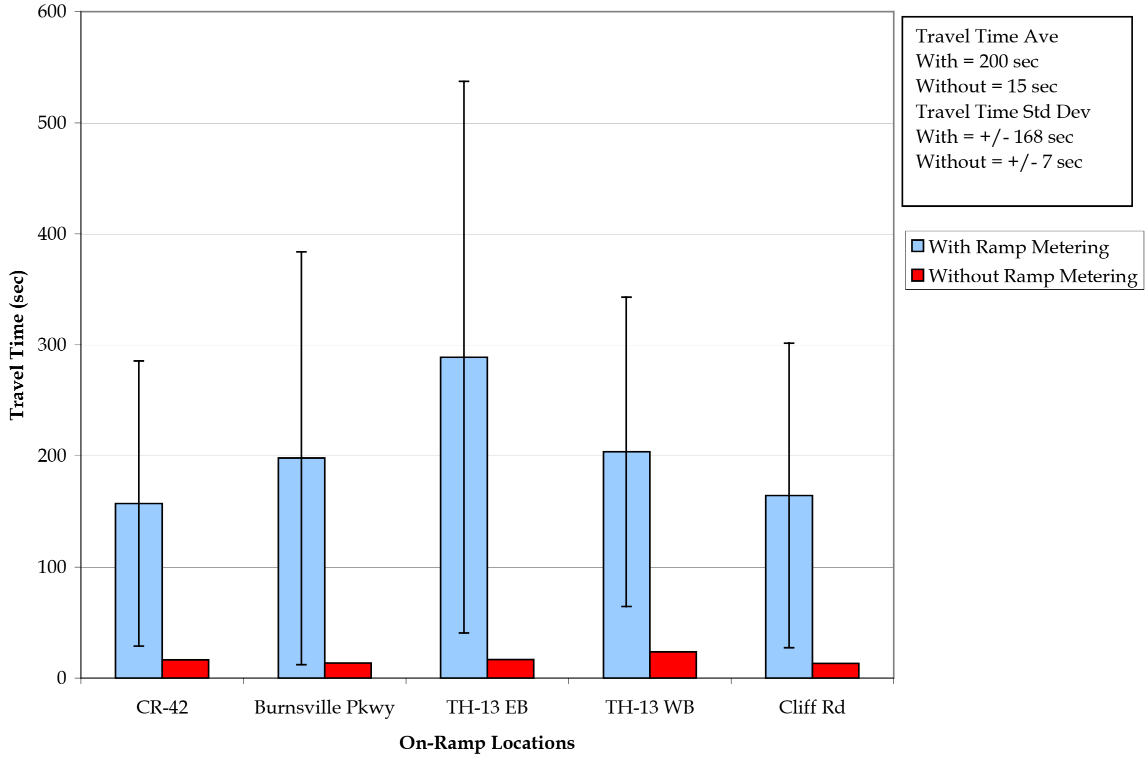


Figure 5.25 I-94 EB Afternoon Ramp Travel Time

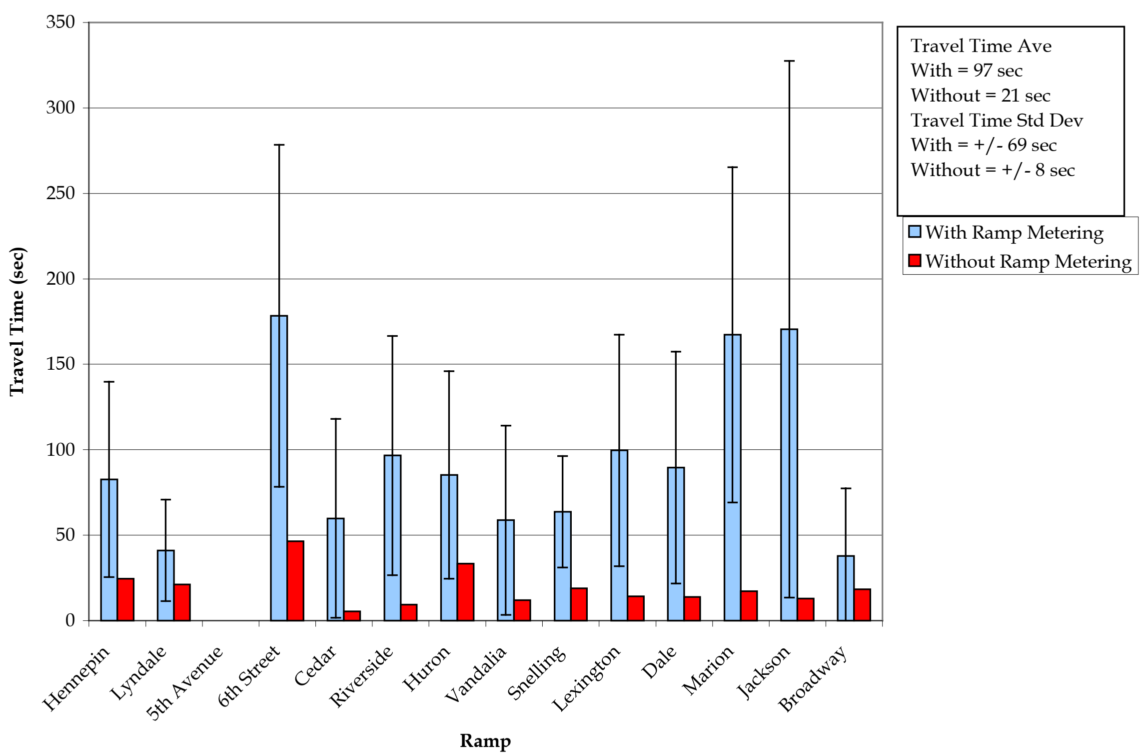


Figure 5.26 I-94 WB Morning Ramp Travel Time

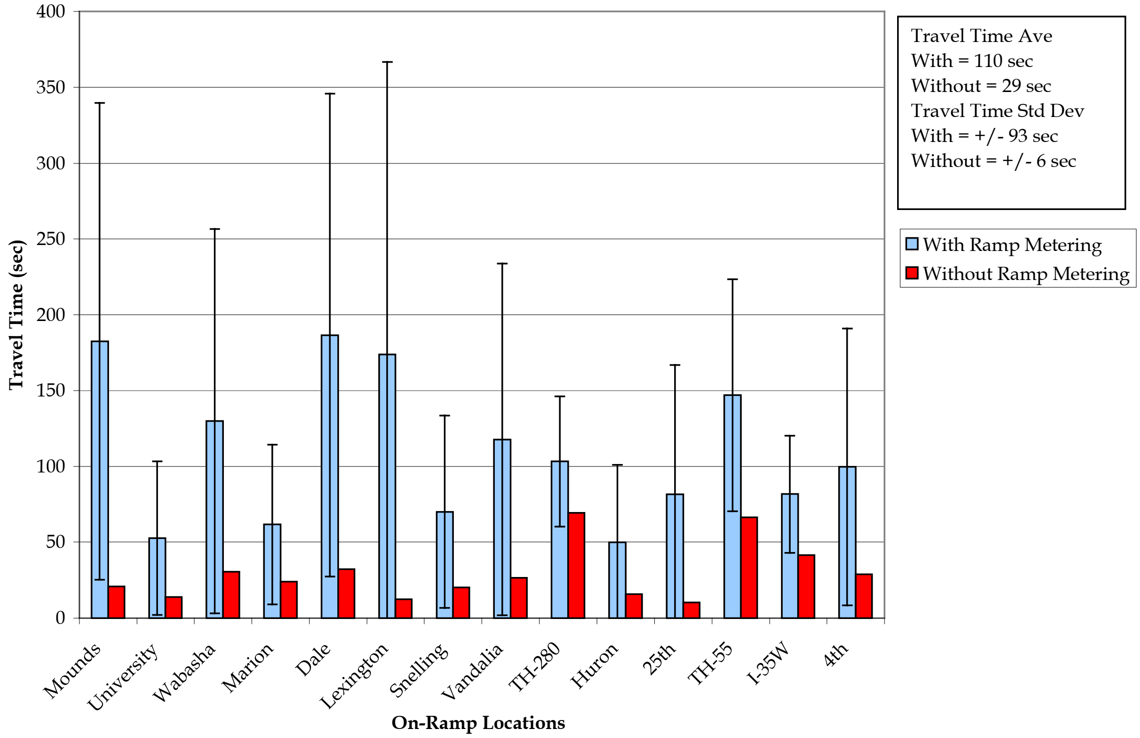


Figure 5.27 I-94 WB Afternoon Ramp Travel Time

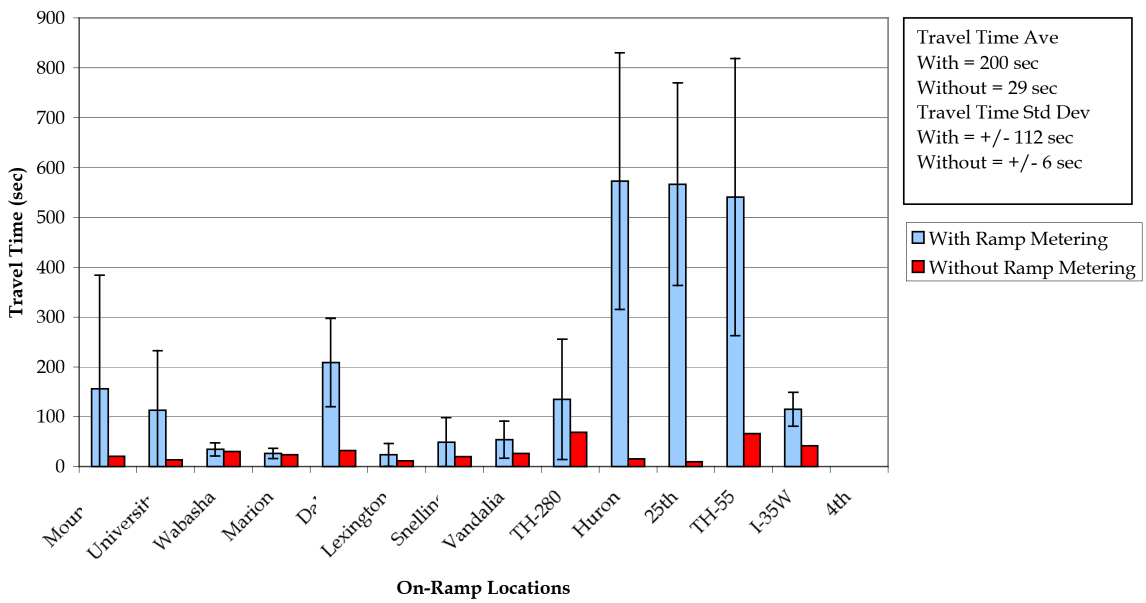


