ATLANTA REGIONAL MANAGED LANE SYSTEM PLAN

GLOBAL DEMAND ESTIMATION PROCESS

PREPARED FOR

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HNTB

Atlanta Regional Managed Lane System Plan

Technical Memorandum 3: Global Demand Estimation Process

Prepared for:

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A. Purpose

Quantifying the potential benefits of priced lanes requires a comprehensive understanding of the forces that drive travel demand. This is of particular importance for managed lanes since managed lanes typically:

- Thrive on deteriorating operating conditions in the general-purpose lanes;
- Improvements in the general-purpose lanes although are usually consumed by latent demand; and
- Function optimally within a system context.

The Georgia Department of Transportation (GDOT) is considering several potential lane management strategies including Truck Only Toll (TOT)[1] Lanes, Express Toll Lanes (ETL)[2] and High Occupancy Toll (HOT) lanes with different occupancy requirements. It is imperative that analysis tools are refined appropriately to define not only the global demand within a corridor but also the composition of that global demand including heavy trucks, light trucks, passenger cars, commercial vehicles, different HOV vehicles and others.

This Tech Memo discusses the following:

- Overview of the travel demand model used by the Atlanta Regional Commission (ARC)
- Refinements to the ARC travel demand model to accurately represent the impact of global demand on managed lanes. The two refinements are:
  - Splitting the High Occupancy Vehicle (HOV) demand tables into HOV2+[3], HOV3+[4] and HOV4+[5]
  - Refining the four time periods in the Travel Demand Model; and
- Impact of peak spreading.

[1] TOT means the managed lanes are reserved for trucks willing to pay a toll.
[2] ETL means that all vehicles in the managed lanes pay a toll. Trucks are not permitted in the managed lanes.
[3] High Occupancy Vehicle lanes reserved for vehicles with two or more occupants.
[4] High Occupancy Vehicle lanes reserved for vehicles with three or more occupants.
[5] High Occupancy Vehicle lanes reserved for vehicles with four or more occupants.

B. Analysis Tools - ARC Travel Demand Model

The projected traffic volumes by vehicle classification, vehicle types, temporal shifts, and route diversions can be estimated by the travel demand model. This aids planners in assessing the existing and future global demand and identifying future managed lane needs.

As the Metropolitan Planning Organization (MPO), ARC has developed a trip-based travel demand model covering 20 counties in the Atlanta region. The ARC model is a valuable resource and was used as the primary quantitative assessment tool to evaluate global demand for the various managed lane corridors in the Atlanta region.

The ARC travel demand model was validated using daily overall traffic counts; however, it does not consider validation of traffic volume by different vehicle classification and occupancy or the validation of peak period assignments. To improve this regional forecasting tool for use in Managed Lane System Plan (MLSP), a series of refinements were incorporated. These are described in the following sections.

C. Refinement to ARC is Travel Demand Model

Vehicle Occupancy

As congestion management strategies begin to emphasize person capacity/throughput versus vehicle capacity/throughput, vehicle occupancy data is becoming increasingly important. In addition, individual managed lane facilities many consider different vehicle occupancy requirements, which are expressed as High Occupancy Toll (HOT) 2+, HOT3+ or HOT4+. Thus, it is crucial that travel demand model volumes under different occupancy requirements are validated to existing conditions.

As part of the Managed Lane System Plan, occupancy data was collected in 2007 for the following corridors:

- I-75 South from I-285 South to SR 16;
- I-85 North from I-285 North to SR 211;
- I-20 West from I-285 West to Post Road; and
- Inside I-285 (I-75, I-85, I-20, and Langford Parkway).

The complete dataset includes occupancy records for over 1.9 million vehicles, covering 382 miles of roadway centerline over almost 144 hours of data collection.

In order to allow comparisons between the field data and model outputs, the individual field records were assigned to one of three categories: Single Occupant Vehicles (SOV), HOV2+ and HOV3+ by different time-of-day (TOD) periods. The TOD parameters used to summarize the data are shown in Table 1.

Table 1: Time of Day (TOD) Definitions

Time of Day	Start Time	End Time
Morning (AM)	6:00 am	9:59 am
Midday (MD)	10:00 am	2:59 pm
Afternoon (PM)	3:00 pm	7:00 pm

Table 2 shows the percentage split of SOV, HOV2+, and HOV3+ by corridors and time-of-day (TOD).

Table 2: Occupancy Split by Corridors and TOD – Observed Field Data

Corridor	Segment	TOD	SOV Average %	HOV2+ Average %	HOV3+ Average %
I-75 South	From I-285 to I-675	AM	92%	7%	1%
		MD	91%	9%	0%
		PM	91%	8%	1%
	From I-675 to SR 20	AM	90%	8%	2%
		MD	90%	8%	2%
		PM	87%	10%	3%
	From SR 20 to SR 16	AM	94%	5%	1%
		MD	96%	4%	0%
		PM	95%	4%	1%
I-85 North	From I-285 to SR 316	AM	91%	8%	1%
		MD	93%	7%	0%
		PM	91%	8%	1%
	From SR 316 to I-985	AM	91%	8%	1%
		MD	93%	7%	0%
		PM	91%	8%	1%
	From I-985 to SR 211	AM	97%	2%	1%
		MD	97%	2%	1%
		PM	97%	2%	1%
I-20 West	From I-285 to SR 6	AM	94%	5%	1%
		MD	96%	3%	1%
		PM	96%	3%	1%
	From SR 6 to SR 92	AM	96%	3%	1%
		MD	92%	7%	1%
		PM	92%	7%	1%

Corridor	Segment	TOD	SOV Average %	HOV2+ Average %	HOV3+ Average %
	From SR 92 to Post Road	AM	95%	4%	1%
		MD	93%	6%	1%
		PM	92%	7%	1%
Inside I-285	Downtown Connector I-75/ I-85	AM	89%	9%	2%
		MD	89%	9%	2%
		PM	89%	9%	2%
	I-75 North	AM	91%	8%	1%
		MD	90%	9%	1%
		PM	91%	8%	1%
	I-75 South	AM	90%	9%	1%
		MD	93%	7%	0%
		PM	92%	7%	1%
Inside I-285	I-85 North	AM	91%	8%	1%
		MD	92%	7%	1%
		PM	90%	9%	1%
	I-85 South	AM	93%	6%	1%
		MD	96%	4%	0%
		PM	90%	8%	2%
	Langford Parkway	AM	97%	3%	0%
		MD	95%	4%	1%
		PM	95%	4%	1%
Average		AM	93%	6%	1%
		MD	93%	6%	1%
		PM	92%	7%	1%

The ARC travel demand model splits auto volume into two occupancy categories: SOV and HOV2++. Other auto occupancy classes, like HOV3+ and HOV4+, are grouped together in the traffic assignment procedures. To fully understand HOV global demand by occupancy within specific corridors, the MLSP analysis disaggregated HOV trips into three classifications of HOV: HOV2+, HOV3, and HOV4+. These were based on the information from ARC's mode choice model.

