2006 Maricopa Association of Governments Vehicle Occupancy Study

Prepared for:

Maricopa Association of Governments

302 N. 1st Avenue, Suite 300

Phoenix, Arizona 85003

Prepared by:

United Civil Group Corporation

2803 N. 7th Avenue

Phoenix, Arizona 85007

September 2007

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... -1-
SECTION 1: INTRODUCTION 1
SECTION 2: STUDY DESIGN AND DATA COLLECTION PROCEDURES 3
SECTION 3: AUTO OCCUPANCY 13
SECTION 4: VEHICLE CLASSIFICATION 27
SECTION 5: HOV LANE EVALUATION 33
SECTION 6: CONCLUSIONS 57

LIST OF TABLES

EXECUTIVE SUMMARY

TABLE ES – 1: STUDY TIME PERIODS ..... - 3 -

TABLE ES – 2: NUMBER OF SITES SURVEYED BY AREA TYPE AND FACILITY TYPE ..... - 5 -

TABLE ES – 3: AVERAGE AUTO OCCUPANCY VS AREA TYPE AND FACILITY TYPE ..... - 8 -

TABLE ES – 4: AVERAGE AUTO AND VEHICLE OCCUPANCIES BY AREA TYPE, FACILITY TYPE, AND HOV FREEWAYS ..... - 8 -

TABLE ES – 5: SITES WITH DATA FROM PREVIOUS STUDIES ..... - 9 -

TABLE ES – 6: COMPARISON OF AUTO OCCUPANCY RATES ..... - 9 -

TABLE ES – 7: OVERALL VEHICLE CLASSIFICATION PERCENTAGES – ALL AREA TYPES AND FACILITY TYPES BY TIME OF DAY ..... - 10 -

TABLE ES – 8: PEAK HOUR AUTO OCCUPANCIES OF HOV LANES AND GENERAL PURPOSE LANES ..... - 11 -

TABLE ES – 9: PEAK HOUR HOV LANE EFFICIENCY DATA ..... - 13 -

FINAL REPORT

TABLE 1: STUDY TIME PERIODS 5

TABLE 2: NUMBER OF SITES SURVEYED BY AREA TYPE AND FACILITY TYPE 6

TABLE 3: SITES WITH DATA FROM PREVIOUS STUDIES 6

TABLE 4: SITE LOCATION LIST 7

TABLE 5: FHWA VEHICLE CLASSIFICATION 11

TABLE 6: ANOVA TEST RESULTS 13

TABLE 7: AVERAGE AUTO OCCUPANCY VS AREA TYPE AND FACILITY TYPE 16

TABLE 8: AVERAGE VEHICLE OCCUPANCY VS AREA TYPE AND FACILITY TYPE 16

TABLE 9: AVERAGE AUTO AND VEHICLE OCCUPANCIES BY AREA TYPE, FACILITY TYPE, AND HOV FREEWAYS 16

TABLE 10: AVERAGE AUTO OCCUPANCY BY AREA TYPE AND FACILITY TYPE BY TIME PERIODS 17

TABLE 11: AVERAGE AUTO OCCUPANCY RATES BY TIME PERIOD, AREA TYPE, AND FACILITY TYPE 20

TABLE 12: CARPOOL AUTO OCCUPANCY RATES BY TIME PERIOD, AREA TYPE, AND FACILITY TYPE 21

TABLE 13: PERCENTAGE OF VEHICLES AND TRAVELERS BY AUTO OCCUPANCY BY HOUR OF DAY – ALL ROADWAYS IN REGION 21

TABLE 14: PERCENTAGE OF VEHICLES AND TRAVELERS BY AUTO OCCUPANCY BY HOUR OF DAY – ALL FREEWAYS IN REGION 22

TABLE 15: PERCENTAGE OF VEHICLES AND TRAVELERS BY AUTO OCCUPANCY BY HOUR OF DAY – ALL ARTERIALS IN REGION 22

TABLE 16: COMPARISON OF AUTO OCCUPANCY CLASSIFICATIONS AND OCCUPANCY RATES 24

TABLE 17: COMPARISON OF AUTO OCCUPANCY RATES 25
TABLE 18: VEHICLE CLASSIFICATION EXAMPLES 27
TABLE 19: OVERALL VEHICLE CLASSIFICATION PERCENTAGES – ALL AREA TYPES AND FACILITY TYPES BY TIME OF DAY 28
TABLE 20: VEHICLE CLASSIFICATION PERCENTAGES BY TIME PERIOD – ALL FREEWAY FACILITIES 29
TABLE 21: VEHICLE CLASSIFICATION PERCENTAGES BY TIME PERIOD – ARTERIALS 30
TABLE 22: VEHICLE CLASSIFICATION PERCENTAGES ON I-10 BY TIME OF DAY 31
TABLE 23: VEHICLE CLASSIFICATION PERCENTAGES ON I-17 BY TIME OF DAY 31
TABLE 24: VEHICLE CLASSIFICATION PERCENTAGES ON US 60 BY TIME OF DAY 31
TABLE 25: VEHICLE CLASSIFICATION PERCENTAGES ON SR 51 BY TIME OF DAY 31
TABLE 26: VEHICLE CLASSIFICATION PERCENTAGES ON LOOP 202 BY TIME OF DAY 32
TABLE 27: VEHICLE CLASSIFICATION PERCENTAGES ON LOOP 101 BY TIME OF DAY 32
TABLE 28: AVERAGE AUTO OCCUPANCIES OF HOV LANES AND GENERAL PURPOSE LANES 33
TABLE 29: PEAK HOUR AUTO OCCUPANCIES OF HOV LANES AND GENERAL PURPOSE LANES 36
TABLE 30: PEAK HOUR VIOLATION RATE OF SINGLE OCCUPANT VEHICLES IN HOV LANES 38
TABLE 31: OVERALL PEAK HOUR VIOLATION RATES 42
TABLE 32: HOV LANE EFFICIENCY DATA 45

LIST OF FIGURES

EXECUTIVE SUMMARY

FIGURE ES – 1: AREA AND FACILITY TYPES WITHIN THE MAG REGION ..... - 4 -
FIGURE ES – 2: DESIGN OF "THE CUBE" ..... - 5 -
FIGURE ES – 3: AVERAGE AUTO OCCUPANCY VS AREA TYPE ..... - 6 -
FIGURE ES – 4: AVERAGE AUTO OCCUPANCY VS FACILITY TYPE ..... - 7 -
FIGURE ES – 5: AVERAGE AUTO OCCUPANCY VS TIME OF DAY ..... - 7 -
FIGURE ES – 6: AVERAGE AUTO OCCUPANCY VS AREA TYPE AND FACILITY TYPE ..... - 8 -
FIGURE ES – 7: HIGH OCCUPANCY VEHICLE LANE OVERALL VIOLATION PERCENTAGE ..... - 12 -
FIGURE ES – 8: OVERALL HOV LANE VIOLATION PERCENTAGE BY SPECIFIC FREEWAY ..... - 12 -
FIGURE ES – 9: HOV EFFICIENCY, ALL HOV FREEWAY SITES, AM + PM PEAK HOUR ..... - 13 -
FIGURE ES – 10: PEAK HOUR HOV LANE EFFICIENCY ..... - 14 -

FINAL REPORT

FIGURE 1: AREA AND FACILITY TYPES WITHIN THE MAG REGION 4
FIGURE 2: DESIGN OF "THE CUBE" 5
FIGURE 3: DATA COLLECTION CONFIGURATION 10
FIGURE 4: DATA COLLECTION UNIT 11
FIGURE 5: HAND-HELD RADAR GUN 12
FIGURE 6: AVERAGE AUTO OCCUPANCY VS AREA TYPE 14
FIGURE 7: AVERAGE AUTO OCCUPANCY VS FACILITY TYPE 14
FIGURE 8: AVERAGE AUTO OCCUPANCY VS TIME OF DAY 15
FIGURE 9: AVERAGE AUTO OCCUPANCY VS AREA TYPE AND FACILITY TYPE 16
FIGURE 10: AVERAGE AUTO OCCUPANCY 18
FIGURE 11: AVERAGE VEHICLE OCCUPANCY 19
FIGURE 12: AVERAGE AUTO OCCUPANCY RATES BY TIME PERIOD, AREA TYPE, AND FACILITY TYPE 20
FIGURE 13: OVERALL VEHICLE CLASSIFICATION PERCENTAGES – ALL AREA TYPES AND FACILITY TYPES 28
FIGURE 14: VEHICLE CLASSIFICATION PERCENTAGES – ALL FREEWAY FACILITIES 29
FIGURE 15: VEHICLE CLASSIFICATION PERCENTAGES – ARTERIALS 30
FIGURE 16: PERCENTAGE OF HIGH OCCUPANCY PASSENGER VEHICLES IN GENERAL PURPOSE LANES 37
FIGURE 17: HIGH OCCUPANCY VEHICLE LANE OVERALL VIOLATION PERCENTAGE 43
FIGURE 18: OVERALL HOV LANE VIOLATION PERCENTAGE BY SPECIFIC FREEWAY 43
FIGURE 19: PEAK HOUR HOV EFFICIENCY, SITE 1 49

FIGURE 20: PEAK HOUR HOV EFFICIENCY, SITE 8 49
FIGURE 21: PEAK HOUR HOV EFFICIENCY, SITE 15 49
FIGURE 22: PEAK HOUR HOV EFFICIENCY, SITE 18 49
FIGURE 23: PEAK HOUR HOV EFFICIENCY, SITE 21 49
FIGURE 24: PEAK HOUR HOV EFFICIENCY, SITE 22 49
FIGURE 25: PEAK HOUR HOV EFFICIENCY, SITE 28 50
FIGURE 26: PEAK HOUR HOV EFFICIENCY, SITE 31 50
FIGURE 27: PEAK HOUR HOV EFFICIENCY, SITE 35 50
FIGURE 28: PEAK HOUR HOV EFFICIENCY, SITE 36 50
FIGURE 29: PEAK HOUR HOV EFFICIENCY, SITE 37 50
FIGURE 30: PEAK HOUR HOV EFFICIENCY, SITE 38 50
FIGURE 31: HOV EFFICIENCY, ALL HOV FREEWAY SITES, AM PEAK HOUR 51
FIGURE 32: HOV EFFICIENCY, ALL HOV FREEWAY SITES, PM PEAK HOUR 51
FIGURE 33: HOV EFFICIENCY, ALL HOV FREEWAY SITES, AM + PM PEAK HOUR 51
FIGURE 34: PEAK HOUR HOV LANE EFFICIENCY 52
FIGURE 35: CONGESTION PERIOD HOV EFFICIENCY, SITE 8 53
FIGURE 36: CONGESTION PERIOD HOV EFFICIENCY, SITE 22 53
FIGURE 37: CONGESTION PERIOD HOV EFFICIENCY, SITE 31 54
FIGURE 38: CONGESTION PERIOD HOV EFFICIENCY, SITE 36 54
FIGURE 39: CONGESTION PERIOD HOV LANE EFFICIENCY 55

EXECUTIVE SUMMARY

Introduction

The Phoenix metropolitan area has continued to experience tremendous growth in recent years as an influx of new residents from all over the country and the world have settled in the region. This population increase has an effect on all reaches of the public, generating different trends and higher levels of commerce, consumption, trade, and travel.

In response to this growth, the Phoenix metropolitan area transportation infrastructure network has greatly expanded. New arterial roadways, freeways, and corresponding high occupancy vehicle (HOV) lanes have been constructed throughout the region, keeping up with the sprawling built environment. The Phoenix regional freeway system, under intensive use by daily commuting travel, has grown two-fold since 1992, increasing from approximately 200 directional miles of freeways to 400 directional miles of freeways presently. The recent construction has completed several new freeways in the region, and the Phoenix metropolitan area is now nearly fully served by I-10, I-17, US 60, SR 51, SR 143, Loop 101, and Loop 202.

The Maricopa Association of Governments (MAG), as the Phoenix Metropolitan planning organization, attempts to monitor the usage, travel behaviors, and patterns of the freeway and arterial facilities in the region. There are several goals for this study, which will provide MAG with an array of existing conditions data. This data will be intensively used by MAG for travel demand model calibration and mobility monitoring purposes.

One of the main goals of the 2006 MAG Vehicle Occupancy Study is to update the occupancy profile of the regional transportation system for travel demand forecasting model calibration. Occupancy data for this purpose is separated based on three main parameters; area type, facility type, and time of day. The collection and analysis of all of the occupancy data falls into these three parameters.

A second goal of the study is to investigate vehicle occupancy rate trends and patterns in the region. Since 1973, several MAG occupancy studies have been performed and a significant amount of data has been compiled, with the last study occurring in 1992. This study allows for continued comparison of the occupancy rates over the passage of time.

An additional goal of this study is to provide an evaluation of the HOV lanes in the region. Data and analysis will aid MAG in their continued monitoring of HOV lane usage. This includes investigations into HOV usage, the violations of the HOV lanes, and how efficient HOV lanes perform during all times of the day, including during the AM and PM peak hours, and during times of freeway congestion (defined as 35 mph traveling speed or below, determined through comprehensive speed data collection within the study).

Vehicle classification is another important focus of this report. Conclusions made related to the types of vehicles traveling around and through the Phoenix Metropolitan area will assist in the calibration of the MAG truck travel model, and have the possibility to be used in future pavement design and noise studies, or among other areas. Current vehicle classification data was collected for these purposes.

Study Requirements and Data Collection

Three types of data were required by MAG to be collected, including: vehicle occupancy, vehicle classification, and vehicle speed. The design of this data collection effort required the consideration of several distinct parameters, including: area type, facility type, and time of day, which are integral pieces of the MAG planning models, and account for much of the variation in the collected and analyzed data. Taking into account these parameters, the collection of data at a total of 119 sites was undertaken, providing a succinct statistical analysis of the traveling situation of the entire MAG region.

It was concluded that at each site location, all required data would be collected continuously throughout the entire day, from 6AM to 7PM. This data was collected only on Tuesdays, Wednesdays, or Thursdays during the week, avoiding holidays, the summertime period, and the dark winter months. On HOV Freeway locations, during the morning and evening/night peak hours (6-9AM and 3-7PM), traffic data collection efforts alternated in 5 minute intervals between the HOV Lane and Lane 2 (second general purpose lane from shoulder), beginning with the HOV Lane in the first interval. At all other off-peak hours of the day (9AM-3PM) the traffic data was collected on each lane, one at a time, in reoccurring order, at 5-minute intervals. On Freeway locations without an HOV lane and Arterial roadway locations, data collection efforts alternated through all lanes of traffic, one at a time, for all hours of the day (6AM-7PM), at 5-minute intervals, beginning with the median lane.

Vehicle volume, occupancy, and classification data was accrued through the use of hand-held JAMAR Technologies, Inc electronic count boards. The data collection technicians synchronized their cell phone clocks with the clocks on the data collection unit to begin the count at exactly 6:00AM. Throughout the count day, each button that was pressed accounted for the visually determined occupancy and classification of each vehicle that passed along the facility. The volumes are then automatically cumulated continuously: one button, one vehicle. The data collection unit let out an audio beep every five minutes, this signaled an interval change within the unit, and directed the technicians to switch to count the next lane.

Area Type

The Area Type of roadways within the MAG planning region is determined based on the intensity of employment and population density of a specific area. MAG uses a total of five stratifications of area type based on these intensities, calculated as the total population summed with two times the employment divided by the area. The five area types are expressed as:

1. Central Business District (CBD) (Intensity = >20,000)
2. Outlying CBD (Intensity = 10,001 – 20,000)
3. Mixed Urban (Intensity = 5,001 – 10,000)
4. Suburban (Intensity = 1,001 – 5,000)
5. Rural (Intensity = 0 – 1,000)

For the purposes of this study, area types 1 and 2 are combined into the “CBD” area type, area type 3 is referred to as the “Urban” area type, and area types 3 and 4 are combined into the “Suburban” area type.

Facility Type
The facility type of the roadways on which data has been collected is categorized by general functional classification. For the purposes of this study, the facility types are broken down into three designations, High Occupancy Vehicle Freeways (HOV Freeways), non-HOV Freeways (Freeways), and Arterials.

"HOV Freeways" are those freeway facilities that include priority or High Occupancy Vehicle (HOV) lanes, in addition to general purpose lanes. The HOV lane functional hours throughout the region are 6-9AM and 3-7PM.

The "Freeway" facility type used within this report is described as a freeway that contains general purpose lanes exclusively, HOV lanes are not present on these freeway facilities.

"Arterial" facilities are described as typical city streets; those that are functionally classified as an arterial roadway.

An overall map of the Phoenix metropolitan area roadway system, depicted by area and facility type is presented in *Figure ES-1: Area and Facility Types within the MAG Region*.

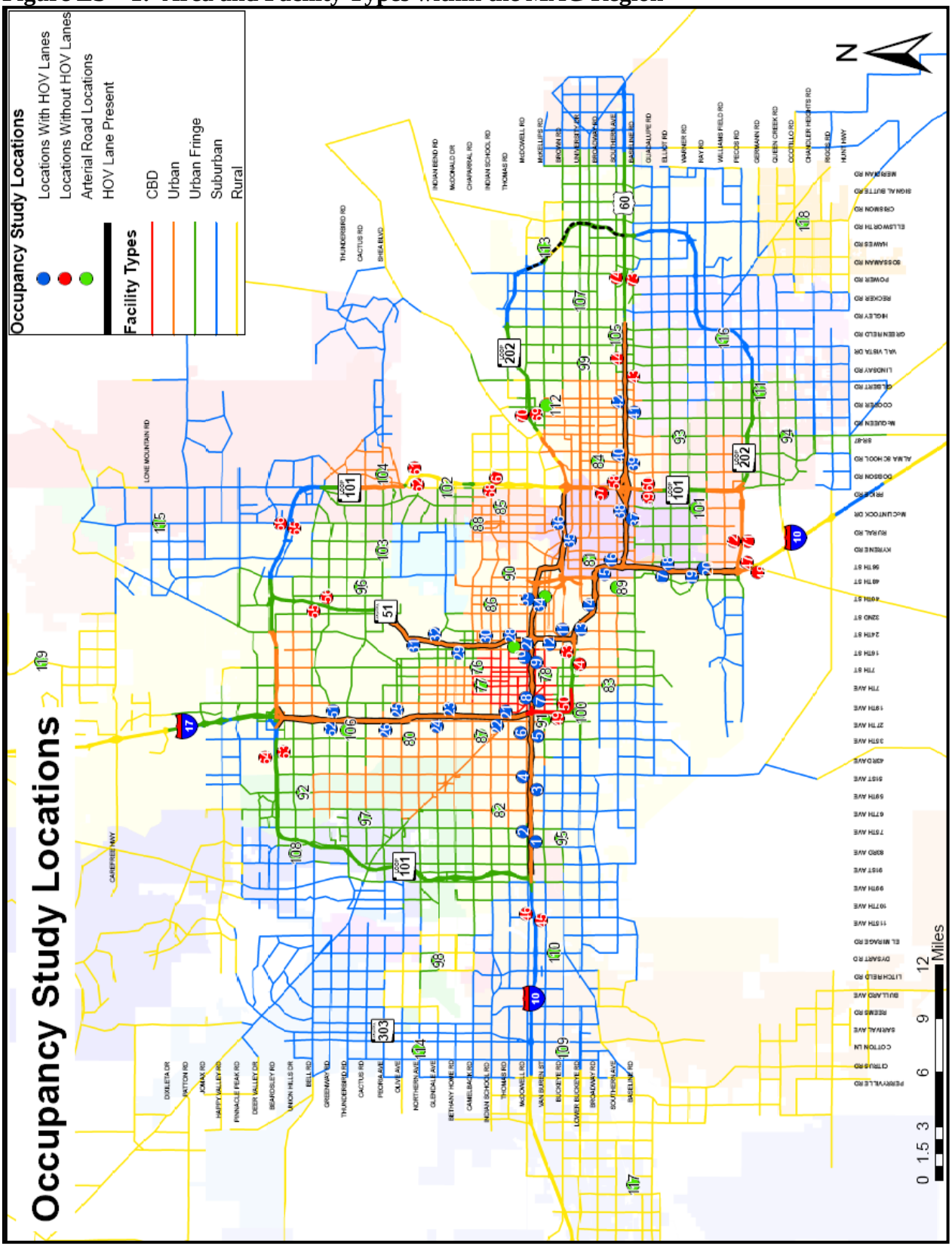
Time of Day
Data collection at each subject site took place continually from 6AM-7PM. *Table ES – 1: Study Time Periods*, details the breakdown of time periods for each time of day for this study.

Table ES – 1: Study Time Periods

Time of Day	Time Period Designation	HOV Lane Function
6AM – 9AM	**AM Peak**	**High Occupancy Vehicles Only**
9AM – 12PM	Morning	General Purpose
12PM – 3PM	Midday	
3PM – 6PM	**PM Peak**	**High Occupancy Vehicles Only**
6PM – 7PM	**Night**	

Of note, the PM peak hour in this study lasts from 3-6PM, however, with respect to in-field HOV lane function on HOV freeways throughout the region, the PM HOV hours are designated as 3-7PM.

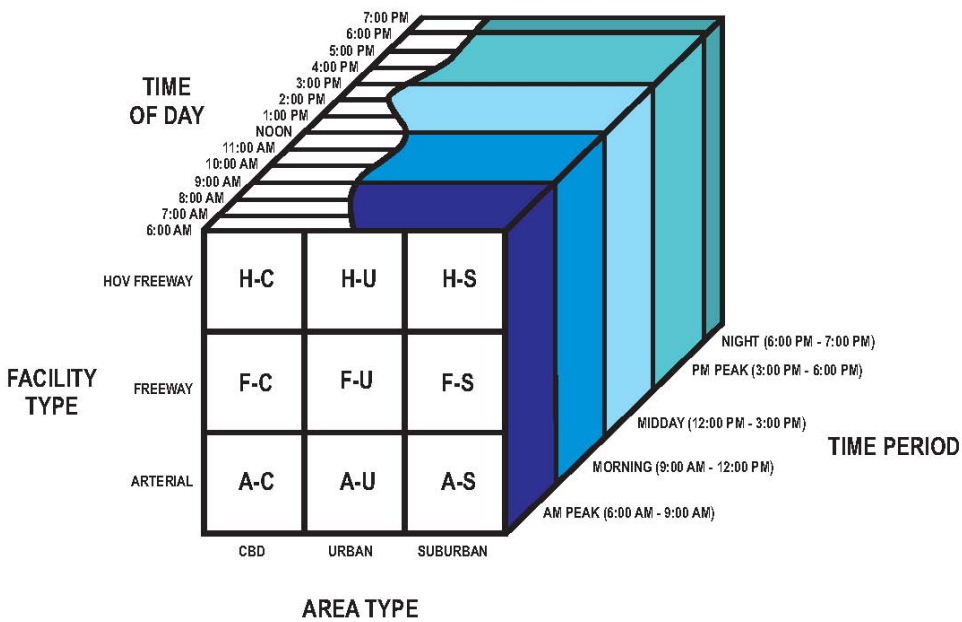
Figure ES – 1: Area and Facility Types within the MAG Region



Project Design, "The Cube"

An experimental design approach was initiated in the 1992 vehicle occupancy study *1992 Study of Occupancy and Vehicle Classification in the Metropolitan Phoenix Area*[1]. In this study, the experimental design uses a 3 by 3 by 5 factorial design, with the parameters of Area Type, Facility Type, and Time Period forming "The Cube" as depicted in *Figure ES – 2: Design of "The Cube"*.

Figure ES – 2: Design of "The Cube"



Within "The Cube", the vehicle occupancy variations relative to each parameter can be determined. Data from a sufficient amount of samples (Sites) for each portion of "The Cube" were collected. Exceptions include Suburban-HOV Freeways, of which no samples exist based on the definitions of "Suburban" intensities; and CBD-Freeways, of which only two samples exist due to the fact that the majority of the freeway facilities within the CBD area are HOV freeways. *Table ES – 2: Number of Sites Surveyed by Area Type and Facility Type* presents the total number of sample sites collected for each segment of "The Cube". For all sample sites, the vehicle occupancy data was collected continuously for all times of day (6AM-7PM).

Table ES – 2: Number of Sites Surveyed by Area Type and Facility Type

		FACILITY TYPE		
		HOV Freeway	Freeway	Arterial
AREA TYPE	CBD	7	2	4
	Urban	37	19	32
	Suburban	0	9	9

[1] 1992 Study of Occ. and Vehicle Classification in the Metro. Phoenix Area, Lee Eng., February 1993.

Results

To determine auto occupancy rates in the region, approximately 1,290,000 passenger vehicles and their occupancy data were collected in-field. The term "Auto", as in auto occupancies, refers only to the passenger vehicle classification data. Only the 1 person passenger vehicle, 2 person passenger vehicle, 3 person passenger vehicle, and 4+ person passenger vehicle data is included, the other classifications of vehicles are not included. For the purposes of the analysis, the 4+ person parameter has been determined to have a value of 4.2 persons.

The overall auto occupancy for the region was found to be **1.23**, which has been determined by the division of the overall total number of auto occupants by the overall total number of passenger vehicles for all area types, facility types and time periods. The overall vehicle occupancy for the region was found to be 1.26, which has been determined by the division of the overall total number of vehicle occupants by the overall total number of all vehicles for all area types, facility types and time periods. This auto and vehicle occupancy data was determined through the continuous 13 hours of data collection at each subject site. In 1992, the overall auto occupancy was determined to be higher, 1.34.

Through statistical analysis, it was found that occupancy samples are different, varying by the three factors, Area Type, Facility Type and Time of Day. *Figure ES – 3: Average Auto Occupancy vs Area Type* illustrates the variability in auto occupancy base on the CBD, Urban, and Suburban area types. As can be seen, the CBD and Urban area types have the highest overall auto occupancy, 1.25. The lowest auto occupancy occurs in the Suburban area type, 1.12.

Figure ES – 3: Average Auto Occupancy vs Area Type

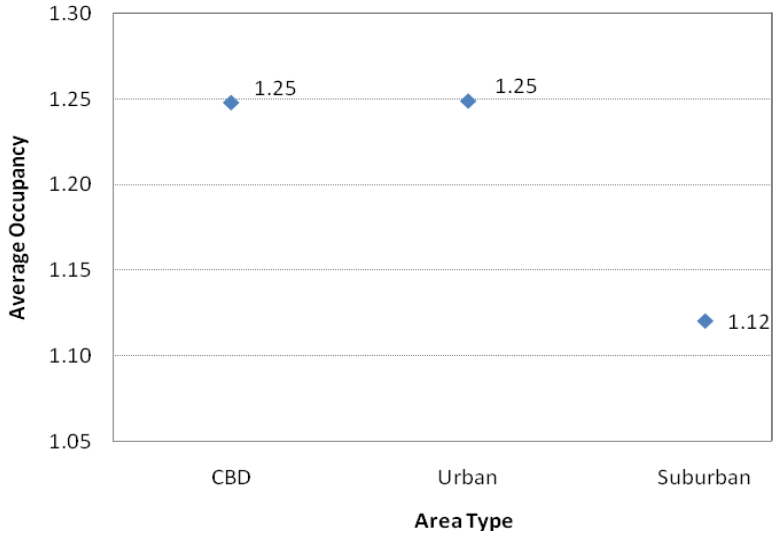


Figure ES – 4: Average Auto Occupancy vs Facility Type, depicts the overall auto occupancy rates based on the HOV Freeway, Freeway, and Arterial facility types. As expected, HOV Freeways, which promote the use of high occupancy travel, have the greatest average auto occupancy rates, 1.35. The lowest auto occupancies occur on non-HOV Freeway facilities, 1.11,

and Arterial roadways have an average auto occupancy of 1.18. Conversely, in the 1992 study it was found that the Arterial facility type had the highest overall average auto occupancy, at 1.34.

Figure ES – 4: Average Auto Occupancy vs Facility Type

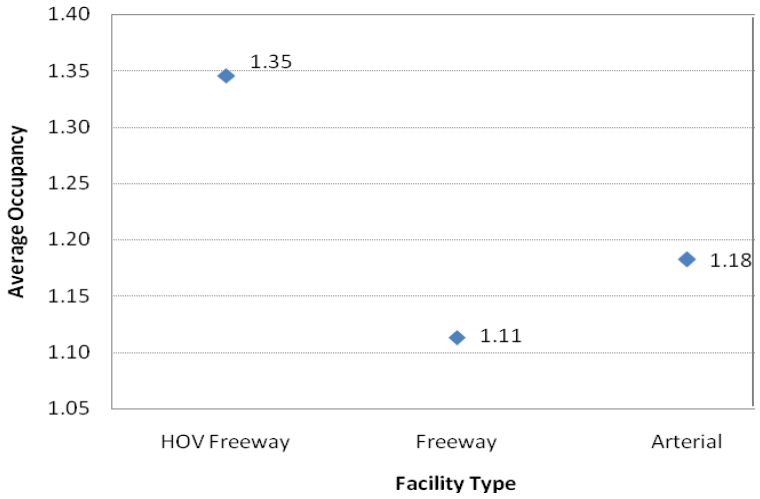
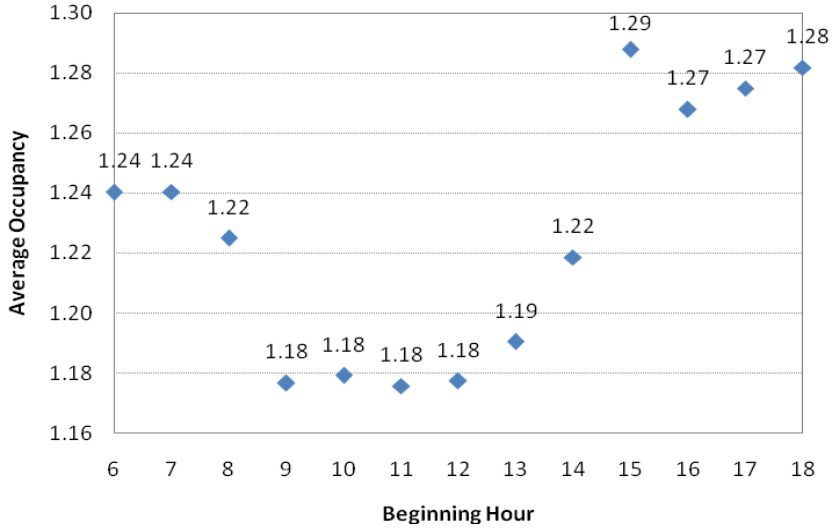


Figure ES – 5: Average Auto Occupancy vs Time of Day presents the overall average auto occupancy versus the time of day (shown as beginning hour for each hour designation). As illustrated in the figure, the morning peak hours (6-9AM) tend to have lower auto occupancies compared to the evening peak hours (3-7PM). In addition, there is a drop in auto occupancy during the Morning and Mid-day time periods (9AM-3PM), mostly apparent due to the HOV lanes on the freeways during this time acting as general purpose lanes. In the 1992 study, however, the average auto occupancy rates were found to be higher in the mid-day than in the morning peak hours.

