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I-15 Express Lanes Study

Phase II: Recommendations

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16. Abstract

The primary objective of this research was to recommend actions that will improve average speeds in the Express Lanes (ELs) such that the lanes meet Utah's goal of 55 mph. To accomplish this objective it was important to investigate the current usage of both the ELs and the General Purpose (GP) lanes along the Wasatch Front. This involved an evaluation of EL and GP lanes by user type (e.g., single-occupant vehicle (SOV), high-occupancy vehicle (HOV) 2, HOV 3+, "C" decal, Express Pass user, motorcycle, bus, freight vehicle, and emergency vehicle) to better understand the breakdown of vehicles in the lanes and to calculate average vehicle occupancy (AVO). A second objective was to examine violation data to determine ways to reduce violator rates. The third objective of the research was to recommend ways to control Express Pass traffic and to evaluate changes to toll rates and to estimate the impacts on speed of specific toll increases along the corridor. The final objective of the research was to analyze "C" decals in the state to evaluate the impacts of increasing the number of "C" decal permits issued statewide.

The data collected were examined to better understand the speed-flow relationship on the ELs and to estimate the impact of volume changes on speeds in the lanes. All of this information allowed the researchers to estimate the impact on EL and GP lane volumes and speeds under a combination of EL education campaigns, increased EL enforcement, increased EL peak period toll rates, and the impact of increasing the "C" decal cap.

Depending on the scenario analyzed, it was determined that the speeds in the ELs could be expected to increase as a result of the recommendations. The extent of the increase is dependent upon the scenario chosen and the response of the traffic to the increases and was projected to range from -4.7 mph (for an increase in "C" decal vehicles) to a maximum of 7.8 mph for a combination of education, enforcement, and increased tolls.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AVO	Average Vehicle Occupancy
BYU	Brigham Young University
CHP	California Highway Patrol
CMV	Commercial Motor Vehicle
DOT	Department of Transportation
EL	Express Lane
FAVORITE	Florida Accident Vehicle Occupancy Rate InformaTion Estimator
FHWA	Federal Highway Administration
GIS	Geographical Information Systems
GP	General Purpose
GPS	Global Positioning Satellite
HOT	High-Occupancy Toll
HOV	High-Occupancy Vehicle
ISTEA	Intermodal Surface Transportation Efficiency Act
MAG	Maricopa Association of Governments
MPO	Metropolitan Planning Organization
NB	Northbound
PeMS	Performance Measurement System
ppv	Persons Per Vehicle
SB	Southbound
SOV	Single Occupant Vehicle
TAC	Technical Advisory Committee
TTI	Texas A&M Transportation Institute
UDOT	Utah Department of Transportation
ULI	Urban Land Institute
VTMS	Variable Toll Message Signs
vphpl	Vehicles per Hour per Lane
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

The primary objective of this research was to recommend actions that will improve average speeds in the Express Lanes (ELs) to Utah's goal of 55 mph. To accomplish this objective it was important to investigate the current usage of both the ELs and the General Purpose (GP) lanes along the Wasatch Front. Specifically, it was necessary to determine the EL and GP lane users by type (e.g., single occupant vehicle (SOV), high-occupancy vehicle (HOV) 2, HOV 3+, "C" decal, Express Pass user, motorcycle, bus, freight vehicle, and emergency vehicle). Information on traffic speeds and flow rates was also needed along both the ELs and GP lanes. These data were examined to better understand the speed-flow relationship on these lanes and to estimate the impact of volume changes on speeds in the lanes. These empirical data were supplemented with literature regarding the impact of EL policies on EL usage. All of this information allowed researchers to estimate the impact on EL and GP lane volumes and speeds under a combination of the following scenarios:

- EL education campaign,
- Increased EL enforcement,
- Increased EL peak period toll rate, and
- Increased "C" decal permits.

One of the key factors in calculating the speed and volume results was the determination of lane users by type for the EL and the GP lanes. The results of the study indicate that the proportion of lane users by type varies depending on time of day and location along the corridor; however, an average of the overall results for both southbound (SB) and northbound (NB) traffic combined indicate that the ELs are comprised of approximately 16% SOVs, 68% carpooling vehicles (HOV 2 and HOV 3+), 11% Express Pass users, 2% "C" decal vehicles, and 3% other (motorcycle, bus, freight, and emergency vehicles). Average vehicle occupancy (AVO) also varies by time of day and location with AVO for the ELs reported to range between 1.55 and 2.23 persons per vehicle (ppv) in the NB direction and 1.84 to 2.15 ppv in the SB direction. The AVO for the GP lanes ranged from 1.11 to 1.36 ppv for the NB and SB directions. The overall AVO for the EL is 1.90 ppv and 1.25 ppv for the GP lanes (for all time periods).

There are three primary areas of recommendations for this research: 1) reduce violation rates along the corridor, 2) reduce volume in the ELs through an increase in tolls (and subsequent increase in speed), and 3) allow an increase in "C" decal vehicles once additional capacity is available. The recommendations should be conducted in a phased manner starting with steps to reduce violators. Continual monitoring will be necessary throughout the implementation process to evaluate the effectiveness of each step. A summary of the recommendations are as follows:

1. Reduce the violation rate along the corridor through methods such as increased enforcement, education campaigns regarding policies related to the proper use of the ELs, the consideration of a "HERO" program for public enforcement, installing rumble strips along the ELs, and considering modifications to the striping of the ELs.
2. Reduce volume in the ELs through an increase in tolls (and subsequent increase in speed) during peak periods, including an increase in the maximum allowable toll.
3. Allow an increase in the number of "C" decals in the lanes once additional capacity is available from the reduction in violators and Express Pass users.

The change in speed on the EL as a result of changing the vehicle percentage by type through the various scenarios ranged from a maximum decrease of -4.7 mph for an increase in "C" decal vehicles only to a maximum increase of 7.8 mph for a combination of education, enforcement, and increases in the maximum toll rate.

To evaluate the effectiveness of the implementation of the proposed recommendations it will be necessary to continually monitor speed, volume, and AVO along the corridor, with specific emphasis on those areas where speeds are less than the current UDOT goal. As the system is monitored, additional recommendations can be considered as needed.

1.0 INTRODUCTION

1.1 Problem Statement

The Utah Department of Transportation (UDOT) and Brigham Young University (BYU) recently completed a research report on the utilization of the High Occupancy Toll (HOT) lanes (i.e., Express Lanes or ELs) along the Wasatch Front (Schultz et al. 2014). The report provided preliminary guidance on the impacts of current traffic levels on the ability of the ELs to meet their performance objectives. The primary objectives of that project were to examine the utilization of the ELs under a limited number of congestion and pricing scenarios and to provide preliminary recommendations on EL use. The researchers analyzed the data for the ELs in Utah, including an analysis of speed, volume, and toll rates within the lanes, as well as a detailed analysis of Express Pass transponder and "C" decal use within the state. The results of the study indicated that the majority of the EL corridor within the state of Utah is operating within the 10^{th} percentile speed goal of 55 mph set by UDOT and the requirement of 45 mph set by the Federal Highway Administration (FHWA). There are, however, some zones where 10^{th} percentile speeds have dropped below 55 mph and some that have also dropped below 45 mph.

That research identified several methods to consider in an effort to reduce the volume in the ELs and subsequently increase the speeds within the lanes. The eight primary methods identified in the research included (Schultz et al. 2014):

1. Increase EL tolls during peak periods, including an increase in the maximum allowable toll.
2. Increase the High Occupancy Vehicle (HOV) limits in the ELs from 2+ to 3+ persons per vehicle during peak periods.
3. Reduce violation rate along the corridor through methods such as increased enforcement, education campaigns regarding policies related to the proper use of the ELs, and the consideration of a "HERO" program for public enforcement.

In an effort to increase the number of "C" decal vehicles in the state, the following was identified as an important component of the EL study:

4. Enforce the current cap for "C" decal vehicles in the ELs and consider options for increasing the number of "C" decals issued for off-peak travel and/or travel outside of the congested areas during peak periods.

In addition to these methods, several other alternatives to reduce the volume in the ELs were brainstormed by the Technical Advisory Committee (TAC) to consider at a future date including:

5. Examine the lanes to see if there are specific locations where the speeds are degrading due to geometric design or weaving with the general purpose (GP) lanes and identify design changes to help improve performance and to address some or all of the speed degradation.
6. Add an additional HOV/HOT lane.
7. Remove some HOT lane access points to reduce the number of merge areas along the corridor.
8. Install rumble strips between the double white lines to discourage drivers from crossing the lines illegally.

The purpose of this research is to evaluate the alternatives in more detail by completing a detailed analysis of average vehicle occupancy (AVO) both in the ELs and the GP lanes, a more detailed analysis of methods available to reduce violation rates, and a more in depth analysis of the impacts on volume and speed of increasing EL tolls. Additional research would be necessary to evaluate all alternatives and their potential impact.

1.2 Objectives

The primary objectives of this research include:

- Evaluate the AVO in both the ELs and the GP lanes to better understand and summarize the EL and GP lane users by type (e.g., single occupant vehicle (SOV), HOV 2, HOV 3+, "C" decal, Express Pass user, motorcycle, bus, violator, etc.).
- Examine violation data in other states and from the AVO evaluation to determine ways to reduce violator rates as an alternative to increase speeds in the ELs.

- Recommend ways to control Express Pass traffic and to evaluate changes to toll rates in an effort to determine impacts of increased tolls and to estimate the impacts on speed of specific toll increases along the corridor.
- Analyze "C" decal use in the state, utilizing the results of the AVO evaluation to determine the proportion of "C" decal vehicles that are HOV, and to evaluate impacts of increasing the number of "C" decals issued.

All of these objectives lead to recommending actions that will improve average speeds in the ELs to Utah's goal of 55 mph.

It is anticipated that this will continue to be an ongoing effort. Future phases of the research will be developed to collect additional data that will aid in better defining issues, evaluating effectiveness of alternatives, and proposing solutions to address the use of the ELs. The results of the research will identify any future work that will be needed to address outstanding issues associated with the ELs.

1.3 Scope

1.3.1 Kickoff Meeting

The first task for this project was a kickoff meeting with the research team and the TAC to discuss and review the scope and schedule, and to introduce all members of the research and UDOT team. This meeting was held on May 29, 2014 and included the members of the BYU research team (including Dr. Mark Burris from Texas A&M University), the UDOT Traffic Management team members, and the UDOT Research Division representative. At this meeting the BYU research team discussed the best methods for data collection along the corridor and determined if there are any data sources that have not been utilized previously that could aid in this project. The meeting was followed by a tour of the ELs corridor by the members of the BYU research team, Dr. Mark Burris, John Haigwood, and Kevin Nichol.

1.3.2 Literature Review

The second task for this project involved the completion of a comprehensive literature review to train and inform new research assistants regarding the general topic of managed lanes

(or ELs) and to address specific topics in the research including, but not limited to: pricing alternatives for managed lanes (i.e., toll rates), vehicle occupancy use and methods to measure AVO, enforcement techniques related to managed lanes, and violation rates across the country. One of the byproducts of the research being conducted in the state is the transfer of knowledge and information to help develop the next generation of transportation engineers. This task was critical in the ongoing workforce development effort.

1.3.3 Data Collection

The third task for the project was the data collection. The key component of the data collection effort was a detailed analysis of AVO by vehicle type on I-15 across the Wasatch Front. Data were collected on both ELs and GP lanes during peak and off-peak periods in both the congested and uncongested zones (based on the work performed in Phase I) to better evaluate the options to control volume in the lane. To perform this task safely and efficiently, the research team used the carousel method to collect AVO and vehicle type data. The carousel method is a manual data collection process identified through the literature review as an effective data collection method for multilane freeways.

In addition to the AVO data, speed and volume data for both the ELs and GP lanes was collected as needed to compare the speed and volume data between the ELs and the GP lanes to aid in the data analysis task.

1.3.4 Data Analysis

The purpose of this task was to analyze the data collected in the previous task to complete the following objectives:

- Evaluate the AVO in both the ELs and the GP lanes to better understand and summarize the EL and GP lane users by type (e.g., SOV, HOV 2, HOV 3+, "C" decal, Express Pass user, motorcycle, bus, violator, etc.).
- Examine violation data in other states and from the AVO evaluation to determine ways to reduce violator rates as an alternative to increase speeds in the ELs.

- Recommend ways to control Express Pass traffic and to evaluate changes to toll rates in an effort to determine impacts of increased tolls and to estimate the impacts on speed of specific toll increases along the corridor.
- Analyze "C" decal use in the state utilizing the results of the AVO evaluation to determine the proportion of "C" decal vehicles that are HOV and to evaluate impacts of increasing the number of "C" decals issued.

The results of the analysis were used to help form the basis for the conclusions and recommendations from the research.

1.3.5 Conclusions and Recommendations

In this task, the research team identified limited conclusions and recommendations for UDOT based upon observations and analyses in each of the aforementioned tasks. The compilation of this project report documenting the results of the research tasks is provided as a culmination of the results of the study. The results listed are not guarantees on what will occur, but are based on engineering principles and lessons learned through the literature.

1.4 Outline of the Report

This report is organized into the following chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 Data Collection, Chapter 4 Data Analysis, Chapter 5 Proposed Recommendations, and Chapter 6 Conclusions and Recommendations. A References section and Appendices follow the indicated chapters.

2.0 LITERATURE REVIEW

2.1 Overview

A comprehensive literature review was performed to gain additional knowledge on HOT lanes (also referred to as managed lanes or ELs) and to address specific topics. The topics included: pricing alternatives for managed lanes or ELs, use of vehicle occupancy data, methods for collecting vehicle occupancy data, enforcement techniques related to managed lanes or ELs, and violation data across the nation and in Utah. The research was performed by locating recent articles and publications from various transportation organizations and from previous research done on the given subjects. The information presented in this chapter is supplementary to that collected in the Phase I report (Schultz et al. 2014).

2.2 Pricing Alternatives for Managed Lanes

The concept of HOT lanes (also known as managed lanes or ELs) presented by Gordon J. Fielding and Daniel B. Klein enables SOVs to utilize HOV facilities for a fee. This was done to help alleviate congestion in the GP lanes as well as to sell unused capacity in the HOV lanes with the intent of generating revenue (Chaudhuri et al. 2010).

An important component of any HOT facility is the method in which fees are imposed on drivers utilizing the facility. According to the Urban Land Institute (ULI), there are three primary methods utilized for pricing: cost pricing, value pricing, and congestion pricing. These can be simplified into the most common method, which is a combination of value and congestion pricing. Congestion pricing is a specific type of value pricing imposed on users to reduce congestion in the travel corridor or to maintain free-flowing conditions. Congestion pricing is highly dependent on the overall conditions in the corridor and changes based on the density of vehicles throughout the corridor (ULI 2013). In simple terms, the fee imposed on the drivers changes throughout the day as the corridor gets more congested and the demand on the HOT facilities fluctuates. These fees are backward calculated using a logit model (Chaudhuri et al. 2010).

An example of congestion pricing in Utah is the ELs along I-15 in Salt Lake and Utah Counties in Utah. This corridor is comprised of six different zones that run along the western slopes of the Wasatch Mountains. As SOV drivers enter a zone, the fee to drive their vehicle in the zone is charged. This fee is dependent on how congested the corridor is, ranging from $0.25 to $1.00. As congestion in the corridor increases, the fee to enter the corridor may also increase. However, if a driver enters a zone before the fee is increased, the driver only needs to pay the fee that was imposed when they entered the corridor, even if the price were to fluctuate (UDOT 2013).

The toll rates charged for managed lanes across the country vary from jurisdiction to jurisdiction. Table 2.1 provides a comparison of the Utah I-15 ELs with other well-known HOT lane systems, including California, Minnesota, and Georgia. The information in Table 2.1 provides information on a variety of factors related to the HOT lane systems, including total entry/exit points, length of the system, toll rates and fees, and violation rates. Average cost of living and median income from counties where the systems exist within these states are also included for socio-economic comparisons. In cases where HOT lane systems cover multiple counties, averages are reported. Based on these results, the last row in Table 2.1 suggests an average toll for the Utah I-15 ELs. This value was calculated by multiplying the out of state's cost of living with their average toll and dividing by the average cost of living in Utah.

Table 2.1 shows that average toll rates per trip in Utah are generally lower than those in the other states evaluated (specifically California, Minnesota, and Georgia). Higher toll rates have been suggested to lower the number of toll users in a facility. Research conducted by Burris et al. (2012) comparing toll increases around the nation indicates that toll elasticity on average can be estimated to be approximately -0.3. This means that as the toll rate is increased by 10%, the number of users is expected to decrease by 3%.

Raising the toll price, however, may not always mitigate excessive traffic in a managed lane. Research conducted by Samuel (2013) reports that drivers oftentimes view the higher tolls as a warning of congested traffic that thereby may incentivize more vehicles (including violators) to enter the managed lane. To dissuade increasing tolls excessively, Samuel warns that drivers may not use the lanes if they don't view price as an accurate representation of road conditions. He proposes that HOT users should be given a dynamically updated travel time to properly

assess the value of using the HOT lane. Increasing toll prices may gain more revenue, but may not necessarily lower lane usage significantly.

Table 2.1 Toll System Comparisons

Highway Name	I-15 Utah	I-15 San Diego	I-394 Minneapolis	I-85 Atlanta
Total Entry/Exit Points	34	9	8	7
Length [mi]	70	20	14	16
Min Toll	$0.25	$0.50	$0.25	$0.01/mile
Max Toll (entire corridor)	$6.00	$8.00	$8.00	$14.40
Avg. Toll Per Trip	$0.80	$1.30	$1.50	$1.79
Cost for New Account	$33.75 ($25 prepaid tolls)	$40 (all prepaid tolls)	$40 (all prepaid tolls)	Min $20 (all prepaid tolls)
Monthly Fee (charged to user)	None	$4.50 min (tolls deductible)	$1.50	None
Toll Range Per Mile Traveled	$0.02 - $0.09	$0.40 (max)	$0 - $0.57	$0.01-0.90
Free Use *(requires registration)	HOV 2+, motorcycles, buses, *low-emission veh.	HOV 2+, motorcycles, buses, *zero-emission veh.	HOV 2+, motorcycles, buses	*HOV 3+, *motorcycles, *buses, *alt. fuel veh.
Avg. Violation Rate Range	8% - 23%	5%-15%	< 5%	11-12%
Illegal Lane Use Fine	$175 (Max)	$481 (Min)	$100 (Min)	$150 (Max)
Cross Double White Line Fine	$162	$400+ (Min)	$142	$150 (Max)
Cost of Living (US Avg. = 100)	88	128	114	96
Median Income	$60,279.00	$60,230.00	$61,695.00	$54,365.50
Suggested Avg. Toll for Utah (based on Cost of Living)	--	$1.88	$1.93	$1.94

Sources: City-Data 2014a, City-Data 2014b, City-Data 2014c, City-Data 2014d, City-Data 2014e, City-Data 2014f, City-Data 2014g, Davidson 2012, Doyle 2011, FHWA 2010, GDOT 2014a, GDOT 2014b, GDOT 2014c, GDOT 2014d, GDOT 2014e, GDOT 2014f, Gephardt 2013, MnDOT 2014a, MnDOT 2014b, Vu et al. 2007, Wikipedia 2014.

Other aspects of HOT lane systems include the monthly fees, as well as the cost of account registrations. Atlanta, Minneapolis, and San Diego deposit the cost of registering for a transponder directly to an account for the payment of future tolls. In San Diego, users pay a

monthly fee of $4.50; however, if the monthly toll totals exceed $4.50, then the user would pay the total toll without additional fees. In Minneapolis, a $1.50 monthly fee is assessed to the user, regardless of use, while in Atlanta, users do not pay monthly fees. With respect to the cost for new accounts, Utah credits $25 of the $33.75 required to open an account to the payment of future tolls and does not charge a monthly fee. Based on transponder use presented in the Phase I report, roughly half of the users do not use their transponder on a monthly basis (Schultz et al. 2014); nevertheless, UDOT must pay $2.85 each month for active accounts.

2.3 Use of Vehicle Occupancy Data

AVO data has multiple uses for transportation professionals. AVO is a key variable for a Metropolitan Planning Organization (MPO) and policy makers, to monitor and assess the effectiveness of facilities serving the community. Federal transportation laws, such as the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, have required continuous evaluations of congestion management strategies, including evaluating person throughput rather than vehicle throughput (Gan et al. 2005).

As an example of the use of AVO data, the Maricopa Association of Governments (MAG) conducted a study in 2012 to monitor the use and effectiveness of their freeways and corridors. MAG wanted to monitor the number of shared ride trips and single occupant trips in the HOV lanes and GP lanes for their regional transportation model. MAG also wanted to monitor the trucks on the freeways and corridors, in order to improve their truck travel model, air quality model, pavement designs, and noise studies (MAG 2013).

In Atlanta, Georgia, an HOV lane was converted to a HOT lane along the I-85 corridor. An AVO study was conducted before and after the lane conversion to assess the impacts on carpooling and the effectiveness of the conversion (D'Ambrosio 2011).

Previous studies have identified a number of trends with respect to AVO. Knowing and understanding these trends is vital in the preparation of a proposed AVO study. For example, the AVO in the AM Peak is typically lower than the AVO of the PM Peak hours, since there are more single passenger commuters in the morning and more multi-passenger vehicles in the evening due to shopping and recreational purposes. AVO can also vary by lane, time of day, and

direction. Looking at daily variation, higher AVOs are generally reported on Fridays, while Mondays can be lower than the other weekdays (Reed et al. 1998). For this reason, it is suggested to avoid collecting AVO data on Mondays and Fridays.

From a study using an accident records database to extract AVO data, the authors reported that the demographics of a driver can alter AVO trends for a given region. For example, young drivers (age 15 to 20) tend to have more passengers in their vehicle than all other drivers (age 20+). Depending on the state/region, the race of the driver can show different AVO figures. In a study done in Florida in 2007, Black and Hispanic drivers had an AVO of about 1.47 persons per vehicle (ppv), while Caucasian drivers had an AVO of 1.38 ppv. In that same study, female drivers tended to have a slightly higher AVO than male drivers (Gan et al. 2007).

2.4 Methods for Collecting Vehicle Occupancy

There are a variety of methods available to collect AVO data, including field observation methods, survey/database methods, and automated methods. Field observation methods include the roadside method, video recording method, and carousel method. Survey/database methods include accident report database and survey methods. Automated methods include infrared cameras and in-vehicle sensors. The following subsections will examine the function, perceived strengths, perceived weaknesses, and suggested application of each of the AVO data collection methods.

2.4.1 Field Observation Methods (Non-automated)

Field observation methods are those performed with human judgment, including the roadside method, the video recording method, and the carousel method. These methodologies are described in the following subsections.

2.4.1.1 Roadside Method

The roadside method for collecting AVO is considered to be the most traditional method, since it is the simplest process to implement. In the roadside method, observers position themselves on the side of the roadway and count the passengers in passing vehicles. A team of observers typically work together, so that each observer can focus on a specific lane and collect

as many samples as possible. Data can be collected by paper and pencil or with a computer program which can record the data as soon as it is observed.

An example of the roadside method was used in Georgia during a comparison study of a HOT lane conversion along Atlanta's I-85. Before the HOT lane conversion, the observation team positioned themselves in the gore area along the I-85 corridor to collect AVO data. After the conversion, the observation team observed from near the new toll gate entrances onto the freeway. Using keypads and computers, this team was able to automate their data collection process (D'Ambrosio 2011).

The roadside method is perceived as a preferable method of collecting AVO data along road corridors, since the observers are able to collect a high sample count of the traffic. A higher count can give a detailed picture of the AVO of the traffic along a corridor or low functioning road. Observers can also be stationed along toll booths or at other vantage points, where they are safe from the flow of traffic.

The roadside method is perceived to be less accurate when collecting AVO data along a high speed road, such as a freeway or interstate. Observing high speed vehicles creates difficulty for the observer to accurately view the occupancy of the vehicle, which increases the chance to record inaccurate data. Tinted windows add to the difficulty of collecting accurate data at high speeds. With longer periods of observation time, the accuracy of the observers can be reduced through observer fatigue. Insufficient lighting or bad weather may also interrupt a data collection schedule, while some road segments do not have the appropriate geometry to allow observers to be able to see the traffic while standing in a safe area.

The roadside method is reported to be the most effective for collecting AVO data for corridors and low functioning roads, while being less effective on multi-lane freeways (Heidtman et al. 1997).

2.4.1.2 Video Recording Method

The video recording method is similar to the process of the roadside method; however, in this method, a video camera replaces the presence of an observer in the field. Once the scheduled recording has finished, the camera is retrieved and the video is processed by an observation

team. As needed, the video recording method could be used concurrently with the roadside method to provide a backup of the observation.

A perceived advantage of using the video collection method is that a copy of the observation can be reviewed in further detail by playing the video at various speeds in an effort to increase the accuracy of the count. Having the video recording can also control the effect of observer fatigue, since the process of reviewing the video can be paused when the observer is feeling fatigued.

The video collection method requires a substantial time investment and initial cost, primarily through the acquisition of video equipment. Once the equipment is acquired, the video equipment is susceptible to damage from weather, tampering, or theft. Despite the advantage of capturing high quality video with modern technology, the time invested to review the video can become excessive. The glare from the sun on a windshield decreases the effectiveness of the video method. If the light intensity from the reflection of the sun off a windshield is greater than the light intensity reflecting off the passengers from within in the vehicle to the observer, then the glare overwhelms any visibility into the vehicle (Hao at al. 2011). The glare off a windshield can be avoided in overcast weather, which is a factor that cannot be controlled by the observation team.

The video collection method has not been considered to be a primary method for collecting reliable AVO data on freeways or corridors. Even today, the video method is more useful as a supplement other collection methods, such as the roadside method (Heidtman et al. 1997).

2.4.1.3 Carousel Method

The carousel method involves one or more observation vehicles driving concurrent with the flow of traffic, ideal for a multi-lane freeway. In each observation vehicle, there is a driver and multiple observers: the driver focuses on maintaining ideal speed; the observers focus on their assigned lane(s). The observation vehicle drives slightly slower than the flow of surrounding traffic (approximately 5-10 mph), which allows the observers to count vehicle occupancy in passing vehicles. The observers are equipped with appropriate data recording tools, such as paper and pen or a computer program designed to record observation data.

In 2012, the Arizona Department of Transportation used the carousel method as a supplement to their roadside observations during an AVO study. Over a period of 10 observation days, vehicle occupancy was observed between 8:00 a.m. to 4:00 p.m. on one of two routes, with scheduled breaks. A Global Positioning Satellite (GPS) enabled touchpad was used to plot the location of each vehicle observed (MAG 2013).

The advantage of the carousel method in collecting AVO data is that the observers have an increased amount of time to look into other vehicles and get a more accurate count of the passengers in that vehicle. By moving along the freeway with the traffic, the observers can observe occupants in vehicles that might not be safely or accurately observed using other methods.

The carousel method is not effective on a two lane corridor or on a low speed road. Although the carousel method yields greater accuracy, this method does not collect as many samples, compared to the roadside method. If there are not many cars traveling on the multi-lane freeway, then this method may have to be repeated in order to collect sufficient sample points to represent the average vehicle occupancy of the highway. The carousel method can also be hindered by lack of lighting, observer fatigue, or by extreme traffic flow patterns.

The carousel method has been demonstrated to be the most effective when determining AVO for multi-lane freeways (Heidtman et al. 1997).

2.4.2 Survey/Database Methods (non-field collection methods)

Survey/database methodologies rely on surveys and data that have already been collected, including regional surveys and accident reports. These methodologies are described in the following subsections.

2.4.2.1 Accident Report Database

In most municipalities, a database of accident records is collected and available for review. These records include multiple fields of information related to the accident, such as location (district, county, section of road), date, time, type of vehicle, accident severity, and demographics of the driver (age, ethnicity) (Gan et al. 2005).

The Florida Department of Transportation has developed a database tool called the Florida Accident Vehicle Occupancy Rate InformaTion Estimator (FAVORITE). This program is designed to search the accident report database in Florida and to provide AVO for the user. The AVO data can be organized using FAVORITE and displayed using Geographical Information Systems (GIS) software (Gan et al. 2005).

Using the information from the accident reports database can illustrate the AVO for a given region or county. Since the data can be extracted without extra field observations, this method can be the most cost effective method, once the data extraction program is developed.

Although the accident report database method can provide cost effective data, the AVO data pulled from accident record databases are susceptible to bias, such as younger drivers have higher AVO occupancy than older drivers, female drivers have a higher AVO than male drivers, and Black/Hispanic drivers have a higher AVO than Caucasians (Gan et al. 2007). In addition, accident records can take time to process and input into the database, which means it cannot provide a real-time representation of AVO on a given roadway. If a specific roadway is being studied for AVO, then the accident databases may not be able to provide a sufficient sample size to give a confident representation of the AVO for that road segment.

Using the information from accidents records provides a reliable, low cost representation of AVO for a given region. This method can also give a long term trend of person throughput and vehicle occupancy, which can be useful for MPOs.

2.4.2.2 Survey Method

Another non-field method to collect AVO data for a region is through a user survey. Traditionally, surveys were conducted through the mail system, by telephone, or on-site (for site-specific studies). With modern technology, sending surveys via the internet reduces the cost of postage for mailing out surveys. Surveys can be designed to collect various amounts of data, including route used frequently, home and work zip codes, time of travel to/from work, and average number of passengers in a commuting vehicle (Heidtman et al. 1997).

Surveys are useful for collecting a sample of AVO data for a region. Repeated surveys could be implemented over time to capture a trend of person throughput and AVO. Using electronic means, a survey can be distributed to a large area of residents at a relatively low cost.

The effectiveness of surveys greatly depends on the number of participants in the survey. For example, if 10% to 15% of a population is sent the survey at random, and only 10% of those respond to the survey, the resulting sample size will be low (Heidtman et al. 1997). Surveys may also be biased by only representing commuters to work and omit the representation of other commuters on the road.

Collecting AVO through surveys is most suitable for collecting AVO for a given region or even at a specific site (such as a work place). The results of a survey can be helpful for tracking long term trends of AVO along a given corridor.

2.4.3 Automated Methods

Automated methods are innovative methods which are able to automate the observation process in the field, including infrared camera systems and in-vehicle sensors. These methodologies are described in the following subsections.

2.4.3.1 Infrared Camera

Infrared systems are being developed to automatically detect vehicle occupancy in a moving vehicle. The infrared light used (wavelength range 1100 nm – 1700 nm) is invisible to the human eye, but can be captured with a specific camera lens. In this system, an infrared illuminator is placed along the roadway being observed and is pointed at oncoming vehicles. A camera with an infrared lens is positioned in a way to capture the refraction of infrared light from vehicle occupants (Hao et al. 2011). An example of an infrared setup is shown in Figure 2.1.

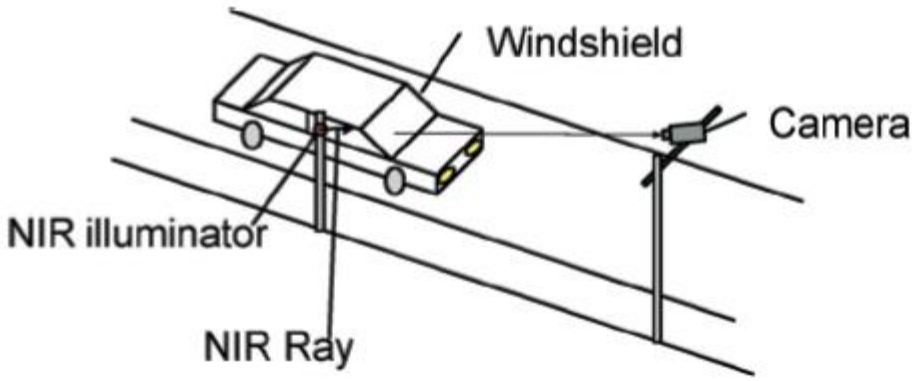


Figure 2.1 Configuration of infrared imaging (Hao et al. 2011).

The advantage of infrared imaging compared to conventional video imaging is that infrared imaging can minimize the effects of windshield glare experienced by conventional video imaging techniques. Infrared imaging has the capability of working during the day or night, and is able to perform within most weather conditions (Hao et al. 2011).

Infrared detection systems are currently being developed and have a high cost for the system. The algorithm to correctly detect occupancy at high speeds is continually being developed and improved. Once the infrared system can be practically applied, it has a great potential for being a reliable method for collecting AVO data along corridors and freeways.

2.4.3.2 In-vehicle sensors

A variety of in-vehicle occupancy sensors have been suggested, as the capabilities of technology improve. These ideas include but are not limited to weight/seatbelt sensors to track vehicle occupancy, GPS prompts for vehicle occupancy and trip tracking, and in-vehicle camera (conventional or infrared) to detect vehicle occupancy per trip. These examples are innovative but may be impractical due to limitations to implement in older vehicles, factors causing the sensors to be "tricked," cost of the implementing automated sensors, and securing user participation in these automated systems.

2.5 Enforcement Techniques Related to Managed Lanes

Enforcement strategies and techniques have been discussed in great detail in the Phase I report and are available in the literature (Schultz et al. 2014). Some of these techniques include strategies for HOV facilities, which are comprised of stationary enforcement patrols, roving enforcement patrols, team patrols, and citations or warnings by mail. Other means include self-enforcement, which mainly comprises of the HERO program, implemented by the Washington State Department of Transportation (WSDOT 2014).

Technology has played a major part in assisting HOV enforcement. Different technological possibilities are also summarized in the Phase I report, and include video systems, infrared and multi-band infrared systems, vehicle transponders, and universal tags or decals on all HOT vehicles. Also included in the Phase I report is a discussion on strategies and techniques regarding HOT lanes and exempt vehicles (Schultz et al. 2014).

The purpose of an HOV lane is to reduce the number of vehicles that are on the road, by combining two or more drivers that are going to similar destinations, and therefore eliminate one car from the road. A number of studies have been completed to identify ways to better track and enforce HOV users. One of these studies looks at changing the definition of what a HOV lane is and rethinking which vehicles are allowed in different lanes, which could also have a major impact on easing the task of enforcing these lanes. For example, the current definition for an HOV 2+ lane is that any passenger vehicle with 2 or more occupants inside the vehicle is allowed to use the HOV lane. If the definition were changed to "any *registered* passenger vehicle with 2 or more occupants are allowed to use the HOV lane" the vehicles eligible to use these lanes would change dramatically and be more easily tracked. In this scenario a passenger would be considered registered by coordinating with already existing carpooling agencies and/or the local department of transportation (DOT) (Poole 2011). Each of these registered carpool vehicles would be given a transponder, identical to those used for HOT lanes. For a group of carpoolers, only one of the registered vehicles would count as the HOV vehicle for a specific time period and be charged a zero toll, and if any other of the registered vehicles for a specific carpool group would be charged the toll rate if they were to use the HOV lane for that time period. This way only one vehicle will be considered the HOV vehicle for that given time period, and all other members of this carpool group will have to pay a toll to use the HOT lane. This will allow for

much easier enforcement as every vehicle in the HOV/HOT lane will have a transponder that is always active. While occasional enforcement will need to be done to make sure that every vehicle in the HOV lane has a transponder, the majority of the time enforcement will be automated by the original tolling software (Poole 2011).

2.6 Violation Data

The American Association of State Highway and Transportation Officials (AASHTO) *Guide for High-Occupancy Vehicle Facilities*, states that "the enforcement policies and programs should be followed to maintain the integrity of the facility by deterring possible violators and to promote the safe and efficient use of the lane" (AASHTO 2004). The following subsections examine reported HOT lane violation rates and studies across the nation, and in Utah.

2.6.1 Violation Data Nationally

Based on a report by Hlavacek et al. (2006), the national average for HOV lane violators varies between 10-15%. According to the FHWA in 2008, the EL violation rates varied across the country from 1% to 43%. Some of the highest rates are shown in Table 2.2. As of 2008, 76 of the 86 HOV facilities reported violation rates at 15% or less (Chang et al. 2008).

Table 2.2 EL Violator Data (Chang et al. 2008)

Road Site	Location	Highest Violation Rates (%)*
I-15; between SR 163 and SR 56	San Diego, California	43%
I-35 W; between 66th St and Burnsville Pkwy	Twin Cities, Minnesota	37%
SR 54 EB; between I-805 and SR 125	San Diego, California	28%
I-495 between Maryland and Virginia	Washington DC region	17%-28%

**The majority of sites experienced a violation rate of 15% or less*

2.6.2 State Violation Rate Studies

Studies to monitor violation rates in Washington, California, Virginia, and Arizona are included in the following subsections.

2.6.2.1 Washington State Violation Study

In the summer of 2003, a two-year pilot program began in Washington State that allowed SOVs to use HOV lanes on corridors in the Seattle area during the hours of 7:00 p.m. and 5:00 a.m., seven days a week (Washington State TRAC 2006). In the two years that followed, Washington measured the violation rates across the state and compared the results, some of which are shown in Table 2.3. It was also noted in this study that the violation rates increased at the end of the time period for public HOV lane access.

Table 2.3 Range of HOV Violation Rates in Washington (Washington State TRAC 2006)

Location	Time Period	Before Program	First Year	Second Year
Statewide	5:00 - 7:00 a.m.	1.3% to 7%	0.8% to 9%	0.8% to 8.4%
Statewide	6:45 - 7:00 p.m.	0.5% to 4.7%	0% to 8.9%	0.0% to 9.3%
SR 167 SB; at Renton	PM Peak			12.4%
I-405 SB near Newcastle	PM Peak			15.4%
SR 167 SB in Auburn*	AM Peak	25.6%		11.6%
SR 167 SB in Auburn*	PM Peak	16.6%		4.5%

**This site has historically had high violation rates and is atypical because of its location just before the end of the HOV lane network, although the violation rates have dropped in the past year.*

2.6.2.2 Los Angeles Violation Study

In the Los Angeles, California region, specifically on I-10, a study was conducted to evaluate the effects of an HOV 3+ compared to and HOV 2+ limit in the HOV lane and to determine how it would affect the volume of traffic (Turnbull et al. 2002). Before the change in the law, the number of vehicle occupants necessary to be in the HOV lane was at least 3 people. With the new law the vehicle only needed 2+ occupants. This caused a drop in the violation rates to 1% during the AM and PM Peak periods from 7% and 2%, respectively. More cars were allowed in the HOV lane, which caused the lane to become more congested.

In response to the congestion, a new policy was implemented where 3+ occupants were required for the HOV lanes during the AM period and 2+ occupants in the PM period. When this rule changed, there was a significant increase in violation rates, increasing to 41% and 56% in the AM and PM Peak periods, respectively. After some investigation it was determined that the reason for this jump in the violation rates was due to the public not knowing about the changes or

the laws. This prompted a four week education period where advertisements were placed in the paper and on the radio. In addition, enforcement of the HOV lane was increase during this time. This prompted a lowering of the violation rates to even better than before the new law came into place. Table 2.4 shows the violations rates through the course of the study. The violation rates declined after a period of heightened enforcement, which included briefings for all California Highway Patrol (CHP) shifts, press releases, and radio broadcasts highlighting the correct occupancy requirements and announcing increased enforcement and four weeks of enforcement saturation with extra CHP officers assigned to the HOV lane.

Table 2.4 Los Angeles Region HOV Violation Rates (Turnbull et al. 2002)

Time Period	Before Requirement Changes	During 2+ Requirement	After 3+/2+ Requirement w/o advertising	After 3+/2+ Requirement w/ advertising
AM	7%	1%	41%	<7%
PM	2%	1%	56%	<2%

2.6.2.3 Virginia's Violation Study

From October 2007 to August 2009 in Northern Virginia, a study observed the effects of manual enforcement techniques on violation rates in the HOV lane (Smith and Yook 2009). To test this, a group of researchers were hired to monitor the AM and PM Peak period violation rates of the HOV lane before, a day after, and a week after an enforcement blitz. The two sites were I-66 and I-395. Table 2.5 and Table 2.6 show the violation rates before and after the enforcement blitzes along I-66 and I-395, respectively.

Table 2.5 HOV Violation Rates along I-66 (Smith and Yook 2009)

	March 17 (Prior to Enforcement)	March 25 (1 Day After Enforcement)	April 2 (9 Days After Enforcement)
AM Peak	23%	26%	28%
PM Peak	28%	28%	28%
Daily Average	26%	27%	28%

Table 2.6 HOV Violation Rates along I-395 (Smith and Yook 2009)

	May 2 (Prior to Enforcement)	May 7 (2 Days After Enforcement)
AM Peak	20%	19%
PM Peak	22%	19%
Daily Average	21%	19%

The results of the study show that the saturation enforcement did not result in a reduction in the HOV violation rate. In fact, the rate rose slightly following the enforcement operation (Smith and Yook 2009). This large-scale field data collection effort demonstrated that saturation enforcement of HOV regulations may have little to no impact on HOV lanes.

2.6.2.4 Phoenix Arizona Violation Study

In 2012, the Phoenix Region MPO and MAG monitored travel behaviors and traffic patterns on area freeways, HOV lanes, and select arterial facilities, in the Phoenix, Arizona region (MAG 2013). Table 2.7 shows the violation rates in the HOV lane along the selected freeways.

Table 2.7 HOV Violation Rates by Freeway (MAG 2013)

Freeway Segment	AM Period Violation (%)	PM Period Violation (%)
I-10	11%	11%
I-17	25%	16%
SR 51	15%	10%
Loop 202	12%	15%
US-60	20%	10%
Loop 101	13%	6%

HOV lane violation rates vary within each peak period with more overall violators in HOV lanes during the AM Peak period than during the PM Peak period. Higher violation rates can also be seen at the beginning and ending of restricted use HOV hours for both AM and PM Peak periods (MAG 2013).