The model output versus field data for auto occupancy, by corridor and by time period, is summarized in Table 3. A review of the comparison indicates that the ARC travel demand model is accurate when it comes to replicating the percentage split of total volume into SOVs and HOVs. However there is significant variation of the model output from the field data when it comes to the percentage split of HOV2+ and HOV3+. The percentage of HOV3+ vehicles in the model is much higher than observed field data.

Based on these comparisons, trips tables were adjusted and revalidated with occupancy counts collected in the field by shifting a portion of HOV3+'s into HOV2+'s.

Table 3: Field Data Occupancy vs. Model Output Occupancy

Corridor	Segment	TOD	SOV Average%		HOV2+ Average %		HOV3 Average %	
			Field	Model	Field	Model	Field	Model
I-75 South	From I-285 to I-675	AM	92%	90%	7%	5%	1%	5%
		MD	91%	84%	9%	7%	0%	9%
		PM	91%	87%	8%	6%	1%	7%
	From I-675 to SR 20	AM	90%	94%	8%	3%	2%	3%
		MD	90%	90%	8%	4%	2%	5%
		PM	87%	92%	10%	4%	3%	4%
	From SR 20 to SR 16	AM	94%	99%	5%	1%	1%	0%
		MD	96%	98%	4%	1%	0%	1%
		PM	95%	98%	4%	1%	1%	1%
I-85 North	From I-285 to SR 316	AM	91%	83%	8%	8%	1%	9%
		MD	93%	76%	7%	11%	0%	13%
		PM	91%	78%	8%	10%	1%	12%
	From SR 316 to I-985	AM	91%	88%	8%	6%	1%	6%
		MD	93%	81%	7%	9%	0%	11%
		PM	91%	85%	8%	7%	1%	8%
	From I-985 to SR 211	AM	97%	94%	2%	3%	1%	3%
		MD	97%	90%	2%	4%	1%	5%
		PM	97%	91%	2%	4%	1%	5%
I-20 West	From I-285 to SR 6	AM	94%	90%	5%	5%	1%	5%
		MD	96%	81%	3%	8%	1%	10%
		PM	96%	86%	3%	6%	1%	7%
	From SR 6 to SR 92	AM	96%	90%	3%	5%	1%	5%

Corridor	Segment	TOD	SOV Average%		HOV2+ Average %		HOV3 Average %	
			Field	Model	Field	Model	Field	Model
I-20 West	From SR 6 to SR 92	MD	92%	83%	7%	8%	1%	10%
		PM	92%	87%	7%	6%	1%	7%
	From SR 92 to Post Road	AM	95%	93%	4%	4%	1%	4%
		MD	93%	87%	6%	6%	1%	7%
		PM	92%	89%	7%	5%	1%	6%
Inside I-285	Downtown Connector I-75/ I-85	AM	89%	84%	9%	8%	2%	9%
		MD	89%	76%	9%	11%	2%	13%
		PM	89%	79%	9%	10%	2%	12%
	I-75 North	AM	91%	84%	8%	8%	1%	8%
		MD	90%	79%	9%	10%	1%	11%
		PM	91%	79%	8%	10%	1%	11%
	I-75 South	AM	90%	83%	9%	8%	1%	9%
		MD	93%	78%	7%	10%	0%	12%
		PM	92%	78%	7%	10%	1%	12%

Table 4: Occupancy Split by Corridors and TOD – Field Data

Corridor	Segment	TOD	SOV Average%		HOV2+ Average %		HOV3+ Average %	
			Field	Model	Field	Model	Field	Model
Inside I-285	I-85 North	AM	91%	81%	8%	9%	1%	10%
		MD	92%	74%	7%	12%	1%	14%
		PM	90%	77%	9%	11%	1%	13%

Corridor	Segment	TOD	SOV Average%		HOV2+ Average %		HOV3+ Average %	
			Field	Model	Field	Model	Field	Model
Inside I-285	I-85 South	AM	93%	90%	6%	5%	1%	5%
		MD	96%	82%	4%	8%	0%	10%
		PM	90%	78%	8%	10%	2%	12%
	Langford Parkway	AM	97%	90%	3%	5%	0%	5%
		MD	95%	82%	4%	8%	1%	10%
		PM	95%	85%	4%	7%	1%	8%
Regional Averages		AM	93%	89%	6%	6%	1%	6%
		MD	93%	83%	6%	8%	1%	9%
		PM	92%	85%	7%	7%	1%	8%

Refinement of Peak and Off-Peak Period Traffic Estimates

Travel time savings are essential to attract users to a managed lane facility, which provide a "premium" service when compared to the adjacent general purpose lanes. Therefore, the forecast of travel time savings under different levels of congestion is extremely important to provide a sound estimation of the demand for the managed lane facility.

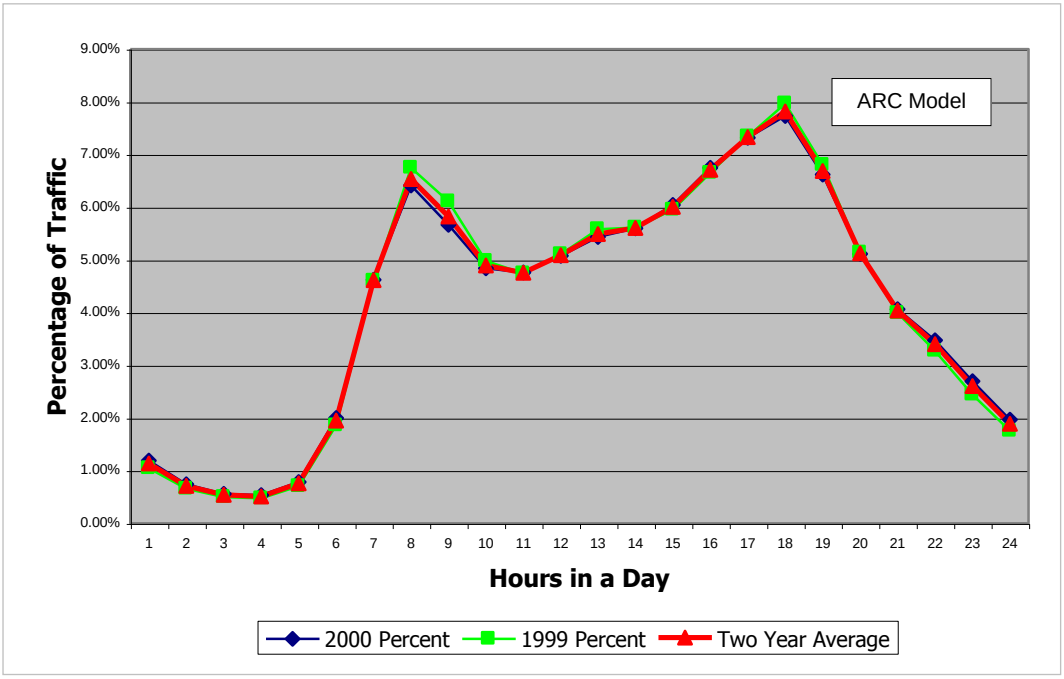
The ARC travel demand model analyzes travel demand in specific time periods of the day. The four analysis periods are:

- a morning peak period from 6:00 AM to 10:00 AM;
- a mid-day period from 10:00 AM to 3:00 PM;
- an evening peak period from 3:00 PM to 7:00 PM, and
- a night period from 7:00 PM to 6:00 AM.