Figure ES – 5: Average Auto Occupancy vs Time of Day

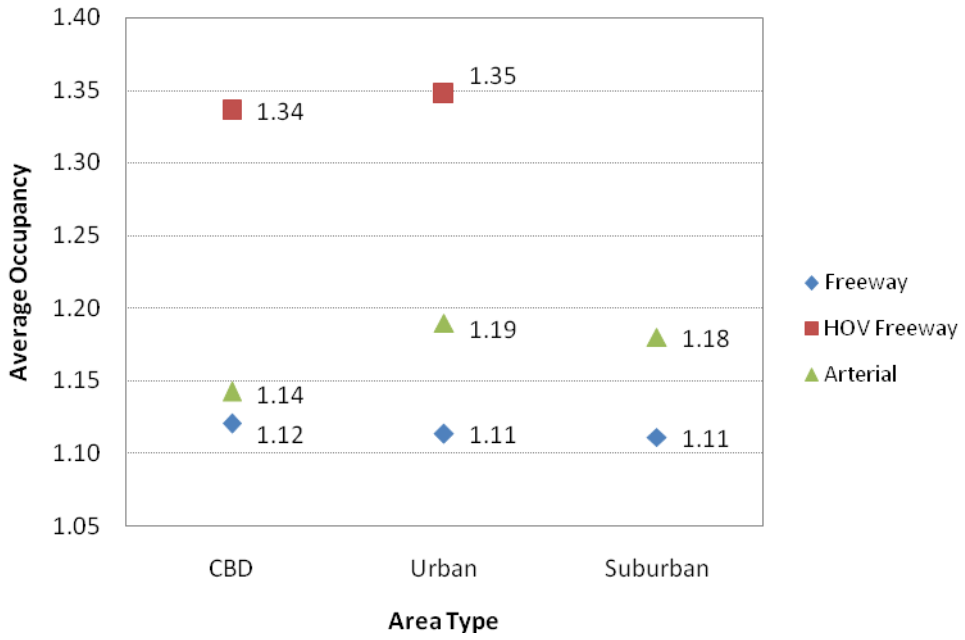


Variations in average auto occupancy due to area type and facility type are tabulated in *Table ES – 3: Average Auto Occupancy vs Area Type and Facility Type*, and illustrated in *Figure ES – 6: Average Auto Occupancy vs Area Type and Facility Type*.

Table ES – 3: Average Auto Occupancy vs Area Type and Facility Type

Area Type	HOV Freeway	Freeway	Arterial
CBD	1.34	1.12	1.14
Urban	1.35	1.11	1.19
Suburban	-	1.11	1.18

Figure ES – 6: Average Auto Occupancy vs Area Type and Facility Type



This graphic shows the wide variation in average auto occupancy in the CBD and Urban area types, with the HOV Freeways having, as expected, much higher occupancies in these area types. As stated previously, there are no existing HOV Freeways within the Suburban area type. Overall, average auto occupancies on Arterial facilities within the CBD area type are lower than in the Urban and Suburban area types.

Table ES – 4: Average Auto and Vehicle Occupancies by Area Type, Facility Type, and HOV Freeways depicts the average auto occupancies by Area Type, Facility Type alone, and average auto occupancies during the peak hours on the HOV freeways.

Table ES – 4: Average Auto and Vehicle Occupancies by Area Type, Facility Type, and HOV Freeways

Area Type		Facility Type		All HOV Freeways	
CBD	1.25	**HOV Freeway**	1.35	**AM Peak Hour**	1.42
Urban	1.25	**Freeway**	1.11	**PM Peak Hour**	1.45
Suburban	1.12	**Arterial**	1.18		

Variation in auto occupancy through the years is another important trend that has been tracked through this study. Incorporated in the 119 sites of this study are six sites that have been previously studied in reports from the past as shown in *Table ES – 5: Sites with data from previous studies*.

Table ES – 5: Sites with Data from Previous Studies

SITE	LOCATION	FROM	TO	DIRECTION
13	I-10	24th St	32nd St	EB
21	I-17	Thomas Rd	Indian School Rd	NB
76	7th St	Camelback Rd	Indian School Rd	SB
84	Broadway Rd	E. of Dobson Rd	Alma School Rd	EB
87	Indian School Rd	W. of 27th Ave	35th Ave	WB
90	Thomas Rd	48th St	52nd St	WB

The overall 12-hour auto occupancy from these six previous sites, as determined in the 1973, 1974, 1977, 1978, 1980, 1981, 1982, 1988, 1992, and this 2006 study, is shown on the following page in *Table ES – 6: Comparison of Auto Occupancy Rates*.

Table ES – 6: Comparison of Auto Occupancy Rates

	STUDY YEAR – 12 HR AVERAGE AUTO OCCUPANCY										
SITE	**73**	**74**	**77**	**78**	**79**	**80**	**81**	**82**	**88**	**92**	**06**
21 (I-17)	-	1.29	1.25	1.31	1.33	1.29	1.29	1.31	1.27	1.28	1.27
84 Broadway	1.43	1.43	1.39	1.35	1.33	1.35	1.34	1.40	1.33	1.32	1.13
87 Indian School	-	1.36	1.28	1.29	1.30	1.27	1.28	1.26	1.32	1.34	1.22
76 7th Street	-	1.30	1.29	1.26	1.29	1.25	1.24	1.25	1.25	1.30	1.23
90 Thomas	-	1.31	1.28	1.27	1.32	1.29	1.27	1.31	1.27	1.28	1.22
13 (1-10)	-	-	1.26	1.30	1.33	1.30	1.28	1.30	1.19	1.26	1.27

Vehicle Classification

Vehicle classification data was obtained as part of the overall data collection process. Five separate categories of vehicle classifications were obtained which included motorcycles, buses, passenger vehicles, delivery vehicles, and heavy vehicles. The five categories collected as part of this study correspond to the FHWA vehicle classification groups as shown in Table 5 on page 11 of the report.

Table ES – 7: Overall Vehicle Classification Percentages – All Area Types and Facility Types by Time of Day below shows the region-wide classification of vehicles.

Table ES – 7: Overall Vehicle Classification Percentages – All Area Types and Facility Types by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	0.96%	0.44%	93.54%	1.42%	3.64%
7AM - 8AM	0.81%	0.40%	94.50%	1.18%	3.11%
8AM - 9AM	0.59%	0.39%	93.60%	1.47%	3.95%
9AM - 10AM	0.33%	0.28%	93.07%	1.69%	4.63%
10AM - 11AM	0.35%	0.22%	93.00%	1.82%	4.61%
11AM - 12PM	0.35%	0.23%	93.39%	1.66%	4.38%
12PM - 1PM	0.39%	0.21%	93.84%	1.54%	4.02%
1PM - 2PM	0.41%	0.25%	94.27%	1.52%	3.55%
2PM - 3PM	0.44%	0.30%	94.67%	1.53%	3.06%
3PM - 4PM	0.66%	0.36%	95.24%	1.19%	2.55%
4PM - 5PM	0.75%	0.33%	96.06%	0.93%	1.92%
5PM - 6PM	0.77%	0.30%	96.55%	0.78%	1.61%
6PM - 7PM	0.70%	0.22%	96.54%	0.61%	1.93%
OVERALL	**0.58%**	**0.30%**	**94.54%**	**1.32%**	**3.26%**

The classifications were broken down further by specific freeway facility to examine their classification differences. It was determined through the data for specific freeway designations that the interstate freeways through the Phoenix metro area (I-10 and I-17) carry a higher percentage of truck traffic as compared to the non-interstate freeway facilities (SR 51, US 60, Loop 101, Loop 202); with I-10 having the highest heavy vehicle percentages of the overall total, at 6.51% heavy vehicles.

Evaluation of HOV Lanes

The existing Phoenix metropolitan area freeway system contains 145 directional miles of HOV lanes. According the MAG's Regional Transportation Plan, HOV facilities in the area are programmed to expand even further, including adding the first HOV lanes on Loop 101.

Through continued HOV lane study, the function of HOV lanes has been adjusted to meet current travel conditions. In 1992, HOV lanes existed as all-day HOV priority lanes. They have since been adjusted to function as HOV priority lanes during the AM (6-9AM) and PM (3-7PM) peak "rush hours" and function as general purpose lanes for all other times of the day.

HOV Lane Utilization and Occupancy

During the peak hours of the day, only autos of 2+ persons, motorcycles, buses, and some alternative fuel vehicles are permitted on the HOV Lanes, whereas during the rest of the day, the HOV Lane acts as a general purpose lane for all types of vehicles. Due to this, occupancies of the HOV Lane during the peak hours should approach 2.0+, assuming zero violators. *Table ES – 8: Auto Occupancies of HOV Lanes and General Purpose (GP) Lanes* depicts the average auto occupancies of those lanes for all HOV Freeway facilities.

Table ES – 8: Peak Hour Auto Occupancies of HOV Lanes and General Purpose Lanes

Time Period	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes
	Site 1		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
AM Peak	1.97	1.15	2.00	1.25	1.94	1.06	2.09	1.22	1.84	1.14	1.97	1.26
PM Peak	1.96	1.25	1.94	1.13	1.94	1.21	2.02	1.14	1.91	1.30	1.97	1.21
	Site 7		**Site 8**		**Site 9**		**Site 10**		**Site 11**		**Site 12**	
AM Peak	1.79	1.17	2.05	1.11	1.77	1.09	2.05	1.11	1.94	1.15	1.96	1.38
PM Peak	1.95	1.23	1.97	1.22	2.07	1.19	2.03	1.18	1.94	1.24	2.01	1.24
	Site 13		**Site 14**		**Site 15**		**Site 16**		**Site 17**		**Site 18**	
AM Peak	1.90	1.18	1.92	1.17	1.89	1.12	2.01	1.13	1.91	1.07	2.02	1.11
PM Peak	1.84	1.11	2.00	1.22	1.99	1.04	2.05	1.29	1.93	1.08	2.02	1.16
	Site 19		**Site 20**		**Site 21**		**Site 22**		**Site 23**		**Site 24**	
AM Peak	1.98	1.12	2.08	1.14	1.80	1.14	1.84	1.30	1.91	1.30	1.76	1.09
PM Peak	1.98	1.06	2.07	1.34	1.75	1.07	1.88	1.30	1.94	1.18	1.90	1.22
	Site 25		**Site 26**		**Site 27**		**Site 28**		**Site 29**		**Site 30**	
AM Peak	1.91	1.19	1.84	1.08	1.81	1.13	1.86	1.20	1.89	1.10	1.85	1.24
PM Peak	1.87	1.23	1.92	1.24	1.79	1.12	1.86	1.16	1.84	1.24	1.91	1.12
	Site 31		**Site 32**		**Site 33**		**Site 34**		**Site 35**		**Site 36**	
AM Peak	1.78	1.07	1.87	1.23	1.98	1.05	1.95	1.15	1.95	1.16	1.93	1.14
PM Peak	1.84	1.25	1.88	1.11	1.98	1.14	2.01	1.15	1.95	1.14	1.97	1.27
	Site 37		**Site 38**		**Site 39**		**Site 40**		**Site 41**		**Site 42**	
AM Peak	1.97	1.22	1.81	1.08	1.90	1.14	1.92	1.06	2.16	1.18	1.93	1.11
PM Peak	1.96	1.16	1.90	1.18	1.97	1.13	1.91	1.11	1.98	1.15	2.00	1.30
	Site 51		**Site 52**									
AM Peak	1.88	1.18	1.77	1.10								
PM Peak	1.75	1.09	1.93	1.28								

As shown in Table ES – 8, auto occupancies during the peak hours on the HOV Lanes are significantly higher than on the general purpose lanes, although due to violations, they are not always greater than 2.0.

HOV Lane Violations

Priority lane violations occur when during the times of HOV lane function peak hours (6-9AM, 3-7PM) single occupant vehicles are utilizing the HOV Lane. Violation rates at all HOV freeway sites have been tabulated and are graphically depicted in *Figure ES – 7: High Occupancy Vehicle Lane Overall Violation Percentage* on the following page. This figure shows the overall system's hourly violation rate percentages for the whole count day. During the off-peak hours, there are no HOV violations, as the HOV lane functions as a general purpose lane.

Figure ES – 7: High Occupancy Vehicle Lane Overall Violation Percentage

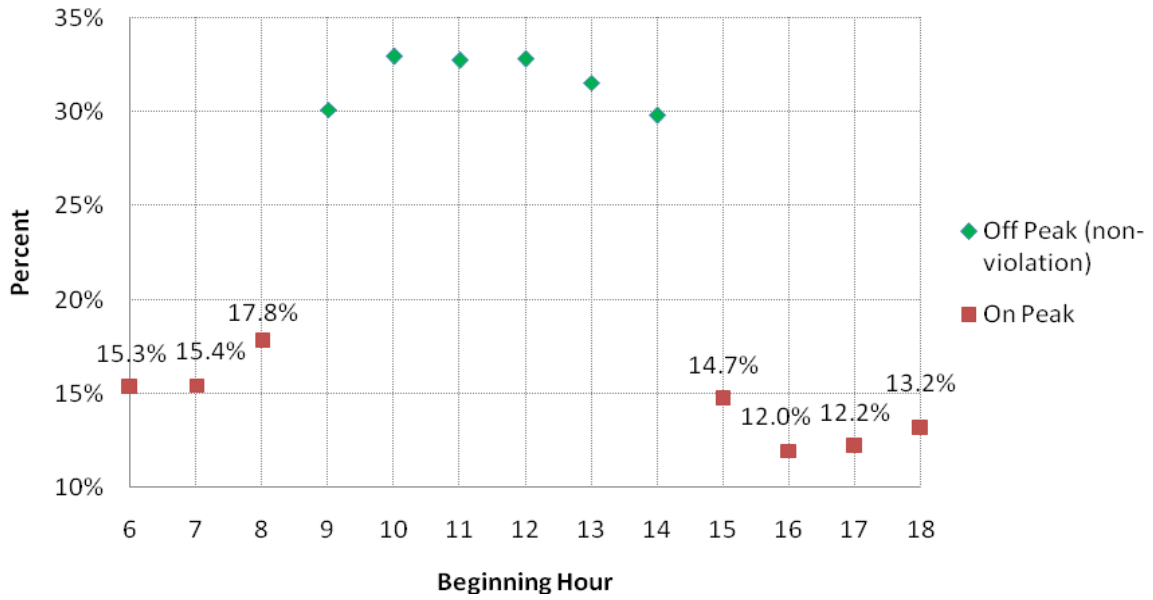
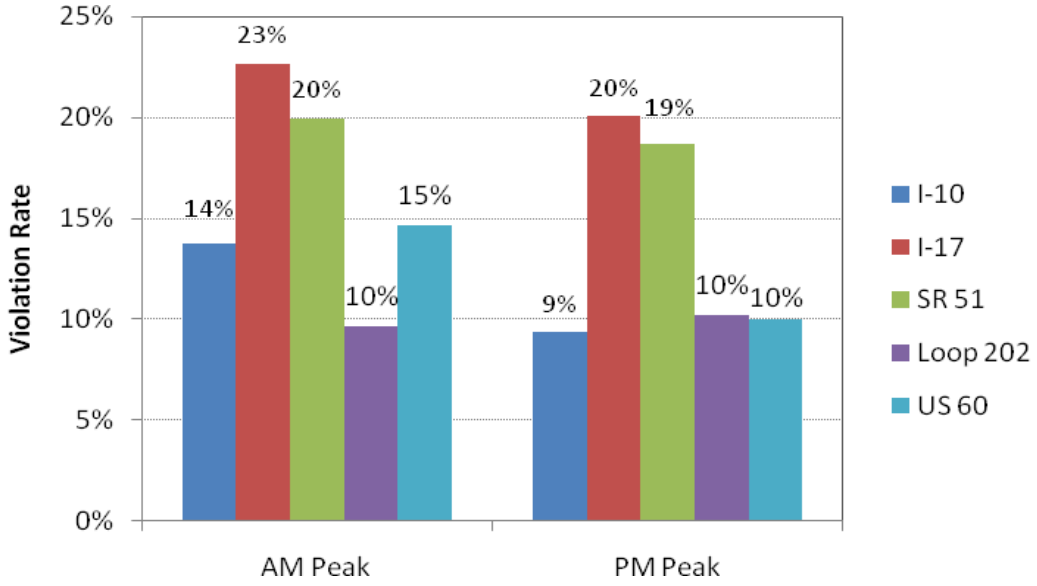


Figure ES – 8: Overall HOV Lane Violation Percentage by Specific Freeway, illustrates the on-peak hour violation rates separately for each specific freeway in the system that has an HOV Lane.

Figure ES – 8: Overall HOV Lane Violation Percentage by Specific Freeway



Violation rates during the HOV Lane function peak hours are approximately 15%. Overall, Interstate 17 has the highest rate of violation for a specific freeway, followed by SR 51.

There are several functional reasons for the higher violation rates present in the MAG region today. Unlike other HOV systems in use throughout the country, the MAG regional freeway

system's HOV lanes are not separated by a barrier from the general purpose lanes. This makes it easy for a violator to use the HOV Lane as a passing lane to accelerate, or as a temporal express lane to avoid congestion. In addition, the HOV lanes are not a 24/7 HOV lane, as they revert back to general purpose lanes for all non-peak hour times of the day. Finally, fuel efficient/hybrid vehicles, many of which are typically used by single passenger vehicles are permitted on the HOV Lanes during the peak hours.

HOV Lane Efficiency

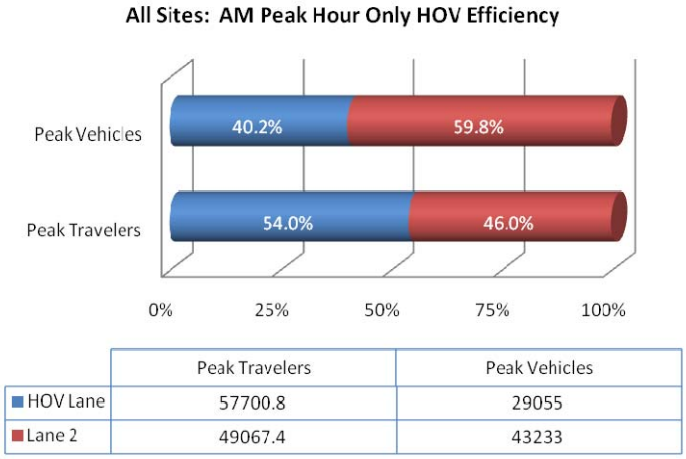
One of the desired goals of an HOV Lane is to move more travelers per vehicle, thereby increasing the overall efficiency of the facility. One important evaluation of the efficiency of HOV Lanes is to compare how it functions relative to the function of a general purpose lane. Over a specific period of time, an HOV lane operates more efficiently than a general purpose lane when it conveys more persons (greater than 50% of the total of persons of both lanes) even though the raw volume of vehicles using that facility is normally lower. The comparison of AM and PM peak hour efficiency for the HOV Lane and general purpose lane (Lane 2) is tabulated in *Table ES – 9: Peak Hour HOV Lane Efficiency Data* below.

Table ES – 9: Peak Hour HOV Lane Efficiency Data

	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2
	ALL Sites - AM & PM		All Sites - AM Only		All Sites - PM Only	
Peak Travelers	137843	125023	57701	49067	80143	75955
Peak Vehicles	68684	109094	29055	43233	39629	65861
Travelers Percent	52.4%	47.6%	54.0%	46.0%	51.3%	48.7%
Vehicles Percent	38.6%	61.4%	40.2%	59.8%	37.6%	62.4%

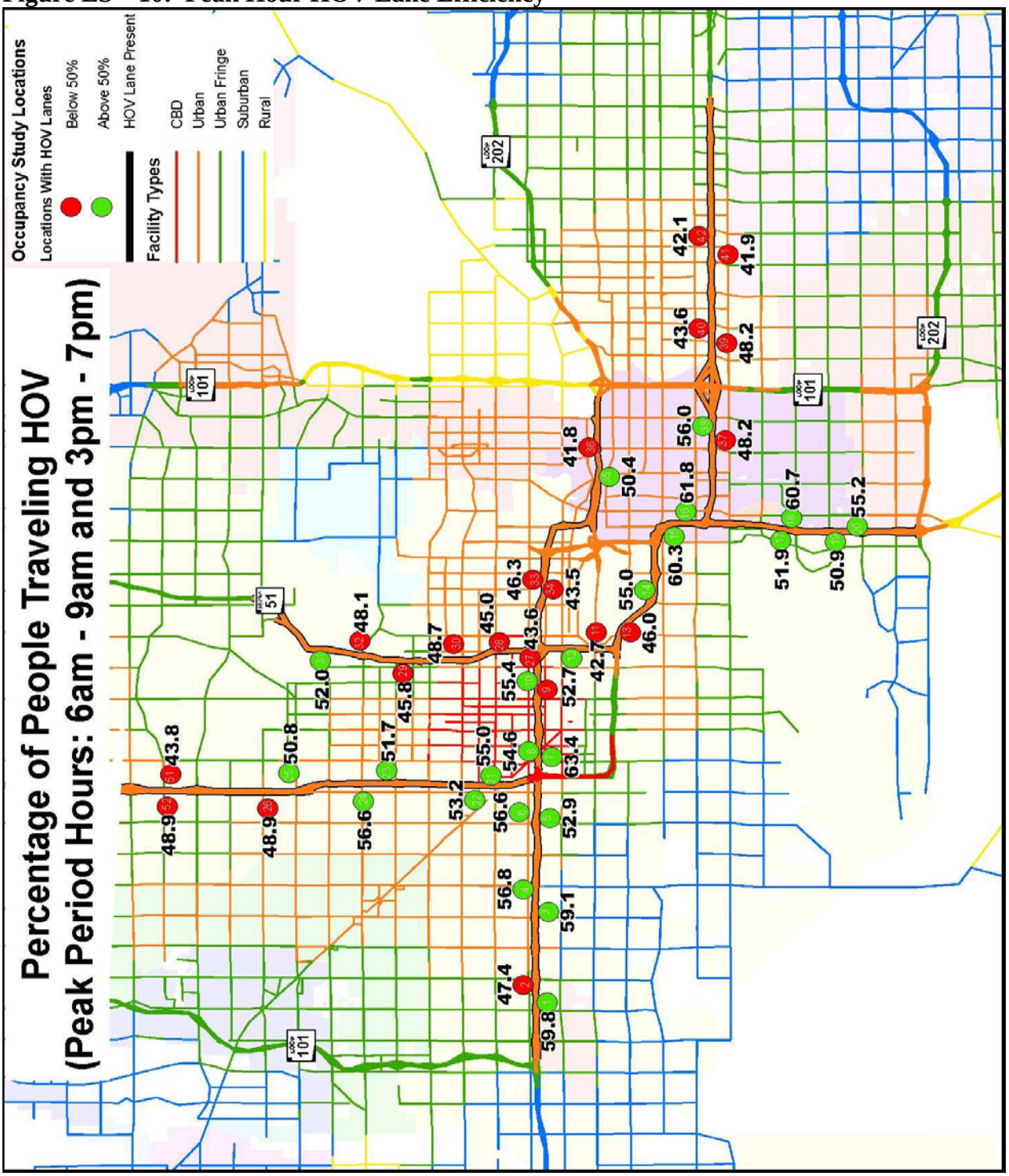
As shown, for each peak time period, the total number of peak hour vehicles traveling Lane 2 is greater than the total number of peak hour vehicles traveling the HOV Lane. Conversely, during the same time, the total number of persons traveling the HOV Lanes during the peak hour is greater, demonstrating higher HOV efficiency. *Figure ES – 9: HOV Efficiency, ALL HOV Freeway Sites, AM + PM Peak Hour* illustrates the efficiency of HOV Lanes for all HOV freeway sites during all peak hours.

Figure ES – 9: HOV Efficiency, ALL HOV Freeway Sites, AM + PM Peak Hour



As illustrated in the previous table and figure, the HOV Lane is more efficient than the general purpose lane, Lane 2, taking the overall system into account. An overview map, *Figure ES – 10: Peak Hour HOV Lane Efficiency* depicts the HOV efficiency at each site location.

Figure ES – 10: Peak Hour HOV Lane Efficiency



Recommendations for Subsequent Studies

During the data collection process, several issues were encountered, hindering the occupancy counts of this study. Due to permit restrictions required to count on ADOT right-of-way and the prevelence of dark tinted windows, it became difficult to accurately count occupancies during the 13 hour count day. It would be advantageous to develop a more effective and accurate way to collect the 13 continuous hours of data in the field.

Additional count sites in locations and on facilities generally ignored in this data collection effort should be studied, including areas of the rapidly growing west valley, and the facilities of Grand Avenue, Loop 303, and SR 143.

Continued monitoring and study of the occupancy and vehicle classification trends would be beneficial. Fifteen years has passed since the last study of this kind, and much has changed in the region. If similar studies in size and scope to this study were undertaken more regularly, beneficial trends could be more closely tracked.

Continue to monitor the occupancy rates on a few selected locations in the region at higher intervals (yearly, bi-yearly, quarterly, etc.) in order to grasp its trends.

2006 Maricopa Association of Governments Vehicle Occupancy Study

Final Report

Prepared for:

Maricopa Association of Governments

302 N. 1st Avenue, Suite 300

Phoenix, Arizona 85003

Prepared by:

United Civil Group Corporation

2803 N. 7th Avenue

Phoenix, Arizona 85007

September 2007

SECTION 1: INTRODUCTION

The Phoenix metropolitan area has continued to experience tremendous growth in recent years as an influx of new residents from all over the country and the world have settled in the region. The population of Maricopa County has grown from 2,122,101 in 1990, to an estimated year 2006 population of 3,768,123[1]. This population increase has an effect on all reaches of the public, generating different trends and higher levels of commerce, consumption, trade, and travel.

In response to this growth, the Phoenix metropolitan area transportation infrastructure network has greatly expanded. New arterial roadways, freeways, and corresponding high occupancy vehicle (HOV) lanes have been constructed throughout the region, keeping up with the sprawling built environment. The Phoenix regional freeway system, under intensive use by daily commuting travel, has grown two-fold since 1992, increasing from approximately 200 directional miles of freeways to 400 directional miles of freeways. The recent construction has completed several new freeways in the region, and the Phoenix metropolitan area is now nearly fully served by I-10, I-17, US 60, SR 51, SR 143, Loop 101, and Loop 202.

The Maricopa Association of Governments (MAG), as the Phoenix Metropolitan planning organization, attempts to monitor the usage, travel behaviors, and patterns of the freeway and arterial facilities in the region. There are several goals for this study, which will provide MAG with an array of existing conditions data. This data will be intensively used by MAG for travel demand model calibration and mobility monitoring purposes.

One of the main goals of the 2006 MAG Vehicle Occupancy Study is to update the occupancy profile of the regional transportation system for travel demand forecasting model calibration. Occupancy data for this purpose is separated based on three main parameters; area type, facility type, and time of day. The collection and analysis of all of the occupancy data falls into these three parameters.

A second goal of the study is to investigate vehicle occupancy rate trends and patterns in the region. Since 1973, several MAG occupancy studies have been performed and a significant amount of data has been compiled, with the last study occurring in 1992. This study allows for continued comparison of the occupancy rates over the passage of time.

An additional goal of this study is to provide an evaluation of the HOV lanes in the region. Data and analysis will aid MAG in their continued monitoring of HOV lane usage. This includes investigations into HOV usage, the violations of the HOV lanes, and how efficient HOV lanes perform during all times of the day, including during the AM and PM peak hours, and during times of freeway congestion (defined as 35 mph traveling speed or below, determined through comprehensive speed data collection within the study).

[1] Source: United States Census Bureau, 2007.

Vehicle classification is another important focus of this report. Conclusions made related to the types of vehicles traveling around and through the Phoenix Metropolitan area will assist in the calibration of the MAG truck travel model, and have the possibility to be used in future pavement design and noise studies, or among other areas. Current vehicle classification data was collected for these purposes.

This report is organized in six sections as follows:

Section 1: Introduction – Provides a brief introduction and background information.
Section 2: Study Design and Data Collection Procedures – Explains the setup and requirements of the study and presents the plan developed to collect all relevant data.
Section 3: Auto Occupancy – Presents the results and different factors of the auto occupancy analyses.
Section 4: Vehicle Classification – Presents the results of the vehicle classification analysis for the entire region.
Section 5: HOV Lane Evaluation – Illustrates effectiveness and efficiency of the HOV lanes, including violation rates and congestion affects.
Section 6: Conclusions – Provides conclusions of the study and gives brief recommendations for further study.

SECTION 2: STUDY DESIGN AND DATA COLLECTION PROCEDURES

The focus of this section is to setup and explain the study design and parameters. In addition, the data collection plan, used for the acquisition of data at each project site, is presented.

Study Requirements

Three types of data were required by MAG to be collected, including: vehicle occupancy, vehicle classification, and vehicle speed. The design of this data collection effort required the consideration of several distinct parameters, including: Area Type, Facility Type, and Time of Day, which are integral pieces of the MAG planning models, and account for much of the variation in the collected and analyzed data. Taking into account these parameters, the collection of data at a total of 119 sites was undertaken, providing a succinct statistical analysis of the traveling situation of the entire MAG region.

Area Type

The Area Type of roadways within the MAG planning region is determined based on the intensity of employment and population density of a specific area. MAG uses a total of five stratifications of area type based on these intensities, calculated as: [(Total Population) + (2 x Employment)] / Area. The five area types are expressed as:

1. Central Business District (CBD) (Intensity = >20,000)
6. Outlying CBD (Intensity = 10,001 – 20,000)
7. Mixed Urban (Intensity = 5,001 – 10,000)
8. Suburban (Intensity = 1,001 – 5,000)
9. Rural (Intensity = 0 – 1,000)

For the purposes of this study, area types 1 and 2 are combined into the "CBD" area type, area type 3 is referred to as the "Urban" area type, and area types 3 and 4 are combined into the "Suburban" area type.

Facility Type

The facility type of the roadways is categorized by general functional classification. For the purposes of this study, the facility types are broken down into three designations, High Occupancy Vehicle Freeways (HOV Freeways), non-HOV Freeways (Freeways), and Arterials.

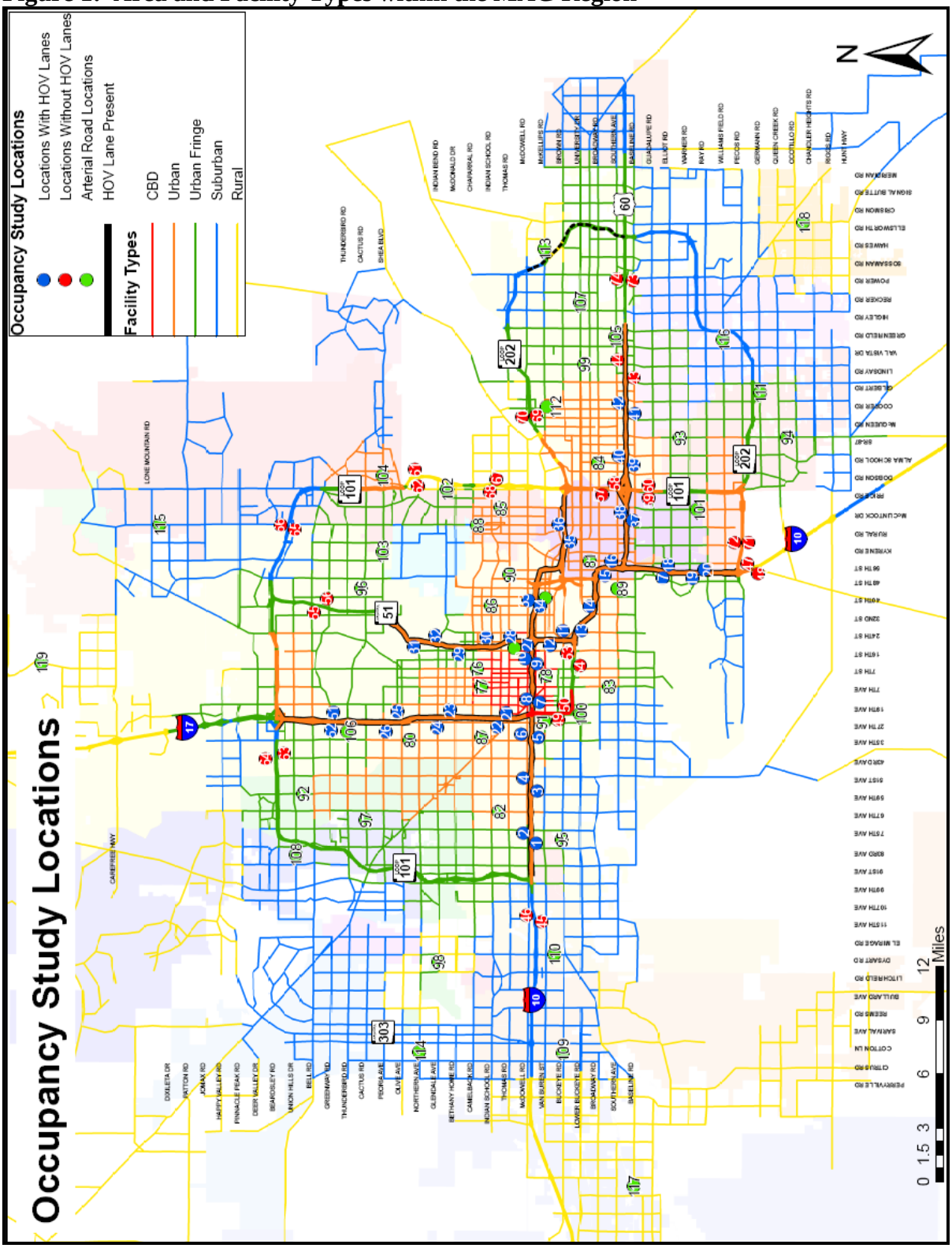
"HOV Freeways" are those freeway facilities that include priority or High Occupancy Vehicle (HOV) lanes, in addition to general purpose lanes. The HOV lane functional hours throughout the region are 6-9AM and 3-7PM.