2.6.3 Violation Data in Utah

Utah reports a violation rate of 17%, according to the Utah State 2012 Annual Report (UDOT 2012). Violator data collected in the 2012 Annual Report include both a summary of the violation reports as well as AVO data from previous studies.

3.0 DATA COLLECTION

3.1 Overview

The method for collecting data is a key component of this analysis and was collected in an effort to quantify the current vehicle occupancy and vehicle types in the Express and GP lanes. The data collected for this analysis was done through the carousel method, which allowed for the acquisition of vehicle occupancy and vehicle type data.

The rationale for choosing the carousel method, carousel method data collection procedure, equipment for recording data, rationale to verify sample size, and a summary of the data collected through the carousel method is included in the following subsections.

3.2 Methodology Chosen: Carousel Method

The carousel method was evaluated and selected based on a comparison of all methods identified in Chapter 2 as well as a cost comparison with the field observation methods. A discussion of each of these is included in the following subsections.

3.2.1 Carousel Method Compared to Other Methods

From the methods for collecting vehicle occupancy summarized in Chapter 2, the carousel method was selected as the most favorable method for collecting AVO data on multi-lane freeways. After comparing the strengths and weakness of each collection method, it was determined that the carousel method would be the most appropriate for the scope of this study. A comparison of the carousel method and each method from Chapter 2 is provided in the following subsections.

3.2.1.1 Carousel Method Compared to Roadside Method

The roadside method is a commonly used method for collecting AVO data on multi-lane freeways. The roadside method is able to collect a high number of samples in a relatively short period of time. The roadside method is effective when the observers have a clear view into the vehicles being observed from a fixed (and safe) location. From several field tests, it was

determined that the accuracy of data collected through the roadside method was lower, since the vehicles being observed were traveling in excess of 65 mph. It was also determined after a thorough review of the corridor that sufficient roadside data collection locations were not available along the I-15 EL corridor.

When compared to the roadside method, the carousel method yields fewer samples; however, the data collected by the carousel method are perceived to be more accurate than data collected by the roadside method. The carousel method allows the observers to see vehicles traveling at a speed difference of 5-10 mph, relative to the observation vehicle. This difference in speed allows for the observer to have additional time to perform a more accurate count of vehicle occupancy.

For freeway studies requiring the vehicles to be classified by type, the carousel method allows for more accurate sample observations. Traveling with the flow of traffic allows for additional time for the observers to identify the small registration stickers and Express Pass transponders, which would be difficult to see from the perspective of a stationary roadside observer.

The mobility of the observers using the carousel method allows observation to be performed on any segment of the freeway, while the roadside method is limited by the number of safe locations along multi-lane freeways. The safety of the observers in the carousel method is preserved through the driver's responsibility to focus on the road and to maintain safety.

Given these factors, the carousel method was selected as the optimal choice for collecting AVO data for this study, when compared to the roadside method. High quality samples can be collected, which can be turned into accurate representations of freeway vehicle occupancies.

3.2.1.2 Carousel Method Compared to Video Method

For freeway observations, the video method is limited in its capabilities to provide reliable AVO data. From several field tests it was determined by the research team that the glare from windshields decreased visibility into the vehicles, which decreased the perceived accuracy of the counts. If the glare was reduced and the video equipment secured, there is still a

significant time commitment to process the video. The carousel method is more favorable by providing accurate data in a more time efficient manner.

3.2.1.3 Carousel Method Compared to Survey/Database Method

Although the survey method is useful for collecting data on AVO and trip data on a wide scale, the survey method may not be sufficient to collect needed data for ELs or specific segments of the freeway.

The information available through an accident database is limited in providing information for specific freeway segments or lanes, such as the EL. Data provided from accident records also needs statistical adjustment when calculating AVO, since the AVO data can be skewed, as stated in Chapter 2. The accident record database cannot provide real time data on AVO, since each record being entered into the database may need time for processing and review.

The survey and accident database methods may be useful in providing long term AVO data over time but was determined to be costly and ineffective in providing real-time data for specific features of multi-lane freeways. For these reasons, the carousel method is more favorable for application in this study than the survey or accident database methods.

3.2.1.4 Carousel Method Compared to Automated Methods

Infrared camera systems and other in-vehicle sensors have a great potential to monitor and provide real-time enforcement and data to managed lanes. This technology is still being developed and the infrastructure to support such systems is not available for all freeway systems. The carousel method is simple to implement and does not require the technological investment as the infrared system or other automated methods. For these reasons, the carousel method is more favorable for this study than available automated methods.

3.2.2 Cost Comparison of Carousel Method to Roadside and Video Method

In addition to evaluating the data collection methodology, a cost comparison was also conducted to compare the different field observation methods. The factors of time, mileage, accuracy, and an overall comparison are considered in the following subsections.

3.2.2.1 Time Cost

Time is an important factor because it dictates the schedules of observations and the timeline to produce results (including time to collect and process results). It was assumed that the video method would require the most time when compared with the other methods, primarily due to the additional time necessary to set up and take down the equipment, to download the video to be processed, and to process the video. While processing the video, the footage can be slowed down to attempt to get more accurate counts. Slowing down the video footage increases the amount of time to process the data in an accurate manner.

The roadside and carousel method were determined to be similar in time commitment, including time to travel to the observation site, observation time, and time to process the data (assuming equal data collection procedures).

3.2.2.2 Mileage Cost

Mileage becomes a factor in selecting a method due to the cost of renting or maintaining observation vehicles. This cost may vary by the availability of vehicles to rent and the extent of the freeway being observed for AVO data collection.

The carousel method incurs the greatest cost related to the observation vehicles, since the entire length of freeway of interest is driven multiple times for observation. An appropriate vehicle is also required to allow the observers adequate visibility of their assigned lanes. This suggests that a larger vehicle is preferred, which could incur a higher cost for rental/maintenance. The roadside and video methods would only require transporting the observers and equipment to and from the observation sites. For this given transportation need, a smaller vehicle could be used, thus reducing the cost of renting/maintaining the vehicle.

3.2.2.3 Accuracy Factor

The factor of accuracy also determines the effectiveness of a method. If a method is not accurate for a given situation (e.g., multi-lane freeway, collector street, etc.), then it should not be considered as a method of observation.

The carousel method was determined to be highest in accuracy for multi-lane freeway studies compared to the roadside and video method. Traveling concurrent with the traffic being

observed allows the observers to see at the same level as the vehicles being observed, which allows the observers to see all passenger seats. When compared to the other alternatives, the carousel method was rated "High" in terms of accuracy based on the speed differential and vantage point of the observers.

The roadside and video methods were ranked lower than the carousel method based on the research teams experience with these methods. Although larger vehicle samples can be gathered with the roadside method, the high speeds of the vehicles on the freeway makes it more difficult to accurately see all passengers in the vehicle. The video method shares similar disadvantages, with the additional disadvantage of windshield glare. As a result, the roadside method was rated "Medium" in terms of accuracy and the video method was rated "Low."

3.2.2.4 Cost Comparison Result

In order to determine the cost of using one of these three observation methods, a calculation of time and mileage cost was done to put a nominal dollar amount to each method. The cost estimations were assumed for a single observation period, in the context of collecting data for I-15 in Utah. Each observation period was planned to be approximately 2 hours (120 minutes). From BYU, it takes about 10-15 minutes (~4-6 miles) to get onto the freeway. From the freeway entrance, the observation sites (or starting points for the carousel method) are within a 50 mile range. For the cost comparison evaluation, it was assumed that the observation team needed an additional 10 minutes to reach the observation site (or starting point) that is 10 miles once on the freeway.

For the carousel method, it was assumed that an observation team of four travels the 110 mile observation loop during the 120 minutes of observation time. The time to walk to and from an observation site is eliminated, since observation begins while in the vehicle on the freeway. The cost per mile for the vehicle is slightly larger than the other methods, since the use of a larger vehicle (to maximize safety and comfort) would be more expensive than if a smaller, more economical vehicle was used.

For the roadside method, it was assumed that an observation team of four would need about 5 minutes to park their vehicle and walk to the observation site. For the video method, it was assumed that an observation team of three needs approximately 1.5 times the amount of

video footage for review time, since the video can be paused and slowed in an attempt to increase accuracy.

As summarized in Table 3.1, with all factors combined, the video method produced the highest overall cost, followed by the carousel method, and finally the roadside method. However, when perceived accuracy is taken into consideration, the carousel method was determined to be superior to the other methods based on the time available to observe each vehicle and the small relative speed difference between the vehicles and the observer. In addition to delivering more accuracy per observation cost, the carousel method gives the flexibility to explore a wider range than the roadside or video method, which can only observe vehicle occupancy from a fixed point.

3.3 Carousel Method Data Collection Procedure

The carousel method involves one or more observation vehicles driving concurrent with the flow of traffic. In each observation vehicle, there is a driver and multiple observers; the driver focuses on maintaining ideal speed; the observers focus on their assigned lane(s). The details on the process of collecting data through the carousel method for this study are included in the following subsections: routes, collection periods, classification of observation data, lane position, vehicle selection, speed of observation vehicle, observer assignment and arrangement, and guidelines for accurate observations.

3.3.1 Routes

The segments of I-15 being observed are outlined by zone in Table 3.2 and illustrated in Figure 3.1. A detailed layout of the zones is shown in Figure 3.2.

From the results of the Phase I study (Schultz et al. 2014), Zones 160 and 240 were not identified as zones of concern, as the peak period speeds exceeded 55 mph in these zones. For this reason, combined with the distance to the zones and construction along the route, these zones were omitted from this study. The remaining zones became the focus of the data collection effort.

Table 3.1 Cost Comparison of Carousel Method to Roadside and Video Methods

TIME COST (min)	Carousel	Roadside	Video
Driving to Site	25	25	25
Walking to Site	0	5	5
Equipment Setup	1	1	5
Observation Time	120	120	120
Equipment Take-down	1	1	5
Walking from Site	0	5	5
Driving from Site	25	25	25
Data Review	1	1	180
Total Time (min)	173	183	370
Total Time (hours)	2.88	3.05	6.17
OBSERVER COST	**Carousel**	**Roadside**	**Video**
Hourly Rate per Observer	$12.00	$12.00	$12.00
Number of Observers	4	4	3
Total Cost of Observer	$138.40	$146.40	$222.00
MILEAGE COST	**Carousel**	**Roadside**	**Video**
To Site (miles)	15	16	16
On Site (miles)	110	0	0
From Site (miles)	15	16	16
Total Miles	140	32	32
Cost per mile	$0.43	$0.38	$0.38
Cost of Miles	$60.20	$12.16	$12.16
OVERVIEW	**Carousel**	**Roadside**	**Video**
Total Cost	$198.60	$158.56	$234.16
Accuracy	High	Medium	Low
Area Observed	Up to 100 miles of roadway	Fixed Point	Fixed Point

Table 3.2 Zone Extents of I-15

Northbound		
Zone	Name	Extents
130	South Utah County	U.S. 6 to University Parkway
135	Central Utah County	University Parkway to Lehi Main Street
140	North Utah County	Lehi Main Street to 14600 South
145	South Valley	14600 South to 7200 South
150	Salt Lake	7200 South to 2300 North
160	North Davis County	Parrish Lane to Layton Parkway
Southbound		
Zone	Name	Extents
240	North Davis County	Layton Parkway to Parrish Lane
250	Salt Lake	2300 North to 7200 South
255	South Valley	7200 South to 14600 South
260	North Utah County	14600 South to Lehi Main Street
265	Central Utah County	Lehi Main Street to University Parkway
270	South Utah County	University Parkway to U.S. 6

Figure 3.1 I-15 EL zones.

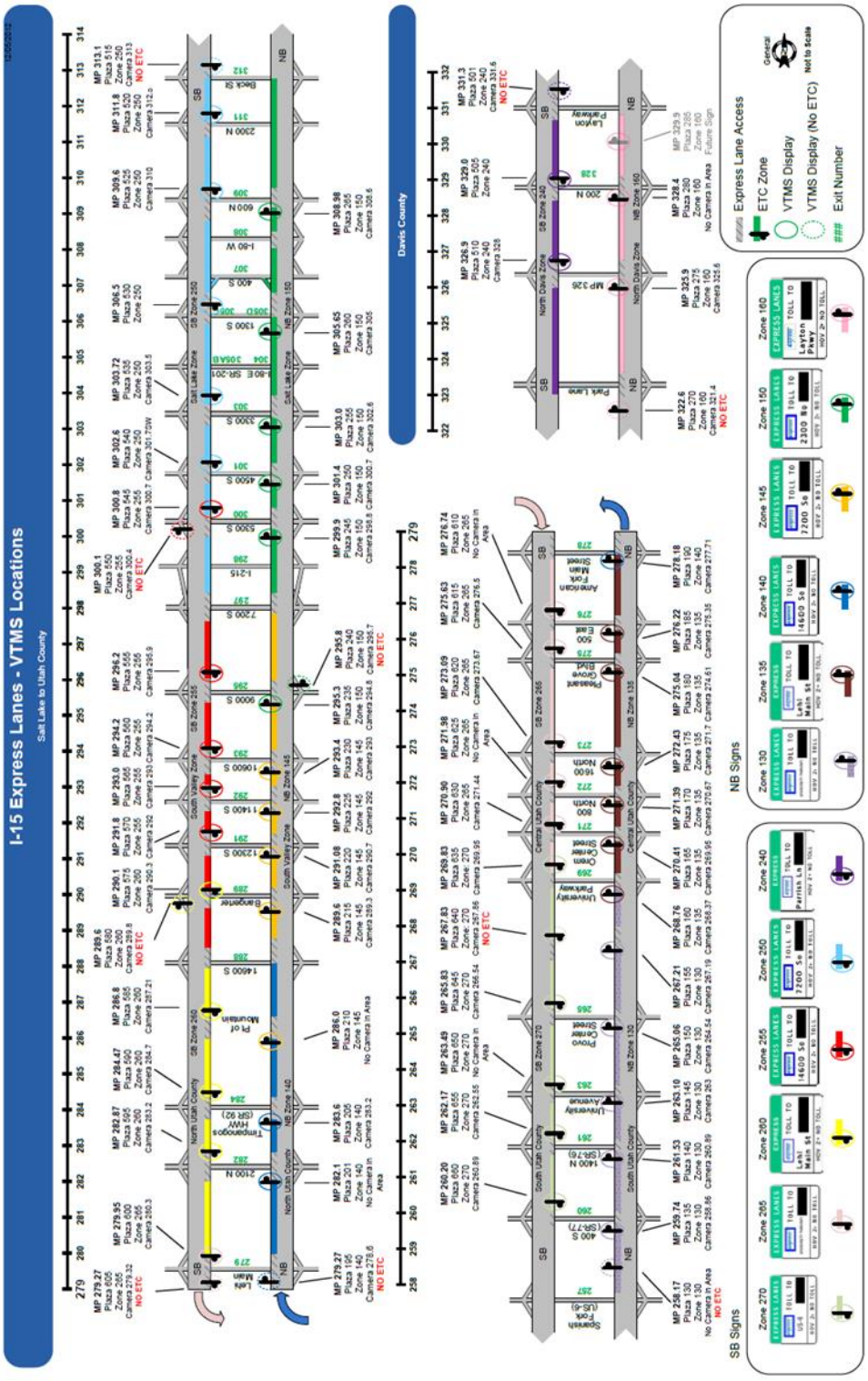


Figure 3.2 I-15 ELs – VTMS locations.

During a typical collection time, the observation team would begin at a randomly selected starting point and drive during the extents of the observation period. One complete route, completed in about 2 hours, totaled to approximately 110 miles. In the occasion that heavy traffic prevented the observation team from covering all 110 miles within an observation time, future observation plans were made to adequately gather samples from each zone during each observation time period.

Towards the end of the collection period, there were several zones that required additional observation time due to lower volumes and subsequently, smaller sample sizes. These zones included primarily Zone 130 and Zone 270 (U.S. 6 to University Parkway). These zones had comparatively less vehicles in the ELs and GP lanes than the zones towards the north. To address these zones, the route was adjusted to focus on the extents of these zones that needed more samples.

3.3.2 Collection Periods

From the results of the Phase I study (Schultz et al. 2014), the AM Peak hours were identified to be between 7:30 a.m. to 8:30 a.m. along the I-15 corridor, with the northbound (NB) traffic more congested than the southbound (SB) traffic. The PM Peak hours were identified between 5:00 p.m. to 6:00 p.m. along the I-15 corridor, with the SB traffic more congested than the NB traffic.

For this study, three collection periods were identified. Vehicle occupancy was collected during the AM Peak hours, Off-Peak hours and PM Peak hours. The range of the observation periods are summarized in Table 3.3.

The data were collected between May 20, 2014 and June 12, 2014. Although this time does not allow for a year round representation for AVO for the entire corridor, the results of the observation were within the appropriate scope for this project.

Table 3.3 Data Collection Periods

Time Name	Time Range
AM Peak	6:50 a.m. to 9:10 a.m.
Off-Peak	11:50 a.m. to 2:10 p.m.
PM Peak	3:50 p.m. to 6:30 p.m.

3.3.3 Classification of Observation Data

Based on the interaction with the TAC, several vehicle types of interest were identified for the study. From the observations of the research team, those types were expanded to include more detailed occupancy information for each vehicle type. Table 3.4 summarizes the types of vehicles of interest for this study.

The passenger vehicles with Express Pass transponders have the option of having the toll transponder turned on or off. From several field tests, it was difficult to accurately identify whether the transponder was in the "on" position or in the "off" position. Therefore; for the scope of this study the occupancy of the Express Pass vehicles observed was recorded if a transponder could be seen, whether it was on or off.

The observation team was trained to recognized and identify passenger vehicles with "C" decals. Since the vehicles that are issued a "C" decal are typically hybrid vehicles, the research team used this clue to correctly identify the "C" decal vehicles. Due to the transparency of the sticker and the placement in the upper corner of the windshield, it is anticipated that some "C" decal vehicles would have been overlooked and considered as a regular passenger vehicle.

Since buses were included in the observations, the occupancy of the bus was estimated. If it was observed that the bus had less than 5 passengers, the bus was counted as "empty." If there were approximately 20 passengers on the bus, the bus was counted as "half full." If the bus looked full to capacity, the bus was counted "full." The exact count of passengers in each bus observed was not recorded.

Freight vehicles, including semi-trucks, multi-axle vehicles and large trucks, were identified as all large and/or multi-axle vehicles whose purpose is to move goods, not people. In addition, security vehicles were counted as a freight vehicle.

Since emergency vehicles (such as police cruisers, ambulances, etc.) may enter the EL in the case of an emergency or an incident, an "Emergency Vehicle" category was included. This prevented the violator data from being skewed from the presence of a single occupancy emergency vehicle in the EL, such as a police cruiser.

Table 3.4 Summary of Vehicle Types of Interest

Vehicle Types Requested by TAC	Vehicle Types Used in Study
SOV HOV with 2 passengers (HOV 2) HOV with 3 or more passengers (HOV 3+) Vehicles with Express Pass Transponders Vehicles with "C" decals Buses Motorcycles Freight Vehicles (Semi's, Multi-axle vehicles, Large Trucks)	Passenger Vehicle with 1 occupant Passenger Vehicle with 2 occupants Passenger Vehicle with 3 occupants Passenger Vehicle with 4 occupants Passenger Vehicle with 5 or more occupants Express Pass Passenger Vehicle with 1 occupant Express Pass Passenger Vehicle with 2 occupants Express Pass Passenger Vehicle with 3 occupants Express Pass Passenger Vehicle with 4 occupants Express Pass Passenger Vehicle with 5 or more occupants "C" Decal Passenger Vehicle with 1 occupant "C" Decal Passenger Vehicle with 2 occupants "C" Decal Passenger Vehicle with 2 occupants "C" Decal Passenger Vehicle with 3 occupants "C" Decal Passenger Vehicle with 4 occupants "C" Decal Passenger Vehicle with 5 or more occupants Bus (empty) Bus (half full) Bus (full) Motorcycle, 1 rider Motorcycle, 2 or more riders Freight Vehicles (semi-truck, multi-axle vehicles, large trucks) Emergency Vehicles (Police cruisers, ambulance, etc.)

3.3.4 Lane Position

From preliminary field tests, the third GP lane from the EL was identified as the optimal lane to observe surrounding vehicles. The third lane allowed for optimal view of vehicles in the EL and all GP lanes, as seen in Figure 3.3. Being in the third lane allowed other vehicles, including freight vehicles, to pass on the left of the observation vehicle. This lane position did not force other vehicle with a high gross vehicle weight or pulling a trailer to violate Utah State Code concerning left lane restrictions (Utah State Code 2014a).

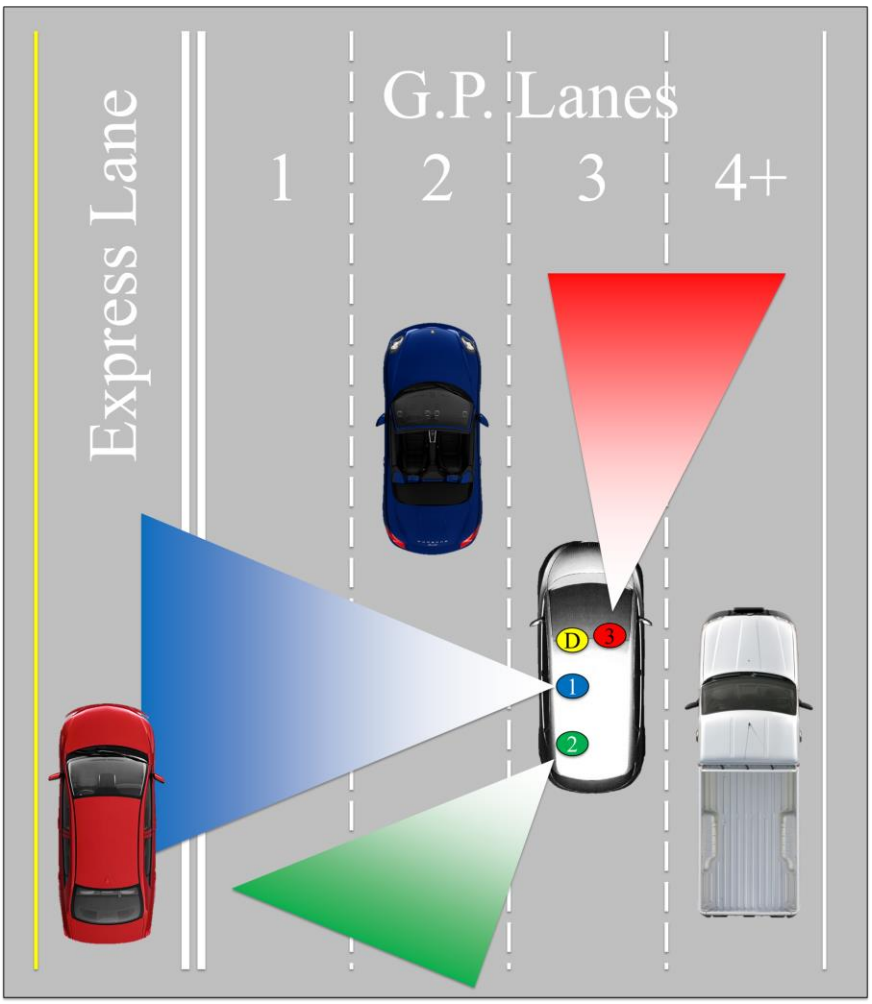


Figure 3.3 Observation vehicle lane positioning example.

3.3.5 Vehicle Selection

Through the BYU Motor Pool, several vehicle options were available for the data collection process, each at a different rental rate. To find the best vehicle for this study, a sedan, a 7-passenger van, and a 12-passenger van were considered and compared in the field. From the results of several sampling runs, the 7-passenger van was favorable over the sedan and 12-passenger van for several reasons. The 7-passenger van allowed the observers to view into other cars from a higher perspective than the sedan offered. The 7-passenger van allowed for more room for the observers to sit in a position to look at traffic that was the most comfortable and with less strain on their necks. Although the 12-passenger van provided a higher perspective than the 7-passenger van, the 12-passenger van was too large to easily maneuver and was not as

comfortable as the 7-passenger van for data collection. Although the sedan was less expensive to rent, the cost difference was not determined to outweigh the benefit that the van gave to the observers.

Towards the end of the observation collection period, it became a priority to focus on sampling from the EL, since sufficient GP lane data were collected. To accommodate for this adjustment, two sedans were used, with a driver and observer in each vehicle. With two vehicles, routes were arranged so that each vehicle was driving in a unique direction to avoid double counting vehicles. This was done by starting at the mid-point of the collection route and having the vehicles drive in opposite directions on the freeway (one NB and one SB).

3.3.6 Speed of Observation Vehicle

The nominal speed of the observation vehicle depended on the flow of traffic and posted speed limits. The speed was maintained approximately 5 to 10 mph slower than the flow of traffic, but no lower than the posted speed limit (unless the general flow of traffic was lower than the speed limit). Driving slower than the flow of traffic yielded the highest sampling rate, while maintaining safety of the observation team and other drivers on the road. During periods of heavy traffic and reduced speeds, the driver remained a safe speed with the flow of traffic, while the observers keep track of the vehicles counted, to prevent double counting.

3.3.7 Observer Assignment and Arrangements

Each observer in the vehicle was assigned a section of the roadway to observe. One observer was assigned to count vehicle occupancy in the EL. The remaining observers were assigned to count vehicle occupancy in the GP lanes, dividing lane assignments evenly. If a third observer was not available, then the second observer counted vehicle occupancy for all GP lanes.

Within the observation vehicle, the observers sat in a position that allowed them the best view of the approaching vehicles. The observer assigned to the EL sat directly behind the driver. The observer assigned to the left-most GP lanes sat in the back of the vehicle, where they could use the rear and side windows to look at approaching vehicles. The observer assigned to the right-most GP lanes sat in the passenger seat next to the driver. An example of seating arrangement is shown in Figure 3.4.

Figure 3.4 Example seating arrangement in observation vehicle.

3.3.8 Guidelines for Accurate Observations

In order to ensure the highest level of accuracy, the observers in the vehicle obeyed the following conventions:

- Do not record vehicle occupancy if all passengers in a vehicle cannot be clearly seen (such as children in the back seats, tinted windows, etc.).
- Request a break when feeling fatigued.
- Only record vehicle occupancy when the other vehicle is in proximity to the observation vehicle. Avoid counting occupancy when vehicles far from the observation vehicle.
- If your assigned lanes aren't currently occupied, assist the other observers by verifying their occupancy counts, especially for the EL.

To ensure uniformity of collection start times, the driver audibly announced the zone being entered, when to begin the observations, when to switch to a new zone, and when to finish a given observation. The driver was also given the responsibility to maintain a speed which allowed other traffic to pass the study vehicle. The driver was given discretion to maneuver into a different lane or adjust speeds in order to allow other traffic to pass the study vehicle. Any

maneuvering of the vehicle should be done considering the safety of the observation team and other vehicles.

In the event that traffic in the GP lanes slows down but the EL continued at free flow speed, assignments were adjusted so that an additional observer could assist with verifying vehicle occupancy in the EL. Once traffic resumed to free-flow speeds for all lanes, then the observers returned to their original assignments. This was done to prevent the observers from becoming idle during traffic congestion periods and improve accuracy of EL counts.

In the event of a crash or other incident, the observation team ceased data collection until the site of the incident was passed or the crash was cleared. Observations made during an incident can produce invalid data, since a managed lane may be opened to all traffic during a severe crash or other incident, as directed by local authorities.

Although every effort was made to provide accurate counts, it is possible that vehicles could have been miscounted. For example, the "C" decal is small and mostly transparent. For this reason, a "C" decal sticker could have been missed and the vehicle could have been identified incorrectly. The research team also noticed that the transponders in vehicles weren't always in the same place in each vehicle. Some were placed in the recommended spot, near the rear view mirror, while other vehicles had the transponders close to the dashboard of the car. The irregular placement of the transponders could also have caused the observers to identify the vehicle type incorrectly.

3.4 Equipment for Recording Data

Several technologies are available for recording and processing the data collected using the carousel method. The technologies include but are not limited to paper and pencil, a data collection board, GPS devices, and a laptop with Microsoft Excel macros. After several field tests, a laptop with Microsoft Excel macro was selected as the preferred technology for collecting and recording data. The rational for this choice and details of the functionality of the Macro are explained in the following subsections.

3.4.1 Paper and Pencil

The paper and pencil method requires a printed form to be filled out by the observers. Although paper copies of the observation data provided a hard copy of the data collected, there is an added time commitment to input the data into a spreadsheet for analysis.

3.4.2 Data Collection Board

The use of an automatic data collection device (e.g., a JAMAR board) allows the observers to automate data entry into a spreadsheet. There are several limitations of using the data collection board, which makes it appropriate for a limited number of studies, for the following reasons:

1. The number of buttons is limited (e.g. 16 buttons on a JAMAR Board), which can be inadequate for studies that need to classify multiple vehicle types along with vehicle occupancy (such as was the case with this study).
2. Once a button was pressed during observation, there is no way to verify or correct the data entered until the data are downloaded from the data collection board.
3. Distinguishing zones with a data collection board can become difficult as zones change.
4. Data extraction can be time consuming since numerous observation files are created.

3.4.3 GPS Devices

In a 2012 study in Arizona, GPS units were used through the carousel method to collect secondary AVO data (MAG 2013). With the capabilities of GPS technology, the approximate location of the vehicles observed can be recorded while in motion and later interfaced with GIS software. The only limitation of implementing GPS devices is the acquisition costs and preparing a program to record AVO data to the specific needs of the study.

3.4.4 Laptops with Excel Macro

The use of laptops with Excel macros allowed for the greatest range of data collection possibilities. To aid in the data collection process, a Microsoft Excel macro UserForm was developed by the research team. A screen shot of the UserForm used in this study is shown in Figure 3.5.

The features of the UserForm allow the observer to instantly switch zones while traveling down the freeway, record the time and date of the observation, and record notes of corrections or observations for a given zone. To assist the observers, a generic "beep" noise plays when a button is clicked. The idea for this feature was suggested from a roadside vehicle observation study in Georgia in 2011 (D'Ambrosio 2011). The beep assists the observer by verifying that an entry was recorded.

The laptops used were tested for battery life and usability. For the three laptops used in this study, the battery life ranged from one hour to six hours. For this reason, a car power-inverter was used to power and recharge the laptops to charge during the duration of the observations.

3.5 Sample Size Verification

After several field tests and initial data collection, a power analysis was conducted to determine the necessary sample size for each zone and time segment. This analysis allowed the research team to know if sufficient samples were being collected to represent each zone adequately.

The initial data showed differences between the 10^{th} and 90^{th} percentiles for AVO in the range of 0.2 to 0.7. Using these ranges it was determined that a conservative estimate of the standard deviation was 0.35, calculated by dividing the maximum range by two. Using the standard values of *a* (0.05) and *b* (0.2, power of 0.8) for power analyses as outlined by Van Belle (2008), the sample size was estimated according to the relationship shown in Equation 3.1.

$$n = 16/\left(\frac{d}{\sigma}\right)^2 \quad (3.1)$$

where: n = number of samples

d = difference in the average number of vehicles that was determined significant

σ = estimated standard deviation in the number of vehicle occupants

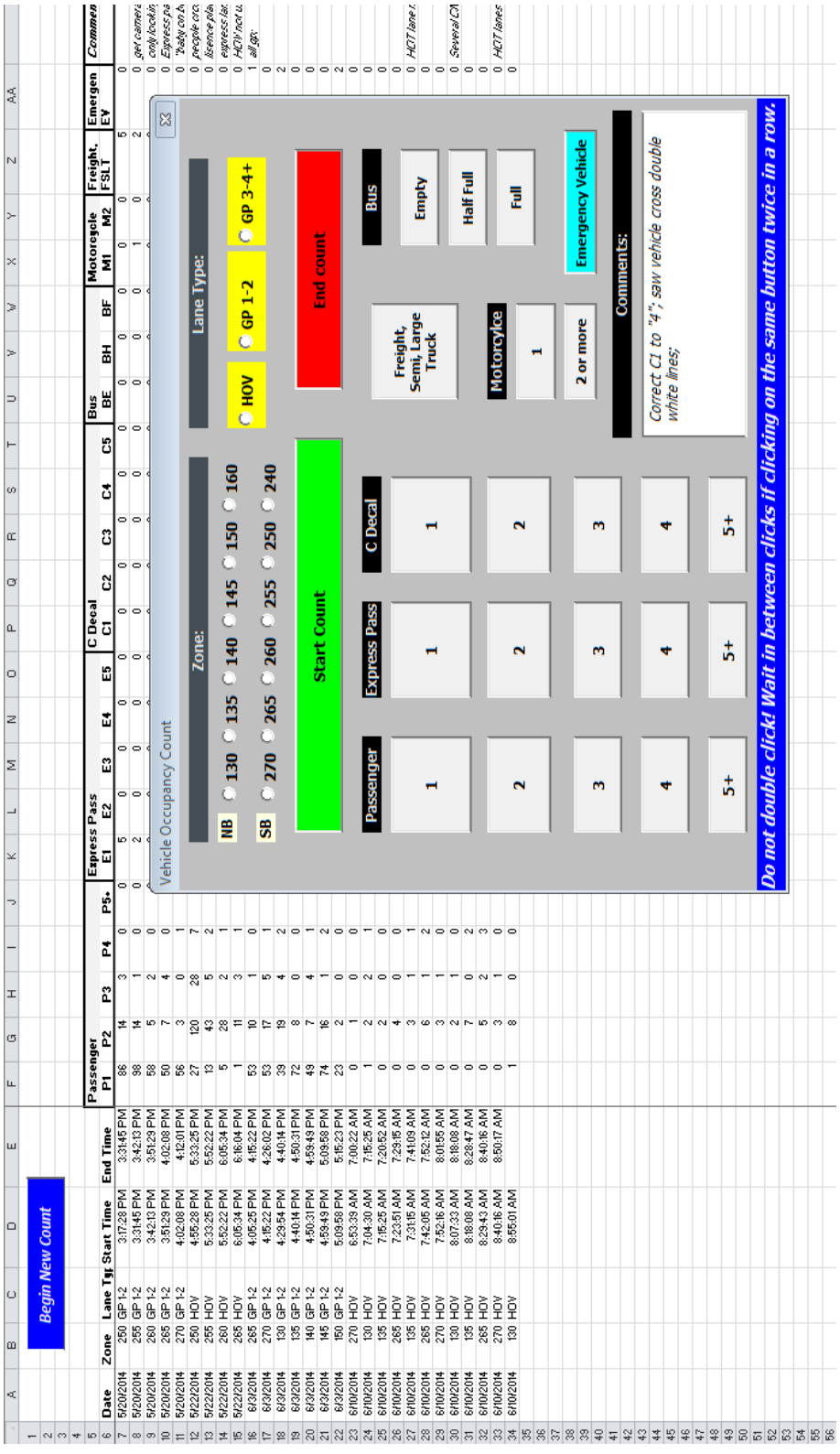


Figure 3.5 UserForm used to record vehicle occupancy observations.

To ensure that the carousel method was providing reliable data, the standard deviation of the AVO reported from each observation log was calculated. Using that dynamic standard deviation value and a value of $d = 0.5$ for the ELs and $d = 0.2$ for the GP lanes, each zone was verified to be sufficiently observed. Using $\sigma = 0.35$ and $d = 0.2$ for the ELs and GP lanes, the minimum number of vehicles needed to be observed for each zone and time period was determined to be 49 vehicles.

Every effort was made by the research team to provide an adequate sample size for the actual conditions. The research team observed fewer vehicles traveling in the ELs between Lehi Main Street and the U.S. 6 connection in Spanish Fork, in both directions (Zones 130, 135, 265, and 270) as well as fewer vehicles in the ELs during the off-peak time. This made it more challenging to collect a sufficient sample size for these locations; however, the sample collected was determined to be accurate for the needs of this study.

3.6 Data Collected

From the field observations, AVO data were collected and organized into a main Excel spreadsheet. Vehicle count by type and total samples collected, including cumulative observation time of the observations are described in the following subsections.

3.6.1 Vehicle Count by Type

Table 3.5 shows a dichotomy of the vehicle types counted during observation and how they are referenced during the data collection effort and in this report.

The results of counting vehicles by type for the NB and SB direction are shown in Table 3.6 and Table 3.7. Additional details of vehicle count by type within each zone are included in Appendix A.

Table 3.5 Vehicle Type Classification

Categories	Vehicle Types from Observations
SOV	Passenger (1)
HOV 2	Passenger (2)
HOV 3+	Passenger (3, 4, 5+)
Express Pass	Express Pass (1, 2, 3, 4, 5+)
"C" decal	"C" decal (1, 2, 3, 4, 5+)
Bus	Bus (empty, half full, full)
Motorcycle	Motorcycle (1, 2+)
Freight	Freight, Semi, Large Truck
Emergency	Emergency Vehicles

Table 3.6 Total Vehicle Count by Type (NB)

	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency	Total
NB	AM Peak	EL	172	319	110	141	19	38	0	0	2	801
		GP	1,647	138	26	21	3	8	2	66	3	1,914
	Off-Peak	EL	27	227	86	13	5	7	1	0	1	367
		GP	1,106	325	84	6	1	8	2	95	1	1,628
	PM Peak	EL	73	381	124	27	11	27	2	0	0	645
		GP	1,623	379	118	6	4	19	4	61	5	2,219
	Total EL		272	927	320	181	35	72	3	0	3	1,813
	Total GP		4,376	842	228	33	8	35	8	222	9	5,761

Table 3.7 Total Vehicle Count by Type (SB)

	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency	Total
SB	AM Peak	EL	45	167	46	21	3	12	3	0	0	297
		GP	1,514	188	47	18	3	12	2	91	3	1,878
	Off-Peak	EL	23	173	51	3	5	3	4	0	0	262
		GP	836	263	63	7	2	3	5	90	0	1,269
	PM Peak	EL	279	713	198	217	11	42	1	0	3	1,464
		GP	2,042	357	79	17	3	13	2	71	2	2,586
	Total EL		347	1,053	295	241	19	57	8	0	3	2,023
	Total GP		4,392	808	189	42	8	28	9	252	5	5,733

3.6.2 Total Samples Collected

After traveling approximately 3,080 miles, over 15,000 vehicles were observed, from which the AVO data were calculated. A summary of the total vehicle samples counted in the EL and GP lanes is shown in Table 3.8. A more detailed listing of samples collected for each zone during each time period is included in Appendix A.

Table 3.8 Summary of Total Vehicle Samples Collected

	EL	GP Lane	Total
NB Samples Collected	1,813	5,761	7,574
SB Samples Collected	2,023	5,733	7,756
Combined Samples Collected	3,836	11,494	15,330

The cumulative man hours for the observations was recorded during the study. The cumulative time represents the sum of time of each observation made by each observer. The cumulative time is much greater than the time spent doing the observations as the team, since the observation team consisted of two to three observers during each run. The total observation time (NB and SB) for the study was just over 61 hours. A summary of the data collection time is provided in Appendix A.

4.0 DATA ANALYSIS

4.1 Overview

The data collected were analyzed to better understand vehicle occupancy and vehicle types within the Express and GP lanes. This analysis will provide UDOT with a concise picture of current AVO and the types of vehicles currently utilizing the ELs. The analysis evaluates the AVO, vehicle percentages by type, violation rates, Express Pass and "C" decal occupancy along the corridor, and a summary of key results.

4.2 Average Vehicle Occupancy

AVO was calculated from the samples of passenger vehicles, Express Pass vehicles, and "C" decal vehicles. Buses, motorcycles and freight vehicles were omitted from the AVO calculation.

AVO was calculated by dividing the number of travelers by the number of vehicles counted. The overall AVO for the NB and SB directions is illustrated in Figure 4.1 and Figure 4.2. The AVO for each zone is shown in Figure 4.3 and Figure 4.4, while all AVO results are tabulated in Appendix B.

The graphs show that the AVO is consistently higher in the EL and lower in the GP lane, with little variability in the AVO across the zones themselves. The AVO was always highest during the Off-Peak time period going as high as 2.23 ppv. While the AM Peak period has a lower AVO than the PM Peak period NB, the AM Peak period has a higher AVO than the PM Peak period SB.

