Title

Baseline Evaluation of the Freeway Service Patrol (FSP) I-710 Big-Rig Demonstration Program

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ABSTRACT

Freeway service patrol (FSP) is an incident management measure designed to assist disabled vehicles along congested freeway segments and reduce congestion through quick detection, response, and removal of accidents and other incidents on freeways. A two-year demonstration project has been proposed to extend FSP service to big-rigs and other heavy vehicles along the I-710 freeway. The report describes the work performed and the findings from the preliminary evaluation of the proposed I-710 Big-rig FSP demonstration project. The results show that the proposed FSP big-rig project will be cost-effective. Next steps in the ongoing research include detailed evaluation of the effectiveness of the FSP service based on field measurements throughout the two-year demonstration, and development of operational procedures for implementing big-rig FSP service to other freeway routes.

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INTRODUCTION

1.1 CALIFORNIA'S FREEWAY SERVICE PATROL PROGRAM

Freeway Service Patrol (FSP) is an incident management measure designed to assist disabled vehicles along congested freeway segments and reduce non-recurring congestion through quick detection, response, and removal of accidents and other incidents on freeways. In California, the program is jointly administered by the California Department of Transportation (Caltrans), the California Highway Patrol (CHP) and local Transportation Planning Organizations (MPOs). Currently, FSP operates on 125 freeway sites ("beats") across the State with 320 tow trucks over 1,500 centerline miles.

In Caltrans District 7, which spans Los Angeles and Ventura Counties, the Metro Freeway Service Patrol is a joint program provided and funded by the Metropolitan Transportation Authority (Metro), Caltrans, and CHP. Currently 147 contracted tow trucks rove 425 center-line miles of the most heavily traveled freeways in District 7 during peak periods on weekday; 34 FSP tow trucks provide weekday midday service; and another 28 FSP trucks provide assistance on weekends and holidays. In 2004, FSP tow truck drivers logged a total of 301,728 assists in District 7 [1].

1.2 PROBLEM STATEMENT

At present, the FSP program provides light duty tow truck service which can tow Class 1 vehicles only – vehicles weighing under 6,000 pounds gross vehicle weight. Class 1 includes passenger vehicles, light trucks, minivans, full size pickups, sport utility vehicles, and full size vans. FSP tow trucks provide little assistance for freeway incidents involving large vehicles, and this limitation may pose serious problems depending upon truck traffic volumes and levels of congestion. On high volume freeways which also are major trucking routes, FSP's inability to clear big-rig incidents might severely constrain FSP's impact on congestion relief.

Interstate 710 is a major trucking route, providing access to the Los Angeles and Long Beach Harbors from the north. It operates at or near capacity on a normal weekday. Incident-induced congestion exasperates this problem; the I-710 has an incident rate that exceeds statewide averages for other freeways of this type with an incident rate of about 5 per day [2,3]. What makes the I-710 so dangerous is not only the number of incidents, but also the type of vehicles involved in those incidents. Trucks currently make up 45% to 60% of the freeway traffic on the I-710 with current truck traffic projected to triple by the year 2030 [4,5]. These two factors, high truck volumes and high incident rates, generate traffic congestion that cost drivers millions of dollars in wasted time each year.

According to CHP data, there were a total of 18,537 collisions on the I-710 from 1992 to 2002 and 5,982 (32.3%) of these involved a truck [6]. That is almost two truck-involved incidents out of an average of five incidents per day. Truck-involved incidents are a major cause of congestion because unlike passenger car incidents, big-rig incidents take longer to clear and usually block more travel lanes.

CHP data further show that approximately 20% of all SigAlerts (incidents taking longer than 30 minutes to resolve) in Los Angeles County involve a truck. As for Interstate 710, trucks were involved in 70 of the 85 SigAlerts (82%) reported during September 1 2002 to August 31 2003; the truck involvement rate in SigAlerts along this corridor is over four times higher than the County-wide average of 20%. [7]. On the I-710, truck-related SigAlerts averaged over two and a half hours in duration. Moreover, incident duration turned out to be a conservative measure of traffic delays, only taking into account the elapsed time between when the SigAlert was issued to the time the SigAlert was cancelled, which does not account for the additional time necessary for traffic to resume to its pre-incident flows and speeds. Delays continue to cost travelers even after SigAlerts are formally pronounced cleared. With these facts, the number and duration of truck-related incidents on I-710 are cause for concern as they directly have major negative impacts on traffic flows and speeds.

