Simulation of Movable Barrier System on I-70

Final Phase 1 Report (Rev. 2)
for the
Colorado Department of Transportation

Dr. Bruce N. Janson
Principal Investigator
Dept. of Civil Engineering
University of Colorado at Denver
P.O. Box 173364, Campus Box 113
Denver, CO 80217-3364
Phone: 303-556-2831
Fax: 303-556-2368
bruce.janson@ucdenver.edu

Susi Marlina
PhD Candidate and Research Assistant
University of Colorado Denver
Parsons Brinkerhoff - Denver Office
555 17th Suite 500 Denver, CO 80202
Direct: 303-728-3055 Main: 303-832-9091
Fax: 303-832-9096
marlina@pbworld.com

Maged Al-Swaidi
Research Assistant
University of Colorado Denver

Period of Performance: April 1, 2010 through June 30, 2010

ACKNOWLEDGEMENT

We express our sincere thanks to many individuals who have contributed to and worked on this project. Bernardo Guevara, Saeed Sobhi, David Reeves, Juan Robles, and all the CDOT personnel in both Regions 1 and 6 who provided us with valuable input and much needed data. The authors are also very thankful for the support of this study by James Daves and Kathie Haire (Parsons Brinckerhoff), Paul Brown (Jacobs), and Dr. Yi-Chang Chiu and Eric Nava (The University of Arizona)

EXECUTIVE SUMMARY

The purpose of this project is to simulate and evaluate the travel impacts of moveable barriers system on I-70 from Floyd Hill (MP 244) to Georgetown (MP 230.5) in order to reverse a westbound lane to the eastbound direction during periods of high eastbound traffic returning to the Denver metro area from the High Country on winter Sunday afternoons using VISSIM micro-simulation software. Factors affecting the preferred location on the zipper lane through this corridor are highway alignment and design, geographical and geological constraint, and travel demand characteristics and bottleneck locations. UCD estimated that under normal operations, the capacity of the Twin Tunnels is approximately 1600 vph per lane similar to the capacity of the improved Callahan Tunnel, or 3200 vph for the each direction. The zipper lane would reduce the capacity of each lane in the westbound bore to about 1350 vph per lane because of the barrier effect on driver behavior and speeds. A review of observed counts of 6.25 years shows that the volume consistently exceeded the capacities of 1350 vph in the WB direction and 3200 vph in the EB direction from 1:00 PM to around 5:30 PM on winter Sunday afternoons.

The UCD research team built a VISSIM simulation model for 25-mile including five additional miles on each end beyond the zipper lane section so that all queuing delay with or without the zipper lane installed would be captured in the travel times. The simulation reported here did not include the option of dynamic traffic assignment to alternative paths, but uses vehicle inputs at the start of the network and at the on ramps, plus routing decision throughout the network to determine vehicle flows. The baseline simulation resulted in an average travel time of 79 minutes in EB direction and 34 minutes in the WB direction. Two scenarios using the zipper lane were run: (1) <u>all vehicles</u> allowed to use both zipper lane and the general purpose lanes in the EB direction and the one WB lane, and (2) <u>no trucks</u> allowed to use the zipper lane in the EB direction and the one WB lane.

Restricting truck travel in the WB direction meant removing all trucks from those WB vehicle input volumes and routing decisions, which resulted in a 10% reduction in all WB volumes, but a larger percent reduction in passenger car equivalent volumes. Thus, it resulted in a reduction in the average WB travel time from 69 minutes to 60 minutes, which is about a 12% decrease. Significant queues formed in the WB direction with the zipper lane installed. The total queue length from the Twin Tunnels is approximately 3.3 miles for Scenario 1 and 2.1 miles for Scenario 2. The queues in both of these scenarios reduced travel speeds to below 10 mph and increased travel time significantly. For the full 25-mile section, the zipper lane scenario that allowed all vehicles to use all lanes reduced the average EB travel time from 79 minutes down to 41 minutes (a 38 minute decrease of 48%). However, it increased the average WB travel time from 34 minutes up to 69 minutes (a 35 minute increase of 100%). These results assume normal operating conditions throughout the analysis period from noon to 9PM. Incidents and poor weather conditions could impact these results dramatically. Also, the results reported here use a fairly high travel demand scenario for January 31, 2010.

Table of Contents

List of Tables

List of Figures

1. OBJECTIVE

The purpose of this project is to simulate and evaluate the travel impacts of moveable barriers system on I-70 from Floyd Hill to Georgetown in order to reverse a westbound lane to the eastbound direction during periods of high eastbound traffic returning to the Denver metro area on winter Sunday afternoons. These moveable barriers systems are often called “zipper lanes” due to the sequential movement of the barriers during implementation (see Figure 1 below).

Zipper lanes have been implemented in Los Angeles, Boston, New York City, Honolulu, Washington DC, and Dallas, usually on freeways with three or more lanes in each direction. The reversed lane is often contiguous with the adjacent lanes flowing in the same direction such that traffic can shift into or out of the reversed lane throughout its length. Interstate 70 is a special case in which the reversed lane could only be entered at the beginning and exited at the end its full length. It would be a single lane bounded by the movable barrier on the left and concrete barrier on the right. The remaining single westbound lane would be of similar design. The unique features of this zipper lane application present some challenges to be discussed later.

Figure 1: Example of Zipper Lane Barrier in Transition

2. STUDY AREA (25 Miles)

The study area, shown in Figure 2, includes portions of Floyd Hill, Twin Tunnels, Idaho Springs, Dumont, Downieville Lawson, Empire Junction, and Georgetown.

Figure 2: Length of I-70 Simulated for the Zipper Lane Evaluation

The zipper lane is proposed from MP 230.5 just to the west of Empire Junction east to MP 244 at the base of Floyd Hill, which is approximately 15 miles including some transition distance on each end. UCD also added 5 miles to each end of the I-70 section analyzed so as to capture the full extent of queuing delay.

Factors affecting the preferred location of the zipper lane through this corridor are:

1. Highway alignment and design, including available lane widths and lateral clearances, and access point density.

2. Geographical and geological constraints. The I-70 corridor passes through rolling and mountainous terrain with many major inclines and declines. Several locations have more than 3 percent grade which affects the vehicle operating speed.

3. Travel demand characteristics and bottleneck locations. The primary bottleneck in this section of I-70 for both eastbound and westbound traffic is the Twin Tunnels. The Twin Tunnels are located at approximately MP 242 west of the base of Floyd Hill, and carry two lanes of traffic in each direction.

Research on tunnel capacities is limited. Levinson et al. (1985) estimated the capacity of the Callahan Tunnel in Boston to be between 1600 and 1650 vphpl after installing traffic management improvements. Levinson et al. (1985) also cite a New York Port Authority estimate of 1660 vphpl as the maximum theoretical capacity of a tunnel lane. However, observed maximum volumes in New York and New Jersey tunnels suggest a maximum practical capacity of 1350 to1450 vphpl. Lin et al. (2009) estimated the capacity of a tunnel in Taiwan after improvements to be 1300 vphpl in the southbound direction, but only 1150 vphpl in the northbound direction. Koshi et al. (1992) observed the capacities of tunnels in Japan under congested conditions to be in the range of 1100 to 1400 vphpl, with the average being about 1325 vphpl. After reviewing these references, capacities of the Twin Tunnels during regular operations are estimated to be similar to the capacity of the improved Callahan Tunnel of about 1600 vphpl. The capacities of the eastbound zipper lane and westbound lane through the Twin Tunnels with the zipper lane barrier installed were estimated to be 1350 vphpl, which is at the high end of the capacities observed in Japan.

Using HCM 2000 to estimate the WB tunnel lane capacities with the zipper lane

The capacity of the eastbound zipper lane or the westbound single lane cannot be analyzed with the Highway Capacity Manual 2000 procedures for freeways because of having only one lane in each direction. Thus the need for our simulation analysis as described later. UCD did apply the HCM 2000 two-lane road analysis module to approximate the capacities of these single lane operations using the following specifications:

10% trucks and buses, 0% RV's (assumed RV's to be in the trucks and buses)
100% no-passing zones
0 access points per mile
60 mph base free-flow speed (BFFS)
50/50 directional split
Rolling terrain
Highway class I or II (doesn't affect results)

With those conditions, 1500 vphpl (3000 for both directions) is the break point between LOS E and F, typically thought of as the capacity. The LOS is based on Percent Time Spent Following (PTSF), which does not vary at all with changes in lane width, right shoulder width, or segment length. The HCM analysis assumes a center stripe (not a concrete barrier).

The lane and shoulder width (but not segment length) slightly affect the average travel speed (ATS) reported by the HCM. Setting the lane and shoulder widths to their highest possible values results in an ATS of 34.6 mph, while setting them to their lowest possible values results in an ATS of 29.3 mph. Also, the single westbound lane does include on and off ramps, which will affect flow similar to access points per mile outside of the tunnel segment.

The HCM 2000 reduces the capacity of an intersection lane by 10% if it is located in an urban area where there are typically shorter sight distances, and narrower lanes and shoulders. The zipper lane barrier would reduce the total width of the westbound bore by 18 to 24 inches, thus reducing the capacities of these lanes (see Figures 3 and 4 below). So it seems reasonable that the tunnel (which we know affects travel speeds quite dramatically) would reduce the 1500 vph per lane capacity by 10% to 1350 vphpl, and reduce the corresponding speed at capacity to below 30 mph (or one-half the FFS). This finding also concurs with the research literature.

However, since the LOS reported by the HCM 2000 two-lane road analysis is insensitive to lane or shoulder width variations, it's not very useful for estimating tunnel lane capacities or zipper lane capacities with concrete barriers on both sides.

Using HCM 2000 to estimate the WB tunnel lane capacities without zipper lane

Since we know tunnels affect travel speeds quite dramatically, using the HCM 2000 general freeway section analysis is not very useful for estimating tunnel lane capacities. UCD did apply the HCM 2000 freeway section analysis to approximate the capacities of the Twin Tunnel lanes without the zipper lane barriers using the following specifications:

10% trucks and buses, 0% RV's (assumed RV's to be in the trucks and buses)
0 interchanges per mile
60 mph base free-flow speed (BFFS)
Rolling terrain, 2 lanes

If the lane and shoulder width assumptions reduce the FFS to below 55 mph, then the HCM does not report a LOS. By adjusting the assumptions, 3600 vph is roughly the break point between LOS E and F for constrained lane and shoulder width conditions.

Thus, a 10% reduction to 3240 vph total or 1620 vphpl seems about right to account for the tunnel effects. Again, the HCM is not well suited to estimating tunnel lane capacities. This finding also concurs with the research literature.

On the basis of the above investigations, UCD estimated that under normal operations, the capacity of the Twin Tunnels is approximately 1600 vph per lane, or 3200 vph for the each direction. The zipper lane would reduce the capacity of each lane in the westbound bore to about 1350 vph per lane because of the barrier effect on driver behavior and speeds. These capacity estimates are shown in Figures 3 and 4. It should also be noted that the zipper lane barrier will also reduce the capacity of the two westbound lanes when it is not installed but is paced to the side of the tunnel. This affect would affect all hours of the year that the zipper lane barrier is present in the tunnel.

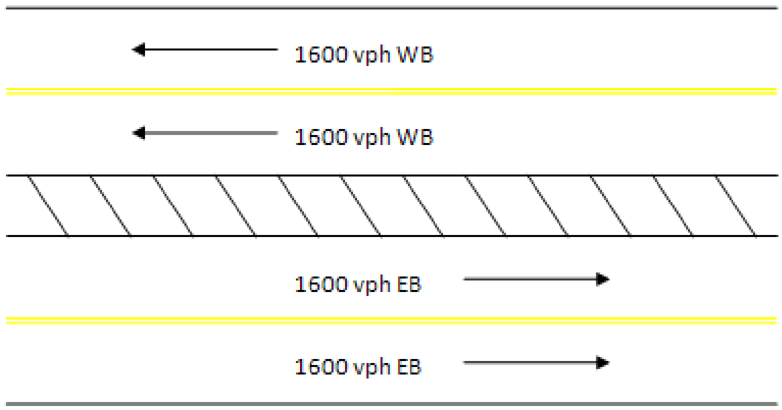

Figure 3: Lane Capacities and Direction in Twin Tunnels – No Zipper Lane

Because of the restrictions on westbound traffic during the hours of zipper lane operation, it is important to examine the history of traffic counts on I-70 near the Twin Tunnels on winter Sunday afternoons.

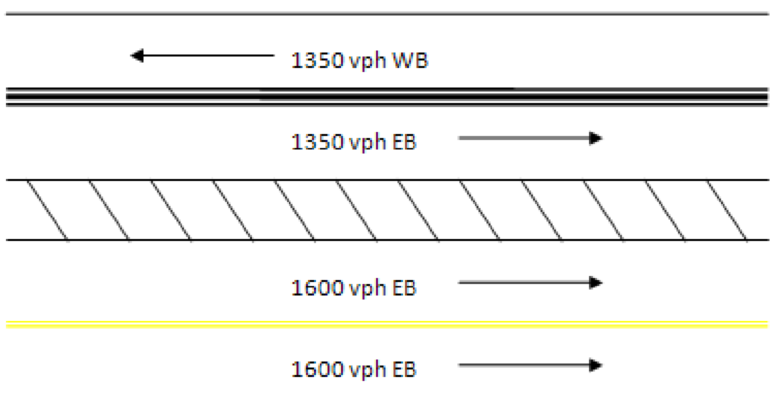

Figure 4: Lane Capacities and Direction in Twin Tunnels with Zipper Lane

3. ANALYSIS OF HISTORICAL TRAFFIC COUNTS

This section of the report presents a summary of Automatic Traffic Recorder (ATR) traffic counts provided by CDOT on I-70 between Idaho Springs and the Twin Tunnels recorded on Sundays from January 2004 through March 2010 (6.25 years). There were 325 Sundays, but only 236 were reported due to equipment errors. Of interest are the hours when WB volumes exceed 1350 vph (which is the estimated capacity of the remaining WB lane through the Twin Tunnels during zipper lane operation) while the EB volumes exceed 3200 vph (which are the hours when additional EB capacity is needed). Figure 5 below shows that I-70 volumes exceeded 3200 vph for EB and 1500 vph for WB capacities from 1:00 PM to around 5:30 PM on January 31, 2010 according to the observed counts.

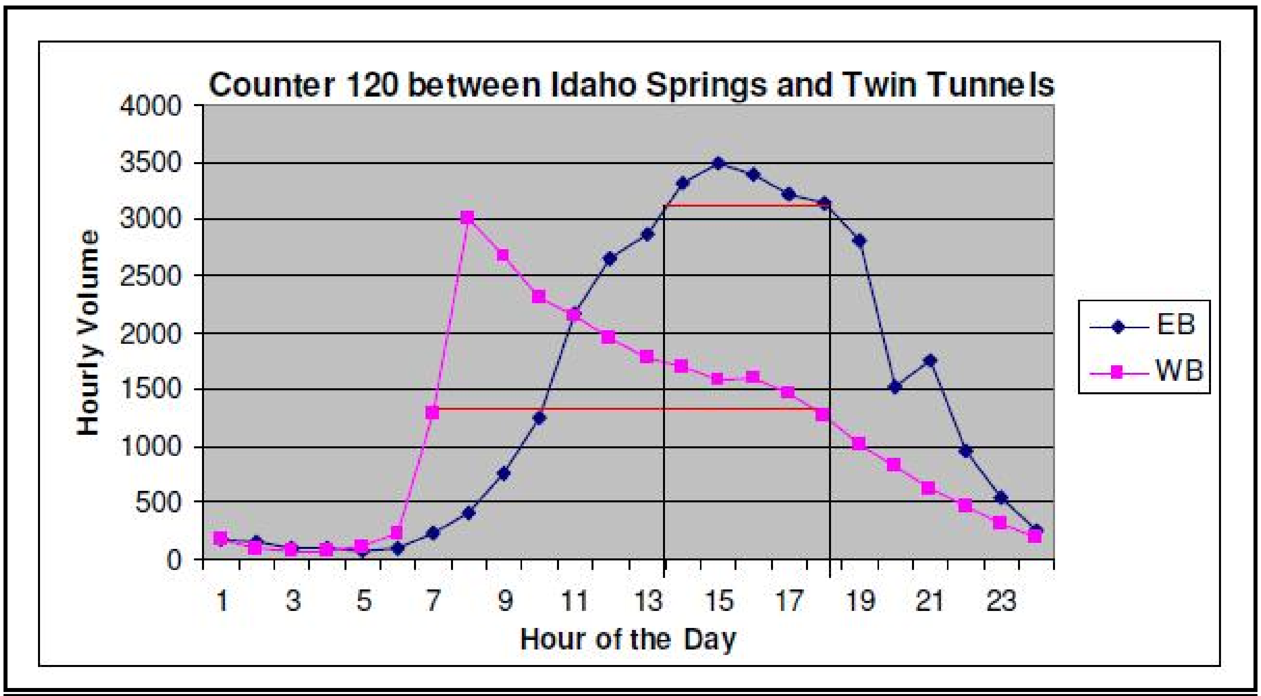

Figure 5: I-70 Volumes between Idaho Springs and the Twin Tunnels on January 31, 2010

These volumes represent just one Sunday in 2010, so an additional analysis of historical volumes was performed and the following observations were made:

- EB volume > 3200 vph on 108 out of 236 Sundays (46%) for a total of 267 hours (average 2.47 hours duration)
- Of those 267 hours, average EB volume = 3334 vph, maximum = 3710 vph

- 76 of those 108 Sundays (70%) were in winter months (mainly January – March, some in December)
- WB volume > 3200 vph on 31 out of 236 Sundays (13%) for a total of 33 hours (average 1.06 hours duration)
- Of those 33 hours, average WB volume = 3477 vph, maximum = 3836 vph
- All 31 Sundays in winter months (January – March)
- WB volume > 1350 vph on 218 out of 236 Sundays (92%) for a total of 1481 hours (average 6.8 hours duration)
- Of those 1481 hours, average WB volume = 1828 vph, maximum = 3836 vph
- 116 of those 218 Sundays were in winter months (mainly January – March, some in December)
- WB volume > 1350 vph and EB volume > 3200 vph on 67 Sundays for a total of 148 hours (average 2.2 hours duration)
- Of those hours, average WB volume = 1605 vph, and average EB volume = 3320 vph
- 37 of those 67 Sundays were in winter months (January – March).