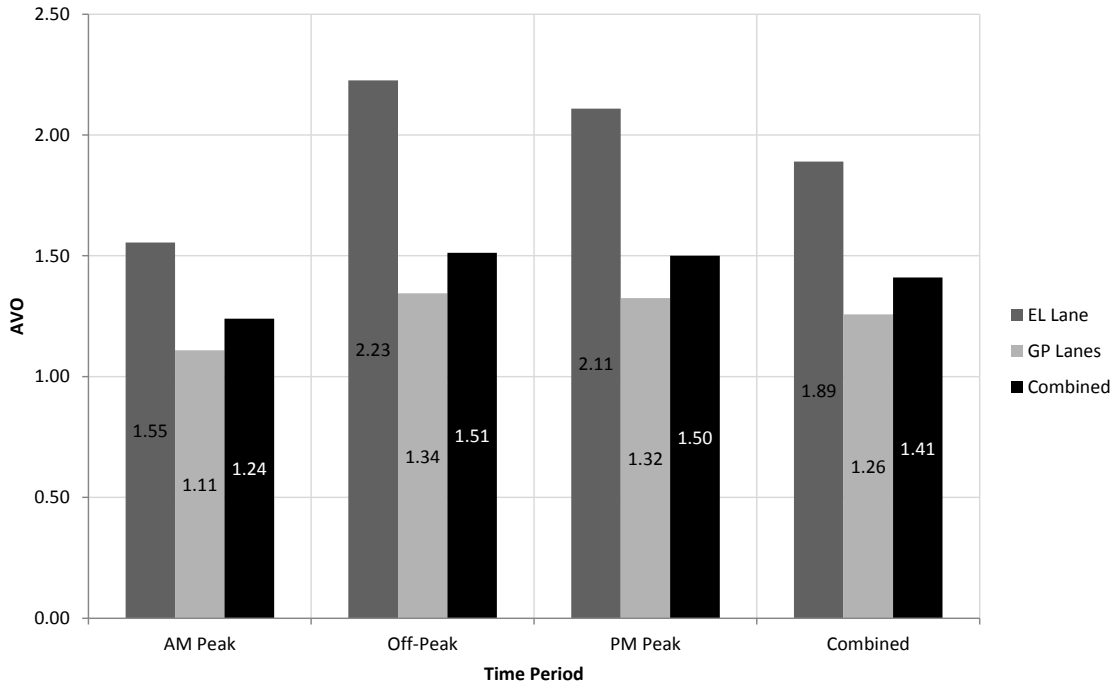


Figure 4.1 Overall AVO (NB).

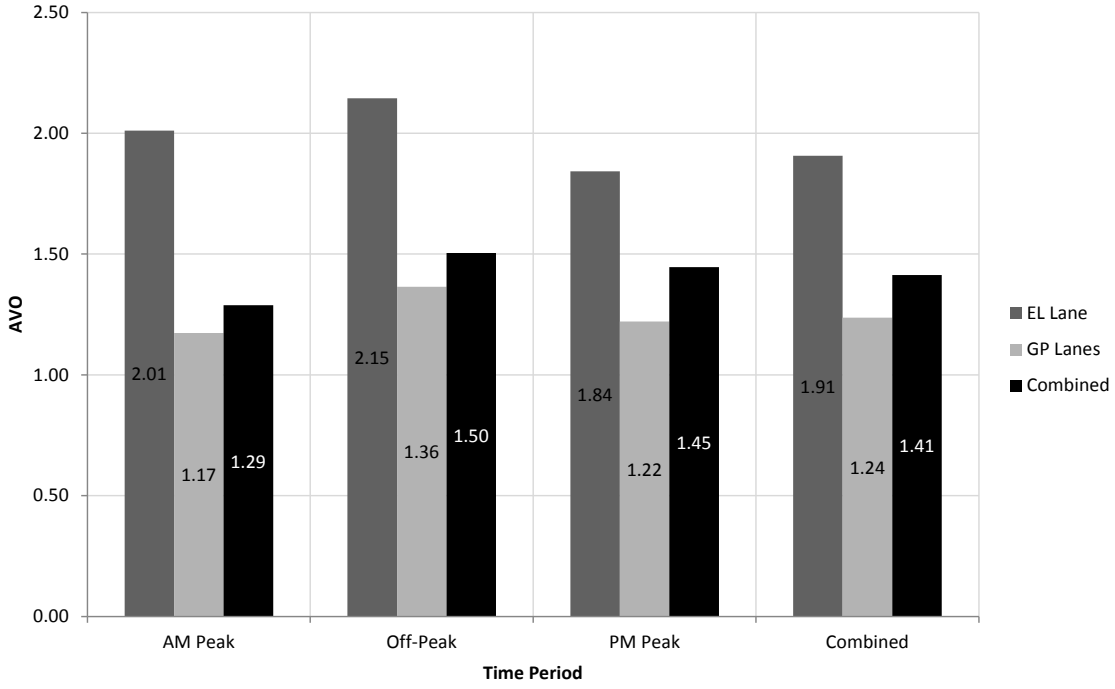


Figure 4.2 Overall AVO (SB).

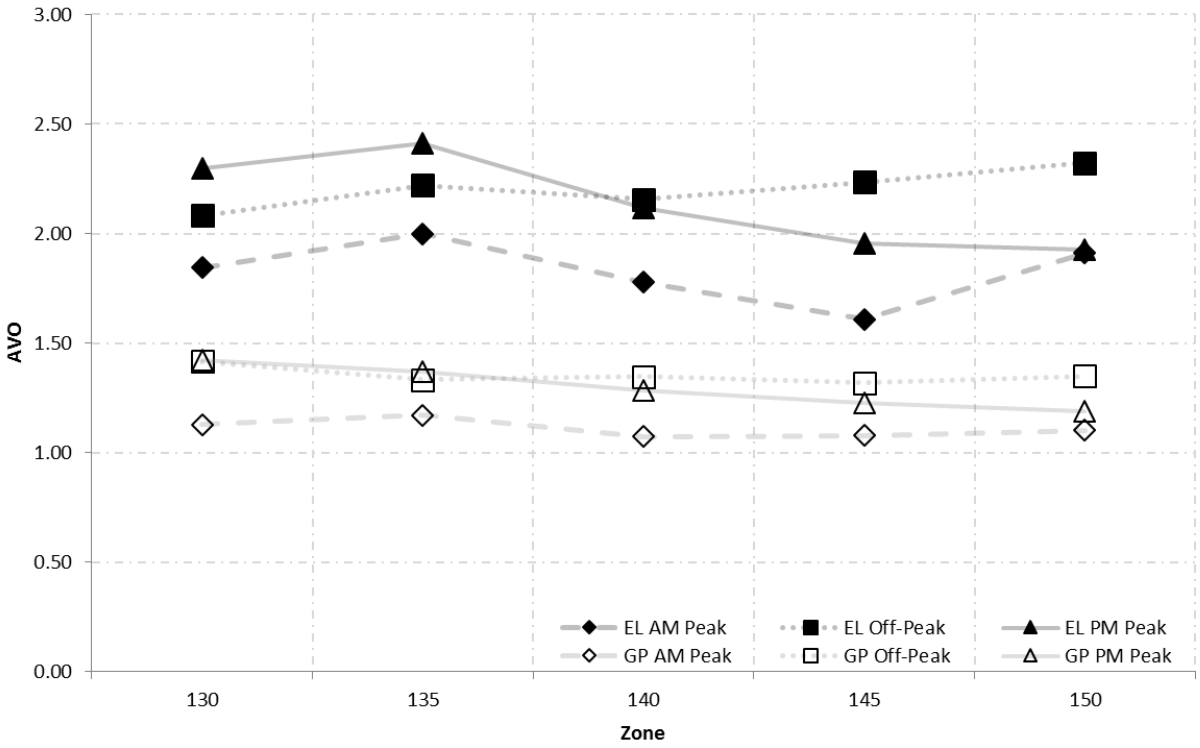


Figure 4.3 AVO by zone (NB).

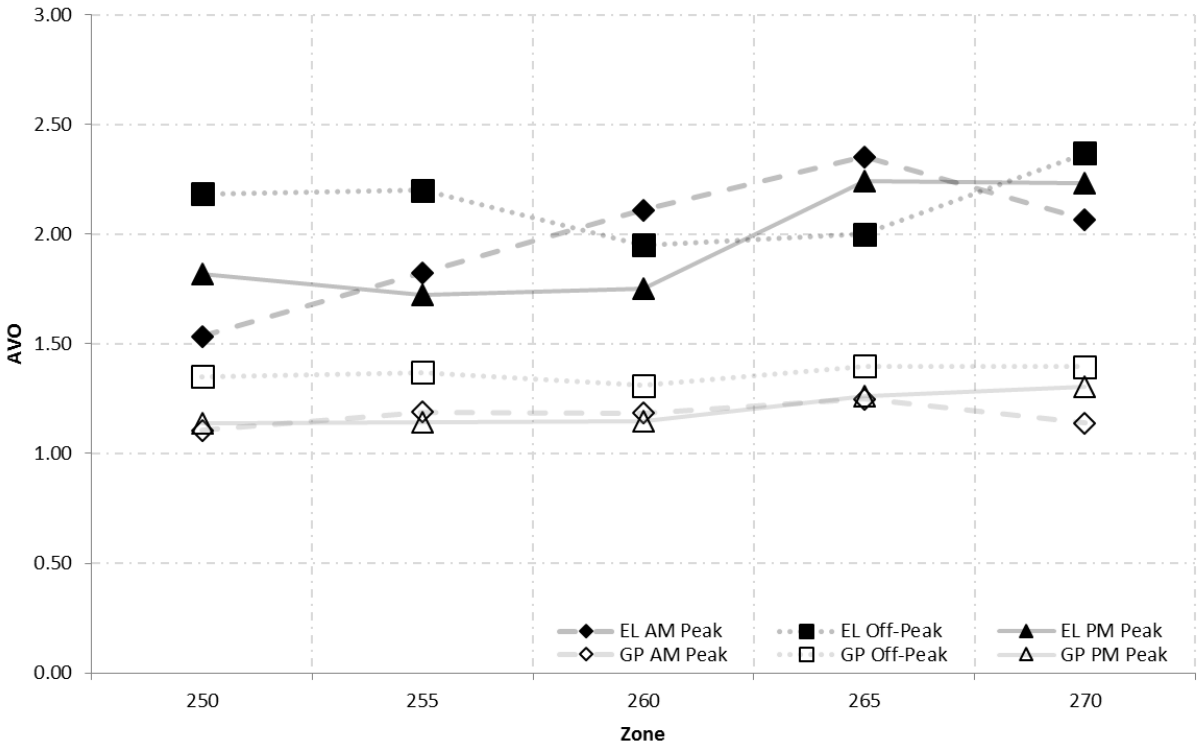


Figure 4.4 AVO by zone (SB).

4.3 Vehicle Percentage by Type

From the vehicle counts by type, the vehicle percentage by type for each lane per zone and time was calculated. This calculation provides an illustration of the percentage of vehicle types in a given lane. The vehicle percentage by type for each zone by lane and time of day is shown in Figure 4.5 through Figure 4.12 for AM Peak, Off-Peak, PM Peak, and Overall for NB and SB, respectively. The detailed results for each zone are tabulated in Appendix C.

The NB direction had 15% SOVs (assumed as violators), 51% HOV 2 vehicles, 18% HOV 3+ vehicles, 10% Express Pass users, 2% "C" decal vehicles, and 4% motorcycle, buses and emergency vehicles. For the SB direction, the ELs are comprised of approximately 17% SOVs (assumed as violators), 52% HOV 2 vehicles, 15% HOV 3+ vehicles, 12% Express Pass users, 1% "C" decal vehicles, and approximately 3% motorcycle, buses and emergency vehicles.

These values show similar results to UDOT automated data collection efforts; however, the data here show slightly higher Express Pass users and slightly lower "C" decal vehicles than reported in Phase I of this study (Schultz et al. 2014). It is not uncommon for the different methodologies and data collection efforts to produce different results. The current data collection effort may differ from the historical values due to human error (e.g., the visual perception of the "C" decals might not have caught all the "C" decals detected through electronic means), or the difference may be due to random fluctuation in the traffic on the days counted. One of the primary differences in the methods is related to whether the Express Pass is on or off. For the automated system, the Express Pass in the off position is not read by the tolling system and is reported as "Free." For the manual data collection, the position of the Express Pass was not recorded (on or off), thus those in the on or off position were reported as Express Pass users. This can explain a large percentage of the variability and has been shown to account for up to 25% of the violators reported.

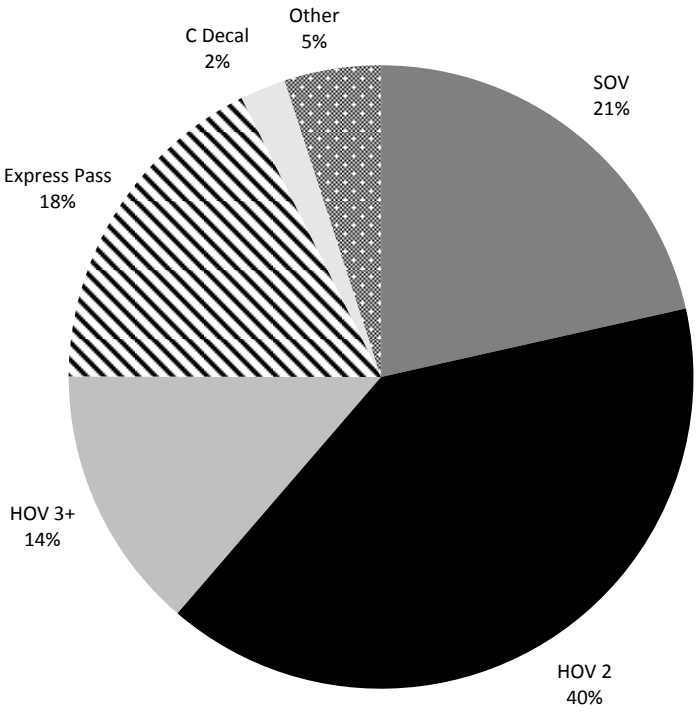


Figure 4.5 EL vehicle percentage by type (AM Peak NB).

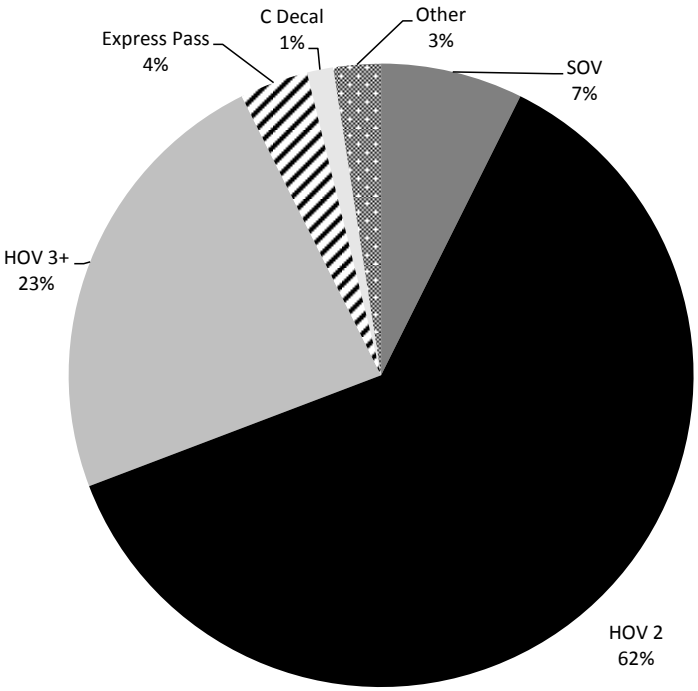


Figure 4.6 EL vehicle percentage by type (Off-Peak NB).

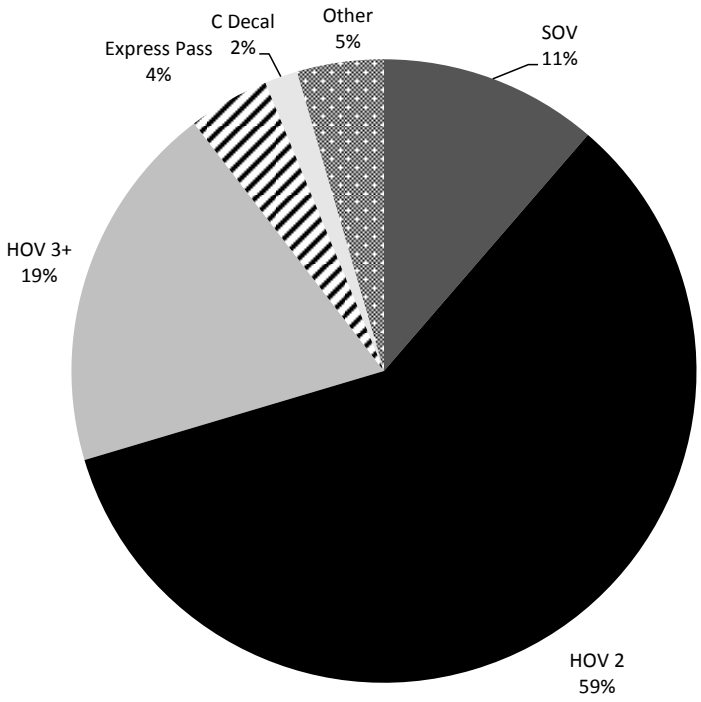


Figure 4.7 EL vehicle percentage by type (PM Peak NB).

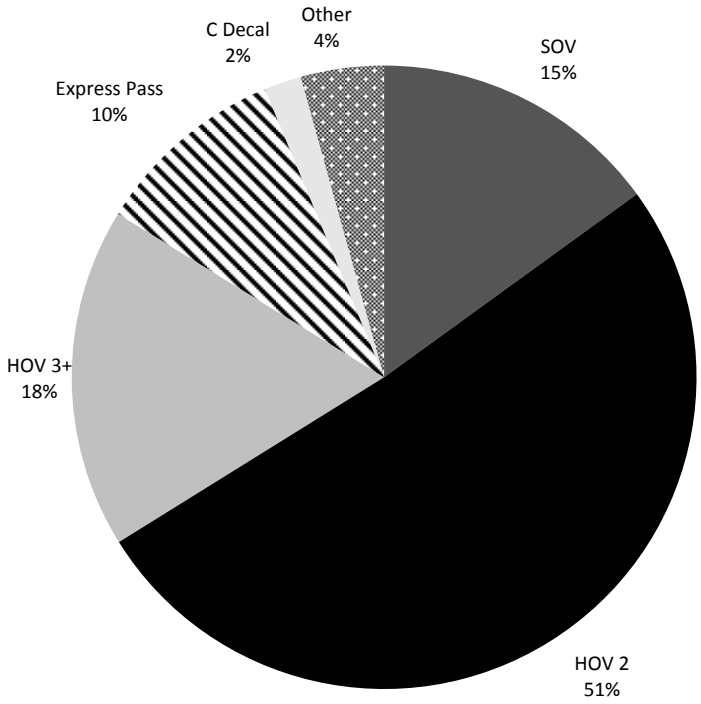


Figure 4.8 EL vehicle percentage by type (Overall NB).

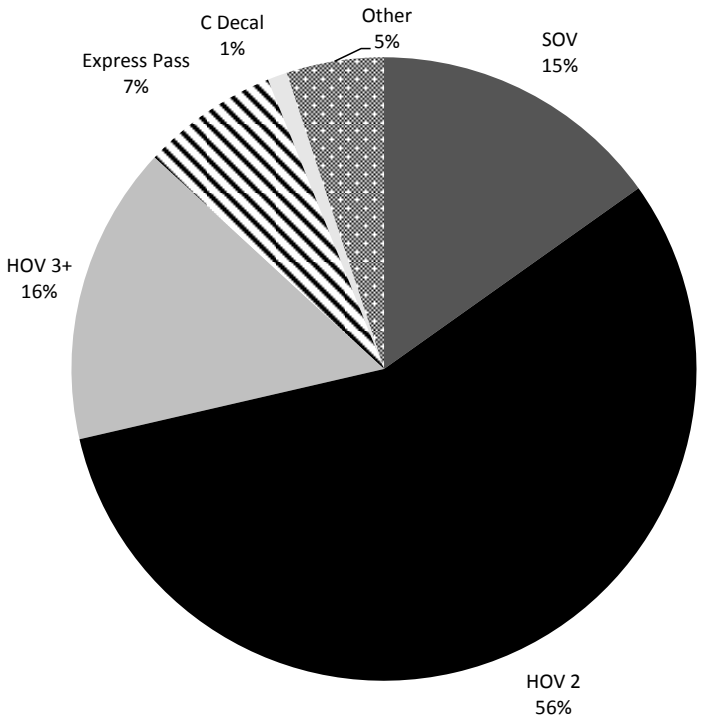


Figure 4.9 EL vehicle percentage by type (AM Peak SB).

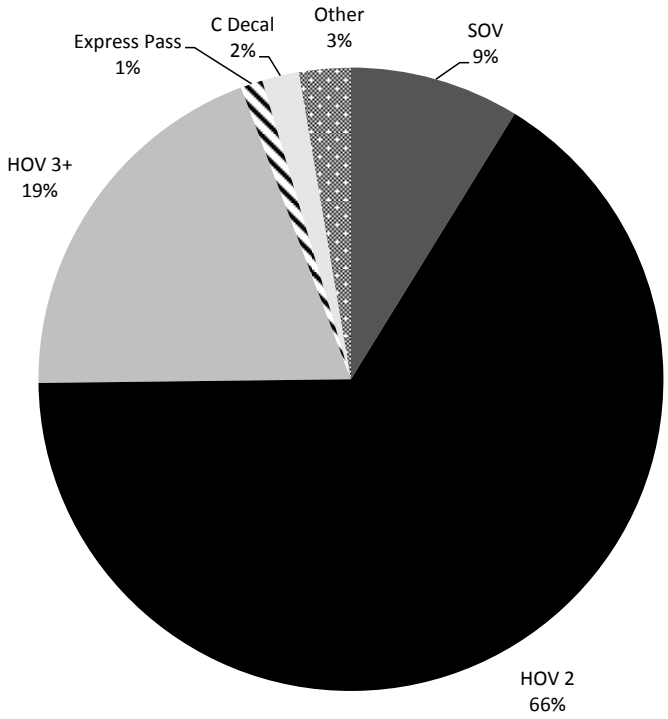


Figure 4.10 EL vehicle percentage by type (Off-Peak SB).

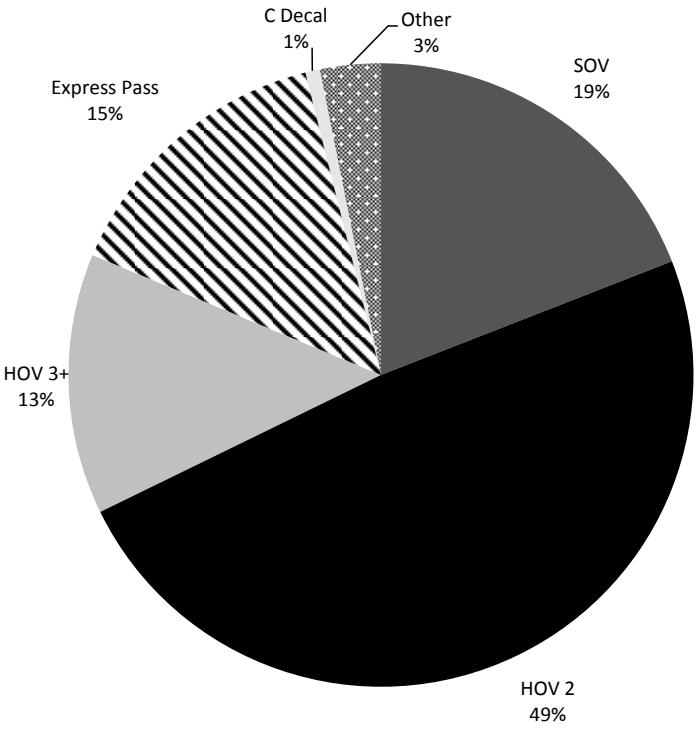


Figure 4.11 EL vehicle percentage by type (PM Peak SB).

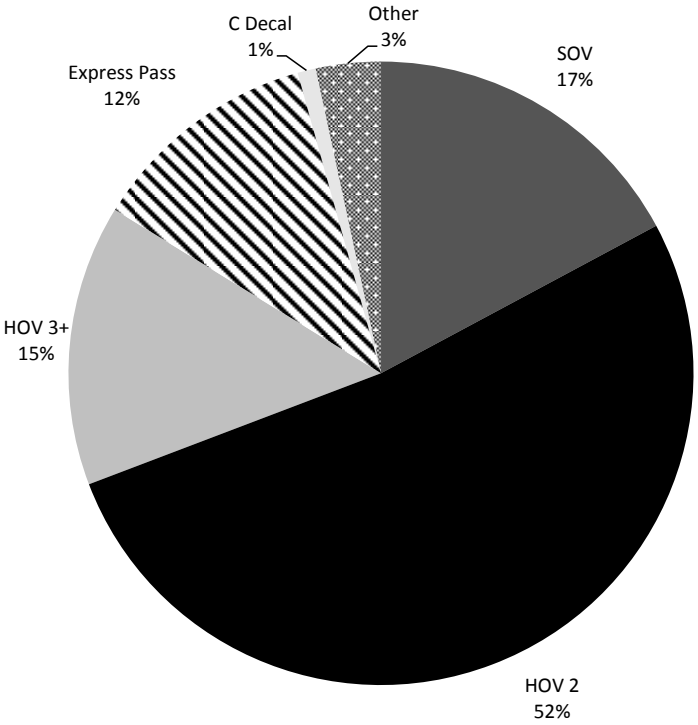


Figure 4.12 EL vehicle percentage by type (Overall SB).

4.4 Violation Rates

Within the parameters of this study, "violators" in the EL are identified as those vehicles that do not meet the passenger requirements to be a HOV, do not have an Express Pass transponder, or do not have a "C" decal registering them as a clean vehicle. The scope of this study was not able to capture violation data the same as was described in previous UDOT studies, including violations such as improper lane usage, crossing the double white line, toll violation, Commercial Motor Vehicle (CMV) left lane violation, HOV on- and off-ramp violation, operating restricted vehicles in the left lane, and left lane restricted vehicles over 12,000 pounds. Violation data for the purposes of this study are a factor of vehicle occupancy violations only. A summary of the violation rates by zone and time for NB and SB direction are shown in Figure 4.13 and Figure 4.14, respectively.

From these results, it was shown that violation rates spike in the EL to over 25% in Zones 145 and 140 during the AM Peak period. In the Phase I research, the 10^{th} percentile speeds for Zone 145 fell below the UDOT goal of 55 mph during the AM Peak period. In the SB direction, zones 250, 255, and 260 show AM and PM Peak period violation rates above the national average. The 10^{th} percentile speeds for these zones also fell below the UDOT goal of 55 mph during the PM Peak period (Schultz et al. 2014). The Off-Peak period is consistently below the national average for violation rates for both directions.

4.5 Express Pass and "C" Decal Vehicle Occupancy

From Phase I of the study, it was determined that passenger vehicles with Express Pass transponders and passenger vehicles with "C" decals make up 10% to 20% of the volume in the ELs. The number of occupants observed in the Express Pass vehicles and "C" decal vehicles are included in Appendix D and Appendix E, including occupancy by count and percentage for each zone by time and lane.

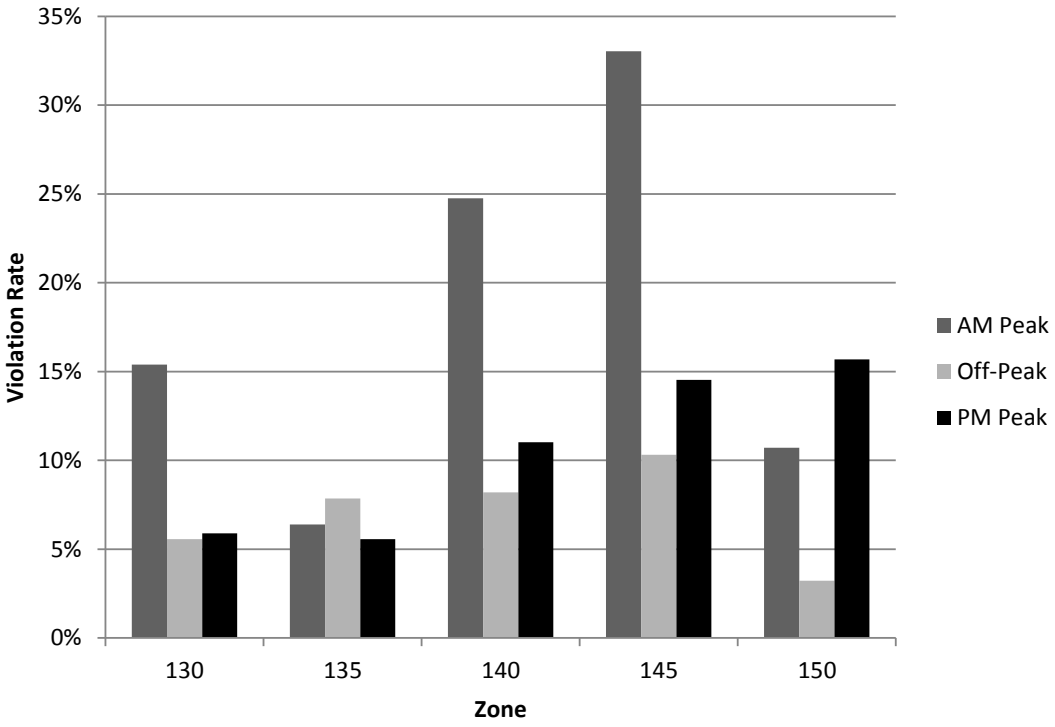


Figure 4.13 Violation rates in the EL by zone and time (NB).

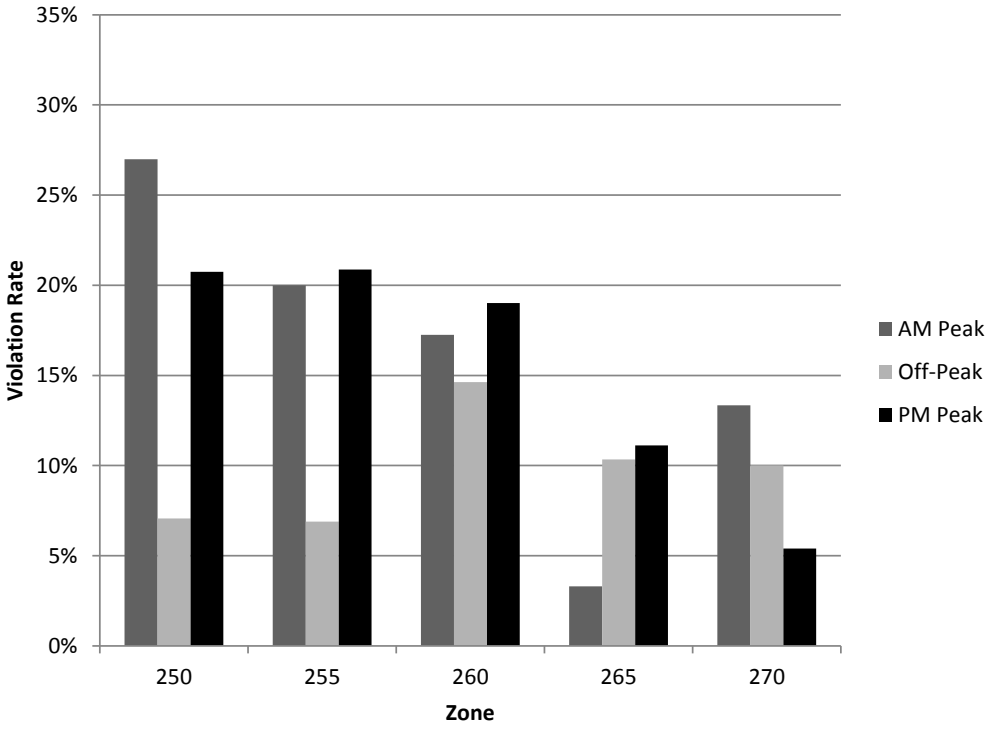


Figure 4.14 Violation rates in the EL by zone and time (SB).

4.6 Summary of Key Results

Phase I of this study was completed to examine the utilization of the I-15 ELs under a limited number of congestion and pricing scenarios. The data for the ELs in Utah were analyzed, including an analysis of speed, volume, and the corresponding toll rates within the ELs. The results of the Phase I report indicated that the majority of the EL corridor in the state of Utah is operating within the 10th percentile speed goal of 55 mph set by UDOT and the 45 mph requirements set by the FHWA. There were; however, several zones identified where the 10th percentile speeds were found to have dropped below 55 mph and two zones where speeds had dropped below 45 mph based on the analysis (Schultz et al. 2014).

One of the recommendations of the Phase I report was to evaluate the users of the system throughout the corridor, paying particular attention to those zones that were below the 55/45 mph requirements. The results of this chapter have provided these results. A summary of the zones where the speeds dropped below the threshold combined with the corresponding vehicle percentage by type is provided in Table 4.1.

The results shown in Table 4.1 indicate that, in general, the violation rates in the zones where speeds were at or below the goals set by UDOT were higher than national and UDOT averages, generally in excess of 20%. Express Pass use in these zones was also high, generally in excess of 15%, and "C" decal use was relatively low. Based on these results, the recommendations provided in Chapter 5 are aimed at identifying alternatives to reduce the volume in the ELs, thus increasing the speeds in the lanes.

Table 4.1 Summary of Results for ELs in Key Zones

From Phase I Results (Table 3.4 & Table 3.5)			Vehicle Percentage by Type (Table C.1 & Table C.2)					
Zone	Time Period	10th Percentile Speed (mph)	SOV (Violator)	HOV 2	HOV 3+	Express Pass	C Decal	Other (Bus, MC, EV)
140	AM Peak	55.0	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%
145	AM Peak	51.0	33.0%	33.3%	10.6%	17.6%	1.5%	3.9%
140	PM Peak	53.0	11.0%	64.2%	16.5%	2.8%	0.0%	5.5%
145	PM Peak	55.0	14.5%	61.6%	11.6%	3.5%	2.3%	6.4%
250	PM Peak	37.0	20.7%	43.6%	14.1%	16.8%	0.8%	3.9%
255	PM Peak	41.0	20.9%	50.1%	8.1%	17.4%	1.2%	2.3%
260	PM Peak	47.0	19.0%	58.5%	7.0%	14.8%	0.0%	0.7%

5.0 PROPOSED RECOMMENDATIONS

5.1 Overview

From Phase I of this study, several zones were identified wherein the speeds were below the UDOT goal of 55 mph. These zones include Zone 140 and 145 in the AM Peak and Zones 140, 145, 250, 255, and 260 in the PM Peak. To improve the performance of the EL, it was determined that the vehicle percentage by type in the EL would need to be adjusted in these zones. From Phase I of this study, several solutions were suggested for changing the vehicle percentage by type in the EL, with the majority of the options resulting in lower volumes (Schultz et al. 2014).

The following analysis of the potential impacts of proposed recommendations was done to assess the expected effects of implementing several scenarios to change the vehicle percentage by type in the EL. The recommendations analyzed include reducing violators (through education and increased enforcement), increasing the toll rate, and allowing more "C" decal permits to be issued. In addition to these recommendations, several scenarios of implementing multiple recommendations are discussed, including: educating the public, increasing enforcement, and increasing the toll; increasing the toll and allowing more "C" decal permits; educating the public, increasing enforcement, and allowing more "C" decal permits; and educating the public, increased enforcement, increasing the toll, and allowing more "C" decal permits. Prior to this analysis, the performance baseline is established.

5.2 Performance Baseline

The following assumptions are made to illustrate the possible effects of speed-volume performance of the EL and GP lanes if a given recommendation were to be implemented. The effects of the assumptions are based on the data collected, as well as the details gained through the literature review. Initially a strategic approach was attempted to pinpoint speed-volume relationships based on empirical speed-volume data points. Due to the variability in the data and the difficulty in obtaining accurate results, a mathematical speed-volume relationship was

developed for the analysis. The basis for this relationship and the assumptions used in the analysis will be explained in greater detail in the following paragraphs.

The initial speed-volume data comes from historical speed-volume data extracted using the UDOT Performance Measurement System (PeMS). The speed-volume values were extracted along the I-15 corridor for those zones which were identified as trouble zones in Phase I of this study. Those zones include: 140 AM Peak, 145 AM Peak, 140 PM Peak, 145 PM Peak, 250 PM Peak, 255 PM Peak, and 260 PM Peak. Data extraction was limited to the extents of the study (Tuesdays and Thursdays; May 20 to June 10; AM Peak [7:00 a.m. to 9:00 a.m.] and PM Peak [5:00 p.m. to 6:00 p.m.]). Two hours were used for the AM Peak as the peak hour was identified to be from 7:30 a.m. to 8:30 a.m. (as reported in Section 3.3.2); however, the PeMS data system does not allow data to be pulled in 30 minute increments, so the full two hour sample was used. A modeled relationship of speed and volume for each zone was created to fit the historical data and to allow for calculations to be done for these scenarios.

Based on observed (historical) values of speed and flow, a speed-volume relationship was calculated using the Greenshields model (Fricker and Whitford 2004). The Greenshields model is a widely accepted model used to represent the relationship between the speed and volume of traffic assuming a linear relationship between speed and density, even though it is known that the relationship is not totally linear. Greenshields proposed the use of a linear function to summarize the speed-density relationship, from which equations were developed for speed and volume (flow rate) as outlined in Equations 5.1, 5.2, and 5.3. By calculating density (volume divided by speed), jam density, and free flow speed, a model is created to correlate a speed value with a specified volume.

$$q = S * D \tag{5.1}$$

where: q = flow rate (vphpl)
S = speed (mph)
D = density (veh/mi)

$$S = S_f * (1 - \frac{D}{D_j}) \quad (5.2)$$

where: S_f = free flow speed (mph)

D_j = jam density (veh/mi)

$$q = S_f * (D - \frac{D^2}{D_j}) \quad (5.3)$$

An example calculated curve laid over the historical data for Zone 140 during the AM Peak hour is shown in Figure 5.1. The free flow speed and jam-density values were extracted from the linear Greenshields speed-density relationship and utilized to develop the speed and flow curves.

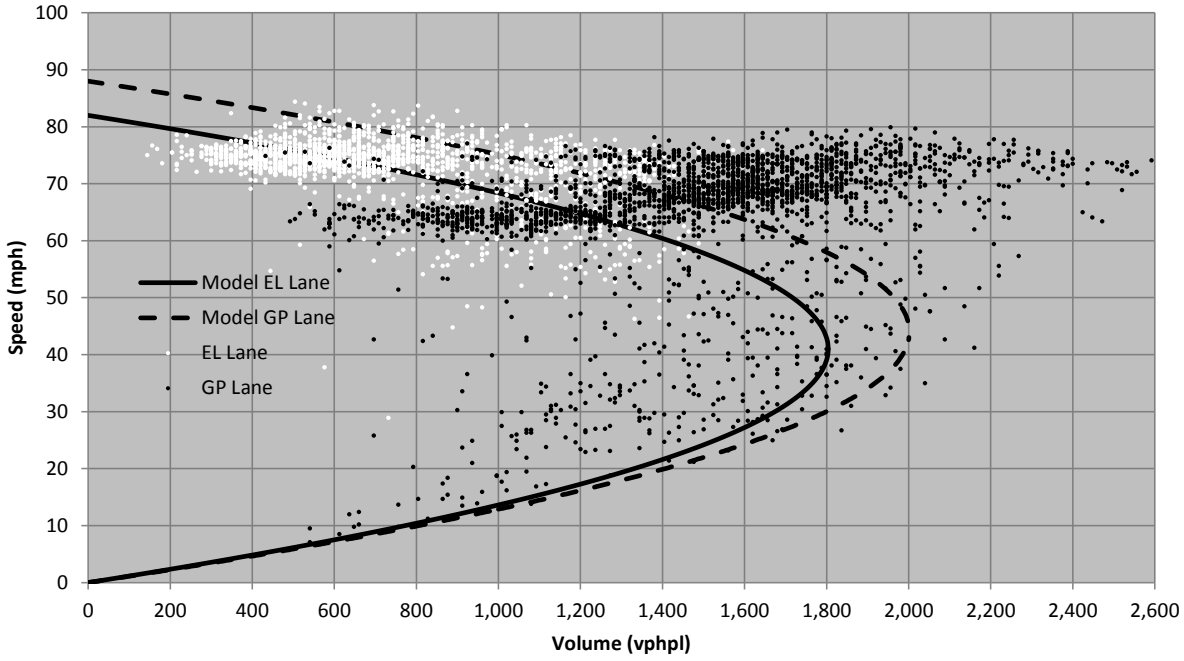


Figure 5.1 Historical speed-volume data with calculated curves (Zone 140 AM Peak).

For the recommendations in this chapter, Zone 140 AM Peak will be used in this analysis. A summary of the analysis for each of the zones mentioned will be included in Appendix F through Appendix K. The following performance statistics were assumed to simulate high congestion situations during peak hour traffic for Zone 140 during the AM Peak hour. The speed values utilized in the analysis are based on the Greenshields speed volume

relationship and represent the speed near capacity (in the uncongested region). Upon examination of the data for the ELs and the GP lanes, it is shown that the capacity for the GP lanes is higher than that in the ELs. Because the model is based on actual data collected for each zone and the free flow speed and jam density values are derived from these data, the model results also show a higher speed at capacity. This is consistent with other research completed in this area (Liu et al. 2011). The reader is encouraged to focus on the changes in speeds before and after the proposed changes, rather than focusing on the absolute model values.

- EL Volume: 1,700 vphpl
- EL Speed: 50.8 mph
- GP Lane Volume: 1,800 vphpl
- GP Lane Speed: 58.0 mph

5.3 Reduction in Violation Rates

To effectively reduce the number of vehicles in the EL and thereby increase speeds, the percentage of vehicles violating the EL use would need to be reduced. Possible methods to reduce violators include educating the public and providing increased enforcement along the corridor. In addition to these methods, implementing the HERO program (WSDOT 2014), installing rumble strips along the EL, and considering modifications to the striping of the ELs could aid in reducing violation rates. More details on the HERO program and other methods to reduce violation rates are found in Chapter 2 of this report and in Chapter 2 of the Phase I report (Schultz et al. 2014).