The "Freeway" facility type used within this report is described as a freeway that contains general purpose lanes exclusively, HOV lanes are not present on these freeway facilities.

"Arterial" facilities are described as typical city streets; those that are functionally classified as an arterial roadway.

An overall map of the Phoenix metropolitan area roadway system, depicted by area and facility type is presented in *Figure 1: Area and Facility Types within the MAG Region*.

Figure 1: Area and Facility Types within the MAG Region



Time of Day

Data collection at each subject site took place continually from 6AM – 7PM. *Table 1: Study Time Periods*, details the breakdown of time periods for each time of day for this study.

Table 1: Study Time Periods

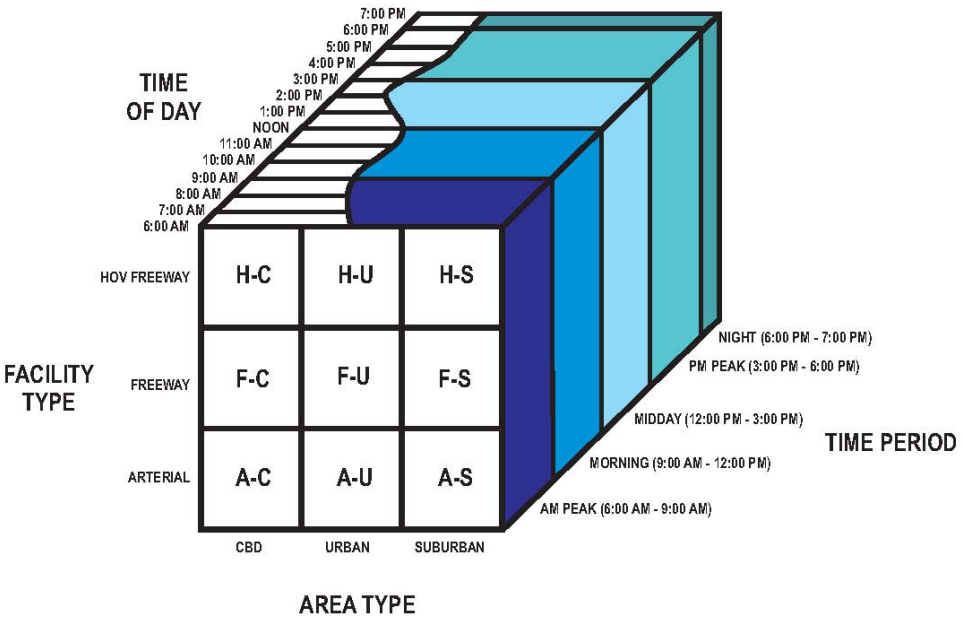
Time of Day	Time Period Designation	HOV Lane Function
6AM – 9AM	**AM Peak**	**High Occupancy Vehicles Only**
9AM – 12PM	Morning	General Purpose
12PM – 3PM	Midday	
3PM – 6PM	**PM Peak**	**High Occupancy Vehicles Only**
6PM – 7PM	**Night**	

Of note, the PM peak hour in this study lasts from 3-6PM, however, with respect to in-field HOV lane function on HOV freeways throughout the region, the PM HOV hours are designated as 3-7PM.

Project Design, "The Cube"

An experimental design approach was initiated in the 1992 vehicle occupancy study *1992 Study of Occupancy and Vehicle Classification in the Metropolitan Phoenix Area*[1]. In this study, the experimental design uses a 3 by 3 by 5 factorial design, with the parameters of Area Type, Facility Type, and Time Period forming "The Cube" as depicted in *Figure 2: Design of "The Cube"*.

Figure 2: Design of "The Cube"



[1] 1992 Study of Occupancy and Vehicle Classification in the Metropolitan Phoenix Area, Lee Engineering, February 1993.

Within "The Cube", the vehicle occupancy variations relative to each parameter can be determined. Data from a sufficient amount of samples (Sites) for each portion of "The Cube" were collected. Exceptions include Suburban-HOV Freeways, of which no samples exist based on the definitions of "Suburban" intensities; and CBD-Freeways, of which only two samples exist due to the fact that the majority of the freeway facilities within the CBD area are HOV freeways.

Table 2: Number of Sites Surveyed by Area Type and Facility Type presents the total number of sample sites collected for each segment of "The Cube". For all sample sites, the vehicle occupancy data was collected continuously for all times of day (6AM-7PM).

Table 2: Number of Sites Surveyed by Area Type and Facility Type

		FACILITY TYPE		
		HOV Freeway	**Freeway**	**Arterial**
AREA TYPE	**CBD**	7	2	4
	Urban	37	19	32
	Suburban	0	9	9

Data Collection Sites

The final total number of data collection locations, determined by MAG staff, came to 119 sites. Some of the sites were selected based on their location within the Phoenix metro area for improvement of the MAG planning models, others were selected in conjunction with ADOT Freeway Management System (FMS) detector locations, and others were selected based on previous study locations. In total, data at six count location sites had been collected in previous studies dating back to the 1977 vehicle occupancy study. These previous locations are presented in *Table 3: Sites with Data from Previous Studies*.

Table 3: Sites with Data from Previous Studies

SITE	LOCATION	FROM	TO	DIRECTION
13	I-10	24th St	32nd St	EB
21	I-17	Thomas Rd	Indian School Rd	NB
76	7th St	Camelback Rd	Indian School Rd	SB
84	Broadway Rd	E. of Dobson Rd	Alma School Rd	EB
87	Indian School Rd	W. of 27th Ave	35th Ave	WB
90	Thomas Rd	48th St	52nd St	WB

As mentioned, many site locations were selected in conjunction with ADOT FMS detector locations. All HOV Freeway count locations are situated at a corresponding ADOT FMS detector, and many of the Freeway locations are as well. It was decided to collect these HOV Freeway and Freeway locations at ADOT FMS detector locations for QA/QC and comparison purposes. A table of all 119 MAG-selected count location sites, broken down by the parameters of "The Cube", with their location information is presented in *Table 4: Site Location List*.

Table 4: Site Location List

	SITE	LOCATION	FROM	TO	DIR	DATE
HOV Fwy- CBD	7	I-10	19th Avenue	15th Avenue	EB	9/28/06
	8	I-10	7th Avenue	15th Avenue	WB	9/26/06
	9	I-10	10th Street	7th Street	EB	9/28/06
	10	I-10	16th Street	7th Street	WB	9/06/06
	27	SR 51	Thomas Rd	McDowell Rd	SB	4/03/07
	28	SR 51	McDowell Rd	Thomas Rd	NB	4/03/07
HOV Fwy- Urban	1	I-10	83rd Avenue	75th Avenue	EB	5/16/06
	2	I-10	75th Avenue	83rd Avenue	WB	5/16/06
	3	I-10	59th Avenue	51st Avenue	EB	5/17/06
	4	I-10	51st Avenue	59th Avenue	WB	5/17/06
	5	I-10	35th Avenue	27th Avenue	EB	8/29/06
	6	I-10	27th Avenue	35th Avenue	WB	8/31/06
	11	I-10	Buckeye Rd	Sky Harbor Cir	WB	9/07/06
	12	I-10	Jefferson St	Buchanan St	EB	9/07/06
	13	I-10	24th Street	32nd Street	EB	9/06/06
	14	I-10	36th Street	University Dr	WB	9/06/06
	15	I-10	52nd Street	Broadway Rd	EB	5/18/06
	16	I-10	Southern Ave	Broadway Rd	WB	5/18/06
	17	I-10	Guadalupe Rd	Elliot Rd	EB	5/23/06
	18	I-10	Elliot Rd	Guadalupe Rd	WB	5/24/06
	19	I-10	Warner Rd	Ray Rd	EB	5/25/06
	20	I-10	Ray Rd	Elliot Rd	WB	5/25/06
	21	I-17	Thomas Rd	Indian School Rd	NB	3/27/07
	22	I-17	Camelback Rd	Indian School Rd	SB	3/27/07
	23	I-17	Bethany Home Rd	Glendale Ave	NB	3/28/07
	24	I-17	Orangewood Ave	Glendale Ave	SB	3/28/07
	25	I-17	Dunlap Rd	Peoria Ave	NB	3/29/07
	26	I-17	Peoria Ave	Dunlap Rd	SB	3/29/07
	29	SR 51	Bethany Home Rd	Camelback Rd	SB	4/04/07
	30	SR 51	Indian School Rd	Camelback Rd	NB	4/04/07
	31	SR 51	Northern Ave	Dunlap Rd	SB	4/05/07
	32	SR 51	Glendale Rd	Dunlap Rd	NB	4/05/07
	33	Loop 202	40th Street	32nd Street	WB	5/24/06
	34	Loop 202	32nd Street	40th Street	EB	5/23/06
	35	Loop 202	Center St	Mill Ave	EB	9/07/06
	36	Loop 202	Scottsdale Rd	Mill Ave	WB	9/12/06
	37	US 60	Rural Rd	McClintock Dr	EB	9/19/06
	38	US 60	McClintock Dr	Rural Rd	WB	9/19/06
	39	US 60	Dobson Rd	Alma School Rd	EB	5/03/07
	40	US 60	Alma School Rd	Dobson Rd	WB	8/22/06
	41	US 60	Mesa Dr	Stapley Dr	EB	5/01/07
	42	US 60	Stapley Dr	Mesa Dr	WB	5/01/07
	51	I-17	Thunderbird Rd	Greenway Rd	NB	4/10/07
	52	I-17	Greenway Rd	Thunderbird Rd	SB	4/10/07

Table 4, Continued

	SITE	LOCATION	FROM	TO	DIR	DATE
Freeway - CBD	49	I-17	Van Buren St	Buckeye Rd	SB	4/24/07
	50	I-17	19th Avenue	Buckeye Rd	NB	4/24/07
Freeway - Urban	43	US 60	Gilbert Rd	Lindsay Rd	EB	5/08/07
	44	US 60	Val Vista Dr	Lindsay Rd	WB	5/08/07
	47	I-10	Pecos Rd	Germann Rd	EB	9/13/06
	48	I-10	Germann Rd	Pecos Rd	WB	9/14/06
	53	I-17	16th Street	7th Street	NB	4/25/07
	54	I-17	7th Street	16th Street	SB	4/25/07
	55	SR 51	Bell Rd	Greenway Rd	SB	4/11/07
	56	SR 51	Greenway Rd	Bell Rd	NB	4/11/07
	57	Loop 101	Broadway Rd	Southern Ave	SB	4/26/07
	58	Loop 101	Southern Ave	Broadway Rd	NB	4/26/07
	59	Loop 101	Baseline Rd	Guadalupe Rd	SB	5/02/07
	60	Loop 101	Guadalupe Rd	Baseline Rd	NB	5/02/07
	63	Loop 101	43rd Avenue	35th Avenue	EB	4/12/07
	69	Loop 202	Country Club Dr	Gilbert Rd	EB	9/14/07
	70	Loop 202	Gilbert Rd	Country Club Dr	WB	9/14/06
	71	Loop 202	Kyrene Rd	McClintock Dr	EB	9/12/06
	72	Loop 202	McClintock Dr	Kyrene Rd	WB	9/13/06
	73	US 60	Higley Rd	Power Rd	EB	5/09/07
	74	US 60	Power Rd	Higley Rd	WB	5/09/07
Freeway - Suburban	45	I-10	El Mirage Rd	Avondale Blvd	EB	9/12/06
	46	I-10	Avondale Blvd	El Mirage Rd	WB	9/12/06
	61	Loop 101	Via De Ventura	Via Linda	NB	4/17/07
	62	Loop 101	Via Linda	Via de Ventura	SB	4/17/07
	64	Loop 101	35th Avenue	43rd Avenue	WB	4/12/07
	65	Loop 101	56th Street	Scottsdale Rd	EB	4/18/07
	66	Loop 101	Scottsdale Rd	56th Street	WB	4/18/07
	67	Loop 101	Thomas Rd	Indian School Rd	NB	4/19/07
	68	Loop 101	Indian School Rd	Thomas Rd	SB	4/19/07
Arterial - CBD	75	16th Street	McDowell Rd	Thomas Rd	NB	5/15/07
	76	7th Street	Camelback Rd	Indian School Rd	SB	4/25/07
	77	7th Avenue	Indian School Rd	Camelback Rd	NB	5/22/07
	78	Van Buren St	7th Street	Central Ave	WB	5/23/07
Arterial - Urban	79	Van Buren St	40th Street	32nd Street	WB	5/22/07
	80	35th Avenue	Olive Ave	Northern Ave	SB	9/20/06
	81	56th Street	University Dr	Broadway Rd	SB	9/14/06
	82	67th Avenue	Camelback Rd	Indian School Rd	SB	5/03/07
	83	7th Avenue	Southern Ave	Broadway Rd	NB	5/16/07
	84	Broadway Rd	Dobson Rd	Alma School Rd	EB	9/21/06

Table 4, Continued

	SITE	LOCATION	FROM	TO	DIR	DATE
	85	Hayden Rd	Indian School Rd	Thomas Rd	SB	9/20/06
	86	Indian School Rd	32nd Street	40th Street	EB	5/23/07
	87	Indian School Rd	27th Avenue	35th Avenue	WB	5/22/07
	88	Scottsdale Rd	Chaparral Rd	Camelback Rd	SB	5/01/07
	89	Southern Ave	40th Street	48th Street	EB	9/13/06
	90	Thomas Rd	52th Street	48nd Street	WB	4/24/07
	91	Van Buren St	27th Avenue	I-17	EB	5/03/07
	92	59th Avenue	Bell Rd	Union Hills Dr	NB	5/08/07
	93	Arizona Ave	Warner Rd	Elliot Rd	NB	9/19/06
	94	Arizona Ave	Ocotillo Rd	Queen Creek Rd	NB	9/21/06
	96	Cactus Rd	Tatum Blvd	40th Street	WB	5/24/07
	97	Cactus Rd	75th Avenue	67th Avenue	EB	9/20/06
	98	Glendale Ave	Dysart Rd	Litchfield Rd	WB	9/21/06
	99	Lindsay Rd	Apache Blvd	University Dr	NB	5/02/07
	100	Lower Buckeye Rd	19th Avenue	27th Avenue	WB	5/17/07
	101	McClintock Dr	Ray Rd	Warner Rd	NB	9/20/06
	102	Pima Rd	McDonald Dr	Indian Bend Rd	NB	5/17/07
	103	Shea Blvd	56th Street	64th Street	EB	5/15/07
	104	Shea Blvd	92nd Street	96th Street	EB	5/16/07
	105	Southern Ave	Greenfield Rd	Val Vista Dr	WB	5/03/07
	106	Thunderbird Rd	35th Avenue	I-17	EB	4/26/07
	107	University Dr	Recker Rd	Higley Rd	WB	5/10/07
	108	Union Hills Dr	91st Avenue	83rd Avenue	EB	5/10/07
	111	Germann Rd	Gilbert Rd	Cooper Rd	WB	5/09/07
	112	McKellips Rd	Stapley Dr	Mesa Dr	WB	9/21/06
	115	Scottsdale Rd	Dixileta Dr	Lone Mountain Rd	NB	5/23/07
Arterial - Suburban	95	Buckeye Rd	83rd Avenue	75th Avenue	EB	5/24/07
	109	Buckeye Rd	Citrus Rd	Cotton Ln	EB	5/16/07
	110	Dysart Rd	Buckeye Rd	Van Buren St	NB	5/15/07
	113	McKellips Rd	Sossoman Rd	Hawes Dr	EB	5/10/07
	114	Northern Ave	Cotton Ln	Citrus Rd	WB	5/09/07
	116	Williams Field Rd	Val Vista Dr	Greenfield Rd	EB	5/10/07
	117	Baseline Rd	Apache Blvd	Watson Rd	EB	5/17/07
	118	Ellsworth Rd	Chandler Heights Rd	Ocotillo Rd	NB	5/08/07
	119	New River Rd	Desert Hills Dr	Honda Bow Rd	NB	5/24/07

Data Collection Procedures

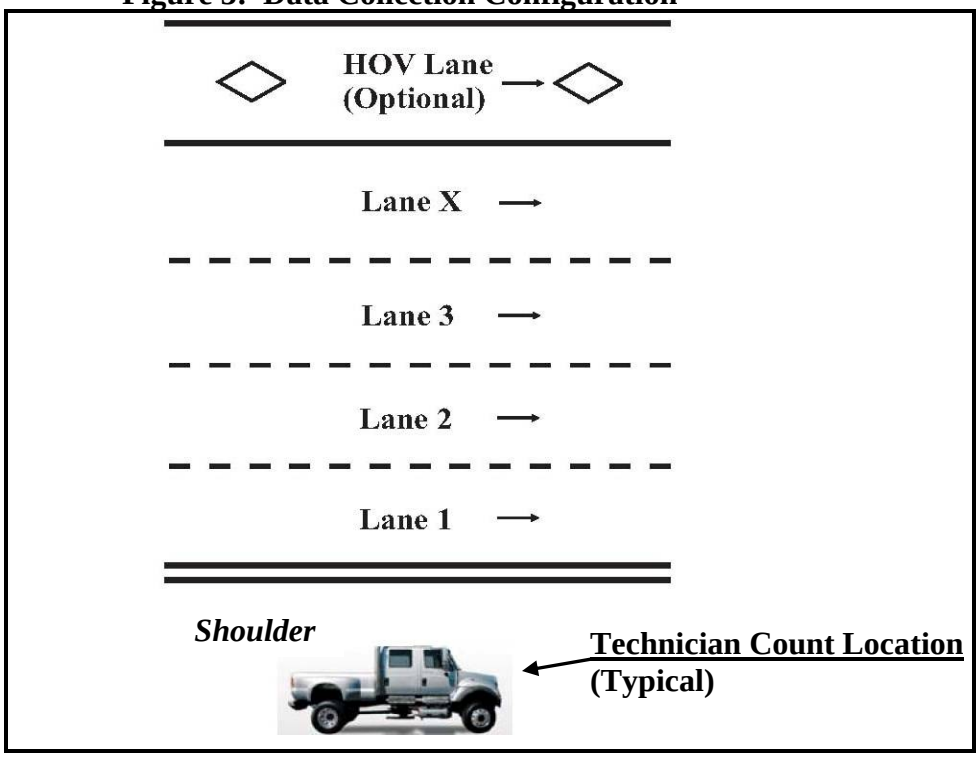
The vehicle occupancy and classification data collection procedures were established based on continued meetings with MAG staff, and through initial "dry runs" and a "pilot study" in which potential count methods and locations were examined. It was concluded that at each site location, all required data would be collected continuously throughout the entire day, from 6AM to 7PM. Using the study time periods from Table 1, specific counting procedures at 5 minute intervals were followed. In addition, data was collected only on Tuesdays, Wednesdays, or

Thursdays during the week, avoiding holidays, the summertime period, and the dark winter months.

Figure 3: Data Collection Configuration depicts the typical in-field data collection setup. On HOV Freeway locations, during the morning and evening/night peak hours (6-9AM and 3-7PM), traffic data collection efforts alternated in 5 minute intervals between the HOV Lane and Lane 2 (second general purpose lane from shoulder, as shown in Figure 3), beginning with the HOV Lane in the first interval. At all other off-peak hours of the day (9AM-3PM) the traffic data was collected on each lane, one at a time, in reoccurring order, at 5-minute intervals.

On Freeway locations without an HOV lane and Arterial roadway locations, data collection efforts alternated through all lanes of traffic, one at a time, for all hours of the day (6AM-7PM), at 5-minute intervals, beginning with Lane X (the median lane, as shown in Figure 3.)

Figure 3: Data Collection Configuration

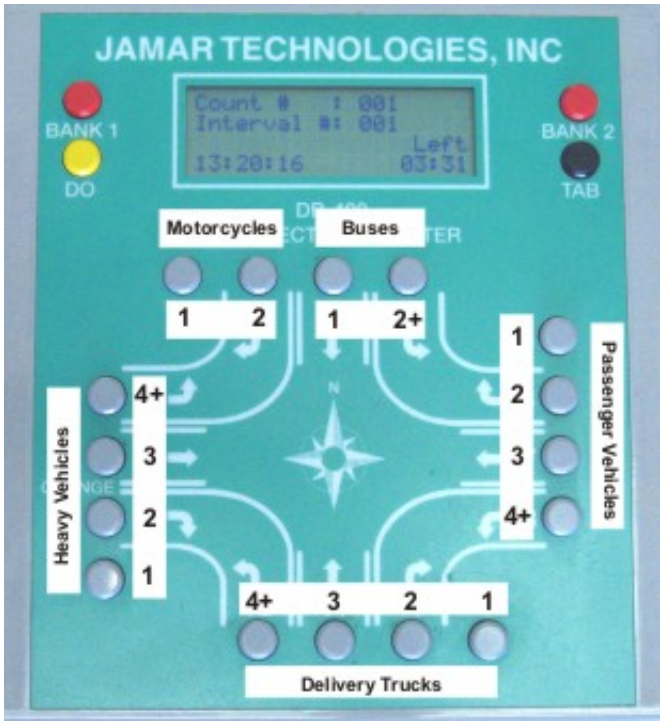


Vehicle volume, occupancy, and classification data was accrued through the use of hand-held JAMAR Technologies, Inc electronic count boards as shown in *Figure 4: Data Collection Unit*. The data collection technicians synchronized their cell phone clocks with the clocks on the data collection unit to begin the count at exactly 6:00AM. Throughout the count day, each button that was pressed accounted for the visually determined occupancy and classification of each vehicle that passed along the facility. The volumes are then automatically cumulated continuously: one button, one vehicle. The data collection unit lets out an audio beep every five minutes, this signals an interval change within the unit, and directs the technicians to switch to count the next lane.

Through initial meetings and discussions with MAG staff, and taking into account the button configurations of the counters, the required categories of vehicle occupancy and classification were determined. As shown in Figure 4 and presented below, five separate vehicle classifications and 16 total classification/occupancy data types were acquired.

1 Person Motorcycles	1 Passenger Vehicle	1 Person Delivery Vehicle	1 Person Heavy Vehicle
2+ Person Motorcycles	2 Passenger Vehicle	2 Person Delivery Vehicle	2 Person Heavy Vehicle
1 Person Buses	3 Passenger Vehicle	3 Person Delivery Vehicle	3 Person Heavy Vehicle
2+ Person Buses	4+ Passenger Vehicle	4+ Person Delivery Vehicle	4+ Person Heavy Vehicle

Figure 4: Data Collection Unit



The data collection technicians, trained extensively on the use of the JAMAR count board units, were also trained to determine FHWA vehicle classifications in the field, and relate it to the categories on the count boards. *Table 5: FHWA Vehicle Classification* presents the relation between FHWA classified vehicles and the vehicle classification categories used in this study. Further information on the FHWA vehicle classifications can be found at www.fhwa.dot.gov.

Table 5: FHWA Vehicle Classification

COUNT BOARD CATEGORY	FHWA VEHICLE CLASSIFICATION GROUP #
Motorcycles	**1**
Buses	**4**
Passenger Vehicles	**2, 3**
Delivery Vehicles	**5, 6, 7**
Heavy Vehicles	**8, 9, 10, 11, 12, 13**

Speed Data

Vehicle speed data at all site locations were collected using police department quality hand-held RADAR guns, as shown in *Figure 5: Hand-held RADAR Gun*. The speed data were collected in accordance with each site's specific peak directional flow of traffic, which occurs during either the AM peak (6-9AM) or PM peak (3-7PM), depending on the roadway location. As determined through discussions with MAG staff, speeds during these peak hours were continuously collected for a block of 2.5 hours. While it was not feasible to collect every vehicle's speed during this 2.5 hour block, as many as possible were collected. Each location had only one peak period interval block collected. In addition, each location had speed data collected during the Morning (9AM-12PM) and Midday (12-3PM) intervals. Vehicle speed data during these intervals were collected by way of 100 total spot speed counts for each lane set of traffic (HOV Lane, Left Lanes, and Right Lanes). The speed data was then tabulated for each site and calculations were performed including 5-minute average speed per lane (during each 2.5 hour peak hour block only), overall average speed per lane, overall 15th percentile speed, and overall 85th percentile speed.

Figure 5: Hand-Held RADAR Gun[1]

[1] Photo Courtesy of Astro Products, Phantom Police Radar Guns

SECTION 3: AUTO OCCUPANCY

In total, 13 continuous hours of data from each of the 119 site locations was collected in-field. This data was downloaded and processed within Microsoft Excel to organize, analyze and calculate auto occupancies for a number of various scenarios. As the site locations are distributed widely to obtain occupancy sample in varied groups, such as by area type, by facility type and by time period, an analysis of variance (ANOVA) was performed within Excel to examine if the occupancy data is significantly different by groups. These tests include three one-way ANOVA tests (AREA, FACILITY, and TIME) and a two-way ANOVA test in-between AREA and FACILITY. The results are presented below in *Table 6: ANOVA Test Results*.

Table 6: ANOVA Test Results

Source	SS	Degree of Freedom	Mean Square	F-Value	P-value
AREA	0.112408	2	0.056204	4.62222	0.01171
FACILITY	1.056628	2	0.528314	131.4294	1.54E-30
TIME	1.375283	5	0.275057	15.42181	2.06E-14
AREA*FACILITY	1.01295	7	0.144707	33.4002	5.44E-23

The results are consistent to ANOVA test results based on the 1992 occupancy study data. It is obvious that, in 95% confidence level, occupancy samples are statistically different by groups (AREA, FACILITY, and TIME). The ANOVA test shows that the variance of occupancy sample by FACILITY type is very significant. In addition, the variance of occupancy by AREA and TIME is significant, only with lower F values. When an attempt is made to test interaction between AREA and FACILITY on occupancy sample variance, the two-way ANOVA test indicates that they are still significantly different with an F value of 33.40.

For this section and the following sections, the term “Auto”, as in auto occupancies, refers only to the passenger vehicle classification data. Only the 1 person passenger vehicle, 2 person passenger vehicle, 3 person passenger vehicle, and 4+ person passenger vehicle data is included. Conversely, the term “Vehicle” refers to anything relating to all vehicle classification data, including motorcycles, buses, passenger vehicles, delivery vehicles and heavy vehicles.

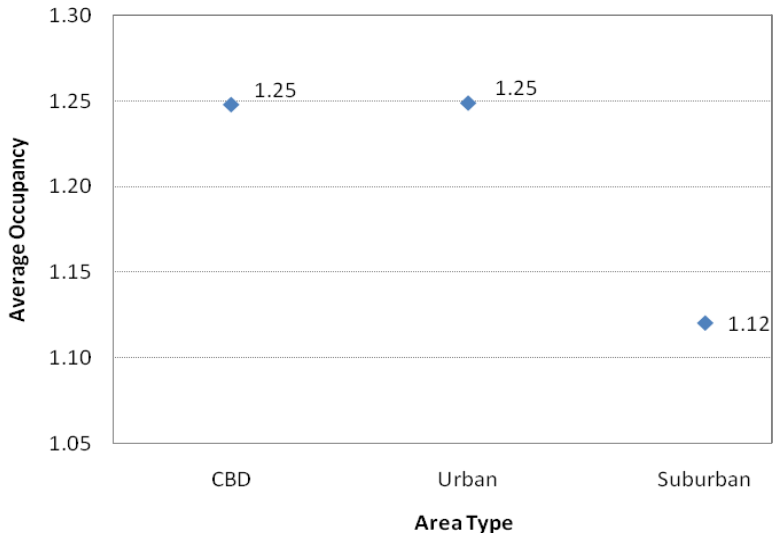
Several parameters were applied to all applicable data in order to distinguish and value variables within the data. Through discussions with MAG, it was determined that the value of “4+” vehicles occupancy for the passenger vehicle, delivery vehicle, and heavy vehicle classifications would be calculated as 4.2 for data analysis purposes. In addition, the average bus occupancy has been estimated as 20. To determine this average bus occupancy value, daily boarding ridership numbers by route and daily number of trips from Fall 2006 and Spring 2007 were provided by the Regional Public Transportation Authority (RPTA). From this overall data, a random selection of 15 routes was selected and the average occupancy was calculated to be 20, which has been used globally within this study.

Auto Occupancy

Auto occupancy rates are the measure of the average number of persons per vehicle, or the number of person-trips per auto-trip. As determined, auto occupancy rates vary by the area type,

facility type, and time of day. *Figure 6: Average Auto Occupancy vs Area Type* illustrates the variability in average auto occupancy based on the CBD, Urban, and Suburban area types.

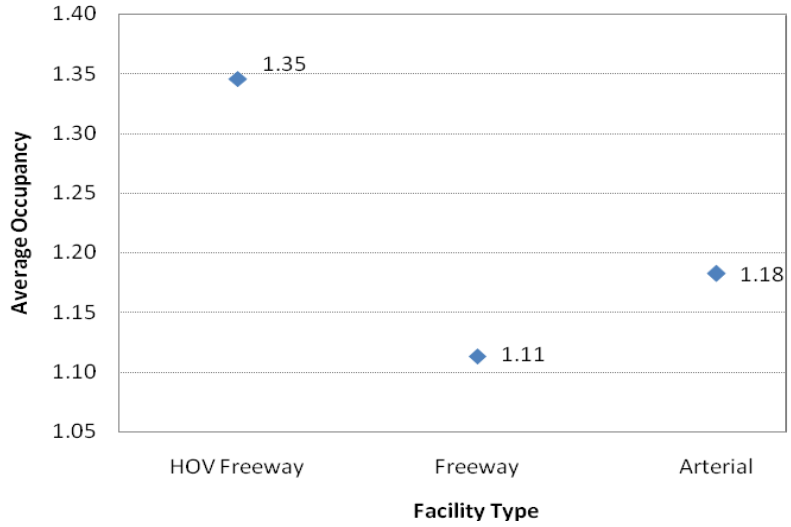
Figure 6: Average Auto Occupancy vs Area Type



As shown in Figure 6, the CBD and Urban area types have the highest overall auto occupancy, 1.25. The lowest auto occupancy occurs in the Suburban area type, 1.12. This may be attributed mostly to the fact that there are zero HOV Freeway facilities located within the suburban area type, which promote the highest vehicle occupancy. Aditionally, as the Phoenix metro area has grown dramatically outward, so has the number of home-based work trips originating from these new suburban locales.

Figure 7: Average Auto Occupancy vs Facility Type depicts the overall auto occupancy rates based on the HOV Freeway, Freeway, and Arterial facility types.