The ARC time-of-day model was calibrated using data from the 1990 Home Interview Survey[6]. The survey data was used to develop a series of travel time factors showing the percent of travel made in half hour increments over the course of an average day. These travel time factors were updated using 1999 and 2000 hourly traffic distribution counts for all classified roads in the 13-county non-attainment area in Atlanta region. A two-year average of the 1999 and 2000 diurnal traffic counts was used to adjust the temporal trip distribution model for the four time-of-day period assignments. Figure 1 represent the diurnal distribution of travel for both 1999 and 2000, as well as the two-year average used to update the trip distribution factors.

[6] SMARTRAQ household survey data will likely be used in the future to update the time-of-day model.

Figure 1: Diurnal Distribution of Travel in the 13-County Non-attainment Area



To validate current temporal distribution patterns along interstate segments, 24-Hour Volume Counts for different weekdays were collected from the GDOT Transportation Management Center (TMC) on multiple study corridors at the following locations:

- I-75 North corridor close to Wade Green Road, Windy Hill Road and Bells Ferry Road
- I-75 North corridor inside of I-285 close to Cumberland Blvd/Chattahoochee River
- I-75 South corridor inside of I-285 close to Central Avenue
- I-85 North of I-285 close to Jimmy Carter Boulevard and Pleasant Hill Road
- I-85 South inside of I-285 close to Sylvan Road
- I-85 North inside of I-285 close to Clairmont Road and Marta Overpass/Lenox Road
- I-75/I-85 Downtown Connector close to Fifth Street/Fourteenth Street and University Avenue
- I-20 inside of I-285 close to Linkwood Road, Cherokee Street, Clifton Street and Columbia Drive
- SR 316 close to Boggs Road

Based on these 24-hour traffic counts, a temporal volume distribution curve and a temporal speed profile were developed for each corridor and the overall system. Figures 2 and 3 represent the temporal distribution curve and the speed profile for the I-85 North corridor in the section close to Pleasant Hill Road. A complete set of volume and speed diurnal profiles developed for other MLSP study corridors are included in Appendix 1.