5.3.1 Education

One suggested method to reducing violators in the ELs is to educate the public regarding the use of the lanes. A Los Angles study has shown that if the public is educated on the correct usage of the EL, the SOVs in the EL can be reduced. Turnbull et al. (2002) found that educating the public about the correct usage of the EL reduced the number of violators in the lane from 56% to less than 2% in the PM Peak and from 41% to less than 7% in the AM Peak. Although this is an extreme case, it does show the potential for reduction.

Possible education techniques could include, but are not limited to; advertisements through the radio, internet, television, billboards, and social media. Increased efforts in educating the public are theorized to result in a less congested EL. Using more conservative estimates than those achieved by Turnbull et al. (2002), it was assumed that education could reduce the number of violators (SOVs) in the EL by approximately 5-15% (violators only), if education efforts were successful. This assumption was used to distribute vehicles throughout the remainder of the system. It was assumed that an increase in education may raise awareness to the benefit of carpooling as well as correct usage of the HOV lane, thus resulting in a possible increase in HOV 2 and HOV 3+ vehicles in the EL; however, for the model it was assumed that all SOVs in the EL vehicles would move to the GP lanes in result to reducing violators in the EL. The assumed changes for the range of reductions are represented in Table 5.1, Table 5.2, and Table 5.3 for reductions in violators of 5%, 10%, and 15%, respectively for Zone 140 AM Peak.

Table 5.1 Impact of EL Education on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 5% violator reduction)

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-22	0	0	0	0	0	0	0	0
		GP	22	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	399	640	270	270	68	34	0	0	0
		GP	1,638	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	23.7%	38.1%	16.1%	16.1%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.3%	0.9%	1.4%	0.0%	0.9%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.2 Impact of EL Education on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 10% violator reduction)

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-43	0	0	0	0	0	0	0	0
		GP	43	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	378	640	270	270	68	34	0	0	0
		GP	1,659	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	22.8%	38.6%	16.3%	16.3%	4.1%	2.0%	0.0%	0.0%	0.0%
		GP	89.8%	5.2%	0.9%	1.4%	0.0%	0.9%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.3 Impact of EL Education on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 15% violator reduction)

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-64	0	0	0	0	0	0	0	0
		GP	64	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	357	640	270	270	68	34	0	0	0
		GP	1,680	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	21.8%	39.0%	16.5%	16.5%	4.1%	2.1%	0.0%	0.0%	0.0%
		GP	89.9%	5.2%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	-15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

From the performance baseline speed-volume model outlined in Section 5.2, reducing violators from the EL through education could be expected to increase the speed of the EL by nearly 1 mph for each 5% reduction in violators. This could increase the speed by 0.9 mph for a 5% reduction of violators, 1.8 mph for a 10% reduction of violators, and 2.6 mph for a 15% reduction of violators. A summary of the estimated change in volume and speed is shown in Table 5.4, Table 5.5, and Table 5.6 for reductions in violators of 5%, 10%, and 15%, respectively.

Table 5.4 Impact of EL Education on EL and GP Lane Performance for Zone 140 AM Peak (assumed 5% violator reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,681	51.7
	GP	1,827	57.0

Table 5.5 Impact of EL Education on EL and GP Lane Performance for Zone 140 AM Peak (assumed 10% violator reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,660	52.6
	GP	1,848	56.2

Table 5.6 Impact of EL Education on EL and GP Lane Performance for Zone 140 AM Peak (assumed 15% violator reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,639	53.4
	GP	1,869	55.3

5.3.2 Increased Enforcement

In the Virginia Study (Smith and Yook 2009) discussed in Chapter 2, it was shown that occasional efforts to increase enforcement along ELs had little or no effect on reducing violators in the EL, unless it was consistently enforced. Occasional enforcement blitzes appeared to exhibit little impact on the long term usage of the EL. It should be pointed out; however, that enforcement tied to education does appear to be successful.

Another action of enforcement includes raising the fine for EL violators. Smith and Yook (2009) also suggest that there is not a direct correlation between violation rates and violation fines; however, it is assumed that increasing the fines for EL violation, and making this information visible, will dissuade further violations.

Using this information, it was assumed that enforcement may reduce the number of SOVs in the EL by a maximum of 10%. Using this information, Table 5.7 represents the possible changes made to the system as well as the adjusted performance for Zone 140 AM Peak.

Table 5.7 Impact of Increased Enforcement on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 10% violator reduction)

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-43	0	0	0	0	0	0	0	0
		GP	43	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	378	640	270	270	68	34	0	0	0
		GP	1,659	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	22.8%	38.6%	16.3%	16.3%	4.1%	2.0%	0.0%	0.0%	0.0%
		GP	89.8%	5.2%	0.9%	1.4%	0.0%	0.9%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.8 suggests that additional police enforcement and increased fines for violation could improve speeds in the EL by approximately 1.8 mph, since not all violators may respond as planned to the increased enforcement.

Table 5.8 Impact of Increased Enforcement on EL and GP Lane Performance for Zone 140 AM Peak (assumed 10% violator reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,660	52.6
	GP	1,848	56.2

5.3.3 Education and Increased Enforcement

As discussed, occasional enforcement efforts have shown to be largely ineffective on a long term basis and therefore a more permanent form of enforcement needs to be implemented. Additional methods, such as public enforcement efforts similar to the HERO program implemented by the Washington State DOT (WSDOT 2014), increasing violation fines, installing rumble strips along the double white line that separates the EL from the GP lanes, and implementing double yellow lines similar to those utilized on I-5 in Southern California (San Diego area), as illustrated in Figure 5.2, may help reduce violation rates even more when used in addition to educating the public on proper use of the EL.

The research team assumed that by using both education and increased enforcement, violation rates may decrease up to 15%, with a maximum reduction that may be achieved of 20%, and that the system would adjust accordingly. Table 5.9 and Table 5.10 represent the changes made and the impact made to the violation rate assuming the maximum 20% reduction in SOVs utilizing the EL as a result of education and increased enforcement, specifically applied to Zone 140 AM Peak. This reduction in violators could provide an increase in speed of approximately 3.4 mph. It should be noted that this would require a substantial effort based on the data collected in the literature review, and is not in any way guaranteed to occur.

Figure 5.2 I-5 Southern California (San Diego area) striping alternative.

Table 5.9 Impact of Education and Increased Enforcement on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 20% violator reduction)

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-85	0	0	0	0	0	0	0	0
		GP	85	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	336	640	270	270	68	34	0	0	0
		GP	1,701	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	20.8%	39.6%	16.7%	16.7%	4.2%	2.1%	0.0%	0.0%	0.0%
		GP	90.0%	5.1%	0.9%	1.3%	0.0%	0.9%	0.0%	1.7%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.10 Impact of Education and Increased Enforcement on EL and GP Lane Performance for Zone 140 AM Peak (assumed 20% violator reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,618	54.2
	GP	1,890	54.4

5.4 Increased Toll Rate

Another method proposed to change the vehicle percentage by type in the EL is raising the toll to use the lane, reducing the volume in the EL. As explained in Chapter 2, toll rates in Utah are relatively low when compared to current rates in California, Minnesota, and Georgia. Comparing the cost of living with current tolls in these states suggest that raising the maximum toll from $1.00 to $2.00 is not unreasonable for Utah compared to rates in other states are reported previously in Table 2.1.

There are two possible effects of raising the toll in the ELs. One possible outcome of a higher toll may suggest to drivers that there is a congestion ahead, thus attracting traffic to the EL (Samuel 2013). For the purposes of this analysis; however, it will be assumed that the number of Express Pass users will decrease as a result of increasing the toll, based on standard elasticity of travel principles.

Using the elasticity equation in Equation 5.4 (Fricker and Whitford 2004), the number of Express Pass users that would be affected by changing the price from $1.00 to $2.00 with an elasticity of -0.3 (Burris et al. 2012) was calculated. It should be noted that the elasticity rate of -0.3 outlined by Burris et al. (2012) was developed based on toll increases in the range of 10-50%. It is assumed for this research that this can be applied for an increase of 100% maximum, even though this is outside of the range of values studied. The elasticity rates for increases in excess of 100% are currently unknown and would need further research and monitoring to determine actual impacts.

$$\varepsilon_{shr} = \frac{(Q_1 - Q_0)P_0}{(P_1 - P_0)Q_0} \tag{5.4}$$

where: ε_{shr} = shrinkage ratio

Q_0 = number of users before change determined significant

Q_1 = number of users after change

P_0 = price before change

P_1 = price after change

It was assumed that the majority of the Express Pass holders that choose not to pay the higher toll would shift in the GP lanes. The projected effects of increasing the toll on the overall system are summarized in Table 5.11 for Zone 140 AM Peak.

Table 5.12 shows increasing the toll from $1.00 to $2.00 has the potential to increase speed in the EL for Zone 140 AM Peak by 3.2 mph.

Table 5.11 Impact of Increased Toll Rate on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 30% Express Pass reduction)

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-81	0	0	0	0	0
		GP	0	0	0	81	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	421	640	270	189	68	34	0	0	0
		GP	1,616	97	17	106	0	17	0	33	0
	Vehicle Percentage by Type	EL	26.0%	39.5%	16.6%	11.7%	4.2%	2.1%	0.0%	0.0%	0.0%
		GP	85.7%	5.1%	0.9%	5.6%	0.0%	0.9%	0.0%	1.7%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-30.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	324.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.12 Impact of Increased Toll Rate on EL and GP Lane Performance for Zone 140 AM Peak (assumed 30% Express Pass reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,622	54.0
	GP	1,886	54.6

5.5 Increased "C" Decal Permits

In Title 41 Chapter 6a Section 702 of Utah State Code, there are 6,000 possible permits for clean energy vehicles that are issued throughout the state (Utah State Code 2014b). From the AVO results, "C" decal vehicles make up approximately 1% to 4% of the volume of the EL. If the limit for "C" decal vehicles was increased from 6,000 permits to 12,000 permits (a 100% increase), it is anticipated that the speed of the EL will decrease. Table 5.13 and Table 5.14 show that if the number of "C" decal vehicles in the EL were to increase by 100% in an area where

approximately 4% of the volume of the EL was "C" decal vehicles (e.g., Zone 140 AM Peak), replacing SOVs in the GP lanes, the speed in the EL could drop approximately 4.3 mph during congested periods. This result is likely on the high end of what could happen, since most of the lanes had a smaller percentage of "C" decals in the ELs.

Table 5.13 Impact of Increased "C" Decals on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 100% "C" decal increase)

Increase "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	0	68	0	0	0	0
		GP	-68	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	421	640	270	270	136	34	0	0	0
		GP	1,548	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	23.8%	36.1%	15.2%	15.2%	7.7%	1.9%	0.0%	0.0%	0.0%
		GP	89.1%	5.6%	1.0%	1.4%	0.0%	1.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.14 Impact of Increased "C" Decals on EL and GP Lane Performance for Zone 140 AM Peak (assumed 100% "C" decal increase)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,771	46.5
	GP	1,737	60.0

5.6 Increased Education and Enforcement and Toll Rate

Based on the analysis presented in previous sections, changing the vehicle percentage by type by reducing SOV violators (through education and enforcement) or reducing the number of Express Pass users (by increasing toll rates) is anticipated to lower the volumes independent of each other, thus increasing the speed of the EL. Combining both efforts together are anticipated to provide an even greater impact on the speeds in the EL.

As shown in Table 5.15 and Table 5.16, combining these methods for Zone 140 AM Peak may result in an increase of speed of approximately 6.0 mph in the EL.

Table 5.15 Impact of Increased Toll Rate and EL Education and Enforcement on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 20% violator reduction and 30% Express Pass reduction)

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-85	0	0	-81	0	0	0	0	0
		GP	85	0	0	81	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	336	640	270	189	68	34	0	0	0
		GP	1,701	97	17	106	0	17	0	33	0
	Vehicle Percentage by Type	EL	21.9%	41.6%	17.6%	12.3%	4.4%	2.2%	0.0%	0.0%	0.0%
		GP	86.3%	4.9%	0.9%	5.4%	0.0%	0.9%	0.0%	1.7%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.3%	0.0%	0.0%	324.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.16 Impact of Increased Toll Rate and EL Education and Enforcement on EL and GP Lane Performance for Zone 140 AM Peak (assumed 20% violator reduction and 30% Express Pass reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,537	56.8
	GP	1,971	49.5

5.7 Increased Education and Enforcement and "C" Decal Permits

Changing the vehicle percentage by type by increasing education and enforcement efforts in addition to increasing the number of "C" decals will help the overall congestion of the EL. The possible congestion caused by an increase of "C" Decals in the system is offset by the efforts to remove violators from the EL.

As shown in Table 5.17 and Table 5.18, increasing efforts to reduce the violators in the lane while allowing for double the "C" decal permits may result in an increase of speed in the EL of 0.7 mph for Zone 140 AM Peak.

Table 5.17 Impact of Increased EL Education and Enforcement and "C" Decal Permits on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 20% violator reduction and 100% "C" Decal increase)

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-85	0	0	0	68	0	0	0	0
		GP	17	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	336	640	270	270	136	34	0	0	0
		GP	1,633	97	17	25	0	17	0	33	0
	Vehicle Percentage by Type	EL	19.9%	38.0%	16.0%	16.0%	8.1%	2.0%	0.0%	0.0%	0.0%
		GP	89.6%	5.3%	0.9%	1.4%	0.0%	0.9%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.18 Impact of Increased EL Education and Enforcement and "C" Decal Permits on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 20% violator reduction and 100% "C" Decal increase)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,686	51.5
	GP	1,822	57.2

5.8 Increased Toll Rates and "C" Decal Permits

Changing the vehicle percentage by type by increasing the toll rates concurrent with an increase in the number of "C" decals will help the overall congestion of the EL. Increasing the toll rates will make Express Pass users more likely to use the GP lane. This would open up additional capacity in the ELs for the increased number of "C" decal permit vehicles. Combined with an increase in toll rates, the "C" decal vehicles could replace Express Pass users in the lane.

As shown in Table 5.19 and Table 5.20, increasing the toll and number of "C" decal vehicles in the EL for Zone 140 AM Peak could result in a slight increase in speed (0.5 mph) in the ELs when 4% of the EL is "C" decal vehicles.

Table 5.19 Impact of Increased Toll Rates and Increased "C" Decals on Vehicle Types in EL and GP Lanes for Zone 140 AM Peak (assumed 100% "C" Decal increase and 30% Express Pass reduction)

Increase Toll Rates and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-81	68	0	0	0	0
		GP	-68	0	0	81	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	421	640	270	189	136	34	0	0	0
		GP	1,548	97	17	106	0	17	0	33	0
	Vehicle Percentage by Type	EL	24.9%	37.9%	16.0%	11.2%	8.0%	2.0%	0.0%	0.0%	0.0%
		GP	85.1%	5.3%	0.9%	5.8%	0.0%	0.9%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-30.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-4.2%	0.0%	0.0%	324.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.20 Impact of Increased Toll Rates and Increased "C" Decals on EL and GP Lane Performance for Zone 140 AM Peak (assumed 100% "C" Decal increase and 30% Express Pass reduction)

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,690	51.3
	GP	1,818	57.3

5.9 Increased Education and Enforcement, Toll, and "C" Decal Permits

The result of combining all methods to change the vehicle percentage by type has the potential to increase the speeds in the EL. A combination of an increase in toll rates, education and enforcement, and allowing additional "C" decal vehicles could have a net effect of reducing the volume and increasing the speeds.

As shown in Table 5.21 and Table 5.22, increasing the toll, the number of "C" decal vehicles and increasing EL education and enforcement could increase speed in the EL by approximately 3.8 mph for Zone 140 AM Peak. This increase assumes an additive impact for all measures, which has not been proven in the field to date and would need to be monitored and verified.

Table 5.21 Impact of EL Education and Enforcement (assumed 20% violator reduction), Increased Toll Rates (assumed 30% Express Pass reduction), and Increased "C" Decals (assumed 100% increase) for Zone 140 AM Peak

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Number of Vehicles by Type	EL	421	640	270	270	68	34	0	0	0
		GP	1,616	97	17	25	0	17	0	33	0
Estimated Changes	Number of Vehicles Displaced	EL	-85	0	0	-81	68	0	0	0	0
		GP	17	0	0	81	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	336	640	270	189	136	34	0	0	0
		GP	1,633	97	17	106	0	17	0	33	0
	Vehicle Percentage by Type	EL	20.9%	39.9%	16.8%	11.8%	8.5%	2.1%	0.0%	0.0%	0.0%
		GP	85.8%	5.1%	0.9%	5.6%	0.0%	0.9%	0.0%	1.7%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.1%	0.0%	0.0%	324.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.22 Impact of EL Education and Enforcement (assumed 20% violator reduction), Increased Toll Rates (assumed 30% Express Pass reduction), and Increased "C" Decals (assumed 100% increase) for Zone 140 AM Peak

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,700	50.8
	GP	1,800	58.0
Performance After Change Implemented	EL	1,605	54.6
	GP	1,903	53.8

5.10 Sensitivity Analysis Results

Due to a variety of factors that cause each zone to perform differently by time of day, the sensitivity analysis outlined in the previous sections was performed for Zones 145 AM Peak, 140 PM Peak, 145 PM Peak, 250 PM Peak, 255 PM Peak, and 260 PM Peak to provide more representative results for each zone. The speed volume curves and results of the sensitivity analysis for each zone are included in Appendix F though Appendix K. A summary of the results for these analysis zones is provided in Table 5.23 for AM Peak results and in Table 5.24 for PM Peak results.

Table 5.23 Summary of Sensitivity Analysis (AM Peak)

Methodology	Lane	Zone 140 AM			Zone 145 AM		
		Speed Before	Speed After	Difference (mph)	Speed Before	Speed After	Difference (mph)
Education (-5% Violators)	HOT	50.8	51.7	0.9	45.2	47.2	2.1
	GP	58.0	57.0	-1.0	52.7	51.6	-1.0
Education (-10% Violators)	HOT	50.8	52.6	1.7	45.2	48.9	3.7
	GP	58.0	56.2	-1.8	52.7	50.6	-2.0
Education (-15% Violators)	HOT	50.8	53.4	2.6	45.2	50.3	5.1
	GP	58.0	55.3	-2.6	52.7	49.6	-3.1
Enforcement (-10% Violators)	HOT	50.8	52.6	1.7	45.2	48.9	3.7
	GP	58.0	56.2	-1.8	52.7	50.6	-2.0
Education & Enforcement (-20% Violators)	HOT	50.8	54.2	3.3	45.2	51.5	6.3
	GP	58.0	54.4	-3.6	52.7	48.3	-4.4
Increased Toll (-30% Express Pass)	HOT	50.8	54.0	3.2	45.2	50.5	5.4
	GP	58.0	54.6	-3.4	52.7	49.3	-3.4
Increased "C" Decal (+100% "C" Decal)	HOT	50.8	46.5	-4.3	45.2	40.0	-5.2
	GP	58.0	60.0	2.0	52.7	53.4	0.7
Education & Enforcement (-20% Violators) plus Increased Toll (-30% Express Pass)	HOT	50.8	56.8	5.9	45.2	54.8	9.6
	GP	58.0	49.5	-8.5	52.7	41.1	-11.5
Education & Enforcement (-20% Violators) plus Increased "C" Decal Permits (+100% "C" Decal)	HOT	50.8	51.5	0.6	45.2	50.4	5.2
	GP	58.0	57.2	-0.8	52.7	49.5	-3.2
Increased Toll (-30% Express Pass) plus Increased "C" Decal Permits (+100% "C" Decal)	HOT	50.8	51.3	0.5	45.2	49.3	4.1
	GP	58.0	57.3	-0.6	52.7	50.4	-2.3
Education & Enforcement (-20% Violators), Increased Toll (-30% Express Pass), plus Increased "C" Decal Permits (+100% "C" Decal)	HOT	50.8	54.6	3.8	45.2	53.9	8.8
	GP	58.0	53.8	-4.2	52.7	44.4	-8.2

Table 5.24 Summary of Sensitivity Analysis (PM Peak)

Methodology	Lane	Zone 140 PM			Zone 145 PM			Zone 250 PM			Zone 255 PM			Zone 260 PM		
		Speed Before	Speed After	Difference (mph)	Speed Before	Speed After	Difference (mph)	Speed Before	Speed After	Difference (mph)	Speed Before	Speed After	Difference (mph)	Speed Before	Speed After	Difference (mph)
Education (-5% Violators)	HOT	49.1	49.6	0.5	46.7	47.4	0.7	45.2	46.4	1.3	52.1	53.3	1.2	55.5	56.3	0.8
	GP	49.8	48.9	-0.9	52.3	51.4	-0.9	59.0	58.1	-0.9	54.2	53.3	-0.9	58.1	57.4	-0.6
Education (-10% Violators)	HOT	49.1	50.2	1.1	46.7	48.1	1.4	45.2	47.7	2.5	52.1	54.5	2.4	55.5	57.2	1.6
	GP	49.8	48.2	-1.6	52.3	50.6	-1.7	59.0	57.3	-1.6	54.2	52.6	-1.6	58.1	56.9	-1.2
Education (-15% Violators)	HOT	49.1	51.3	2.2	46.7	48.8	2.1	45.2	48.7	3.5	52.1	55.5	3.5	55.5	58.0	2.4
	GP	49.8	46.4	-3.4	52.3	49.7	-2.7	59.0	56.5	-2.4	54.2	51.8	-2.4	58.1	56.2	-1.8
Enforcement (-10% Violators)	HOT	49.1	50.2	1.1	46.7	48.1	1.4	45.2	47.7	2.5	52.1	54.5	2.4	55.5	57.2	1.6
	GP	49.8	48.2	-1.6	52.3	50.6	-1.7	59.0	57.3	-1.6	54.2	52.6	-1.6	58.1	56.9	-1.2
Education & Enforcement (-20% Violators)	HOT	49.1	51.3	2.2	46.7	49.4	2.8	45.2	49.6	4.5	52.1	56.5	4.4	55.5	58.7	3.2
	GP	49.8	46.4	-3.4	52.3	48.5	-3.8	59.0	55.6	-3.3	54.2	50.9	-3.3	58.1	55.6	-2.5
Increased Toll (-30% Express Pass)	HOT	49.1	49.9	0.8	46.7	47.7	1.0	45.2	50.3	5.2	52.1	57.4	5.3	55.5	59.2	3.7
	GP	49.8	48.7	-1.2	52.3	51.1	-1.2	59.0	54.9	-4.1	54.2	50.0	-4.2	58.1	55.1	-2.9
Increased "C" Decal (+100% "C" Decal)	HOT	49.1	48.9	-0.2	46.7	42.1	-4.6	45.2	43.4	-1.7	52.1	49.7	-2.3	55.5	55.4	-0.1
	GP	49.8	49.6	-0.2	52.3	54.2	1.9	59.0	59.3	0.3	54.2	59.3	5.1	58.1	58.0	-0.1
Education & Enforcement (-20% Violators) plus Increased Toll (-30% Express Pass)	HOT	49.1	52.1	3.0	46.7	50.3	3.6	45.2	53.3	8.1	52.1	60.5	8.4	55.5	61.7	6.2
	GP	49.8	43.9	-5.9	52.3	45.9	-6.4	59.0	49.4	-9.5	54.2	43.3	-10.9	58.1	51.9	-6.1
Education & Enforcement (-20% Violators) plus Increased "C" Decal Permits (+100% "C" Decal)	HOT	49.1	51.3	2.2	46.7	47.2	0.5	45.2	48.9	3.8	52.1	55.4	3.4	55.5	58.7	3.2
	GP	49.8	46.4	-3.4	52.3	51.6	-0.7	59.0	56.3	-2.7	54.2	51.9	-2.3	58.1	55.6	-2.5
Increased Toll (-30% Express Pass) plus Increased "C" Decal Permits (+100% "C" Decal)	HOT	49.1	49.9	0.8	46.7	44.6	-2.0	45.2	49.7	4.6	52.1	56.4	4.3	55.5	59.2	3.7
	GP	49.8	48.7	-1.2	52.3	53.4	1.1	59.0	55.5	-3.4	54.2	51.1	-3.2	58.1	55.1	-2.9
Education & Enforcement (-20% Violators), Increased Toll (-30% Express Pass), plus Increased "C" Decal Permits (+100% "C" Decal)	HOT	49.1	52.1	3.0	46.7	48.3	1.6	45.2	52.8	7.6	52.1	59.7	7.6	55.5	61.7	6.2
	GP	49.8	43.5	-6.3	52.3	50.4	-1.9	59.0	50.8	-8.1	54.2	46.2	-8.0	58.1	51.9	-6.1

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The primary objective of this research was to recommend actions that will improve average speeds in the HOT lane or EL to Utah's goal of 55 mph. To accomplish this objective it was important to investigate the current usage of both the ELs and the GP lanes along the Wasatch Front. Specifically, it was necessary to determine the EL and GP lane users by type (e.g., SOV, HOV 2, HOV 3+, "C" decal, Express Pass user, motorcycle, bus, freight vehicle, and emergency vehicle). Also needed was information on traffic speeds and flow rates along both the ELs and GP lanes. These data were examined to better understand the speed-flow relationship on these lanes and to estimate the impact of volume changes on speeds in the lanes. These empirical data were supplemented with literature regarding the impact of EL policies on EL usage. All of this information allowed researchers to estimate the impact on EL and GP lane volumes and speeds under a combination of the following scenarios:

- EL education campaign,
- Increased EL enforcement,
- Increased EL peak period toll rate, and
- Increased "C" decal permits.

One of the key factors in calculating the speed and volume results was the determination of lane users by type for the EL and the GP lanes. The results of the study indicate that the proportion of lane users by type varies depending on time of day and location along the corridor; however, an average of the overall results for both SB and NB traffic combined indicate that the ELs are comprised of approximately 16% SOVs, 68% carpooling vehicles (HOV 2 and HOV 3+), 11% Express Pass users, 2% "C" decal vehicles, and 3% other (motorcycle, bus, freight, and emergency vehicles). AVO also varies by time of day and location with AVO for the ELs reported to range between 1.55 and 2.23 ppv in the NB direction and 1.84 to 2.15 ppv in the SB direction. The AVO for the GP lanes ranged from 1.11 to 1.36 ppv for the NB and SB directions. The overall AVO for the EL is 1.90 ppv and 1.25 ppv for the GP lanes (for all time periods).

This chapter provides conclusions based on the research and recommendations on next steps to reduce volume in the ELs, and subsequently, increase speed.

6.2 Recommendations

There are three primary areas of recommendations for this research: 1) reduce violation rates along the corridor, 2) increase speeds in the ELs through an increase in tolls (and subsequent decrease in volume), and 3) allow an increase in "C" decal vehicles once additional capacity is available. The recommendations should be conducted in a phased manner starting with steps to reduce violators. Continual monitoring will be necessary throughout the implementation process to evaluate the effectiveness of each step. A summary of the recommendations are as follows:

1. Reduce the violation rate along the corridor through methods such as increased enforcement, education campaigns regarding policies related to the proper use of the ELs, the consideration of a "HERO" program for public enforcement, installing rumble strips along the ELs, and considering modifications to the striping of the ELs:
    a. Based on the results of the Literature Review, education will need to be a key component of this recommendation. Several studies have shown that enforcement alone often does not have a noticeable impact on violation rates, unless it can be very pronounced and consistent.
    b. Another consideration to reduce violation rates could be to install rumble strips or temporary barriers between the double white lines to discourage drivers from crossing into the lanes illegally, and/or considering modifications to the striping of the ELs to include a double yellow line to deter illegal maneuvers. Safety and maintenance effects of this recommendation need further study.
    c. A variety of scenarios were developed in Chapter 5 to determine the impact that these changes may have on the volume and speed of the lanes using a general Greenshields model of traffic flow. A summary of these results is provided in Table 6.1.

2. Increase speeds in the ELs through an increase in tolls (and subsequent decrease in volume) during peak periods, including an increase in the maximum allowable toll:
    a. Toll rates in Utah have been shown to be relatively low when compared to other states. A comparison in Chapter 2 of the cost of living compared to current tolls in these states suggest that an average toll rate at or near $2.00 per zone would not be unreasonable for Utah. Based on this analysis, a $1.00 toll increase (100%) is recommended; increasing the maximum toll to $2.00. Assuming an elasticity rate of -0.3, this is expected to result in a 30% reduction in Express Pass users. Any increase beyond 100% would require additional analyses to determine an appropriate elasticity rate and subsequent reductions in Express Pass users as the elasticity rate of -0.3 used in the analysis was developed based on toll increases in the range of 10-50%. The elasticity rates for increases in excess of 100% are currently unknown and would need further research and monitoring to determine actual impacts.
    b. A variety of scenarios were developed in Chapter 5 to determine the impact that these changes may have on the volume and speed of the lanes using a general Greenshields model of traffic flow. A summary of these results is provided in Table 6.1.
    c. To better understand actual elasticity rates in Utah, it was also recommended that UDOT participate in the EL travel survey being conducted by the Texas A&M Transportation Institute (TTI). The results of the Utah specific data are provided in Appendix L. Although the elasticity rate calculated in this study for Utah (-0.38) is slightly higher than that used in this analysis (-0.3), the results were not recalculated for two reasons. First, a sensitivity analysis of the differences did not show noticeable results, and second, it was determined that the -0.3 elasticity rate was slightly more conservative and would therefore be used.
3. Allow an increase in the number of "C" decals in the lanes once additional capacity is available from the reduction in violators and Express Pass users:
    a. The total number of "C" decal vehicles in the lanes was calculated to be between 1% and 4% of the volume in the EL. An increase in the "C" decal cap will cause a

reduction in speed in the ELs; however, if other changes are made as summarized in Table 6.1, the impact will not be substantial.

The literature varies on the effectiveness of any one of the above recommendations. As a result it is recommended that traffic be monitored following implementation of the proposed recommendation to determine how effective the recommendations are. Monitoring would include an analysis of system speed, volume, and AVO throughout the implementation period. As illustrated in Table 6.1, the change in speed on the EL as a result of the various scenarios ranged from a maximum decrease of -4.7 mph for an increase in "C" decal vehicles only to a maximum increase of 7.8 mph for a combination of education, enforcement, and increases in the maximum toll rate. A summary of how the different scenarios are affected by zone is provided in Figure 6.1. As illustrated here, alternative "H" (Education, Enforcement, and Increase Toll) provides the best overall results for each zone.

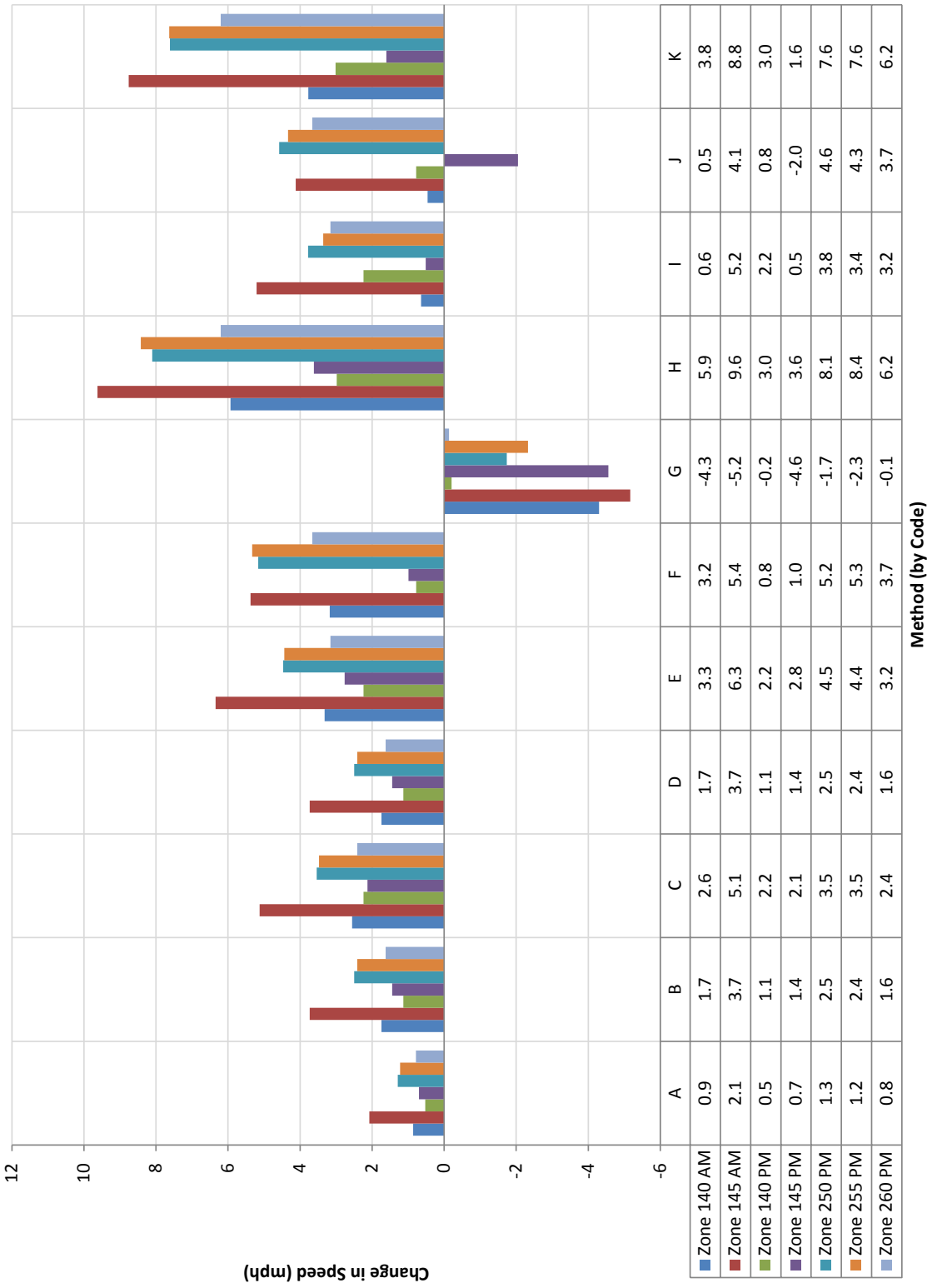
If it is determined that the recommendations outlined are unsuccessful, several other alternatives to reduce the volume in the ELs were identified in the Phase I report including:

1. Examine the lanes to see if there are specific locations where the speeds are degrading due to geometric design or weaving with the GP lanes and identify design changes to help improve performance and to address some or all of the speed degradation.
2. Adding an additional HOV/HOT lane.
3. Remove some EL access points to reduce the number of merge areas along the corridor.

Additional research would be necessary to evaluate these alternatives and their potential impacts. Based on recent research by Liu et al. (2011) and Liu et al. (2012) it is recommended that a more detailed analysis of speed and volume data on the ELs compared with the GP lanes be conducted to address the possible frictional effect between ELs and the adjacent GP lanes. The results of this research indicate that because of a possible frictional effect, a congested GP lane could have a negative effect on the EL, even if the EL is operating below capacity. This relationship needs to be addressed in more detail in future research.

Table 6.1 Summary of EL Changes in Speed

Methodology	Code	Zone 140 AM	Zone 145 AM	Zone 140 PM	Zone 145 PM	Zone 250 PM	Zone 255 PM	Zone 260 PM	AM Peak Average Change in Speed	PM Peak Average Change in Speed
Education (-5% Violators)	A	0.9	2.1	0.5	0.7	1.3	1.2	0.8	1.5	0.9
Education (-10% Violators)	B	1.7	3.7	1.1	1.4	2.5	2.4	1.6	2.7	1.8
Education (-15% Violators)	C	2.6	5.1	2.2	2.1	3.5	3.5	2.4	3.8	2.8
Enforcement (-10% Violators)	D	1.7	3.7	1.1	1.4	2.5	2.4	1.6	2.7	1.8
Education & Enforcement (-20% Violators)	E	3.3	6.3	2.2	2.8	4.5	4.4	3.2	4.8	3.4
Increased Toll (-30% Express Pass)	F	3.2	5.4	0.8	1.0	5.2	5.3	3.7	4.3	3.2
Increased "C" Decal (+100% "C" Decal)	G	-4.3	-5.2	-0.2	-4.6	-1.7	-2.3	-0.1	-4.7	-1.8
Education & Enforcement (-20% Violators) plus Increased Toll (-30% Express Pass)	H	5.9	9.6	3.0	3.6	8.1	8.4	6.2	7.8	5.9
Education & Enforcement (-20% Violators) plus Increased "C" Decal Permits (+100% "C" Decal)	I	0.6	5.2	2.2	0.5	3.8	3.4	3.2	2.9	2.6
Increased Toll (-30% Express Pass) plus Increased "C" Decal Permits (+100% "C" Decal)	J	0.5	4.1	0.8	-2.0	4.6	4.3	3.7	2.3	2.3
Education & Enforcement (-20% Violators), Increased Toll (-30% Express Pass), plus Increased "C" Decal Permits (+100% "C" Decal)	K	3.8	8.8	3.0	1.6	7.6	7.6	6.2	6.3	5.2



	A	B	C	D	E	F	G	H	I	J	K
Zone 140 AM	0.9	1.7	2.6	1.7	3.3	3.2	-4.3	5.9	0.6	0.5	3.8
Zone 145 AM	2.1	3.7	5.1	3.7	6.3	5.4	-5.2	9.6	5.2	4.1	8.8
Zone 140 PM	0.5	1.1	2.2	1.1	2.2	0.8	-0.2	3.0	2.2	0.8	3.0
Zone 145 PM	0.7	1.4	2.1	1.4	2.8	1.0	-4.6	3.6	0.5	-2.0	1.6
Zone 250 PM	1.3	2.5	3.5	2.5	4.5	5.2	-1.7	8.1	3.8	4.6	7.6
Zone 255 PM	1.2	2.4	3.5	2.4	4.4	5.3	-2.3	8.4	3.4	4.3	7.6
Zone 260 PM	0.8	1.6	2.4	1.6	3.2	3.7	-0.1	6.2	3.2	3.7	6.2

Figure 6.1 Change in speed summary by zone and alternative.

6.3 Implementation Plan

To evaluate the effectiveness of the implementation of the proposed recommendations it will be necessary to continually monitor speed, volume, and AVO along the corridor, with specific emphasis on those areas where speeds are less than the current UDOT goal. As the system is monitored, additional recommendations can be considered as needed.

In addition to the work outlined in the Recommendations section, future efforts could include an analysis of the safety issues associated with the use of the ELs and a comprehensive analysis of the ELs travel survey results.