Figures 6-19 show representative volumes on Sundays throughout this 6.25 year period of analysis. (*These figures were part of a course project report by Markos Atamo and used with his permission.*) The sudden increase in WB traffic volumes each Sunday morning is due to skiers wanting to reach the slopes when the lifts open. EB traffic volumes increase as skiers depart the slopes from midday until the lifts close, then they gradually decline. The volumes shown in these graphs are not “travel demands” in that they are restricted by the capacity of the Twin Tunnels in both directions. Based on the several tunnel research articles, the tunnel capacity used in this study without the zipper lane installed was estimated to be 1600 vphpl.

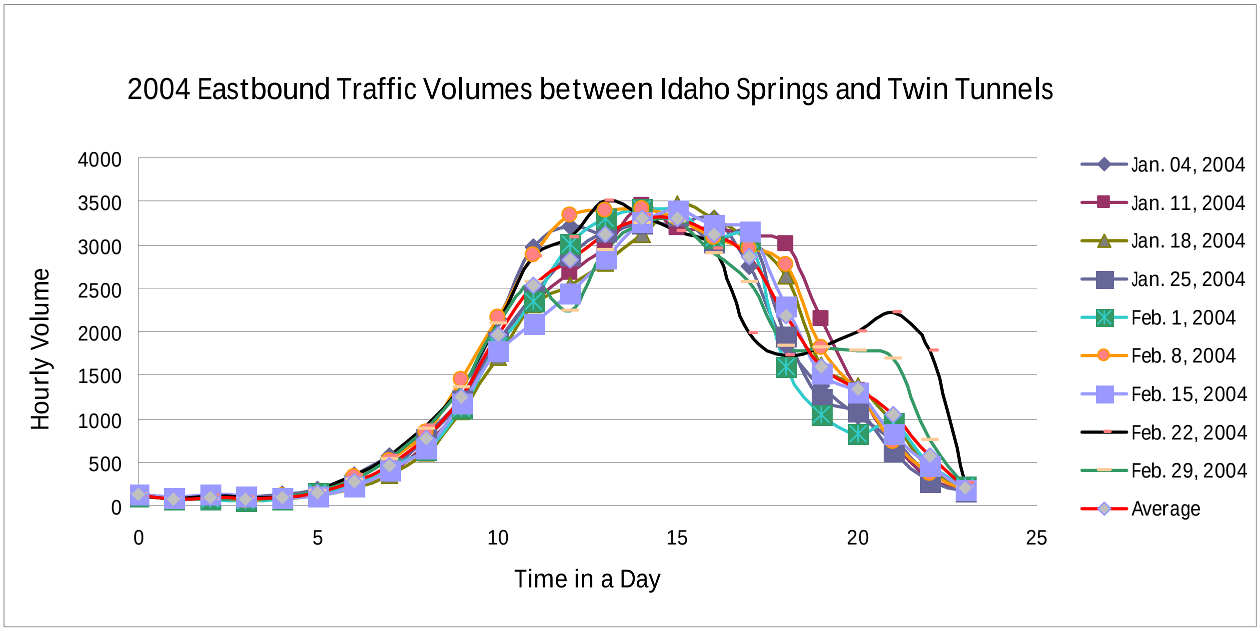

Figure 6: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2004

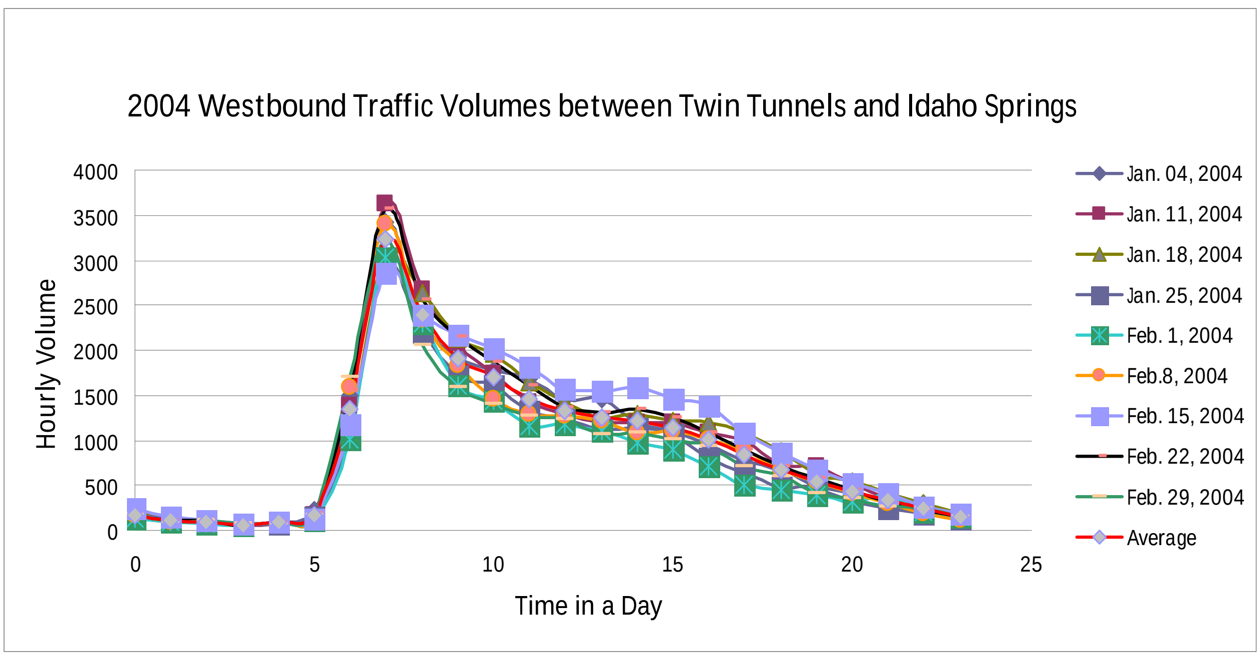

Figure 7: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2004

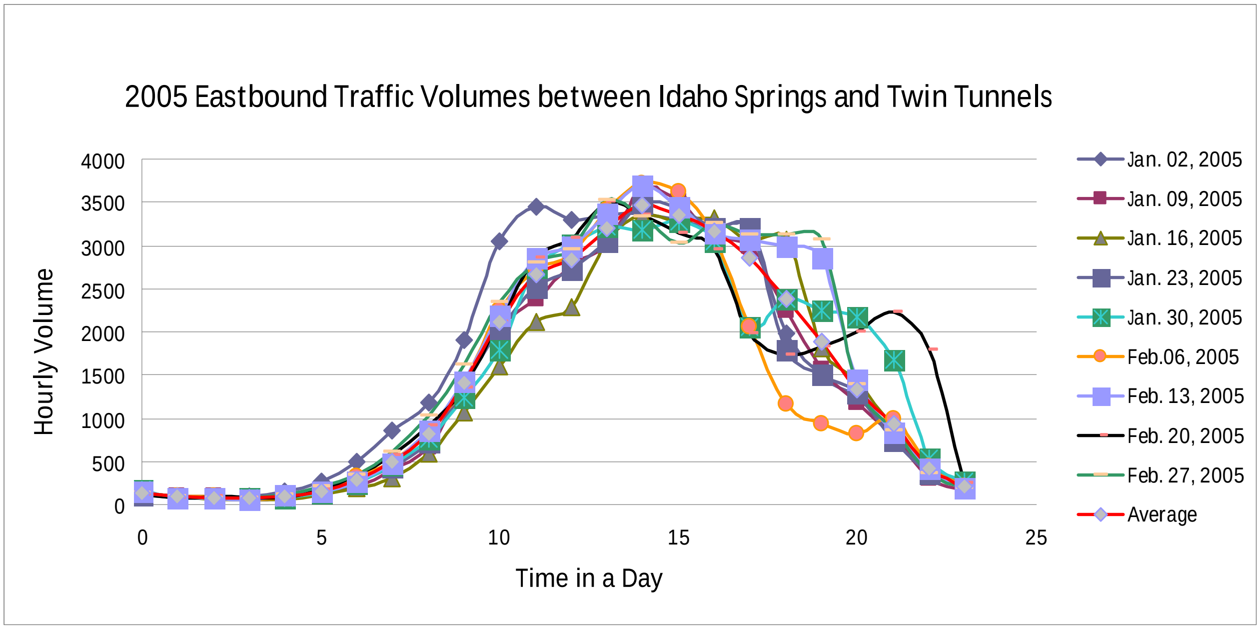

Figure 8: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2005

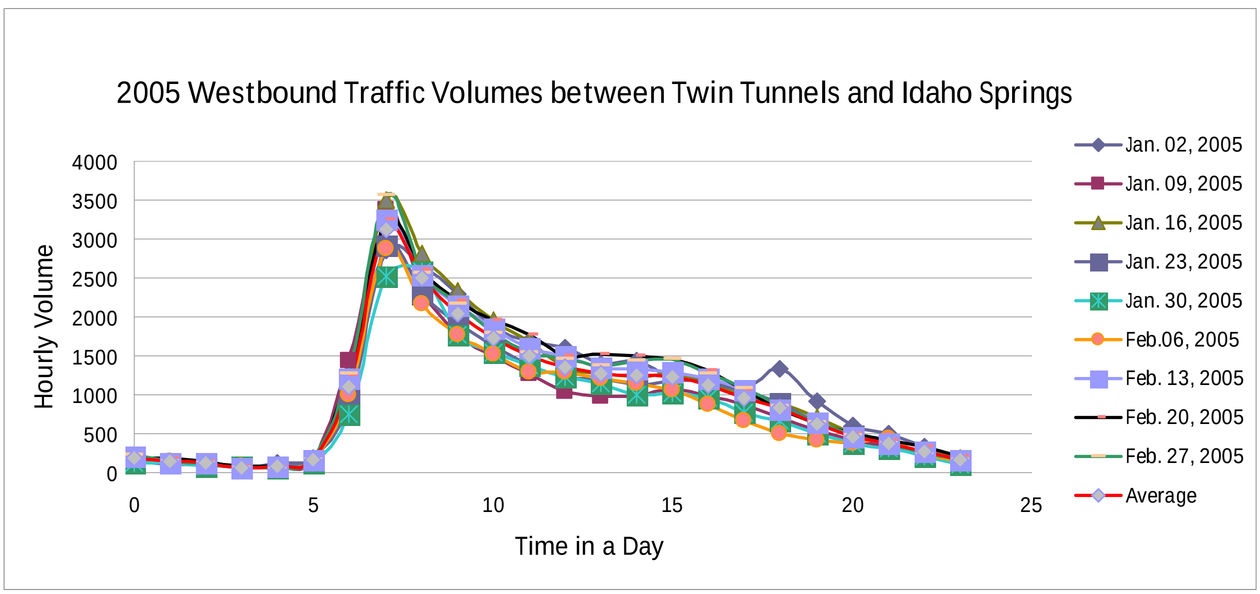

Figure 9: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2005

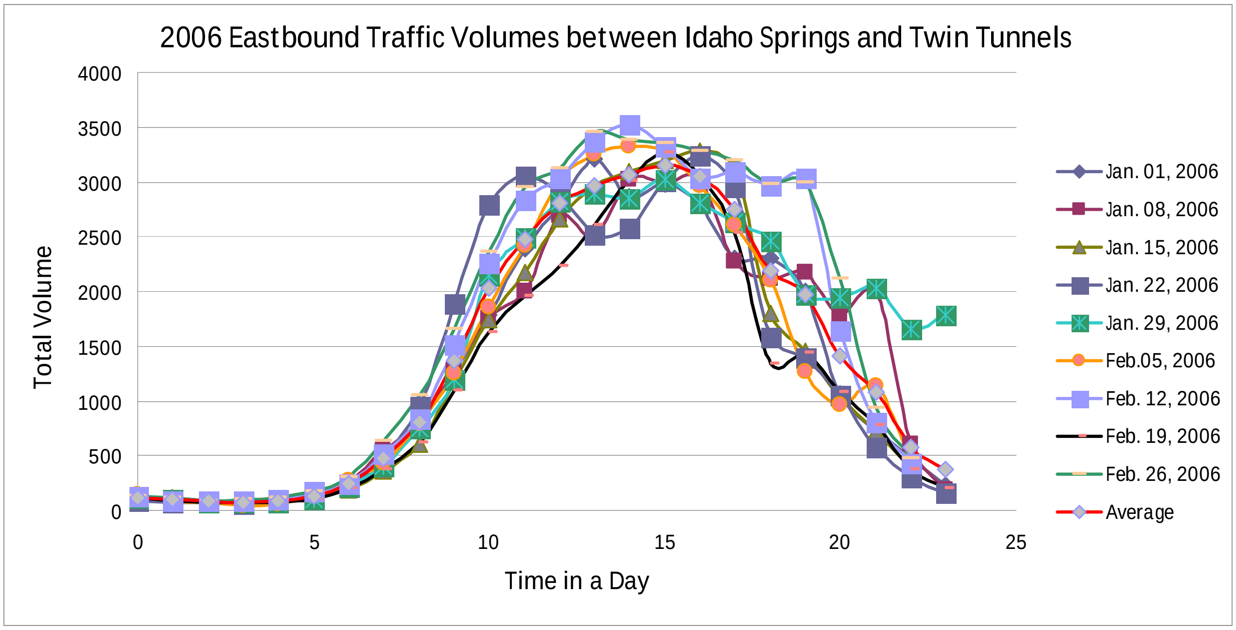

Figure 10: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2006