In response to the unacceptably long incident durations for truck involved incidents on I-710, Metro, CHP, and Caltrans have worked jointly to institute a Big-rig FSP Demonstration Project, a 2-year pilot project to improve incident response and clearance times for big-rig related incidents thus easing congestion on the most congested truck route in the State.

1.3 THE I-710 BIG-RIG FSP DEMONSTRATION PROJECT

The Big-rig FSP pilot program would expand the capabilities of the current FSP program to include two heavy-duty (Class D) tow trucks on a section of I-710 freeway. These tow trucks have the capability of towing a disabled big-rig up to 80,000 GVWR. The Big-rig FSP tow trucks could either be staged and/or constantly roving.

The selected stretch of the I-710 freeway for this demonstration is 18.3 miles long, from south of Ocean Blvd at milepost 4.96 in Long Beach to the I-5 interchange at milepost 23.28 near downtown Los Angeles. While this is less than the entire length of the freeway, this is the optimal length for the project because of the high volumes of truck traffic operating on this segment. The annual average daily traffic (AADT) for I-710 is the heaviest along this particular stretch [8]. The AADT at milepost 4.96 is 54,000 vehicles per day (vpd), and steadily increases until it peaks at milepost 15.69 at 237,000 vpd. The AADT decreases steadily until milepost 23.28 with 185,000 vpd. After milepost 24.63, the AADT drops to 45,000 vpd or less. Figure 1.1 displays a map showing I-710 and the Los Angeles region.

1.4 OBJECTIVES OF THE STUDY

The objectives of this research project is to evaluate the effectiveness of the pilot FSP Big-rig demonstration project along I-710, and to develop recommendations and operational procedures for implementing FSP big-rig service on other freeway routes. The research effort is undertaken into three phases:

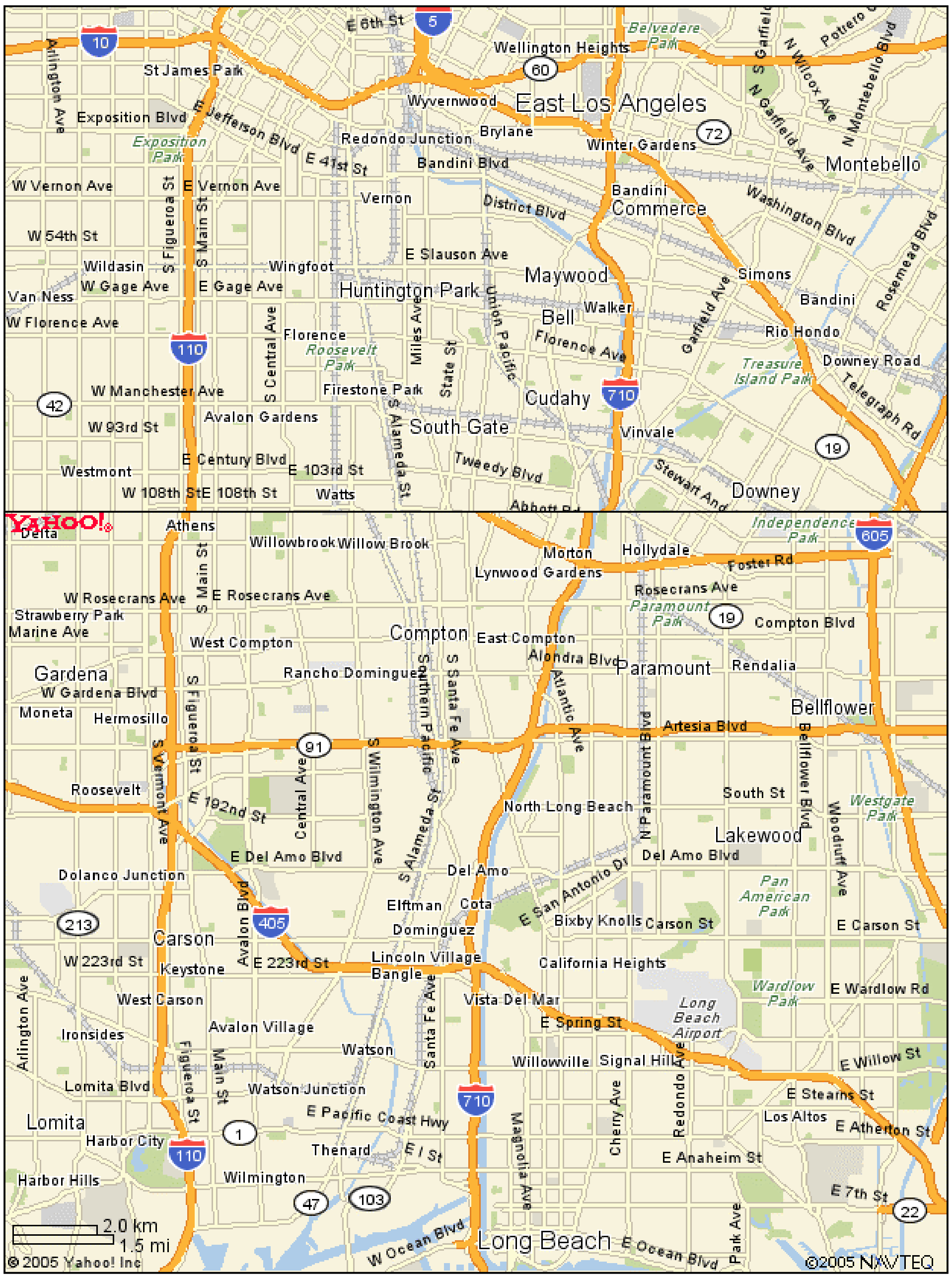
- Pre-demonstration (preliminary) evaluation: perform a preliminary evaluation of the proposed FSP big-rig service prior to implementation
- Mid-demonstration evaluation: evaluate the effectiveness of the I-710 Big-rig FSP demonstration project approximately one year from the beginning of the project, using field data on FSP assists to update the delay savings and benefit-cost ratio estimates, and to refine the FSP service operation as appropriate

- Post-demonstration evaluation: evaluate the I-710 Big-rig FSP Demonstration Project at the conclusion of the pilot project, and develop recommendations and operational guidelines for extending FSP big-rig service to other freeway truck routes in the State

1.5 ORGANIZATION OF THE REPORT

This report documents the work performed and the findings from Phase I (Pre-demonstration evaluation). Chapter 2 describes the collection and processing of field data on incidents and traffic conditions. Chapter 3 describes the evaluation methodology, and presents the results from the preliminary evaluation of the proposed FSP big-rig project. Chapter 4 summarizes the study findings, and outlines the next steps in the I-710 FSP Big-rig evaluation project.

Figure 1.1: I-710 FSP Big Rig Test Section



CHAPTER 2

DATA COLLECTION AND PROCESSING

The evaluation of the I-710 Big-rig demonstration project will be performed based on field data. Data on incidents and freeway operating conditions were collected during April and May 2005, prior to the implementation of the FSP big-rig service. Section 2.1 describes the incident data and data sources used for these analyses and Section 2.2 describes the traffic data that are used to quantify traffic conditions along I-710.

2.1 INCIDENT DATA

Incident data were obtained from the following sources. (1) CHP Los Angeles Communications Center (LACC) provided information & data on incidents logged at District 7's Traffic Management Center (TMC), (2) Data from FSP assisted incidents were provided by Metro's FSP Program Manager. (3) CHP logged incidents were also obtained from the freeway Performance Measurement System (PeMS).