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APPENDIX A: VEHICLE OCCUPANCY DATA COLLECTION RESULTS

Table A.1 Vehicle Count by Type by Zone, Time, and Lane (NB)

Zone	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency	Total
130	AM Peak	EL	8	25	6	3	3	6	0	0	1	52
		GP	179	19	3	0	0	1	0	6	0	208
	Off-Peak	EL	2	28	5	1	0	0	0	0	0	36
		GP	103	44	8	1	0	1	0	12	0	169
	PM Peak	EL	5	48	25	4	2	1	0	0	0	85
		GP	311	109	31	0	0	4	1	12	3	471
	Total EL		15	101	36	8	5	7	0	0	1	173
	Total GP		593	172	42	1	0	6	1	30	3	848
135	AM Peak	EL	6	52	16	11	3	6	0	0	0	94
		GP	283	34	9	3	0	0	1	12	0	342
	Off-Peak	EL	4	34	11	0	1	0	1	0	0	51
		GP	197	65	12	0	0	1	2	17	0	294
	PM Peak	EL	7	59	44	3	4	8	1	0	0	126
		GP	617	148	59	5	3	7	3	22	0	864
	Total EL		17	145	71	14	8	14	2	0	0	271
	Total GP		1,097	247	80	8	3	8	6	51	0	1,500
140	AM Peak	EL	25	38	16	16	4	2	0	0	0	101
		GP	201	12	2	3	0	2	0	4	0	224
	Off-Peak	EL	5	38	13	2	0	2	0	0	1	61
		GP	161	35	17	3	0	0	0	14	0	230
	PM Peak	EL	12	70	18	3	0	5	1	0	0	109
		GP	192	34	14	0	0	1	0	9	0	250
	Total EL		42	146	47	21	4	9	1	0	1	271
	Total GP		554	81	33	6	0	3	0	27	0	704
145	AM Peak	EL	109	110	35	58	5	13	0	0	0	330
		GP	366	23	3	6	1	0	0	16	3	418
	Off-Peak	EL	13	70	33	7	1	2	0	0	0	126
		GP	319	92	21	2	1	2	0	29	0	466
	PM Peak	EL	25	106	20	6	4	11	0	0	0	172
		GP	265	54	7	0	1	6	0	12	0	345
	Total EL		147	286	88	71	10	26	0	0	0	628
	Total GP		950	169	31	8	3	8	0	57	3	1,229
150	AM Peak	EL	24	94	37	53	4	11	0	0	1	224
		GP	618	50	9	9	2	5	1	28	0	722
	Off-Peak	EL	3	57	24	3	3	3	0	0	0	93
		GP	326	89	26	0	0	4	0	23	1	469
	PM Peak	EL	24	98	17	11	1	2	0	0	0	153
		GP	238	34	7	1	0	1	0	6	2	289
	Total EL		51	249	78	67	8	16	0	0	1	470
	Total GP		1,182	173	42	10	2	10	1	57	3	1,480

Table A.2 Vehicle Count by Type by Zone, Time, and Lane (SB)

Zone	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency	Total
250	AM Peak	EL	17	24	3	13	1	4	1	0	0	63
		GP	472	42	6	5	1	1	1	20	3	551
	Off-Peak	EL	6	54	18	1	3	0	3	0	0	85
		GP	319	98	22	2	1	1	2	30	0	475
	PM Peak	EL	163	343	111	132	6	29	1	0	1	786
		GP	440	38	12	3	0	3	0	11	0	507
	Total EL		186	421	132	146	10	33	5	0	1	934
	Total GP		1,231	178	40	10	2	5	3	61	3	1,533
255	AM Peak	EL	11	31	5	3	1	4	0	0	0	55
		GP	328	42	13	4	0	3	1	20	0	411
	Off-Peak	EL	6	61	17	1	0	1	1	0	0	87
		GP	227	68	18	3	0	2	0	20	0	338
	PM Peak	EL	72	173	28	60	4	6	0	0	2	345
		GP	376	45	8	4	3	1	0	13	0	450
	Total EL		89	265	50	64	5	11	1	0	2	487
	Total GP		931	155	39	11	3	6	1	53	0	1,199
260	AM Peak	EL	10	32	11	2	0	2	1	0	0	58
		GP	262	35	8	3	0	2	0	19	0	329
	Off-Peak	EL	6	28	5	0	1	1	0	0	0	41
		GP	80	20	5	1	0	0	0	13	0	119
	PM Peak	EL	27	83	10	21	0	1	0	0	0	142
		GP	136	16	3	0	0	0	0	3	0	158
	Total EL		43	143	26	23	1	4	1	0	0	241
	Total GP		478	71	16	4	0	2	0	35	0	606
265	AM Peak	EL	3	59	22	3	1	2	1	0	0	91
		GP	328	52	19	4	2	3	0	19	0	427
	Off-Peak	EL	3	21	4	1	0	0	0	0	0	29
		GP	125	41	11	0	1	0	0	18	0	196
	PM Peak	EL	13	66	31	2	0	5	0	0	0	117
		GP	566	139	22	7	0	5	0	22	1	762
	Total EL		19	146	57	6	1	7	1	0	0	237
	Total GP		1,019	232	52	11	3	8	0	59	1	1,385
270	AM Peak	EL	4	21	5	0	0	0	0	0	0	30
		GP	124	17	1	2	0	3	0	13	0	160
	Off-Peak	EL	2	9	7	0	1	1	0	0	0	20
		GP	85	36	7	1	0	0	3	9	0	141
	PM Peak	EL	4	48	18	2	1	1	0	0	0	74
		GP	524	119	34	3	0	4	2	22	1	709
	Total EL		10	78	30	2	2	2	0	0	0	124
	Total GP		733	172	42	6	0	7	5	44	1	1,010

Table A.3 Vehicle Samples Collected by Zone, Time and Lane (NB)

Zone	Time	Express Lane	GP Lanes	Total
130	AM Peak	52	208	260
	Off-Peak	36	169	205
	PM Peak	85	471	556
135	AM Peak	94	342	436
	Off-Peak	51	294	345
	PM Peak	126	864	990
140	AM Peak	101	224	325
	Off-Peak	61	230	291
	PM Peak	109	250	359
145	AM Peak	330	418	748
	Off-Peak	126	466	592
	PM Peak	172	345	517
150	AM Peak	224	722	946
	Off-Peak	93	469	562
	PM Peak	153	289	442

Table A.4 Vehicle Samples Collected by Zone, Time and Lane (SB)

Zone	Time	Express Lane	GP Lanes	Total
250	AM Peak	63	551	614
	Off-Peak	85	475	560
	PM Peak	786	507	1,293
255	AM Peak	55	411	466
	Off-Peak	87	338	425
	PM Peak	345	450	795
260	AM Peak	58	329	387
	Off-Peak	41	119	160
	PM Peak	142	158	300
265	AM Peak	91	427	518
	Off-Peak	29	196	225
	PM Peak	117	762	879
270	AM Peak	30	160	190
	Off-Peak	20	141	161
	PM Peak	74	709	783

Table A.5 Data Collection Observation Time by Zone, Time and Lane (NB) (h:mm:ss)

Zone	Time	Express Lane	GP Lanes	Total
130	AM Peak	1:23:26	0:40:41	2:04:07
	Off-Peak	0:43:54	0:33:55	1:17:49
	PM Peak	1:16:33	1:38:08	2:54:41
135	AM Peak	1:28:29	1:02:52	2:31:21
	Off-Peak	1:00:19	0:43:49	1:44:08
	PM Peak	1:29:49	1:50:21	3:20:10
140	AM Peak	0:35:30	1:06:38	1:42:08
	Off-Peak	0:44:16	0:35:25	1:19:41
	PM Peak	0:42:37	0:36:39	1:19:16
145	AM Peak	0:56:13	1:20:49	2:17:02
	Off-Peak	1:03:35	0:50:51	1:54:26
	PM Peak	0:54:57	0:42:31	1:37:28
150	AM Peak	1:06:10	1:45:15	2:51:25
	Off-Peak	1:20:45	1:10:08	2:30:53
	PM Peak	1:01:14	0:34:41	1:35:55

Table A.6 Data Collection Observation Time by Zone, Time and Lane (SB) (h:mm:ss)

Zone	Time	Express Lane	GP Lanes	Total
250	AM Peak	0:49:43	1:30:57	2:20:40
	Off-Peak	1:26:02	1:11:42	2:37:44
	PM Peak	2:08:14	0:59:41	3:07:55
255	AM Peak	0:40:10	1:01:39	1:41:49
	Off-Peak	0:57:06	0:48:53	1:45:59
	PM Peak	1:16:09	0:39:54	1:56:03
260	AM Peak	0:43:44	0:53:03	1:36:47
	Off-Peak	0:35:09	0:26:17	1:01:26
	PM Peak	0:43:10	0:31:37	1:14:47
265	AM Peak	1:39:11	1:04:30	2:43:41
	Off-Peak	0:42:43	0:32:10	1:14:53
	PM Peak	1:14:41	1:27:39	2:42:20
270	AM Peak	1:16:02	0:41:10	1:57:12
	Off-Peak	0:40:31	0:31:24	1:11:55
	PM Peak	1:15:31	1:36:35	2:52:06

Table A.7 Data Collection Observation Time Summary (NB and SB)

(h:mm:ss)	Express Lane	GP Lanes	Total
NB Collection Time	15:47:47	15:12:43	31:00:30
SB Collection Time	16:08:06	13:57:11	30:05:17
Cumulative Observation Time	31:55:53	29:09:54	61:05:47

APPENDIX B: AVERAGE VEHICLE OCCUPANCY

Table B.1 AVO by Zone, Time, and Lane (NB)

Zone	Time	Lane	Average
130	AM Peak	EL	1.84
		GP	1.13
		Combined	1.26
	Off-Peak	EL	2.08
		GP	1.42
		Combined	1.54
	PM Peak	EL	2.30
		GP	1.42
		Combined	1.56
135	AM Peak	EL	2.00
		GP	1.17
		Combined	1.35
	Off-Peak	EL	2.22
		GP	1.33
		Combined	1.47
	PM Peak	EL	2.41
		GP	1.37
		Combined	1.50
140	AM Peak	EL	1.78
		GP	1.07
		Combined	1.29
	Off-Peak	EL	2.16
		GP	1.35
		Combined	1.52
	PM Peak	EL	2.12
		GP	1.28
		Combined	1.53
145	AM Peak	EL	1.61
		GP	1.08
		Combined	1.31
	Off-Peak	EL	2.23
		GP	1.32
		Combined	1.52
	PM Peak	EL	1.96
		GP	1.23
		Combined	1.47
150	AM Peak	EL	1.91
		GP	1.10
		Combined	1.29
	Off-Peak	EL	2.32
		GP	1.35
		Combined	1.51
	PM Peak	EL	1.93
		GP	1.19
		Combined	1.45

Table B.2 AVO by Zone, Time, and Lane (NB)

Zone	Time	Lane	Average
250	AM Peak	EL	1.53
		GP	1.11
		Combined	1.15
	Off-Peak	EL	2.18
		GP	1.35
		Combined	1.48
	PM Peak	EL	1.82
		GP	1.14
		Combined	1.55
255	AM Peak	EL	1.82
		GP	1.19
		Combined	1.26
	Off-Peak	EL	2.20
		GP	1.37
		Combined	1.55
	PM Peak	EL	1.72
		GP	1.14
		Combined	1.40
260	AM Peak	EL	2.11
		GP	1.19
		Combined	1.33
	Off-Peak	EL	1.95
		GP	1.31
		Combined	1.49
	PM Peak	EL	1.75
		GP	1.15
		Combined	1.44
265	AM Peak	EL	2.35
		GP	1.25
		Combined	1.45
	Off-Peak	EL	2.00
		GP	1.40
		Combined	1.48
	PM Peak	EL	2.24
		GP	1.26
		Combined	1.39
270	AM Peak	EL	2.07
		GP	1.14
		Combined	1.30
	Off-Peak	EL	2.37
		GP	1.40
		Combined	1.52
	PM Peak	EL	2.23
		GP	1.30
		Combined	1.39

Table B.3 AVO Summary (NB)

		EL	GP	Combined
NB	AM Peak Total	1.55	1.11	1.24
	Off-Peak Total	2.23	1.34	1.51
	PM Peak Total	2.11	1.32	1.50
	Combined	1.89	1.26	1.41

Table B.4 AVO Summary (SB)

		EL	GP	Combined
SB	AM Peak Total	2.01	1.17	1.29
	Off-Peak Total	2.15	1.36	1.50
	PM Peak Total	1.84	1.22	1.45
	Combined	1.91	1.24	1.41

APPENDIX C: VEHICLE PERCENTAGE BY TYPE

Table C.1 Vehicle Percentage by Type by Zone, Time and Lane (NB)

Zone	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
130	AM Peak	EL	15.4%	48.1%	11.5%	5.8%	5.8%	11.5%	0.0%	0.0%	1.9%
		GP	86.1%	9.1%	1.4%	0.0%	0.0%	0.5%	0.0%	2.9%	0.0%
	Off-Peak	EL	5.6%	77.8%	13.9%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	60.9%	26.0%	4.7%	0.6%	0.0%	0.6%	0.0%	7.1%	0.0%
	PM Peak	EL	5.9%	56.5%	29.4%	4.7%	2.4%	1.2%	0.0%	0.0%	0.0%
		GP	66.0%	23.1%	6.6%	0.0%	0.0%	0.8%	0.2%	2.5%	0.6%
	Average EL		8.7%	58.4%	20.8%	4.6%	2.9%	4.0%	0.0%	0.0%	0.6%
	Average GP		69.9%	20.3%	5.0%	0.1%	0.0%	0.7%	0.1%	3.5%	0.4%
135	AM Peak	EL	6.4%	55.3%	17.0%	11.7%	3.2%	6.4%	0.0%	0.0%	0.0%
		GP	82.7%	9.9%	2.6%	0.9%	0.0%	0.0%	0.3%	3.5%	0.0%
	Off-Peak	EL	7.8%	66.7%	21.6%	0.0%	2.0%	0.0%	2.0%	0.0%	0.0%
		GP	67.0%	22.1%	4.1%	0.0%	0.0%	0.3%	0.7%	5.8%	0.0%
	PM Peak	EL	5.6%	46.8%	34.9%	2.4%	3.2%	6.3%	0.8%	0.0%	0.0%
		GP	71.4%	17.1%	6.8%	0.6%	0.3%	0.8%	0.3%	2.5%	0.0%
	Average EL		6.3%	53.5%	26.2%	5.2%	3.0%	5.2%	0.7%	0.0%	0.0%
	Average GP		73.1%	16.5%	5.3%	0.5%	0.2%	0.5%	0.4%	3.4%	0.0%
140	AM Peak	EL	24.8%	37.6%	15.8%	15.8%	4.0%	2.0%	0.0%	0.0%	0.0%
		GP	89.7%	5.4%	0.9%	1.3%	0.0%	0.9%	0.0%	1.8%	0.0%
	Off-Peak	EL	8.2%	62.3%	21.3%	3.3%	0.0%	3.3%	0.0%	0.0%	1.6%
		GP	70.0%	15.2%	7.4%	1.3%	0.0%	0.0%	0.0%	6.1%	0.0%
	PM Peak	EL	11.0%	64.2%	16.5%	2.8%	0.0%	4.6%	0.9%	0.0%	0.0%
		GP	76.8%	13.6%	5.6%	0.0%	0.0%	0.4%	0.0%	3.6%	0.0%
	Average EL		15.5%	53.9%	17.3%	7.7%	1.5%	3.3%	0.4%	0.0%	0.4%
	Average GP		78.7%	11.5%	4.7%	0.9%	0.0%	0.4%	0.0%	3.8%	0.0%
145	AM Peak	EL	33.0%	33.3%	10.6%	17.6%	1.5%	3.9%	0.0%	0.0%	0.0%
		GP	87.6%	5.5%	0.7%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Off-Peak	EL	10.3%	55.6%	26.2%	5.6%	0.8%	1.6%	0.0%	0.0%	0.0%
		GP	68.5%	19.7%	4.5%	0.4%	0.2%	0.4%	0.0%	6.2%	0.0%
	PM Peak	EL	14.5%	61.6%	11.6%	3.5%	2.3%	6.4%	0.0%	0.0%	0.0%
		GP	76.8%	15.7%	2.0%	0.0%	0.3%	1.7%	0.0%	3.5%	0.0%
	Average EL		23.4%	45.5%	14.0%	11.3%	1.6%	4.1%	0.0%	0.0%	0.0%
	Average GP		77.3%	13.8%	2.5%	0.7%	0.2%	0.7%	0.0%	4.6%	0.2%
150	AM Peak	EL	10.7%	42.0%	16.5%	23.7%	1.8%	4.9%	0.0%	0.0%	0.4%
		GP	85.6%	6.9%	1.2%	1.2%	0.3%	0.7%	0.1%	3.9%	0.0%
	Off-Peak	EL	3.2%	61.3%	25.8%	3.2%	3.2%	3.2%	0.0%	0.0%	0.0%
		GP	69.5%	19.0%	5.5%	0.0%	0.0%	0.9%	0.0%	4.9%	0.2%
	PM Peak	EL	15.7%	64.1%	11.1%	7.2%	0.7%	1.3%	0.0%	0.0%	0.0%
		GP	82.4%	11.8%	2.4%	0.3%	0.0%	0.3%	0.0%	2.1%	0.7%
	Average EL		10.9%	53.0%	16.6%	14.3%	1.7%	3.4%	0.0%	0.0%	0.2%
	Average GP		79.9%	11.7%	2.8%	0.7%	0.1%	0.7%	0.1%	3.9%	0.2%

Table C.2 Vehicle Percentage by Type by Zone, Time and Lane (SB)

Zone	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
250	AM Peak	EL	27.0%	38.1%	4.8%	20.6%	1.6%	6.3%	1.6%	0.0%	0.0%
		GP	85.7%	7.6%	1.1%	0.9%	0.2%	0.2%	0.2%	3.6%	0.5%
	Off-Peak	EL	7.1%	63.5%	21.2%	1.2%	3.5%	0.0%	3.5%	0.0%	0.0%
		GP	67.2%	20.6%	4.6%	0.4%	0.2%	0.2%	0.4%	6.3%	0.0%
	PM Peak	EL	20.7%	43.6%	14.1%	16.8%	0.8%	3.7%	0.1%	0.0%	0.1%
		GP	86.8%	7.5%	2.4%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Average EL		19.9%	45.1%	14.1%	15.6%	1.1%	3.5%	0.5%	0.0%	0.1%
	Average GP		80.3%	11.6%	2.6%	0.7%	0.1%	0.3%	0.2%	4.0%	0.2%
255	AM Peak	EL	20.0%	56.4%	9.1%	5.5%	1.8%	7.3%	0.0%	0.0%	0.0%
		GP	79.8%	10.2%	3.2%	1.0%	0.0%	0.7%	0.2%	4.9%	0.0%
	Off-Peak	EL	6.9%	70.1%	19.5%	1.1%	0.0%	1.1%	1.1%	0.0%	0.0%
		GP	67.2%	20.1%	5.3%	0.9%	0.0%	0.6%	0.0%	5.9%	0.0%
	PM Peak	EL	20.9%	50.1%	8.1%	17.4%	1.2%	1.7%	0.0%	0.0%	0.6%
		GP	83.6%	10.0%	1.8%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Average EL		18.3%	54.4%	10.3%	13.1%	1.0%	2.3%	0.2%	0.0%	0.4%
	Average GP		77.6%	12.9%	3.3%	0.9%	0.3%	0.5%	0.1%	4.4%	0.0%
260	AM Peak	EL	17.2%	55.2%	19.0%	3.4%	0.0%	3.4%	1.7%	0.0%	0.0%
		GP	79.6%	10.6%	2.4%	0.9%	0.0%	0.6%	0.0%	5.8%	0.0%
	Off-Peak	EL	14.6%	68.3%	12.2%	0.0%	2.4%	2.4%	0.0%	0.0%	0.0%
		GP	67.2%	16.8%	4.2%	0.8%	0.0%	0.0%	0.0%	10.9%	0.0%
	PM Peak	EL	19.0%	58.5%	7.0%	14.8%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.1%	10.1%	1.9%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Average EL		17.8%	59.3%	10.8%	9.5%	0.4%	1.7%	0.4%	0.0%	0.0%
	Average GP		78.9%	11.7%	2.6%	0.7%	0.0%	0.3%	0.0%	5.8%	0.0%
265	AM Peak	EL	3.3%	64.8%	24.2%	3.3%	1.1%	2.2%	1.1%	0.0%	0.0%
		GP	76.8%	12.2%	4.4%	0.9%	0.5%	0.7%	0.0%	4.4%	0.0%
	Off-Peak	EL	10.3%	72.4%	13.8%	3.4%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	63.8%	20.9%	5.6%	0.0%	0.5%	0.0%	0.0%	9.2%	0.0%
	PM Peak	EL	11.1%	56.4%	26.5%	1.7%	0.0%	4.3%	0.0%	0.0%	0.0%
		GP	74.3%	18.2%	2.9%	0.9%	0.0%	0.7%	0.0%	2.9%	0.1%
	Average EL		8.0%	61.6%	24.1%	2.5%	0.4%	3.0%	0.4%	0.0%	0.0%
	Average GP		73.6%	16.8%	3.8%	0.8%	0.2%	0.6%	0.0%	4.3%	0.1%
270	AM Peak	EL	13.3%	70.0%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	77.5%	10.6%	0.6%	1.3%	0.0%	1.9%	0.0%	8.1%	0.0%
	Off-Peak	EL	10.0%	45.0%	35.0%	0.0%	5.0%	5.0%	0.0%	0.0%	0.0%
		GP	60.3%	25.5%	5.0%	0.7%	0.0%	0.0%	2.1%	6.4%	0.0%
	PM Peak	EL	5.4%	64.9%	24.3%	2.7%	1.4%	1.4%	0.0%	0.0%	0.0%
		GP	73.9%	16.8%	4.8%	0.4%	0.0%	0.6%	0.3%	3.1%	0.1%
	Average EL		8.1%	62.9%	24.2%	1.6%	1.6%	1.6%	0.0%	0.0%	0.0%
	Average GP		72.6%	17.0%	4.2%	0.6%	0.0%	0.7%	0.5%	4.4%	0.1%

Table C.3 Vehicle Percentage by Type by Zone, Time and Lane (NB)

	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
NB	AM Peak	EL	21.5%	39.8%	13.7%	17.6%	2.4%	4.7%	0.0%	0.0%	0.2%
		GP	86.1%	7.2%	1.4%	1.1%	0.2%	0.4%	0.1%	3.4%	0.2%
	Off-Peak	EL	7.4%	61.9%	23.4%	3.5%	1.4%	1.9%	0.3%	0.0%	0.3%
		GP	67.9%	20.0%	5.2%	0.4%	0.1%	0.5%	0.1%	5.8%	0.1%
	PM Peak	EL	11.3%	59.1%	19.2%	4.2%	1.7%	4.2%	0.3%	0.0%	0.0%
		GP	73.1%	17.1%	5.3%	0.3%	0.2%	0.9%	0.2%	2.7%	0.2%
	Total EL		15.0%	51.1%	17.7%	10.0%	1.9%	4.0%	0.2%	0.0%	0.2%
	Total GP		76.0%	14.6%	4.0%	0.6%	0.1%	0.6%	0.1%	3.9%	0.2%

Table C.4 Vehicle Percentage by Type by Zone, Time and Lane (SB)

	Time	Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB	AM Peak	EL	15.2%	56.2%	15.5%	7.1%	1.0%	4.0%	1.0%	0.0%	0.0%
		GP	80.6%	10.0%	2.5%	1.0%	0.2%	0.6%	0.1%	4.8%	0.2%
	Off-Peak	EL	8.8%	66.0%	19.5%	1.1%	1.9%	1.1%	1.5%	0.0%	0.0%
		GP	65.9%	20.7%	5.0%	0.6%	0.2%	0.2%	0.4%	7.1%	0.0%
	PM Peak	EL	19.1%	48.7%	13.5%	14.8%	0.8%	2.9%	0.1%	0.0%	0.2%
		GP	79.0%	13.8%	3.1%	0.7%	0.1%	0.5%	0.1%	2.7%	0.1%
	Total EL		17.2%	52.1%	14.6%	11.9%	0.9%	2.8%	0.4%	0.0%	0.1%
	Total GP		76.6%	14.1%	3.3%	0.7%	0.1%	0.5%	0.2%	4.4%	0.1%

APPENDIX D: EXPRESS PASS DATA ANALYSIS RESULTS

Table D.1 Express Pass Vehicle Occupancy Count by Zone, Time, and Lane (NB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
130	AM Peak	EL	3	0	0
		GP	0	0	0
	Off-Peak	EL	1	0	0
		GP	0	1	0
	PM Peak	EL	4	0	0
		GP	0	0	0
	Total EL		8	0	0
	Total GP		0	1	0
135	AM Peak	EL	11	0	0
		GP	2	1	0
	Off-Peak	EL	0	0	0
		GP	0	0	0
	PM Peak	EL	3	0	0
		GP	4	0	1
	Total EL		14	0	0
	Total GP		6	1	1
140	AM Peak	EL	16	0	0
		GP	3	0	0
	Off-Peak	EL	2	0	0
		GP	3	0	0
	PM Peak	EL	1	2	0
		GP	0	0	0
	Total EL		19	2	0
	Total GP		6	0	0
145	AM Peak	EL	57	1	0
		GP	6	0	0
	Off-Peak	EL	5	1	1
		GP	2	0	0
	PM Peak	EL	4	2	0
		GP	0	0	0
	Total EL		66	4	1
	Total GP		8	0	0
150	AM Peak	EL	52	1	0
		GP	9	0	0
	Off-Peak	EL	3	0	0
		GP	0	0	0
	PM Peak	EL	10	1	0
		GP	1	0	0
	Total EL		65	2	0
	Total GP		10	0	0

Table D.2 Express Pass Vehicle Occupancy Count by Zone, Time, and Lane (SB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
250	AM Peak	EL	12	1	0
		GP	5	0	0
	Off-Peak	EL	0	1	0
		GP	1	1	0
	PM Peak	EL	123	9	0
		GP	2	1	0
	Total EL		135	11	0
	Total GP		8	2	0
255	AM Peak	EL	3	0	0
		GP	3	1	0
	Off-Peak	EL	1	0	0
		GP	3	0	0
	PM Peak	EL	60	0	0
		GP	3	1	0
	Total EL		64	0	0
	Total GP		9	2	0
260	AM Peak	EL	2	0	0
		GP	2	1	0
	Off-Peak	EL	0	0	0
		GP	1	0	0
	PM Peak	EL	21	0	0
		GP	0	0	0
	Total EL		23	0	0
	Total GP		3	1	0
265	AM Peak	EL	2	1	0
		GP	4	0	0
	Off-Peak	EL	1	0	0
		GP	0	0	0
	PM Peak	EL	2	0	0
		GP	6	1	0
	Total EL		5	1	0
	Total GP		10	1	0
270	AM Peak	EL	0	0	0
		GP	1	1	0
	Off-Peak	EL	0	0	0
		GP	1	0	0
	PM Peak	EL	2	0	0
		GP	3	0	0
	Total EL		2	0	0
	Total GP		5	1	0

Table D.3 Express Pass Vehicle Occupancy by Count Summary (NB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
NB	AM Peak	EL	139	2	0
		GP	20	1	0
	Off-Peak	EL	11	1	1
		GP	5	1	0
	PM Peak	EL	22	5	0
		GP	5	0	1
	Total EL		172	8	1
	Total GP		30	2	1

Table D.4 Express Pass Vehicle Occupancy by Count Summary (SB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
SB	AM Peak	EL	19	2	0
		GP	15	3	0
	Off-Peak	EL	2	1	0
		GP	6	1	0
	PM Peak	EL	208	9	0
		GP	14	3	0
	Total EL		229	12	0
	Total GP		35	7	0

Table D.5 Express Pass Vehicle Occupancy Percentage by Zone, Time, and Lane (NB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
130	AM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	100.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		0.0%	100.0%	0.0%
135	AM Peak	EL	100.0%	0.0%	0.0%
		GP	66.7%	33.3%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	80.0%	0.0%	20.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		75.0%	12.5%	12.5%
140	AM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	33.3%	66.7%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		90.5%	9.5%	0.0%
	Total GP		100.0%	0.0%	0.0%
145	AM Peak	EL	98.3%	1.7%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	71.4%	14.3%	14.3%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	66.7%	33.3%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		93.0%	5.6%	1.4%
	Total GP		100.0%	0.0%	0.0%
150	AM Peak	EL	98.1%	1.9%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	90.9%	9.1%	0.0%
		GP	100.0%	0.0%	0.0%
	Total EL		97.0%	3.0%	0.0%
	Total GP		100.0%	0.0%	0.0%

Table D.6 Express Pass Vehicle Occupancy Percentage by Zone, Time, and Lane (SB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
250	AM Peak	EL	92.3%	7.7%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	0.0%	100.0%	0.0%
		GP	50.0%	50.0%	0.0%
	PM Peak	EL	93.2%	6.8%	0.0%
		GP	66.7%	33.3%	0.0%
	Total EL		92.5%	7.5%	0.0%
	Total GP		80.0%	20.0%	0.0%
255	AM Peak	EL	100.0%	0.0%	0.0%
		GP	75.0%	25.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	75.0%	25.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		81.8%	18.2%	0.0%
260	AM Peak	EL	100.0%	0.0%	0.0%
		GP	66.7%	33.3%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		75.0%	25.0%	0.0%
265	AM Peak	EL	66.7%	33.3%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	85.7%	14.3%	0.0%
	Total EL		83.3%	16.7%	0.0%
	Total GP		90.9%	9.1%	0.0%
270	AM Peak	EL	0.0%	0.0%	0.0%
		GP	50.0%	50.0%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		83.3%	16.7%	0.0%

Table D.7 Express Pass Vehicles Occupancy Percentage Summary (NB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
NB	AM Peak	EL	98.6%	1.4%	0.0%
		GP	95.2%	4.8%	0.0%
	Off-Peak	EL	84.6%	7.7%	7.7%
		GP	83.3%	16.7%	0.0%
	PM Peak	EL	81.5%	18.5%	0.0%
		GP	83.3%	0.0%	16.7%
	Total EL		95.0%	4.4%	0.6%
	Total GP		90.9%	6.1%	3.0%

Table D.8 Express Pass Vehicles Occupancy Percentage Summary (SB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
SB	AM Peak	EL	90.5%	9.5%	0.0%
		GP	83.3%	16.7%	0.0%
	Off-Peak	EL	66.7%	33.3%	0.0%
		GP	85.7%	14.3%	0.0%
	PM Peak	EL	95.9%	4.1%	0.0%
		GP	82.4%	17.6%	0.0%
	Total EL		95.0%	5.0%	0.0%
	Total GP		83.3%	16.7%	0.0%

APPENDIX E: "C" DECAL DATA ANALYSIS RESULTS

Table E.1 "C" Decal Vehicle Occupancy Count by Zone, Time, and Lane (NB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
130	AM Peak	EL	3	0	0
		GP	0	0	0
	Off-Peak	EL	0	0	0
		GP	0	0	0
	PM Peak	EL	2	0	0
		GP	0	0	0
	Total EL		5	0	0
	Total GP		0	0	0
135	AM Peak	EL	3	0	0
		GP	0	0	0
	Off-Peak	EL	1	0	0
		GP	0	0	0
	PM Peak	EL	2	2	0
		GP	2	0	1
	Total EL		6	2	0
	Total GP		2	0	1
140	AM Peak	EL	4	0	0
		GP	0	0	0
	Off-Peak	EL	0	0	0
		GP	0	0	0
	PM Peak	EL	0	0	0
		GP	0	0	0
	Total EL		4	0	0
	Total GP		0	0	0
145	AM Peak	EL	5	0	0
		GP	1	0	0
	Off-Peak	EL	1	0	0
		GP	1	0	0
	PM Peak	EL	3	0	1
		GP	0	1	0
	Total EL		9	0	1
	Total GP		2	1	0
150	AM Peak	EL	4	0	0
		GP	2	0	0
	Off-Peak	EL	3	0	0
		GP	0	0	0
	PM Peak	EL	1	0	0
		GP	0	0	0
	Total EL		8	0	0
	Total GP		2	0	0

Table E.2 "C" Decal Vehicle Occupancy Count by Zone, Time, and Lane (SB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
250	AM Peak	EL	1	0	0
		GP	1	0	0
	Off-Peak	EL	2	1	0
		GP	1	0	0
	PM Peak	EL	5	1	0
		GP	0	0	0
	Total EL		8	2	0
	Total GP		2	0	0
255	AM Peak	EL	1	0	0
		GP	0	0	0
	Off-Peak	EL	0	0	0
		GP	0	0	0
	PM Peak	EL	4	0	0
		GP	3	0	0
	Total EL		5	0	0
	Total GP		3	0	0
260	AM Peak	EL	0	0	0
		GP	0	0	0
	Off-Peak	EL	1	0	0
		GP	0	0	0
	PM Peak	EL	0	0	0
		GP	0	0	0
	Total EL		1	0	0
	Total GP		0	0	0
265	AM Peak	EL	0	1	0
		GP	2	0	0
	Off-Peak	EL	0	0	0
		GP	1	0	0
	PM Peak	EL	0	0	0
		GP	0	0	0
	Total EL		0	1	0
	Total GP		3	0	0
270	AM Peak	EL	0	0	0
		GP	0	0	0
	Off-Peak	EL	1	0	0
		GP	0	0	0
	PM Peak	EL	1	0	0
		GP	0	0	0
	Total EL		2	0	0
	Total GP		0	0	0

Table E.3 “C” Decal Vehicle Occupancy Summary (NB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
NB	AM Peak	EL	19	0	0
		GP	3	0	0
	Off-Peak	EL	5	0	0
		GP	1	0	0
	PM Peak	EL	8	2	1
		GP	2	1	1
	Total EL		32	2	1
	Total GP		6	1	1

Table E.4 “C” Decal Vehicle Occupancy Summary (SB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
SB	AM Peak	EL	2	1	0
		GP	3	0	0
	Off-Peak	EL	4	1	0
		GP	2	0	0
	PM Peak	EL	10	1	0
		GP	3	0	0
	Total EL		16	3	0
	Total GP		8	0	0

Table E.5 "C" Decal Vehicle Occupancy Percentage by Zone, Time, and Lane (NB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
130	AM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		0.0%	0.0%	0.0%
135	AM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	50.0%	50.0%	0.0%
		GP	66.7%	0.0%	33.3%
	Total EL		75.0%	25.0%	0.0%
	Total GP		66.7%	0.0%	33.3%
140	AM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		0.0%	0.0%	0.0%
145	AM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	75.0%	0.0%	25.0%
		GP	0.0%	100.0%	0.0%
	Total EL		90.0%	0.0%	10.0%
	Total GP		66.7%	33.3%	0.0%
150	AM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		100.0%	0.0%	0.0%

Table E.6 “C” Decal Vehicle Occupancy Percentage by Zone, Time, and Lane (SB)

Zone	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
250	AM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	66.7%	33.3%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	83.3%	16.7%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		80.0%	20.0%	0.0%
	Total GP		100.0%	0.0%	0.0%
255	AM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		100.0%	0.0%	0.0%
260	AM Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		0.0%	0.0%	0.0%
265	AM Peak	EL	0.0%	100.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	0.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		0.0%	100.0%	0.0%
	Total GP		100.0%	0.0%	0.0%
270	AM Peak	EL	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	PM Peak	EL	100.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%
	Total EL		100.0%	0.0%	0.0%
	Total GP		0.0%	0.0%	0.0%

Table E.7 "C" Decal Vehicle Occupancy Percentage Summary (NB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
NB	AM Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	100.0%	0.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	72.7%	18.2%	9.1%
		GP	50.0%	25.0%	25.0%
	Total EL		91.4%	5.7%	2.9%
	Total GP		75.0%	12.5%	12.5%

Table E.8 "C" Decal Vehicle Occupancy Percentage Summary (SB)

	Time	Lane	1 Passenger	2 Passengers	3+ Passengers
SB	AM Peak	EL	66.7%	33.3%	0.0%
		GP	100.0%	0.0%	0.0%
	Off-Peak	EL	80.0%	20.0%	0.0%
		GP	100.0%	0.0%	0.0%
	PM Peak	EL	90.9%	9.1%	0.0%
		GP	100.0%	0.0%	0.0%
	Total EL		84.2%	15.8%	0.0%
	Total GP		100.0%	0.0%	0.0%

APPENDIX F: SENSITIVITY ANALYSIS RESULTS: ZONE 145 AM PEAK

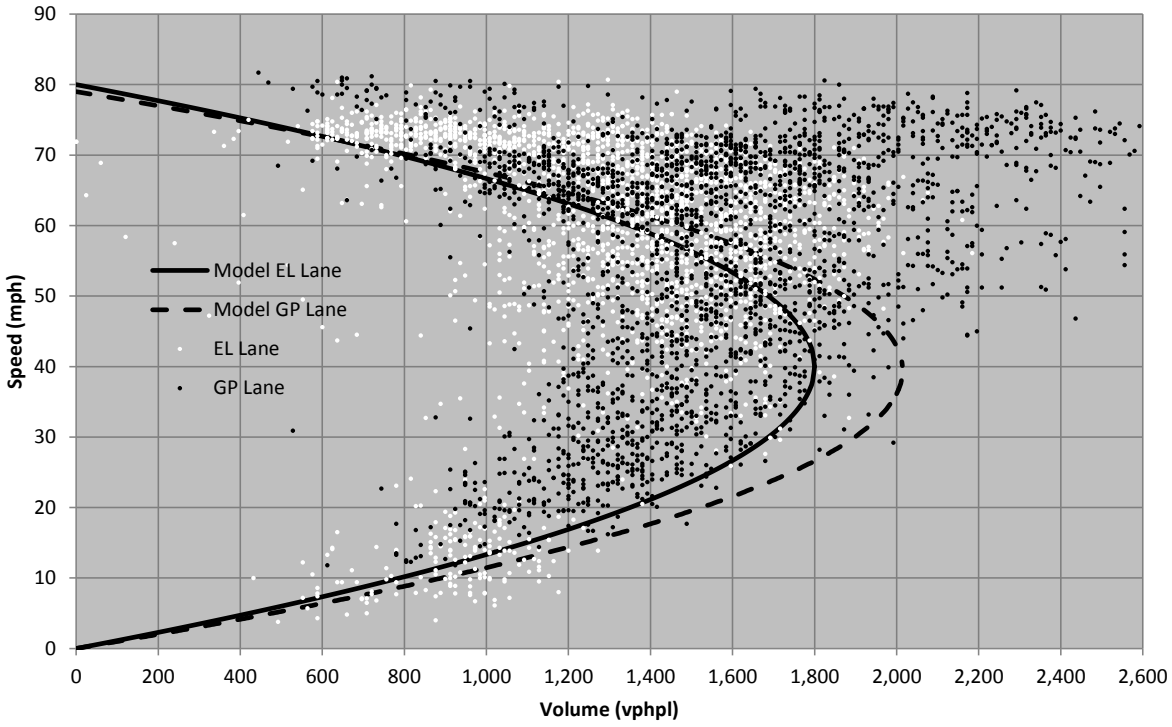

Figure F.1 Historical speed-volume data with calculated curves (Zone 145 AM Peak).

Table F.1 Education (-5% violators) for Zone 145 AM Peak Vehicle Percentage by Type

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-31	0	0	0	0	0	0	0	0
		GP	31	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	572	609	139	321	28	72	0	0	0
		GP	1,603	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	32.9%	35.0%	8.0%	18.4%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.9%	5.4%	0.5%	1.4%	0.3%	0.0%	0.0%	3.8%	0.7%
	Vehicle Percent Change by Type	EL	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.2 Education (-5% violators) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,741	47.2
	GP	1,824	51.6

Table F.3 Education (-10% violators) for Zone 145 AM Peak Vehicle Percentage by Type

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-61	0	0	0	0	0	0	0	0
		GP	61	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	542	609	139	321	28	72	0	0	0
		GP	1,633	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	31.7%	35.6%	8.1%	18.8%	1.6%	4.2%	0.0%	0.0%	0.0%
		GP	88.1%	5.3%	0.5%	1.4%	0.3%	0.0%	0.0%	3.7%	0.7%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.4 Education (-10% violators) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,711	48.9
	GP	1,854	50.6

Table F.5 Education (-15% violators) for Zone 145 AM Peak Vehicle Percentage by Type

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-91	0	0	0	0	0	0	0	0
		GP	91	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	512	609	139	321	28	72	0	0	0
		GP	1,663	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	30.5%	36.2%	8.3%	19.1%	1.7%	4.3%	0.0%	0.0%	0.0%
		GP	88.3%	5.3%	0.5%	1.4%	0.3%	0.0%	0.0%	3.7%	0.7%
	Vehicle Percent Change by Type	EL	-15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.6 Education (-15% violators) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,681	50.3
	GP	1,884	49.6

Table F.7 Enforcement (-10% violators) for Zone 145 AM Peak Vehicle Percentage by Type

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-61	0	0	0	0	0	0	0	0
		GP	61	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	542	609	139	321	28	72	0	0	0
		GP	1,633	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	31.7%	35.6%	8.1%	18.8%	1.6%	4.2%	0.0%	0.0%	0.0%
		GP	88.1%	5.3%	0.5%	1.4%	0.3%	0.0%	0.0%	3.7%	0.7%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.8 Enforcement (-10% violators) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,711	48.9
	GP	1,854	50.6

Table F.9 Education and Enforcement (-20% violators) for Zone 145 AM Peak Vehicle Percentage by Type

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-121	0	0	0	0	0	0	0	0
		GP	121	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	482	609	139	321	28	72	0	0	0
		GP	1,693	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	29.2%	36.9%	8.4%	19.4%	1.7%	4.4%	0.0%	0.0%	0.0%
		GP	88.5%	5.2%	0.5%	1.4%	0.3%	0.0%	0.0%	3.6%	0.7%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.10 Education and Enforcement (-20% violators) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,651	51.5
	GP	1,914	48.3

Table F.11 Toll Increase (-30% Express Pass) for Zone 145 AM Peak Vehicle Percentage by Type

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-97	0	0	0	0	0
		GP	0	0	0	97	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	603	609	139	224	28	72	0	0	0
		GP	1,572	99	9	123	5	0	0	69	13
	Vehicle Percentage by Type	EL	36.0%	36.4%	8.3%	13.4%	1.7%	4.3%	0.0%	0.0%	0.0%
		GP	83.2%	5.2%	0.5%	6.5%	0.3%	0.0%	0.0%	3.7%	0.7%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-30.2%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	373.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.12 Toll Increase (-30% Express Pass) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,675	50.5
	GP	1,890	49.3

Table F.13 "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Vehicle Percentage by Type

Increase C-Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	0	28	0	0	0	0
		GP	-28	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	603	609	139	321	56	72	0	0	0
		GP	1,544	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	33.5%	33.8%	7.7%	17.8%	3.1%	4.0%	0.0%	0.0%	0.0%
		GP	87.5%	5.6%	0.5%	1.5%	0.3%	0.0%	0.0%	3.9%	0.7%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.14 "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,800	40.0
	GP	1,765	53.4

Table F.15 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 145 AM Peak Vehicle Percentage by Type

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-121	0	0	-97	0	0	0	0	0
		GP	0	0	0	218	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	482	609	139	224	28	72	0	0	0
		GP	1,572	99	9	244	5	0	0	69	13
	Vehicle Percentage by Type	EL	31.0%	39.2%	8.9%	14.4%	1.8%	4.6%	0.0%	0.0%	0.0%
		GP	78.2%	4.9%	0.4%	12.1%	0.2%	0.0%	0.0%	3.4%	0.6%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.2%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	838.5%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.16 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,554	54.8
	GP	2,011	41.1

Table F.17 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-121	0	0	0	28	0	0	0	0
		GP	93	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	482	609	139	321	56	72	0	0	0
		GP	1,665	99	9	26	5	0	0	69	13
	Vehicle Percentage by Type	EL	28.7%	36.3%	8.3%	19.1%	3.3%	4.3%	0.0%	0.0%	0.0%
		GP	88.3%	5.2%	0.5%	1.4%	0.3%	0.0%	0.0%	3.7%	0.7%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.18 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,679	50.4
	GP	1,886	49.5

Table F.19 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Vehicle Percentage by Type

Increase Toll Rates and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-97	28	0	0	0	0
		GP	-28	0	0	97	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	603	609	139	224	56	72	0	0	0
		GP	1,544	99	9	123	5	0	0	69	13
	Vehicle Percentage by Type	EL	35.4%	35.8%	8.2%	13.2%	3.3%	4.2%	0.0%	0.0%	0.0%
		GP	82.9%	5.3%	0.5%	6.6%	0.3%	0.0%	0.0%	3.7%	0.7%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-30.2%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-1.8%	0.0%	0.0%	373.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.20 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,703	49.3
	GP	1,862	50.4

Table F.21 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Vehicle Percentage by Type

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	34.1%	34.4%	7.8%	18.1%	1.6%	4.1%	0.0%	0.0%	0.0%
		GP	87.8%	5.5%	0.5%	1.4%	0.2%	0.0%	0.0%	3.8%	0.7%
	Number of Vehicles by Type	EL	603	609	139	321	28	72	0	0	0
		GP	1,572	99	9	26	5	0	0	69	13
Estimated Changes	Number of Vehicles Displaced	EL	-121	0	0	-97	28	0	0	0	0
		GP	93	0	0	97	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	482	609	139	224	56	72	0	0	0
		GP	1,665	99	9	123	5	0	0	69	13
	Vehicle Percentage by Type	EL	30.5%	38.5%	8.8%	14.2%	3.5%	4.6%	0.0%	0.0%	0.0%
		GP	84.0%	5.0%	0.5%	6.2%	0.3%	0.0%	0.0%	3.5%	0.7%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.2%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.9%	0.0%	0.0%	373.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Table F.22 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 AM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,770	45.2
	GP	1,790	52.7
Performance After Change Implemented	EL	1,582	53.9
	GP	1,983	44.4

APPENDIX G: SENSITIVITY ANALYSIS RESULTS: ZONE 140 PM PEAK

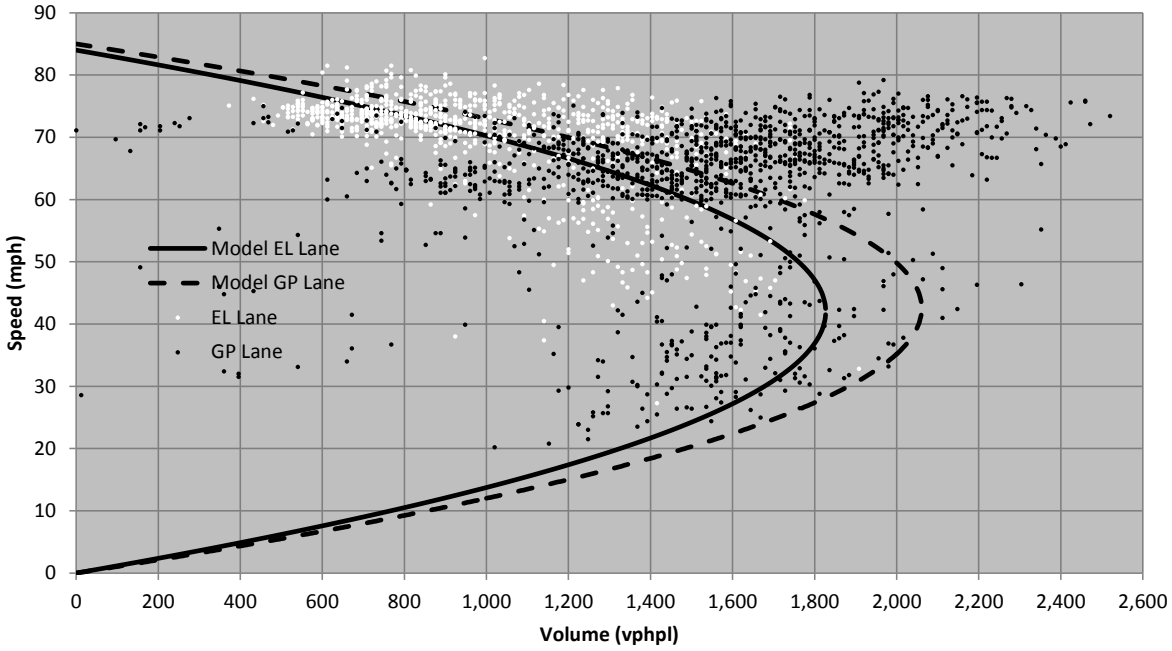

Figure G.1 Historical speed-volume data with calculated curves (Zone 140 PM Peak).