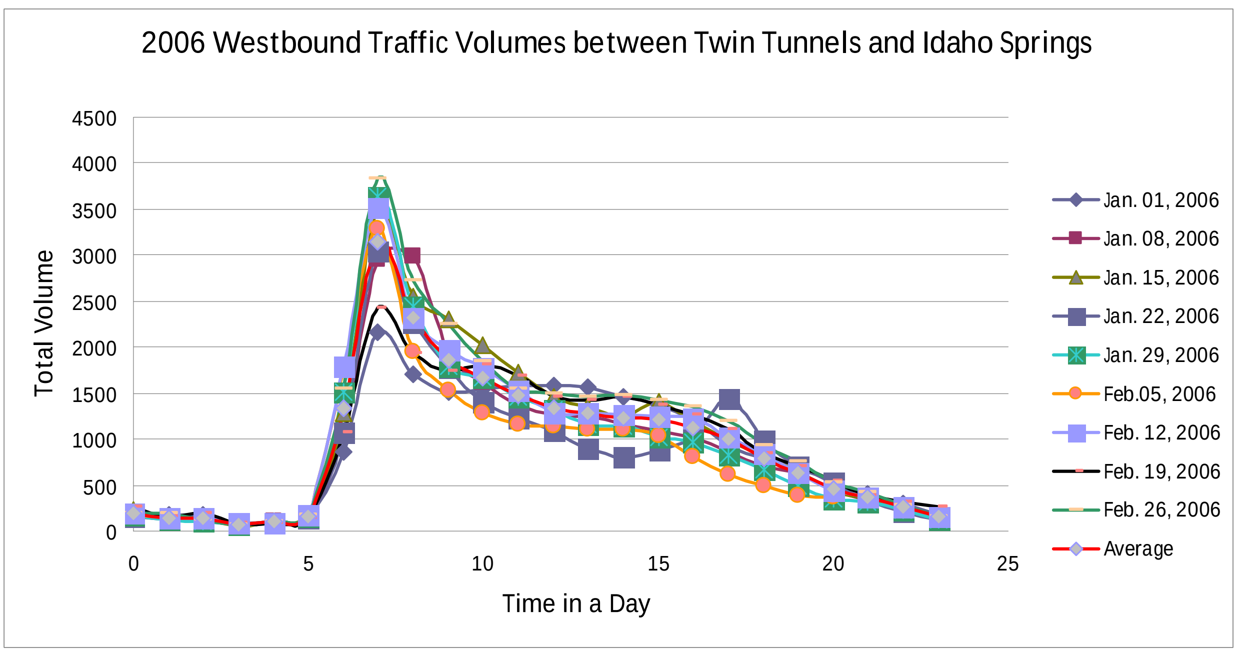

Figure 11: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2006

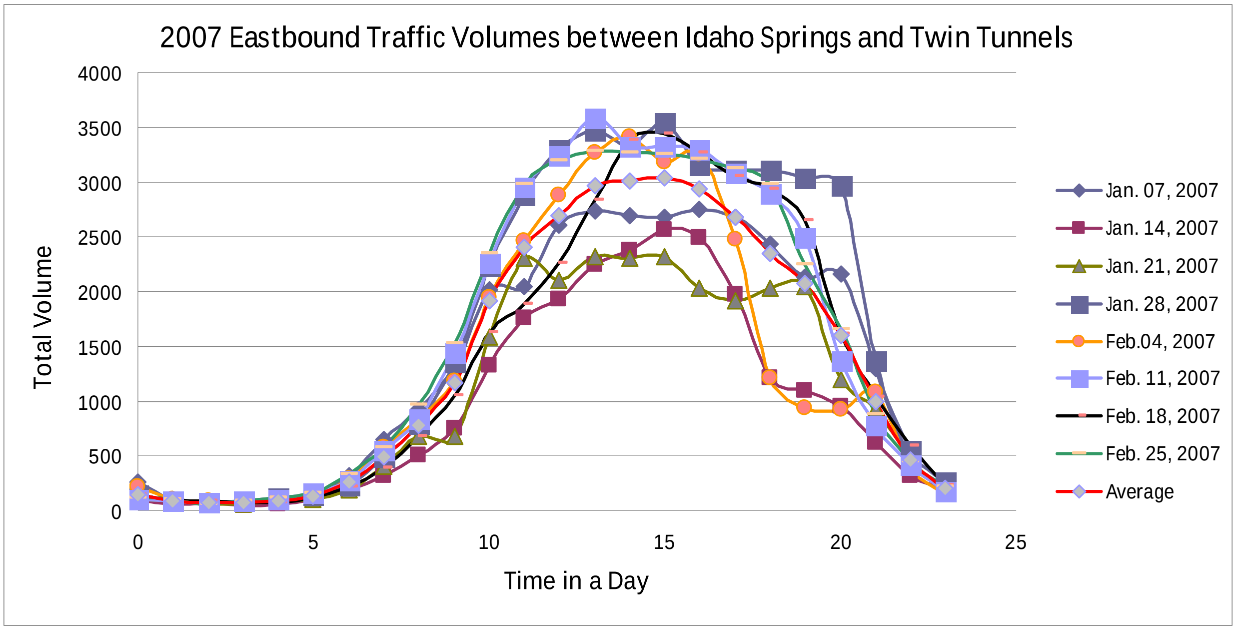

Figure 12: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2007

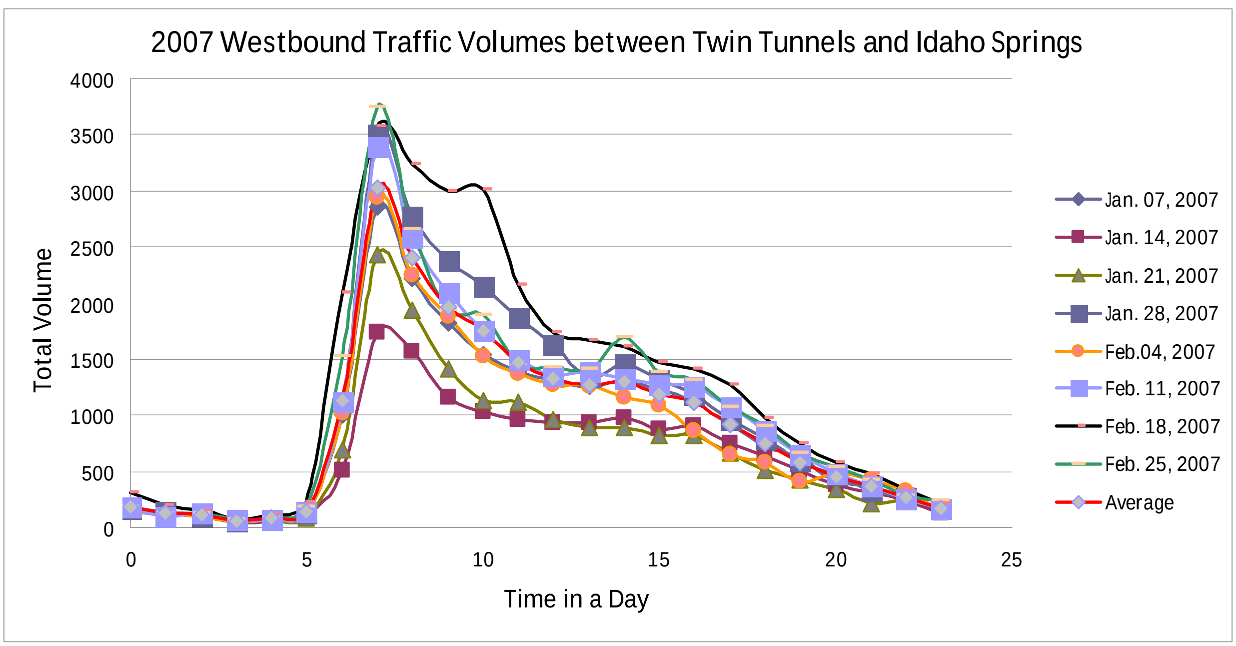

Figure 13: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2007

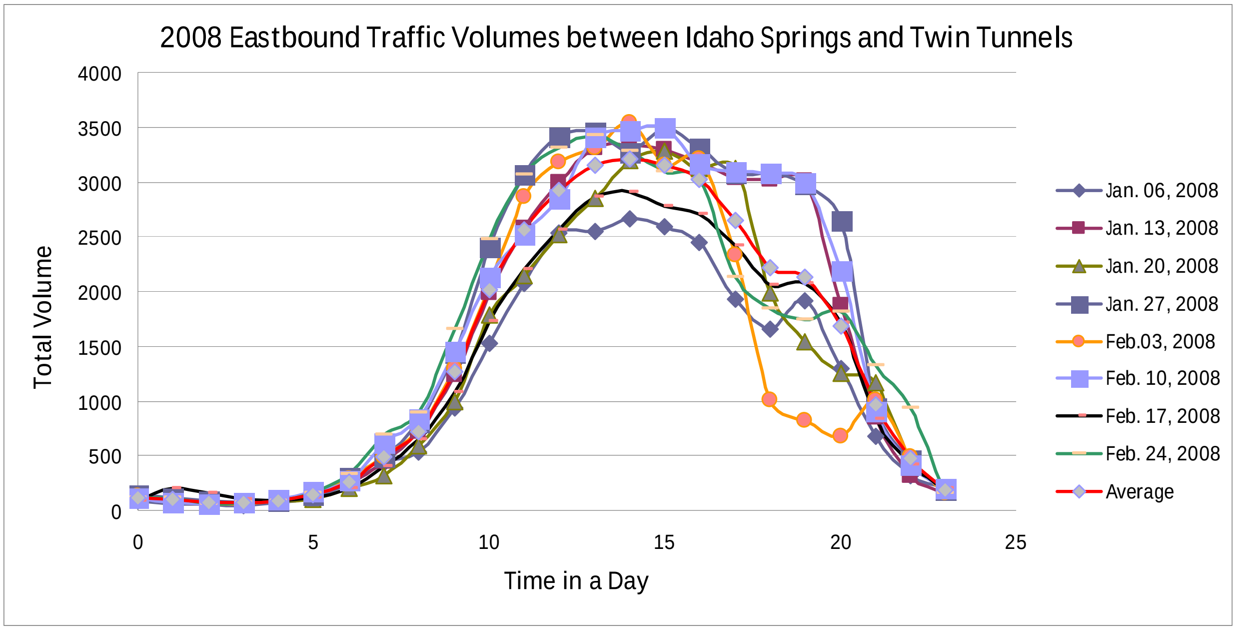

Figure 14: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2008

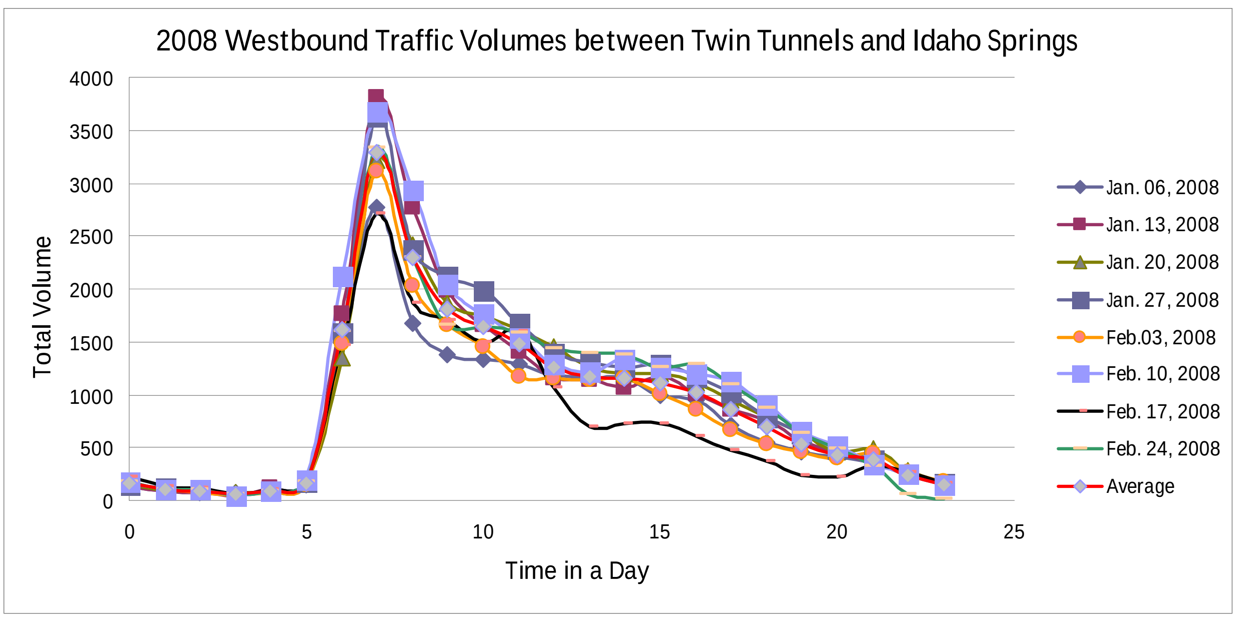

Figure 15: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2008

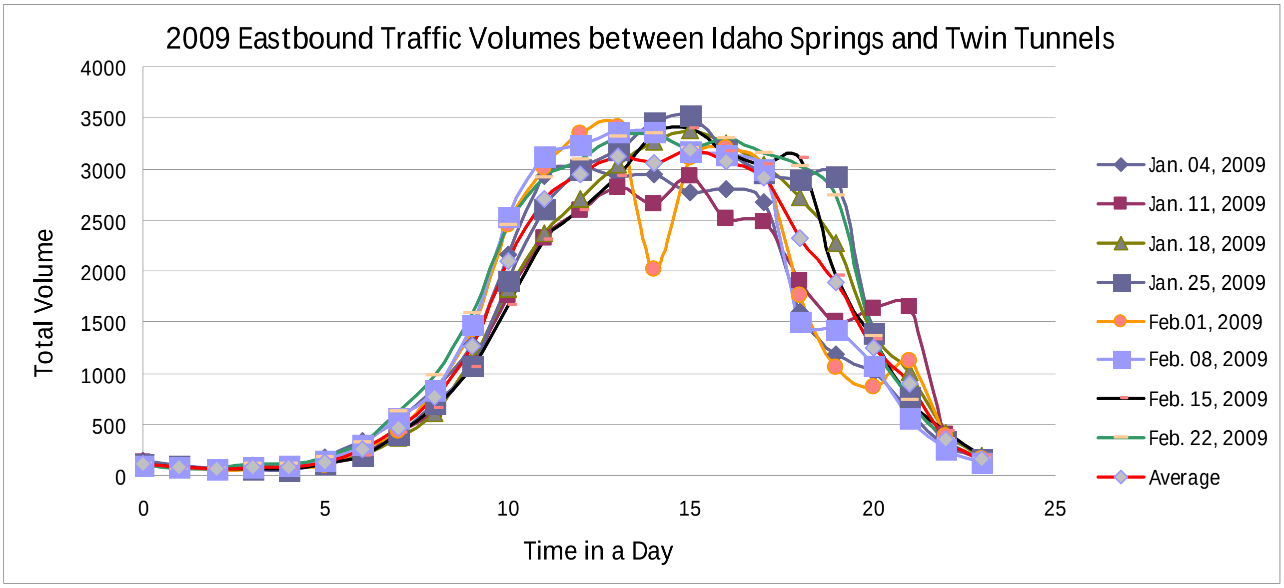

Figure 16: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2009

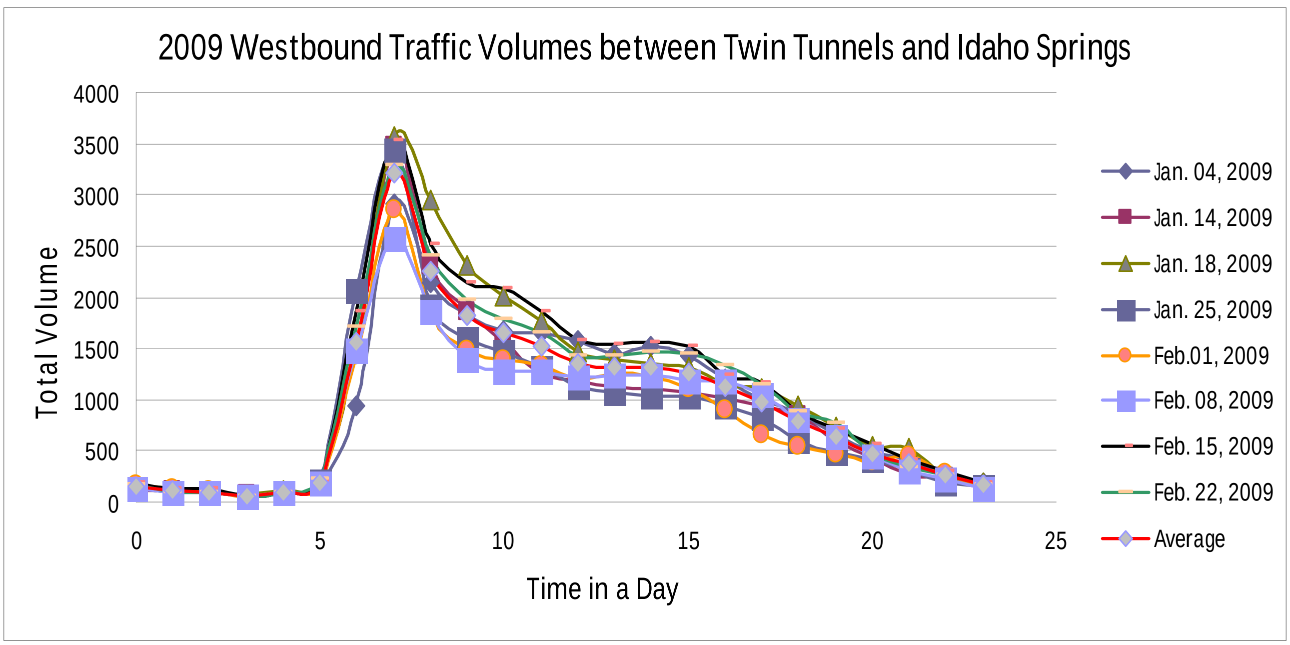

Figure 17: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2009

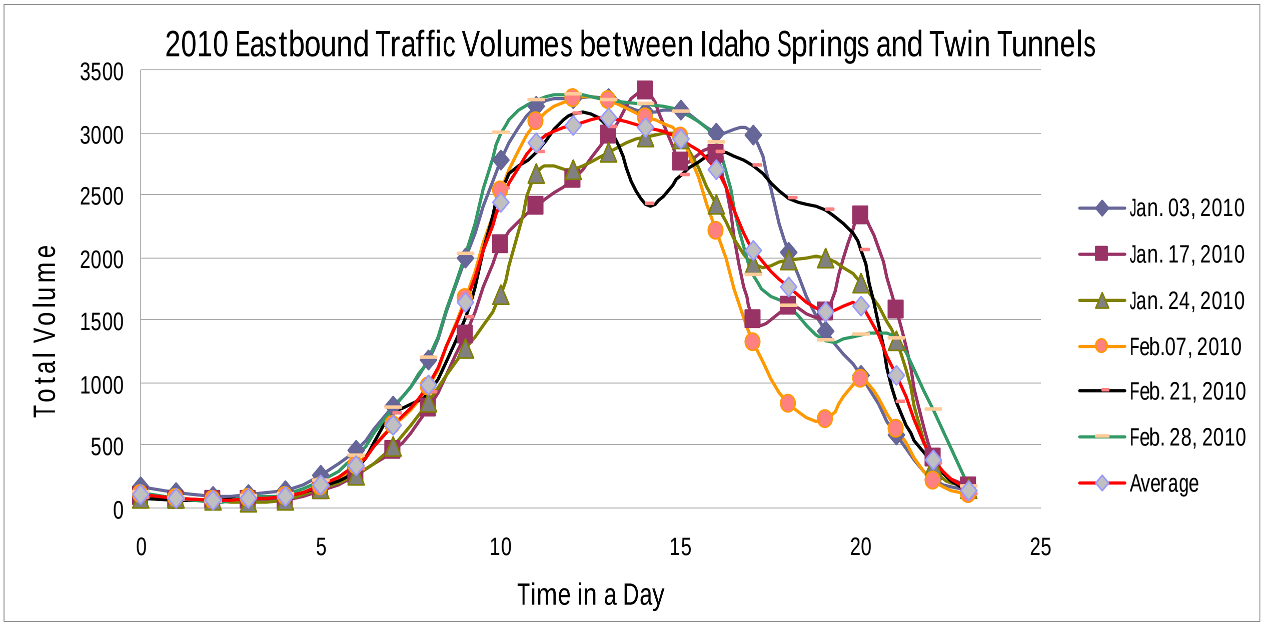

Figure 18: EB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2010

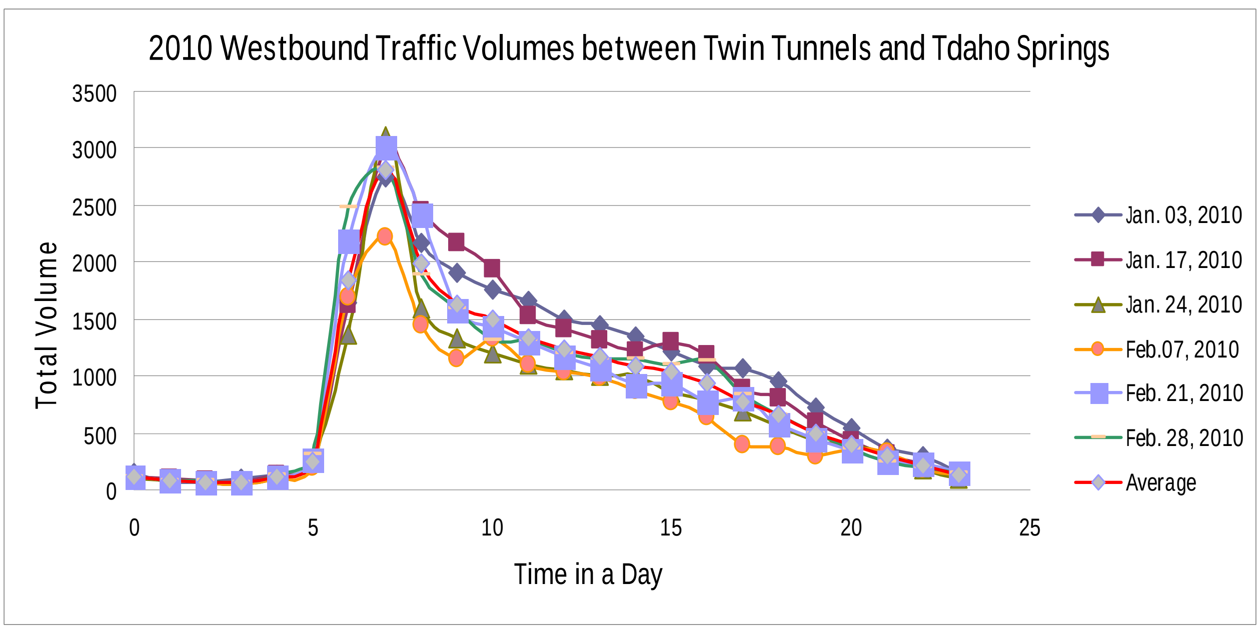

Figure 19: WB Volumes between Idaho Springs and the Twin Tunnels on Sundays in 2010

A review of these volumes for the years shows that they consistently exceeded the capacities of 1350 vph in the WB direction and 3200 vph in the EB direction from 1:00 PM to around 5:30 PM on winter Sunday afternoons according to 6.25 years of observed counts.