2.1.1 LACC Logged Incidents

Incidents from 911 calls, CHP freeway call boxes, FSP operators, and those reported by patrolling CHP officers are logged by CHP's LACC staff. The LACC logged incidents on I-710 for April and May 2005 were provided by CHP. The incident duration measured from the CHP data is the time starting when the incident is first reported to CHP and ending when the CHP officer at the scene declares the incident closed and leaves the scene. The incident response time measured from the CHP data is the time starting when the incident is first reported to CHP and ending when the first CHP officer arrives at the scene. Of the 653 total incidents logged, 634 incidents were recorded as needing time to resolve with a median duration of 40.5 minutes and a median CHP response-time of 18 minutes. For various reasons, the actual incident duration may be different than the incident duration obtained from the CHP data. For example, if an incident occurs and it reported to CHP 5 minutes later, then the reported incident duration would be 5 minutes shorter than the actual incident duration. Additionally, the traffic lanes might be reopened for use by motorists several minutes prior to the CHP officer leaving the scene. In these instances, the actual incident duration will be shorter than the CHP reported incident duration.

Table 2.1 shows detailed statistics on those 634 incidents. Of the 634 incidents, 565 were blocking travel lanes (the third row in table 2.1). Sixty nine of the lane blocking incidents involved big-rigs. The median duration of these big-rig lane-blocking incident was 76 minutes and the median CHP response-time was 18 minutes. These are the delay-causing incidents that the Big-rig FSP service most probably would assist. Of the 69 big-rig incidents, 16 (48%) were coded as SigAlert incidents.

Tables 2.2 and 2.3 show the average incident duration and response times by CHP incident description categories. The distributions of incident durations and response times are shown in Figures 2.1 and 2.2. Figures 2.3 and Figure 2.4 show the temporal distribution of the CHP logged I-710 incidents for the Northbound and Southbound travel directions, respectively.

Table 2.1: CHP Incidents on I-710, Incident Summary by Incident Categories

BigRig	CHP	Caltrans	FSP	Sig-Alert	Lanes Blocked	Incident Count	Median Duration (minutes)	Median CHP Response Time (min)
						634	40.5	18.0
	X					587	41.5	18.0
					X	565	40.0	18.0
			X			197	37.5	18.0
X						106	51.5	16.0
X					X	69	76.0	18.0
		X				28	117.5	26.0
				X		33	96.0	9.0
	X			X		33	96.0	9.0
X	X			X	X	16	126.0	10.5
X	X			X		16	126.0	10.5
X				X		16	126.0	10.5
X	X	X		X	X	6	191.5	13.5

Table 2.2: CHP Incidents on I-710, Durations by Incident Type Categories

CHP Incident Type Code	Mean Duration (minutes)	Incident Count	CHP Incident Type Description
10851	73.0	1	STOLEN VEHICLE
1125	29.6	368	TRAFFIC HAZARD
1126	10.5	11	DISABLED VEHICLE
1141	30.5	4	AMBULANCE REQUIRED
1144	243.0	2	TRAFFIC ACCIDENT, POSSIBLE FATALITY
1179	66.2	62	TRAFFIC ACCIDENT, PARAMEDICS RESPONDED
1181	42.6	8	ACCIDENT, MINOR INJURY
1182	43.9	98	TRAFFIC ACCIDENT, NO INJURIES
1183	41.6	53	TRAFFIC ACCIDENT, NO DETAILS
20001	42.0	2	HIT AND RUN TRAFFIC ACCIDENT, INJURIES
20002	41.3	7	HIT AND RUN TRAFFIC ACCIDENT
BREAK	32.9	18	CAL TRANS/CHP/FSP REQUEST FOR TRAFFIC BREAK
C/FIRE	42.0	11	CAR FIRE
FIRE	71.0	1	REPORT OF FIRE, STRUCTURE OR GRASS
FLOOD	81.5	2	ROADWAY FLOODING
PED	18.3	3	PEDESTRIAN ON FREEWAY
PUR	324.0	1	PURSUIT
SPILL	138.0	1	INCIDENT INVOLVING SPILLED CARGO/HAZARDOUS MATERIAL