Table G.1 Education (-5% violators) for Zone 140 PM Peak Vehicle Percentage by Type

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-11	0	0	0	0	0	0	0	0
		GP	11	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	194	1,195	222	52	0	86	18	0	0
		GP	1,579	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	11.0%	67.6%	12.6%	2.9%	0.0%	4.9%	1.0%	0.0%	0.0%
		GP	78.4%	13.8%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Vehicle Percent Change by Type	EL	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.2 Education (-5% violators) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,767	49.6
	GP	2,014	48.9

Table G.3 Education (-10% violators) for Zone 140 PM Peak Vehicle Percentage by Type

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-21	0	0	0	0	0	0	0	0
		GP	21	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	184	1,195	222	52	0	86	18	0	0
		GP	1,589	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	10.5%	68.0%	12.6%	3.0%	0.0%	4.9%	1.0%	0.0%	0.0%
		GP	78.5%	13.7%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.4 Education (-10% violators) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,757	50.2
	GP	2,024	48.2

Table G.5 Education (-15% violators) for Zone 140 PM Peak Vehicle Percentage by Type

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-41	0	0	0	0	0	0	0	0
		GP	41	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	164	1,195	222	52	0	86	18	0	0
		GP	1,609	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	9.4%	68.8%	12.8%	3.0%	0.0%	5.0%	1.0%	0.0%	0.0%
		GP	78.7%	13.6%	3.6%	0.0%	0.0%	0.4%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.6 Education (-15% violators) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,737	51.3
	GP	2,044	46.4

Table G.7 Enforcement (-10% violators) for Zone 140 PM Peak Vehicle Percentage by Type

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-21	0	0	0	0	0	0	0	0
		GP	21	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	184	1,195	222	52	0	86	18	0	0
		GP	1,589	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	10.5%	68.0%	12.6%	3.0%	0.0%	4.9%	1.0%	0.0%	0.0%
		GP	78.5%	13.7%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.8 Enforcement (-10% violators) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,757	50.2
	GP	2,024	48.2

Table G.9 Education and Enforcement (-20% violators) for Zone 140 PM Peak Vehicle Percentage by Type

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-41	0	0	0	0	0	0	0	0
		GP	41	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	164	1,195	222	52	0	86	18	0	0
		GP	1,609	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	9.4%	68.8%	12.8%	3.0%	0.0%	5.0%	1.0%	0.0%	0.0%
		GP	78.7%	13.6%	3.6%	0.0%	0.0%	0.4%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.10 Education and Enforcement (-20% violators) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,737	51.3
	GP	2,044	46.4

Table G.11 Toll Increase (-30% Express Pass) for Zone 140 PM Peak Vehicle Percentage by Type

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-15	0	0	0	0	0
		GP	0	0	0	15	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	205	1,195	222	37	0	86	18	0	0
		GP	1,568	278	74	15	0	9	0	74	0
	Vehicle Percentage by Type	EL	11.6%	67.8%	12.6%	2.1%	0.0%	4.9%	1.0%	0.0%	0.0%
		GP	77.7%	13.8%	3.7%	0.7%	0.0%	0.4%	0.0%	3.7%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-28.8%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.12 Toll Increase (-30% Express Pass) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,763	49.9
	GP	2,018	48.7

Table G.13 "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Vehicle Percentage by Type

Increase C-Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	0	0	0	0	0	0
		GP	0	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	11.5%	67.2%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.3%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.14 "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,778	48.9
	GP	2,003	49.6

Table G.15 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 140 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-41	0	0	-15	0	0	0	0	0
		GP	0	0	0	56	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	164	1,195	222	37	0	86	18	0	0
		GP	1,568	278	74	56	0	9	0	74	0
	Vehicle Percentage by Type	EL	9.5%	69.4%	12.9%	2.1%	0.0%	5.0%	1.0%	0.0%	0.0%
		GP	76.2%	13.5%	3.6%	2.7%	0.0%	0.4%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-28.8%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.16 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,722	52.1
	GP	2,059	43.9

Table G.17 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-41	0	0	0	0	0	0	0	0
		GP	41	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	164	1,195	222	52	0	86	18	0	0
		GP	1,609	278	74	0	0	9	0	74	0
	Vehicle Percentage by Type	EL	9.4%	68.8%	12.8%	3.0%	0.0%	5.0%	1.0%	0.0%	0.0%
		GP	78.7%	13.6%	3.6%	0.0%	0.0%	0.4%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.18 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,737	51.3
	GP	2,044	46.4

Table G.19 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Vehicle Percentage by Type

Increased Toll Rate & C-Decal		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-15	0	0	0	0	0
		GP	0	0	0	15	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	205	1,195	222	37	0	86	18	0	0
		GP	1,568	278	74	15	0	9	0	74	0
	Vehicle Percentage by Type	EL	11.6%	67.8%	12.6%	2.1%	0.0%	4.9%	1.0%	0.0%	0.0%
		GP	77.7%	13.8%	3.7%	0.7%	0.0%	0.4%	0.0%	3.7%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-28.8%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.20 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,763	49.9
	GP	2,018	48.7

Table G.21 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Vehicle Percentage by Type

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	11.5%	67.3%	12.5%	2.9%	0.0%	4.8%	1.0%	0.0%	0.0%
		GP	78.4%	13.9%	3.7%	0.0%	0.0%	0.4%	0.0%	3.7%	0.0%
	Number of Vehicles by Type	EL	205	1,195	222	52	0	86	18	0	0
		GP	1,568	278	74	0	0	9	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-41	0	0	-16	0	0	0	0	0
		GP	43	0	0	14	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	164	1,195	222	36	0	86	18	0	0
		GP	1,611	278	74	14	0	9	0	74	0
	Vehicle Percentage by Type	EL	9.5%	69.4%	12.9%	2.1%	0.0%	5.0%	1.0%	0.0%	0.0%
		GP	78.2%	13.5%	3.6%	0.7%	0.0%	0.4%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table G.22 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 140 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,775	49.1
	GP	2,000	49.8
Performance After Change Implemented	EL	1,721	52.1
	GP	2,060	43.5

APPENDIX H: SENSITIVITY ANALYSIS RESULTS: ZONE 145 PM PEAK

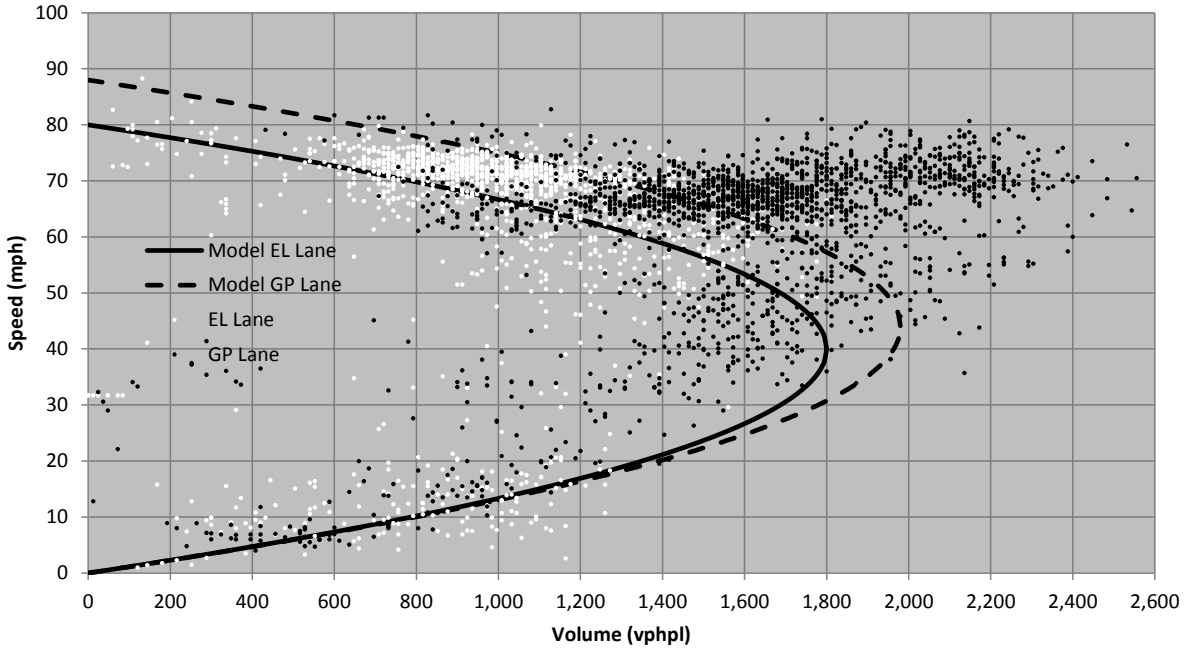

Figure H.1 Historical speed-volume data with calculated curves (Zone 145 PM Peak).

Table H.1 Education (-5% violators) for Zone 145 PM Peak Vehicle Percentage by Type

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	EL	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	EL	-14	0	0	0	0	0	0	0	0
		GP	14	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	247	1,105	167	63	42	115	0	0	0
		GP	1,646	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	EL	14.2%	63.5%	9.6%	3.6%	2.4%	6.6%	0.0%	0.0%	0.0%
		GP	77.8%	15.7%	0.9%	0.0%	0.3%	1.7%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	EL	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.2 Education (-5% violators) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	EL	1,739	47.4
	GP	2,116	51.4

Table H.3 Education (-10% violators) for Zone 145 PM Peak Vehicle Percentage by Type

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-27	0	0	0	0	0	0	0	0
		GP	27	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	234	1,105	167	63	42	115	0	0	0
		GP	1,659	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	HOT	13.6%	64.0%	9.7%	3.7%	2.4%	6.7%	0.0%	0.0%	0.0%
		GP	77.9%	15.6%	0.9%	0.0%	0.3%	1.7%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	HOT	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.4 Education (-10% violators) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,726	48.1
	GP	2,129	50.6

Table H.5 Education (-15% violators) for Zone 145 PM Peak Vehicle Percentage by Type

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-40	0	0	0	0	0	0	0	0
		GP	40	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	221	1,105	167	63	42	115	0	0	0
		GP	1,672	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	HOT	12.9%	64.5%	9.7%	3.7%	2.5%	6.7%	0.0%	0.0%	0.0%
		GP	78.1%	15.5%	0.9%	0.0%	0.3%	1.7%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	HOT	-15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.6 Education (-15% violators) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,713	48.8
	GP	2,142	49.7

Table H.7 Enforcement (-10% violators) for Zone 145 PM Peak Vehicle Percentage by Type

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-27	0	0	0	0	0	0	0	0
		GP	27	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	234	1,105	167	63	42	115	0	0	0
		GP	1,659	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	HOT	13.6%	64.0%	9.7%	3.7%	2.4%	6.7%	0.0%	0.0%	0.0%
		GP	77.9%	15.6%	0.9%	0.0%	0.3%	1.7%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	HOT	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.8 Enforcement (-10% violators) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,726	48.1
	GP	2,129	50.6

Table H.9 Education and Enforcement (-20% violators) for Zone 145 PM Peak Vehicle Percentage by Type

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-53	0	0	0	0	0	0	0	0
		GP	53	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	208	1,105	167	63	42	115	0	0	0
		GP	1,685	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	HOT	12.2%	65.0%	9.8%	3.7%	2.5%	6.8%	0.0%	0.0%	0.0%
		GP	78.2%	15.5%	0.9%	0.0%	0.3%	1.7%	0.0%	3.4%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.10 Education and Enforcement (-20% violators) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,700	49.4
	GP	2,155	48.5

Table H.11 Toll Increase (-30% Express Pass) for Zone 145 PM Peak Vehicle Percentage by Type

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	**Vehicle Percentage by Type**	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	**Number of Vehicles Displaced**	HOT	0	0	0	-19	0	0	0	0	0
		GP	0	0	0	19	0	0	0	0	0
After Changes Made	**Number of Vehicles by Type**	HOT	261	1,105	167	44	42	115	0	0	0
		GP	1,632	333	19	19	7	37	0	74	0
	Vehicle Percentage by Type	HOT	15.1%	63.7%	9.6%	2.5%	2.4%	6.6%	0.0%	0.0%	0.0%
		GP	76.9%	15.7%	0.9%	0.9%	0.3%	1.7%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	-30.2%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.12 Toll Increase (-30% Express Pass) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,734	47.7
	GP	2,121	51.1

Table H.13 "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Vehicle Percentage by Type

Increase C-Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	0	42	0	0	0	0
		GP	-42	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	261	1,105	167	63	84	115	0	0	0
		GP	1,590	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	HOT	14.5%	61.6%	9.3%	3.5%	4.7%	6.4%	0.0%	0.0%	0.0%
		GP	77.2%	16.2%	0.9%	0.0%	0.3%	1.8%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.14 "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,795	42.1
	GP	2,060	54.2

Table H.15 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 145 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-53	0	0	-19	0	0	0	0	0
		GP	53	0	0	19	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	208	1,105	167	44	42	115	0	0	0
		GP	1,685	333	19	19	7	37	0	74	0
	Vehicle Percentage by Type	HOT	12.4%	65.7%	9.9%	2.6%	2.5%	6.8%	0.0%	0.0%	0.0%
		GP	77.5%	15.3%	0.9%	0.9%	0.3%	1.7%	0.0%	3.4%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	-30.2%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.16 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,681	50.3
	GP	2,174	45.9

Table H.17 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-53	0	0	0	42	0	0	0	0
		GP	11	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	208	1,105	167	63	84	115	0	0	0
		GP	1,643	333	19	0	7	37	0	74	0
	Vehicle Percentage by Type	HOT	11.9%	63.4%	9.6%	3.6%	4.8%	6.6%	0.0%	0.0%	0.0%
		GP	77.8%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.18 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,742	47.2
	GP	2,113	51.6

Table H.19 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Vehicle Percentage by Type

Increase Toll Rates and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	-19	42	0	0	0	0
		GP	-42	0	0	19	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	261	1,105	167	44	84	115	0	0	0
		GP	1,590	333	19	19	7	37	0	74	0
	Vehicle Percentage by Type	HOT	14.7%	62.2%	9.4%	2.5%	4.7%	6.5%	0.0%	0.0%	0.0%
		GP	76.5%	16.0%	0.9%	0.9%	0.3%	1.8%	0.0%	3.6%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	-30.2%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.20 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,776	44.6
	GP	2,079	53.4

Table H.21 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Vehicle Percentage by Type

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	HOT	14.9%	63.1%	9.5%	3.6%	2.4%	6.5%	0.0%	0.0%	0.0%
		GP	77.7%	15.8%	0.9%	0.0%	0.3%	1.8%	0.0%	3.5%	0.0%
	Number of Vehicles by Type	HOT	261	1,105	167	63	42	115	0	0	0
		GP	1,632	333	19	0	7	37	0	74	0
Estimated Changes	Number of Vehicles Displaced	HOT	-53	0	0	-19	42	0	0	0	0
		GP	11	0	0	19	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	HOT	208	1,105	167	44	84	115	0	0	0
		GP	1,643	333	19	19	7	37	0	74	0
	Vehicle Percentage by Type	HOT	12.1%	64.1%	9.7%	2.6%	4.9%	6.7%	0.0%	0.0%	0.0%
		GP	77.1%	15.6%	0.9%	0.9%	0.3%	1.7%	0.0%	3.5%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	-30.2%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table H.22 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 145 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,750	46.7
	GP	2,100	52.3
Performance After Change Implemented	HOT	1,723	48.3
	GP	2,132	50.4

APPENDIX I: SENSITIVITY ANALYSIS RESULTS: ZONE 250 PM PEAK

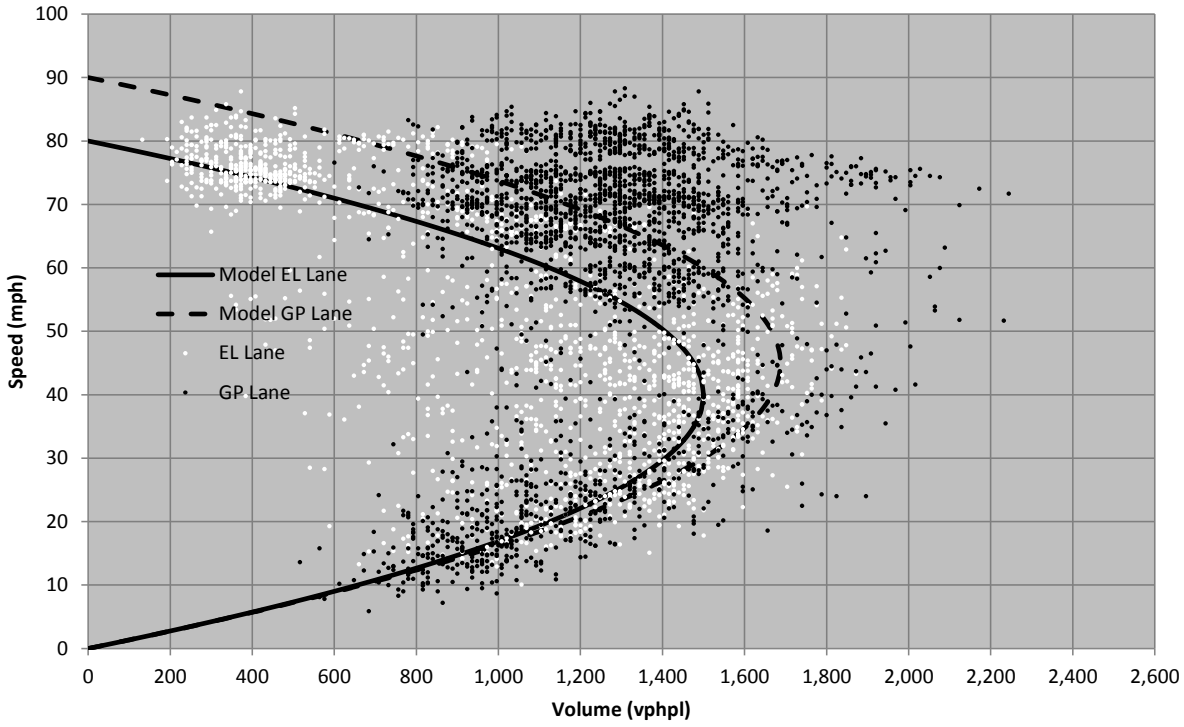

Figure I.1 Historical speed-volume data with calculated curves (Zone 250 PM Peak).

Table I.1 Education (-5% violators) for Zone 250 PM Peak Vehicle Percentage by Type

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-16	0	0	0	0	0	0	0	0
		GP	16	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	304	672	153	259	12	57	2	0	2
		GP	1,350	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	20.8%	46.0%	10.5%	17.7%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.4%	7.5%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Vehicle Percent Change by Type	EL	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.2 Education (-5% violators) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,461	46.4
	GP	1,545	58.1

Table I.3 Education (-10% violators) for Zone 250 PM Peak Vehicle Percentage by Type

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-32	0	0	0	0	0	0	0	0
		GP	32	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	288	672	153	259	12	57	2	0	2
		GP	1,366	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	19.9%	46.5%	10.6%	17.9%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.4%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.4 Education (-10% violators) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,445	47.7
	GP	1,561	57.3

Table I.5 Education (-15% violators) for Zone 250 PM Peak Vehicle Percentage by Type

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-48	0	0	0	0	0	0	0	0
		GP	48	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	272	672	153	259	12	57	2	0	2
		GP	1,382	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	19.0%	47.0%	10.7%	18.1%	0.8%	4.0%	0.1%	0.0%	0.1%
		GP	87.6%	7.4%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Vehicle Percent Change by Type	EL	-15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.6 Education (-15% violators) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,429	48.7
	GP	1,577	56.5

Table I.7 Enforcement (-10% violators) for Zone 250 PM Peak Vehicle Percentage by Type

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-32	0	0	0	0	0	0	0	0
		GP	32	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	288	672	153	259	12	57	2	0	2
		GP	1,366	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	19.9%	46.5%	10.6%	17.9%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.4%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Vehicle Percent Change by Type	EL	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.8 Enforcement (-10% violators) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,445	47.7
	GP	1,561	57.3

Table I.9 Education and Enforcement (-20% violators) for Zone 250 PM Peak Vehicle Percentage by Type

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-64	0	0	0	0	0	0	0	0
		GP	64	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	256	672	153	259	12	57	2	0	2
		GP	1,398	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	18.1%	47.6%	10.8%	18.3%	0.8%	4.0%	0.1%	0.0%	0.1%
		GP	87.8%	7.3%	1.6%	0.6%	0.0%	0.6%	0.0%	2.1%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.10 Education and Enforcement (-20% violators) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,413	49.6
	GP	1,593	55.6

Table I.11 Toll Increase (-30% Express Pass) for Zone 250 PM Peak Vehicle Percentage by Type

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-77	0	0	0	0	0
		GP	0	0	0	77	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	320	672	153	182	12	57	2	0	2
		GP	1,334	116	25	87	0	10	0	34	0
	Vehicle Percentage by Type	EL	22.9%	48.0%	10.9%	13.0%	0.9%	4.1%	0.1%	0.0%	0.1%
		GP	83.1%	7.2%	1.6%	5.4%	0.0%	0.6%	0.0%	2.1%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-29.7%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	770.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.12 Toll Increase (-30% Express Pass) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,400	50.3
	GP	1,606	54.9

Table I.13 "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Vehicle Percentage by Type

Increase C-Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	0	12	0	0	0	0
		GP	-12	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	320	672	153	259	24	57	2	0	2
		GP	1,322	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	21.5%	45.1%	10.3%	17.4%	1.6%	3.8%	0.1%	0.0%	0.1%
		GP	87.1%	7.6%	1.6%	0.7%	0.0%	0.7%	0.0%	2.2%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.14 "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,489	43.4
	GP	1,517	59.3

Table I.15 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 250 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-64	0	0	-78	0	0	0	0	0
		GP	64	0	0	78	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	256	672	153	181	12	57	2	0	2
		GP	1,398	116	25	88	0	10	0	34	0
	Vehicle Percentage by Type	EL	19.2%	50.3%	11.5%	13.6%	0.9%	4.3%	0.1%	0.0%	0.1%
		GP	83.7%	6.9%	1.5%	5.3%	0.0%	0.6%	0.0%	2.0%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.1%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.8%	0.0%	0.0%	780.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.16 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,335	53.3
	GP	1,671	49.4

Table I.17 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-64	0	0	0	12	0	0	0	0
		GP	52	0	0	0	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	256	672	153	259	24	57	2	0	2
		GP	1,386	116	25	10	0	10	0	34	0
	Vehicle Percentage by Type	EL	18.0%	47.2%	10.7%	18.2%	1.7%	4.0%	0.1%	0.0%	0.1%
		GP	87.7%	7.3%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.18 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,425	48.9
	GP	1,581	56.3

Table I.19 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Vehicle Percentage by Type

Increase Toll Rates and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	0	0	0	-78	12	0	0	0	0
		GP	-12	0	0	78	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	320	672	153	181	24	57	2	0	2
		GP	1,322	116	25	88	0	10	0	34	0
	Vehicle Percentage by Type	EL	22.7%	47.6%	10.8%	12.8%	1.7%	4.0%	0.1%	0.0%	0.1%
		GP	82.9%	7.3%	1.6%	5.5%	0.0%	0.6%	0.0%	2.1%	0.0%
	Vehicle Percent Change by Type	EL	0.0%	0.0%	0.0%	-30.1%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-0.9%	0.0%	0.0%	780.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.20 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,411	49.7
	GP	1,595	55.5

Table I.21 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Vehicle Percentage by Type

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
Before Changes Made	Vehicle Percentage by Type	EL	21.6%	45.6%	10.4%	17.5%	0.8%	3.9%	0.1%	0.0%	0.1%
		GP	87.5%	7.6%	1.6%	0.6%	0.0%	0.6%	0.0%	2.2%	0.0%
	Number of Vehicles by Type	EL	320	672	153	259	12	57	2	0	2
		GP	1,334	116	25	10	0	10	0	34	0
Estimated Changes	Number of Vehicles Displaced	EL	-64	0	0	-78	12	0	0	0	0
		GP	52	0	0	78	0	0	0	0	0
After Changes Made	Number of Vehicles by Type	EL	256	672	153	181	24	57	2	0	2
		GP	1,386	116	25	88	0	10	0	34	0
	Vehicle Percentage by Type	EL	19.0%	49.9%	11.4%	13.4%	1.8%	4.2%	0.1%	0.0%	0.1%
		GP	83.5%	7.0%	1.5%	5.3%	0.0%	0.6%	0.0%	2.0%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.1%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.9%	0.0%	0.0%	780.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.22 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 250 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,475	45.2
	GP	1,525	59.0
Performance After Change Implemented	EL	1,347	52.8
	GP	1,659	50.8

APPENDIX J: SENSITIVITY ANALYSIS RESULTS: ZONE 255 PM PEAK

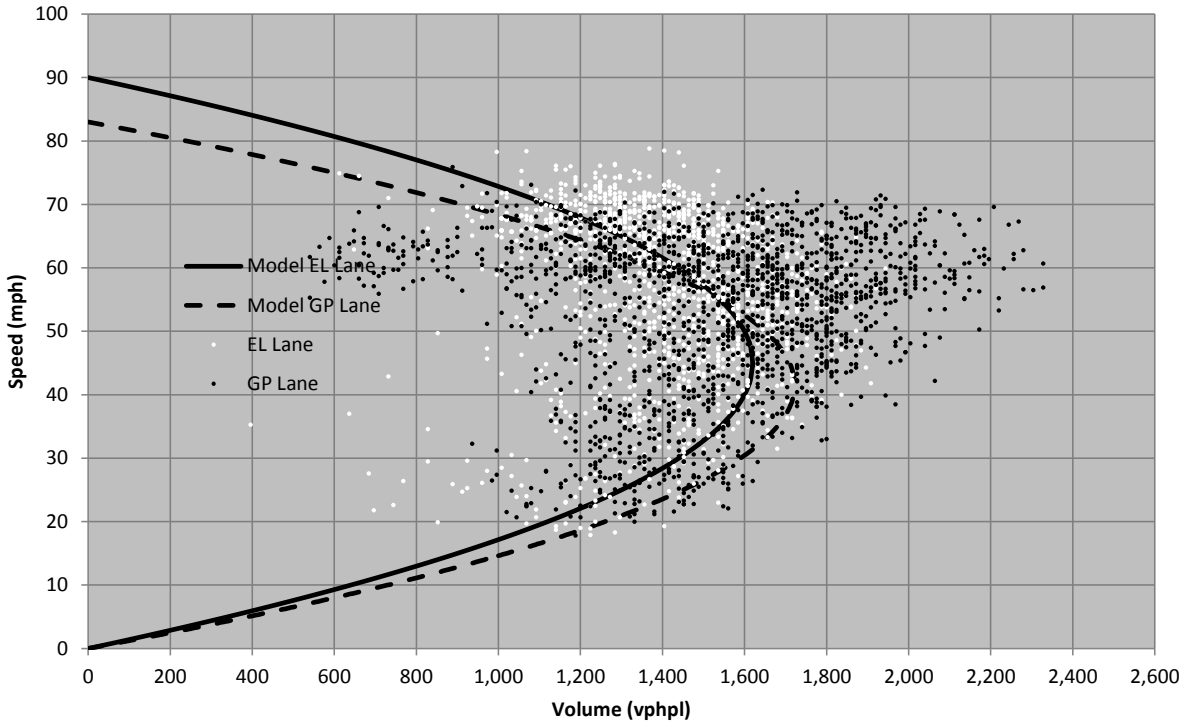

Figure J.1 Historical speed-volume data with calculated curves (Zone 255 PM Peak).

Table J.1 Education (-5% violators) for Zone 255 PM Peak Vehicle Percentage by Type

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-18	0	0	0	0	0	0	0	0
		GP	18	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	323	819	81	284	19	29	0	0	10
		GP	1,325	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	20.6%	52.3%	5.2%	18.1%	1.2%	1.9%	0.0%	0.0%	0.6%
		GP	83.8%	9.9%	1.6%	0.9%	0.7%	0.3%	0.0%	2.9%	0.0%
	Vehicle Percent Change by Type	HOT	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.2 Education (-5% violators) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,565	53.3
	GP	1,582	53.3

Table J.3 Education (-10% violators) for Zone 255 PM Peak Vehicle Percentage by Type

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-35	0	0	0	0	0	0	0	0
		GP	35	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	306	819	81	284	19	29	0	0	10
		GP	1,342	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	19.8%	52.9%	5.2%	18.3%	1.2%	1.9%	0.0%	0.0%	0.6%
		GP	83.9%	9.8%	1.6%	0.9%	0.7%	0.3%	0.0%	2.9%	0.0%
	Vehicle Percent Change by Type	HOT	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.4 Education (-10% violators) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,548	54.5
	GP	1,599	52.6

Table J.5 Education (-15% violators) for Zone 255 PM Peak Vehicle Percentage by Type

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-52	0	0	0	0	0	0	0	0
		GP	52	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	289	819	81	284	19	29	0	0	10
		GP	1,359	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	18.9%	53.5%	5.3%	18.5%	1.2%	1.9%	0.0%	0.0%	0.7%
		GP	84.1%	9.7%	1.5%	0.9%	0.7%	0.2%	0.0%	2.8%	0.0%
	Vehicle Percent Change by Type	HOT	-15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.6 Education (-15% violators) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,531	55.5
	GP	1,616	51.8

Table J.7 Enforcement (-10% violators) for Zone 255 PM Peak Vehicle Percentage by Type

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-35	0	0	0	0	0	0	0	0
		GP	35	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	306	819	81	284	19	29	0	0	10
		GP	1,342	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	19.8%	52.9%	5.2%	18.3%	1.2%	1.9%	0.0%	0.0%	0.6%
		GP	83.9%	9.8%	1.6%	0.9%	0.7%	0.3%	0.0%	2.9%	0.0%
	Vehicle Percent Change by Type	HOT	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.8 Enforcement (-10% violators) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,548	54.5
	GP	1,599	52.6

Table J.9 Education and Enforcement (-20% violators) for Zone 255 PM Peak Vehicle Percentage by Type

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-69	0	0	0	0	0	0	0	0
		GP	69	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	272	819	81	284	19	29	0	0	10
		GP	1,376	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	18.0%	54.1%	5.4%	18.8%	1.3%	1.9%	0.0%	0.0%	0.7%
		GP	84.3%	9.6%	1.5%	0.9%	0.7%	0.2%	0.0%	2.8%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.10 Education and Enforcement (-20% violators) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,514	56.5
	GP	1,633	50.9

Table J.11 Toll Increase (-30% Express Pass) for Zone 255 PM Peak Vehicle Percentage by Type

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	-86	0	0	0	0	0
		GP	0	0	0	86	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	341	819	81	198	19	29	0	0	10
		GP	1,307	157	25	100	11	4	0	46	0
	Vehicle Percentage by Type	HOT	22.8%	54.7%	5.4%	13.2%	1.3%	1.9%	0.0%	0.0%	0.7%
		GP	79.2%	9.5%	1.5%	6.1%	0.7%	0.2%	0.0%	2.8%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	-30.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	614.3%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.12 Toll Increase (-30% Express Pass) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,497	57.4
	GP	1,650	50.0

Table J.13 "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Vehicle Percentage by Type

Increase C-Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	0	19	0	0	0	0
		GP	-19	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	341	819	81	284	38	29	0	0	10
		GP	1,288	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	21.3%	51.1%	5.1%	17.7%	2.4%	1.8%	0.0%	0.0%	0.6%
		GP	83.4%	10.2%	1.6%	0.9%	0.7%	0.3%	0.0%	3.0%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	-1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.14 "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,602	49.7
	GP	1,545	54.8

Table J.15 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 255 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	EL	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	EL	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	EL	-69	0	0	-86	0	0	0	0	0
		GP	69	0	0	86	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	EL	272	819	81	198	19	29	0	0	10
		GP	1,376	157	25	100	11	4	0	46	0
	Vehicle Percentage by Type	EL	19.0%	57.4%	5.7%	13.9%	1.3%	2.0%	0.0%	0.0%	0.7%
		GP	80.0%	9.1%	1.5%	5.8%	0.6%	0.2%	0.0%	2.7%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	5.3%	0.0%	0.0%	614.3%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.16 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	EL	1,428	60.5
	GP	1,719	43.3

Table J.17 Education & Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-69	0	0	0	19	0	0	0	0
		GP	50	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	272	819	81	284	38	29	0	0	10
		GP	1,357	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	17.7%	53.4%	5.3%	18.5%	2.5%	1.9%	0.0%	0.0%	0.7%
		GP	84.1%	9.7%	1.5%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.18 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,533	55.4
	GP	1,614	51.9

Table J.19 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-69	0	0	0	19	0	0	0	0
		GP	50	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	272	819	81	284	38	29	0	0	10
		GP	1,357	157	25	14	11	4	0	46	0
	Vehicle Percentage by Type	HOT	17.7%	53.4%	5.3%	18.5%	2.5%	1.9%	0.0%	0.0%	0.7%
		GP	84.1%	9.7%	1.5%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.20 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,533	55.4
	GP	1,614	51.9

Table J.21 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Vehicle Percentage by Type

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	21.6%	51.8%	5.1%	18.0%	1.2%	1.8%	0.0%	0.0%	0.6%
		GP	83.7%	10.0%	1.6%	0.9%	0.7%	0.2%	0.0%	2.9%	0.0%
	Number of Vehicles by Type	HOT	341	819	81	284	19	29	0	0	10
		GP	1,307	157	25	14	11	4	0	46	0
Estimated Changes	Number of Vehicles Displaced	HOT	-69	0	0	-86	19	0	0	0	0
		GP	50	0	0	86	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	272	819	81	198	38	29	0	0	10
		GP	1,357	157	25	100	11	4	0	46	0
	Vehicle Percentage by Type	HOT	18.8%	56.6%	5.6%	13.7%	2.6%	2.0%	0.0%	0.0%	0.7%
		GP	79.8%	9.2%	1.5%	5.9%	0.6%	0.2%	0.0%	2.7%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	-30.3%	100.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.8%	0.0%	0.0%	614.3%	0.0%	0.0%	0.0%	0.0%	0.0%

Table J.22 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 255 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,580	52.1
	GP	1,560	54.2
Performance After Change Implemented	HOT	1,447	59.7
	GP	1,700	46.2

APPENDIX K: SENSITIVITY ANALYSIS RESULTS: ZONE 260 PM PEAK

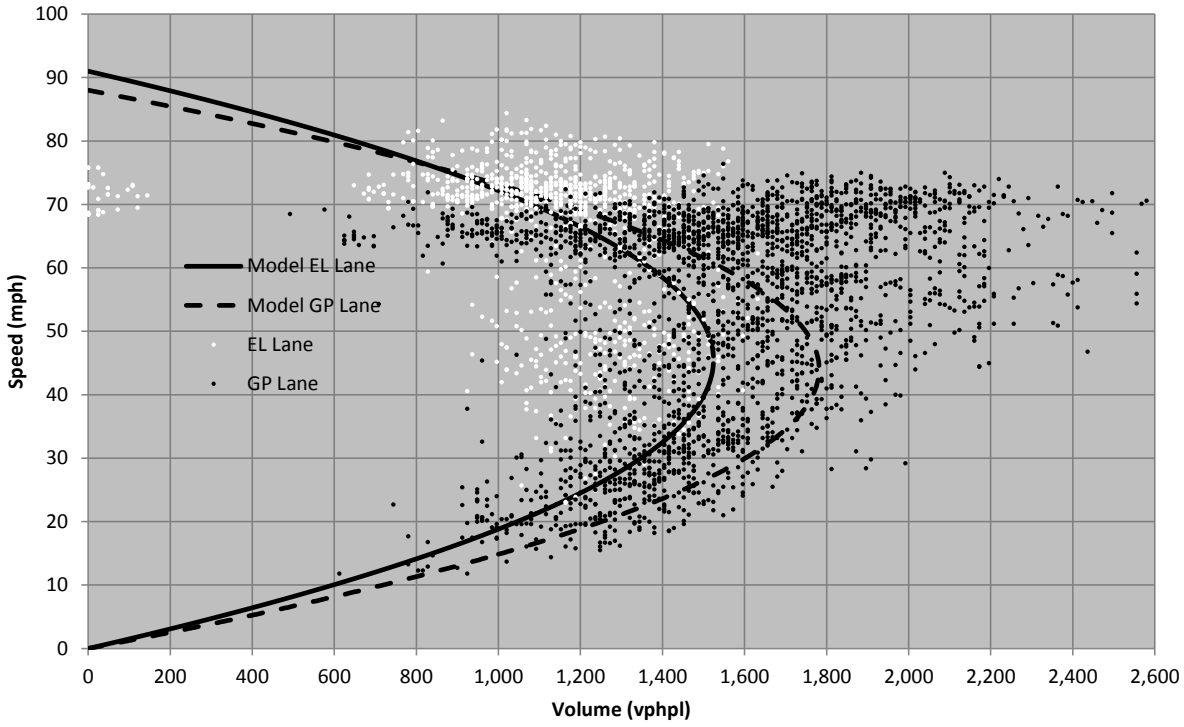

Figure K.1 Historical speed-volume data with calculated curves (Zone 260 PM Peak).