Additional observations of the historical counts are the following:

Only 236 of 325 Sundays recorded Jan ’04 – Mar ‘10

- Only 142 Sundays in the period November thru April
- 1278 hrs between noon and 9 PM on 142 Sundays

WB Volumes < 1000 vph

- 563 hours (44%)
- 142 Sundays (100%)
- avg. volume = 671 vph
- avg. duration = 4.0 hrs

WB Volumes ≥ 1000 vph and < 1350 vph

- 451 hours (35%)
- 132 Sundays (93%)
- avg. volume = 1169 vph
- avg. duration = 3.4 hrs

WB Volumes ≥ 1350 vph and < 1600 vph

- 191 hours (15%)
- 74 Sundays (52%)
- avg. volume = 1435 vph
- avg. duration = 2.6 hrs

WB Volumes ≥ 1600 vph

- 73 hours (6%)
- 25 Sundays (18%)
- avg. volume = 1792 vph
- avg. duration = 2.9 hrs

4. VISSIM MICRO-SIMULATION OF I-70 OF THE ZIPPER LANE SECTION PLUS 10 MILES

The UCD research team built a VISSIM simulation model for this analysis entirely from the beginning without so as to be confident of each aspect of the model runs. The VISSIM model was built to include five additional miles on each end beyond the zipper lane section so that all queuing delay with or without the zipper lane installed would be captured in the travel times. Volume and speed calibrations for the base case were performed after the VISSIM model was completed. Observed counts collected by CDOT on the I-70 main lanes with some ramp counts from an earlier study by J.F. Sato were used to calibrate the model parameters for the base case representing January 31, 2010. For calibration, we required percent differences from the observed volumes to be less than five percent. Figures 20 and 21 depict those volume comparisons used for calibration at the mile points along this section of I-70.

The VISSIM model uses vehicle inputs at the start of the network and at the on ramps, plus routing decisions throughout the network to determine vehicle flows. The VISSIM simulation is controlled by several parameters affecting driving behavior, car following distances, desired speeds, gap acceptance rules, acceleration and deceleration characteristics, and lane changing maneuvers. The characteristics of each vehicle type are also defined including passenger cars and several truck classes, which affect the model results such as lane changing, queuing, and weaving.

The baseline vehicle inputs used for our analyses are shown in Table 1. All VISSIM runs were made for the analysis period of noon to 9 PM with a 2-hour “warm up” period prior to noon to load the network adequately with representative travel volumes. The simulations reported here did not include the option of dynamic traffic assignment to alternative paths. The animation was reviewed for queue lengths and lane changing maneuvers. Reviewing the visualization of the model is one of the key means to determine whether the model is realistic or unrealistic.

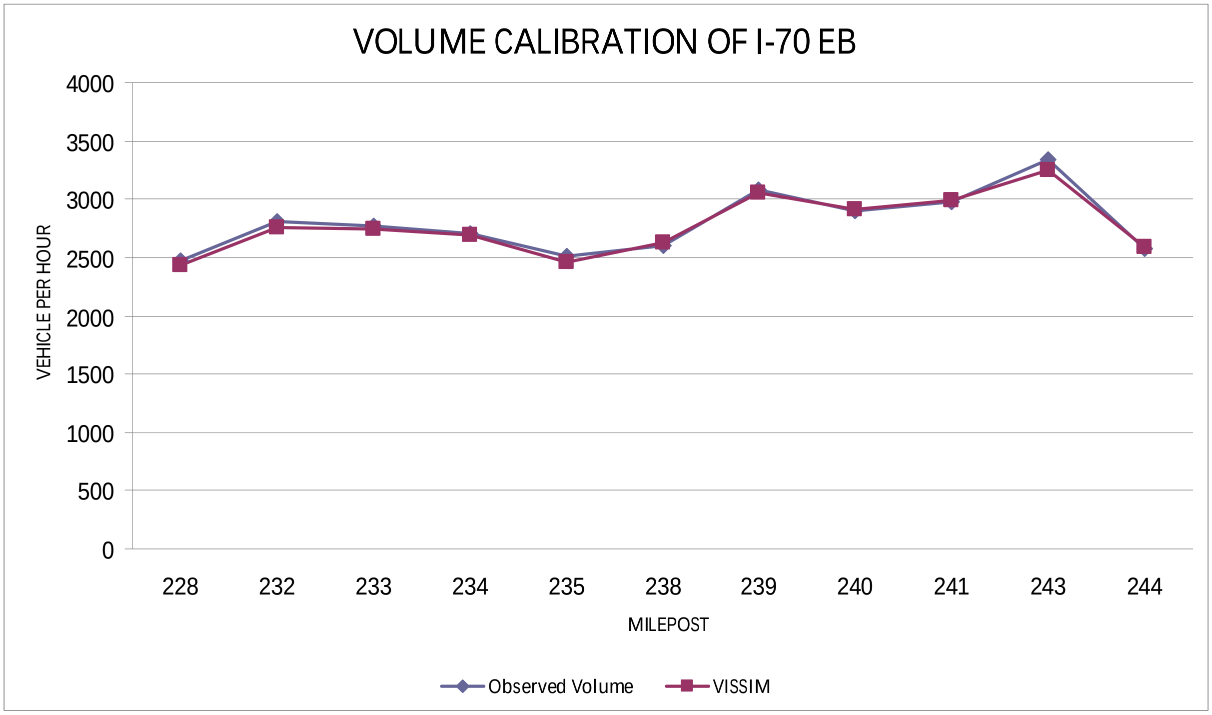

Figure 20: EB Volumes between Georgetown and Floyd Hill used for Calibration

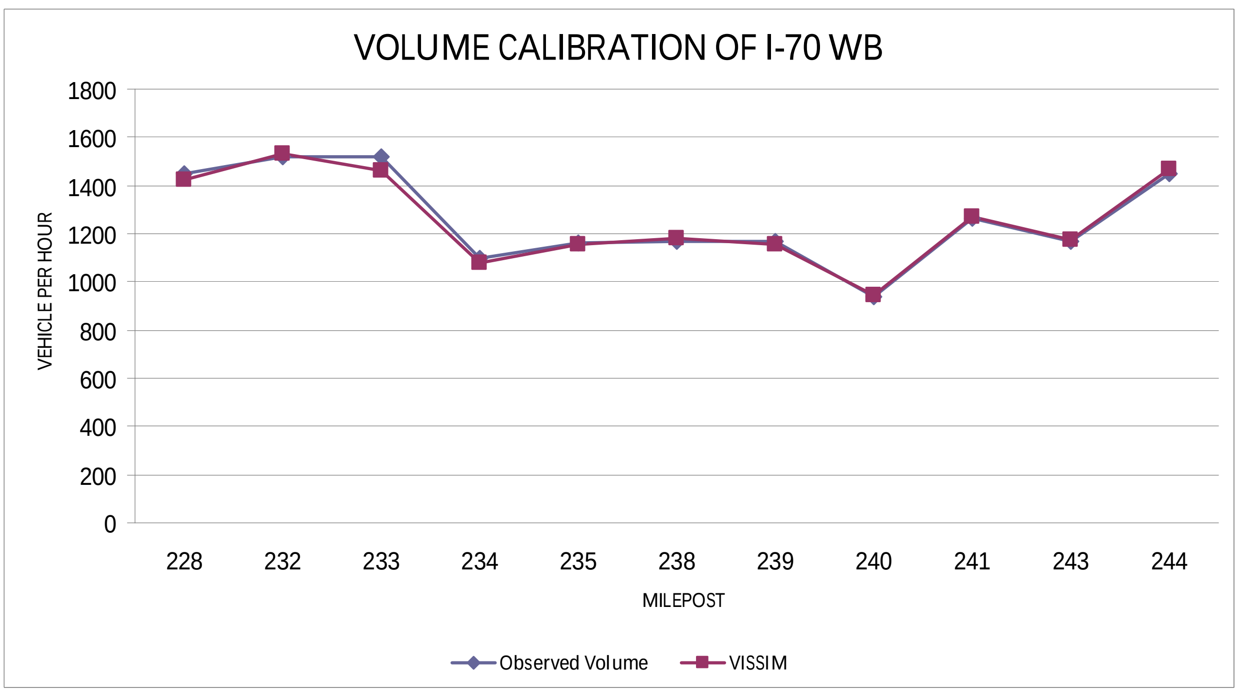

Figure 21: WB Volumes between Georgetown and Floyd Hill used for Calibration

Table 1: Baseline Vehicle Inputs

Link No.	Link Name	0 - 3600	3600 - 7200	7200 - 10800	10800 - 14400	14400 -18000	18000 - 21600	21600 - 25200	25200 -28800	28800- 32400
1	Start I-70 EB	2755	2428	2981	1847	1692	2111	2397	2088	1443
4	EB On-Ramp 228	551	776	569	877	1001	720	322	233	8
8	EB On-Ramp 232	142	167	203	138	119	99	78	59	39
14	EB On-Ramp 234	31	16	132	58	50	47	12	20	6
16	EB On-Ramp 235	63	70	188	135	109	70	89	36	10
20	EB On-Ramp 238	3	6	156	638	476	452	173	423	763
26	EB On-Ramp 240	547	742	606	941	713	633	550	317	189
30	EB On-Ramp 241	545	605	606	481	517	598	410	247	297
36	EB On-Ramp 243	58	103	120	91	78	67	54	48	40
39	Starting WB I-70	1764	1787	1861	1761	1619	1336	1059	625	517
106	WB On-Ramp 244	110	112	113	110	105	105	105	108	108
47	WB On-Ramp 243	227	212	215	196	200	205	165	141	143
55	WB On-Ramp 241	177	145	104	144	120	102	82	66	38
59	WB On-Ramp 241	83	84	119	90	70	72	46	36	33
63	WB On-Ramp Colorado Blvd-239	15	6	10	3	3	14	5	2	2
67	WB On-Ramp 238	46	53	59	54	56	43	35	16	16
73	WB On-Ramp 234	530	583	545	636	530	424	339	318	212
75	WB On-Ramp 234-Trucks	198	179	150	127	138	174	163	139	139
79	WB On-Ramp 232	106	95	136	129	83	69	47	35	25
83	WB On-Ramp 228	12	17	26	25	11	11	3	2	2

The proportion of trucks significantly affects traffic operations on I-70 because the hilly terrain causes them to travel at lower speeds. Heavy vehicles in this study were divided into three classifications (single unit, medium, and heavy trucks), which together comprise 10 percent of the vehicle composition in this corridor. This percentage agrees with CDOT data showing that single unit, medium and heavy trucks, between 35 and 60 ft long, comprise approximately 10 percent of the vehicle mix composition in this corridor.

Desired speed distribution in this VISSIM model divided into two types: passenger car is between 50 – 70 mph and truck is between 40 – 60 mph when vehicles travel during free flow condition. However, the congestion dictates by the vehicle behavior itself including grade and number of vehicle.

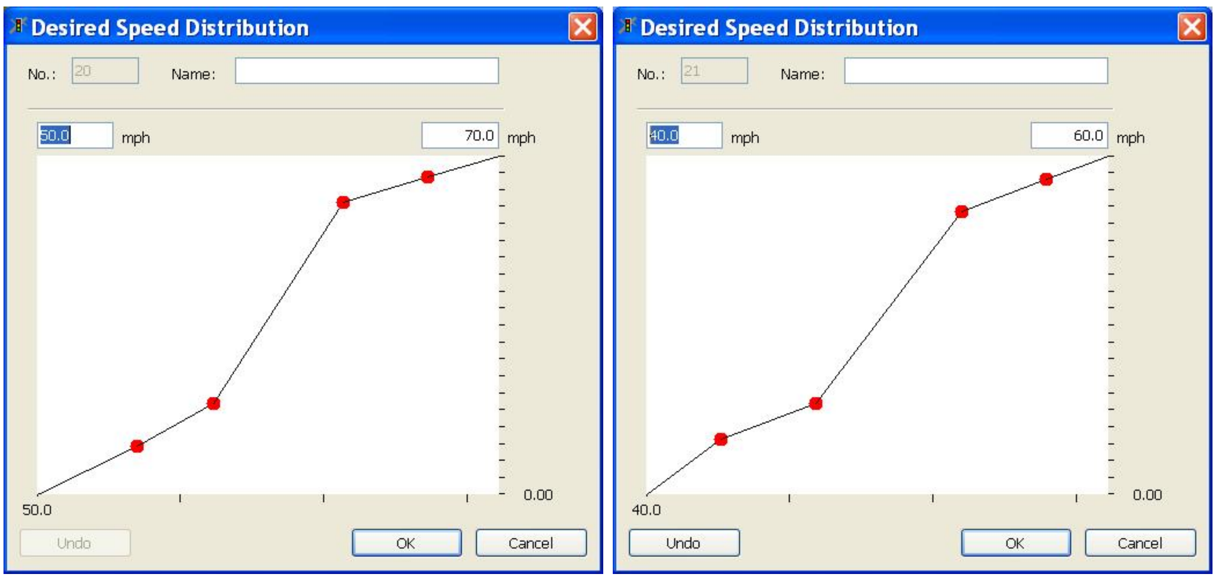

Figure 22: VISSIM Desired Speed Distribution

5. SUMMARY OF BASELINE SCENARIO RESULTS

The following results represent the baseline case for January 31, 2010. The travel times reported are for the entire zipper lane section plus 5 miles on each end to capture all queuing delays in both directions of travel. The average travel times are weighted by the numbers of vehicles traveling the entire length of the 25-mile section. These numbers of vehicles are lower than link volumes at any given location of the 25-mile section, since many vehicles entire and exit along the way. The baseline simulation resulted in an average travel time of 79 minutes in EB direction and 34 minutes in the WB direction for the entire 25-mile section. Travel times are shown in Table 2 and Figure 22 by time at which vehicles first enter this section of highway and include all queuing delays. The EB travel time reaches a maximum of 91.31 minutes (approximately 1.5 hours) for vehicles entering this section at 4:00 PM.

Table 2: Results of Baseline Scenario Simulation

Time of Day	Travel Time Minutes	# of Vehs	TT * Vehs Hours	Travel Time Minutes	# of Vehs	TT * Vehs Hours
	EB			WB		
1:00	59.39	989	979	35.33	389	229
2:00	72.31	1047	1262	35.38	448	264
3:00	87.22	924	1343	34.77	466	270
4:00	91.31	940	1431	33.16	421	233
5:00	84.15	1119	1569	33.68	401	225
6:00	79.60	1470	1950	30.24	221	111
7:00	81.54	1569	2132	29.90	147	73
8:00	74.98	595	744	29.32	107	52
Total		8653	11410		2600	1458
Weighted Average Travel Time (hours)			1.32			0.56
Weighted Average Travel Time (minutes)			79.11			33.64

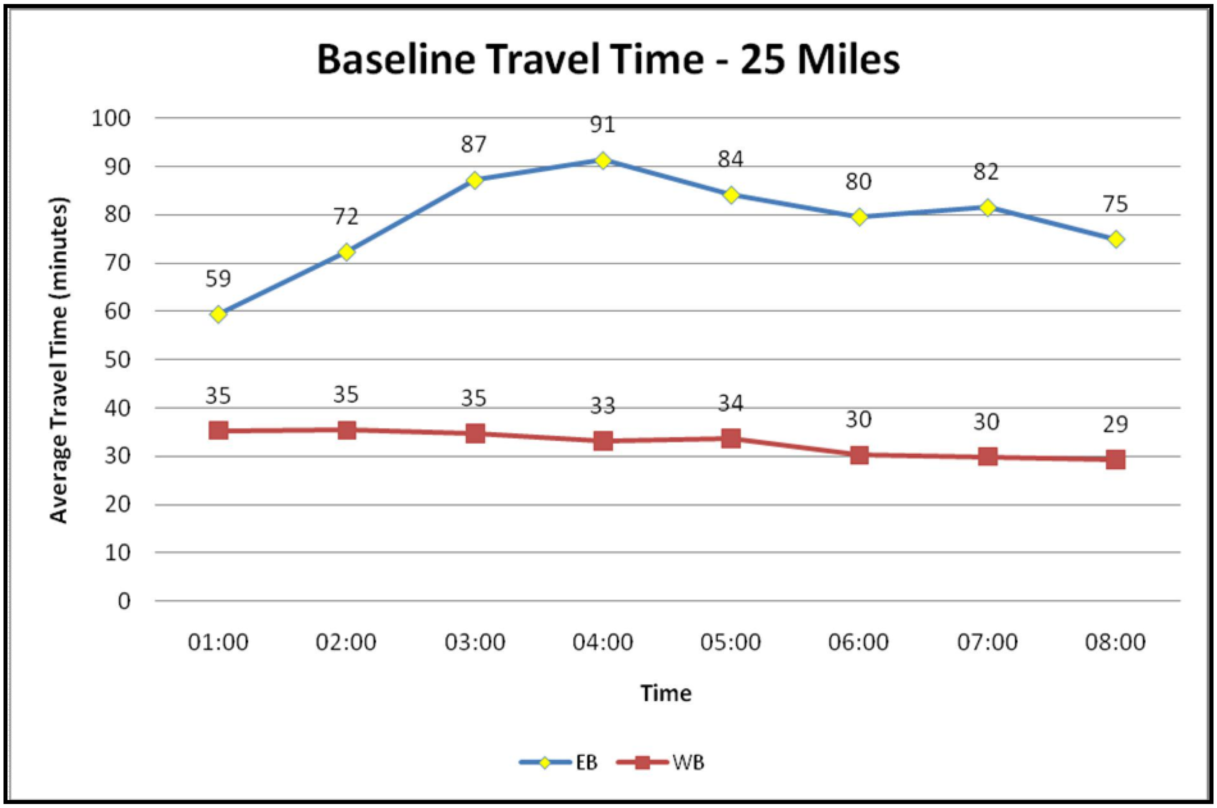

Figure 23: Baseline Scenario Travel Times for the Entire 25 Mile Section

EB travel speeds are shown in Figure 23 and WB travel speeds are shown in Figure 24. Note that EB travel speeds are in the low 10 to 15 mph range for most of the 14 mile section where the zipper lane would be installed. These low speeds are due to queuing that begins at the Twin Tunnels. WB travel speeds remain in the 50 to 55 mph range for much of this section, but WB speeds are slower in areas where grades cause the heavier trucks to slow down. The speed increases back up to the normal range after 5 PM when demand decreases.