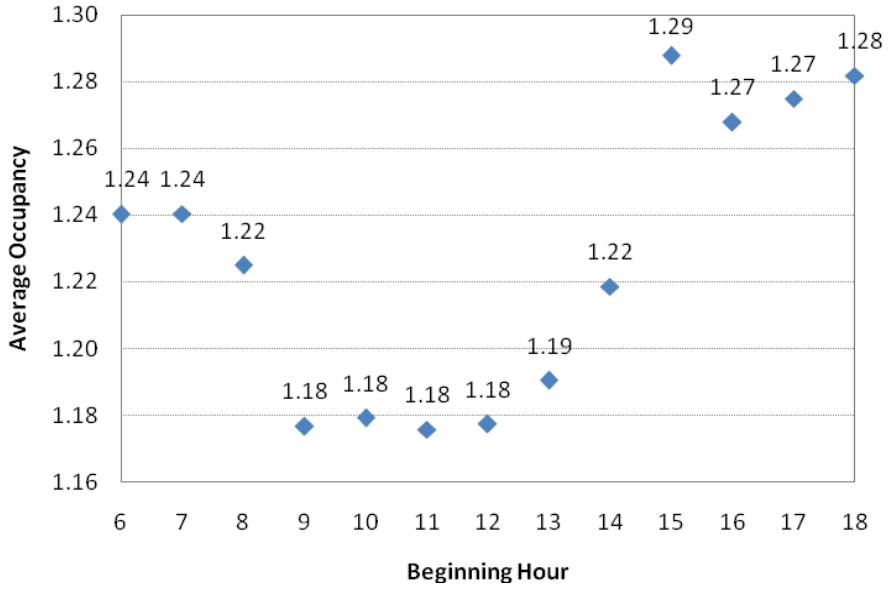
Figure 7: Average Auto Occupancy vs Facility Type



As expected, HOV Freeways have the greatest auto occupancy rates (1.35). Although HOV violations (single-occupant vehicles traveling in the HOV Lane) occur in the HOV Lane during the HOV hours, a greater total number of high occupancy vehicles, or carpools, are located on the HOV facilities overall. The lowest auto occupancies occur on non-HOV Freeway facilities (1.11), in which drivers have no potential travel-time saving incentive to carpool. Arterial roadways have higher auto occupancies (1.18) than non-HOV Freeways which may be attributed to having a greater amount of home-based school and shopping trips, which typically have high occupancies. Of note, in the 1992 study, arterial roadway facilities had the highest vehicle occupancy out of all facility types.

Figure 8: Average Auto Occupancy vs Time of Day presents the overall average auto occupancy versus the time of day (shown as beginning hour for each hour designation). As illustrated in the figure, the morning peak hours (6-9AM) tend to have lower auto occupancies compared to the evening peak hours (3-7PM) as a greater number of higher occupant shopping and school-activity trips occur during the evening hours, which has been apparent in previous studies. In addition, there is a drop in auto occupancy during the Morning and Mid-day time periods (9AM-3PM), mostly apparent due to the HOV lanes on the freeways during this time acting as general purpose lanes. In the 1992 study, however, the average auto occupancy rates were found to be higher in the mid-day than in the morning peak hours.

Figure 8: Average Auto Occupancy vs Time of Day



Variations in average auto and vehicle occupancy due to area type and facility type are shown tabulated in *Table 7: Average Auto Occupancy vs Area Type and Facility Type* and *Table 8: Average Vehicle Occupancy vs Area Type and Facility Type*, and the average auto occupancies are depticted in *Figure 9: Average Auto Occupancy vs Area Type and Facility Type*.

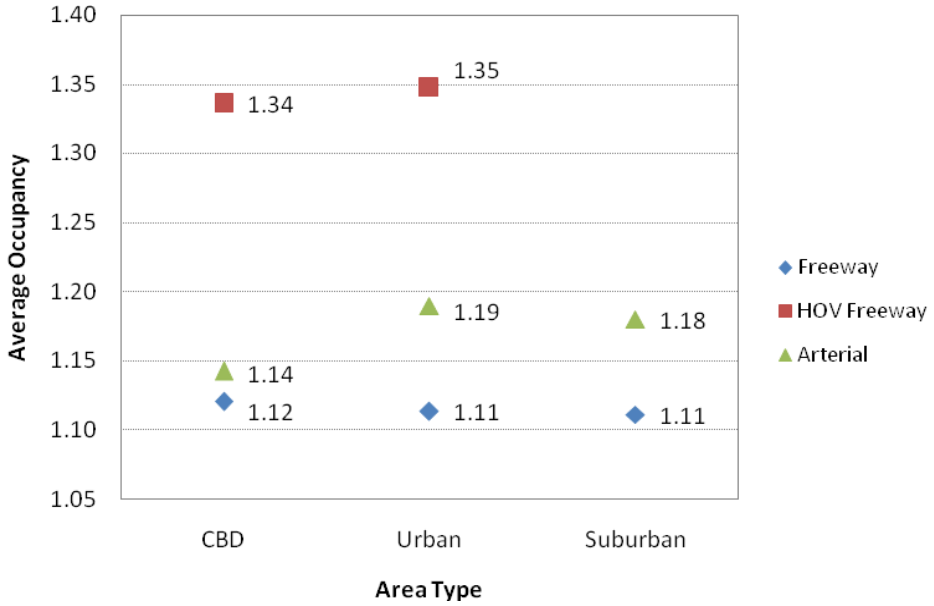
Table 7: Average Auto Occupancy vs Area Type and Facility Type

Area Type	HOV Freeway	Freeway	Arterial
CBD	1.34	1.12	1.14
Urban	1.35	1.11	1.19
Suburban	-	1.11	1.18

Table 8: Average Vehicle Occupancy vs Area Type and Facility Type

Area Type	HOV Freeway	Freeway	Arterial
CBD	1.37	1.14	1.30
Urban	1.37	1.13	1.28
Suburban	-	1.12	1.25

Figure 9: Average Auto Occupancy vs Area Type and Facility Type



This graphic shows the wide variation in average auto occupancy in the CBD and Urban area types, with the HOV Freeways having, as expected, much higher occupancies in these area types. As stated previously, there are no existing HOV Freeways within the Suburban area type. Overall, average auto occupancies on Arterial facilities within the CBD area type are lower than in the Urban and Suburban area types. This is to be expected as single-occupant commuters are more prevalent and fewer home-based school or shopping trips would be likely.

Table 9: Average Auto and Vehicle Occupancies by Area Type, Facility Type and HOV Freeway tabulates the values for both auto occupancy and vehicle occupancy for the assorted variables.

Table 9: Average Auto and Vehicle Occupancies by Area Type, Facility Type, and HOV Freeways

Area Type	Auto	Vehicle	Facility Type	Auto	Vehicle	All HOV Freeways	Auto	Vehicle
CBD	1.25	1.30	**HOV Freeway**	1.35	1.37	**AM Peak Hour**	1.42	1.45
Urban	1.25	1.29	**Freeway**	1.11	1.13	**PM Peak Hour**	1.45	1.49
Suburban	1.12	1.14	**Arterial**	1.18	1.28			

Table 10: Average Auto Occupancy by Area Type and Facility Type by Time Periods presents the average auto occupancies for each parameter of "The Cube".

Table 10: Average Auto Occupancy by Area Type and Facility Type by Time Periods

	Time Periods				
Area Type - Facility	**6-9AM**	**9AM-12PM**	**12-3PM**	**3-6PM**	**6-7PM**
CBD-HOV Fwy	1.40	1.23	1.23	1.46	1.47
CBD-Freeway	1.10	1.08	1.12	1.17	1.19
CBD-Arterial	1.09	1.15	1.16	1.13	1.26
Urban-HOV Fwy	1.42	1.24	1.26	1.45	1.45
Urban-Freeway	1.09	1.11	1.12	1.12	1.12
Urban-Arterial	1.14	1.16	1.19	1.23	1.26
Suburban-HOV Fwy	-	-	-	-	-
Suburban-Freeway	1.08	1.10	1.12	1.12	1.12
Suburban-Arterial	1.14	1.13	1.19	1.22	1.29
Period Totals	1.24	1.18	1.20	1.28	1.28
Overall	1.23				

Overall, the auto occupancy for the region was found to be **1.23**, which has been determined by the division of the overall total number of auto occupants by the overall total number of passenger vehicles for all area types, facility types and time periods. The overall vehicle occupancy for the region was found to be 1.26, which has been determined by the division of the overall total number of vehicle occupants by the overall total number of all vehicles for all area types, facility types and time periods. This auto and vehicle occupancy data was determined through the continuous 13 hours of data collection at each subject site. In 1992, the overall auto occupancy was found greater, 1.34.

To present a visual overview of the overall MAG area average auto occupancies, *Figure 10: Average Auto Occupancy* depicts the average auto occupancy value at each of the 119 site locations.

Figure 10: Average Auto Occupancy

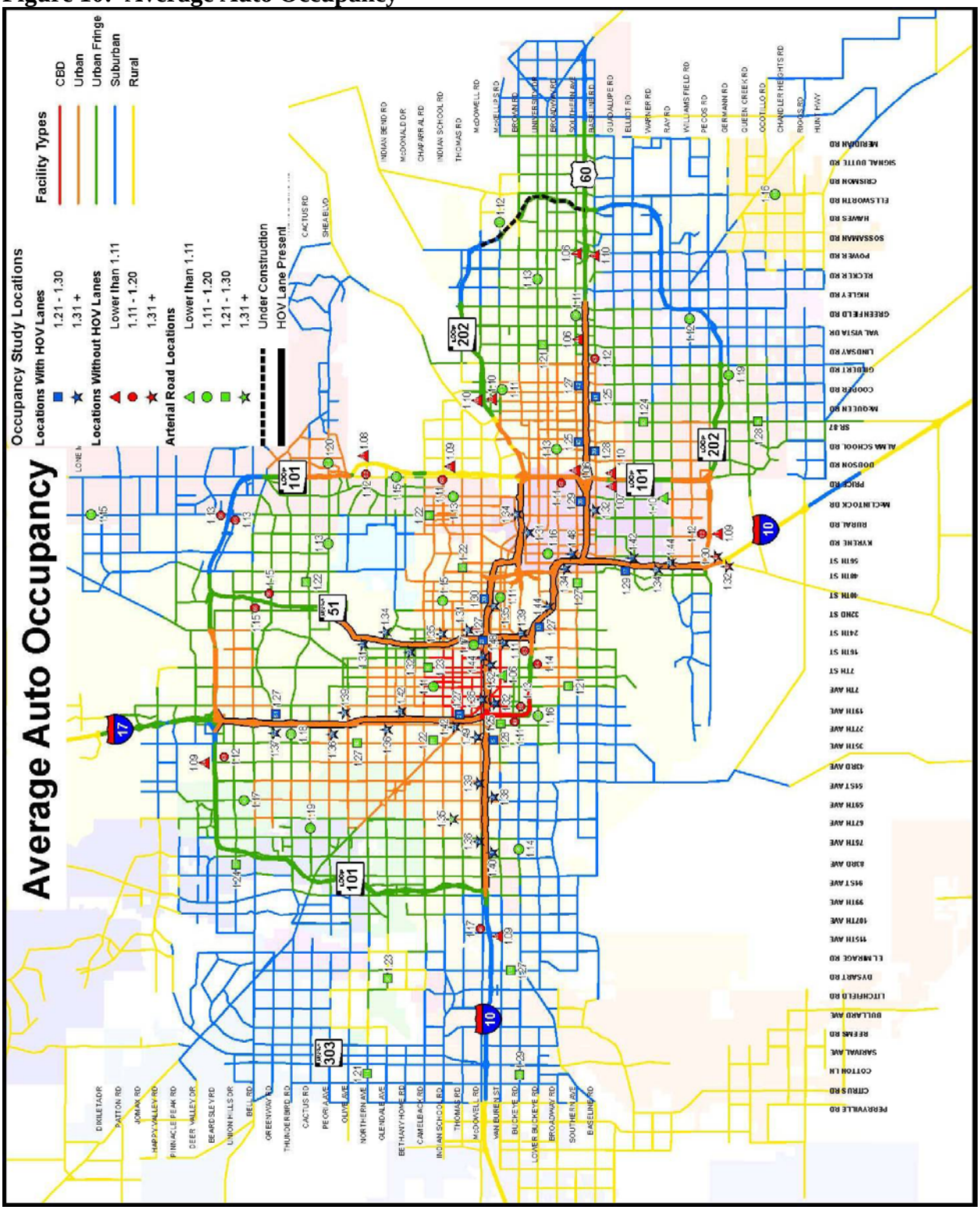


Figure 11: Average Vehicle Occupancy presents the average vehicle occupancy at each of the 119 site locations. In comparison, globally, the average vehicle occupancy is slightly higher than the average auto occupancy as it takes into account the higher occupancy bus classification.

Figure 11: Average Vehicle Occupancy

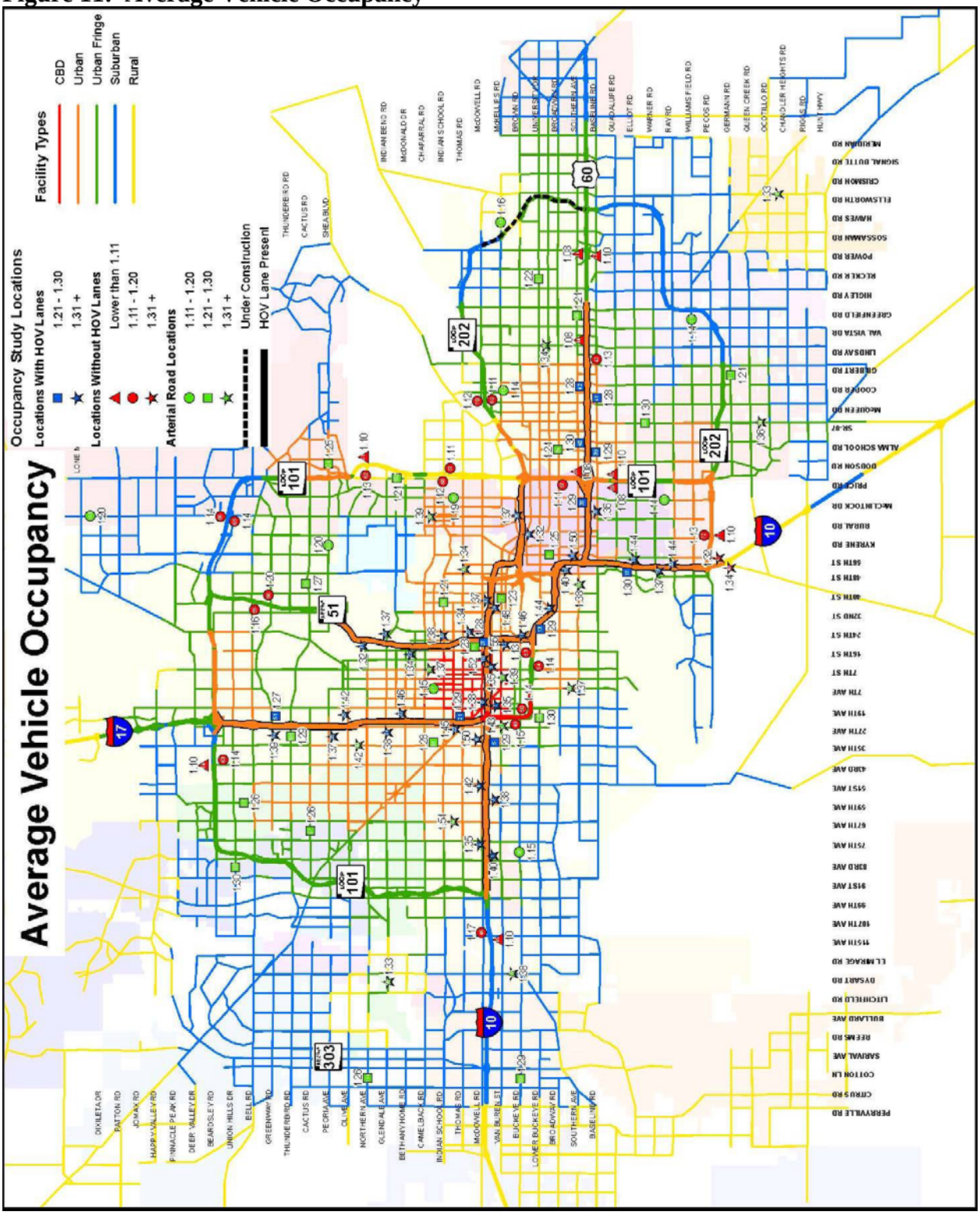


Table 11: Average Auto Occupancy Rates by Time Period, Area Type, and Facility Type and *Figure 12: Average Auto Occupancy Rates by Time Period, Area Type, and Facility Type* show the average auto occupancy rates based on the main study time periods. The HOV Freeway and Freeway facility types have had their data combined, as was the case in the previous study, from 1992. The tabulation shows that average auto occupancy rates are typically higher in the PM Peak and Night time periods than the other time periods, and average occupancy rates tend higher on Freeway facilities than on Arterial facilities.

Table 11: Average Auto Occupancy Rates by Time Period, Area Type, and Facility Type

	6-9am	9-12pm	12-3pm	3-6pm	6-7pm	All Day
All Facilities in Region	1.24	1.18	1.20	1.28	1.28	1.23
All Freeways in Region	1.26	1.18	1.20	1.29	1.29	1.24
All Arterials in Region	1.14	1.16	1.18	1.21	1.26	1.18
All Facilities in CBD	1.27	1.18	1.19	1.32	1.36	1.25
All Freeways in CBD	1.31	1.18	1.20	1.38	1.39	1.27
All Arterials in CBD	1.09	1.15	1.16	1.13	1.26	1.14
All Facilities in Urban	1.26	1.19	1.21	1.31	1.30	1.25
All Freeways in Urban	1.29	1.20	1.22	1.32	1.32	1.26
All Arterials in Urban	1.14	1.16	1.19	1.23	1.26	1.19
All Facilities in Suburban	1.09	1.11	1.13	1.13	1.14	1.12
Freeways in Suburban	1.08	1.10	1.12	1.12	1.12	1.11
Arterials in Suburban	1.14	1.13	1.19	1.22	1.29	1.18

Figure 12: Average Auto Occupancy Rates by Time Period, Area Type, and Facility Type

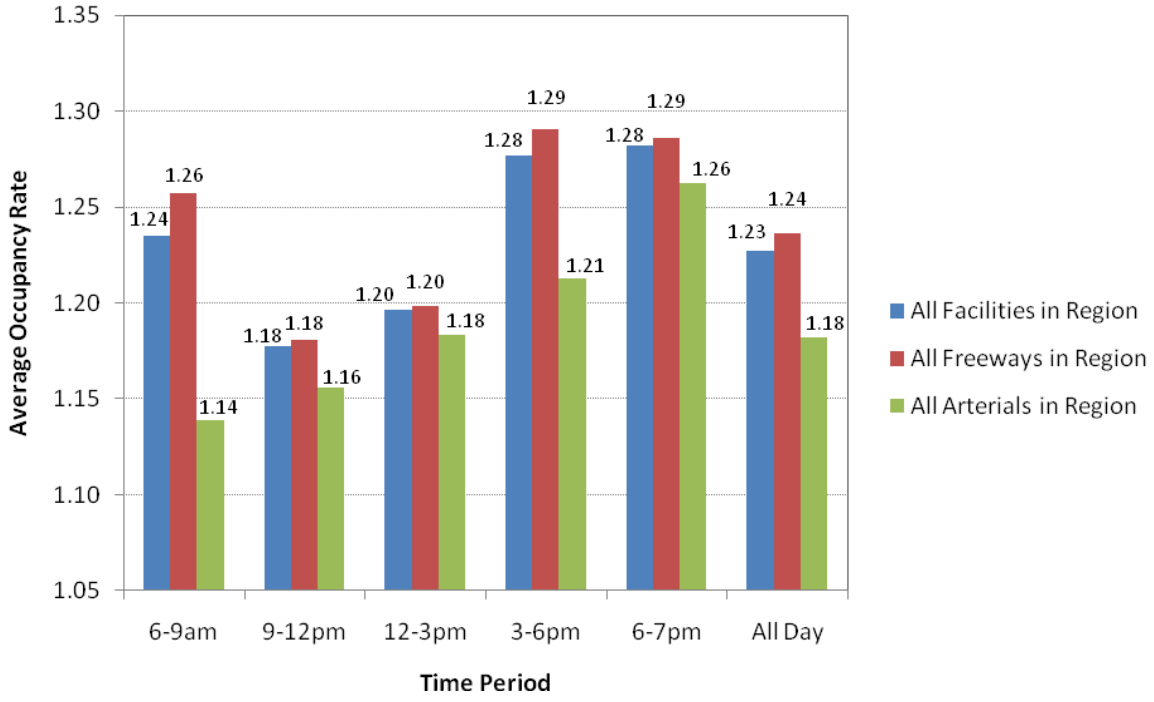


Table 12: Carpool Auto Occupancy Rates by Time Period, Facility Type and Area Type depict similar data as in Table 7, but Table 8 only accounts for carpools (2, 3, 4+ auto occupancies).

Table 12: Carpool Auto Occupancy Rates by Time Period, Area Type, and Facility Type

	6-9am	9-12pm	12-3pm	3-6pm	6-7pm	All Day
All Facilities in Region	2.093	2.079	2.094	2.100	2.100	2.094
All Freeways in Region	2.088	2.073	2.087	2.091	2.085	2.086
All Arterials in Region	2.137	2.119	2.139	2.159	2.180	2.146
All Facilities in CBD	2.072	2.087	2.088	2.109	2.098	2.091
All Freeways in CBD	2.070	2.082	2.082	2.106	2.085	2.086
All Arterials in CBD	2.098	2.119	2.125	2.144	2.173	2.131
All Facilities in Urban	2.092	2.077	2.094	2.097	2.099	2.092
All Freeways in Urban	2.087	2.071	2.087	2.088	2.085	2.085
All Arterials in Urban	2.139	2.121	2.141	2.158	2.175	2.147
All Facilities in Suburban	2.148	2.086	2.097	2.114	2.114	2.109
Freeways in Suburban	2.147	2.081	2.088	2.099	2.085	2.098
Arterials in Suburban	2.148	2.107	2.137	2.173	2.223	2.154

Table 13: Percentage of Vehicles and Travelers by Auto Occupancy by Hour of Day – All Roadways in Region, *Table 14: Percentage of Vehicles and Travelers by Auto Occupancy by Hour of Day – All Freeways in Region* and *Table 15: Percentage of Vehicles and Travelers by Auto Occupancy by Hour of Day – All Arterials* show the information that is explained in their respective titles. The data reveals that generally the freeways in the region carry higher percentages of high occupancy vehicles (2+) than arterials, due to the effect of HOV lanes.

Table 13: Percentage of Vehicles and Travelers by Auto Occupancy by Hour of Day – All Roadways in Region

	1 Person		2 Person		3 Person		4+ Person	
Time	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers
6:00 AM	81.86%	67.99%	16.36%	27.17%	1.33%	3.31%	0.46%	1.53%
7:00 AM	81.44%	67.62%	17.06%	28.34%	1.12%	2.79%	0.38%	1.25%
8:00 AM	82.94%	69.86%	15.79%	26.60%	0.90%	2.29%	0.37%	1.25%
9:00 AM	87.26%	76.63%	11.85%	20.81%	0.63%	1.67%	0.25%	0.89%
10:00 AM	86.85%	75.86%	12.11%	21.16%	0.75%	1.96%	0.29%	1.01%
11:00 AM	87.07%	76.24%	11.95%	20.94%	0.69%	1.82%	0.29%	1.01%
12:00 PM	86.95%	76.08%	12.08%	21.15%	0.69%	1.82%	0.27%	0.95%
1:00 PM	86.09%	74.57%	12.73%	22.06%	0.84%	2.18%	0.34%	1.19%
2:00 PM	84.24%	71.52%	14.20%	24.11%	1.11%	2.84%	0.45%	1.53%
3:00 PM	77.33%	61.71%	20.59%	32.87%	1.51%	3.61%	0.57%	1.82%
4:00 PM	78.06%	62.84%	20.15%	32.44%	1.32%	3.18%	0.48%	1.54%
5:00 PM	77.57%	62.16%	20.61%	33.04%	1.30%	3.13%	0.52%	1.67%
6:00 PM	77.01%	61.39%	21.11%	33.65%	1.33%	3.19%	0.55%	1.77%

Table 14: Percentage of Vehicles and Travelers by Auto Occupancy by Hour of Day – All Freeways in Region

	1 Person		2 Person		3 Person		4+ Person	
	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers
6:00 AM	80.64%	66.22%	17.45%	28.65%	1.41%	3.48%	0.50%	1.65%
7:00 AM	80.00%	65.62%	18.46%	30.29%	1.14%	2.81%	0.39%	1.28%
8:00 AM	81.77%	68.21%	16.96%	28.30%	0.89%	2.24%	0.38%	1.25%
9:00 AM	87.22%	76.61%	11.94%	20.97%	0.60%	1.57%	0.24%	0.86%
10:00 AM	87.00%	76.11%	11.99%	20.97%	0.71%	1.87%	0.30%	1.05%
11:00 AM	87.49%	76.97%	11.62%	20.44%	0.62%	1.65%	0.27%	0.94%
12:00 PM	87.39%	76.85%	11.75%	20.67%	0.62%	1.63%	0.24%	0.85%
1:00 PM	86.39%	75.09%	12.51%	21.75%	0.76%	1.99%	0.34%	1.18%
2:00 PM	84.40%	71.79%	14.10%	23.98%	1.05%	2.69%	0.45%	1.55%
3:00 PM	76.52%	60.68%	21.43%	33.99%	1.48%	3.53%	0.57%	1.79%
4:00 PM	77.34%	61.95%	20.93%	33.53%	1.24%	2.98%	0.48%	1.54%
5:00 PM	77.01%	61.53%	21.31%	34.05%	1.18%	2.83%	0.50%	1.60%
6:00 PM	76.90%	61.40%	21.46%	34.26%	1.14%	2.74%	0.50%	1.60%

Table 15: Percentage of Vehicles and Travelers by Auto Occupancy by Hour of Day – All Arterials in Region

	1 Person		2 Person		3 Person		4+ Person	
	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers	% of Vehicles	% of Travelers
6:00 AM	88.27%	78.04%	10.60%	18.75%	0.88%	2.33%	0.25%	0.88%
7:00 AM	87.77%	77.08%	10.90%	19.15%	1.02%	2.68%	0.31%	1.09%
8:00 AM	88.49%	78.20%	10.21%	18.05%	0.96%	2.53%	0.34%	1.22%
9:00 AM	87.50%	76.76%	11.32%	19.86%	0.86%	2.25%	0.32%	1.13%
10:00 AM	85.92%	74.38%	12.87%	22.28%	0.98%	2.54%	0.23%	0.79%
11:00 AM	84.47%	71.91%	14.02%	23.87%	1.10%	2.82%	0.41%	1.40%
12:00 PM	84.37%	71.70%	14.04%	23.86%	1.14%	2.90%	0.45%	1.55%
1:00 PM	84.18%	71.42%	14.13%	23.98%	1.32%	3.35%	0.37%	1.26%
2:00 PM	83.30%	69.97%	14.80%	24.86%	1.47%	3.71%	0.43%	1.45%
3:00 PM	81.54%	67.24%	16.25%	26.80%	1.62%	4.01%	0.59%	1.95%
4:00 PM	81.69%	67.54%	16.13%	26.68%	1.72%	4.26%	0.46%	1.52%
5:00 PM	80.29%	65.36%	17.18%	27.98%	1.89%	4.61%	0.63%	2.06%
6:00 PM	77.51%	61.35%	19.44%	30.77%	2.24%	5.32%	0.81%	2.56%

Previous Studies and Locations

Table 16: Comparison of Auto Occupancy Classifications and Occupancy Rates for Phoenix on the following page is a similar table as used in the 1992 study, updated to include the 2006 vehicle occupancy data. This table presents the overall percentages based on vehicle occupancies, and presents an overall occupancy rate for the entire study, in comparison to previous studies.

A closer look into the Table 16 data depicts a trend toward higher overall vehicle occupancy during the AM peak hour, and a lower overall vehicle occupancy during the PM peak hours. During the mid-day time periods, the HOV lane reverts back to a general purpose lane, which wasn't the case in the past, so overall occupancy during this time is lower, as is expected.

Vehicle occupancies have been collected at six standard locations for every study since the 1977 study. The six locations have been previously presented in Table 3. *Table 17: Comparison of Auto Occupancy Rates* on the following page depicts how these occupancy rates have changed over the past studies at these six common site locations.

As can be expected, these locations, and how their area types are categorized based on the density calculations, have transformed over the past 30 years due to the continued growth of the region. Based on the potential change in each area, it can be expected that average auto occupancies will react and change accordingly. Overall, on the four arterial sites from previous studies, sites 76, 84, 87, and 90, the occupancy rates have dropped for all time periods as compared to the occupancy rate data determined in previous studies. Conversely, the occupancy rates on the two freeway sites, site 13 and site 21, are higher during the AM and PM peak hours as compared to the occupancy rates from previous studies. This higher occupancy can be attributed to the fact that HOV lanes didn't exist on I-17, at site 21, in the past, and the HOV lane on I-10, at site 13, was very new at the time of the 1992 study.

With continuous vehicle occupancy studies similar in scope and design to this 2006 study, trends and comparisons can be further determined.

Table 16: Comparison of Auto Occupancy Classifications and Occupancy Rates

Time of Day	Year	Vehicles by Persons per Vehicle 1	2	3	4+	Occupancy Rate
		Percent (%)				
Morning Peak [1]	2006	82.07	16.42	1.11	0.4	1.24
	1992U	81.97	15.22	2.01	0.8	1.22
	1992W	81.74	15.08	2.35	0.83	1.226
	1988	84	13	2	1	1.2
	1982	84	13	2	1	1.2
	1981	84	13	2	1	1.2
	1980	82	15	2	1	1.22
	1979	83	14	2	1	1.21
	1978 [6]	-	-	-	-	1.21
	1977	83	14	2	1	1.21
Morning Off-Peak [2]	2006	87.06	11.97	0.69	0.28	1.18
	1992U	73.78	22.36	2.65	1.21	1.318
	1992W	74.36	21.55	2.86	1.23	1.315
	1988	74	22	3	1	1.31
	1982	77	19	3	1	1.29
	1981	78	19	2	1	1.27
	1980	77	19	3	1	1.26
	1979	74	21	3	2	1.31
	1978 [6]	-	-	-	-	1.29
	1977	82	15	2	1	1.24
Afternoon Off-Peak [3]	2006	85.71	13.04	0.89	0.36	1.20
	1992U	72.82	22.45	3.22	1.52	1.34
	1992W	71.79	22.93	3.65	1.63	1.358
	1988	74	22	3	1	1.33
	1981	76	20	3	1	1.32
	1980	75	21	3	1	1.32
	1979	74	20	4	2	1.34
	1978 [6]	-	-	-	-	1.33
	1977	75	20	4	1	1.33
Afternoon Peak [4]	2006	77.66	20.45	1.37	0.52	1.28
	1992U	73.9	20.79	3.38	1.92	1.341
	1992W	71.82	21.45	4.18	2.55	1.385
	1988	76	20	3	1	1.31
	1982	76	18	4	2	1.32
	1981	76	19	3	2	1.3
	1980	77	19	3	1	1.3
	1979	71	24	3	2	1.35
	1978 [6]	-	-	-	-	1.32
Daily Average [5]	2006	82.53	16.01	1.05	0.41	1.23
	1992U	74.69	20.9	2.96	1.45	1.318
	1992W	73.88	20.94	3.47	1.71	1.337
	1988	74	21	3	2	1.32
	1982	77	19	3	1	1.3
	1981	78	18	3	1	1.28
	1980	77	19	3	1	1.29
	1979	74	21	3	2	1.32
	1978 [6]	-	-	-	-	1.3
	1977	78	18	3	1	1.29

1 Defined as 6:30-8:30AM for 1977-1982, 7-9AM for 1988, and 6-9AM for 1992 and 2006.
2 Defined as 8AM-12PM for 1977-1982 and 9AM-12PM for 1988-2006
3 Defined as 12-4:30PM for 1977-1982, 2-4PM for 1988-1992, and 12-3PM for 2006.
4 Defined as 4:30-6:30PM for 1977-1982, 4-6PM for 1988-1992, and 3-6PM for 2006
5 Defined as between 6:30AM to 6:30PM from 1977-1982, 7AM-7PM for 1988, and 6AM-7PM for 1992-2006.
6 Information not available in format needed for table for vehicles/person.
Sources: For 1977-1988 data – Vehicle occupancy Determinators, Barton-Aschman, Aug. 1989, 1992 data, 1992 Vehicle Occupancy Study, Lee Engineering, 1993.