Table K.1 Education (-5% violators) for Zone 260 PM Peak Vehicle Percentage by Type

Education (5%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-14	0	0	0	0	0	0	0	0
		GP	14	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	266	860	83	218	0	11	0	0	0
		GP	1,400	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	18.5%	59.8%	5.8%	15.2%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	86.6%	10.1%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.2 Education (-5% violators) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,438	56.3
	GP	1,616	57.4

Table K.3 Education (-10% violators) for Zone 260 PM Peak Vehicle Percentage by Type

Education (10%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-28	0	0	0	0	0	0	0	0
		GP	28	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	252	860	83	218	0	11	0	0	0
		GP	1,414	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	17.7%	60.4%	5.8%	15.3%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	86.7%	10.1%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.4 Education (-10% violators) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,424	57.2
	GP	1,630	56.9

Table K.5 Education (-15% violators) for Zone 260 PM Peak Vehicle Percentage by Type

Education (15%)		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-42	0	0	0	0	0	0	0	0
		GP	42	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	238	860	83	218	0	11	0	0	0
		GP	1,428	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	16.9%	61.0%	5.9%	15.5%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	86.9%	10.0%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	-15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.6 Education (-15% violators) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,410	58.0
	GP	1,644	56.2

Table K.7 Enforcement (-10% violators) for Zone 260 PM Peak Vehicle Percentage by Type

Increased Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-28	0	0	0	0	0	0	0	0
		GP	28	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	252	860	83	218	0	11	0	0	0
		GP	1,414	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	17.7%	60.4%	5.8%	15.3%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	86.7%	10.1%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	-10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.8 Enforcement (-10% violators) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,424	57.2
	GP	1,630	56.9

Table K.9 Education and Enforcement (-20% violators) for Zone 260 PM Peak Vehicle Percentage by Type

Education & Enforcement		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-56	0	0	0	0	0	0	0	0
		GP	56	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	224	860	83	218	0	11	0	0	0
		GP	1,442	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	16.0%	61.6%	5.9%	15.6%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	87.0%	9.9%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.10 Education and Enforcement (-20% violators) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,396	58.7
	GP	1,658	55.6

Table K.11 Toll Increase (-30% Express Pass) for Zone 260 PM Peak Vehicle Percentage by Type

Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	-66	0	0	0	0	0
		GP	0	0	0	66	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	280	860	83	152	0	11	0	0	0
		GP	1,386	164	21	66	0	0	0	31	0
	Vehicle Percentage by Type	HOT	20.2%	62.0%	6.0%	11.0%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	83.1%	9.8%	1.3%	4.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	-30.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.12 Toll Increase (-30% Express Pass) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,386	59.2
	GP	1,668	55.1

Table K.13 "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Vehicle Percentage by Type

Increase C-Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	0	0	0	0	0	0
		GP	0	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	19.3%	59.2%	5.7%	15.0%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	86.5%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.14 "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,452	55.4
	GP	1,602	58.0

Table K.15 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 260 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased Toll Rate		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-56	0	0	-66	0	0	0	0	0
		GP	56	0	0	66	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	224	860	83	152	0	11	0	0	0
		GP	1,442	164	21	66	0	0	0	31	0
	Vehicle Percentage by Type	HOT	16.8%	64.7%	6.2%	11.4%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	83.6%	9.5%	1.2%	3.8%	0.0%	0.0%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	-30.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.16 Education and Enforcement (-20% violators) plus Increased Toll (-30% Express Pass) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,330	61.7
	GP	1,724	51.9

Table K.17 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Vehicle Percentage by Type

Education & Enforcement and Increased "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	-56	0	0	0	0	0	0	0	0
		GP	56	0	0	0	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	224	860	83	218	0	11	0	0	0
		GP	1,442	164	21	0	0	0	0	31	0
	Vehicle Percentage by Type	HOT	16.0%	61.6%	5.9%	15.6%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	87.0%	9.9%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	-20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.18 Education and Enforcement (-20% violators) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,396	58.7
	GP	1,658	55.6

Table K.19 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Vehicle Percentage by Type

Increase Toll Rates and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	HOT	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	HOT	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	HOT	0	0	0	-66	0	0	0	0	0
		GP	0	0	0	66	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	HOT	280	860	83	152	0	11	0	0	0
		GP	1,386	164	21	66	0	0	0	31	0
	Vehicle Percentage by Type	HOT	20.2%	62.0%	6.0%	11.0%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	83.1%	9.8%	1.3%	4.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Vehicle Percent Change by Type	HOT	0.0%	0.0%	0.0%	-30.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.20 Increased Toll (-30% Express Pass) plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	HOT	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	HOT	1,386	59.2
	GP	1,668	55.1

Table K.21 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Vehicle Percentage by Type

Education & Enforcement, Increase Toll Rate, and "C" Decal Permits		Lane	SOV	HOV 2	HOV 3+	Express Pass	C Decal	Motorcycle	Bus	Freight	Emergency
SB Before Changes Made	Vehicle Percentage by Type	EL	19.3%	59.3%	5.7%	15.0%	0.0%	0.7%	0.0%	0.0%	0.0%
		GP	86.6%	10.2%	1.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%
	Number of Vehicles by Type	EL	280	860	83	218	0	11	0	0	0
		GP	1,386	164	21	0	0	0	0	31	0
Estimated Changes	Number of Vehicles Displaced	EL	-56	0	0	-66	0	0	0	0	0
		GP	56	0	0	66	0	0	0	0	0
SB After Changes Made	Number of Vehicles by Type	EL	224	860	83	152	0	11	0	0	0
		GP	1,442	164	21	66	0	0	0	31	0
	Vehicle Percentage by Type	EL	16.8%	64.7%	6.2%	11.4%	0.0%	0.8%	0.0%	0.0%	0.0%
		GP	83.6%	9.5%	1.2%	3.8%	0.0%	0.0%	0.0%	1.8%	0.0%
	Vehicle Percent Change by Type	EL	-20.0%	0.0%	0.0%	-30.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		GP	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table K.22 Education and Enforcement (-20% violators), Increased Toll (-30% Express Pass), plus "C" Decal Permit Increase (+100% "C" Decal) for Zone 260 PM Peak Speed and Volume

	Lane	Volume (vphpl)	Speed (mph)
Performance Before Change Implemented	EL	1,450	55.5
	GP	1,600	58.1
Performance After Change Implemented	EL	1,330	61.7
	GP	1,724	51.9

APPENDIX L: I-15 EXPRESS LANE TRAVELER SURVEY

By: Mark Burris, David Florence, and Lisa Green

L.1 Acknowledgments

The research described in this appendix is the outcome of several research efforts examining psychological factors behind managed lane use. The initial work was performed under a grant from the University Transportation Center for Mobility which was sponsored by both the Texas Department of Transportation (TxDOT) and the United States Department of Transportation (USDOT). The research continued with support from an Eisenhower Fellowship from the USDOT for a student, Lisa Green. Another student, David Florence, was supported in the summer of 2014 by the Southwest University Transportation Center (SWUTC) which was funded by both TxDOT and the USDOT. Most recently, funds to focus on the analysis of Wasatch Front (in Northern Utah) survey respondents were through a contract from the Utah Department of Transportation (UDOT). We are grateful for the support of these many agencies.

The contents of this appendix reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of any of our sponsors or the Texas A&M Transportation Institute (TTI).

L.2 Executive Summary

Managed lanes or express lanes (ELs) are designed to offer congestion-free travel as an alternative to the general purpose (GP) lanes. Predicting the use of these ELs has proven difficult as many travelers use the lanes even when travel time savings and reliability gains are minimal to non-existent. Therefore, researchers have begun to examine the relationship between managed lane use and psychological characteristics of travelers. To examine this relationship, a survey was developed and administered to travelers in five areas with ELs. This report examines responses from one of those areas, the Wasatch Front in Northern Utah, with a focus on travelers' willingness to pay for EL use in the Wasatch Front area.

Wasatch Front survey respondents were generally on commute or work related trips for their most recent trip on I-15. Two thirds of them were using the ELs on that trip. Thus the

respondents were generally very familiar with the EL concept. Using standard logit modeling techniques these travelers were found to have a value of time of $24.49 per hour. Their toll-price elasticity of demand was -0.38. Both of these values are fairly typical of toll road and managed lane travelers. Therefore, it is reasonable to use these values when attempting to estimate the impact of a toll price change on the I-15 ELs.

L.3 Introduction

Managed lanes or express Lanes (ELs) have emerged as a useful tool in optimizing roadway usage. They are intended to offer congestion-free travel as an alternative to the general purpose (GP) lanes, which are often congested. The Federal Highway Administration (FHWA) defines managed lanes (another common term used for ELs) as "a limited number of lanes set aside within an expressway cross section where multiple operational strategies are utilized, and actively adjusted as needed, for the purpose of achieving pre-defined performance objectives" (FHWA 2004). Given this fairly broad definition, various techniques can be used in structuring and implementing ELs. ELs are typically kept congestion free by requiring travelers to pay a toll or meet a certain criteria (such as 3 or more occupants per vehicle or using transit). These tolls typically fluctuate with the time of day, or congestion level, depending on the demand for the lane (Burris et al. 2012a). Although ELs are a relatively new tool, many states already use ELs to ease congestion. With many other states planning on creating ELs, it is important to understand the usage of these lanes.

Recent analysis of EL use on the Katy Freeway in Texas showed that some travelers were paying a toll to use the ELs during off-peak hours, when the expected travel time savings are minimal or non-existent because of lack of congestion on the other lanes (Devarasetty et al. 2012). Figure L.1 summarizes the travel time savings from approximately 289,000 tolled Katy Freeway EL trips during April 2012. During this particular month just over 10% of those paying to use the ELs went slower on the ELs than they would have if they had chosen the GP lanes for the exact same trip at that exact same time. Similar findings were reported by Burris et al. (2012b) from an analysis of I-394 in Minnesota, where the median willingness to pay for travel time savings (TTS) for toll paying travelers was $166 per hour for the entire afternoon and

approximately 70% of paying EL travelers were paying for one minute or less of TTS (Burris et al. 2012b).

Devarasetty et al. (2012) conclude that travel time reliability should be included in EL related studies along with TTS. They also note that travelers use the ELs "simply for a mental habit of doing so, and stick with their chosen lanes even when the conditions vary" (Devarasetty et al. 2012). These findings suggest that psychological factors could play a role in EL use. Despite efforts made to understand the extent to which psychological traits can play a role in predicting EL use decisions, the extent to which the psychological traits impact traveler decisions remains unknown. Some ELs are becoming congested, including those in the Wasatch Front area of Northern Utah. This results in a need to deter some travelers from using the lanes – often through an increase in the toll rate (Malone 2014). Therefore, further investigation into the impact of psychological traits on traveler behavior in ELs is warranted to help predict the impact of a toll change on demand for EL travel.

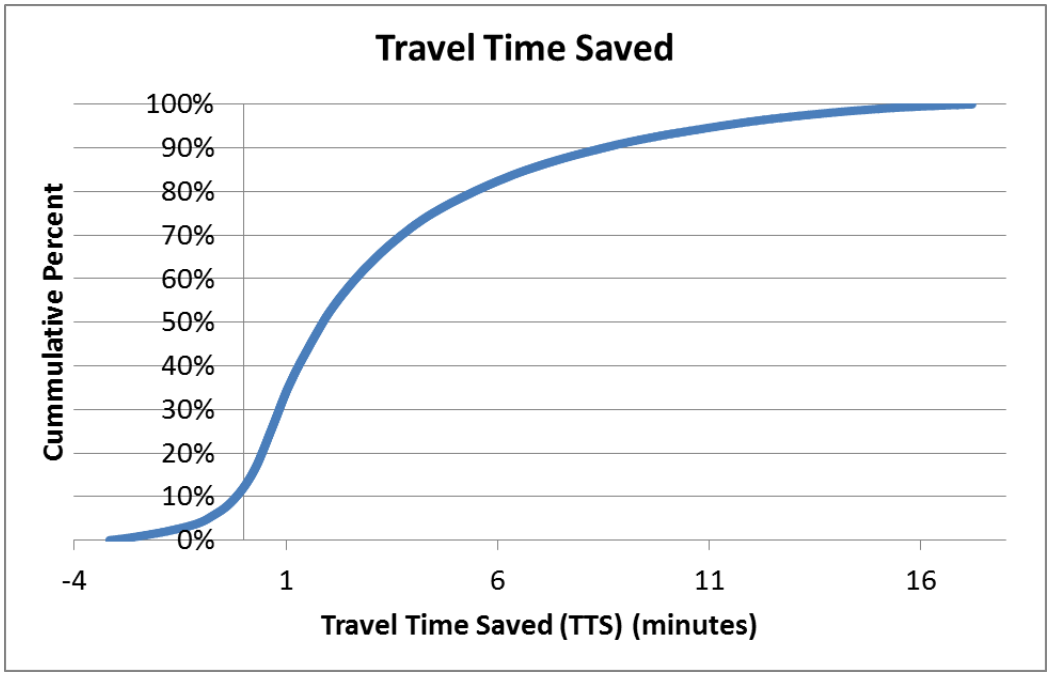

Figure L.1 Travel Time Savings for Katy Freeway EL Users in April 2012.

Burris et al. (2012a) performed preliminary research on the impact of psychological traits on EL use. This study used traditional psychological constructs and questions, and had some encouraging results. It led to a new 2014 survey where the psychological questions were

adjusted to be more transportation focused. This 2014 survey, its development, administration and results for the Northern Utah (Wasatch Front) area respondents is described in this appendix (note that "Salt Lake City" was used in the survey to represent the entire Wasatch Front area for the survey).

L.4 Study Locations

This research effort initially targeted eight highways spread across six different areas, as listed below. This report focuses on the results from one of those areas, the Wasatch Front in Northern Utah.

- SR 167 in Seattle, Washington
- I-15 along the Wasatch Front, Utah
- I-10 in Los Angeles, California
- I-110 in Los Angeles, California
- I-495 in the Capital Beltway in the Washington D.C. area
- I-394 in Minneapolis, Minnesota
- I-35W in Minneapolis, Minnesota
- I-85 in Atlanta, Georgia

In order to create an applicable survey for each city, the toll rate, high occupancy vehicle (HOV) requirements, and wording were altered, depending on the city the respondent states they travel in. The following sections provide a brief description of the ELs along the Wasatch Front and any adjustments made for the survey of those travelers.

I-15 along the Wasatch Front in Northern Utah, has the longest and least expensive ELs of all the corridors surveyed. These ELs cover a 62 mile stretch of roadway and are divided into 6 different zones of varying lengths (UDOT 2013). Figure L.2 is a map of the I-15 ELs in Northern Utah.

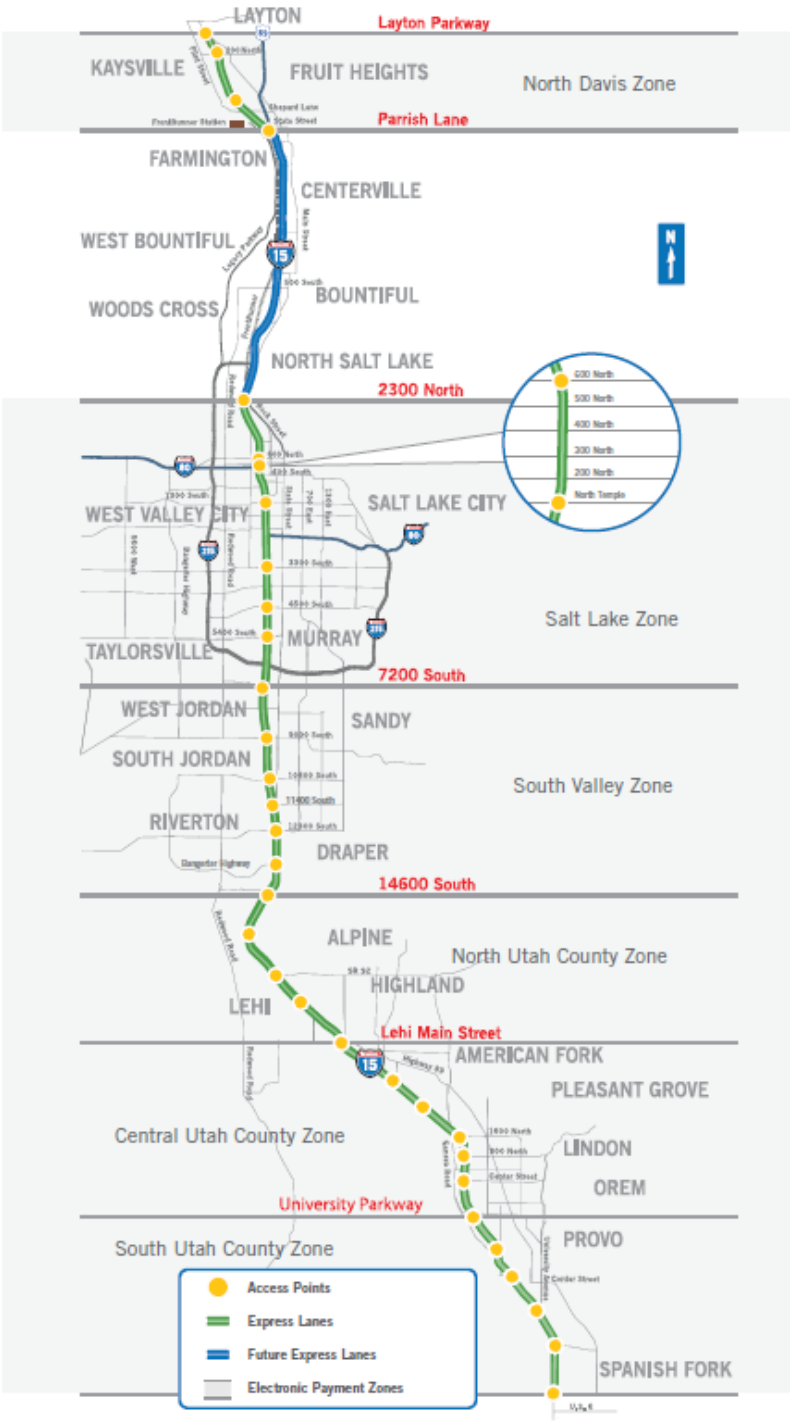

Figure L.2 Map of I-15 express lanes along the Wasatch Front, Utah (UDOT 2013).

As illustrated in the figure, the ELs in Northern Utah extend continuously from Spanish Fork (Utah County) in the south to North Salt Lake (Salt Lake County) in the north, and then after a short break pick up again from Farmington to Layton (Davis County). Travelers driving

alone are charged a toll on a zone-by-zone basis ranging from 25 cents to $1 per zone (UDOT 2013). Carpoolers (consisting of two or more persons per vehicle), buses, clean fuel ("C" decal) vehicles, and motorcycles are allowed to travel on the I-15 ELs free of charge. In order to travel in the I-15 ELs travelers need to purchase an *Express Pass*, which allows for electronic payment for the use of I-15 ELs. The *Express Pass* has a tab that travelers can pull to signify that they are riding as a carpool and should not be charged for the trip. Researchers noticed that tolls on I-15 along the Wasatch Front were significantly less per mile that those seen in the other cities. Even if a toll-paying traveler were to drive the entire length of the ELs, they would only be paying a maximum of $6. For this reason the tolls in the survey for the Wasatch Front survey respondents were reduced by one third (see methodology section).

L.5 Methodology

Stated preference (SP) questions reflecting the same designs and administration as those used by Burris et al. (2012a) were used for the survey. These questions were designed to represent a realistic travel scenario in the respondent's respective region in relation to their most recent trip on the EL corridor. This was accomplished by gathering data regarding the distance, toll rate, average speed, and the average TTS for each highway in the study. Since the toll and average speed vary according to the time of day, data were gathered for different times of day and the appropriate values were used according to the time of day the respondent stated they began their most recent trip on the EL corridor. Using these values, appropriate hypothetical scenarios regarding toll and travel time were generated via two different design methods: D_b-efficient design and adaptive random design. The N-Gene computer program was used in the creation the D_b-efficient design used for the SP questions. Both of these designs are discussed in the following subsections.

L.5.1 D_b-Efficient Design

The D_b-efficient design is a form of Bayesian efficient design. Efficiency in design means the reduction of asymptotic standard errors and covariance of the model parameters in order to increase the asymptotic *t*-ratios of the model estimates (Bliemer et al. 2008). This means that a lower number of respondents are required to produce statistically significant

parameter estimates. D_b-efficient designs are those that minimize the D_b-error (a measure of efficiency calculated as the determinate of the AVC matrix raised to the power of one over the number of parameters). D_b-efficient, or Bayesian efficient, designs are created by minimizing the D_b-error which can be calculated using Equation L.1 (Bliemer et al. 2008).

$$D_{\mathrm{b}}\text{error} = \int_{\tilde{\beta}} \det AVC\left(\tilde{\beta}|\boldsymbol{X}\right)^{1/K} \phi\left(\tilde{\beta}|\theta\right) d\tilde{\beta} \qquad \text{(L.1)}$$

where: $\boldsymbol{X}$ = matrix of attribute levels in design:

$\tilde{\beta}$ = vector of parameter priors

$\phi\left(\tilde{\beta}|\theta\right)$ = joint distribution of the assumed parameter priors

θ = corresponding parameters of the distribution

K = number of parameters in the model

The computation of the integral in Equation L.1 is complicated and cannot be solved analytically. The integral is approximated using several methods. In this study, Halton draws were used for simulating the distributions in the same manner described by Burris et al. (2012a). As stated before, this design was accomplished through the use of the N-Gene computer program which used 400 Halton draws to create an efficient design. In order to run properly, N-Gene needed prior estimates for the utility functions. The mean and standard deviation of the priors used for obtaining the D_b-efficient design and the exact levels of the attributes used for each model at different times of day are shown in Table L.1.

The speed and toll attributes gathered for Table L.1 were based on data regarding EL distance, average speed, and toll rates for the eight different highways targeted for this study. The three numbers for each provide a range for the travel speed and toll values shown in the survey. The survey software assigns speed (and thus travel time) and toll values to each SP question for each respondent staring with one of these numbers as a base and adjusting for subsequent SP questions. This process creates a huge variation in SP questions allowing for better estimation of lane choice models. These attributes were first set so that the tolls were higher to reflect the maximum range for the tolls in Washington, D.C. (Express Lanes 2014), Atlanta (GDOT 2012) and Los Angeles, California (Caltrans 2010). However, the tolls were unreasonably high for a single trip on the ELs, so the tolls were lowered to allow the survey to be

more reasonable for the targeted travelers. For certain cities, including on I-15 in Utah, the tolls were reduced further to reflect the actual tolls paid in that area.

Table L.1 Mean, Standard Deviation of Attribute Priors, and Attribute Levels for Different Times of Day

Attribute	Attribute Levels				Mean Value of Priors	Standard Deviation of Priors
	Mode	Time of Day				
		Peak Hours	Shoulder Hours	Off-Peak Hours		
Toll (cents/mile)	CP-EL	0	0	0	-0.12	0.1
	DA-EL	45,67.5,90	22.5,33.75,45	15,22.5,30		
	CP-GPL	0	0	0		
	DA-GPL	0	0	0		
Speed (mph)	CP-EL	55,60,65	55,60,65	60,65,70	-0.14*	0.64
	DA-EL	55,60,65	55,60,65	60,65,70		
	CP-GPL	25,35,45	30,40,50	35,45,55		
	DA-GPL	25,35,45	30,40,50	35,45,55		

Note: CP = carpool, DA = drive alone

**Prior is the coefficient of travel time from a previous survey on managed lane use done by Burris et al. (2012a). Necessary transformation was performed to use it as a coefficient for speed.*

Similarly, the speeds were determined by ensuring that there is time savings from using the ELs with respect to the GP lanes. This was an important decision because there would be times, especially during the off-peak hours, where the GP lanes would be traveling at the same speeds as the ELs. If that was the case, the SP questions would display an equal travel time for each lane, and the vast majority of respondents would choose the GP lanes. For that reason, the GP lanes were kept at least 5 miles per hour (mph) slower than the ELs.

The attributes for the peak hours were coded into N-Gene and used for the design. The N-Gene code used for this study is presented in Appendix M. The relationship between the attributes for the three time periods was used to obtain the designs for the shoulder and off-peak hours based on the N-Gene results from the peak hours. The design had 15 rows divided into 5 blocks of 3 rows. Each respondent was randomly presented with all choice sets from one of the blocks. The D_b-error for the design was found to be 0.09. As stated before, the D_b-error should be as close to zero as possible. Seeing as this D_b-error is very close to zero, the design is acceptable. The optimal D_b-efficient design found can be viewed in Table L.2.

Table L.2 D_b-Efficient Design Generated Using N-Gene Software (for Peak Hours)

Mode	CP-EL	DA-EL		CP-GPL	DA-GPL	
Choice Situation	**Speed (mph)**	**Speed (mph)**	**Toll (cents/mile)**	**Speed (mph)**	**Speed (mph)**	**Block**
1	60	60	90	35	35	**1**
2	55	55	67.5	35	35	**1**
3	65	65	67.5	35	35	**1**
4	65	65	45	25	25	**2**
5	55	55	45	45	45	**2**
6	60	60	90	45	45	**2**
7	55	55	45	35	35	**3**
8	65	65	67.5	25	25	**3**
9	60	60	67.5	25	25	**3**
10	60	60	45	45	45	**4**
11	55	55	90	45	45	**4**
12	65	65	90	25	25	**4**
13	55	55	67.5	45	45	**5**
14	60	60	45	25	25	**5**
15	65	65	90	35	35	**5**

L.5.2 Adaptive Random Design

The second design strategy for SP questions was the adaptive random attribute level generation method. For the first SP question, this design generated values in a range corresponding with the appropriate toll and speed based on the time of day for each city as illustrated in Table L.3. The choice sets for the second and third SP questions were partially dependent on the response to the previous SP question. If the respondent chose a toll option on the prior SP question the toll rates were increased by a random percentage anywhere between 15 and 75 and if the respondent chose a non-toll option the toll rate would decrease by a random percentage between 15 and 50. The attributes for the first SP question of the adaptive random design are presented in Table L.3.

Table L.3 Attribute Levels for the First SP Question using the Adaptive Random Design

Attribute		Attribute Levels		
		Time of Day		
	Mode	Peak Hours	Shoulder Hours	Off-Peak Hours
Toll (cents/mile)	CP-EL	0	0	0
	DA-EL	45+(0 to 45)	22.5+(0 to 22.5)	15+(0 to 15)
	CP-GPL	0	0	0
	DA-GPL	0	0	0
Speed (mph)	CP-EL	55+(0 to 10)	55+(0 to 10)	60+(0 to 10)
	DA-EL	55+(0 to 10)	55+(0 to 10)	60+(0 to 10)
	CP-GPL	25+(0 to 20)	30+(0 to 20)	35+(0 to 20)
	DA-GPL	25+(0 to 20)	30+(0 to 20)	35+(0 to 20)

The first number is the lowest possible value. Added to that is a randomly generated value between the numbers found in brackets.

Although the speeds used in this design are identical to the ones used by Burris et al. (2012a), the tolls are higher to reflect the higher tolls seen in Los Angeles, Washington D.C., and Atlanta (Caltrans 2010, Express Lanes 2014, GDOT 2012) just like in the D_b-efficient design. The cities with lower tolls received reduced rates compared to Los Angeles, Washington D.C., and Atlanta in both designs. This caused the maximum toll for the D_b-efficient design to be $6 on I-15 along the Wasatch Front. The adaptive random design was still allowed to reach tolls as high as $1 per mile on I-15 along the Wasatch Front, but the initial toll was reduced by one third, just like the D_b-efficient design. The minimum toll shown, in the off-peak hours, could be very small if the traveler took a relatively short trip. For example, if they took a 5-mile trip then the minimum toll in SP question 1 would be 75 cents (5 miles x 15 cents per mile). If the respondent did not select the toll option in the first question then the toll for the next question would be even lower in the D_b-efficient design and could be lower in the next question under the random design.

In order to compare the two designs, the ranges for the tolls and speeds for this design (random adjusting) were selected to be identical to those found in the D_b-efficient design. The first question would charge between 45 and 90 cents per mile and the other two SP questions were not allowed to charge a toll greater than $1 per mile if the respondent chose the tolled option on the previous SP question. The minimum rate allowed in this design is 10 cents per mile.

L.6 Exploratory/TEST Survey Results

As part of the development of the survey, a smaller survey (exploratory or test survey) was developed and administered. This helped to narrow down the number of psychological questions and improve the wording of those questions. The exploratory survey data collection period began on June 9, 2014 and ended on June 16, 2014. In that time 118 responses were collected (102 filled out electronically and 16 filled out on a paper copy) from friends and family members of the researchers involved in this effort. Appendix N contains a copy of the exploratory survey.

L.7 Survey Administration

The final survey administered was largely an adaptation of the survey used in the research conducted by Burris et al. (2012a) with the new psychological questions discussed previously. The tool used for the administration of this survey was LimeSurvey, a free survey hosting website. This tool allows all data to be collected via a web-based survey. The survey was made available through the *www.TravelSurveys.org* website. This survey included the 25 remaining psychological questions after the analysis conducted on the exploratory survey, questions about the respondent's most recent trip on the targeted highway, questions about their opinion of ELs, and questions regarding their socio-demographic information (see Appendix O for the survey and note that "Salt Lake City" was used in the survey to represent the entire Wasatch Front area for the survey). Respondents were given incentive to take the survey through $250 MasterCard gift cards that were to be given to a randomly chosen individual from one of each of the five cities (note Atlanta had to be removed from this survey by request of Atlanta officials who had just conducted a survey and did not want to overburden their travelers). Each respondent's contact information was stored separately from their survey results. Small and large advertisements were created for each city to aid the contacts in advertising this survey. A sample ad of each format is presented in Figure L.3 and Figure L.4, respectively.

Figure L.3 Sample small advertisement.

Figure L.4 Sample large advertisement.

The survey was sent to the contacts in the six cities on July 22, 2014 for their review. This resulted in a few minor changes to the survey and the final form of the survey shown in Appendix O. The survey went live July 24, 2014 and closed on September 15, 2014. A total of 4,830 people completed the survey questions. However only 4,813 surveys were used as the starting point for analysis of the survey data presented in this report as illustrated in Table L.4.

Table L.4 Number of Survey Respondents by City

City*	Completed Surveys	Number of Surveys Remaining After Filtering as described below
Los Angeles	2	None
Minneapolis	2,657	2,602
Salt Lake City (Wasatch Front)	2,063	2,032
Seattle	6	None-Too Small of Sample Size, So Removed from Analysis
Washington, DC.	82	78

**20 surveys did not indicate a city.*

In examining the completed surveys for each city there were a small number of surveys that (a) appeared to be from the same person, (b) were non-auto modes or (c) provided clearly illogical/erroneous responses. Responses that were clearly in one of those categories were removed from the analysis. For I-15 along the Wasatch Front, the initial 2,063 completed responses were reduced to 2,032 responses used in the analysis described below.

L.8 Survey Results From I-15 along the Wasatch Front

L.8.1 Descriptive Statistics

Analysis of the survey began with an examination of the percentage of respondents who selected the various answers to each question. Table L.5 contains a summary of responses received by those 2,032 survey respondents who indicated they lived in the Wasatch Front area.

Table L.5 Survey Responses by Utah Residents

Trip Purpose of Most Recent Trip on I-15	(% of respondents)
Didn't Specify/Other	2.3
Commuting (going to or from work)	73.7
Recreational/Social/Shopping/Entertainment/Personal Errands	11.3
School	0.9
Work Related (other than between home and work)	11.8
Day of Week of Most Recent Trip on I-15	(% of respondents)
Mon	6.0
Tues	8.9
Wed	11.9
Thurs	32.8
Fri	35.8
Sat	3.0
Sun	1.5
Didn't Specify	0.1
Length of Trip	(% of respondents)
Less than 2 miles	0.2
3 to 5 miles	0.9
6 to 10 miles	4.8
11 to 15 miles	10.5
16 to 20 miles	15.0
21 to 25 miles	14.5
26 to 30 miles	14.4
More than 30 miles	39.3
Didn't Specify	0.4
Number of People (including yourself) in the Passenger Car/SUV/Pick-up Truck	
1	83.1
2	11.9
3	2.2
4	1.6
5+	0.7
Didn't Specify	0.5
Were you the driver or a passenger on this recent trip? (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck, who responded to this question)	
Driver	83.3
Passenger	16.7

Table L.5 Continued

Who did you travel with on this recent trip? (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%)	
Co-worker/person in the same, or a nearby, office building	28.9
Neighbor	2.4
Adult family member	55.9
Child	19.8
Other	6.7
How much extra time did it take to pick up and drop off the passenger(s)? (minutes) (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck, who responded to this question.)	
0	47.5
1-5	19.0
6-10	15.6
11-15	6.1
16-20	6.5
21-30	3.0
31-60	1.5
Greater than 60	0.8
Did you use the EL for that trip?	
Yes	67.1
No	32.6
Didn't Specify	0.3
How much travel time do you think you saved (by using the EL) compared to the general purpose lanes? (minutes) (Calculated based on those who indicated they used the EL for that trip, who responded to this question.)	
0	3.1
1-5	36.6
6-10	29.1
11-15	17.3
16-20	7.6
21-30	5.1
31-60	1.1
Greater than 60	0.1
Have you ever used the EL on I-15? (Calculated based on those who responded to the question.)	
Yes	99.9
No	0.1

Table L.5 Continued

What are the main reasons you used the EL? (Calculated based on those who said they had used the EL. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%.))	
Being able to use the EL for free as a carpool	28.5
During the peak hours the ELs will not be congested	59.2
Travel times on the ELs are constant and predictable	26.6
The ELs are safer/less stressful than driving on the general purpose lanes	42.6
Travel times on ELs are less than those on the general purpose lanes	87.8
Trucks and larger vehicles are not allowed on the ELs	28.7
My employer pays for the tolls	5.2
Other	5.4
Reasons you have never used the EL (Calculated based on those who said they had not used the EL).	
I have the flexibility to travel at less congested times	50.0
Participation in a carpool is difficult/undesirable	50.0
How many total trips did you make during the past full work week (Monday to Friday) on I-15? (Each direction of travel is one trip, include trips on the EL or general purpose lanes)	
0 trips per week	2.0
1-5 trips per week	36.8
6-10 trips per week	47.9
11-15 trips per week	10.2
16-20 trips per week	2.1
21 or more trips per week	0.9
Didn't Specify/Unrealistic Answer	0.1
How many of those Freeway trips were using the EL?	
0 trips per week	10.1
1-5 trips per week	56.0
6-10 trips per week	28.1
11-15 trips per week	3.0
16-20 trips per week	0.4
21 or more trips per week	0.5
Didn't Specify/Unrealistic Answer	1.9
How many of those trips would you say you were unusually pressed for time or had a tight schedule?	
0 urgent trips per week	25.8
1-5 urgent trips per week	58.6
6-10 urgent trips per week	10.7
11-15 urgent trips per week	1.2
16-20 urgent trips per week	0.2
21 or more	0.2
Didn't Specify/Unrealistic Answer	3.3

Table L.5 Continued

Think about those trips that you were pressed for time. What percentage of the time did you use the ELs for those trips? (Calculated based on % of respondents who answered this question)	
Never use the EL for those urgent trips	0.3
Rarely use the EL for those urgent trips	4.3
About half the time I use the EL for those urgent trips	17.9
Most of my urgent trips are on the EL	29.8
Always use the EL for those urgent trips	47.7
On average, how much did you pay for the toll for a typical trip on the EL? (Calculated based on % of respondents who answered this question)	
Less than $1.00	43.6
$1.01 to $3.00	35.6
$3.01 to $5.00	5.7
More than $5.00	1.6
Do not remember	7.4
I am a toll free user so I did not pay a toll (carpool, C-Decal or motorcycle)	6.1
Approximately how much time did you save by using the EL? (Calculated based on % of respondents who answered this question)	
0 minutes	1.6
1-5 minutes	23.9
6-10 minutes	29.3
11-15 minutes	15.2
16-20 minutes	9.0
21-30 minutes	7.8
31-60 minutes	7.6
More than 60 minutes	5.6
Responses to SP Travel Choice Question 1	
Drive Alone on the GPL (DA-GPL)	44.7
Carpool on the GPL (CP-GPL)	1.3
Drive Alone on the EL (DA-EL) (average toll paid was $2.74)	33.4
Carpool on the EL (CP-EL)	20.6
Respondents to SP Travel Choice Question 2	
Drive Alone on the GPL (DA-GPL)	49.4
Carpool on the GPL (CP-GPL)	1.4
Drive Alone on the EL (DA-EL) (average toll paid was $2.90)	30.0
Carpool on the EL (CP-EL)	19.2
Respondents to SP Travel Choice Question 3	
Drive Alone on the GPL (DA-GPL)	48.1
Carpool on the GPL (CP-GPL)	1.0
Drive Alone on the EL (DA-EL) (average toll paid was $3.29)	31.2
Carpool on the EL (CP-EL)	19.7

Table L.5 Continued

What is your age?	
16 to 24	0.7
25 to 34	17.2
35 to 44	27.7
45 to 54	25.4
55 to 64	21.7
65 and over	6.4
Didn’t Specify	0.9
What is your gender? (% of respondents who answered this question)	
Male	66.4
Female	31.6
Didn’t Specify	2.0
Please describe the type of household you live in.	
Single Adult	14.7
Unrelated adults	1.6
Married without children	20.6
Married with child(ren)	56.7
Single parent family	4.0
Other/Didn't Specify	2.4
Is your child(ren) between 5 to 7 years old (school age)? (Calculated based on % of respondents who answered this question)	
Yes	62.6
No	37.4
Including yourself, how many people live in your household?	
1	10.9
2	30.6
3	16.6
4	17.3
5+	24.0
Didn't Specify/Unrealistic	0.6
Altogether, how many motor vehicles (including cars, vans, trucks, and motorcycles) are available for use by members of your household?	
1	8.9
2	39.7
3	28.0
4	14.0
5+	8.9
Didn’t Specify/Unrealistic	0.5

Table L.5 Continued

What category best describes your occupational or work status?	
Professional/Managerial	52.7
Technical	12.7
Sales	7.6
Administrative/Clerical	6.1
Manufacturing	1.0
Stay-at-home homemaker/parent	0.7
Student	0.8
Self employed	7.2
Unemployed/Seeking work	0.8
Retired	3.0
Educator	2.6
Other/Didn't Specify	4.8
What was the last year of school that you have completed?	
Less than high school	0.4
High school graduate	3.8
Some college or vocational school	26.2
College graduate	40.8
Postgraduate degree	27.2
Other/Didn't Specify	1.6
What was your gross annual household income before taxes in 2013?	
Less than $10,000	0.3
$10,00 to $14,999	0.3
$15,000 to $24,999	0.9
$25,000 to $34,999	2.0
$35,000 to $49,999	6.1
$50,000 to $74,999	16.5
$75,000 to $99,999	19.3
$100,000 to $199,999	38.5
$200,000 or more	12.5
It's easier to tell hourly wage rate	0.8
Didn't Specify	2.8

L.8.2 Mode Choice Modeling

Each of the 2,032 Wasatch Front respondents answered three SP questions (see Figure L.5 for an example). Therefore, there were 6,096 mode choice responses to analyze. Standard logit modeling was used to determine the impact of trip and traveler characteristics on mode

choice. Many different independent variables were tested in the mode choice models including characteristics of the trip (such as trip purpose and length of trip) and characteristics of the traveler (such as income, age, gender, household type, number of people in household, number of vehicles in household and education level). Models separating the respondents by income level (low, medium, and high) were also examined. The best models developed are shown in Equations L.2 through L.5.