Figure 5.28 I-35E NB Afternoon Ramp Travel Time

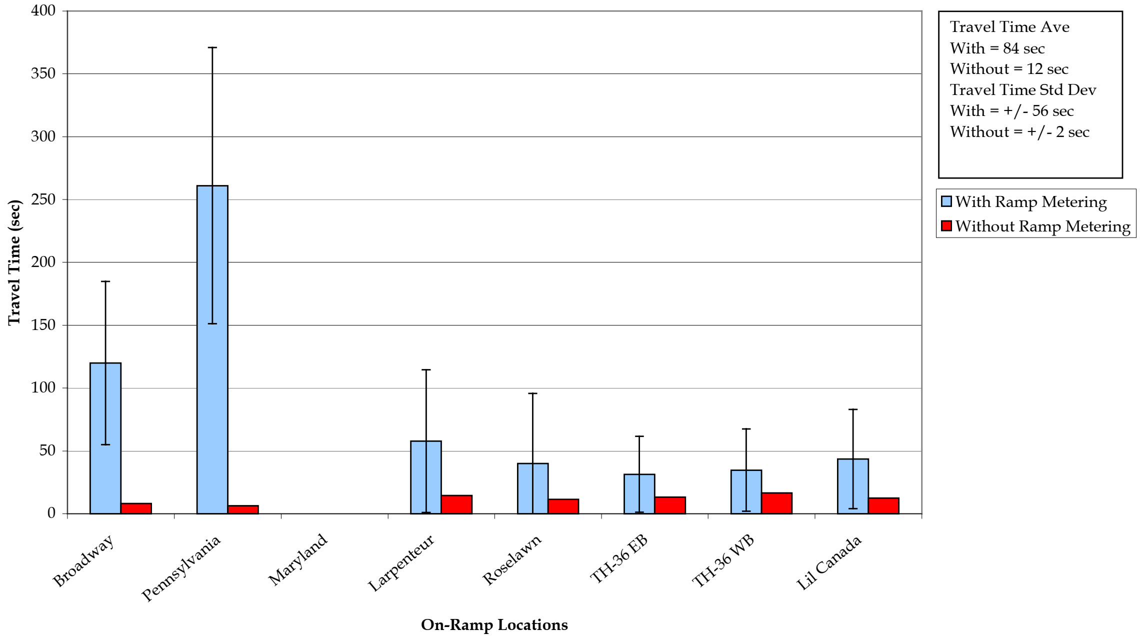


Figure 5.29 I-35E SB Morning Ramp Travel Time

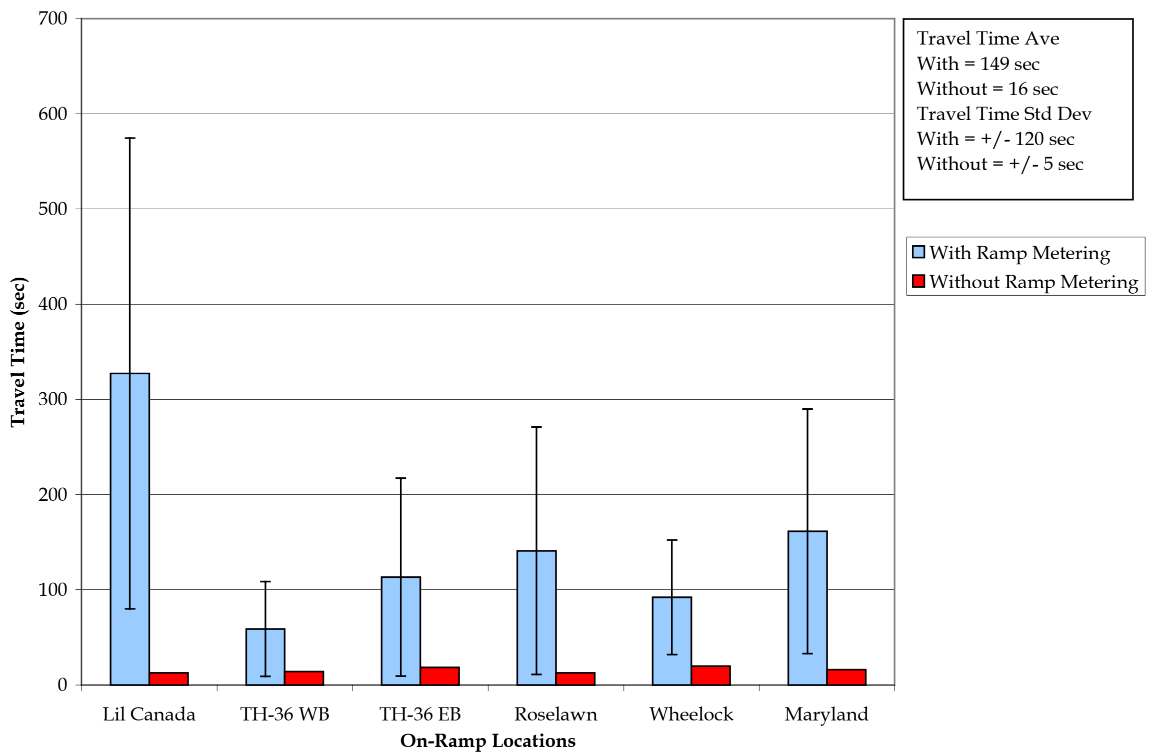
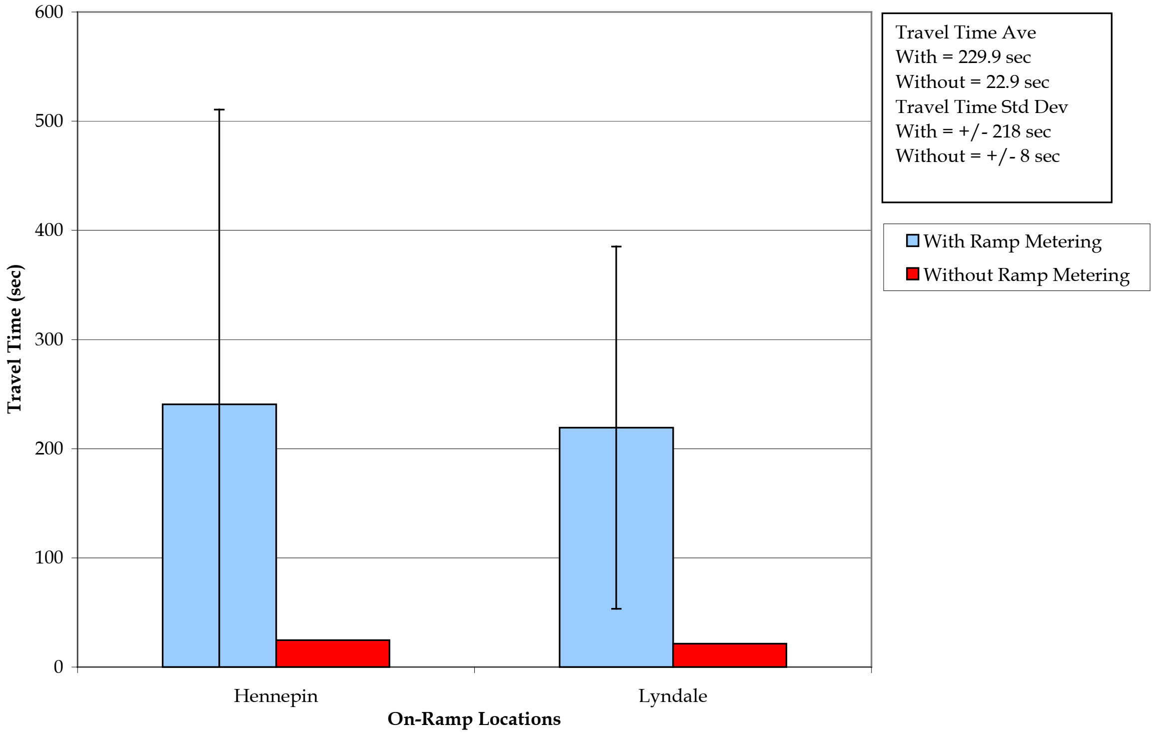


Figure 5.30 I-94 EB Morning Ramp Travel Time



of 13,400 vehicles per peak period and experienced 2.31 minutes of greater delay per vehicle. This equates to 516 hours of ramp delay on average per peak period. An example of this calculation, based on averages across all corridors, is presented in Table 5.5.

Table 5.5 Calculation of Net Travel Time for Selected Corridors During a 3.5-Hour Peak Period

Average Corridor Freeway Volume	14,442 vehicles
Average Travel Time Change on Freeway Segments	2.45 minutes
Subtotal Freeway Travel Time Change	*589.7 hours saved*
Average Corridor Ramp Volume	13,424 vehicles
Average Travel Time Change on Ramps	2.31 minutes
Subtotal Ramp Travel Time Change	*-516.4 hours spent*
Net Travel Time Change	**73.5 hours saved**

Table 5.5 provides an example calculation only, based on observed average impacts. In the calculation of travel time changes in the benefit/cost analysis, the specific impacts

observed for each individual corridor and time period was extrapolated to the appropriate similar corridors to estimate changes in freeway and ramp travel times.