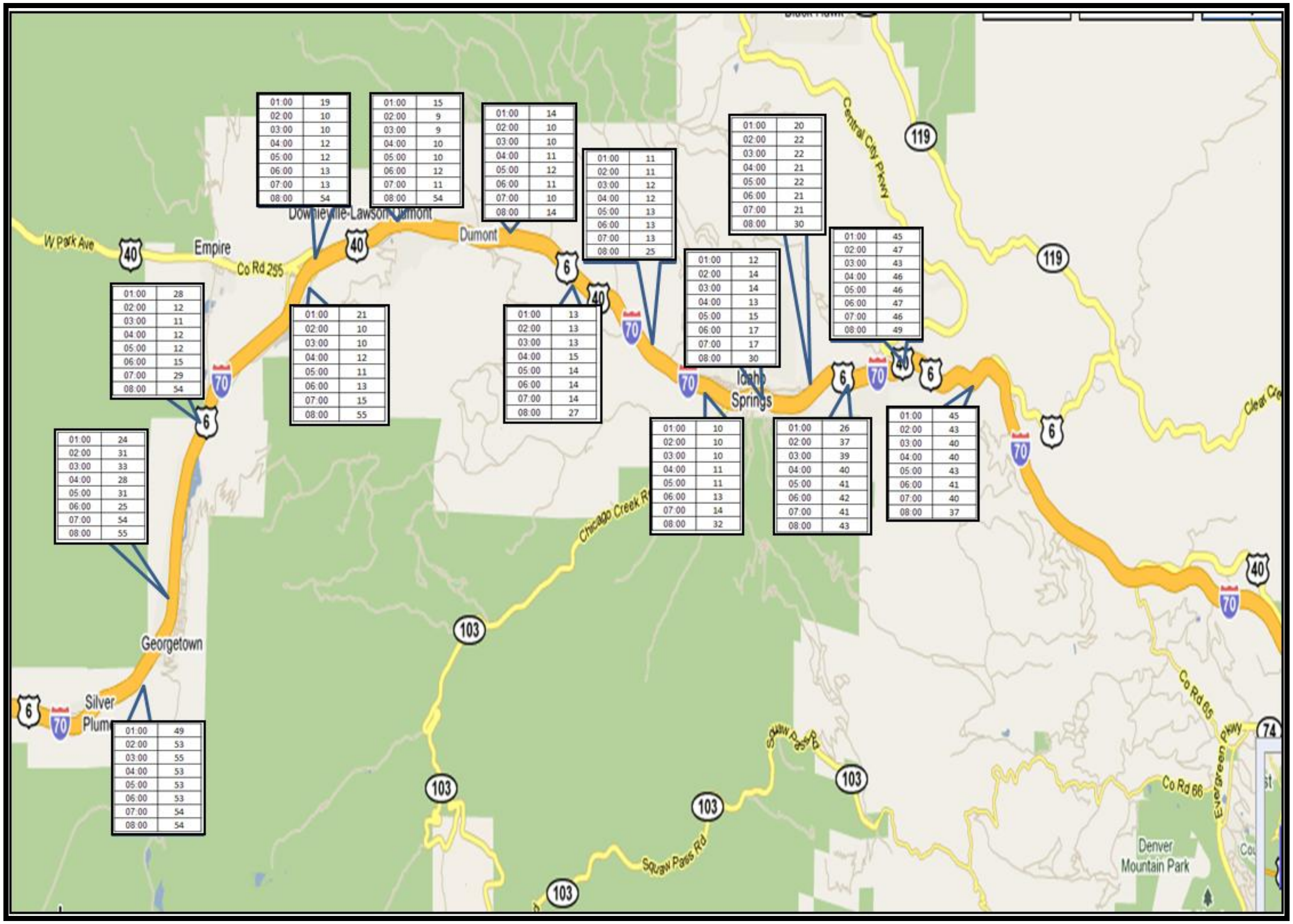

Figure 24: Baseline Scenario Travel Speeds (mph) for the Eastbound Direction

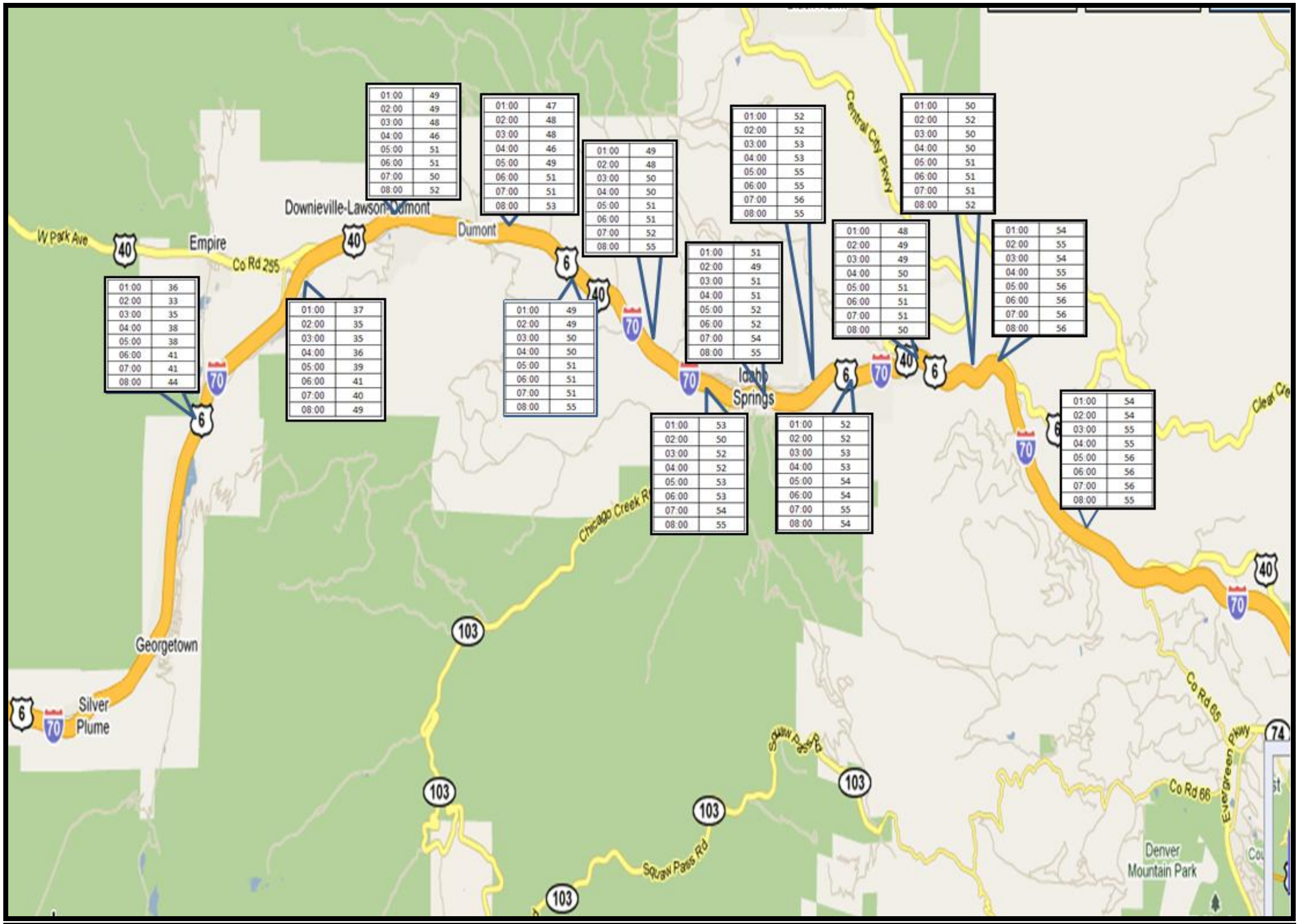

Figure 25: Baseline Scenario Travel Speeds (mph) for the Westbound Direction

6. SUMMARY OF ZIPPER LANE SCENARIO RESULTS

The reversible lane option simulated was to install the zipper lane in the EB direction from MP 230.5 east of Empire Junction to MP 244 near the base of Floyd Hill. The zipper lane reduces the number of WB lanes from two to one lane along this same 15-mile section from its ingress point on the west end to its egress point on the east end.

Two scenarios using the zipper lane were run. (1) all vehicles allowed to use both the zipper lane and the general purpose lanes in the EB direction and all vehicles allowed to use the one WB lane, and (2) no trucks allowed to use the zipper lane in the EB direction and no trucks allowed to use the one WB lane. Hence, no truck travel is allowed in the WB direction in this second scenario, but trucks can still travel in the EB direction using the two regular general purpose lanes.

The vehicle inputs for the zipper lane case are the same as for the baseline input, except the EB volumes entering the zipper lane were assumed to distribute themselves evenly across the three lanes as shown in Table 3.

Table 3: Zipper Lane Vehicle Inputs

Time of Day	Zipper Lane	EB-Two lanes
01:00	1041	2038
02:00	1003	1969
03:00	1082	2043
04:00	876	1584
05:00	883	1555
06:00	904	1675
07:00	877	1735
08:00	756	1500
09:00	434	859

The EB and WB input volumes are shown in Figures 25 and 26, respectively, at the start of the zipper lane and at the Twin Tunnels. Volumes at the Twin Tunnels are higher because of traffic entering I-70 after the start of the zipper lane. Eastbound volumes in particular increase at the on-ramps to I-70 at both Empire Junction and Idaho Springs.

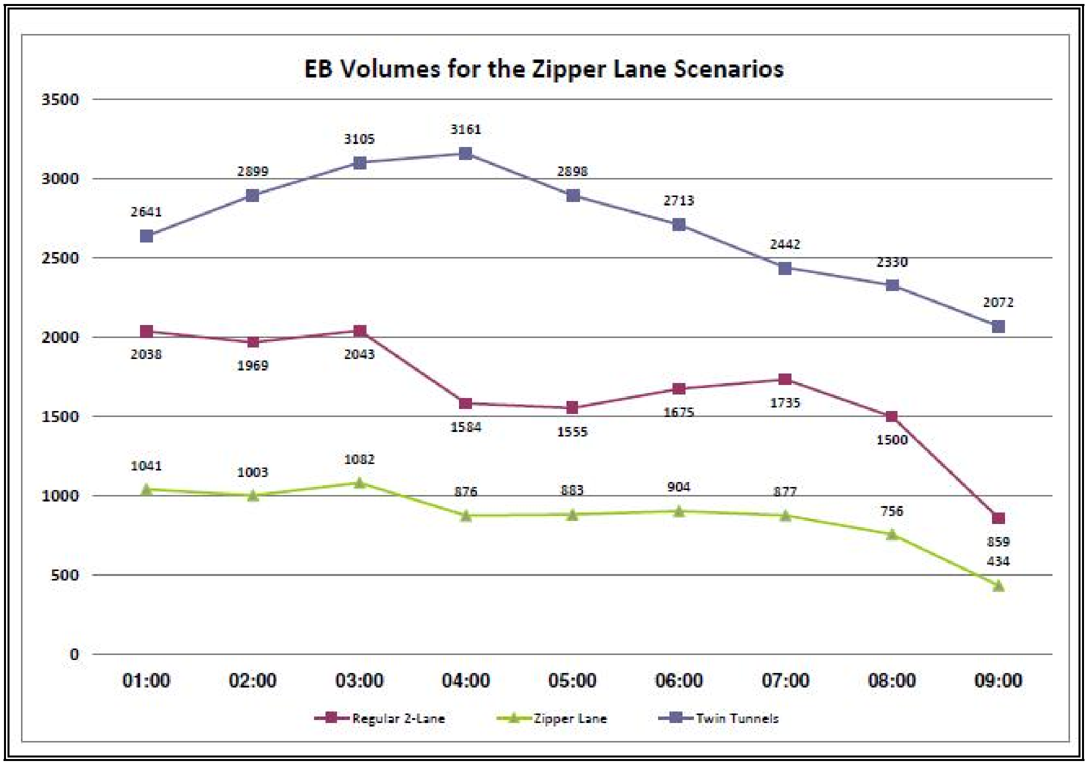

Figure 26: Eastbound Volumes for the Zipper Lane Scenarios

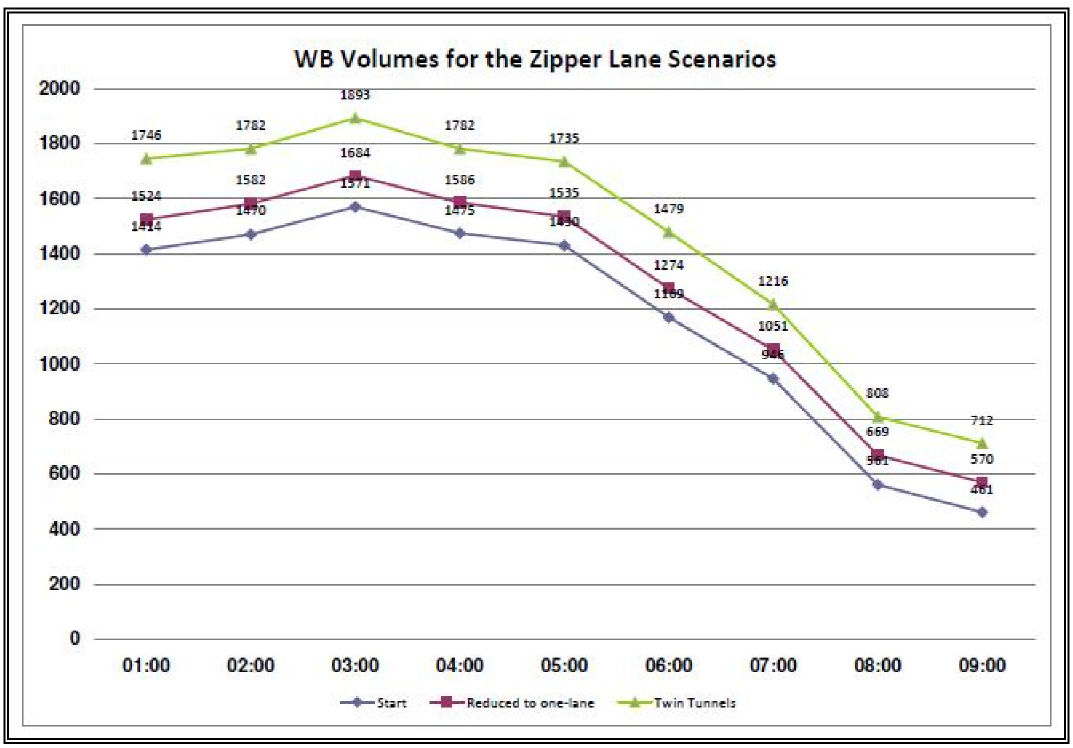

Figure 27: Westbound Volumes for the Zipper Lane Scenarios

These two zipper lane scenarios (with and without truck restrictions) resulted in the following average travel times:

(1) All Vehicles Allowed in All Lanes - The average travel time was 41 minutes in the EB direction and 69 minutes in the WB direction for all vehicles combined for the full 25 miles analyzed in each direction. For just the 15-mile section of the zipper lane, the average EB travel time was 22 minutes for vehicles that used the zipper lane and 24.5 minutes for vehicles that used the two general purpose lanes.

(2) Trucks Restricted from Zipper Lane and No WB Trucks - The average travel time was 40 minutes in the EB direction and 60 minutes in the WB direction for all vehicles combined for the full 25 miles analyzed in each direction. For just the 15-mile section of the zipper lane, the average EB travel time was 19 minutes for vehicles that used the zipper lane and 25.5 minutes for vehicles that used the two general purpose lanes.

By comparison, the baseline simulation resulted in an average travel time of 79 minutes in eastbound direction and 34 minutes in the westbound direction.

6.1 SUMMARY OF ZIPPER LANE RESULTS WITH ALL VEHICLES ALLOWED IN ALL LANES

With all vehicles allowed in all lanes, average travel times for the full 25 miles were 41 minutes in the EB direction and 69 minutes in the WB direction. For just the 15-mile section of the zipper lane, the average EB travel time was 22 minutes for the zipper lane and 24.5 minutes the two general purpose lanes.

Travel speeds in the westbound direction are also impacted by the narrower lane width and lower capacity of the Twin Tunnels with the zipper lane barriers installed. Merge and diverge movements at the on and off ramps to the single westbound lane also impact travel speeds because of the acceleration and deceleration characteristics of vehicles at these junctions.