Table 17: Comparison of Auto Occupancy Rates

Site	Morning Peak											Morning Off-Peak										
	73	74	77	78	79	80	81	82	88	92	06	73	74	77	78	79	80	81	82	88	92	06
21 (I-17) At Thomas Rd	1.20	1.20	1.18	1.22	1.22	1.26	1.22	1.20	1.18	1.17	1.31	1.51	1.41	1.22	1.35	1.40	1.31	1.30	1.34	1.31	1.32	1.19
84 Broadway	1.35	1.30	1.24	1.23	1.24	1.24	1.25	1.24	1.17	1.14	1.14	1.46	1.39	1.35	1.31	1.32	1.29	1.26	1.33	1.34	1.20	1.14
87 Indian School	-	1.25	1.22	1.21	1.18	1.19	1.18	1.15	1.18	1.21	1.11	-	1.38	1.25	1.27	1.29	1.23	1.26	1.24	1.32	1.24	1.19
76 7th Street	-	1.22	1.25	1.19	1.22	1.22	1.23	1.21	1.16	1.27	1.11	-	1.25	1.20	1.22	1.25	1.22	1.21	1.24	1.26	1.20	1.21
90 Thomas	-	1.20	1.16	1.16	1.20	1.21	1.18	1.22	1.13	1.13	1.11	-	1.22	1.20	1.26	1.29	1.23	1.25	1.26	1.28	1.21	1.20
13 (1-10) At 24th St	-	-	1.20	1.22	1.22	1.22	1.17	1.21	1.14	1.18	1.42	-	-	1.24	1.33	1.33	1.30	1.29	1.30	1.25	1.28	1.12
Composite	1.22	1.25	1.21	1.21	1.21	1.22	1.20	1.20	1.20	1.18	-	1.44	1.32	1.24	1.29	1.31	1.26	1.27	1.29	n/a	1.24	-
Site	**Afternoon Off-Peak**											**Afternoon Peak**										
21 (I-17) At Thomas Rd	-	1.32	1.28	1.33	1.33	1.30	1.32	1.33	1.31	1.26	1.19	1.24	1.28	1.27	1.31	1.40	1.28	1.30	1.30	1.23	1.18	1.37
84 Broadway	1.40	1.50	1.41	1.39	1.34	1.40	1.37	1.43	1.34	1.35	1.16	1.50	1.48	1.46	1.41	1.38	1.38	1.40	1.47	1.33	1.33	1.11
87 Indian School	-	1.36	1.30	1.31	1.33	1.31	1.30	1.27	1.32	1.43	1.21	-	1.41	1.29	1.33	1.33	1.28	1.34	1.31	1.33	1.39	1.26
76 7th Street	-	1.36	1.34	1.31	1.32	1.29	1.25	1.30	1.26	1.35	1.27	-	1.31	1.34	1.26	1.33	1.25	1.25	1.22	1.32	1.36	1.29
90 Thomas	-	1.41	1.36	1.29	1.37	1.35	1.31	1.35	1.28	1.32	1.22	-	1.32	1.27	1.32	1.32	1.30	1.29	1.33	1.31	1.40	1.27
13 (1-10) At 24th St	-	-	1.29	1.33	1.36	1.32	1.30	1.32	1.25	1.30	1.18	-	-	1.28	1.29	1.35	1.31	1.29	1.33	1.15	1.26	1.39
Composite	-	1.36	1.33	1.33	1.34	1.32	1.31	1.32	1.35	1.34	-	1.29	1.34	1.32	1.32	1.35	1.30	1.30	1.32	1.31	1.32	-
Site	**12-Hour Average**																					
21 (I-17) At Thomas Rd	-	1.29	1.25	1.31	1.33	1.29	1.29	1.31	1.27	1.28	1.27											
84 Broadway	1.43	1.43	1.39	1.35	1.33	1.35	1.34	1.40	1.33	1.32	1.13											
87 Indian School	-	1.36	1.28	1.29	1.30	1.27	1.28	1.26	1.32	1.34	1.22											
76 7th Street	-	1.30	1.29	1.26	1.29	1.25	1.24	1.25	1.25	1.30	1.23											
90 Thomas	-	1.31	1.28	1.27	1.32	1.29	1.27	1.31	1.27	1.28	1.22											
13 (1-10) At 24th St	-	-	1.26	1.30	1.33	1.30	1.28	1.30	1.19	1.26	1.27											
Composite	-	1.33	1.29	1.30	1.32	1.29	1.28	1.31	1.32	1.30	-											

1973-1982 Data from Phoenix Urban Area Auto Occupancy Study, 1982.
1988 Data From Vehicle Occupancy Determinators, Barton-Aschman, Inc. Final Report, August, 1989.
1992 Data from 1992 Vehicle Occupancy Study, Lee Engineering, 1993.

SECTION 4: VEHICLE CLASSIFICATION

Vehicle classification data was obtained as part of the overall data collection process. Five separate categories of vehicle classifications were obtained which included motorcycles, buses, passenger vehicles, delivery vehicles, and heavy vehicles. The five categories collected as part of this study correspond to the FHWA vehicle classification groups as shown in Table 5. Technicians were trained to recognize and properly categorize all types of vehicles on the roadways.

Various examples of vehicles and how they were classified in the field and within this report are shown below in *Table 18: Vehicle Classification Examples*.

Table 18: Vehicle Classification Examples

Motorcycles	Buses	Passenger Vehicles	Delivery Vehicles	Heavy Vehicles
Motorcycles	School buses	Private autos	Typical single-unit vans/trucks	Multi-axle tractor-trailers
Motorcycles with sidecars	City transit buses	Private vans	Marked vehicles (glass trucks, catering vans, etc.)	Heavy construction vehicles
	Chartered buses	Private pickup trucks	UPS/FedEx/DHL vehicles	
		SUVs		

All vehicle classification data were tabulated. Based on the determined project parameters including Area Type, Facility Time, and Time of Day, etc, vehicle classification percentages are presented in the tables and figures herein.

Table 19: Overall Vehicle Classification Percentages – All Area Types and Facility Types by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	0.96%	0.44%	93.54%	1.42%	3.64%
7AM - 8AM	0.81%	0.40%	94.50%	1.18%	3.11%
8AM - 9AM	0.59%	0.39%	93.60%	1.47%	3.95%
9AM - 10AM	0.33%	0.28%	93.07%	1.69%	4.63%
10AM - 11AM	0.35%	0.22%	93.00%	1.82%	4.61%
11AM - 12PM	0.35%	0.23%	93.39%	1.66%	4.38%
12PM - 1PM	0.39%	0.21%	93.84%	1.54%	4.02%
1PM - 2PM	0.41%	0.25%	94.27%	1.52%	3.55%
2PM - 3PM	0.44%	0.30%	94.67%	1.53%	3.06%
3PM - 4PM	0.66%	0.36%	95.24%	1.19%	2.55%
4PM - 5PM	0.75%	0.33%	96.06%	0.93%	1.92%
5PM - 6PM	0.77%	0.30%	96.55%	0.78%	1.61%
6PM - 7PM	0.70%	0.22%	96.54%	0.61%	1.93%
OVERALL	**0.58%**	**0.30%**	**94.54%**	**1.32%**	**3.26%**

Figure 13: Overall Vehicle Classification Percentages – All Area Types and Facility Types

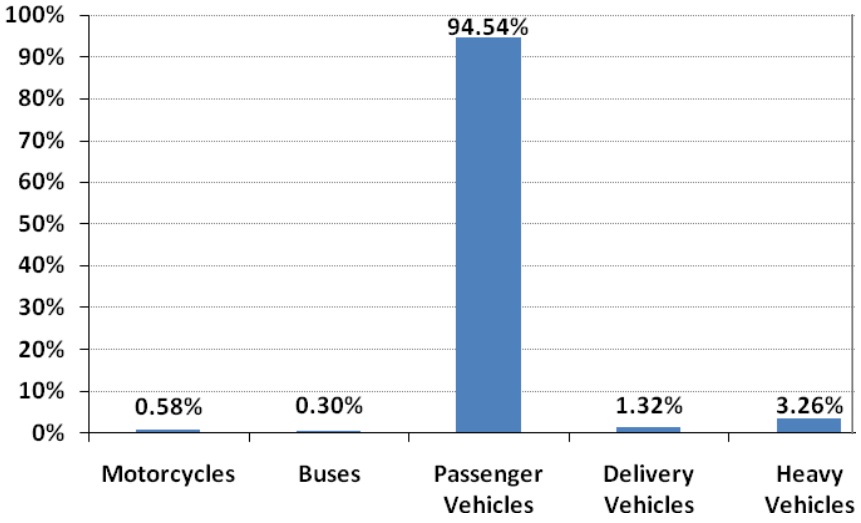


Table 20: Vehicle Classification Percentages by Time Period – ALL Freeway Facilities

Area Type	Time Periods	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
CBD	6AM - 9AM	0.85%	0.41%	93.84%	1.71%	3.19%
	9AM - 12PM	0.27%	0.17%	93.27%	1.62%	4.68%
	12PM - 3PM	0.33%	0.15%	93.90%	1.65%	3.97%
	3PM - 6PM	0.85%	0.36%	95.17%	1.28%	2.33%
	6PM - 7PM	1.06%	0.32%	95.76%	0.74%	2.12%
	OVERALL	**0.59%**	**0.27%**	**94.14%**	**1.52%**	**3.48%**
Urban	6AM - 9AM	0.99%	0.31%	93.26%	1.54%	3.89%
	9AM - 12PM	0.35%	0.19%	92.80%	1.77%	4.90%
	12PM - 3PM	0.44%	0.18%	93.98%	1.52%	3.88%
	3PM - 6PM	0.88%	0.29%	95.82%	0.89%	2.12%
	6PM - 7PM	0.81%	0.23%	96.45%	0.50%	2.00%
	OVERALL	**0.67%**	**0.24%**	**94.20%**	**1.35%**	**3.54%**
Suburban	6AM - 9AM	0.26%	0.17%	96.12%	0.51%	2.94%
	9AM - 12PM	0.23%	0.10%	95.07%	0.75%	3.85%
	12PM - 3PM	0.25%	0.09%	96.75%	0.72%	2.19%
	3PM - 6PM	0.25%	0.10%	97.92%	0.29%	1.43%
	6PM - 7PM	0.22%	0.04%	97.95%	0.23%	1.56%
	OVERALL	**0.25%**	**0.11%**	**96.68%**	**0.53%**	**2.44%**

Figure 14: Vehicle Classification Percentages – ALL Freeway Facilities

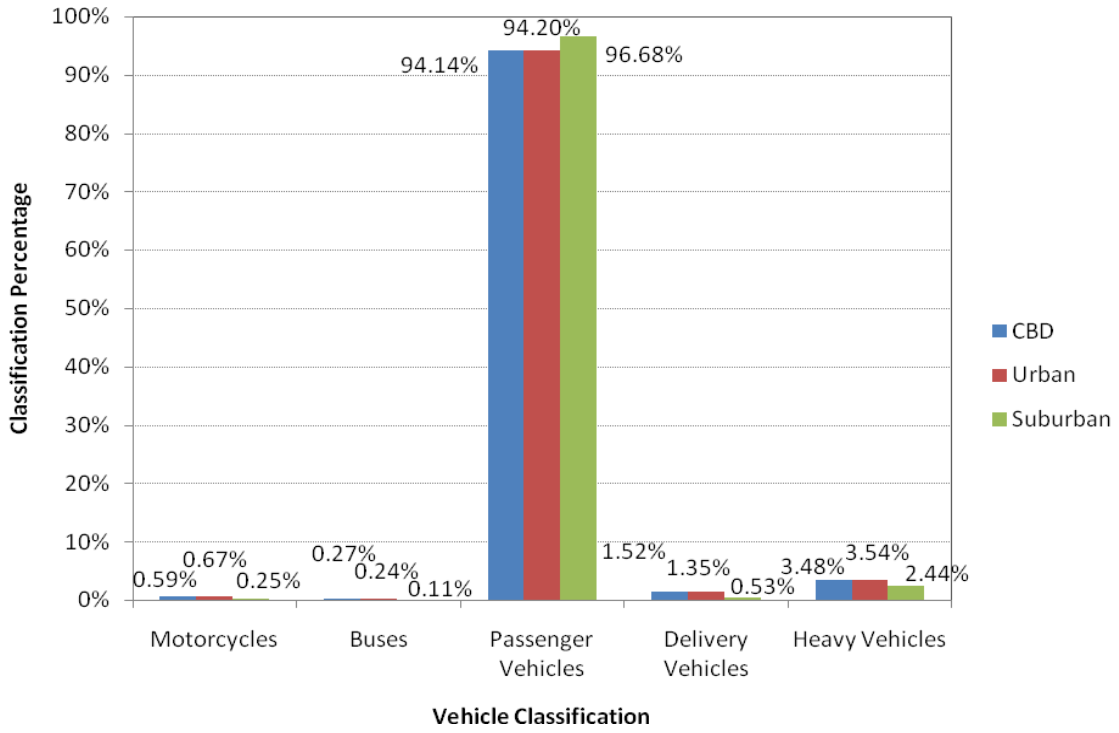
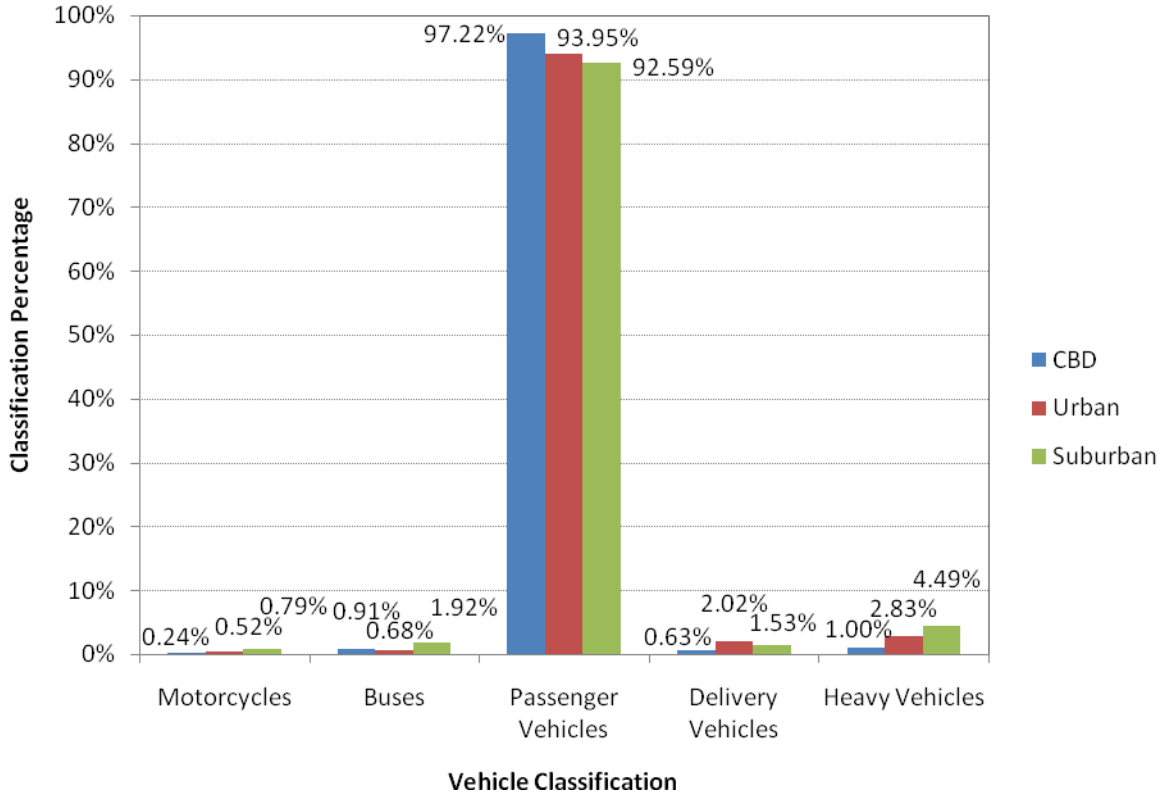


Table 21: Vehicle Classification Percentages by Time Period – Arterials

Area Type	Time Periods	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
CBD	6AM - 9AM	0.25%	1.06%	96.98%	0.44%	1.27%
	9AM - 12PM	0.16%	0.89%	96.68%	1.01%	1.26%
	12PM - 3PM	0.25%	0.89%	96.91%	0.82%	1.13%
	3PM - 6PM	0.30%	0.93%	97.82%	0.32%	0.63%
	6PM - 7PM	0.19%	0.53%	98.22%	0.67%	0.38%
	OVERALL	**0.24%**	**0.91%**	**97.22%**	**0.63%**	**1.00%**
Urban	6AM - 9AM	0.50%	0.87%	94.06%	1.39%	3.17%
	9AM - 12PM	0.52%	0.64%	92.21%	2.90%	3.73%
	12PM - 3PM	0.49%	0.74%	93.33%	2.47%	2.97%
	3PM - 6PM	0.53%	0.61%	94.93%	1.84%	2.09%
	6PM - 7PM	0.62%	0.29%	96.09%	1.17%	1.83%
	OVERALL	**0.52%**	**0.68%**	**93.95%**	**2.02%**	**2.83%**
Suburban	6AM - 9AM	0.53%	2.81%	93.28%	0.86%	4.49%
	9AM - 12PM	0.56%	1.22%	92.21%	1.58%	5.24%
	12PM - 3PM	0.84%	2.13%	90.86%	2.14%	5.39%
	3PM - 6PM	1.16%	1.77%	93.70%	1.53%	3.07%
	6PM - 7PM	0.95%	0.00%	93.14%	1.76%	4.14%
	OVERALL	**0.79%**	**1.92%**	**92.59%**	**1.53%**	**4.49%**

Figure 15: Vehicle Classification Percentages – Arterials



The following tables include overall vehicle classification percentages based on the freeway designations in the Phoenix metro region, by time of day.

Table 22: Vehicle Classification Percentages on I-10 by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	1.30%	0.51%	89.36%	2.63%	6.19%
7AM - 8AM	1.21%	0.52%	90.42%	2.34%	5.51%
8AM - 9AM	0.85%	0.33%	88.53%	2.58%	7.70%
9AM - 10AM	0.32%	0.29%	86.93%	2.83%	9.63%
10AM - 11AM	0.29%	0.19%	87.08%	3.21%	9.22%
11AM - 12PM	0.34%	0.17%	87.22%	2.85%	9.43%
12PM - 1PM	0.30%	0.16%	88.08%	3.04%	8.42%
1PM - 2PM	0.40%	0.23%	89.78%	2.50%	7.10%
2PM - 3PM	0.41%	0.18%	91.84%	2.09%	5.48%
3PM - 4PM	0.83%	0.31%	91.76%	2.03%	5.07%
4PM - 5PM	0.90%	0.46%	93.12%	1.66%	3.87%
5PM - 6PM	0.95%	0.48%	94.01%	1.23%	3.34%
6PM - 7PM	0.87%	0.29%	93.61%	0.86%	4.38%
OVERALL	**0.68%**	**0.31%**	**90.21%**	**2.28%**	**6.51%**

Table 23: Vehicle Classification Percentages on I-17 by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	1.04%	0.40%	92.10%	1.60%	4.86%
7AM - 8AM	1.08%	0.33%	93.27%	1.16%	4.15%
8AM - 9AM	0.65%	0.26%	92.27%	1.45%	5.37%
9AM - 10AM	0.30%	0.21%	92.88%	1.33%	5.28%
10AM - 11AM	0.37%	0.19%	93.05%	1.36%	5.02%
11AM - 12PM	0.41%	0.11%	93.47%	1.18%	4.83%
12PM - 1PM	0.71%	0.14%	93.26%	1.06%	4.84%
1PM - 2PM	0.55%	0.12%	94.20%	1.28%	3.85%
2PM - 3PM	0.46%	0.20%	94.15%	1.53%	3.66%
3PM - 4PM	0.66%	0.29%	95.11%	0.87%	3.07%
4PM - 5PM	0.91%	0.30%	95.73%	0.55%	2.50%
5PM - 6PM	1.02%	0.35%	95.76%	0.58%	2.29%
6PM - 7PM	0.98%	0.31%	95.40%	0.59%	2.71%
OVERALL	**0.69%**	**0.24%**	**93.95%**	**1.11%**	**4.00%**

Table 24: Vehicle Classification Percentages on US 60 by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	1.21%	0.20%	95.48%	1.10%	2.01%
7AM - 8AM	1.01%	0.16%	96.60%	0.82%	1.42%
8AM - 9AM	0.82%	0.23%	95.97%	0.93%	2.05%
9AM - 10AM	0.24%	0.18%	96.82%	0.76%	2.00%
10AM - 11AM	0.32%	0.16%	96.28%	0.80%	2.45%
11AM - 12PM	0.22%	0.08%	97.03%	0.70%	1.96%
12PM - 1PM	0.26%	0.11%	96.76%	0.71%	2.16%
1PM - 2PM	0.44%	0.19%	96.90%	0.66%	1.82%
2PM - 3PM	0.49%	0.16%	96.81%	1.01%	1.53%
3PM - 4PM	1.08%	0.16%	97.34%	0.41%	1.01%
4PM - 5PM	1.09%	0.15%	97.56%	0.40%	0.80%
5PM - 6PM	0.98%	0.21%	97.96%	0.28%	0.58%
6PM - 7PM	0.89%	0.24%	97.81%	0.38%	0.68%
OVERALL	**0.67%**	**0.17%**	**96.90%**	**0.68%**	**1.58%**

Table 25: Vehicle Classification Percentages on SR 51 by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	1.58%	0.30%	95.58%	0.81%	1.72%
7AM - 8AM	0.93%	0.27%	96.71%	0.82%	1.28%
8AM - 9AM	0.83%	0.20%	96.36%	1.31%	1.30%
9AM - 10AM	0.50%	0.22%	96.25%	1.27%	1.75%
10AM - 11AM	0.37%	0.15%	96.23%	1.40%	1.85%
11AM - 12PM	0.40%	0.23%	96.97%	0.83%	1.57%
12PM - 1PM	0.31%	0.16%	97.27%	0.96%	1.30%
1PM - 2PM	0.55%	0.24%	96.76%	1.06%	1.40%
2PM - 3PM	0.46%	0.15%	97.26%	1.09%	1.04%
3PM - 4PM	0.71%	0.23%	97.56%	0.72%	0.78%
4PM - 5PM	1.13%	0.32%	97.47%	0.59%	0.49%
5PM - 6PM	0.95%	0.21%	98.07%	0.46%	0.31%
6PM - 7PM	0.90%	0.08%	98.45%	0.17%	0.40%
OVERALL	**0.73%**	**0.21%**	**97.03%**	**0.88%**	**1.15%**

Table 26: Vehicle Classification Percentages on Loop 202 by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	1.15%	0.36%	93.62%	1.14%	3.73%
7AM - 8AM	0.90%	0.34%	94.51%	1.23%	3.03%
8AM - 9AM	0.69%	0.40%	94.60%	1.39%	2.92%
9AM - 10AM	0.43%	0.33%	93.56%	1.86%	3.82%
10AM - 11AM	0.35%	0.03%	92.96%	2.03%	4.63%
11AM - 12PM	0.41%	0.16%	92.82%	2.53%	4.08%
12PM - 1PM	0.36%	0.12%	93.90%	1.53%	4.09%
1PM - 2PM	0.32%	0.20%	94.56%	1.61%	3.31%
2PM - 3PM	0.48%	0.23%	95.19%	1.26%	2.84%
3PM - 4PM	0.81%	0.29%	95.64%	1.24%	2.03%
4PM - 5PM	1.13%	0.19%	96.37%	0.90%	1.42%
5PM - 6PM	0.95%	0.25%	97.24%	0.52%	1.04%
6PM - 7PM	0.81%	0.24%	97.82%	0.32%	0.80%
OVERALL	**0.69%**	**0.24%**	**94.95%**	**1.31%**	**2.80%**

Table 27: Vehicle Classification Percentages on Loop 101 by Time of Day

Time	Motor-cycles %	Buses %	Passenger Vehicles %	Delivery Vehicles %	Heavy Vehicles %
6AM - 7AM	0.28%	0.13%	97.99%	0.28%	1.32%
7AM - 8AM	0.30%	0.11%	97.94%	0.45%	1.20%
8AM - 9AM	0.24%	0.16%	97.72%	0.45%	1.44%
9AM - 10AM	0.23%	0.16%	97.57%	0.72%	1.32%
10AM - 11AM	0.29%	0.10%	97.19%	0.75%	1.66%
11AM - 12PM	0.20%	0.08%	98.16%	0.35%	1.22%
12PM - 1PM	0.29%	0.04%	98.11%	0.48%	1.08%
1PM - 2PM	0.22%	0.13%	98.16%	0.48%	1.02%
2PM - 3PM	0.34%	0.14%	97.52%	0.78%	1.22%
3PM - 4PM	0.32%	0.15%	98.34%	0.37%	0.83%
4PM - 5PM	0.19%	0.10%	99.03%	0.24%	0.44%
5PM - 6PM	0.31%	0.06%	99.14%	0.21%	0.29%
6PM - 7PM	0.24%	0.07%	99.18%	0.19%	0.32%
OVERALL	**0.26%**	**0.11%**	**98.20%**	**0.44%**	**1.00%**

The vehicle classification data for specific freeway designations in Tables 22 – 27 above show the Interstate freeways through the Phoenix metro area (I-10 and I-17) carry a higher percentage of truck traffic as compared to the non-interstate freeway facilities; with I-10 having the highest heavy vehicle percentages overall, 6.51%. In addition, the data shows that on all freeways during the data collection period, the PM Peak time periods have the lowest heavy vehicle percentages as compared to the rest of the day.

SECTION 5: HOV LANE EVALUATION

The current existing Phoenix metropolitan area freeway system contains 145 directional miles of HOV lanes, the locations of which are depicted in Figure 1. According the MAG's Regional Transportation Plan, HOV facilities in the area are programmed to expand even further, including adding the first HOV lanes on Loop 101.

Through continued HOV lane study, the function of HOV lanes has been adjusted to meet current travel conditions. In 1992, HOV lanes existed as all-day HOV priority lanes. They have since been adjusted to function as HOV priority lanes during the AM (6-9AM) and PM (3-7PM) peak "rush hours" and function as general purpose lanes for all other times of the day. To further study the use and function of the HOV lanes, this section will examine the utilization, violation rates, and efficiency of the HOV lanes in the region during these peak hours and throughout the entire study day.

HOV Lane Utilization and Occupancy

Currently, HOV Lanes function differently during the AM and PM peak hours (6-9AM, 3-7PM) than during the morning and midday time periods (9AM-3PM). During the peak hours, only autos of 2+ persons, motorcycles, buses, and some alternative fuel/hybrid vehicles are permitted (mid-way through the data collection phase it became lawful for these single-occupant vehicles to use the HOV Lane), whereas during the rest of the day, the HOV Lane acts as a general purpose lane for all types of vehicles. Due to this, occupancies of the HOV Lane during the peak hours should approach 2.0+, assuming zero violators. *Table 28: Auto Occupancies of HOV Lanes and General Purpose Lanes* depicts the average auto occupancies of those lanes for all HOV Freeway facilities.