Figure 2: Volume-Speed Curves - I-85 Northbound at Pleasant Hill Rd

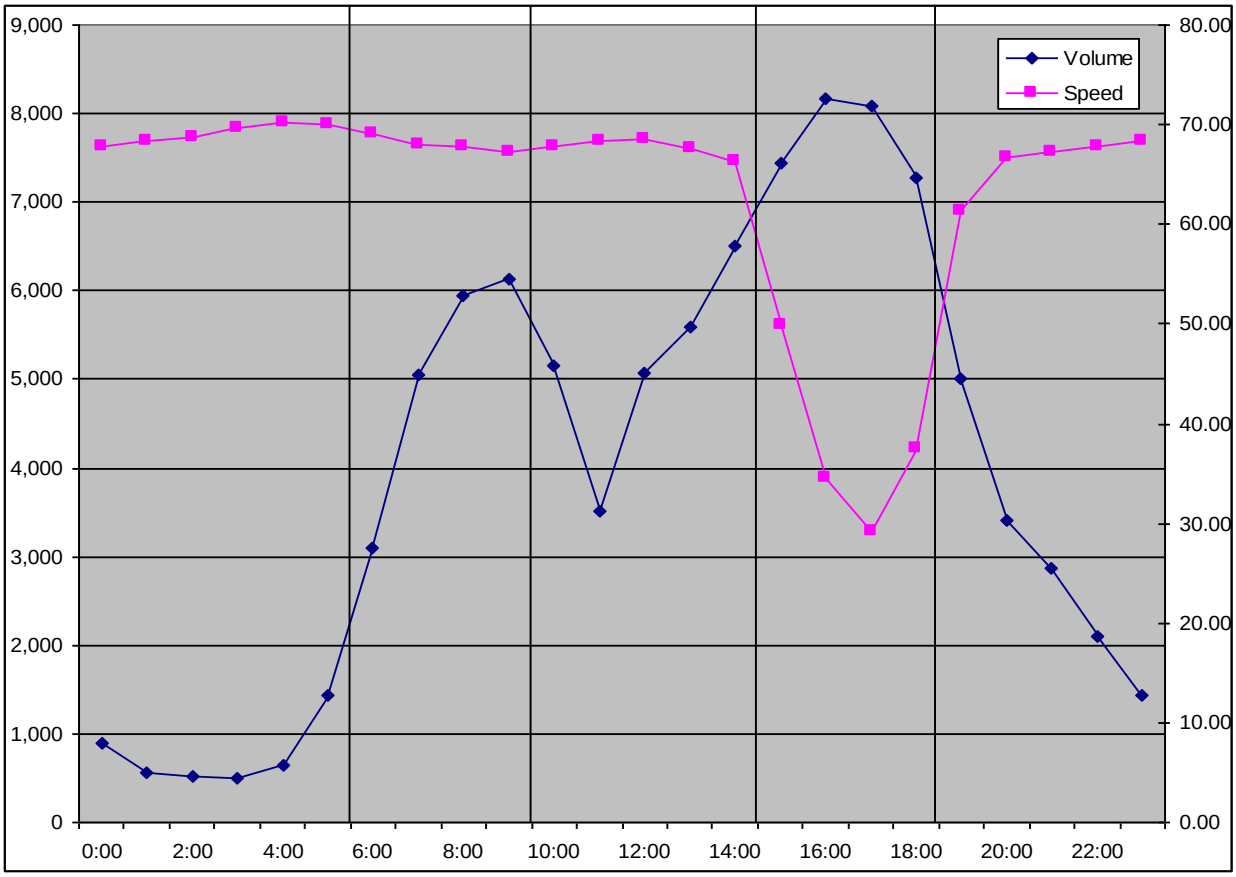


Figure 3: Volume-Speed Curves - I-85 Southbound at Pleasant Hill Rd

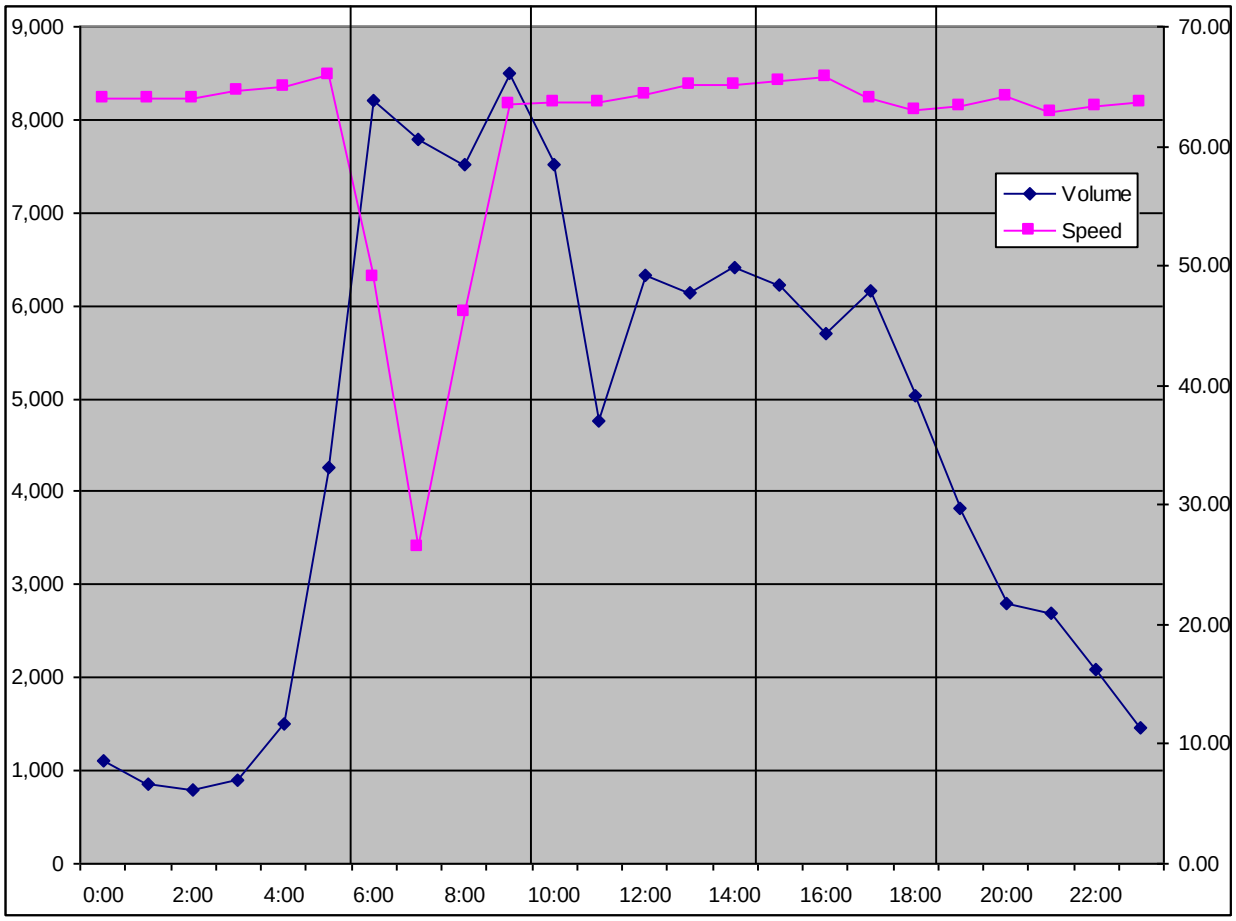


Figure 4 presents the ARC travel demand model's temporal distribution curve (two-year average) and the temporal distribution curve developed based on 24-hour TMC counts. Overall, the comparison of these two temporal distribution curves indicates that ARC's travel demand model is doing a fairly good job replicating the travel patterns during four time periods along the interstate corridors. When compared to field traffic counts, the ARC model has slightly higher distribution percentage during PM and NT periods and slightly lower distribution percentage during AM and MD periods.

To better quantify global demand and the potential impacts on managed lanes, the MLSP study refined ARC's time-of-day model and introduced a late evening period. Table 3 represent the diurnal distribution of travel for four time periods from ARC model and TMC Counts, as well as the MLSP refined time-of-day period. A late evening period (from 10 PM to 6 AM) was also incorporated in the model.