Table 4: Results of Zipper Lane Scenario with All Vehicles Allowed in All Lanes (full 25 miles)

Time of Day	Travel Time Minutes	# of Vehs	TT * Vehs Hours	Travel Time Minutes	# of Vehs	TT * Vehs Hours
	EB			WB		
1:00	42.99	1027	736	60.2	319	320
2:00	44.93	1052	788	67.29	379	425
3:00	46.4	890	688	75.62	436	549
4:00	41.17	792	543	78.73	425	558
5:00	39.72	1016	673	78.05	410	533
6:00	38.34	1438	919	64.67	433	467
7:00	37.42	1251	780	45.25	179	135
8:00	34.26	512	292	40.46	48	32
Total		7978	5419		2629	3020
Weighted Average Travel Time (hours)			0.68			1.15
Weighted Average Travel Time (minutes)			40.76			68.92

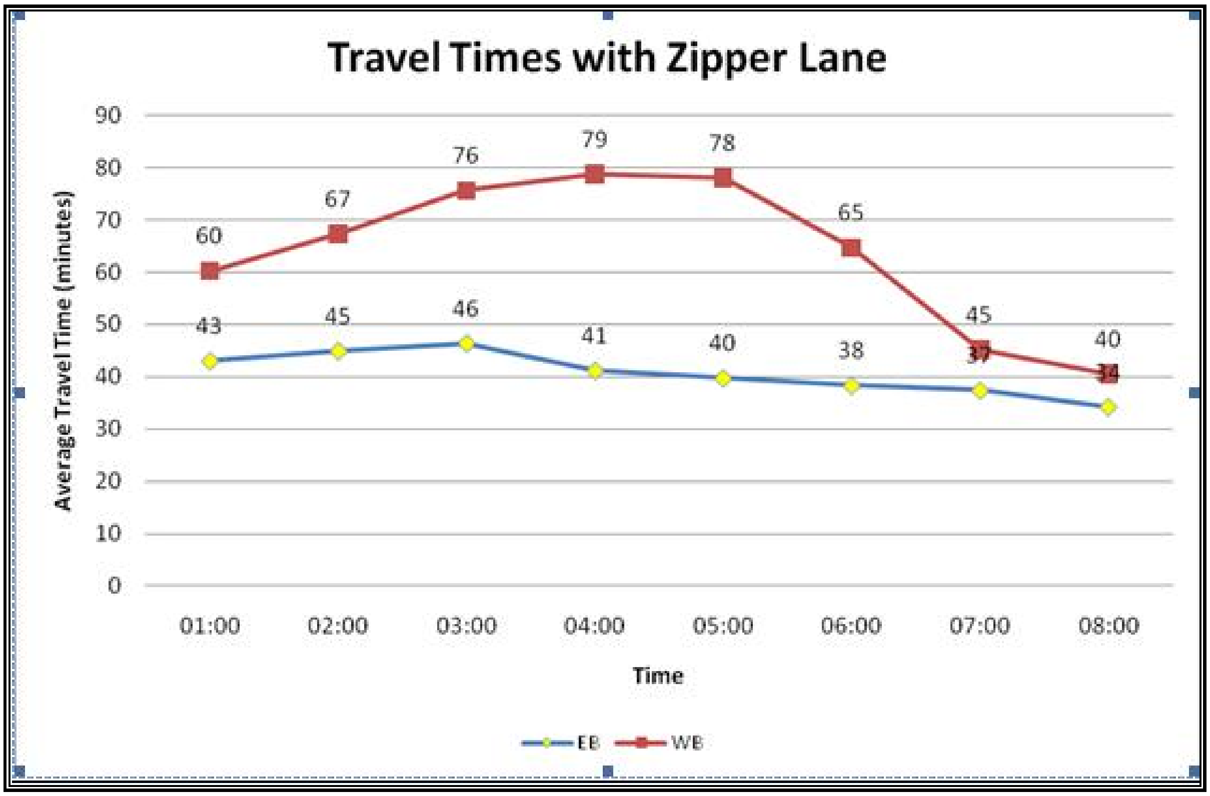

Figure 28: Zipper Lane Scenario for All Vehicles for the Entire 25-mile Section

Table 5: Zipper Lane Scenario with All Vehicles Allowed (only the 15-mile zipper lane)

Time of Day	Travel Time Minutes	# of Vehs	TT * Vehs Hours	Travel Time Minutes	# of Vehs	TT * Vehs Hours
	EB			WB		
1:00	22.74	999	379	26.41	944	415
2:00	22.71	1073	406	27.45	889	407
3:00	22.17	947	350	28.48	926	439
4:00	22.02	824	302	25.85	844	364
5:00	21.88	865	315	24.76	1001	413
6:00	22.2	832	308	21.67	1270	459
7:00	22.16	643	237	20.81	1018	353
8:00	21.19	297	105	16.11	216	58
Total		6480	2403		7108	2908
Weighted Average Travel Time (hours)			1.32			0.41
Weighted Average Travel Time (minutes)			22.25			24.55

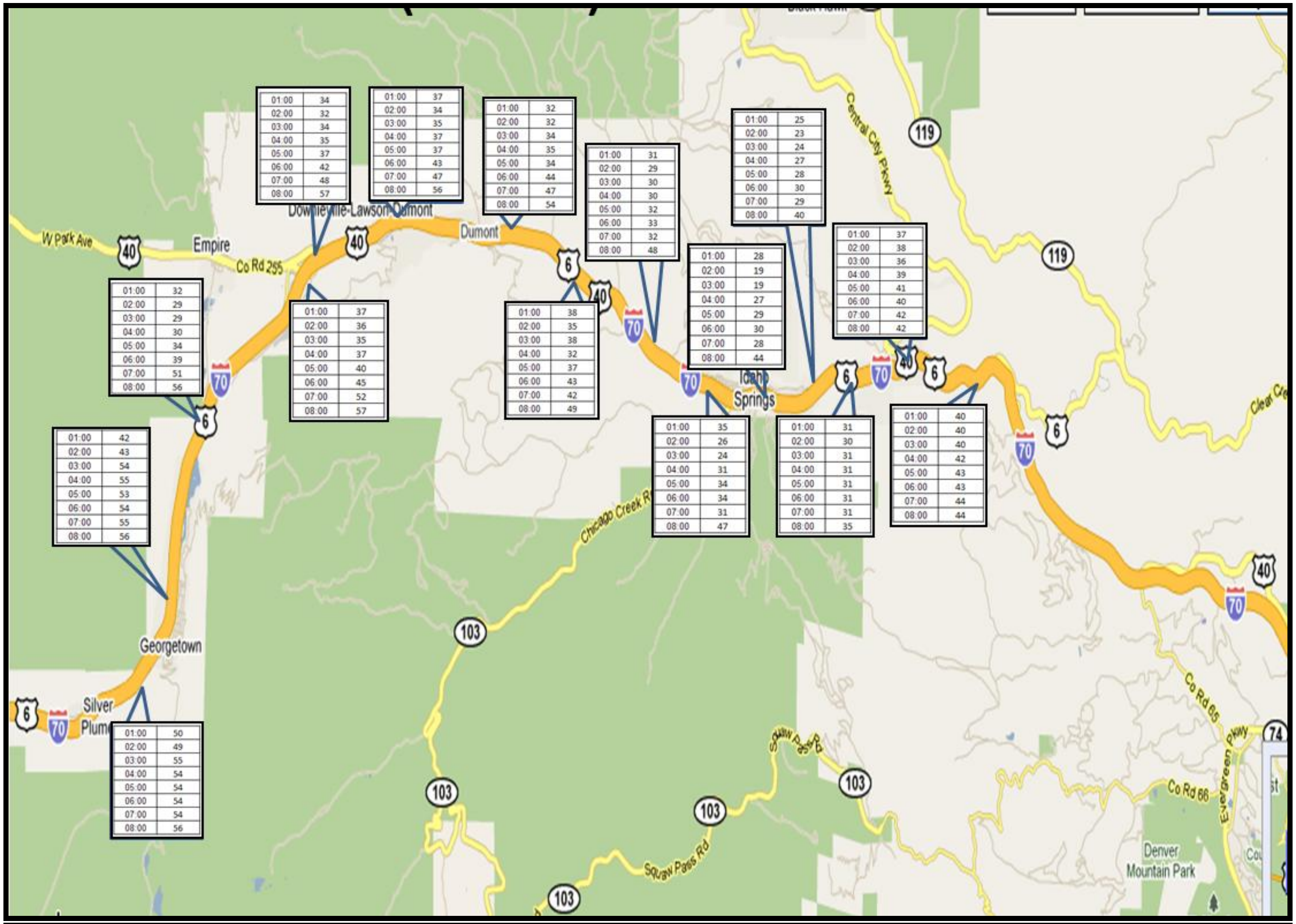

Figure 29: Eastbound Zipper Lane Scenario Speeds (mph) for All Vehicles Allowed

Beginning		In zipper lane		Twin Tunnel		Ending	
Time	Start						
01:00	44	01:00	40	01:00	31	01:00	31
02:00	43	02:00	41	02:00	30	02:00	31
03:00	45	03:00	42	03:00	30	03:00	31
04:00	45	04:00	42	04:00	32	04:00	31
05:00	45	05:00	42	05:00	31	05:00	31
06:00	44	06:00	41	06:00	33	06:00	32
07:00	45	07:00	42	07:00	33	07:00	31
08:00	46	08:00	41	08:00	37	08:00	32

Figure 30: Eastbound Zipper Lane Scenario Speeds (mph) for All Vehicles Allowed

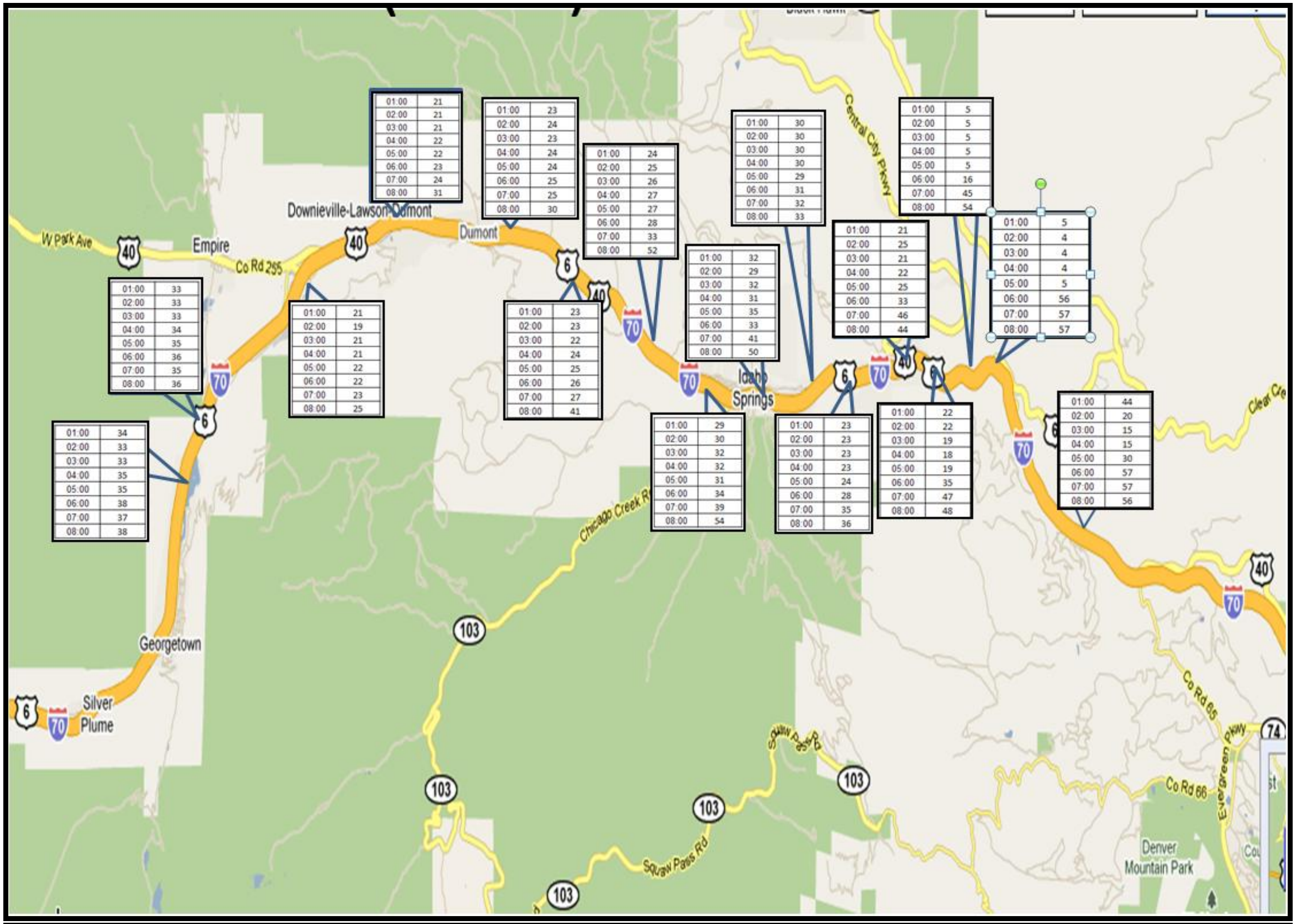

Figure 31: Westbound Zipper Lane Scenario Speeds (mph) for All Vehicles Allowed

6.2 SUMMARY OF RESULTS WITH TRUCKS RESTRICTED FROM ZIPPER LANE AND WB LANE

Restricting truck travel in the WB direction meant removing all trucks from those WB vehicle input volumes and routing decisions, which resulted in a 10% reduction in all WB volumes, but a larger percent reduction in passenger car equivalent volumes. Although total volumes in the EB direction were not different with or without trucks using the zipper lane, the vehicle routing decisions were changed to prevent trucks from entering the zipper lane in the EB direction.

With trucks restricted from zipper lane and no trucks in the WB direction, average travel times were 40 minutes in the EB direction and 60 minutes in the WB direction for the full 25 miles. For just the 15-mile section of the zipper lane, the average EB travel time was 19 minutes for the zipper lane and 25.5 minutes for the two general purpose lanes. Removing trucks from the vehicle mix resulted in a reduction in the average WB travel time from 69 to 60 minutes, which is about a 12% decrease and perhaps not as large as anticipated. While speeds before the WB lane reduction improve somewhat, they still drop into the 5 to 10 mph range for some of the analysis period. Speeds in the WB direction remain in the 20 to 30 mph range for much of the WB section adjacent to the zipper lane.

Table 6: Results of Zipper Lane Scenario with Truck Restrictions (full 25 miles)

Time	Travel Time Minutes	# of Vehs	TT * Vehs Hours	Travel Time Minutes	# of Vehs	TT * Vehs Hours
	EB			WB		
1:00	41.82	1071	746	55.55	340	315
2:00	44.23	1010	744	61.39	396	405
3:00	46.50	895	694	68.06	442	501
4:00	41.74	818	569	68.58	458	524
5:00	39.26	1012	662	63.76	458	487
6:00	38.01	1437	910	48.40	341	275
7:00	37.41	1288	803	45.44	161	122
8:00	33.04	513	283	40.10	52	35
Total		8044	5412		2648	2663
Weighted Average Travel Time (hours)			0.67			1.01
Weighted Average Travel Time (minutes)			40.36			60.35

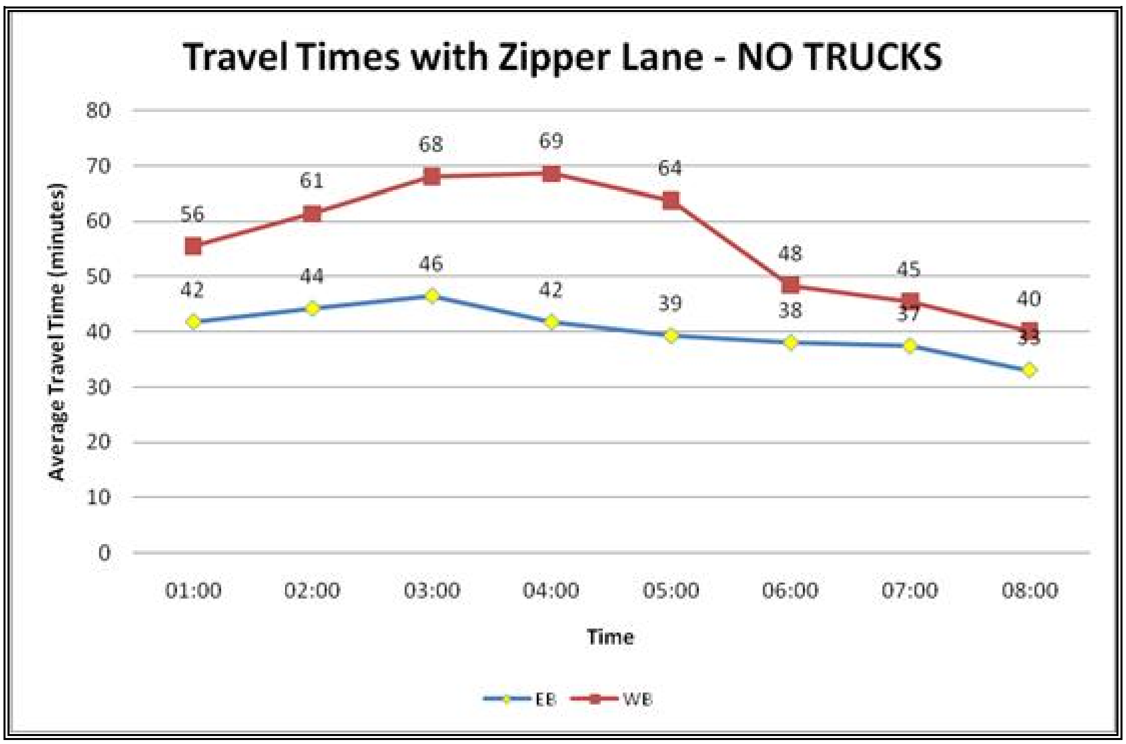

Figure 32: Zipper Lane Scenario with Truck Restrictions for the Entire 25-mile Section

Table 7: Results of Zipper Lane with Truck Restrictions (only the 15-mile zipper lane section)

Time	Travel Time Minutes	# of Vehs	TT * Vehs Hours	Travel Time Minutes	# of Vehs	TT * Vehs Hours
	EB			WB		
1:00	19.08	915	291	26.95	963	432
2:00	19.05	916	291	28.99	931	450
3:00	18.95	819	259	31.07	961	498
4:00	19.12	773	246	26.95	942	423
5:00	18.93	793	250	25.01	1020	425
6:00	18.82	742	233	22.23	1295	480
7:00	18.76	524	164	21.91	1134	414
8:00	20.21	302	102	16.17	221	60
Total		5784	1835		7467	3181
Weighted Average Travel Time (hours)			0.32			0.43
Weighted Average Travel Time (minutes)			19.04			25.56