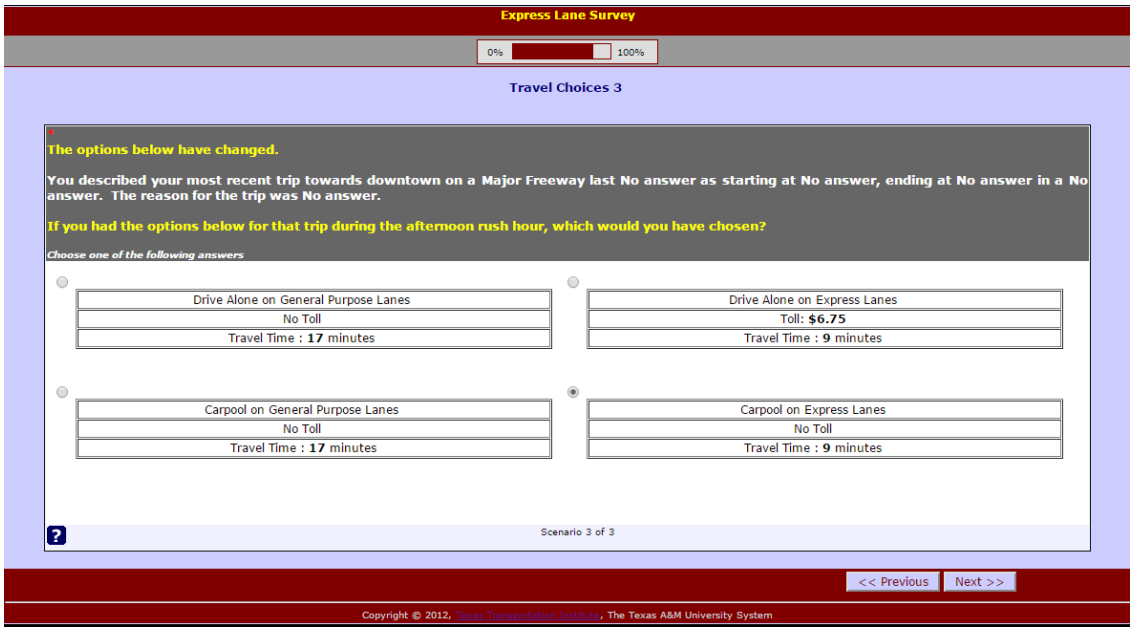

Figure L.5 Typical stated preference question.

$$U_{DA-GPL} = -0.05 \times TT_{GPL} - 0.17 \times Male - 0.48 \times VehOcc \quad \text{(L.2)}$$

$$U_{DA-EL} = -3.78 - 0.05 \times TT_{EL} - 0.12 \times Toll - 0.48 \times VehOcc - 0.19 \times TPComm \quad \text{(L.3)}$$

$$U_{CP-GPL} = -1.22 - 0.05 \times TT_{GPL} \quad \text{(L.4)}$$

$$U_{CP-EL} = -1.88 - 0.05 \times TT_{EL} - 0.19 \times TPComm \quad \text{(L.5)}$$

where: U = Utility,

DA = Drive Alone,

CP = Carpool

GPL = General Purpose Lane

EL = Express Lane

TT = Travel Time

Toll = Express Lane Toll

Male = 1 if person is male, 0 if not

VehOcc = the number of people in the vehicle

TPComm = 1 if the person was on a commute trip, 0 if not

The ρ^2 value for the model was 0.22, fairly typical for mode choice models of ELs. The travelers' value of time can be obtained by dividing the time coefficient (-0.05) by the toll coefficient (-0.12). The value of time was therefore $0.41/minute or $24.49 per hour. This is higher than standard values of time (FHWA guidance has value of time of $12.50 per person in 2009 dollars). However, it is not surprising to see in a EL corridor where many studies have found higher than average values of time. Plus the average income and education level of the respondents was quite high, often leading to higher values of time.

Another important piece of information the model provides is the toll price elasticity of demand. In this case it is -0.38. This means a 10% increase in toll price results in a 3.8% decrease in demand. Typical toll price elasticity's are around -0.30; therefore, the elasticity here is a bit higher than average. Again, this is not surprising in an EL setting since the alternative to the EL is very convenient. If a tolled transportation choice has a convenient alternative then the price elasticity of demand will be greater as it is relatively easy to avoid the toll.

This research effort could continue to examine other potential improvements on the above models. This includes using a mixed logit model to help account for the fact each respondent answered three SP questions and thus those three answers are not independent of each other. Also, the answers to the psychological questions could be used in the models in an effort to improve the predictive power of the models.

L.9 Conclusions

This appendix details the development and administration of a survey of EL users in multiple cities across the country. The focus of the survey was to examine if psychological traits of travelers can be used to help improve the predictive power of mode choice models when

trying to predict EL use. However, this question has not been addressed in this report and is still being studied. Rather, the results presented in this report focuses on basic descriptive statistics and logit modeling from one of these locations (Wasatch Front, Utah).

Approximately 85% of the 2,032 Wasatch Front survey respondents most recent I-15 trip was a commute trip (home to work or vice versa) or a work related trip on a weekday. Almost all (93.8%) trips were 11 miles or more, with almost 40% being 30 miles or more. Two-thirds indicated that most recent trip was on the ELs. Most were single occupant vehicles, so most were tolled EL trips. The main reasons for using the ELs focused on TTS, but some indicated they felt driving in the ELs was less stressful and some indicated they felt safer on the ELs.

The survey included three stated preference questions where respondents were asked to choose between four modes given the time and toll rate for those modes. The modes included driving alone on the ELs or GP lanes, and carpooling on the ELs or GP lanes. A logit model was developed based on the survey respondents' answers to these questions. The model is used to predict travelers mode choice but also is useful to determine how travelers value certain trade-offs, like time and toll. In this case respondents valued their travel time at $24.49 per hour and had a price elasticity of demand of -0.38. Both of these values are as expected for an EL corridor.

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APPENDIX M: N-GENE CODE

```
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;rdraws=halton(400)
;cond:
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dagl.spdlvl_g,cpgl.spdlvl_g=dagl.spdlvl_g)
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/
U(daml)=c2[-1.90]+spd*spdlvl_m+toll[n,-0.12,0.1]*tlvl[45,67.5,90]
/
U(cpgl)=c1[-4.25]+spd*spdlvl_g[25,35,45]
/
U(dagl)=spd*spdlvl_g
$
```

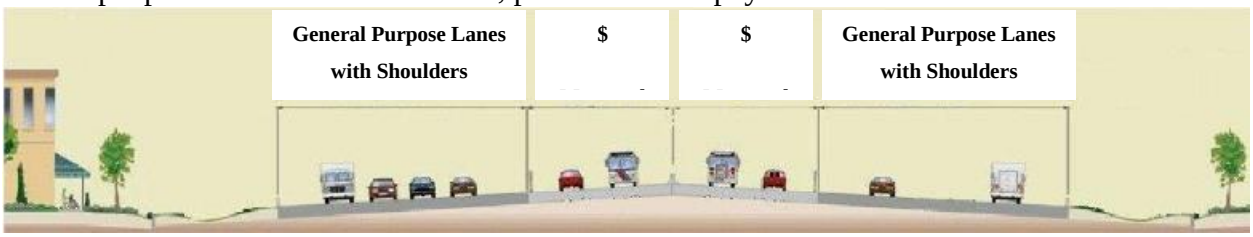
APPENDIX N: EXPLORATORY SURVEY

Stated Preference Questions

Each of the following questions will ask you to choose between two potential travel choices on a managed lane corridor. Please put an "X" in the box next to the one option that you would be most likely to choose if faced with these specific options. Remember that carpooling may require added travel time to pick up or drop off your passenger(s).
Please select one option for each question (i.e., **answer all three questions**) by putting an "X" inside the box beside your choice.

Note: A "managed lane" refers to a lane that can only be used by vehicles meeting certain criteria. Two common types of EL include the following:

- **High Occupancy Vehicle (HOV) lanes**: Where vehicles with at least a certain number of people—for example vehicles with 2 or more occupants—can use the lane for free.
- **High Occupancy Toll (HOT) lanes**: Where vehicles with at least a certain number of people can use the lane for free, plus others can pay a toll to use the lane.



Note: General Purpose Lanes are regular freeway lanes.

Question 1

If you had the options below for your morning commute during rush hour, which would you choose?

☐	Drive Alone on General Purpose Lanes No Toll Travel Time: **40** minutes
☐	Drive Alone on Managed Lanes Toll: **$5.00** Travel Time: **18** minutes
☐	Carpool on General Purpose Lanes No Toll Travel Time: **40** minutes
☐	Carpool on Managed Lanes No Toll Travel Time: **18** minutes

Question 2

If you had the options below for your morning commute during rush hour, which would you choose?

☐	Drive Alone on General Purpose Lanes No Toll Travel Time: **30** minutes
☐	Drive Alone on Managed Lanes Toll: **$2.00** Travel Time: **20** minutes
☐	Carpool on General Purpose Lanes No Toll Travel Time: **30** minutes
☐	Carpool on Managed Lanes No Toll Travel Time: **20** minutes

Question 3

If you had the options below for your morning commute during rush hour, which would you choose?

☐	Drive Alone on General Purpose Lanes No Toll Travel Time: **45** minutes
☐	Drive Alone on Managed Lanes Toll: **$8.00** Travel Time: **25** minutes
☐	Carpool on General Purpose Lanes No Toll Travel Time: **45** minutes
☐	Carpool on Managed Lanes No Toll Travel Time: **25** minutes

Psychological Questions

Please rate the extent to which you agree with each statement using the following scale:

Strongly disagree	Disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7	8	9

Note: These are destined for travelers who live near managed lanes. If you can't answer managed lane questions (like #1 and #2) just skip them.

1.	It does not matter if I choose the general purpose lane or managed lane since it is just luck if the managed lane saves me time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
2.	Unless there is no traffic on the freeway, I choose the managed lane since traffic could become congested at any time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
3.	If I were listening to the radio and heard there is an accident on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
4.	I only choose to use the managed lane if the general purpose lane seems crowded.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
5.	When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
6.	I have often found that what is going to happen will happen.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
7.	I usually choose to use the managed lane only at the last second.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
8.	Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
9.	Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
10.	Before purchasing a new vehicle, I spend an extensive amount of time researching potential makes, models, and prices before making a decision.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
11.	If pulled over by a police officer, I do not try to talk my way out of a ticket since it will not help.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
12.	If I were to carpool, my carpool partner(s) would have to be very dependable.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
13.	I cannot understand why someone would pay to use the managed lanes when the general purpose lanes are available for "free", especially when it may or may not save time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
14.	I rarely complain about traffic problems because that will not help fix the problem.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Strongly disagree	Disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7	8	9

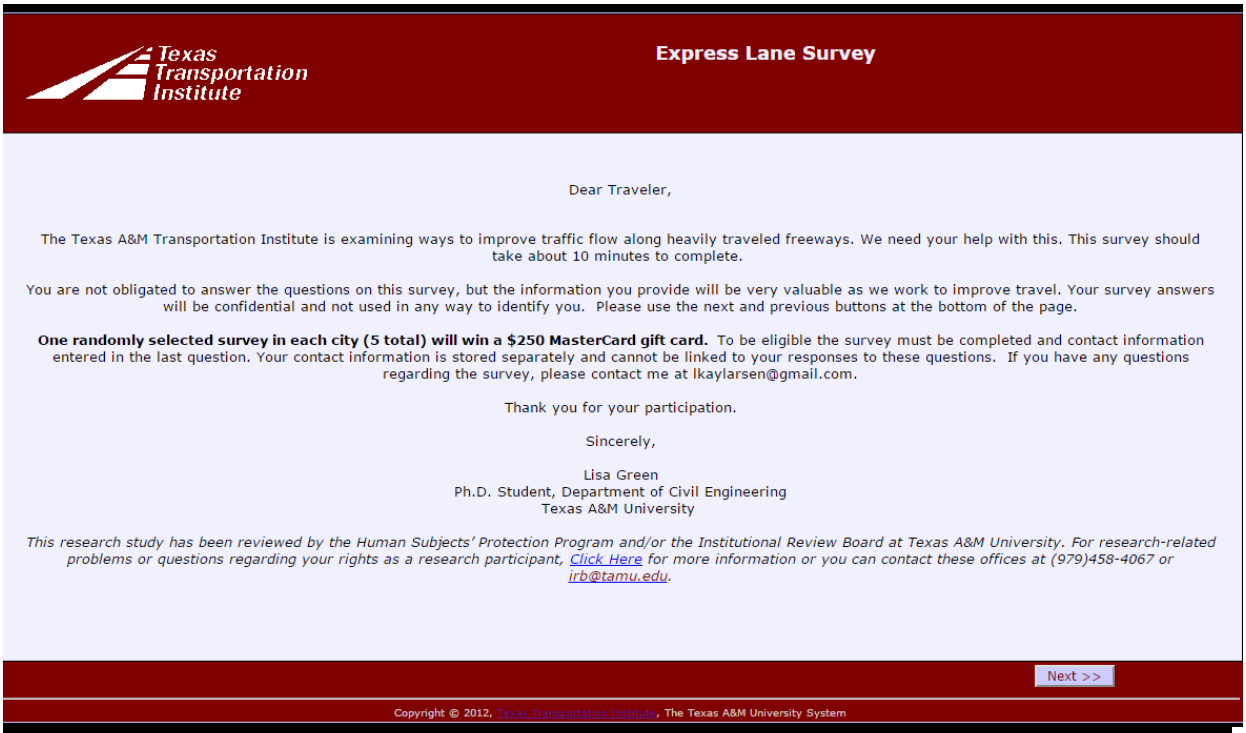
15.	The coordination involved with carpooling is more hassle than it is worth.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
16.	When taking a road trip, I map out the route I will follow prior to beginning the trip.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
17.	Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
18.	I often look up information about the traffic conditions prior to driving anywhere.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
19.	The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
20.	I tend to make choices about which road to use based on the traffic I encounter.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
21.	I would rather consistently have a 20 minute commute than a commute that varies anywhere from 10 minutes to 30 minutes.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
22.	I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
23.	When the reliability of transit system schedules is questionable, it deters me from using transit.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
24.	I generally choose to use the managed lanes when I feel it is the only way I will make it to my destination on time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
25.	I listen to the radio while driving so I can get updates on traffic.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
26.	I do not like relying on others for rides.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

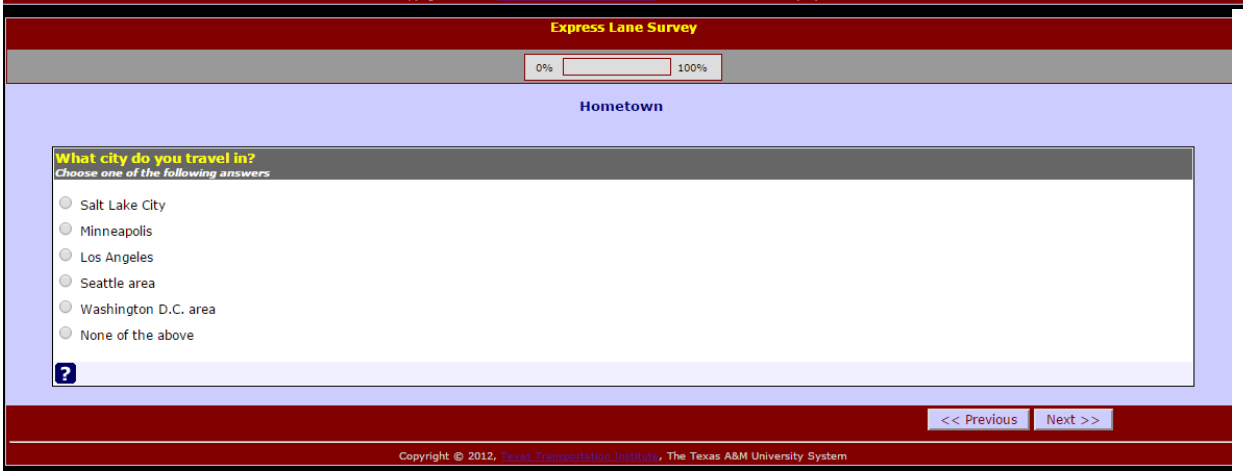
For each of the following statements, please indicate your likelihood of engaging in each activity. Provide a rating from 1 to 9, using the following scale:

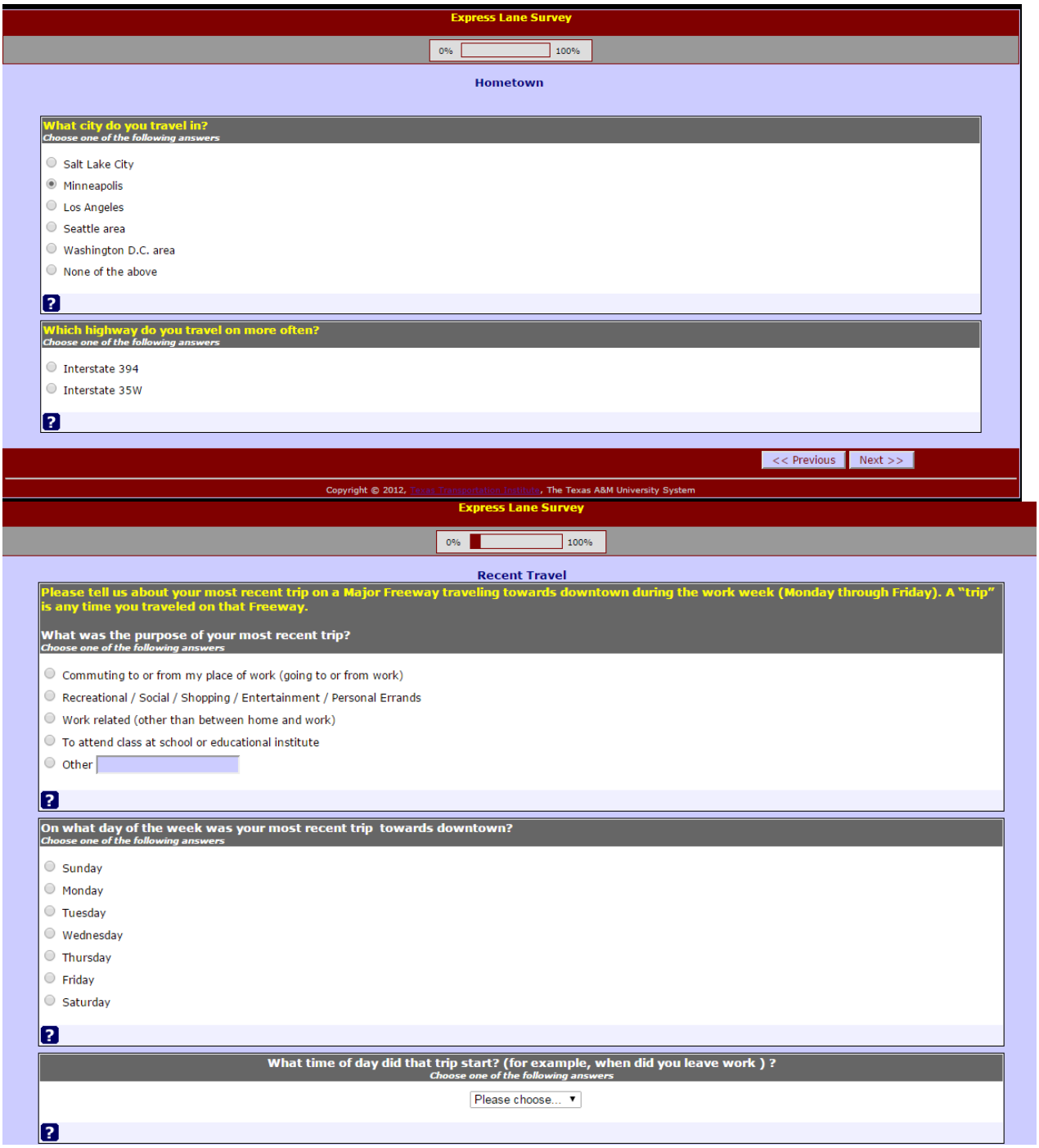
Extremely unlikely	**Unlikely**	**Somewhat unlikely**	**Slightly unlikely**	**Neither likely nor unlikely**	**Slightly likely**	**Somewhat likely**	**Likely**	**Extremely Likely**
1	2	3	4	5	6	7	8	9

27.	Choosing to use the managed lane, knowing there is a 50% chance it will not save me time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
28.	Investing 10% of your annual income in a blue chip stock.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
29.	Lending a friend the money needed to purchase a $20 toll tag so they could use the managed lane.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
30.	Taking a job where you get paid exclusively on a commission basis.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
31.	Lending a friend an amount of money equivalent to one month's income.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
32.	Betting a day's income at the horse races.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

APPENDIX O: SURVEY AS TAKEN ONLINE






Express Lane Survey
0%
100%
Hometown
What city do you travel in?
Choose one of the following answers
Salt Lake City
Minneapolis
Los Angeles
Seattle area
Washington D.C. area
None of the above
Which highway do you travel on more often?
Choose one of the following answers
Interstate 394
Interstate 35W
<< Previous
Next >>
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Express Lane Survey
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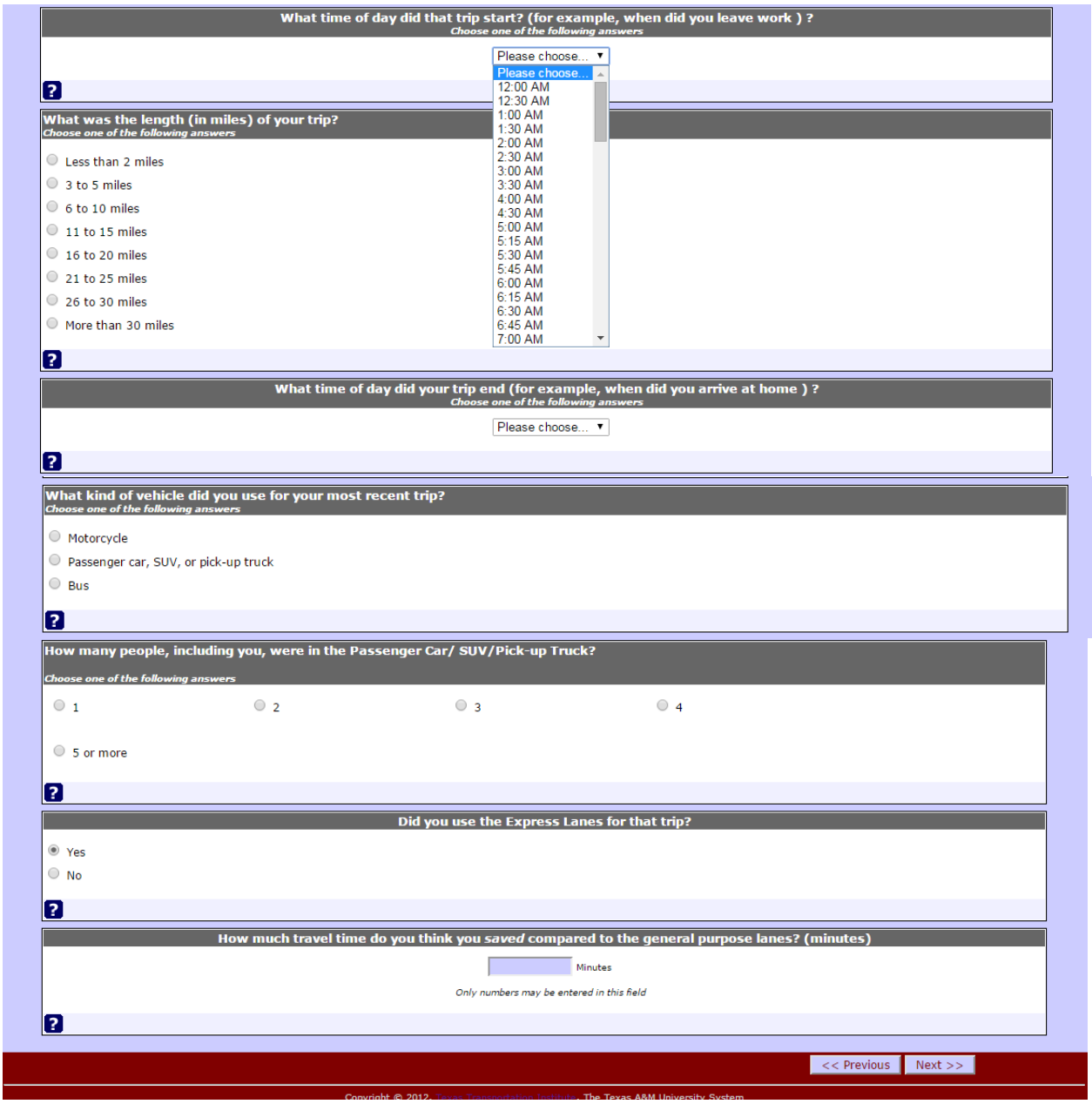
100%
Recent Travel
Please tell us about your most recent trip on a Major Freeway traveling towards downtown during the work week (Monday through Friday). A "trip" is any time you traveled on that Freeway.
What was the purpose of your most recent trip?
Choose one of the following answers
Commuting to or from my place of work (going to or from work)
Recreational / Social / Shopping / Entertainment / Personal Errands
Work related (other than between home and work)
To attend class at school or educational institute
Other
On what day of the week was your most recent trip towards downtown?
Choose one of the following answers
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
What time of day did that trip start? (for example, when did you leave work) ?
Choose one of the following answers
Please choose...


What time of day did that trip start? (for example, when did you leave work) ?
Choose one of the following answers
Please choose...
Please choose...
12:00 AM
12:30 AM
1:00 AM
1:30 AM
2:00 AM
2:30 AM
3:00 AM
3:30 AM
4:00 AM
4:30 AM
5:00 AM
5:15 AM
5:30 AM
5:45 AM
6:00 AM
6:15 AM
6:30 AM
6:45 AM
7:00 AM
What was the length (in miles) of your trip?
Choose one of the following answers
Less than 2 miles
3 to 5 miles
6 to 10 miles
11 to 15 miles
16 to 20 miles
21 to 25 miles
26 to 30 miles
More than 30 miles
What time of day did your trip end (for example, when did you arrive at home) ?
Choose one of the following answers
Please choose...
What kind of vehicle did you use for your most recent trip?
Choose one of the following answers
Motorcycle
Passenger car, SUV, or pick-up truck
Bus
How many people, including you, were in the Passenger Car/ SUV/Pick-up Truck?
Choose one of the following answers
1
2
3
4
5 or more
Did you use the Express Lanes for that trip?
Yes
No
How much travel time do you think you saved compared to the general purpose lanes? (minutes)
Minutes
Only numbers may be entered in this field
<< Previous
Next >>
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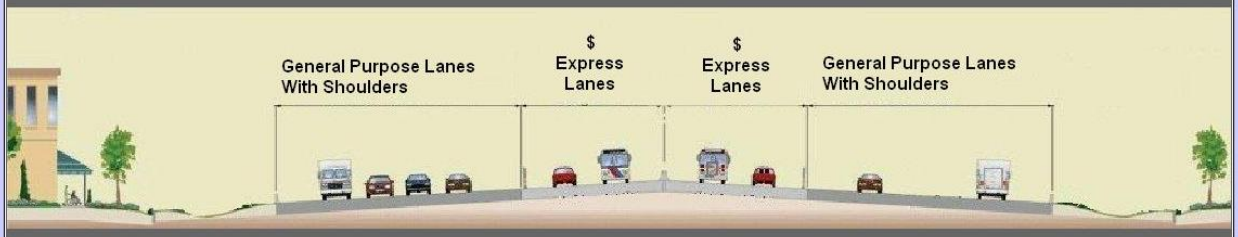
Express Lane Survey

0% 100%

Express Lanes Description

Express Lanes are a set of lanes within a freeway which are managed continuously to achieve predefined performance objectives. A typical example of an express lane facility is shown in the figure below. During the rush hour the toll is higher and during other times the toll is lower. Drivers often have multiple entrances and exit locations to get on the express lanes. Qualifying high-occupancy vehicles can often travel for free during the peak hours.



Have you ever used the Express Lanes on a Major Freeway?
Choose one of the following answers

- ○ Yes
- ○ No

What are the main reasons you used the Express Lanes?
Check any that apply

- ☐ Travel times on Express Lanes are less than those on the general purpose lanes
- ☐ Travel times on the Express Lanes are consistent and predictable
- ☐ My employer pays for the tolls
- ☐ Being able to use the Express Lanes for free as a carpool
- ☐ During the peak hours the Express Lanes will not be congested
- ☐ The Express Lanes are safer / less stressful than driving on the general purpose lanes
- ☐ Trucks and larger vehicles are not allowed on the Express Lanes
- ☐ Other:

What are the primary reasons why you have never used the Express Lanes?
Check any that apply

- ☐ I do not want to pay the toll for this trip
- ☐ I don't like that the toll changes based on time of day
- ☐ I have the flexibility to travel at less congested times
- ☐ I can easily use other routes than the Freeway, so I'll just avoid it if I think there is a lot of traffic
- ☐ Express Lane use is complicated or confusing
- ☐ Participation in a carpool is difficult / undesirable
- ☐ Access to the Express Lanes is not convenient for my trips
- ☐ I do not have a credit card so it is inconvenient to set up a toll account
- ☐ The tolls are too high for me
- ☐ I do not feel safe traveling on Express Lanes
- ☐ I do not want a toll transponder in my car
- ☐ The Express Lanes do not offer me enough time savings
- ☐ Other:

We want you to now think about all of your trips during the last full week on I-15 in Salt Lake City.
How many *total trips* did you make during the past full work week (Monday to Friday) on I-15 in Salt Lake City? (Each direction of travel is one trip, include trips on the express lanes or general purpose lanes)

Only numbers may be entered in these fields

Trips per week:

How many of those Freeway trips were using the Express Lanes?

Only numbers may be entered in these fields

Trips per week:

How many of those trips would you say you were unusually pressed for time or had a tight schedule ?

Only numbers may be entered in these fields

Urgent Trips Per Week:

<< Previous | Next >>

Express Lane Survey

0% 100%

Read each of the following statements and decide how much you agree with each according to your attitudes, beliefs, and experiences. There is no "right" or "wrong" answer to these questions. People are different, and we are interested in how you feel. Please respond according to the following 9-point scale:

	Strongly disagree 1	Disagree 2	Somewhat disagree 3	Slightly disagree 4	Neither agree nor disagree 5	Slightly agree 6	Somewhat agree 7	Agree 8	Strongly agree 9
It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time.									
Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.									
If I were listening to the radio and heard there is a major crash on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.									
When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.									
I have often found that what is going to happen will happen.									
I usually choose to use the express lane only at the last second, after observing freeway traffic for as long as I can.									

Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	○	○	○	○	○	○	○	○	○
Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	○	○	○	○	○	○	○	○	○
I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.	○	○	○	○	○	○	○	○	○
I only choose to use the express lane if the general purpose lanes seem crowded.	○	○	○	○	○	○	○	○	○

<< Previous Next >>

Express Lane Survey

0% 100%

Read each of the following statements and decide how much you agree with each according to your attitudes, beliefs, and experiences. There is no "right" or "wrong" answer to these questions. People are different, and we are interested in how you feel. Please respond according to the following 9-point scale:

	Strongly disagree 1	Disagree 2	Somewhat disagree 3	Slightly disagree 4	Neither agree nor disagree 5	Slightly agree 6	Somewhat agree 7	Agree 8	Strongly agree 9
I rarely complain about traffic problems because that will not help fix the problem.	○	○	○	○	○	○	○	○	○
The coordination involved with carpooling is more hassle than it is worth.	○	○	○	○	○	○	○	○	○
Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	○	○	○	○	○	○	○	○	○
I often look up information about traffic conditions prior to driving anywhere.	○	○	○	○	○	○	○	○	○
The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	○	○	○	○	○	○	○	○	○
I tend to make choices about which road to use based on the traffic I encounter.	○	○	○	○	○	○	○	○	○
I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	○	○	○	○	○	○	○	○	○
I listen to the radio while driving so I can get updates on traffic.	○	○	○	○	○	○	○	○	○

I do not like relying on others for rides.	○	○	○	○	○	○	○	○	○
I generally choose to use express lanes only when I feel it is the only way I will make it to my destination on time.	○	○	○	○	○	○	○	○	○
I would choose to use the express lane, knowing there is a 50 percent chance it will not save me time.	○	○	○	○	○	○	○	○	○

<< Previous Next >>

Express Lane Survey

0% 100%

For each of the following statements, please indicate your likelihood of engaging in each activity. Provide a rating from 1 to 9, using the following scale:

	Extremely unlikely 1	Unlikely 2	Somewhat unlikely 3	Slightly unlikely 4	Neither likely nor unlikely 5	Slightly likely 6	Somewhat likely 7	Likely 8	Extremely likely 9
I would invest 10% of my annual income in a quality/blue-chip stock.	○	○	○	○	○	○	○	○	○
I would lend a friend the money needed to purchase a $45 toll tag so they could use the express lane.	○	○	○	○	○	○	○	○	○
I would lend a friend an amount of money equivalent to one month's income.	○	○	○	○	○	○	○	○	○
I would bet a day's income at the horse races.	○	○	○	○	○	○	○	○	○

Please note that after clicking Next, you will not be able to go back. Make sure your responses on this and previous pages are final before proceeding.

<< Previous Next >>

Express Lane Survey

0% 100%

Travel Choices 1

Each of the following questions will ask you to choose between four potential travel choices on a Major Freeway. For your most recent trip, please click on the one option that you would be most likely to choose if faced with these specific options. Remember that carpooling may require added travel time to pick up or drop off your passenger(s).

You described your most recent trip towards downtown on a Major Freeway last No answer as starting at No answer, ending at No answer in a No answer. The reason for the trip was No answer.

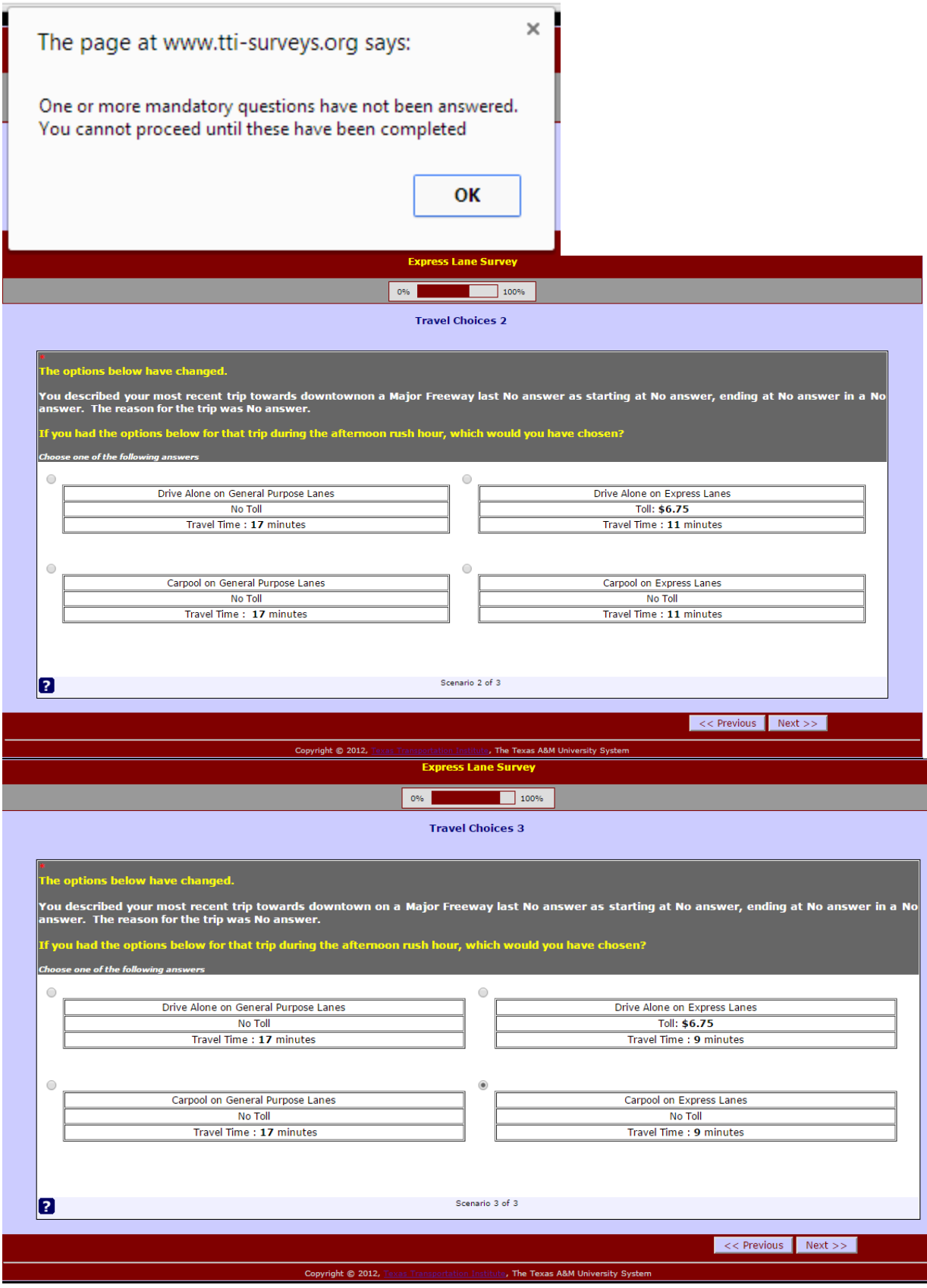
If you had the options below for that trip during the afternoon rush hour, which would you have chosen?

Choose one of the following answers

○ Drive Alone on General Purpose Lanes No Toll Travel Time : **17** minutes	○ Drive Alone on Express Lanes Toll: **$9.00** Travel Time : **10** minutes
○ Carpool on General Purpose Lanes No Toll Travel Time : **17** minutes	○ Carpool on Express Lanes No Toll Travel Time : **10** minutes

Scenario 1 of 3

<< Previous Next >>


The page at www.tti-surveys.org says:
One or more mandatory questions have not been answered.
You cannot proceed until these have been completed
OK
Express Lane Survey
0%
100%
Travel Choices 2
The options below have changed.
You described your most recent trip towards downtownon a Major Freeway last No answer as starting at No answer, ending at No answer in a No answer. The reason for the trip was No answer.
If you had the options below for that trip during the afternoon rush hour, which would you have chosen?
Choose one of the following answers
Drive Alone on General Purpose Lanes
No Toll
Travel Time : 17 minutes
Drive Alone on Express Lanes
Toll: $6.75
Travel Time : 11 minutes
Carpool on General Purpose Lanes
No Toll
Travel Time : 17 minutes
Carpool on Express Lanes
No Toll
Travel Time : 11 minutes
Scenario 2 of 3
<< Previous
Next >>
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Express Lane Survey
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100%
Travel Choices 3
The options below have changed.
You described your most recent trip towards downtown on a Major Freeway last No answer as starting at No answer, ending at No answer in a No answer. The reason for the trip was No answer.
If you had the options below for that trip during the afternoon rush hour, which would you have chosen?
Choose one of the following answers
Drive Alone on General Purpose Lanes
No Toll
Travel Time : 17 minutes
Drive Alone on Express Lanes
Toll: $6.75
Travel Time : 9 minutes
Carpool on General Purpose Lanes
No Toll
Travel Time : 17 minutes
Carpool on Express Lanes
No Toll
Travel Time : 9 minutes
Scenario 3 of 3
<< Previous
Next >>
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Express Lane Survey

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Demographics

The following questions will be used for statistical purposes only and answers will remain confidential. All of your answers are very important to us and in no way will they be used to identify you or released to any other person outside the research team.

What is your age?

Choose one of the following answers

- ○ 16 to 24
- ○ 25 to 34
- ○ 35 to 44
- ○ 45 to 54
- ○ 55 to 64
- ○ 65 and over

What is your gender?

Choose one of the following answers

- ○ Male
- ○ Female

Please describe the type of household you live in.

Choose one of the following answers

- ○ Single adult
- ○ Married without children
- ○ single parent family
- ○ Unrelated adults
- ○ Married with child(ren)
- ○ Other

Including yourself, how many people live in your household?

Only numbers may be entered in this field

All together, how many motor vehicles (including cars, vans, trucks, and motorcycles) are available for use by members of your household?

Only numbers may be entered in this field

What category best describes your occupational or work status?

Choose one of the following answers

- ○ Professional / Managerial
- ○ Administrative / Clerical
- ○ Stay-at-home homemaker / parent
- ○ Self employed
- ○ Manufacturing
- ○ Sales
- ○ Student
- ○ Educator
- ○ Technical
- ○ Retired
- ○ Unemployed / seeking work
- ○ Other

What was the last year of school that you have completed?

Choose one of the following answers

- ○ Less than high school
- ○ Some college or vocational school
- ○ Postgraduate degree
- ○ High school graduate
- ○ College graduate

What was your gross annual household income before taxes in 2013?

Choose one of the following answers

- ○ Less than $10,000
- ○ $35,000 to $49,999
- ○ $200,000 or more
- ○ $10,000 to $14,999
- ○ $50,000 to $74,999
- ◉ Its easier to tell my hourly wage rate
- ○ $15,000 to $24,999
- ○ $75,000 to $99,999
- ○ $25,000 to $34,999
- ○ $100,000 to $199,999

Hourly wage rate ($/hour)

Only numbers may be entered in this field

Thank you for taking the time to fill in this survey. Your responses will be helpful as we work to improve travel in your area. If you have any general comments about travel on I-394 in Minneapolis, please type them below.

Please finish the survey by hitting "Submit" below. You will then have a chance to enter your contact information to be eligible to win one of the $250 MasterCard gift cards. Your contact information is stored separately and cannot be linked to your responses to these questions.

The survey results will be made available at www.TravelSurveys.org/SurveyResults.html. Thanks!

<< Previous | Submit

Texas A&M Transportation Institute

Contact Information

Thanks! We appreciate the time you took to fill in this survey. The next page will ask for contact information so that you can be entered into a drawing for five, $250 MasterCard gift cards. The rules of the contest are below:

1. Contest is void where prohibited by law. No purchase necessary to win, but the survey must be fully completed by September 15, 2014. Late or duplicate entries will not be accepted.

2. All contestants must be 18 or older.

3. Five winners will be chosen, one from each city. Each prize is a MasterCard gift card worth $250. The winner will be selected on September 30, 2014 at CE/TTI tower on the campus of Texas A & M campus. Winner need not be present.

4. The winner is responsible for all applicable federal, state and local taxes including income tax.

5. Employees of the Texas A&M Transportation Institute, the Utah Department of Transportation, the Minnesota Department of Transportation, the California Department of Transportation, the Washington State Department of Transportation, Transurban, State Road and Tollway Authority and members of their families are not eligible to enter to win.

6. Contest is void where prohibited by law.

Next >>

Contact Information

0% 100%

Contact Information

What city do you travel in?

Choose one of the following answers

- Salt Lake City
- Minneapolis
- Los Angeles
- Seattle area
- Washington D.C. area
- None of the above

Please enter your name

Please enter your email address or phone number

Submit

Thank you!
Your responses are saved, you may now close the window.