Figure 4: Temporal Distribution Curve – TMC vs. ARC Model

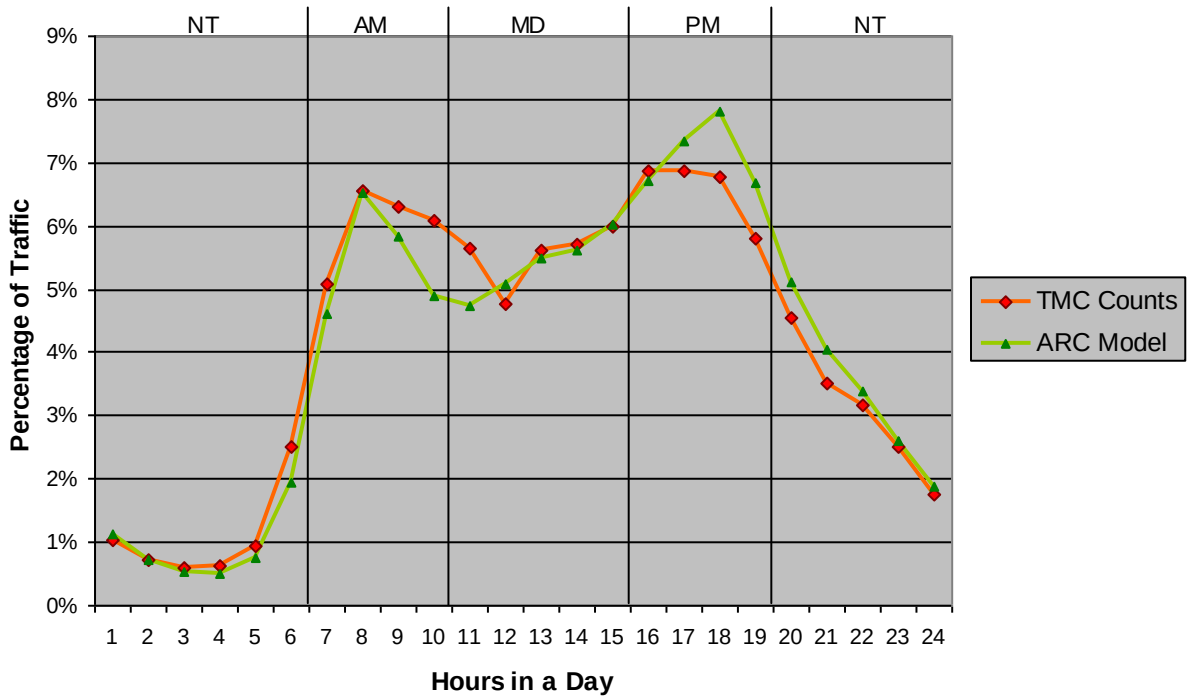


Table 5: MLSP Refined Time-of-Day Period

ARC Time-of-Day Period	ARC Model (Daily Percentage)	TMC Counts (Daily Percentage)	MLSP Refined Time-of-Day Period
AM 6 AM – 10 AM	21.86%	24.03%	AM 6 AM – 10 AM
MD 10 AM – 3 PM	26.94%	27.71%	MD 10 AM – 3 PM
PM 3 PM – 7 PM	28.55%	26.30%	PM 3 PM – 7 PM
NT 7 PM – 6 AM	22.66%	21.95%	Late Evening Period (7 PM-10 PM)
			NT Period (10 PM – 6 AM)

The refined travel demand model was used for subsequent traffic and revenue analyses to determine the impact of tolled managed lanes on the transportation system performance.

D. Peak Spreading

The second level of global demand estimation was to examine peak spreading and incorporate it into the global demand estimation. Peak spreading can be seen as having two broad dimensions. The first may be described as 'passive' peak spreading, which is a natural increase in the duration of a peak period as travel demand exceeds the capacity of a roadway facility. The second dimension is 'active' peak spreading, in which individual travelers deliberately change their travel behavior to avoid peak periods, or when transport policies are enacted to encourage people to travel outside of the peak periods[7]. Several studies have found that variable tolling, as a lane management strategy and techniques, has an impact on travel behavior by 'active' peak spreading. In New Jersey, recent traffic increases on the Turnpike have been smaller in the morning and evening rush hours than in off peak periods. In New York, traffic has been reduced in the morning and afternoon peak, resulting in increased demand during "shoulder periods".

It is therefore important to assess the traveler's temporal response to congestion and evaluate the potential effects of peak spreading in a modeling environment for managed lane global demand estimation. The I-285 Strategic Implementation Plan (SIP) study conducted for the Georgia Department of Transportation (GDOT) introduced a matrix variegation procedure to account for peak spreading so that excessive travel demand could be diverted into neighboring hours in the peak period. As part of the Managed Lane System Plan this study was reviewed in order to understand its methodologies with respect to the evaluation of global demand for managed lane increments.

In summary, the matrix variegation assumes a different temporal distribution for each origin-destination pair. The estimated temporal distribution is related to the level of congestion between each origin-destination pair. For a trip with little or no congestion, little or no peak spreading is estimated to occur. On the other hand, for trips in corridors with high congestion levels, significant peak spreading is expected to occur. The methodology also assumes that additional peak spreading will occur for any particular origin-destination pair as congestion increases over time (i.e., the peak spreading does not remain constant over time or for alternate transportation systems). In the I-285 Strategic Implementation Plan, twenty-four sets of temporal distribution curves were developed based on different "Ratio of Total Daily Traffic to Total Hourly Capacity" (see Figure 5). The detailed percent of daily trips by hour is illustrated in Table 4.

It is recommended that the Managed Lane System Plan should incorporate peak shifting/spreading in the travel demand model as a result of the tolling and travel time changes due to congestion. The matrix variegator percent daily trips by "Ratio of Total Daily Traffic to Total Hourly Capacity" will be employed to test the sensitivity of peak spreading on the global demand. In addition, the system wide shifting of five percent, seven percent and ten percent of trips from the peak periods to shoulder and off-peak periods will be evaluated in the Scenario Testing Task.

[7] Modeling trip timing behavior and the influence of peak spreading; N. Holyoak & M. A. P. Taylor