Table 2.3: CHP Incidents on I-710, Response-times by Incident Type Categories

CHP Incident Type Code	Mean CHP Response Time (minutes)	Incident Count	CHP Incident Type Description
10851	12.0	1	STOLEN VEHICLE
1125	15.5	368	TRAFFIC HAZARD
1126	-	11	DISABLED VEHICLE
1141	12.8	4	AMBULANCE REQUIRED
1144	10.0	2	TRAFFIC ACCIDENT, POSSIBLE FATALITY
1179	9.8	62	TRAFFIC ACCIDENT, PARAMEDICS RESPONDED
1181	8.1	8	ACCIDENT, MINOR INJURY
1182	18.5	98	TRAFFIC ACCIDENT, NO INJURIES
1183	10.9	53	TRAFFIC ACCIDENT, NO DETAILS
20001	10.0	2	HIT AND RUN TRAFFIC ACCIDENT, INJURIES
20002	11.7	7	HIT AND RUN TRAFFIC ACCIDENT
BREAK	20.3	18	CAL TRANS/CHP/FSP REQUEST FOR TRAFFIC BREAK
C/FIRE	20.0	11	CAR FIRE
FIRE	7.0	1	REPORT OF FIRE, STRUCTURE OR GRASS
FLOOD	1.5	2	ROADWAY FLOODING
PED	13.7	3	PEDESTRIAN ON FREEWAY
PUR	9.0	1	PURSUIT
SPILL	14.0	1	INCIDENT INVOLVING SPILLED CARGO/HAZARDOUS MATERIAL