5.3 Safety Impacts

Crash data were collected for both the “with” and “without” metering periods to analyze any changes occurring in the number and severity of crashes. Detailed crash data were obtained from the Twin Cities crash database maintained by the Department of Public Safety and Mn/DOT. This crash database provided a record for each crash, including information on:

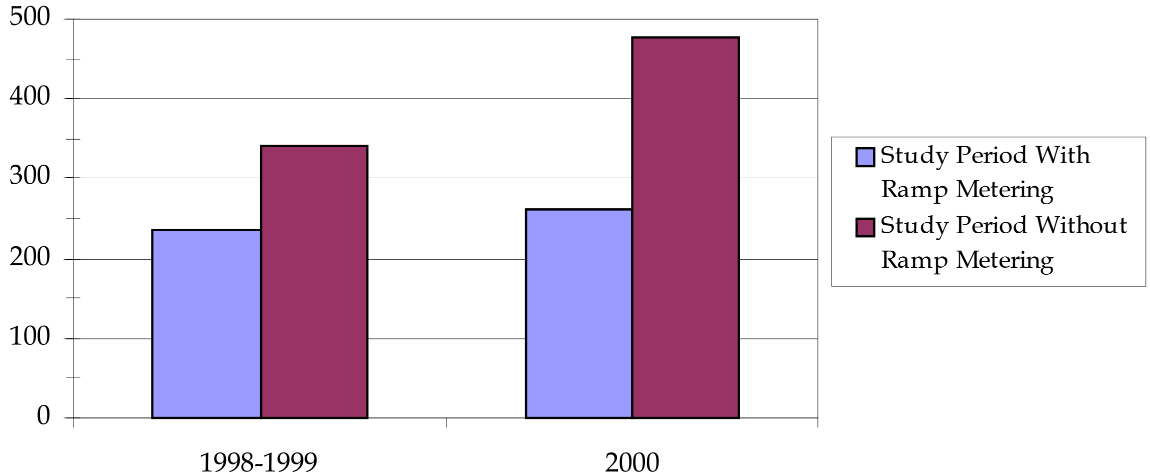
- Crash severity (fatality, injury, property damage);
- Type of crash (rear-end, side-swipe, etc.);
- Location of the crash;
- Facility type;
- Time of crash; and
- Other factors, including pavement condition, lighting, weather, etc.

In addition to collecting these data for the study period, the evaluation team analyzed the identical crash data for the equivalent periods in 1998 and 1999. These historical data were used to control for any seasonal variation typically occurring between the two study periods. The three years of data were then statistically analyzed to identify any change in crash rates resulting from the ramp metering shutdown.

The analysis found that there is typically a seasonal increase in the number of crashes observed between the two study periods. The crash rates on metered freeways during the peak periods were specifically analyzed to isolate any seasonal variation between the two study periods. The results showed that, on average, there was an increase from 236 to 341 crashes observed between the equivalent “with” and “without” study periods in 1998 and 1999 – representing an overall 44.5-percent increase in the number of crashes.

An analysis of the crashes occurring on metered freeways during the peak periods during the ramp metering evaluation showed an increase from 261 to 476 crashes, or an 82 percent increase, as shown in Figure 5.31. Based on historical seasonal variations, the crashes in the “without” period would be expected to increase by only 116 crashes to 377 total crashes. *The analysis shows that in the absence of ramp metering the number of crashes increased by 26.2 percent above the increase normally expected due to seasonal variation on metered freeways.* This finding is consistent with accident reduction observed on metered facilities documented in an evaluation of conditions with and without ramp metering in the Phoenix metropolitan region. The observed increase in crashes is supported by data from the Mn/DOT incident management center which reported 60 percent more incidents (crashes plus disablements) during the “without” period.