Figure 5: Matrix Variegator Percent Daily Trips by ADT/C Ratio

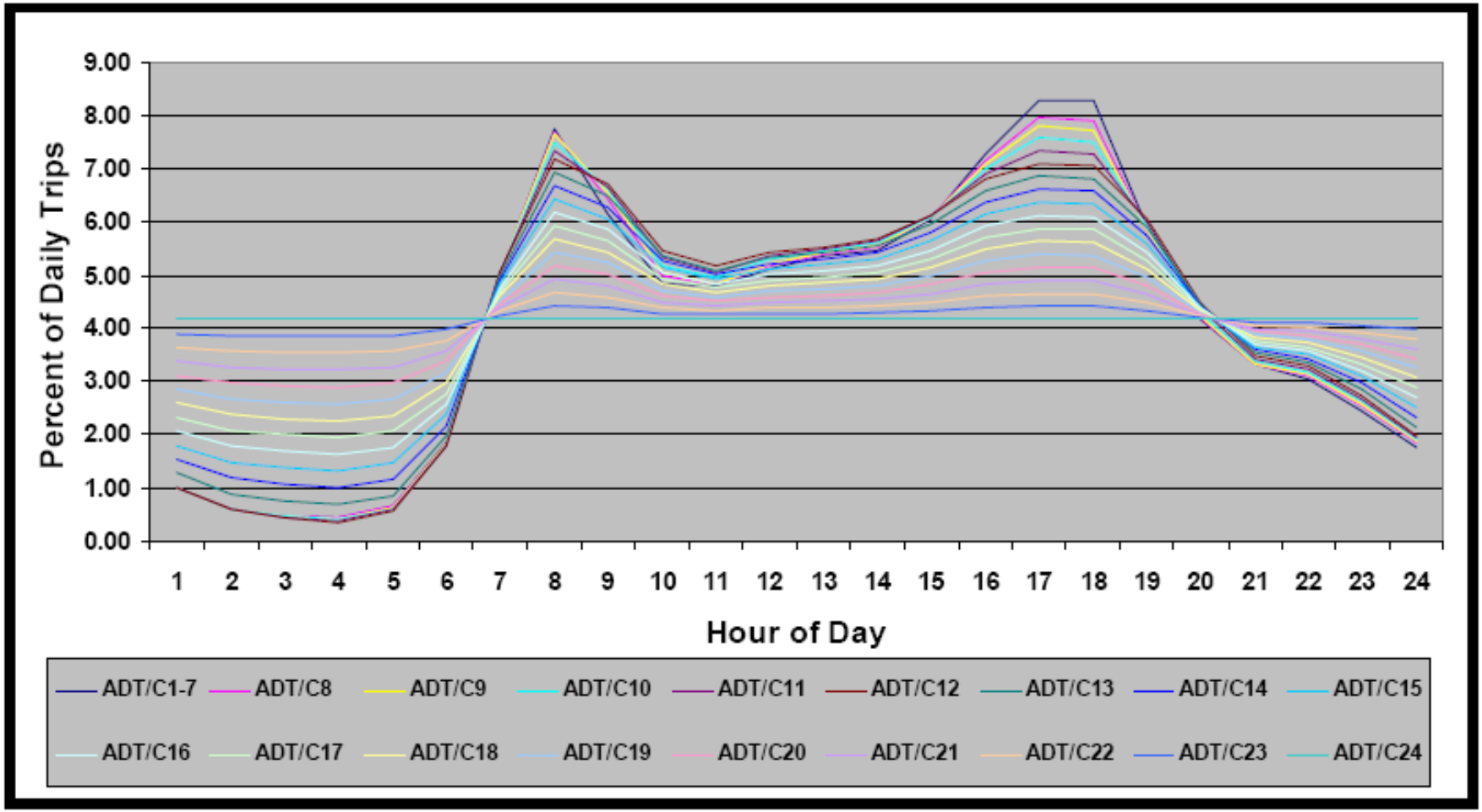


Table 4: Percent of Daily Trips by Hour Based Upon Ration of Total Daily Traffic to Total Hourly Capacity

Hour	Ratio of ADT to Hourly Capacity																	
	1 - 7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1.00	1.01	1.01	1.01	1.01	1.01	1.27	1.54	1.80	2.06	2.33	2.59	2.85	3.11	3.38	3.64	3.90	4.17
2	0.60	0.61	0.61	0.60	0.60	0.59	0.89	1.19	1.48	1.78	2.08	2.38	2.68	2.97	3.27	3.57	3.87	4.17
3	0.48	0.48	0.48	0.47	0.45	0.44	0.75	1.06	1.37	1.68	1.99	2.30	2.61	2.92	3.24	3.55	3.86	4.17
4	0.45	0.43	0.42	0.40	0.38	0.36	0.68	0.99	1.31	1.63	1.95	2.26	2.58	2.90	3.22	3.53	3.85	4.17
5	0.67	0.64	0.63	0.61	0.58	0.56	0.86	1.16	1.46	1.76	2.06	2.36	2.66	2.96	3.27	3.57	3.87	4.17
6	1.85	1.82	1.81	1.80	1.79	1.78	1.98	2.18	2.38	2.58	2.77	2.97	3.17	3.37	3.57	3.77	3.97	4.17
7	5.01	5.04	5.06	5.05	5.05	5.04	4.97	4.90	4.82	4.75	4.68	4.60	4.53	4.46	4.39	4.31	4.24	4.17
8	7.73	7.67	7.64	7.49	7.33	7.17	6.92	6.67	6.42	6.17	5.92	5.67	5.42	5.17	4.92	4.67	4.42	4.17
9	6.13	6.42	6.56	6.61	6.65	6.70	6.49	6.28	6.07	5.86	5.65	5.43	5.22	5.01	4.80	4.59	4.38	4.17
10	4.82	4.97	5.05	5.19	5.33	5.47	5.36	5.25	5.14	5.04	4.93	4.82	4.71	4.60	4.49	4.38	4.28	4.17
11	4.79	4.82	4.84	4.95	5.06	5.17	5.09	5.00	4.92	4.84	4.75	4.67	4.59	4.50	4.42	4.33	4.25	4.17
12	5.12	5.19	5.22	5.29	5.35	5.42	5.32	5.21	5.11	5.00	4.90	4.79	4.69	4.58	4.48	4.38	4.27	4.17
13	5.36	5.41	5.43	5.46	5.50	5.53	5.42	5.30	5.19	5.08	4.96	4.85	4.74	4.62	4.51	4.39	4.28	4.17
14	5.47	5.53	5.56	5.60	5.64	5.68	5.55	5.43	5.30	5.18	5.05	4.92	4.80	4.67	4.55	4.42	4.29	4.17
15	6.05	6.07	6.08	6.09	6.11	6.12	5.96	5.80	5.63	5.47	5.31	5.14	4.98	4.82	4.66	4.49	4.33	4.17
16	7.27	7.14	7.08	6.99	6.90	6.81	6.59	6.37	6.15	5.93	5.71	5.49	5.27	5.05	4.83	4.61	4.39	4.17
17	8.28	7.97	7.81	7.58	7.34	7.10	6.86	6.61	6.37	6.12	5.88	5.63	5.39	5.14	4.90	4.66	4.41	4.17
18	8.27	7.90	7.71	7.50	7.28	7.06	6.82	6.58	6.34	6.10	5.86	5.61	5.37	5.13	4.89	4.65	4.41	4.17
19	5.89	5.87	5.86	5.92	5.98	6.04	5.88	5.73	5.57	5.42	5.26	5.10	4.95	4.79	4.64	4.48	4.32	4.17
20	4.18	4.21	4.22	4.31	4.39	4.48	4.45	4.43	4.40	4.38	4.35	4.32	4.30	4.27	4.25	4.22	4.19	4.17
21	3.32	3.33	3.33	3.38	3.43	3.48	3.54	3.60	3.65	3.71	3.77	3.82	3.88	3.94	4.00	4.05	4.11	4.17
22	3.03	3.10	3.13	3.18	3.23	3.28	3.35	3.43	3.50	3.58	3.65	3.72	3.80	3.87	3.95	4.02	4.09	4.17
23	2.44	2.53	2.58	2.63	2.68	2.73	2.85	2.97	3.09	3.21	3.33	3.45	3.57	3.69	3.81	3.93	4.05	4.17
24	1.77	1.84	1.88	1.91	1.93	1.96	2.14	2.33	2.51	2.70	2.88	3.06	3.25	3.43	3.62	3.80	3.98	4.17
Total	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***