Table 28: Average Auto Occupancies of HOV Lanes and General Purpose Lanes

Time	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane
	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
6-7a	**1.94**	**1.22**	**2.05**	**1.24**	**1.97**	**1.06**	**2.18**	**1.29**	**1.88**	**1.12**	**1.96**	**1.28**
7-8a	**1.99**	**1.16**	**1.99**	**1.27**	**1.90**	**1.07**	**2.06**	**1.19**	**1.85**	**1.14**	**1.97**	**1.28**
8-9a	**1.99**	**1.07**	**1.95**	**1.24**	**1.96**	**1.03**	**2.03**	**1.18**	**1.81**	**1.15**	**1.98**	**1.21**
9-10a	1.73	1.16	1.76	1.16	1.69	1.10	1.75	1.16	1.67	1.04	1.70	1.26
10-11a	1.71	1.19	1.78	1.21	1.75	1.23	1.71	1.07	1.63	1.04	1.85	1.29
11a-12p	1.66	1.14	1.77	1.21	1.74	1.23	1.65	1.09	1.64	1.02	1.78	1.39
12-1p	1.63	1.18	1.77	1.21	1.75	1.24	1.70	1.05	1.70	1.02	1.76	1.37
1-2p	1.65	1.20	1.70	1.21	1.78	1.21	1.72	1.19	1.67	1.03	1.77	1.42
2-3p	1.77	1.30	1.79	1.15	1.76	1.11	1.77	1.23	1.70	1.07	1.74	1.30
3-4p	**1.94**	**1.21**	**1.88**	**1.14**	**1.92**	**1.12**	**2.04**	**1.16**	**1.94**	**1.33**	**2.00**	**1.24**
4-5p	**1.93**	**1.35**	**1.95**	**1.06**	**1.96**	**1.16**	**2.03**	**1.07**	**1.92**	**1.23**	**1.98**	**1.16**
5-6p	**1.97**	**1.25**	**1.97**	**1.14**	**1.90**	**1.42**	**1.99**	**1.07**	**1.92**	**1.35**	**1.96**	**1.20**
6-7p	**2.01**	**1.14**	**1.94**	**1.22**	**1.97**	**1.16**	**2.00**	**1.29**	**1.81**	**1.30**	**1.95**	**1.23**

Table 28, Continued

Time	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane
	Site 7		Site 8		Site 9		Site 10		Site 11		Site 12	
6-7a	**1.88**	**1.11**	**2.12**	**1.12**	**1.80**	**1.11**	**2.09**	**1.11**	**1.99**	**1.12**	**1.95**	**1.25**
7-8a	**1.75**	**1.40**	**1.99**	**1.09**	**1.82**	**1.10**	**2.04**	**1.07**	**1.92**	**1.15**	**1.98**	**1.40**
8-9a	**1.77**	**1.06**	**2.03**	**1.13**	**1.72**	**1.06**	**2.04**	**1.14**	**1.95**	**1.16**	**1.94**	**1.52**
9-10a	1.73	1.07	1.66	1.14	1.67	1.14	1.71	1.18	1.77	1.11	1.91	1.38
10-11a	1.66	1.07	1.66	1.12	1.65	1.12	1.73	1.37	1.80	1.17	1.77	1.30
11a-12p	1.65	1.08	1.75	1.13	1.65	1.12	1.70	1.27	1.81	1.21	1.75	1.16
12-1p	1.66	1.09	1.74	1.18	1.68	1.05	1.74	1.23	1.72	1.19	1.77	1.26
1-2p	1.68	1.07	1.72	1.13	1.74	1.13	1.71	1.29	1.70	1.25	1.72	1.18
2-3p	1.72	1.11	1.69	1.08	1.80	1.20	1.72	1.30	1.86	1.27	1.77	1.29
3-4p	**1.87**	**1.12**	**1.89**	**1.15**	**2.05**	**1.19**	**2.03**	**1.18**	**1.95**	**1.21**	**2.04**	**1.30**
4-5p	**2.06**	**1.23**	**1.93**	**1.21**	**2.10**	**1.19**	**2.07**	**1.17**	**1.97**	**1.17**	**2.02**	**1.25**
5-6p	**2.00**	**1.28**	**2.01**	**1.23**	**2.07**	**1.20**	**2.03**	**1.17**	**1.97**	**1.26**	**1.98**	**1.17**
6-7p	**1.98**	**1.34**	**2.01**	**1.31**	**2.06**	**1.19**	**2.00**	**1.21**	**1.85**	**1.41**	**1.96**	**1.22**
	Site 13		Site 14		Site 15		Site 16		Site 17		Site 18	
6-7a	**1.92**	**1.19**	**2.03**	**1.14**	**1.89**	**1.08**	**2.05**	**1.10**	**1.86**	**1.06**	**2.07**	**1.08**
7-8a	**1.92**	**1.18**	**1.92**	**1.16**	**1.92**	**1.21**	**2.02**	**1.16**	**1.92**	**1.14**	**2.03**	**1.10**
8-9a	**1.85**	**1.15**	**1.82**	**1.23**	**1.87**	**1.01**	**1.95**	**1.13**	**1.95**	**1.03**	**1.98**	**1.15**
9-10a	1.70	1.05	1.83	1.20	1.71	1.11	1.78	1.17	1.69	1.03	1.71	1.12
10-11a	1.63	1.03	1.68	1.29	1.65	1.11	1.74	1.19	1.63	1.17	1.70	1.13
11a-12p	1.66	1.07	1.77	1.28	1.68	1.05	1.77	1.23	1.70	1.18	1.66	1.10
12-1p	1.69	1.21	1.81	1.34	1.69	1.08	1.70	1.18	1.64	1.09	1.68	1.16
1-2p	1.69	1.11	1.73	1.30	1.66	1.06	1.78	1.20	1.68	1.02	1.80	1.27
2-3p	1.62	1.05	1.71	1.24	1.74	1.03	1.84	1.36	1.65	1.00	1.84	1.34
3-4p	**1.91**	**1.14**	**2.01**	**1.18**	**1.96**	**1.05**	**2.08**	**1.33**	**1.86**	**1.04**	**2.10**	**1.26**
4-5p	**1.87**	**1.13**	**2.03**	**1.21**	**2.00**	**1.01**	**2.02**	**1.27**	**1.87**	**1.20**	**1.97**	**1.06**
5-6p	**1.75**	**1.08**	**1.93**	**1.26**	**2.01**	**1.03**	**1.93**	**1.23**	**1.97**	**1.03**	**2.00**	**1.09**
6-7p	**1.80**	**1.08**	**2.07**	**1.28**	**1.99**	**1.06**	**2.12**	**1.33**	**1.98**	**1.02**	**2.02**	**1.26**
	Site 19		Site 20		Site 21		Site 22		Site 23		Site 24	
6-7a	**2.02**	**1.11**	**2.07**	**1.08**	**1.88**	**1.19**	**1.79**	**1.19**	**1.88**	**1.26**	**1.77**	**1.11**
7-8a	**1.94**	**1.13**	**2.11**	**1.13**	**1.74**	**1.11**	**1.88**	**1.37**	**1.98**	**1.29**	**1.75**	**1.10**
8-9a	**1.99**	**1.14**	**2.03**	**1.23**	**1.80**	**1.12**	**1.88**	**1.35**	**1.88**	**1.33**	**1.75**	**1.06**
9-10a	1.87	1.29	1.79	1.13	1.71	1.07	1.87	1.16	1.75	1.19	1.67	1.12
10-11a	1.90	1.34	1.70	1.13	1.78	1.13	1.76	1.21	1.85	1.27	1.71	1.14
11a-12p	1.81	1.31	1.84	1.14	1.66	1.09	1.68	1.21	1.76	1.22	1.67	1.13
12-1p	1.83	1.22	1.89	1.29	1.66	1.07	1.86	1.24	1.72	1.19	1.68	1.14
1-2p	1.84	1.26	1.84	1.32	1.64	1.05	1.79	1.29	1.81	1.28	1.72	1.22
2-3p	1.64	1.01	1.87	1.41	1.66	1.08	1.77	1.26	1.84	1.26	1.79	1.18
3-4p	**1.88**	**1.04**	**2.04**	**1.21**	**1.73**	**1.07**	**1.86**	**1.29**	**1.97**	**1.27**	**1.90**	**1.18**
4-5p	**1.99**	**1.09**	**2.06**	**1.12**	**1.78**	**1.08**	**1.89**	**1.30**	**1.96**	**1.11**	**1.92**	**1.24**
5-6p	**2.00**	**1.04**	**2.03**	**1.42**	**1.78**	**1.07**	**1.94**	**1.32**	**1.90**	**1.11**	**2.00**	**1.27**
6-7p	**2.04**	**1.05**	**2.19**	**1.62**	**1.70**	**1.07**	**1.84**	**1.30**	**1.95**	**1.29**	**1.77**	**1.20**
	Site 25		Site 26		Site 27		Site 28		Site 29		Site 30	
6-7a	**1.85**	**1.15**	**1.82**	**1.07**	**1.83**	**1.14**	**1.84**	**1.28**	**1.92**	**1.10**	**1.88**	**1.28**
7-8a	**1.88**	**1.18**	**1.88**	**1.07**	**1.83**	**1.15**	**1.88**	**1.20**	**1.85**	**1.12**	**1.84**	**1.25**
8-9a	**2.03**	**1.25**	**1.82**	**1.09**	**1.77**	**1.10**	**1.88**	**1.14**	**1.94**	**1.09**	**1.84**	**1.20**
9-10a	1.82	1.26	1.73	1.13	1.70	1.16	1.74	1.14	1.83	1.14	1.72	1.15
10-11a	1.71	1.22	1.68	1.14	1.65	1.12	1.78	1.16	1.69	1.16	1.84	1.23
11a-12p	1.84	1.22	1.68	1.16	1.70	1.15	1.81	1.20	1.69	1.14	1.79	1.17
12-1p	1.72	1.07	1.69	1.19	1.68	1.08	1.71	1.08	1.68	1.12	1.79	1.13
1-2p	1.69	1.15	1.72	1.15	1.65	1.05	1.69	1.13	1.80	1.20	1.89	1.21
2-3p	1.81	1.22	1.78	1.20	1.71	1.17	1.74	1.16	1.72	1.16	1.77	1.21
3-4p	**1.80**	**1.15**	**1.92**	**1.25**	**1.76**	**1.09**	**1.91**	**1.13**	**1.84**	**1.25**	**1.90**	**1.10**
4-5p	**1.93**	**1.12**	**1.94**	**1.23**	**1.87**	**1.15**	**1.83**	**1.10**	**1.88**	**1.25**	**1.94**	**1.12**
5-6p	**1.84**	**1.19**	**1.95**	**1.25**	**1.84**	**1.13**	**1.84**	**1.26**	**1.85**	**1.21**	**1.87**	**1.09**
6-7p	**1.91**	**1.50**	**1.86**	**1.20**	**1.72**	**1.12**	**1.89**	**1.16**	**1.80**	**1.23**	**1.90**	**1.19**

Table 28, Continued

Time	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane	HOV Lane	GP Lane
	Site 31		Site 32		Site 33		Site 34		Site 35		Site 36	
6-7a	**1.77**	**1.07**	**1.80**	**1.24**	**1.98**	**1.01**	**2.06**	**1.16**	**1.96**	**1.16**	**1.93**	**1.19**
7-8a	**1.80**	**1.07**	**1.85**	**1.22**	**1.99**	**1.03**	**1.89**	**1.14**	**1.97**	**1.16**	**1.98**	**1.10**
8-9a	**1.77**	**1.08**	**1.98**	**1.24**	**1.95**	**1.12**	**1.91**	**1.16**	**1.90**	**1.17**	**1.88**	**1.13**
9-10a	1.70	1.14	1.75	1.20	1.71	1.14	1.77	1.17	1.80	1.13	1.74	1.13
10-11a	1.71	1.14	1.76	1.19	1.72	1.14	1.72	1.22	1.75	1.17	1.74	1.26
11a-12p	1.69	1.15	1.82	1.15	1.69	1.17	1.73	1.19	1.75	1.18	1.73	1.23
12-1p	1.70	1.14	1.80	1.15	1.65	1.10	1.71	1.25	1.79	1.16	1.85	1.19
1-2p	1.72	1.17	1.79	1.19	1.67	1.07	1.78	1.20	1.65	1.13	1.80	1.28
2-3p	1.67	1.10	1.77	1.13	1.64	1.15	1.80	1.20	1.76	1.15	1.80	1.28
3-4p	**1.74**	**1.24**	**1.87**	**1.17**	**2.01**	**1.14**	**1.96**	**1.11**	**1.92**	**1.17**	**1.96**	**1.25**
4-5p	**1.90**	**1.22**	**1.84**	**1.07**	**2.00**	**1.20**	**1.99**	**1.09**	**1.99**	**1.15**	**1.97**	**1.29**
5-6p	**1.88**	**1.29**	**1.89**	**1.07**	**2.02**	**1.20**	**2.04**	**1.15**	**1.96**	**1.14**	**1.98**	**1.23**
6-7p	**1.83**	**1.24**	**1.94**	**1.12**	**1.88**	**1.03**	**2.07**	**1.27**	**1.88**	**1.10**	**1.98**	**1.32**
	Site 37		Site 38		Site 39		Site 40		Site 41		Site 42	
6-7a	**1.95**	**1.32**	**1.81**	**1.10**	**1.96**	**1.19**	**1.89**	**1.07**	**2.26**	**1.21**	**1.93**	**1.08**
7-8a	**2.01**	**1.18**	**1.83**	**1.09**	**1.96**	**1.14**	**1.94**	**1.08**	**2.10**	**1.15**	**1.92**	**1.10**
8-9a	**1.94**	**1.16**	**1.79**	**1.05**	**1.81**	**1.12**	**1.94**	**1.01**	**2.09**	**1.18**	**1.94**	**1.14**
9-10a	1.79	1.15	1.67	1.05	1.67	1.11	1.80	1.02	1.72	1.09	1.65	1.16
10-11a	1.69	1.06	1.67	1.07	1.64	1.08	1.69	1.05	1.67	1.08	1.67	1.18
11a-12p	1.77	1.17	1.79	1.10	1.64	1.08	1.63	1.06	1.63	1.08	1.62	1.14
12-1p	1.79	1.21	1.69	1.06	1.64	1.14	1.61	1.06	1.68	1.09	1.67	1.12
1-2p	1.74	1.26	1.75	1.12	1.66	1.13	1.68	1.14	1.70	1.06	1.63	1.08
2-3p	1.76	1.19	1.89	1.13	1.68	1.14	1.72	1.25	1.67	1.11	1.63	1.10
3-4p	**1.99**	**1.29**	**1.90**	**1.17**	1.94	1.14	1.87	1.24	2.02	1.15	2.02	1.31
4-5p	**1.98**	**1.13**	**1.91**	**1.18**	2.00	1.11	1.92	1.04	1.96	1.15	2.01	1.27
5-6p	**1.93**	**1.08**	**1.88**	**1.19**	1.99	1.14	1.91	1.03	1.94	1.14	2.01	1.29
6-7p	**1.93**	**1.13**	**1.95**	**1.19**	1.96	1.13	1.97	1.11	2.02	1.16	1.93	1.31
	Site 51		Site 52									
6-7a	**1.96**	**1.18**	**1.72**	**1.13**								
7-8a	**1.85**	**1.17**	**1.80**	**1.07**								
8-9a	**1.83**	**1.19**	**1.80**	**1.09**								
9-10a	1.68	1.08	1.79	1.17								
10-11a	1.71	1.15	1.78	1.12								
11a-12p	1.67	1.09	1.79	1.17								
12-1p	1.63	1.05	1.75	1.25								
1-2p	1.64	1.03	1.82	1.22								
2-3p	1.66	1.10	1.80	1.22								
3-4p	**1.74**	**1.13**	**1.94**	**1.22**								
4-5p	**1.75**	**1.06**	**1.95**	**1.34**								
5-6p	**1.75**	**1.09**	**1.93**	**1.30**								
6-7p	**1.75**	**1.09**	**1.86**	**1.29**								

Table 29: Peak Hour Auto Occupancies for HOV Lanes and General Purpose Lanes presents the average auto occupancies for each the HOV Lane and General Purpose Lanes during the AM and PM Peak of the facility (6-9AM and 3-7PM, respectively).

Table 29: Peak Hour Auto Occupancies of HOV Lanes and General Purpose Lanes

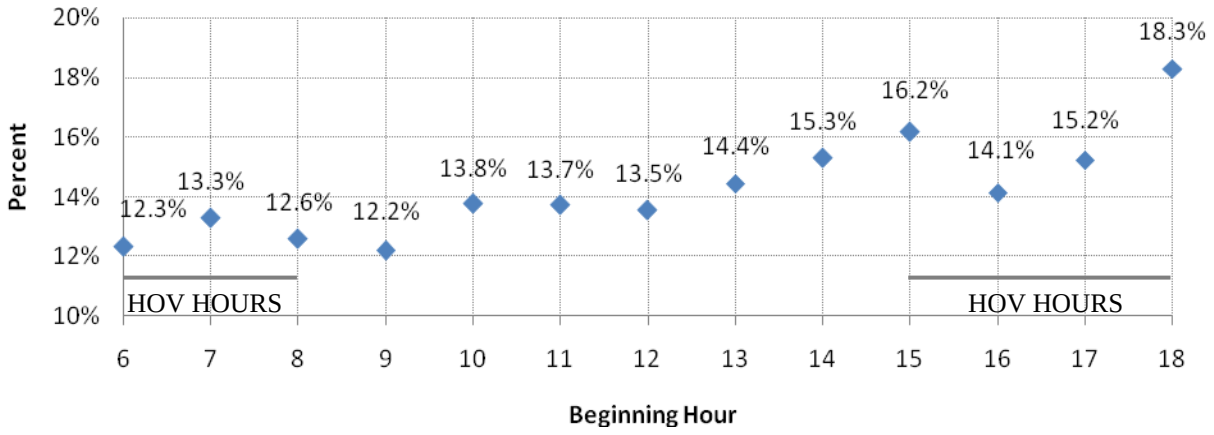
Time Period	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes	HOV Lane	GP Lanes
	Site 1		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
AM Peak	1.97	1.15	2.00	1.25	1.94	1.06	2.09	1.22	1.84	1.14	1.97	1.26
PM Peak	1.96	1.25	1.94	1.13	1.94	1.21	2.02	1.14	1.91	1.30	1.97	1.21
	Site 7		**Site 8**		**Site 9**		**Site 10**		**Site 11**		**Site 12**	
AM Peak	1.79	1.17	2.05	1.11	1.77	1.09	2.05	1.11	1.94	1.15	1.96	1.38
PM Peak	1.95	1.23	1.97	1.22	2.07	1.19	2.03	1.18	1.94	1.24	2.01	1.24
	Site 13		**Site 14**		**Site 15**		**Site 16**		**Site 17**		**Site 18**	
AM Peak	1.90	1.18	1.92	1.17	1.89	1.12	2.01	1.13	1.91	1.07	2.02	1.11
PM Peak	1.84	1.11	2.00	1.22	1.99	1.04	2.05	1.29	1.93	1.08	2.02	1.16
	Site 19		**Site 20**		**Site 21**		**Site 22**		**Site 23**		**Site 24**	
AM Peak	1.98	1.12	2.08	1.14	1.80	1.14	1.84	1.30	1.91	1.30	1.76	1.09
PM Peak	1.98	1.06	2.07	1.34	1.75	1.07	1.88	1.30	1.94	1.18	1.90	1.22
	Site 25		**Site 26**		**Site 27**		**Site 28**		**Site 29**		**Site 30**	
AM Peak	1.91	1.19	1.84	1.08	1.81	1.13	1.86	1.20	1.89	1.10	1.85	1.24
PM Peak	1.87	1.23	1.92	1.24	1.79	1.12	1.86	1.16	1.84	1.24	1.91	1.12
	Site 31		**Site 32**		**Site 33**		**Site 34**		**Site 35**		**Site 36**	
AM Peak	1.78	1.07	1.87	1.23	1.98	1.05	1.95	1.15	1.95	1.16	1.93	1.14
PM Peak	1.84	1.25	1.88	1.11	1.98	1.14	2.01	1.15	1.95	1.14	1.97	1.27
	Site 37		**Site 38**		**Site 39**		**Site 40**		**Site 41**		**Site 42**	
AM Peak	1.97	1.22	1.81	1.08	1.90	1.14	1.92	1.06	2.16	1.18	1.93	1.11
PM Peak	1.96	1.16	1.90	1.18	1.97	1.13	1.91	1.11	1.98	1.15	2.00	1.30
	Site 51		**Site 52**									
AM Peak	1.88	1.18	1.77	1.10								
PM Peak	1.75	1.09	1.93	1.28								

As can be seen in Table 28, a significant drop in auto occupancy occurs during the morning and midday time periods when the HOV Lane acts as a general purpose lane, yet the occupancies on the HOV Lane during this time period are still higher than on the general purpose lanes. As shown in Table 28 and Table 29, auto occupancies during the peak hours on the HOV Lanes are significantly higher than on the general purpose lanes, although due to violations, they are not always greater than 2.0.

High Occupancy Vehicles in General Purpose Lanes

At times, a high occupancy passenger vehicle will not just travel in the HOV Lane, which gives rise to 1.0+ occupancies in the general purpose lanes. This will happen for various reasons. Sometimes, the HOV and general purpose lanes both have slow predominant travel speeds, or both are flowing freely, not giving the HOV driver any benefit to move over to the HOV Lane. Other times, the trip might be short, giving the driver no reason to shift over to the HOV Lane. Finally, at the point the high occupancy vehicle was counted in the field on the general purpose lane, the driver may have been moving from the HOV lane to exit the freeway. *Figure 16: Percentage of High Occupancy Passenger Vehicles in General Purpose Lanes* on the following page, depicts the times of the day when the overall percentages of high occupancy vehicles are using general purpose lanes.

Figure 16: Percentage of High Occupancy Passenger Vehicles in General Purpose Lanes



HOV lane Violations

Priority lane violations occur when during the times of HOV lane function peak hours (6-9AM, 3-7PM) single occupant vehicles are utilizing the HOV Lane. Violation rates at all HOV freeway sites have been tabulated in *Table 30: Peak Hour Violation Rate of Single Occupant Vehicles in HOV lanes*. This tabulation shows the number of one passenger vehicles in the HOV lane, the total number of vehicles in the HOV lane, and the violation rate percentages for each hour during the peak hours. Following Table 30, *Table 31: Overall Peak Hour Violation Rates* shows the overall peak hour violation rates for each site location.

Table 30: Peak Hour Violation Rate of Single Occupant Vehicles in HOV Lanes

Time	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %
		Site 1			Site 2			Site 3	
6-7a	**37**	**381**	**10%**	**22**	**165**	**13%**	**28**	**381**	**7%**
7-8a	**22**	**299**	**7%**	**15**	**145**	**10%**	**71**	**508**	**14%**
8-9a	**16**	**272**	**6%**	**14**	**137**	**10%**	**22**	**272**	**8%**
9-10a	80	201	40%	30	119	25%	56	172	33%
10-11a	60	142	43%	30	106	28%	35	142	25%
11a-12p	65	130	50%	32	122	27%	55	194	28%
12p-1p	48	110	44%	30	101	30%	89	110	81%
1-2p	60	123	49%	37	121	31%	102	303	34%
2-3p	33	96	34%	60	230	26%	32	96	34%
3-4p	**22**	**212**	**10%**	**54**	**347**	**16%**	**34**	**366**	**9%**
4-5p	**37**	**185**	**20%**	**32**	**460**	**7%**	**23**	**185**	**13%**
5-6p	**19**	**182**	**10%**	**46**	**541**	**8%**	**36**	**245**	**15%**
6-7p	**8**	**152**	**6%**	**39**	**307**	**13%**	**16**	**152**	**10%**
		Site 4			Site 5			Site 6	
6-7a	**14**	**175**	**8%**	**77**	**414**	**19%**	**30**	**140**	**22%**
7-8a	**20**	**169**	**12%**	**105**	**537**	**20%**	**13**	**114**	**11%**
8-9a	**18**	**160**	**11%**	**147**	**600**	**25%**	**27**	**189**	**14%**
9-10a	38	135	28%	61	175	35%	31	78	40%
10-11a	32	98	33%	89	227	39%	21	48	45%
11a-12p	61	162	38%	87	239	36%	17	52	33%
12p-1p	36	102	36%	56	167	34%	36	90	40%
1-2p	51	161	32%	92	267	35%	45	109	41%
2-3p	125	442	28%	36	109	33%	46	126	37%
3-4p	**68**	**625**	**11%**	**69**	**398**	**17%**	**36**	**482**	**8%**
4-5p	**35**	**575**	**6%**	**52**	**340**	**15%**	**35**	**528**	**7%**
5-6p	**23**	**665**	**4%**	**44**	**270**	**16%**	**42**	**529**	**8%**
6-7p	**60**	**525**	**12%**	**55**	**228**	**24%**	**36**	**452**	**8%**
		Site 7			Site 8			Site 9	
6-7a	**116**	**683**	**17%**	**15**	**251**	**6%**	**158**	**654**	**24%**
7-8a	**295**	**1064**	**28%**	**14**	**196**	**7%**	**60**	**292**	**20%**
8-9a	**226**	**901**	**25%**	**18**	**207**	**9%**	**180**	**633**	**28%**
9-10a	108	371	29%	55	133	41%	55	141	39%
10-11a	77	224	35%	43	116	37%	74	179	41%
11a-12p	169	462	37%	47	140	34%	50	123	40%
12p-1p	69	199	34%	46	155	30%	140	394	36%
1-2p	92	266	35%	56	173	32%	39	117	34%
2-3p	129	406	32%	101	309	33%	35	107	33%
3-4p	**114**	**618**	**18%**	**54**	**355**	**15%**	**49**	**562**	**9%**
4-5p	**14**	**288**	**5%**	**55**	**526**	**10%**	**14**	**341**	**4%**
5-6p	**15**	**256**	**6%**	**24**	**492**	**5%**	**7**	**283**	**2%**
6-7p	**24**	**225**	**11%**	**36**	**523**	**7%**	**4**	**224**	**2%**
		Site 10			Site 11			Site 12	
6-7a	**24**	**311**	**8%**	**11**	**183**	**6%**	**29**	**222**	**13%**
7-8a	**10**	**338**	**3%**	**52**	**385**	**14%**	**26**	**219**	**12%**
8-9a	**11**	**387**	**3%**	**37**	**280**	**13%**	**35**	**188**	**19%**
9-10a	107	274	39%	62	241	26%	41	184	22%
10-11a	95	224	43%	21	86	24%	37	135	27%
11a-12p	79	182	43%	24	101	24%	26	95	28%
12p-1p	67	182	37%	49	116	43%	28	102	27%
1-2p	111	286	39%	25	72	35%	62	195	32%
2-3p	82	210	39%	64	223	29%	48	163	30%
3-4p	**62**	**582**	**11%**	**51**	**373**	**14%**	**41**	**487**	**8%**
4-5p	**20**	**417**	**5%**	**33**	**320**	**10%**	**39**	**530**	**7%**
5-6p	**22**	**444**	**5%**	**36**	**338**	**11%**	**28**	**459**	**6%**
6-7p	**33**	**398**	**8%**	**57**	**267**	**21%**	**16**	**232**	**7%**

Table 30, Continued

Time	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %
		Site 13			Site 14			Site 15	
6-7a	**47**	**314**	**15%**	**21**	**332**	**6%**	**42**	**283**	**15%**
7-8a	**51**	**332**	**15%**	**84**	**574**	**15%**	**32**	**273**	**12%**
8-9a	**48**	**252**	**19%**	**74**	**347**	**21%**	**58**	**341**	**17%**
9-10a	44	141	31%	69	243	28%	72	241	30%
10-11a	48	128	38%	57	125	46%	55	154	36%
11a-12p	55	154	36%	63	153	41%	110	298	37%
12p-1p	39	117	33%	64	164	39%	85	252	34%
1-2p	53	146	36%	43	90	47%	96	274	35%
2-3p	75	194	39%	55	143	38%	75	282	27%
3-4p	**75**	**575**	**13%**	**32**	**400**	**8%**	**39**	**689**	**6%**
4-5p	**74**	**419**	**18%**	**22**	**329**	**7%**	**21**	**870**	**2%**
5-6p	**130**	**471**	**28%**	**84**	**392**	**21%**	**5**	**774**	**1%**
6-7p	**83**	**398**	**21%**	**13**	**183**	**7%**	**11**	**630**	**2%**
		Site 16			Site 17			Site 18	
6-7a	**68**	**864**	**8%**	**39**	**246**	**16%**	**33**	**499**	**7%**
7-8a	**78**	**1042**	**8%**	**19**	**221**	**9%**	**44**	**607**	**7%**
8-9a	**89**	**732**	**12%**	**10**	**142**	**7%**	**77**	**647**	**12%**
9-10a	122	410	30%	33	102	33%	78	253	31%
10-11a	59	199	30%	70	183	38%	56	176	32%
11a-12p	55	191	29%	48	158	30%	72	201	36%
12p-1p	98	319	31%	69	189	36%	81	244	33%
1-2p	72	275	26%	38	120	32%	62	245	25%
2-3p	121	458	27%	67	188	36%	83	355	23%
3-4p	**58**	**612**	**10%**	**63**	**319**	**20%**	**36**	**415**	**9%**
4-5p	**62**	**497**	**12%**	**76**	**456**	**17%**	**22**	**457**	**5%**
5-6p	**61**	**366**	**17%**	**20**	**564**	**4%**	**8**	**662**	**1%**
6-7p	**45**	**462**	**10%**	**24**	**409**	**6%**	**16**	**277**	**6%**
		Site 19			Site 20			Site 21	
6-7a	**14**	**115**	**12%**	**37**	**471**	**8%**	**43**	**210**	**20%**
7-8a	**14**	**142**	**10%**	**28**	**634**	**4%**	**73**	**264**	**28%**
8-9a	**22**	**177**	**12%**	**34**	**327**	**11%**	**61**	**221**	**28%**
9-10a	18	79	22%	38	167	23%	65	189	34%
10-11a	28	96	29%	51	180	28%	44	161	27%
11a-12p	21	83	25%	39	181	22%	71	197	36%
12p-1p	24	100	24%	29	135	21%	83	233	36%
1-2p	25	113	22%	32	148	22%	79	222	36%
2-3p	72	199	36%	37	171	22%	154	425	36%
3-4p	**55**	**415**	**13%**	**16**	**246**	**6%**	**156**	**550**	**28%**
4-5p	**40**	**351**	**12%**	**6**	**322**	**2%**	**140**	**593**	**24%**
5-6p	**30**	**446**	**7%**	**14**	**187**	**7%**	**146**	**580**	**25%**
6-7p	**27**	**406**	**7%**	**12**	**130**	**10%**	**161**	**485**	**33%**
		Site 22			Site 23			Site 24	
6-7a	**113**	**461**	**25%**	**46**	**278**	**16%**	**123**	**525**	**23%**
7-8a	**79**	**474**	**17%**	**38**	**230**	**17%**	**166**	**621**	**27%**
8-9a	**63**	**297**	**21%**	**85**	**351**	**24%**	**135**	**488**	**28%**
9-10a	47	217	22%	56	197	29%	103	311	33%
10-11a	40	140	29%	40	182	22%	103	307	33%
11a-12p	71	212	33%	54	201	27%	95	260	37%
12p-1p	31	165	19%	70	239	29%	111	324	34%
1-2p	54	209	26%	50	221	23%	93	297	31%
2-3p	88	286	31%	53	251	21%	83	303	27%
3-4p	**96**	**410**	**23%**	**44**	**389**	**11%**	**113**	**588**	**19%**
4-5p	**73**	**350**	**21%**	**69**	**532**	**13%**	**91**	**529**	**17%**
5-6p	**73**	**391**	**19%**	**82**	**538**	**15%**	**97**	**488**	**20%**
6-7p	**50**	**244**	**20%**	**52**	**429**	**12%**	**100**	**390**	**26%**

Table 30, Continued

Time	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %
		Site 25			Site 26			Site 27	
6-7a	**51**	**274**	**19%**	**85**	**408**	**21%**	**57**	**300**	**19%**
7-8a	**76**	**339**	**22%**	**104**	**538**	**19%**	**61**	**251**	**24%**
8-9a	**27**	**198**	**13%**	**93**	**388**	**24%**	**65**	**252**	**26%**
9-10a	43	178	24%	100	309	32%	42	129	33%
10-11a	66	222	30%	89	258	34%	55	151	37%
11a-12p	35	157	22%	91	265	34%	44	137	32%
12p-1p	59	191	31%	79	265	30%	43	125	34%
1-2p	94	274	34%	96	318	30%	87	238	36%
2-3p	59	266	22%	101	355	28%	69	212	32%
3-4p	**118**	**477**	**25%**	**107**	**582**	**18%**	**116**	**409**	**28%**
4-5p	**87**	**580**	**15%**	**80**	**486**	**17%**	**69**	**292**	**24%**
5-6p	**132**	**647**	**20%**	**82**	**422**	**19%**	**60**	**241**	**25%**
6-7p	**51**	**486**	**10%**	**79**	**386**	**21%**	**73**	**245**	**30%**
		Site 28			Site 29			Site 30	
6-7a	**52**	**239**	**22%**	**56**	**355**	**16%**	**37**	**189**	**19%**
7-8a	**49**	**331**	**15%**	**96**	**542**	**18%**	**60**	**291**	**21%**
8-9a	**35**	**179**	**19%**	**51**	**388**	**13%**	**56**	**270**	**21%**
9-10a	49	171	29%	48	214	22%	50	181	28%
10-11a	31	110	28%	59	171	35%	25	118	21%
11a-12p	17	73	24%	41	134	30%	35	136	26%
12p-1p	37	121	31%	58	173	33%	35	144	24%
1-2p	63	207	31%	49	181	27%	38	174	22%
2-3p	55	200	28%	63	190	33%	63	236	27%
3-4p	**49**	**303**	**16%**	**88**	**350**	**25%**	**65**	**437**	**15%**
4-5p	**104**	**519**	**20%**	**57**	**272**	**21%**	**58**	**514**	**11%**
5-6p	**92**	**494**	**19%**	**59**	**260**	**23%**	**74**	**454**	**16%**
6-7p	**35**	**232**	**15%**	**42**	**194**	**22%**	**44**	**354**	**12%**
		Site 31			Site 32			Site 33	
6-7a	**76**	**335**	**23%**	**73**	**277**	**26%**	**15**	**233**	**6%**
7-8a	**107**	**502**	**21%**	**62**	**278**	**22%**	**12**	**438**	**3%**
8-9a	**119**	**514**	**23%**	**34**	**234**	**15%**	**24**	**344**	**7%**
9-10a	68	222	31%	45	162	28%	62	206	30%
10-11a	31	106	29%	45	155	29%	49	164	30%
11a-12p	33	98	34%	26	137	19%	52	160	33%
12p-1p	28	85	33%	38	170	22%	71	199	36%
1-2p	36	122	30%	35	159	22%	84	240	35%
2-3p	70	206	34%	56	235	24%	126	346	36%
3-4p	**86**	**305**	**28%**	**41**	**299**	**14%**	**40**	**355**	**11%**
4-5p	**61**	**326**	**19%**	**83**	**496**	**17%**	**34**	**283**	**12%**
5-6p	**53**	**261**	**20%**	**73**	**504**	**15%**	**14**	**170**	**8%**
6-7p	**59**	**269**	**22%**	**33**	**395**	**8%**	**26**	**186**	**14%**
		Site 34			Site 35			Site 36	
6-7a	**21**	**222**	**9%**	**18**	**138**	**13%**	**32**	**208**	**15%**
7-8a	**32**	**233**	**14%**	**11**	**110**	**10%**	**17**	**251**	**7%**
8-9a	**30**	**224**	**13%**	**9**	**74**	**13%**	**49**	**332**	**15%**
9-10a	52	180	29%	21	103	20%	93	309	30%
10-11a	52	179	29%	36	127	28%	18	67	27%
11a-12p	47	168	28%	33	113	29%	29	90	32%
12p-1p	56	188	30%	16	74	22%	13	64	20%
1-2p	68	247	28%	59	162	36%	27	108	25%
2-3p	86	313	27%	47	178	26%	29	133	22%
3-4p	**50**	**411**	**12%**	**55**	**370**	**15%**	**19**	**157**	**12%**
4-5p	**37**	**418**	**9%**	**44**	**451**	**10%**	**8**	**108**	**7%**
5-6p	**25**	**412**	**6%**	**44**	**535**	**8%**	**7**	**114**	**6%**
6-7p	**24**	**277**	**9%**	**33**	**238**	**14%**	**10**	**103**	**9%**