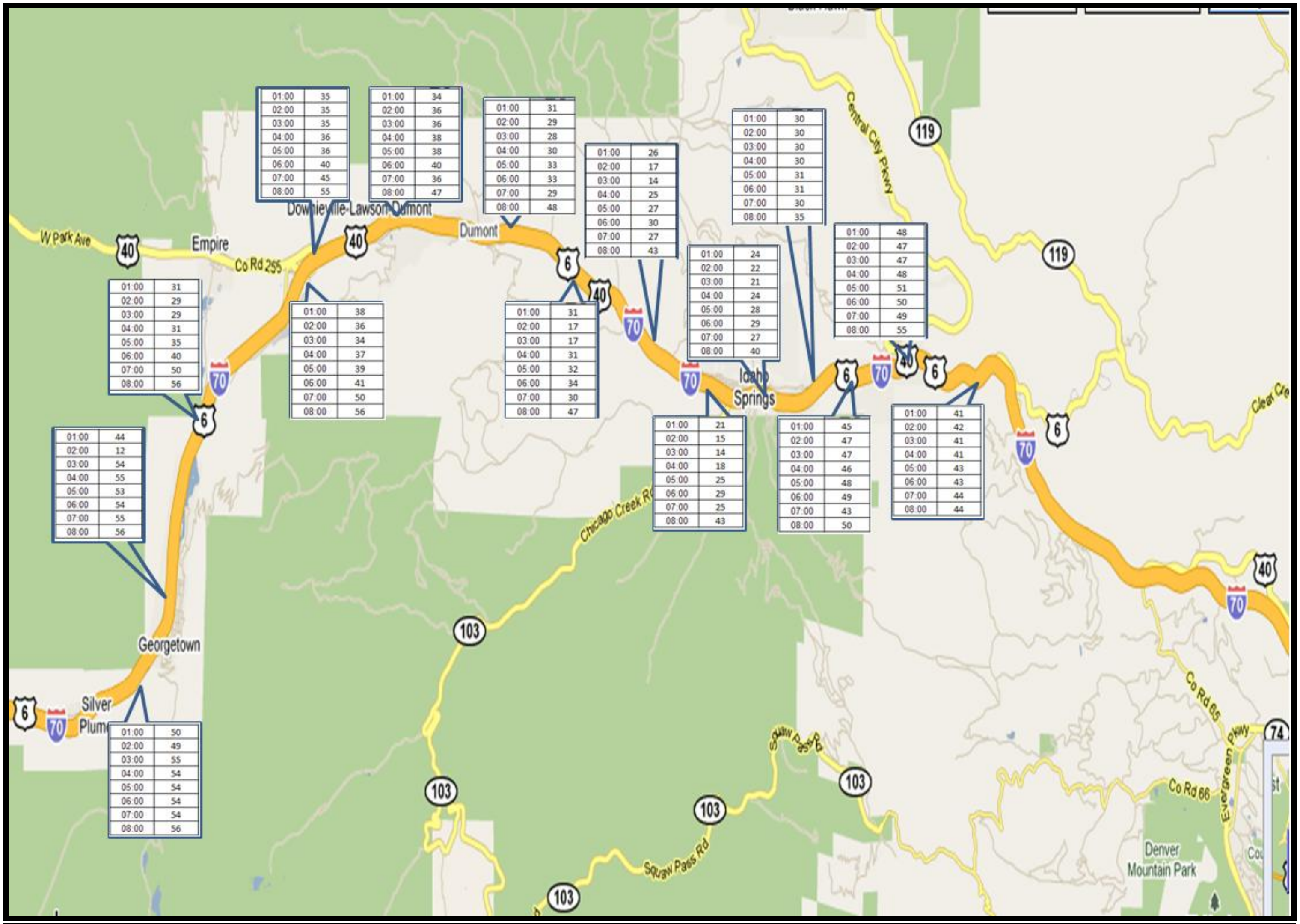

Figure 33: Eastbound Zipper Lane Scenario Speeds (mph) with Truck Restrictions

Beginning		In zipper lane		Twin Tunnel		Ending	
Time	Start						
01:00	48	01:00	47	01:00	39	01:00	32
02:00	48	02:00	47	02:00	39	02:00	32
03:00	48	03:00	47	03:00	39	03:00	33
04:00	47	04:00	47	04:00	39	04:00	32
05:00	49	05:00	47	05:00	40	05:00	32
06:00	49	06:00	48	06:00	40	06:00	33
07:00	50	07:00	48	07:00	40	07:00	33
08:00	50	08:00	48	08:00	40	08:00	33

Figure 34: Eastbound Zipper Lane Scenario Speeds (mph) with Truck Restrictions

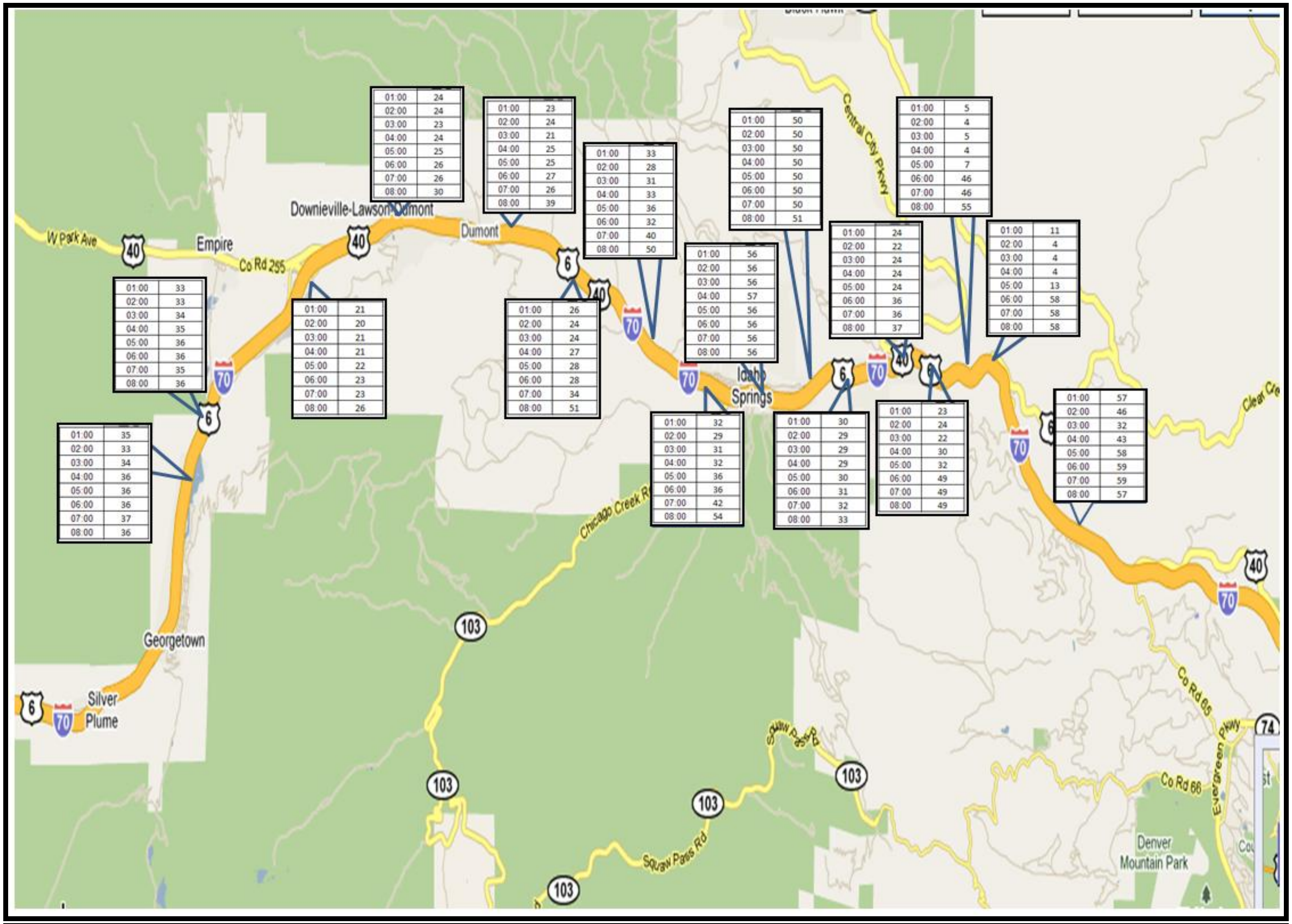

Figure 35: Westbound Zipper Lane Scenario Speeds (mph) with Truck Restrictions

7. QUEUE LENGTHS

Significant queues form in the WB direction with the zipper lane installed. In the zipper lane scenario in which all vehicles are allowed to use all lanes, the WB queue started where the WB lanes reduced from two to one and extended approximately 2.5 miles up Floyd Hill after a few hours. In the zipper lane scenario in which no trucks were allowed in the WB direction, the WB queue forming at this location extended approximately 1.3 miles up Floyd Hill after a few hours. Queuing also develops in the westbound direction at the entrance to the Twin Tunnels because of the lower capacity with the zipper lane barriers installed. Since the entrance to the Twin Tunnels is roughly 0.8 miles west of the lane reduction point for the zipper lane, the total queue length from the Twin Tunnels is approximately 3.3 miles when all vehicles are allowed in all lanes and 2.1 miles when trucks are restricted from the single WB lane and EB zipper lane.

The queues in both of these scenarios reduced travel speeds to below 10 mph and increased travel times significantly. Example pictures of these queues from the VISSIM model are shown in Figure 36 and 37 with and without truck restrictions, respectively. No significant queues or delays were observed at the merge and diverge points of the zipper lane for vehicles traveling in the EB direction. The EB vehicles travel at lower speeds than the posted speed limit, but not stop and go.

Table 8: Lengths of Westbound Queues Observed in the Zipper Lane Scenarios

WB	All Vehicles	No Trucks
Time	**Queue Length (miles)**	**Queue Length (miles)**
1:00	0.8	0.5
2:00	1.6	1.0
3:00	2.5	1.3
4:00	1.8	1.0
5:00	0.9	0.3
6:00	No queue	No queue
7:00	No queue	No queue
8:00	No queue	No queue
9:00	No queue	No queue

Figure 36 shows a picture of the WB queue that forms by the by the reduction to one lane with truck restrictions, and Figure 37 shows the WB queue that forms when all types of vehicles can use the single westbound lane.

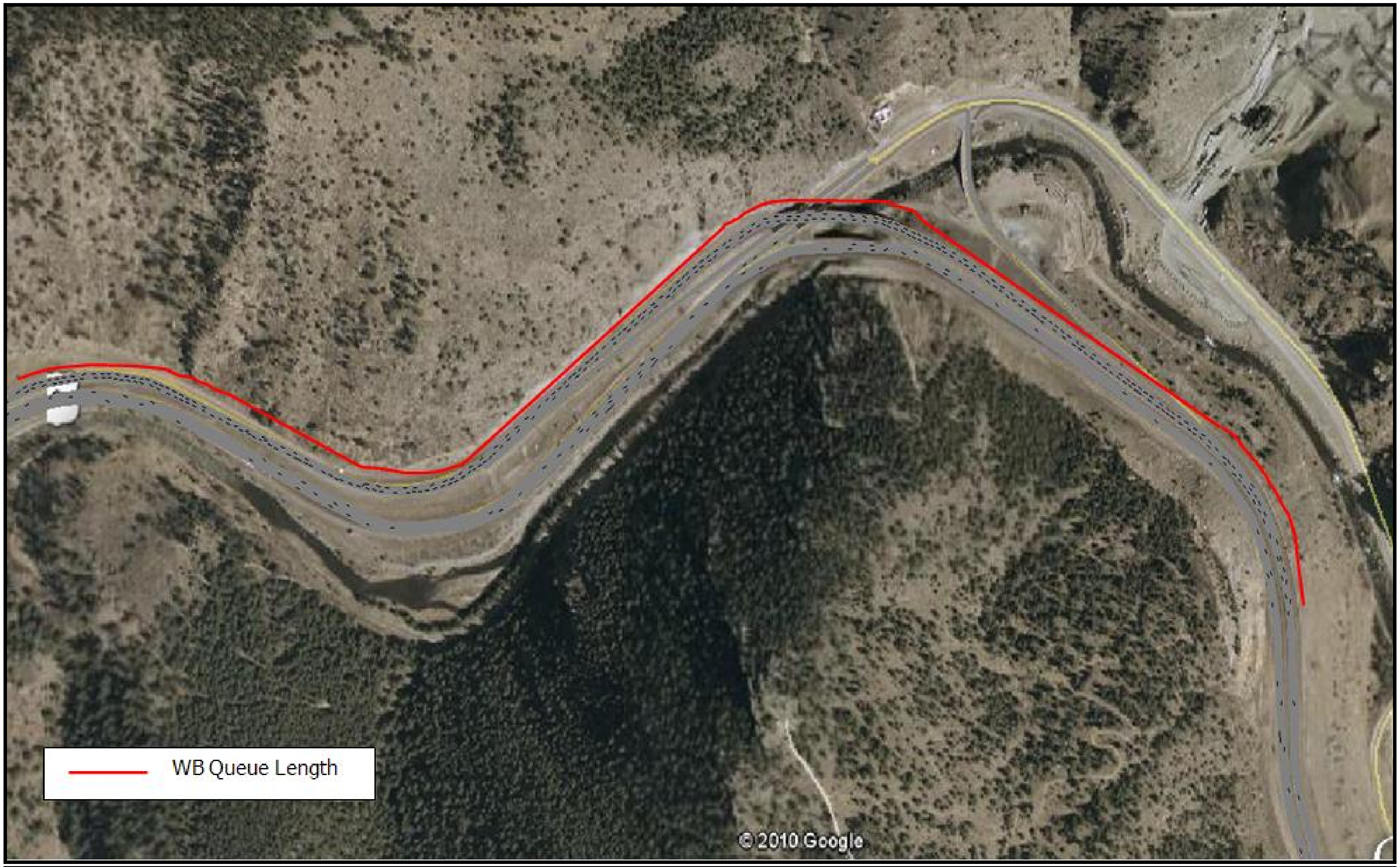

Figure 36: Picture of WB Queue Formed by the Reduction to One Lane NO TRUCKS

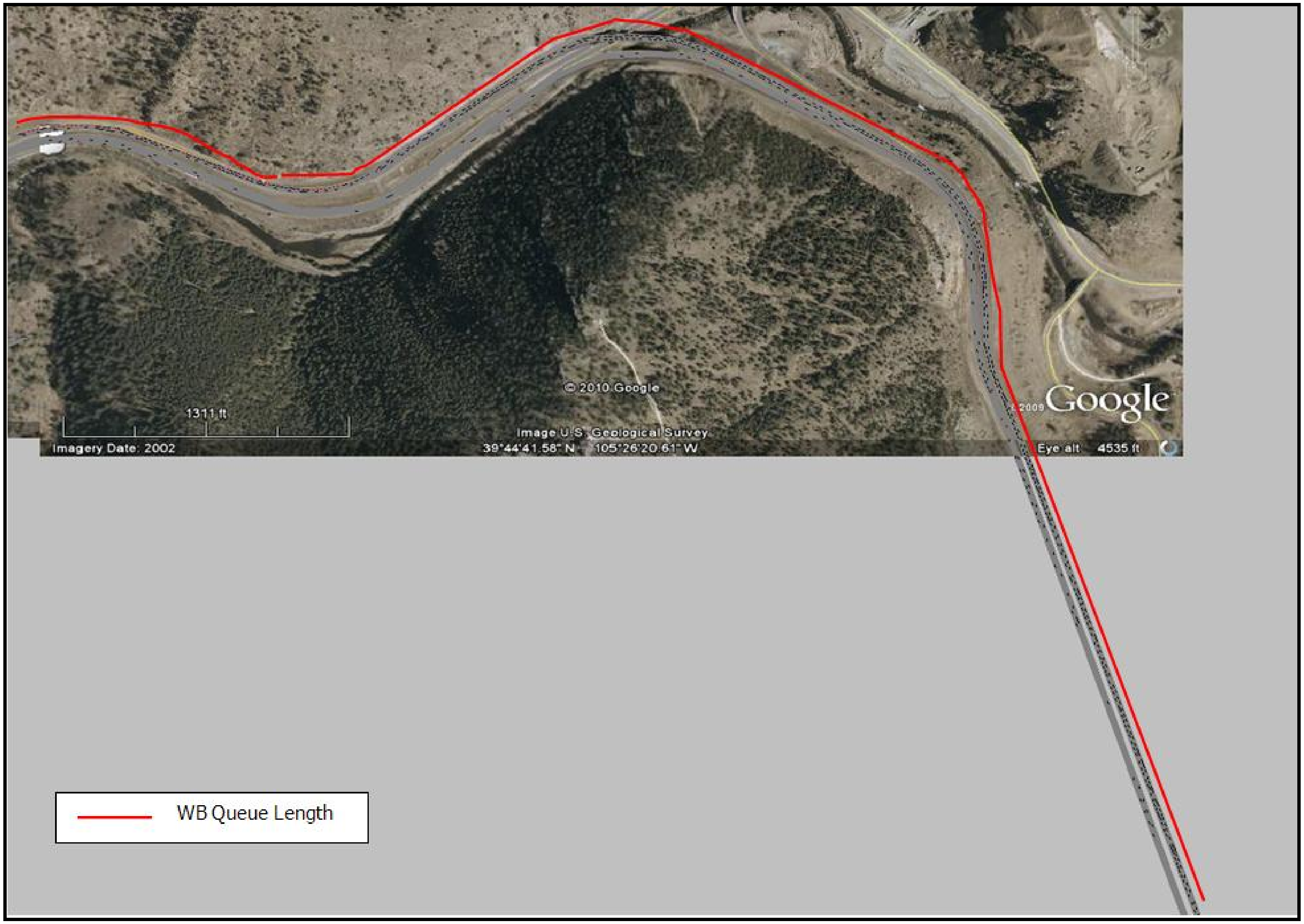

Figure 37: Picture of WB Queue Formed by the Reduction to One Lane ALL VEHICLES

8. CONCLUSIONS

For the full 25-mile section, the zipper lane scenario that allowed all vehicles to use all lanes reduced the average EB travel time from 79 minutes down to 41 minutes (a 38 minute decrease of 48%). However, it increased the average WB travel time from 34 minutes up to 69 minutes (a 35 minute increase of 100%). From the lane reduction point in the WB direction, the queue length observed in the simulation extended approximately 2.5 miles up Floyd Hill.