Data Source: I-285 Strategic Implementation Plan

Appendix

Figure A: Volume-Speed Curves - I-20 Eastbound at Clifton St

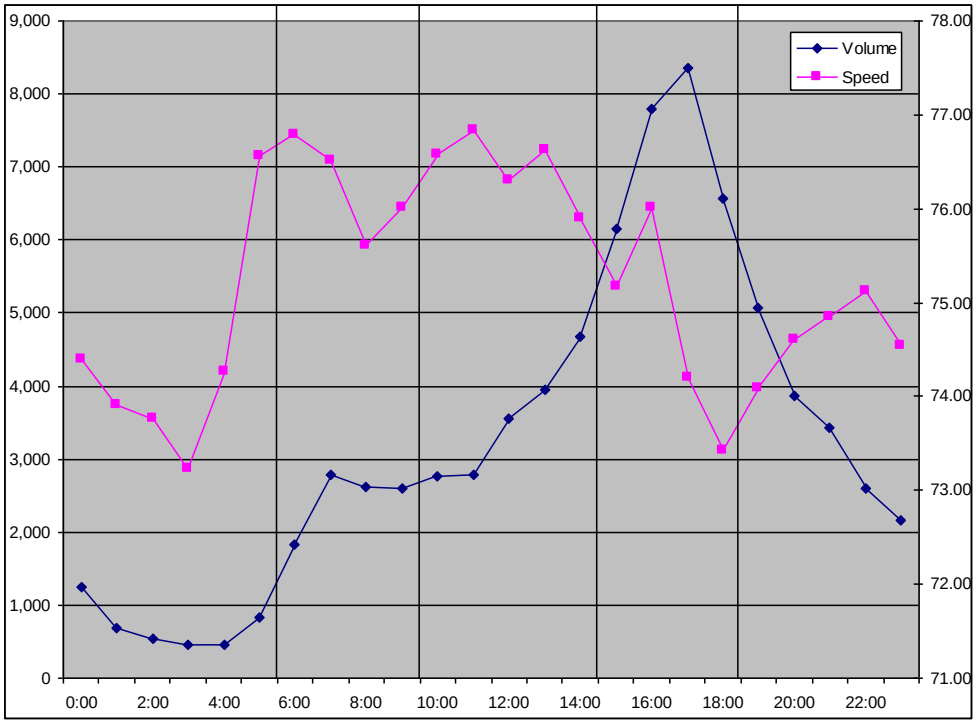


Figure B: Volume-Speed Curves - I-20 Westbound at Clifton St

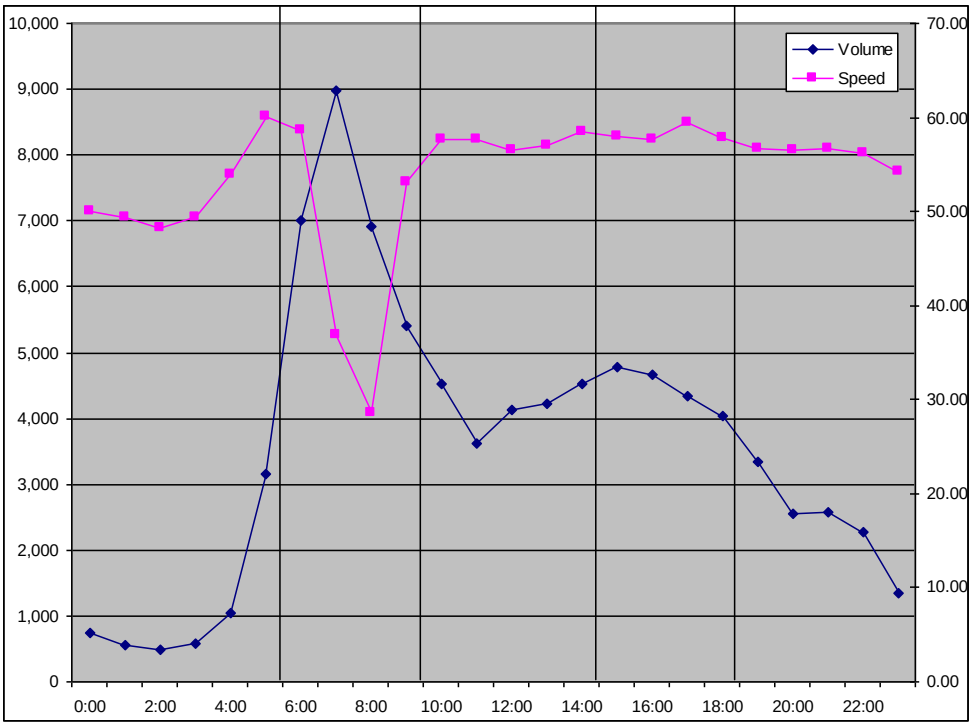


Figure C: Volume-Speed Curves - I-75 Northbound at Wade Green Rd