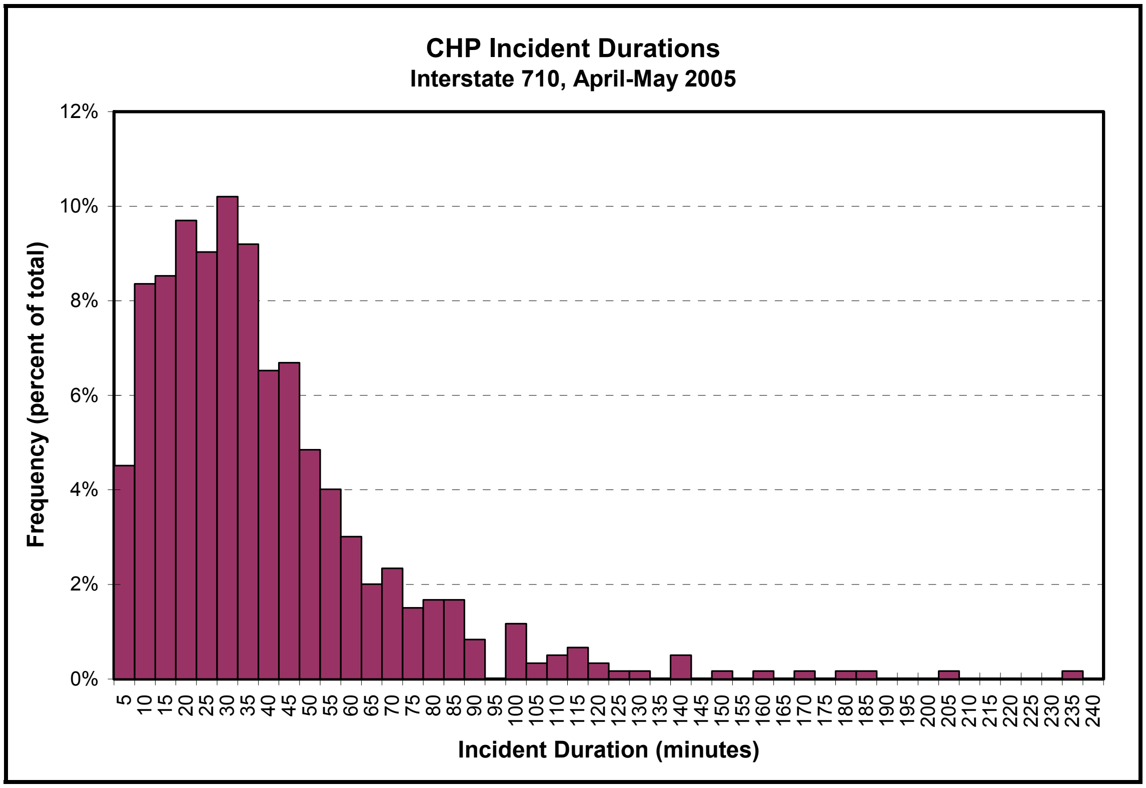


Figure 2.1: Incident Duration Distribution of CHP Incidents on I-710

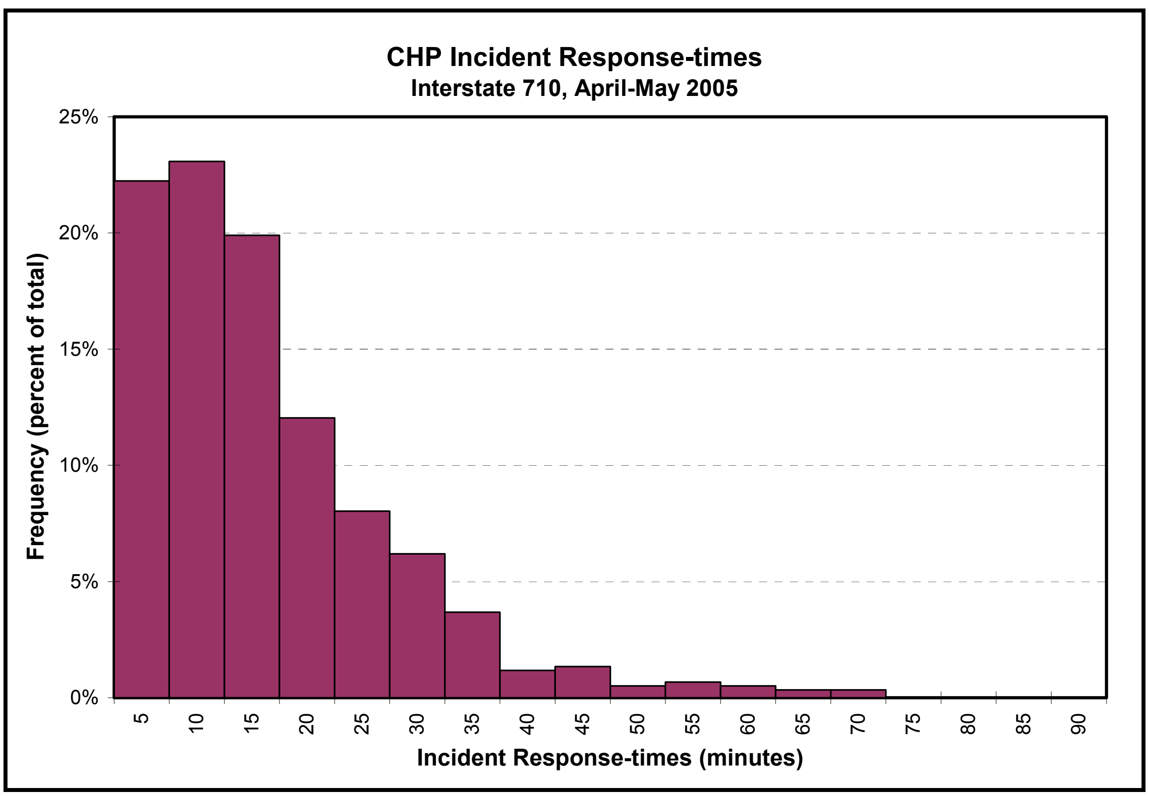


Figure 2.2: Incident Response-time Distribution of CHP Incidents on I-710

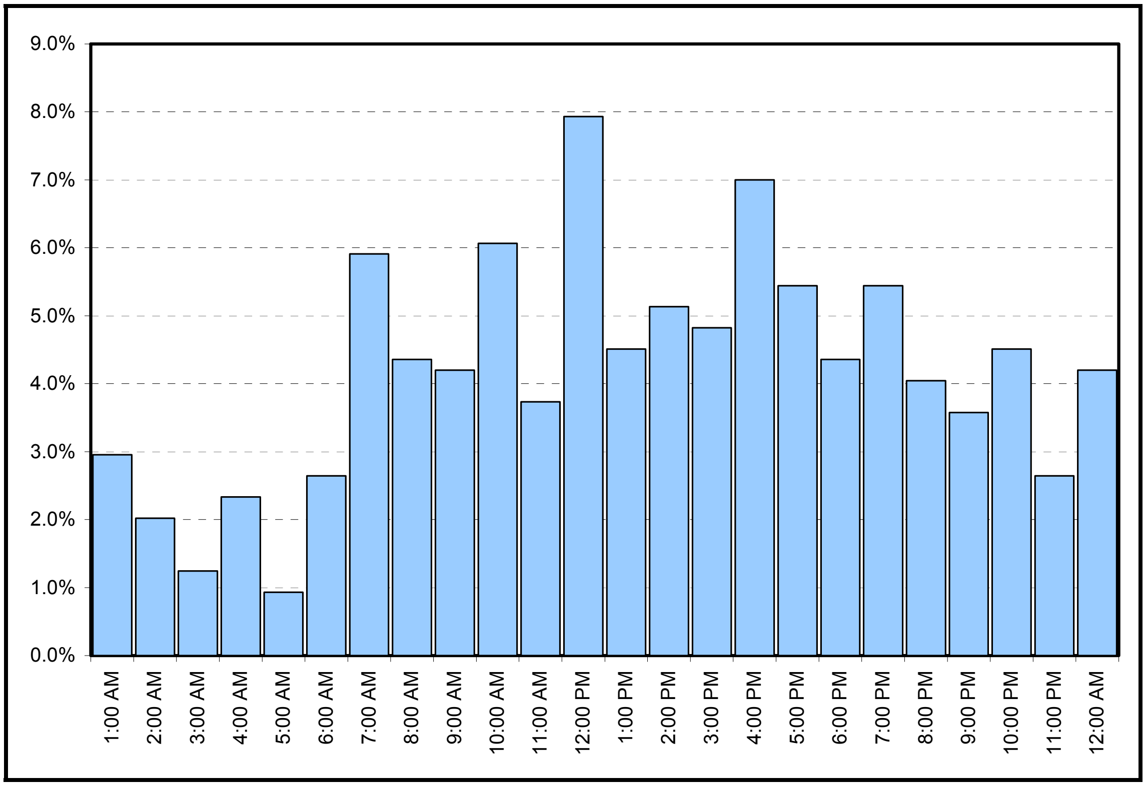


Figure 2.3: Temporal Distribution of CHP Incidents on I-710 Northbound

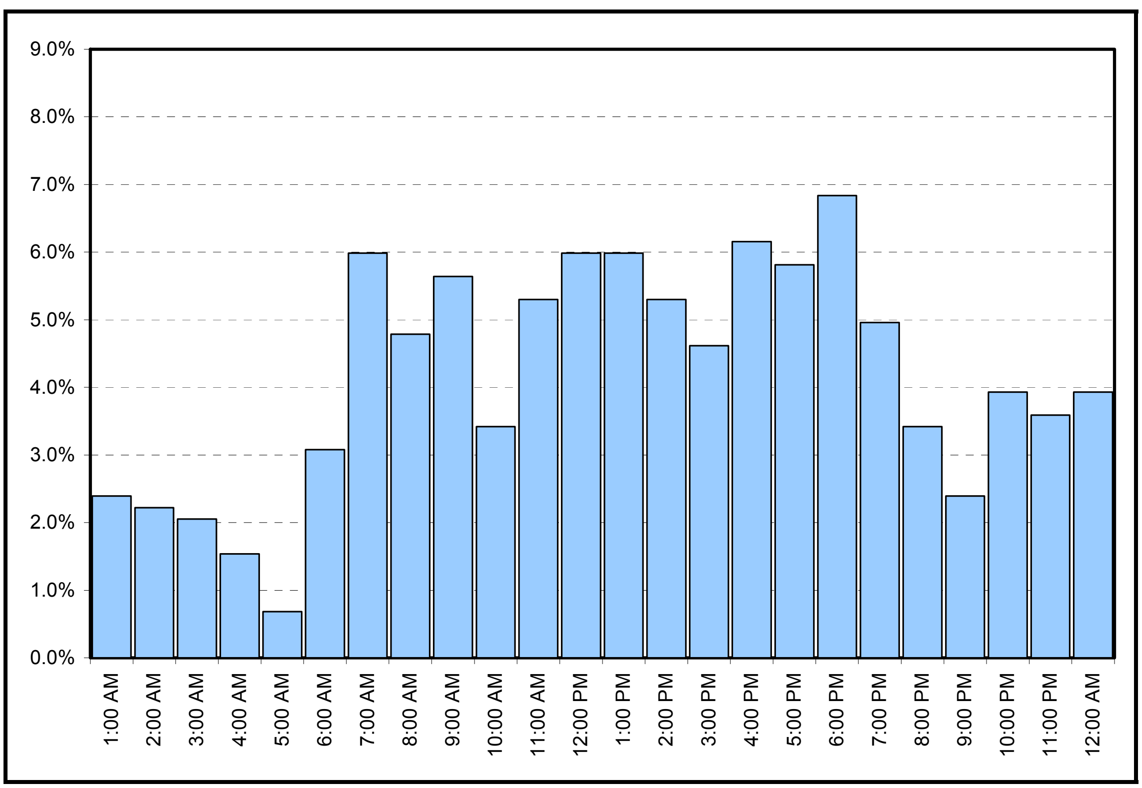


Figure 2.4: Temporal Distribution of CHP Incidents on I-710 Southbound

2.1.2 Freeway Service Patrol (FSP) Assisted Incidents

FSP-assisted incident data were provided by Metro FSP. On non-holiday weekdays, tow trucks rove I-710 on two FSP Beats (Beat #23 and #30), and, on average, assist 64 motorists/day [9].

- Three FSP tow trucks patrol Beat #23 during the AM and PM peak periods (6:00 – 10:00AM and 3:00 – 7:00PM) on non-holiday weekdays. Beat #23 covers an 8.9 miles stretch of I-710 between Firestone Boulevard