Figure 5.31 Comparison of Crash Occurrence in the "With" and "Without" Study Periods (for Metered Freeways in the Morning and Afternoon Peak Periods)



The crash severity from the "with" and "without" periods was analyzed and compared with historical averages. Fortunately, no fatality crashes were reported during either the "with" or "without" study period. Injury crashes were shown to increase by approximately three percent over the seasonally adjusted rate; however, the sample size of crashes is generally too small to draw any firm conclusions. Property damage crashes, which did have a significant sample size, increased by 33 percent above the seasonally adjusted estimate.

Analysis of Crash Types

Table 5.6 shows the results of an analysis of the seasonally adjusted number of crashes by type occurring on metered freeways in the peak period. Rear-end, side-swipe, and ran-off road crashes are the most typical types of crashes reported near ramp merge locations. All these crash types show significant increases in the "without" study period.

Table 5.6 Comparison of Crash Occurrence by Crash Type (for Peak Period Metered Freeways)

Crash Type	Percent Change in the Absence of Metering
Rear-end	+15%
Side-swipe	+200%
Ran off road	+60%
Other crashes	+9%

■ 5.4 Transit and Park-and-Ride Impacts

Performance data from regional transit providers was analyzed for the "with" and "without" study periods to evaluate the impacts of ramp metering on transit. No overall change in transit ridership was observed during the "without" study period. Generally, transit impacts were minor with no overall statistically significant changes being noted in the brief "without" period. The net transit ridership increase between the two study periods was only 1.1 percent (about 300 additional riders out of 30,000 from 18 bus lines). This increase was well within the expected seasonal variation. Park-and-ride usage increased by 6.4 percent, or approximately 300 more vehicles out of 3,000 at 18 park-and-ride lots. The summary of the transit impacts analysis is provided in Tables 5.7 and 5.8.

Transit operators provided useful information, based on operational analysis and the experience of transit drivers during the two study periods. Some of the major findings reported are shown in Table 5.9.

Table 5.7 Transit Ridership Summary

Route	With Meters	Without Meters	Difference	% Difference
431	144	125	-19	-13.1%
440	362	301	-61	-16.9%
442	1,197	1,133	-64	-5.4%
444	2,073	2,105	31	1.5%
35M	2,333	2,352	18	0.8%
35N	3,600	3,688	88	2.4%
35R	333	369	37	11.0%
35T	3,846	3,922	76	2.0%
35V	404	435	32	7.8%
35Y	652	649	-4	-0.5%
37W	2,066	1,967	-99	-4.8%
445/6	1,246	1,240	-6	-0.5%
77A	3,368	3,467	99	2.9%
77BC	1,716	1,823	107	6.2%
77PV	2,192	2,215	23	1.0%
77S	275	264	-11	-4.1%
77T	2,348	2,364	16	0.7%
77W	1,031	1094	62	6.0%
Total	**29,185**	**29,509**	**324**	**1.1%**

Table 5.8 Park-and-Ride Usage

Corridor	With Meters	Without Meters	Difference	% Difference
I-35E	534	532	-2	-0.4%
I-35W	1,965	2,129	164	7.7%
I-94	437	462	25	5.3%
All Corridors	**2,936**	**3,123**	**187**	**6.4%**

Table 5.9 Impacts of Ramp Metering Shutdown Reported by Transit Providers

Positive or Neutral Impacts	Negative Impacts
Metro Transit did not observe significant systemwide delays.	Longer distance express routes had more difficulty with on-time performance than Minneapolis express routes.
Traffic through downtown and on local arterials appeared to move better, improving the operation of some routes.	Due to congestion, buses were reported to use bus-only shoulders more frequently during the meter shutdown.
	Metro Transit's Transit Control Center indicated that bus operators experienced higher instances of automobile drivers intentionally blocking bus-only shoulders to keep the bus from passing their vehicles.

The transit providers also noted that, although no significant ridership impacts were observed, the "without" metering period was too brief to evaluate any long-term impacts. Transit operators were concerned that the reduction in the transit travel time advantage over single-occupancy vehicles, attributable to the elimination of ramp queues, may eventually promote greater use of automobiles by current transit users.