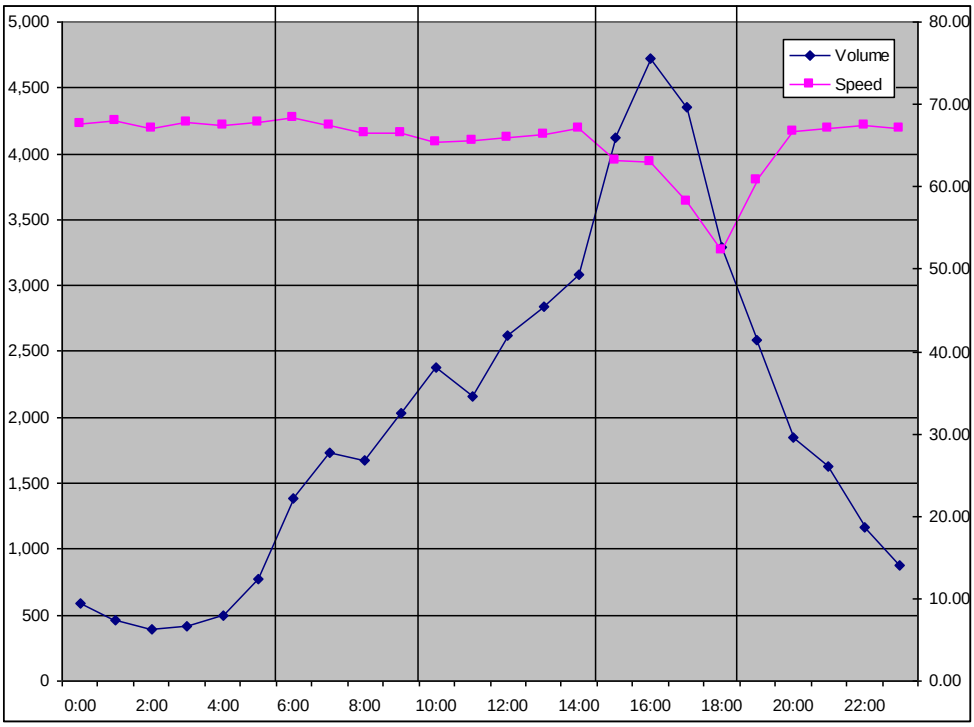


Figure D: Volume-Speed Curves - I-75 Southbound at Wade Green Rd

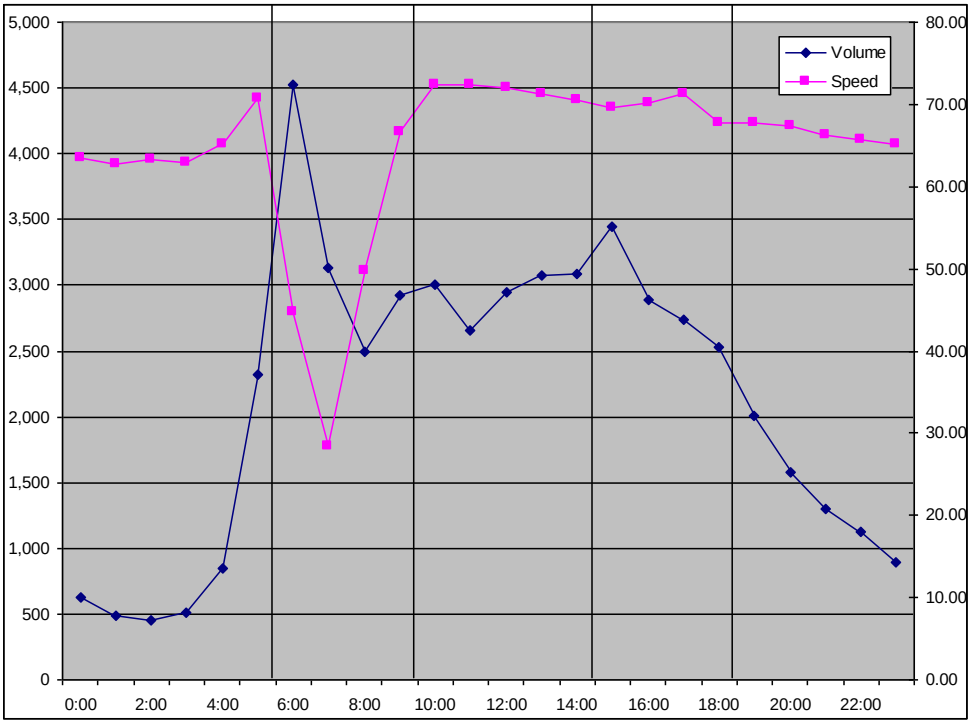


Figure E: Volume-Speed Curves - I-75 / I-85 Northbound at Fifth St

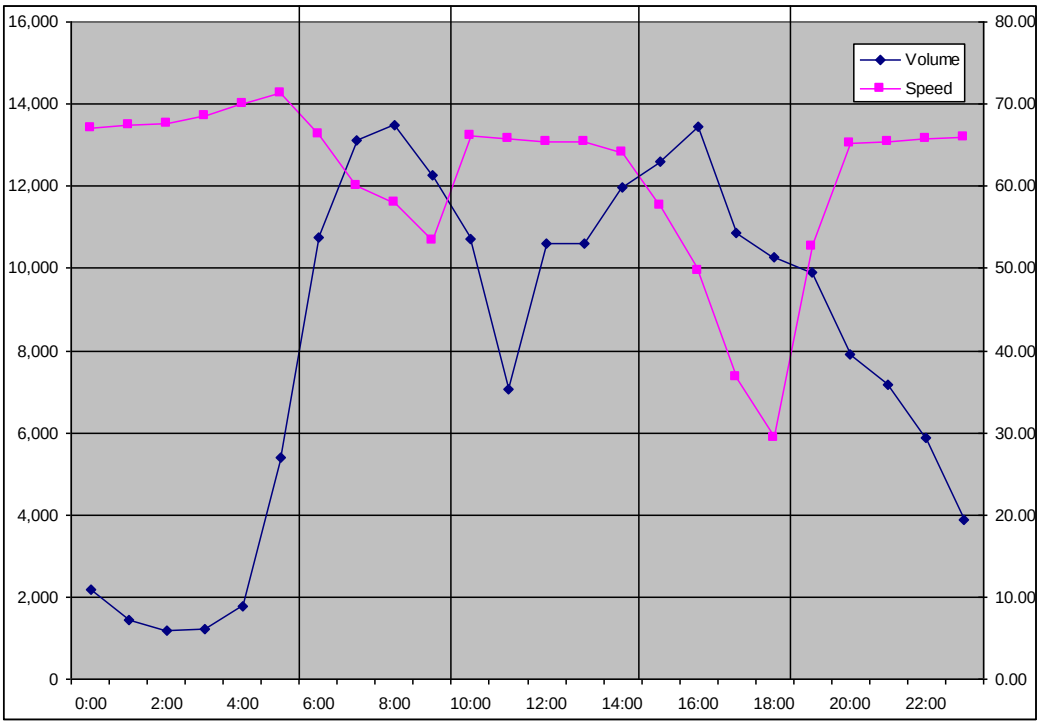
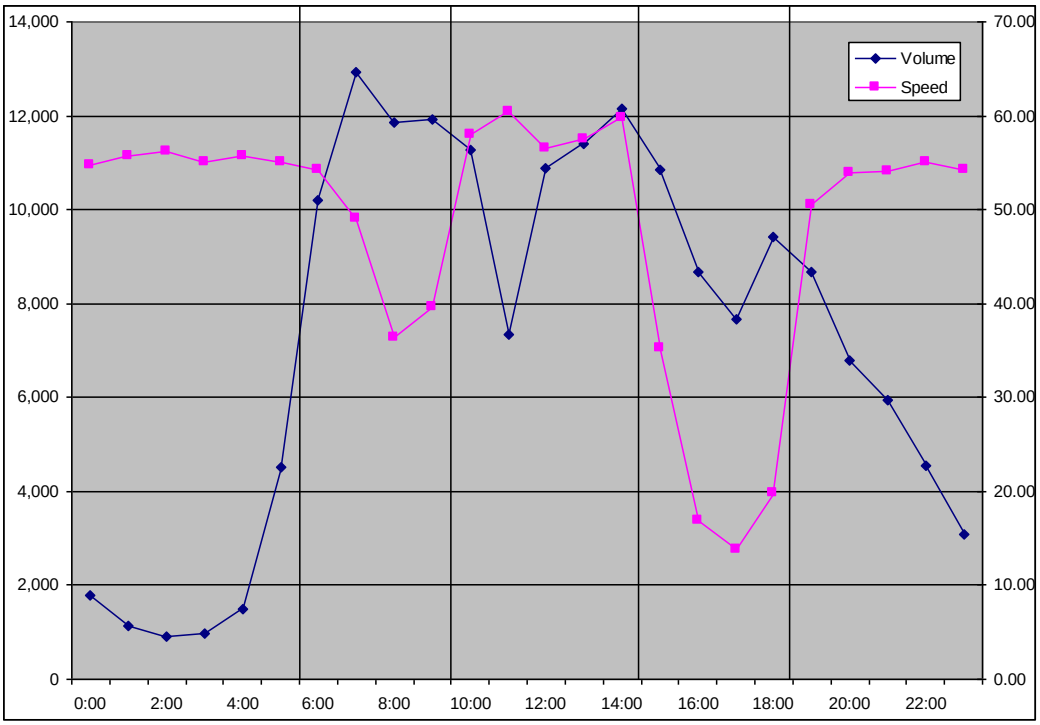



Figure F: Volume-Speed Curves - I-75 / I-85 Southbound at Fifth St