VISSIM reports total travel time for all vehicles in the simulation, many of which do not travel the entire 25-mile section, since many vehicles enter and exit at intermediate points. The table below shows that total travel time for all vehicles entering the network from noon to 8 PM. It decreases by 6065 hours per Sunday from the base case to the case with truck restrictions.

	Total Travel Time (hours)
Baseline Case	36914
Trucks Allowed in Zipper Lane and WB	32350
No Trucks in Zipper Lane or WB	30849

This total travel time savings would need to be multiplied by a value of time in order to estimate the benefit of the zipper lane. This calculation needs to be performed before the full comparison of these scenarios can be made as part of a complete benefit-cost analysis.

These results assume normal operating conditions throughout the analysis period from noon to 9 PM. Incidents and poor weather conditions could impact these results dramatically. Also, the results reported here use a fairly high travel demand scenario for January 31, 2010.

REFERENCES

Highway Capacity Manual, 2000, Transportation Research Board.

Koshi, M., M. Kuwarara, and M. Acahane. Capacity of Sags and Tunnels on Japanese Motorways. *ITE Journal,* Vol. 62, No. 5, 1992, pp. 17–22.

Levinson, H.S., M. Golenberg, and J. Howard. Callahan Tunnel Capacity Management. In *Transportation Research Record 1005,* TRB, National Research Council, Washington, D.C., 1985, pp. 1–10.

Lin F-B, C-W Chang, P-Y Tseng, and C-W Su. Capacity and Other Traffic Characteristics in Taiwan's 12.9-km-Long Shea-San Tunnel. In *Transportation Research Record 2130,* TRB, National Research Council, Washington, D.C., 2009, pp. 101-108.

APPENDIX A: ROUTING DECISIONS

1. Baseline

Decision No.	Route No.	At [ft]	0 - 3600	3600 - 7200	7200 - 10800	10800 - 14400	14400 - 18000	18000 - 21600	21600 - 25200	25200 - 28800	28800 - 32400
1	2:EB Off-Ramp 228	33.88	184	194	203	97	43	117	89	53	150
1	3	31.95	2571	2234	2778	1750	1649	1994	2308	2035	1293
2	2:EB Off-Ramp 228	785.31	1	1	1	1	1	1	1	1	1
3	5	2.72	551	776	569	877	1001	720	322	233	8
4	5	5.60	3122	3010	3847	2627	2649	2713	2630	2269	1301
5	7:EB Off-Ramp 232	13.43	44	37	222	167	211	134	19	12	8
5	6	13.86	3078	2973	3625	2460	2438	2579	2611	2257	1293
7	9	7.91	142	167	203	138	119	99	78	59	39
8	9	10.14	3220	3140	3828	2597	2557	2678	2690	2316	1332
9	10:EB Off-Ramp 233	29.26	23	29	67	101	42	92	6	4	2
9	11	24.66	3197	3111	3761	2496	2515	2586	2684	2312	1330
11	12:EB Off-Ramp 234	25.57	293	268	251	204	157	231	149	133	29
11	13	20.69	2904	2843	3510	2292	2358	2355	2535	2179	1301
12	12:EB Off-Ramp 234	1230.35	1	1	1	1	1	1	1	1	1
13	15	35.47	31	16	132	58	50	47	12	20	6
14	15	12.68	2935	2859	2642	2351	2408	2401	2546	2199	1308
15	17	9.92	2998	2929	2830	2485	2517	2471	2636	2235	1317
16	17	29.51	63	70	188	135	109	70	89	36	10
17	18:EB Off-Ramp 238	18.02	12	10	32	85	51	36	68	6	3
17	19	11.38	2986	2919	2798	2400	2466	2435	2568	2229	1314
18	18:EB Off-Ramp 238	505.33	1	1	1	1	1	1	1	1	1
19	21	36.24	3	6	297	602	449	426	163	399	720
20	21	24.94	2989	2925	3095	3002	2915	2861	2731	2628	2034
21	22:EB Off-Ramp 239	40.01	113	113	177	189	153	197	177	46	11
21	23	18.38	2876	2812	2918	2813	2762	2664	2554	2582	2023
22	22:EB Off-Ramp 239	1076.38	1	1	1	1	1	1	1	1	1
23	24:EB Off-Ramp 240	16.55	224	201	236	179	174	229	144	62	19
23	25	19.17	2652	2611	2682	2634	2588	2435	2410	2520	2004
24	24:EB Off-Ramp 240	448.91	1	1	1	1	1	1	1	1	1
25	27	15.15	547	742	606	441	713	633	550	317	189
26	27	11.36	3199	3353	3288	3076	3301	3068	2960	2837	2193
27	28:EB Off-Ramp 241	12.06	63	56	66	56	64	74	61	22	27

27	29	11.57	3136	3297	3222	3020	3237	2994	2899	2815	2166
28	28:EB Off-Ramp 241	111.65	1	1	1	1	1	1	1	1	1
29	31	16.44	546	605	606	481	517	598	410	247	297
30	31	12.75	3682	3902	3827	3501	3755	3592	3309	3062	2463
31	34:EB Off-Ramp 243	37.95	685	942	873	655	567	480	393	306	218
31	35	22.79	3627	2960	2954	2846	3188	3112	2916	2756	2245
32	34:EB Off-Ramp 243	944.86	1	1	1	1	1	1	1	1	1
33	37	20.24	55	97	114	86	74	63	51	45	38
34	37	17.49	3737	3057	3068	2932	3262	3175	2967	2801	2283
35	43	13.18	320	405	432	374	359	343	342	227	107
35	38:End EB I-70	10.29	3417	2652	3500	3306	2903	2832	2625	2574	2176
36	104	164.18	1	1	1	1	1	1	1	1	1
37	38:End EB I-70	3294.35	3417	2652	3500	3306	2903	2832	2625	2574	2176
38	40:WB Off-Ramp 244	13.38	350	317	290	286	189	167	113	64	56
38	41	13.06	1414	1470	1571	1475	1430	1169	946	561	461
39	40:WB Off-Ramp 244	1277.42	1	1	1	1	1	1	1	1	1
40	44	197.24	110	112	113	110	105	105	105	108	108
41	44	165.78	1524	1582	1684	1586	1535	1274	1051	669	570
42	45:WB Off-Ramp 243	19.15	5	12	6	0	0	0	0	2	0
42	46	31.53	1519	1570	1678	1586	1535	1274	1051	667	570
43	45:WB Off-Ramp 243	659.05	1	1	1	1	1	1	1	1	1
44	49	167.61	227	212	215	196	200	205	165	141	143
45	49	147.24	1746	1782	1893	1782	1735	1479	1216	808	712
46	51:WB Off-Ramp 241A	10.30	630	651	600	631	594	545	410	290	211
46	52	9.69	1116	1131	1293	1151	1141	934	806	518	501
47	51:WB Off-Ramp 241A	865.28	1	1	1	1	1	1	1	1	1
48	56	124.10	177	144	104	144	120	102	82	66	38
49	56	94.51	1293	1275	1397	1295	1261	1036	888	583	540
50	57:WB Off-Ramp 240	12.00	305	275	392	341	296	252	194	143	116
50	58	13.92	988	1000	1005	954	965	784	694	440	424
51	57:WB Off-Ramp 240	640.13	1	1	1	1	1	1	1	1	1
52	60	243.62	83	84	119	90	70	72	46	36	33
53	60	181.63	1070	1084	1124	1044	1035	856	739	476	456
54	61:WB Off-Ramp 239	18.00	11	13	10	11	8	11	10	5	0
54	62	25.57	1081	1097	1134	1055	1043	867	749	481	456
55	61:WB Off-Ramp 239	653.12	1	1	1	1	1	1	1	1	1
56	64	216.33	15	6	10	3	3	14	5	2	2

57	64	186.80	1096	1103	1144	1058	1046	881	754	484	459
58	65:WB Off-Ramp 238	33.94	71	110	63	89	63	49	34	21	18
58	66	30.85	1025	993	1081	969	983	832	720	463	441
59	65:WB Off-Ramp 238	629.75	1	1	1	1	1	1	1	1	1
60	68	217.27	46	53	59	54	56	43	35	16	16
61	68	189.96	1071	1046	1140	1023	1039	875	755	478	456
62	69:WB Off-Ramp 235	20.59	50	37	68	79	47	49	24	31	21
62	70	32.87	1021	1009	1072	944	992	826	731	447	435
63	69:WB Off-Ramp 235	1535.00	1	1	1	1	1	1	1	1	1
64	71:WB Off-Ramp 234	45.84	188	199	235	121	129	117	61	106	90
64	72	45.72	833	810	837	823	863	709	670	341	345
65	71:WB Off-Ramp 234	803.28	1	1	1	1	1	1	1	1	1
66	74	158.67	530	583	545	636	530	424	339	318	212
67	74	127.18	1363	1393	1382	1459	1393	1133	1010	659	557
68	76	168.89	198	179	150	127	138	174	163	139	139
69	76	136.59	1561	1573	1532	1587	1531	1307	1173	798	696
70	77:WB Off-Ramp 232	18.01	114	100	229	126	191	167	138	91	81
70	78	17.67	1447	1473	1303	1461	1340	1140	1035	707	615
71	77:WB Off-Ramp 232	1917.02	1	1	1	1	1	1	1	1	1
72	80	300.39	106	95	136	129	83	69	47	35	25
73	80	250.01	1553	1568	1439	1590	1422	1209	1082	742	641
74	81:WB Off-Ramp 228	18.78	185	175	155	141	113	123	70	86	55
74	82	19.65	1368	1393	1284	1449	1309	1086	1012	656	586
75	81:WB Off-Ramp 228	735.95	1	1	1	1	1	1	1	1	1
76	84:End WB I-70	115.05	12	17	27	25	11	11	3	2	2
77	84:End WB I-70	91.74	1380	1410	1312	1474	1320	1096	1015	658	588
78	84:End WB I-70	474.09	1380	1410	1312	1474	1320	1096	1015	658	588

2. Zipper Lane Installed

Decision No.	Route No.	Dest. Link	At [ft]	0 - 3600	3600 - 7200	7200 - 10800	10800 - 14400	14400 - 18000	18000 - 21600	21600 - 25200	25200 - 28800
1	2:EB Off-Ramp 228		24.64	184	194	203	97	43	117	89	53	150
1	3		29.60	2571	2234	2778	1750	1649	1994	2308	2035	1293
2	2:EB Off-Ramp 228		776.06	1	1	1	1	1	1	1	1	1
3	5		28.35	551	776	569	877	1001	720	322	233	8

4	5	32.84	3122	3010	3347	2627	2649	2713	2630	2269	1301
5	7:EB Off-Ramp 232	13.43	44	37	222	167	211	134	19	12	8
5	6	13.86	2038	1969	2043	1584	1555	1675	1735	1500	859
5	142	2153.93	1041	1003	1082	876	883	904	877	756	434
7	9	7.91	142	167	203	138	119	99	78	59	39
8	9	10.14	2180	2137	2245	1722	1674	1773	1813	1560	899
9	10:EB Off-Ramp 233	29.26	23	29	67	101	42	92	6	4	2
9	11	24.66	2157	2108	2178	1621	1632	1681	1807	1556	897
11	12:EB Off-Ramp 234	25.57	293	268	251	204	157	231	149	133	29
11	13	20.69	1864	1840	1927	1417	1475	1450	1658	1423	868
12	12:EB Off-Ramp 234	1230.35	1	1	1	1	1	1	1	1	1
13	15	35.47	31	16	132	58	50	47	12	20	6
14	15	12.68	1894	1856	2060	1475	1525	1497	1670	1443	874
15	17	9.92	1957	1926	2247	1610	1634	1567	1759	1479	884
16	17	29.51	63	70	188	135	109	70	89	36	10
17	18:EB Off-Ramp 238	18.02	12	10	32	85	51	36	68	6	3
17	19	11.38	1945	1916	2315	1525	1583	1567	1759	1479	884
18	18:EB Off-Ramp 238	505.33	1	1	1	1	1	1	1	1	1
19	21	36.24	3	6	156	638	476	452	173	423	763
20	21	24.94	1948	1922	2372	2163	2059	1983	1864	1896	1644
21	22:EB Off-Ramp 239	40.26	113	113	177	189	153	197	177	46	11
21	23	18.38	1835	1809	2195	1974	1905	1786	1687	1850	1633
22	22:EB Off-Ramp 239	1076.64	1	1	1	1	1	1	1	1	1
23	24:EB Off-Ramp 240	17.88	224	201	236	179	174	229	144	62	19
23	25	19.17	1611	1608	1959	1795	1732	1557	1543	1788	1614
24	24:EB Off-Ramp 240	450.24	1	1	1	1	1	1	1	1	1
25	27	15.15	547	742	606	941	713	633	550	317	189
26	27	11.36	2158	2350	2565	2736	2445	2189	2093	2105	1802
27	28:EB Off-Ramp 241	12.06	63	56	66	56	64	74	61	22	27

27	29	11.57	2095	2294	2499	2680	2381	2115	2032	2083	1775
28	28:EB Off-Ramp 241	111.65	1	1	1	1	1	1	1	1	1
29	31	16.44	546	605	606	481	517	598	410	247	297
30	31	12.75	2641	2899	3105	3161	2898	2713	2442	2330	2072
31	34:EB Off-Ramp 243	37.95	685	942	873	655	567	480	393	306	218
31	35	22.79	1956	1957	2332	2506	2331	2233	2049	2024	1854
32	34:EB Off-Ramp 243	944.86	1	1	1	1	1	1	1	1	1
33	37	20.24	55	97	114	86	74	63	51	45	38
34	37	17.49	2011	2054	2346	2592	2405	2296	2100	2069	1892
35	43	13.18	320	405	432	374	359	343	342	227	107
35	38:End EB I-70	10.29	3052	3057	3428	3468	3289	3201	2977	2825	2326
36	104	164.18	1	1	1	1	1	1	1	1	1
37	38:End EB I-70	3294.35	3052	3057	3428	3468	3289	3201	2977	2825	2326
38	40:WB Off-Ramp 244	13.04	350	317	290	286	189	167	113	64	56
38	41	13.06	1414	1470	1571	1475	1430	1169	946	561	461
39	40:WB Off-Ramp 244	1277.08	1	1	1	1	1	1	1	1	1
40	143	15.74	110	112	113	110	105	105	105	108	108
41	143	24.54	1524	1582	1684	1586	1535	1274	1051	669	570
42	45:WB Off-Ramp 243	21.90	5	12	6	0	0	0	0	2	0
42	46	32.85	1519	1570	1678	1586	1535	1274	1051	667	570
43	45:WB Off-Ramp 243	661.94	1	1	1	1	1	1	1	1	1
44	49	160.00	227	212	215	196	200	205	165	141	143
45	49	139.64	1746	1782	1893	1782	1735	1479	1216	808	712
46	51:WB Off-Ramp 241A	3.71	630	651	600	631	594	545	410	290	211
46	52	9.69	1116	1131	1293	1151	1141	934	806	518	501
47	51:WB Off-Ramp 241A	858.69	1	1	1	1	1	1	1	1	1
48	56	124.10	167	136	104	136	113	96	77	62	36
49	56	94.51	1293	1275	1397	1295	1261	1036	888	583	540
50	57:WB Off-Ramp 240	10.59	305	275	392	341	296	252	194	143	116

50	58	13.92	988	1000	1005	954	965	784	694	440	424
51	57:WB Off-Ramp 240	638.72	1	1	1	1	1	1	1	1	1
52	60	243.62	83	84	119	90	70	72	46	36	33
53	60	181.63	1070	1084	1124	1044	1035	856	739	476	456
54	61:WB Off-Ramp 239	17.20	11	13	10	11	8	11	10	5	0
54	62	25.57	1081	1097	1134	1055	1043	867	749	481	456
55	61:WB Off-Ramp 239	652.33	1	1	1	1	1	1	1	1	1
56	64	216.33	15	6	10	3	3	14	5	2	2
57	64	186.80	1096	1103	1144	1058	1046	881	754	484	459
58	65:WB Off-Ramp 238	29.49	71	110	63	89	63	49	34	21	18
58	66	30.85	1025	993	1081	969	983	832	720	463	441
59	65:WB Off-Ramp 238	625.31	1	1	1	1	1	1	1	1	1
60	68	217.27	46	53	59	54	56	43	35	16	16
61	68	189.96	1071	1046	1140	1023	1039	875	755	478	456
62	69:WB Off-Ramp 235	19.16	50	37	68	79	47	49	24	31	21
62	70	32.87	1021	1009	1072	944	992	826	731	447	435
63	69:WB Off-Ramp 235	1533.56	1	1	1	1	1	1	1	1	1
64	71:WB Off-Ramp 234	48.92	188	199	235	121	129	117	61	106	90
64	72	45.72	833	810	837	823	863	709	670	341	345
65	71:WB Off-Ramp 234	806.36	1	1	1	1	1	1	1	1	1
66	74	158.67	530	583	545	636	530	424	339	318	212
67	74	127.18	1363	1393	1382	1459	1393	1133	1010	659	557
68	76	167.08	198	179	150	127	138	174	163	139	139
69	76	134.78	1561	1573	1532	1587	1531	1307	1173	798	696
70	77:WB Off-Ramp 232	13.55	114	100	229	126	191	167	138	91	81
70	78	17.66	1447	173	1303	1461	1340	1140	1035	707	615
71	77:WB Off-Ramp 232	1912.55	1	1	1	1	1	1	1	1	1
72	129	26.02	106	95	136	129	83	69	47	35	25
73	129	29.66	1553	1568	1439	1590	1422	1209	1082	742	641

74	81:WB Off-Ramp 228	18.32	185	175	155	141	113	123	70	86	55
74	82	19.65	1368	1393	1284	1449	1309	1086	1012	656	586
75	81:WB Off-Ramp 228	735.49	1	1	1	1	1	1	1	1	1
76	84:End WB I-70	115.05	12	17	27	25	11	11	3	2	2
77	84:End WB I-70	91.74	1380	1410	1312	1474	1320	1096	1015	658	588
78	84:End WB I-70	474.09	1380	1410	1312	1474	1320	1096	1015	658	588