Table 30, Continued

Time	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %
		Site 37			Site 38			Site 39	
6-7a	**10**	**112**	**9%**	**100**	**400**	**25%**	**20**	**147**	**14%**
7-8a	**11**	**120**	**9%**	**75**	**362**	**21%**	**10**	**98**	**10%**
8-9a	**7**	**80**	**8%**	**123**	**534**	**23%**	**30**	**154**	**20%**
9-10a	20	81	24%	73	211	35%	29	88	33%
10-11a	51	146	35%	59	160	37%	45	122	37%
11a-12p	35	118	29%	37	143	26%	83	226	37%
12p-1p	27	117	23%	16	51	31%	74	208	36%
1-2p	36	129	28%	30	113	26%	101	296	34%
2-3p	54	227	24%	46	232	20%	82	246	33%
3-4p	**31**	**359**	**9%**	**54**	**345**	**16%**	**48**	**413**	**12%**
4-5p	**23**	**388**	**6%**	**25**	**181**	**14%**	**32**	**443**	**7%**
5-6p	**28**	**313**	**9%**	**38**	**252**	**15%**	**34**	**505**	**7%**
6-7p	**24**	**213**	**11%**	**4**	**88**	**5%**	**29**	**341**	**8%**
		Site 40			Site 41			Site 42	
6-7a	**42**	**329**	**13%**	**3**	**91**	**4%**	**48**	**408**	**12%**
7-8a	**14**	**229**	**6%**	**6**	**77**	**7%**	**50**	**447**	**11%**
8-9a	**13**	**202**	**6%**	**9**	**79**	**11%**	**26**	**204**	**13%**
9-10a	10	52	20%	48	166	29%	148	423	35%
10-11a	19	55	35%	59	159	37%	108	300	36%
11a-12p	47	122	39%	52	140	37%	44	116	38%
12p-1p	33	81	40%	65	200	33%	87	258	34%
1-2p	40	119	33%	52	171	31%	74	198	37%
2-3p	58	186	31%	60	172	35%	59	153	38%
3-4p	**37**	**197**	**19%**	**32**	**336**	**10%**	**16**	**150**	**11%**
4-5p	**14**	**159**	**9%**	**39**	**389**	**10%**	**13**	**126**	**10%**
5-6p	**19**	**150**	**13%**	**42**	**392**	**11%**	**10**	**117**	**9%**
6-7p	**12**	**109**	**11%**	**22**	**288**	**8%**	**9**	**91**	**10%**
		Site 51			Site 52				
6-7a	**45**	**290**	**16%**	**99**	**344**	**29%**			
7-8a	**86**	**335**	**26%**	**99**	**419**	**24%**			
8-9a	**96**	**351**	**27%**	**58**	**270**	**21%**			
9-10a	56	176	32%	44	192	23%			
10-11a	52	161	33%	34	134	26%			
11a-12p	72	202	36%	36	159	23%			
12p-1p	78	218	36%	56	213	26%			
1-2p	103	284	36%	45	211	21%			
2-3p	103	296	35%	60	243	25%			
3-4p	**106**	**372**	**29%**	**66**	**447**	**15%**			
4-5p	**116**	**431**	**27%**	**51**	**441**	**12%**			
5-6p	**118**	**441**	**27%**	**40**	**282**	**14%**			
6-7p	**107**	**364**	**29%**	**52**	**313**	**17%**			

Table 31: Overall Peak Hour Violation Rates

Time Period	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %	One Passenger Vehicles	Total Vehicles	Violation Rate %
		Site 1			**Site 2**			**Site 3**	
AM Peak	75	952	8%	51	447	11%	122	1161	11%
PM Peak	86	731	12%	171	1655	10%	109	948	11%
		Site 4			**Site 5**			**Site 6**	
AM Peak	52	504	10%	330	1551	21%	70	443	16%
PM Peak	188	2390	8%	221	1236	18%	149	1991	8%
		Site 7			**Site 8**			**Site 9**	
AM Peak	637	2648	24%	46	654	7%	398	1579	25%
PM Peak	167	1387	12%	169	1896	9%	73	1410	5%
		Site 10			**Site 11**			**Site 12**	
AM Peak	45	1036	4%	101	848	12%	90	629	14%
PM Peak	137	1841	7%	176	1298	14%	125	1708	7%
		Site 13			**Site 14**			**Site 15**	
AM Peak	146	898	16%	179	1253	14%	131	897	15%
PM Peak	362	1863	19%	151	1304	12%	76	2963	3%
		Site 16			**Site 17**			**Site 18**	
AM Peak	235	2638	9%	68	609	11%	154	1753	9%
PM Peak	227	1937	12%	183	1748	10%	81	1811	4%
		Site 19			**Site 20**			**Site 21**	
AM Peak	49	434	11%	99	1432	7%	177	695	26%
PM Peak	153	1618	9%	48	885	5%	604	2208	27%
		Site 22			**Site 23**			**Site 24**	
AM Peak	256	1232	21%	168	859	20%	423	1634	26%
PM Peak	291	1395	21%	247	1888	13%	401	1995	20%
		Site 25			**Site 26**			**Site 27**	
AM Peak	153	811	19%	283	1334	21%	183	803	23%
PM Peak	388	2190	18%	348	1876	19%	318	1187	27%
		Site 28			**Site 29**			**Site 30**	
AM Peak	135	749	18%	202	1285	16%	153	750	20%
PM Peak	279	1548	18%	247	1076	23%	241	1759	14%
		Site 31			**Site 32**			**Site 33**	
AM Peak	301	1351	22%	169	789	21%	51	1015	5%
PM Peak	259	1161	22%	230	1694	14%	114	994	11%
		Site 34			**Site 35**			**Site 36**	
AM Peak	83	679	12%	38.6	322	12%	98	791	12%
PM Peak	135	1518	9%	177	1594	11%	43	482	9%
		Site 37			**Site 38**			**Site 39**	
AM Peak	27	312	9%	299	1296	23%	60	399	15%
PM Peak	105	1273	8%	121	866	14%	143	1702	8%
		Site 40			**Site 41**			**Site 42**	
AM Peak	68	760	9%	18	247	7%	125	1059	12%
PM Peak	82	615	13%	134	1405	10%	48	484	10%
		Site 51			**Site 52**				
AM Peak	228	976	23%	256	1033	25%			
PM Peak	447	1608	28%	209	1483	14%			

Figure 17: High Occupancy Vehicle Lane Overall Violation Percentage, depicts the overall system's hourly violation rate percentages for the whole count day. During the off-peak hours, there are no HOV violations, as the HOV lane functions as a general purpose lane; the green data points simply represent the percentage of single-occupant vehicles.

Figure 17: High Occupancy Vehicle Lane Overall Violation Percentage

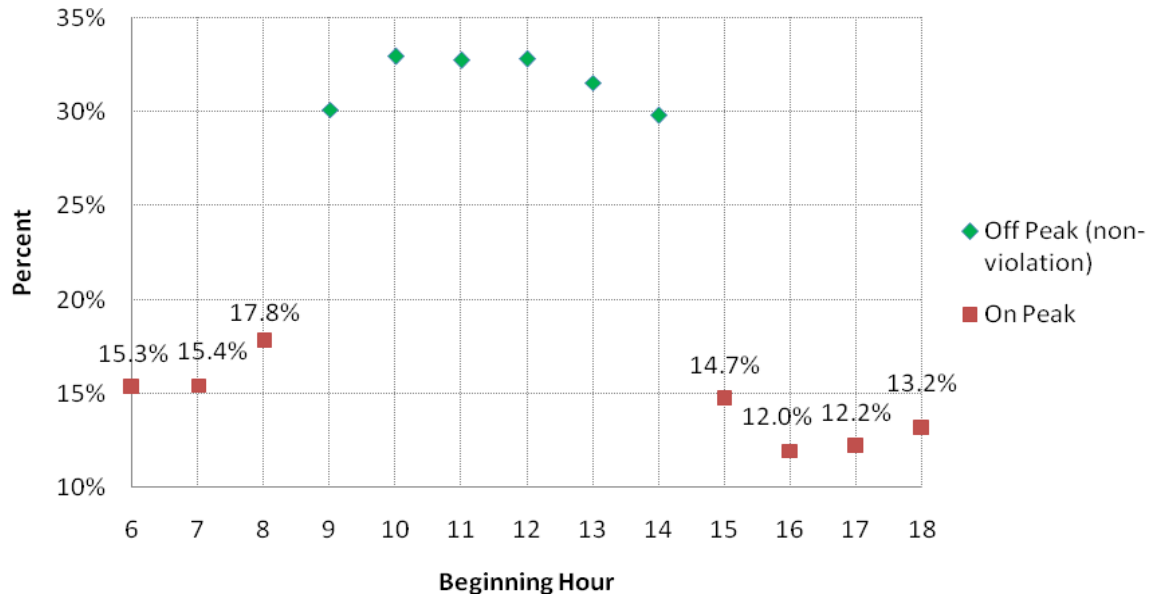
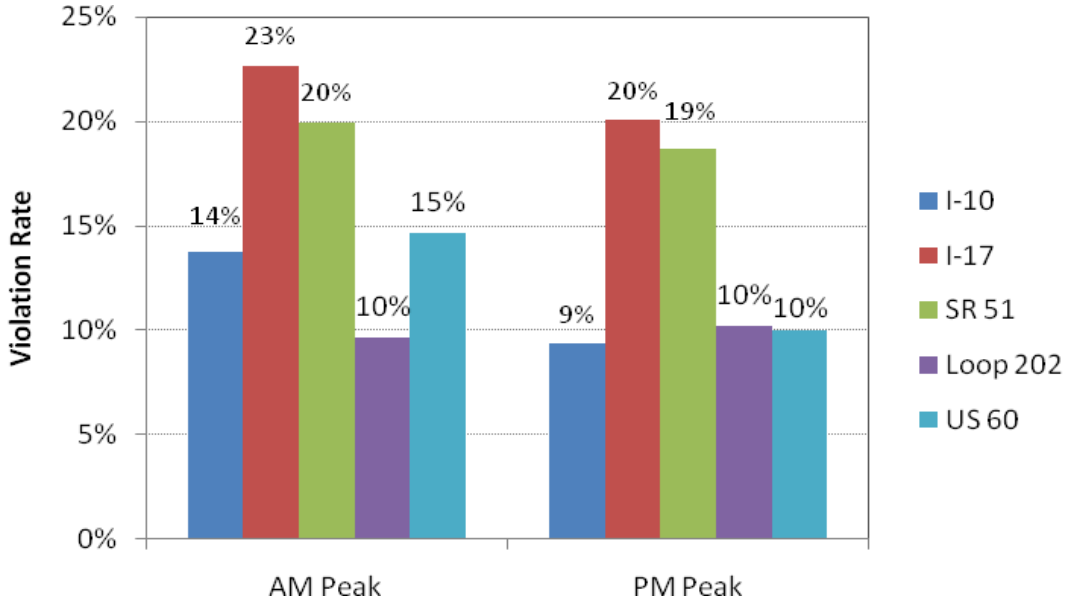


Figure 18: Overall HOV Lane Violation Percentage by Specific Freeway, illustrates the on-peak hour violation rates separately for each specific freeway in the system that has an HOV Lane.

Figure 18: Overall HOV Lane Violation Percentage by Specific Freeway



As can be seen in Table 30, Table 31, Figure 17, and Figure 18, violation rates during the HOV Lane function peak hours are approximately 15%. Overall, Interstate 17 has the highest rate of violation, with SR 51 close behind.

There are several functional reasons for the higher violation rates present in the MAG region today. Unlike other HOV systems in use throughout the country, the MAG regional freeway system's HOV lanes are not separated by a barrier from the general purpose lanes. This makes it easy for a violator to use the HOV Lane as a passing lane to accelerate, or as a temporal express lane to avoid congestion. In addition, the HOV lanes are not a 24/7 HOV lane, as they revert back to general purpose lanes for all non-peak hour times of the day. Finally, fuel efficient/hybrid vehicles, many of which are typically used by single passenger vehicles are permitted on the HOV Lanes during the peak hours.

Another reason for apparent higher violation rate percentages could be attributed to intrinsic error in the data collection process. One reason for this error includes the high number of vehicles with dark window tinting, hindering interior views into the vehicles for the count technicians collecting data. In addition, due to permit restrictions imposed by ADOT to use the freeway rights-of-way for data collection, count technicians were confined to the cabs of their vehicles, and these vehicles were required to remain parked in the direction of traffic. This caused strain and sometimes limited view of the vehicles in the HOV lane, depending on roadway geometrics and conditions.

HOV Lane Efficiency

One of the desired goals of an HOV Lane is to move more travelers per vehicle, thereby increasing the overall efficiency of the facility. One important evaluation of the efficiency of HOV Lanes is to compare how it functions relative to the function of a general purpose lane.

An important measure of the efficiency of the HOV Lanes within the MAG region is to determine the number of persons carried by the number of vehicles on a facility. Over a specific period of time, an HOV lane operates more efficiently than a general purpose lane when it conveys more persons (greater than 50% of the total of persons of both lanes) even though the raw volume of vehicles using that facility is normally lower.

Table 32: HOV Lane Efficiency Data contains a tabulation of the actual counted total travelers for each hour in the HOV Lane and in Lane 2. The sum of the travelers during the directional peak hours and the sum of the corresponding peak hour vehicles are included, and the percentage of the total of all HOV Lane and Lane 2 traveler and vehicle volumes are shown. This table includes data for each specific HOV Freeway Site, in addition, includes the combined data for ALL HOV Freeway Sites during the AM peak hour, ALL HOV Freeway Sites during the PM peak hour, and ALL HOV Freeway Sites during the AM + PM peak hour.

Table 32: HOV Lane Efficiency Data

Time	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2
	Site 1 - AM		Site 2 - PM		Site 3 - AM		Site 4 - PM		Site 5 - AM	
6-7a	**778**	**442**	**368**	**619**	**963**	**716**	**414**	**661**	**812**	**976**
7-8a	**578**	**402**	**282**	**433**	**963**	**598**	**371**	**616**	**977**	**840**
8-9a	**569**	**397**	**260**	**575**	**732**	**500**	**316**	**579**	**1072**	**726**
9-10a	326	143	208	163	288	257	271	226	288	287
10-11a	227	171	189	335	233	398	167	281	364	273
11-12p	196	164	234	224	335	269	263	205	391	153
12-1p	170	197	176	220	340	453	170	196	302	240
1-2p	186	149	203	362	559	291	276	393	443	384
2-3p	160	206	404	280	235	218	811	365	187	175
3-4p	**441**	**523**	**714**	**936**	**698**	**644**	**1291**	**922**	**772**	**963**
4-5p	**353**	**520**	**894**	**954**	**524**	**696**	**1279**	**915**	**657**	**793**
5-6p	**374**	**455**	**1038**	**877**	**452**	**749**	**1416**	**927**	**525**	**749**
6-7p	**305**	**285**	**586**	**748**	**501**	**587**	**1062**	**907**	**410**	**692**
Peak Travelers	**1924**	**1241**	**3231**	**3516**	**2658**	**1814**	**5049**	**3672**	**2861**	**2542**
Peak Vehicles	**952**	**1086**	**1655**	**3100**	**1351**	**1688**	**2390**	**3174**	**1551**	**2198**
Travelers Percent	**60.8%**	**39.2%**	**47.9%**	**52.1%**	**59.4%**	**40.6%**	**57.9%**	**42.1%**	**53.0%**	**47.0%**
Vehicles Percent	**46.7%**	**53.3%**	**34.8%**	**65.2%**	**44.5%**	**55.5%**	**43.0%**	**57.0%**	**41.4%**	**58.6%**
Time	**Site 6 - PM**		**Site 7 - AM**		**Site 8 - PM**		**Site 9 - PM**		**Site 10 - AM**	
6-7a	**283**	**540**	**1299**	**1008**	**645**	**716**	**1183**	**977**	**756**	**600**
7-8a	**256**	**463**	**1843**	**874**	**428**	**712**	**598**	**1432**	**973**	**506**
8-9a	**367**	**403**	**1592**	**865**	**415**	**696**	**1084**	**1114**	**973**	**689**
9-10a	122	204	655	334	213	125	227	555	464	266
10-11a	81	48	372	539	189	364	303	176	359	236
11-12p	106	128	773	389	242	242	197	243	288	191
12-1p	148	114	329	310	268	183	682	323	299	309
1-2p	175	191	444	487	312	389	198	272	464	229
2-3p	207	161	709	464	519	282	188	204	365	353
3-4p	**966**	**838**	**1203**	**871**	**666**	**691**	**1182**	**942**	**1256**	**798**
4-5p	**1082**	**768**	**625**	**878**	**1097**	**828**	**723**	**877**	**987**	**839**
5-6p	**1095**	**686**	**523**	**831**	**1034**	**718**	**622**	**862**	**970**	**584**
6-7p	**899**	**708**	**494**	**812**	**1041**	**879**	**458**	**765**	**794**	**736**
Peak Travelers	**4042**	**3001**	**4734**	**2747**	**3838**	**3117**	**2985**	**3447**	**2702**	**1794**
Peak Vehicles	**1991**	**2492**	**2648**	**2289**	**1896**	**2509**	**1410**	**2862**	**1036**	**1568**
Travelers Percent	**57.4%**	**42.6%**	**63.3%**	**36.7%**	**55.2%**	**44.8%**	**46.4%**	**53.6%**	**60.1%**	**39.9%**
Vehicles Percent	**44.4%**	**55.6%**	**53.6%**	**46.4%**	**43.0%**	**57.0%**	**33.0%**	**67.0%**	**39.8%**	**60.2%**

Table 32, Continued

Time	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2
	Site 11 - AM		Site 12 - PM		Site 13 - PM		Site 14 - AM		Site 15 - PM	
6-7a	**496**	**666**	**423**	**444**	**607**	**862**	**819**	**788**	**530**	**455**
7-8a	**892**	**733**	**417**	**390**	**635**	**821**	**1210**	**672**	**550**	**767**
8-9a	**576**	**979**	**352**	**402**	**457**	**607**	**654**	**514**	**705**	**423**
9-10a	458	184	337	182	257	289	427	321	410	310
10-11a	153	229	237	155	209	207	193	126	256	230
11-12p	199	147	164	153	256	264	245	189	483	320
12-1p	185	57	174	259	214	178	289	180	441	389
1-2p	119	225	332	206	262	242	140	168	492	415
2-3p	490	259	284	293	314	325	234	44	489	388
3-4p	**722**	**822**	**1031**	**1120**	**1137**	**858**	**807**	**895**	**1372**	**728**
4-5p	**662**	**807**	**1249**	**984**	**852**	**1188**	**660**	**693**	**1991**	**1075**
5-6p	**695**	**848**	**1186**	**799**	**927**	**945**	**733**	**524**	**1903**	**1008**
6-7p	**485**	**489**	**597**	**366**	**747**	**1143**	**371**	**326**	**1259**	**1186**
Peak Travelers	**1964**	**2378**	**4063**	**3269**	**3662**	**4135**	**2682**	**1975**	**6525**	**3997**
Peak Vehicles	**848**	**1917**	**1708**	**2493**	**1863**	**3611**	**1253**	**1697**	**2963**	**3765**
Travelers Percent	**45.2%**	**54.8%**	**55.4%**	**44.6%**	**47.0%**	**53.0%**	**57.6%**	**42.4%**	**62.0%**	**38.0%**
Vehicles Percent	**30.7%**	**69.3%**	**40.7%**	**59.3%**	**34.0%**	**66.0%**	**42.5%**	**57.5%**	**44.0%**	**56.0%**
Time	Site 16 - AM		Site 17 - PM		Site 18 - AM		Site 19 - PM		Site 20 - AM	
6-7a	**2001**	**1022**	**452**	**584**	**1071**	**850**	**263**	**460**	**966**	**910**
7-8a	**2266**	**1142**	**415**	**474**	**1373**	**698**	**270**	**517**	**1392**	**648**
8-9a	**1427**	**1091**	**275**	**550**	**1317**	**758**	**344**	**476**	**691**	**834**
9-10a	858	299	171	321	433	363	182	134	351	346
10-11a	344	235	293	348	350	349	179	123	344	358
11-12p	335	399	269	345	347	318	149	282	368	330
12-1p	538	247	308	353	406	486	182	385	289	469
1-2p	483	489	201	294	476	439	242	401	285	462
2-3p	821	349	328	285	651	516	326	400	316	503
3-4p	**1314**	**1003**	**582**	**655**	**863**	**1027**	**776**	**850**	**515**	**764**
4-5p	**1023**	**908**	**891**	**1005**	**934**	**741**	**724**	**751**	**695**	**633**
5-6p	**694**	**862**	**1244**	**874**	**1340**	**1035**	**940**	**720**	**409**	**878**
6-7p	**977**	**511**	**871**	**608**	**574**	**819**	**913**	**777**	**292**	**915**
Peak Travelers	**5694**	**3256**	**3588**	**3142**	**3762**	**2306**	**3353**	**3099**	**3048**	**2392**
Peak Vehicles	**2638**	**2884**	**1748**	**2889**	**1753**	**2067**	**1618**	**2905**	**1432**	**2110**
Travelers Percent	**63.6%**	**36.4%**	**53.3%**	**46.7%**	**62.0%**	**38.0%**	**52.0%**	**48.0%**	**56.0%**	**44.0%**
Vehicles Percent	**47.8%**	**52.2%**	**37.7%**	**62.3%**	**45.9%**	**54.1%**	**35.8%**	**64.2%**	**40.4%**	**59.6%**
	Site 21 - PM		Site 22 - AM		Site 23 - PM		Site 24 - AM		Site 25 - PM	
6-7a	**419**	**746**	**914**	**718**	**566**	**429**	**1002**	**674**	**570**	**713**
7-8a	**507**	**771**	**940**	**682**	**477**	**670**	**1129**	**816**	**622**	**687**
8-9a	**412**	**818**	**586**	**603**	**677**	**731**	**898**	**749**	**410**	**685**
9-10a	319	351	402	362	341	388	537	434	337	376
10-11a	302	389	242	407	349	328	520	428	375	376
11-12p	325	468	351	424	363	421	431	401	285	431
12-1p	405	467	316	391	427	483	538	508	328	390
1-2p	360	426	365	424	415	418	503	474	456	397
2-3p	716	472	498	501	473	478	593	575	475	343
3-4p	**942**	**755**	**768**	**1099**	**746**	**819**	**1162**	**960**	**879**	**1097**
4-5p	**1061**	**876**	**661**	**812**	**1110**	**930**	**1072**	**1160**	**1176**	**943**
5-6p	**1072**	**766**	**755**	**887**	**1128**	**813**	**991**	**1072**	**1293**	**862**
6-7p	**820**	**750**	**461**	**710**	**913**	**858**	**719**	**798**	**969**	**1064**
Peak Travelers	**3895**	**3148**	**2441**	**2003**	**3897**	**3420**	**3029**	**2239**	**4317**	**3967**
Peak Vehicles	**2208**	**2913**	**1232**	**1549**	**1888**	**2881**	**1634**	**2002**	**2190**	**3203**
Travelers Percent	**55.3%**	**44.7%**	**54.9%**	**45.1%**	**53.3%**	**46.7%**	**57.5%**	**42.5%**	**52.1%**	**47.9%**
Vehicles Percent	**43.1%**	**56.9%**	**44.3%**	**55.7%**	**39.6%**	**60.4%**	**44.9%**	**55.1%**	**40.6%**	**59.4%**

Time	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2
	Site 26 - AM		Site 27 - AM		Site 28 - PM		Site 29 - AM		Site 30 - PM	
6-7a	734	879	573	623	449	610	681	967	344	608
7-8a	1009	729	455	683	650	883	1045	929	542	548
8-9a	687	963	457	559	349	823	756	980	504	721
9-10a	527	334	217	354	298	406	390	405	305	318
10-11a	430	449	245	306	195	338	288	341	214	359
11-12p	436	510	230	309	131	253	223	527	257	357
12-1p	428	455	207	387	205	381	288	308	256	393
1-2p	593	445	388	351	365	376	322	347	358	290
2-3p	624	542	360	435	346	400	324	431	412	349
3-4p	1104	1010	716	755	600	961	643	894	817	924
4-5p	970	858	537	683	1004	863	519	823	1050	885
5-6p	829	806	441	627	941	878	475	805	941	806
6-7p	703	676	455	523	428	782	345	675	658	877
Peak Travelers	2429	2571	1485	1865	2971	3484	2481	2876	3466	3493
Peak Vehicles	1334	2335	803	1644	1548	3009	1285	2583	1759	3100
Travelers Percent	48.6%	51.4%	44.3%	55.7%	46.0%	54.0%	46.3%	53.7%	49.8%	50.2%
Vehicles Percent	36.4%	63.6%	32.8%	67.2%	34.0%	66.0%	33.2%	66.8%	36.2%	63.8%
	Site 31 - AM		Site 32 - PM		Site 33 - AM		Site 34 - PM		Site 35 - PM	
6-7a	577	756	492	550	508	743	459	860	280	490
7-8a	910	729	503	660	896	764	442	942	225	460
8-9a	898	700	508	600	708	837	451	909	136	775
9-10a	377	284	278	279	363	471	318	452	219	334
10-11a	199	302	271	346	282	393	321	456	221	316
11-12p	165	233	266	303	274	400	328	474	195	201
12-1p	144	211	321	340	332	397	332	451	133	292
1-2p	227	391	301	310	403	346	485	455	262	234
2-3p	342	320	446	394	567	445	572	526	308	423
3-4p	547	736	606	908	715	735	813	1003	711	721
4-5p	612	894	956	897	582	700	816	1092	886	795
5-6p	486	886	1008	919	338	642	890	953	1081	774
6-7p	487	547	756	723	361	635	566	910	457	741
Peak Travelers	2385	2185	3327	3447	2112	2345	3084	3958	3135	3032
Peak Vehicles	1351	2026	1694	3099	1015	2144	1518	3244	1594	2626
Travelers Percent	52.2%	47.8%	49.1%	50.9%	47.4%	52.6%	43.8%	56.2%	50.8%	49.2%
Vehicles Percent	40.0%	60.0%	35.3%	64.7%	32.1%	67.9%	31.9%	68.1%	37.8%	62.2%
Time	Site 36 - AM		Site 37 - PM		Site 38 - AM		Site 39 - PM		Site 40 - AM	
6-7a	428	687	215	603	696	534	281	512	647	612
7-8a	508	718	254	764	640	540	206	583	442	796
8-9a	652	729	151	543	975	717	278	580	408	561
9-10a	526	451	143	333	347	222	147	211	94	198
10-11a	117	339	246	296	261	318	199	238	93	184
11-12p	154	182	206	394	251	213	371	110	197	39
12-1p	116	162	209	466	86	190	339	363	129	91
1-2p	209	362	223	465	195	320	492	364	212	109
2-3p	237	362	433	411	431	248	408	352	317	116
3-4p	303	838	756	684	655	660	779	829	363	564
4-5p	206	730	818	702	373	807	892	973	301	437
5-6p	237	849	688	662	487	690	1052	963	299	463
6-7p	221	751	472	663	166	761	663	796	214	575
Peak Travelers	1588	2134	2733	2712	2311	1791	3386	3561	1498	1969
Peak Vehicles	791	1843	1273	2304	1296	1670	1702	3141	760	1752
Travelers Percent	42.7%	57.3%	50.2%	49.8%	56.3%	43.7%	48.7%	51.3%	43.2%	56.8%
Vehicles Percent	30.0%	70.0%	35.6%	64.4%	43.7%	56.3%	35.1%	64.9%	30.3%	69.7%

Table 32, Continued

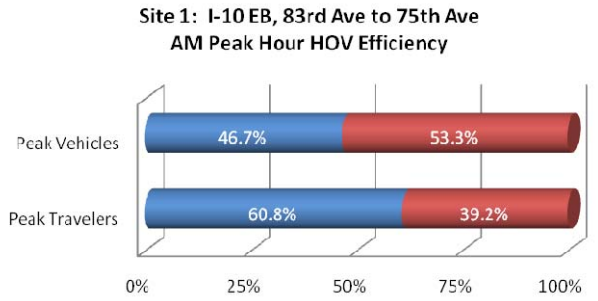
Time	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2
	Site 41 - PM		Site 42 - AM		Site 51 - PM		Site 52 - AM	
6-7a	**200**	**475**	**796**	**981**	**573**	**833**	**623**	**607**
7-8a	**192**	**535**	**835**	**854**	**602**	**792**	**773**	**606**
8-9a	**159**	**562**	**400**	**891**	**646**	**836**	**486**	**703**
9-10a	282	250	697	435	330	274	342	336
10-11a	280	220	493	260	273	360	274	334
11-12p	227	304	188	345	334	350	281	367
12-1p	334	348	430	343	353	350	365	406
1-2p	290	212	321	299	460	401	377	438
2-3p	286	336	247	267	485	440	434	453
3-4p	**659**	**932**	**318**	**753**	**642**	**786**	**857**	**924**
4-5p	**760**	**947**	**253**	**702**	**755**	**934**	**870**	**790**
5-6p	**791**	**1015**	**265**	**759**	**784**	**1050**	**554**	**870**
6-7p	**577**	**860**	**208**	**596**	**626**	**814**	**566**	**692**
Peak Travelers	**2786**	**3755**	**2031**	**2727**	**2807**	**3585**	**1881**	**1916**
Peak Vehicles	**1405**	**3272**	**1059**	**2467**	**1608**	**3269**	**1033**	**1714**
Travelers Percent	**42.6%**	**57.4%**	**42.7%**	**57.3%**	**43.9%**	**56.1%**	**49.5%**	**50.5%**
Vehicles Percent	**30.0%**	**70.0%**	**30.0%**	**70.0%**	**33.0%**	**67.0%**	**37.6%**	**62.4%**

	HOV Lane	Lane 2	HOV Lane	Lane 2	HOV Lane	Lane 2
	ALL Sites - AM & PM		All Sites - AM Only		All Sites - PM Only	
Peak Travelers	**137843**	**125023**	**57701**	**49067**	**80143**	**75955**
Peak Vehicles	**68684**	**109094**	**29055**	**43233**	**39629**	**65861**
Travelers Percent	**52.4%**	**47.6%**	**54.0%**	**46.0%**	**51.3%**	**48.7%**
Vehicles Percent	**38.6%**	**61.4%**	**40.2%**	**59.8%**	**37.6%**	**62.4%**

As shown in the tables, at each and every site location, the total number of peak hour vehicles traveling Lane 2 is greater than the total number of peak hour vehicles traveling the HOV Lane. Conversely, at some locations, the total number of persons traveling the HOV Lanes during the peak hour is greater, which demonstrates higher HOV efficiency. Generally speaking, the sites on I-10 and I-17 have HOV lanes that carry more travelers than the general purpose lane, lane 2, whereas sites on the US 60, SR 51, and Loop 202 carry less travelers in the HOV Lane than the general purpose lane, potentially due to lighter HOV Lane usage.

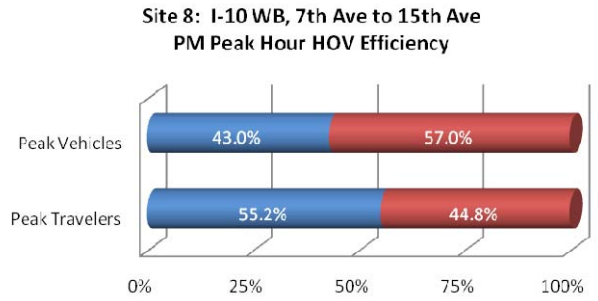
In the following figures, *Figure 19 – Figure 30*, the HOV efficiency data is graphically depicted for a selection of specific sites on each of the aforementioned study freeways. The corresponding HOV Lane and Lane 2 percentages of the sum of the total peak travelers and peak vehicles of these two lanes is illustrated.

Figure 19: Peak Hour HOV Efficiency, Site 1



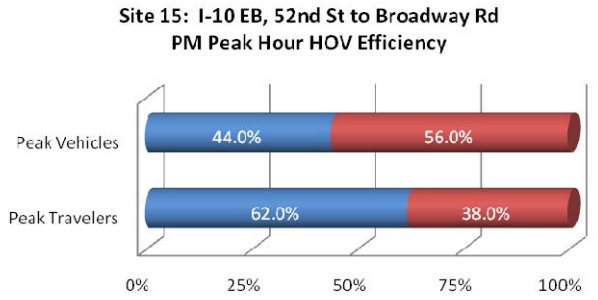
	Peak Travelers	Peak Vehicles
HOV Lane	1924.4	952
Lane 2	1241	1086

Figure 20: Peak Hour HOV Efficiency, Site 8



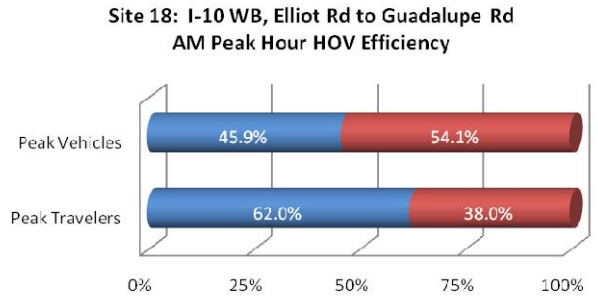
	Peak Travelers	Peak Vehicles
HOV Lane	3837.6	1896
Lane 2	3116.6	2509

Figure 21: Peak Hour HOV Efficiency, Site 15



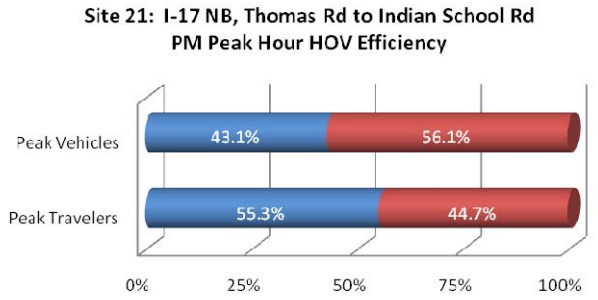
	Peak Travelers	Peak Vehicles
HOV Lane	6525.4	2963
Lane 2	3997.2	3765

Figure 22: Peak Hour HOV Efficiency, Site 18



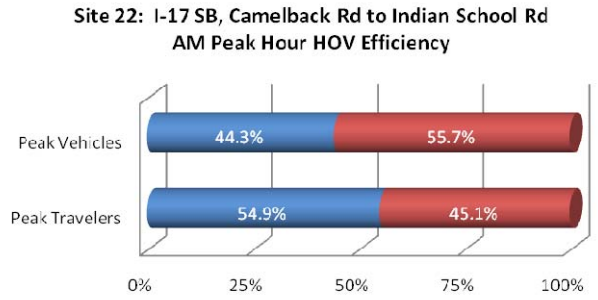
	Peak Travelers	Peak Vehicles
HOV Lane	3761.6	1753
Lane 2	2306.2	2067

Figure 23: Peak Hour HOV Efficiency, Site 21



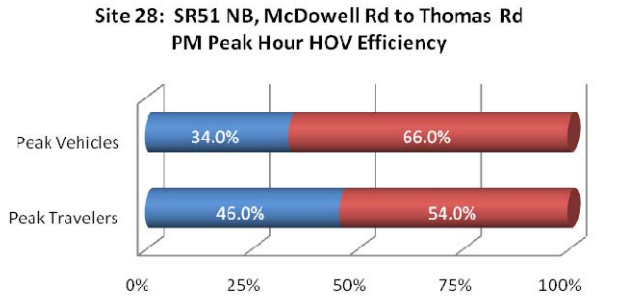
	Peak Travelers	Peak Vehicles
HOV Lane	3895.2	2208
Lane 2	3147.6	2913

Figure 24: Peak Hour HOV Efficiency, Site 22



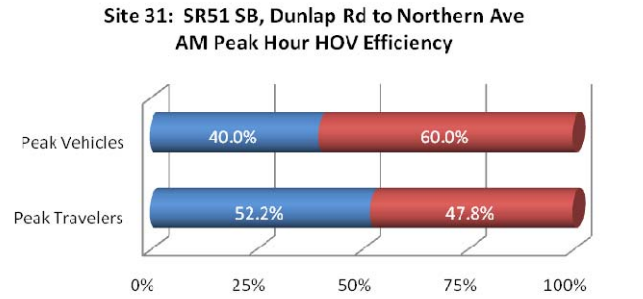
	Peak Travelers	Peak Vehicles
HOV Lane	2441	1232
Lane 2	2003	1549

Figure 25: Peak Hour HOV Efficiency, Site 28



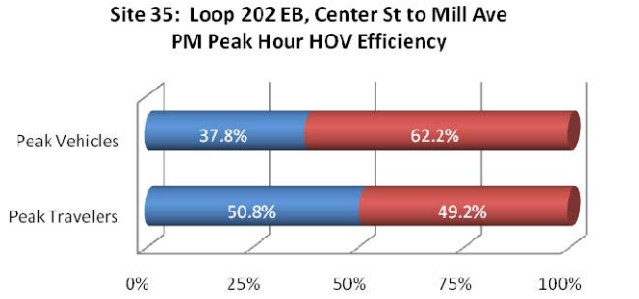
	Peak Travelers	Peak Vehicles
HOV Lane	2971.4	1548
Lane 2	3483.6	3009

Figure 26: Peak Hour HOV Efficiency, Site 31



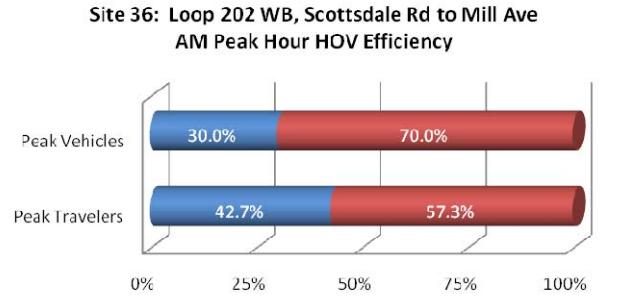
	Peak Travelers	Peak Vehicles
HOV Lane	2385.4	1351
Lane 2	2185.4	2026

Figure 27: Peak Hour HOV Efficiency, Site 35



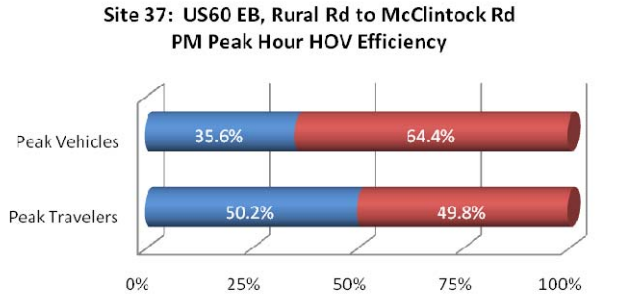
	Peak Travelers	Peak Vehicles
HOV Lane	3134.6	1594
Lane 2	3032.2	2626

Figure 28: Peak Hour HOV Efficiency, Site 36



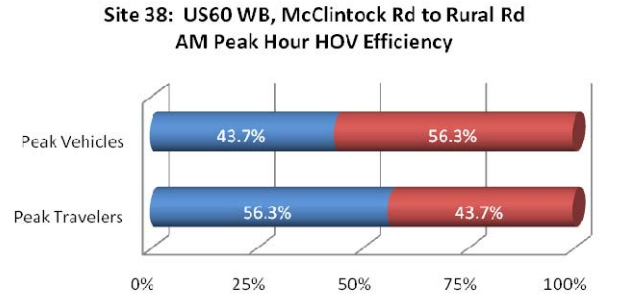
	Peak Travelers	Peak Vehicles
HOV Lane	1588	791
Lane 2	2134.4	1843

Figure 29: Peak Hour HOV Efficiency, Site 37



	Peak Travelers	Peak Vehicles
HOV Lane	2733.2	1273
Lane 2	2712	2304

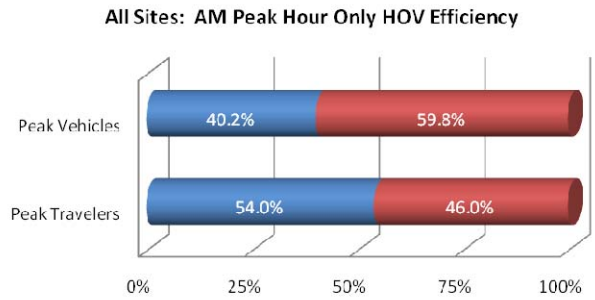
Figure 30: Peak Hour HOV Efficiency, Site 38



	Peak Travelers	Peak Vehicles
HOV Lane	2310.6	1296
Lane 2	1791.4	1670

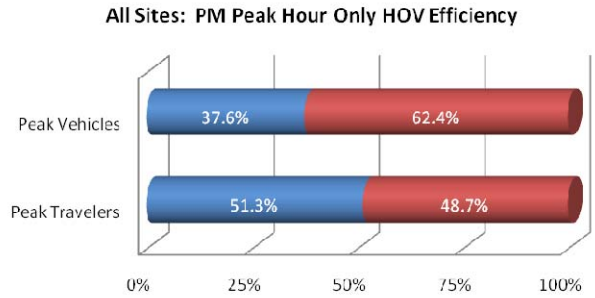
In addition to the Site specific HOV efficiency figures, the following figures illustrate the HOV efficiency for ALL HOV Freeway Sites during the AM peak hour, ALL HOV Freeway Sites during the PM peak hour, and ALL HOV Freeway Sites during the AM + PM peak hour. These are depicted in *Figure 31: HOV Efficiency, ALL HOV Freeway Sites, AM Peak Hour*, *Figure 32: HOV Efficiency, ALL HOV Freeway Sites, PM Peak Hour*, and *Figure 33: HOV Efficiency, ALL HOV Freeway Sites, AM + PM Peak Hour*.

Figure 31: HOV Efficiency, ALL HOV Freeway Sites, AM Peak Hour



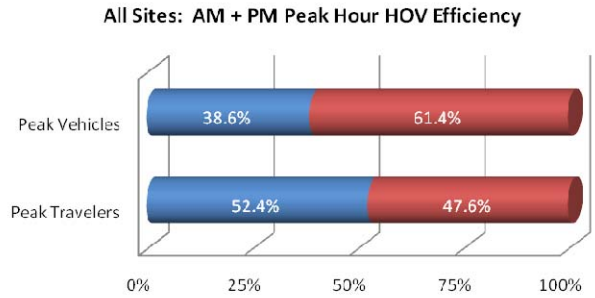
	Peak Travelers	Peak Vehicles
HOV Lane	57700.8	29055
Lane 2	49067.4	43233

Figure 32: HOV Efficiency, ALL HOV Freeway Sites, PM Peak Hour



	Peak Travelers	Peak Vehicles
HOV Lane	80142.6	39629
Lane 2	75955.4	65861

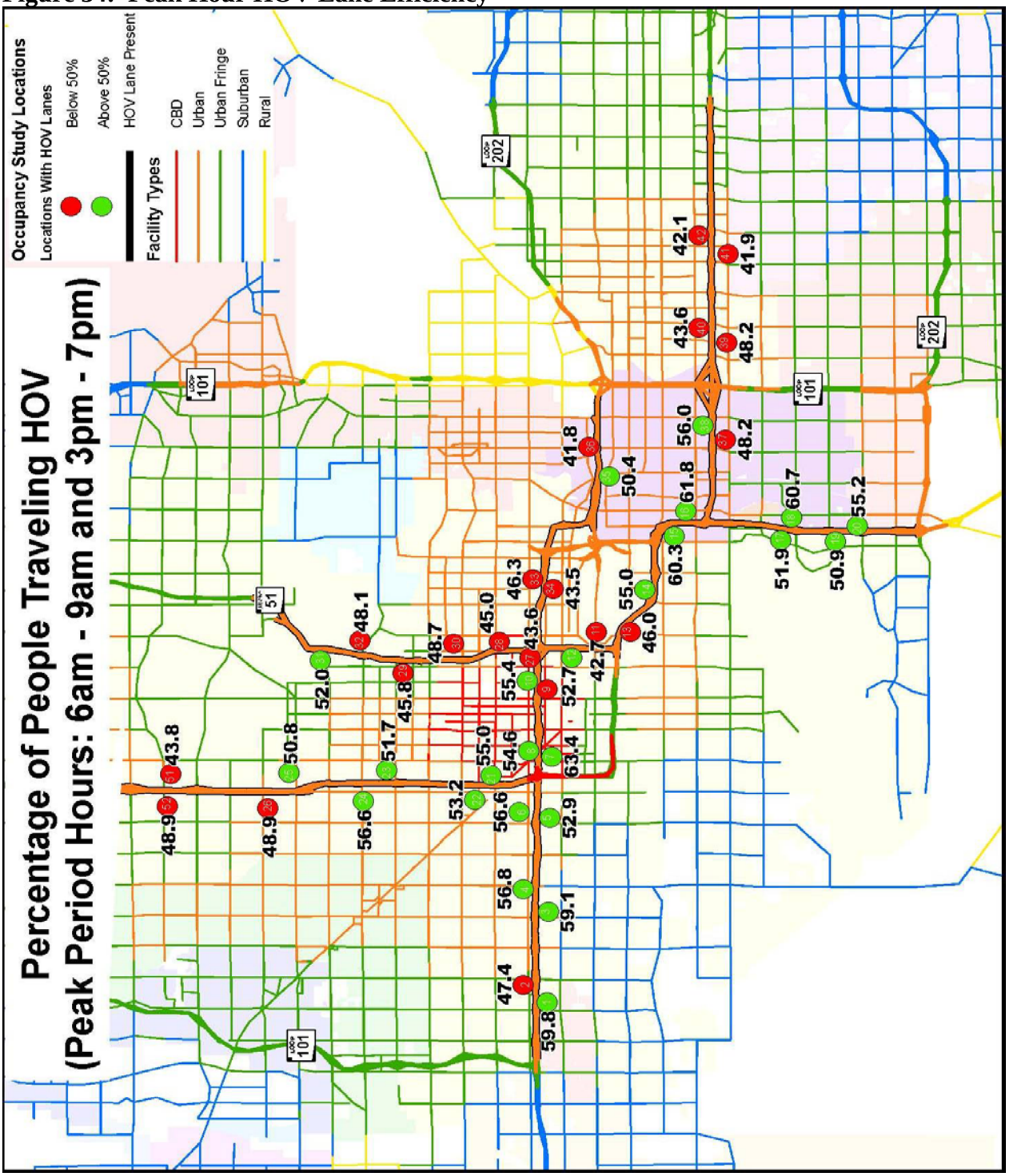
Figure 33: HOV Efficiency, ALL HOV Freeway Sites, AM + PM Peak Hour



	Peak Travelers	Peak Vehicles
HOV Lane	137843.4	68684
Lane 2	125022.8	109094

As illustrated in the previous Figures 31 – 33 depicting ALL HOV Freeway Sites during the peak hours, the HOV Lane is more efficient than the general purpose lane, Lane 2. While the raw volume of vehicles using the HOV Lane is lower than Lane 2, over 50% of the travelers are being carried by the HOV Lane, which is attributed to higher occupancies. An overview map, *Figure 34: Peak Hour HOV Lane Efficiency* depicts the HOV efficiency at all Site locations.

Figure 34: Peak Hour HOV Lane Efficiency



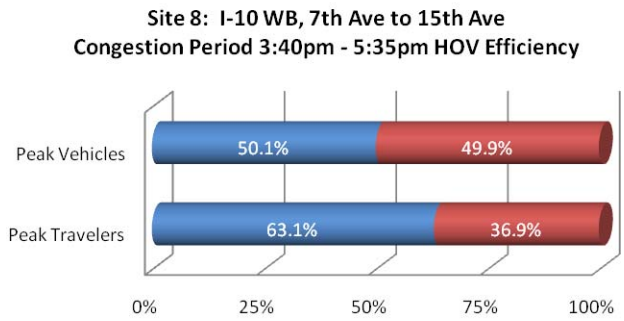
HOV Efficiency During Times of Congestion

In the past, an incentive to traveling with additional persons (carpooling) was that during peak periods of congestion on the general purpose lanes, high occupancy vehicles could use the uncongested HOV Lane to lessen their travel times. As the growth of the MAG region has continued, however, many HOV Lane locations have also experienced the onset of congestion.

Determining the reaction of the efficiency of the HOV Lanes during times of congestion on the freeway was examined. *Figure 35 – Figure 38*, on the following pages, depict HOV Lane Efficiency trends during times of peak hour congestion. As in Figures 19-30, the corresponding HOV Lane and Lane 2 percentages of the sum of the total peak travelers and peak vehicles of these two lanes are illustrated, and for each specific site, the time periods of congestion are shown.

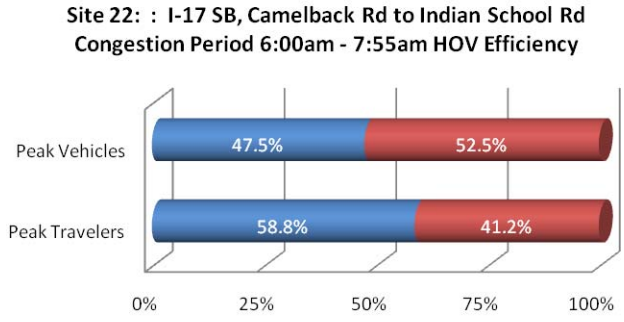
Congestion is defined as when the speeds of traveling vehicles reach an average of 35 mph or less. This average speed data was collected in-field, as explained in Section 2.

Figure 35: Congestion Period HOV Efficiency, Site 8



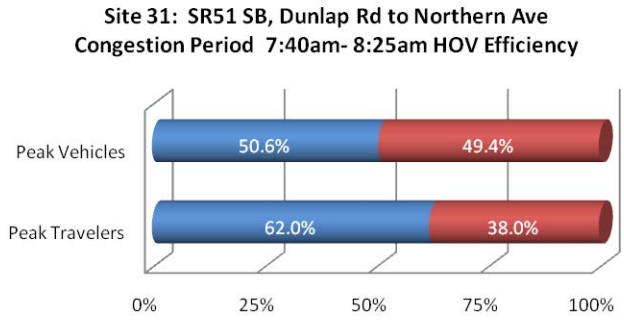
	Peak Travelers	Peak Vehicles
HOV Lane	2231.8	1080
Lane 2	1305.6	1076

Figure 36: Congestion Period HOV Efficiency, Site 22



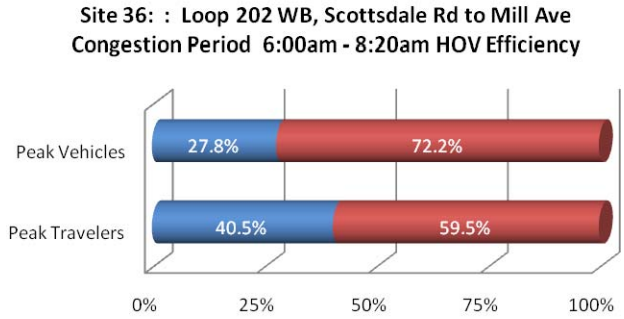
	Peak Travelers	Peak Vehicles
HOV Lane	1854.6	935
Lane 2	1301.8	1032

Figure 37: Congestion Period HOV Efficiency, Site 31



	Peak Travelers	Peak Vehicles
HOV Lane	765.2	434
Lane 2	469.2	423

Figure 38: Congestion Period HOV Efficiency, Site 36

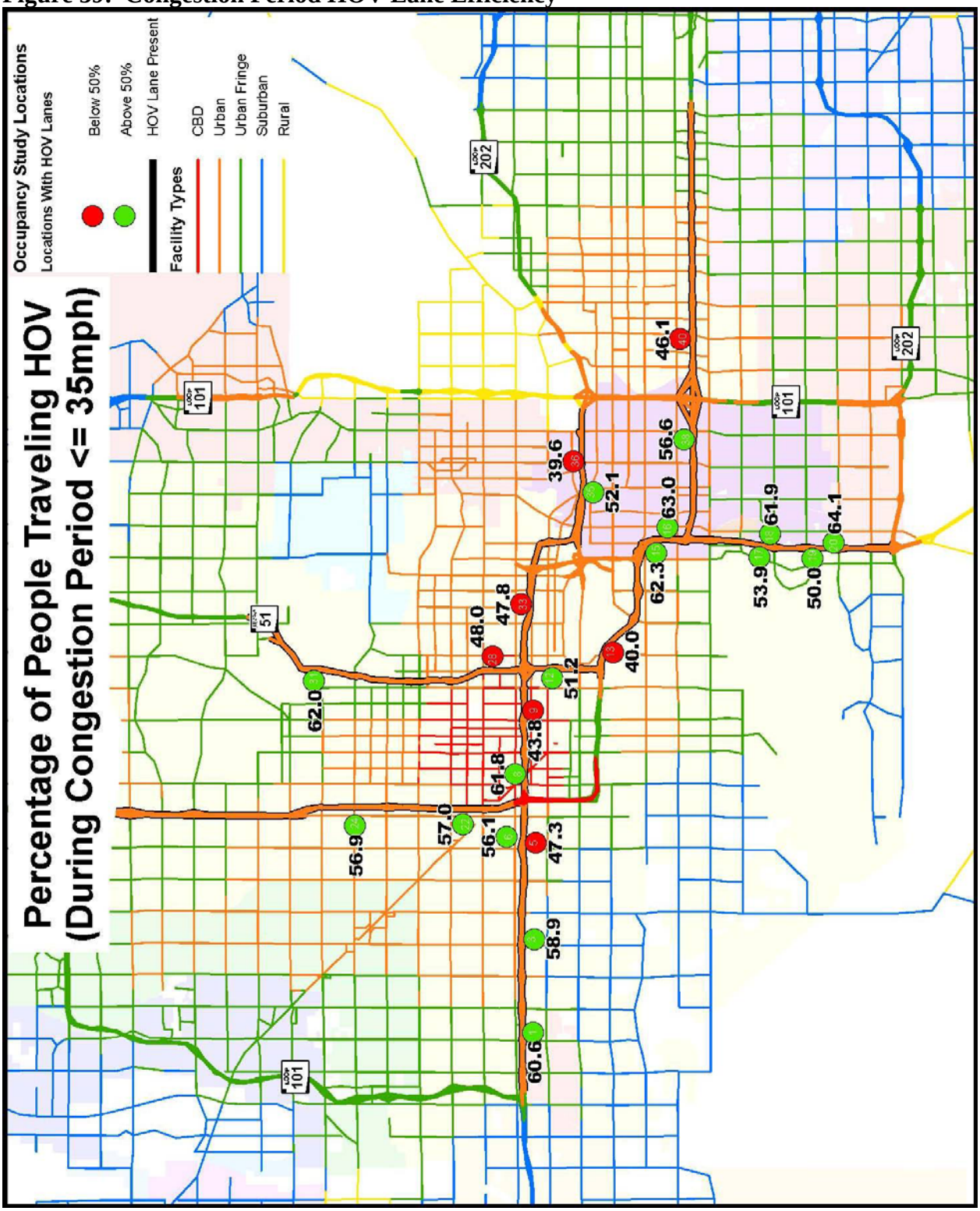


	Peak Travelers	Peak Vehicles
HOV Lane	1138.6	557
Lane 2	1674	1446

The effect on the HOV Lane due to congestion typically involves greater efficiency. When the speeds on the freeways drop to 35 mph or less, a higher percentage of vehicles and travelers use the HOV Lane compared to normal peak hour use. This may be attributed to HOV vehicles shifting to take advantage of the HOV Lane, which typically experiences at least slightly higher travel speeds, or it could be attributed to impatient HOV Lane violators. In only one instance, Site 36, was HOV Lane efficiency slightly less during its congestion period as compared to the efficiency during the normal peak hour period.

Figure 39: Congestion Period HOV Lane Efficiency on the following page illustrates the HOV lane efficiency during all times of congestion that occurred during each Site's directional peak hours.

Figure 39: Congestion Period HOV Lane Efficiency



SECTION 6: CONCLUSIONS

This study and corresponding report provides an overview of the occupancy and vehicle classification for the Maricopa Association of Government's Phoenix Metropolitan planning area. This study has been conducted through the in-field collection of 13 consecutive hours of occupancy, classification, and speed data at 119 separate site locations on weekdays (Tuesday, Wednesday, and Thursday) during May, August and September of 2006, and March, April, and May of 2007. The data collected included the number of travelers (occupancy) within each vehicle, classified in one of five ways; as a motorcycle, bus, passenger vehicle, delivery vehicle, or heavy vehicle. All data was downloaded into and analyzed through the use of Microsoft Excel.

Project Design Conclusions and Auto Occupancy

As was the case in the previous vehicle occupancy study performed in the MAG region, the 1992 Study of Occupancy and Vehicle Classification in the Metropolitan Phoenix Area, by Lee Engineering, statistical tests confirm that three factors account for a large part of the variation in the occupancy data. The factors include Area Type, Facility Type, and Time of Day. The design of the project took into account these three factors, giving rise to "The Cube" as illustrated in Section, Figure 2, in which all data and determined values have been classified and organized. "The Cube" depicts that area type is further classified into CBD, Urban, and Suburban; facility type is further classified into HOV Freeway, non-HOV Freeway, and Arterial locations; and the time of day has five separate time periods.

To be consistent with the 1992 study and MAG models, auto occupancy has been calculated as the occupancy of only those vehicles classified as a passenger vehicle, with average auto occupancy formulated as the number of travelers per vehicle. Since 1992, the overall region-wide average auto occupancy rate has dropped. From the 1992 study, the overall average auto occupancy rate was 1.34. Currently, the overall average auto occupancy has been determined to be 1.23 and the overall average vehicle occupancy has been determined to be 1.26.

Overall auto occupancy data, as determined versus the area type stratifications, has been found to be highest in the CBD and Urban areas (1.25 auto occupancy rates), and lowest in the suburban areas (1.12 auto occupancy rate). This can potentially be attributed to the fact that zero HOV-facilities are located in the suburban area type, which generally have higher occupancies.

Variation in occupancy is also apparent when determined based on facility type. As expected, it has been determined that HOV Freeway facilities have the highest auto occupancy rates. The lowest auto occupancies occur on non-HOV freeways, likely due to the fact that carpooling on non-HOV freeways offers no travel time savings, so trips tend to be single-occupant. Arterial roadways have slightly higher auto occupancies than non-HOV Freeways, which may be attributed to arterials having a greater amount of home-based school and shopping trips, which typically have high occupancies, rather than just home-based work trips.

The third factor, time of day, illustrates additional variation in auto occupancies. It has been determined that during the AM Peak period (6-9AM) and the PM Peak periods (3-7PM), auto occupancies are greater than during the rest of the day. This is attrubuted to high percentages of

carpools (2+ occupant vehicles) taking advantage of the potential time-saving HOV Lanes. Further, the PM peak hours tend to have higher auto occupancies than the AM peak hour, potentially attributed to the PM hours typically having more of the home-based shopping trips.

Vehicle Classifications

Based on vehicle classifications for all area types and facility types, during all times of day, the most prevalent classification type using the roadway system was the passenger vehicle, at 94.54% of the total. The next highest is the heavy vehicle, at 3.26%, followed by delivery vehicles (1.32%), motorcycles (0.58%) and buses (0.30%).

On the region's freeways, truck (heavy vehicle) travel was the highest on the interstate freeways (I-10 and I-17), with I-10 having the highest percentage of heavy vehicles, at 6.51% of its total. Loop 101 carried the lowest percentage of heavy vehicles, just 1.00% of its total.

HOV Lane Evaluation

During all HOV Lane peak hours (6-9AM and 3-7PM), data was collected on the HOV Lane and one general purpose lane, Lane 2, as explained in Section 2. It was found that at every HOV freeway site location, the general purpose lane, Lane 2, conveyed a higher volume of overall vehicles than did the HOV lane. However, at many locations, the HOV Lane had a greater efficiency, conveying a greater number of travelers. Generally speaking, the HOV lanes on interstate freeways, I-10 and I-17, had higher efficiencies than did SR 51, the US 60, or Loop 202. Based on speed data collected, when congestion occurs on the freeways (traveling speeds of 35 mph or less), the efficiency of the HOV lanes typically increases.

Violation Rates

Priority lane violations occur when during the times of HOV lane function peak hours (6-9AM), 3-7PM) single occupant vehicles are utilizing the HOV Lane. Overall violation rates throughout the region during the HOV Lane function peak hours were determined to be approximately 15%. Based on violation rates of individual freeways, Interstate 17 had the highest rate of violation, with SR 51 a close second.

There are several functional reasons for the higher violation rates in the MAG region. Unlike other HOV systems in use throughout the country, the MAG regional freeway system's HOV lanes are not separated by a barrier from the general purpose lanes, making it easy for a violator to use the HOV lane as a passing lane to accelerate, or as a temporal express lane to avoid congestion. HOV lanes may also be used by single-occupant alternative fuel/hybrid vehicles, which cause higher apparent violations. In addition, the HOV lanes are not a 24/7 HOV lane, as they revert back to general purpose lanes for all non-peak hour times of the day.

Recommendations for Subsequent Studies

During the data collection process, several issues were encountered, hindering the occupancy counts of this study. Due to permit restrictions required to count on ADOT right-of-way and the prevelence of dark tinted windows, it became difficult to accurately count occupancies during the 13 hour count day. It would be advantageous to develop a more effective and accurate way to collect the 13 continuous hours of data in the field.

Additional count sites in locations and on facilities generally ignored in this data collection effort should be studied, including areas of the rapidly growing west valley, and the facilities of Grand Avenue, Loop 303, and SR 143.

Continued monitoring and study of the occupancy and vehicle classification trends would be beneficial. Fifteen years has passed since the last study of this kind, and much has changed in the region. If similar studies in size and scope to this study were undertaken more regularly, beneficial trends could be more closely tracked.

Continue to monitor the occupancy rates on a few selected locations in the region at higher intervals (yearly, bi-yearly, quarterly, etc.) in order to grasp its trends.