and Valley Boulevard. One FSP tow truck provides service for Beat #23 during the midday (10:00AM to 3:00PM). On weekends and holidays, two FSP tow trucks provide assistance to motorists from 10:00AM to 6:30PM.
- FSP Beat #30 spans the 10.6 mile stretch of the I-710 between Willow Street and Firestone Boulevard. During the peak periods (6:00 – 10:00 AM and 3:00 – 7:00 PM) on non-holiday weekdays, four tow trucks rove Beat #30 providing assistance to motorist. No FSP assistance is provided on Beat #30 during the midday (10:00AM to 3:00PM) and on weekends/holidays.

At the time of an assist, the FSP tow truck drivers record the date, time of day, assist duration, incident description (e.g. traffic accident, flat tire, out-of-gas), and incident location (e.g. on- or off-ramp, left shoulder, right shoulder, in-lane). However, the FSP-assisted incidents are not recorded in sufficient detail to determine a specific location on the freeway (e.g. direction of travel is not recorded nor is Caltrans post-mile nor nearest cross-street). As such, the FSP-assists data were of limited use in correlating traffic delays to freeway incidents. Table 2.4 lists the FSP incident descriptions and the proportion of all FSP-assists that fall in the appropriate categories for FSP-assists occurring in April and May 2005 on I-710. Table 2.5 lists the FSP-assists by type of vehicle assisted. Table 2.6 lists the assists by location with respect to freeway geometry, e.g. "in-lane", "left shoulder". Figures 2.5 and 2.6 show the distributions of the durations of the FSP-assisted incidents and the motorist reported wait-times, respectively.

Table 2.4: FSP-Assists, Problem with Vehicle Assisted

Problem With Vehicle Assisted	Count	Percent
Out of Gas	346	14.1%
Over Heated	158	6.5%
Flat Tire	620	25.3%
Accident	218	8.9%
Electrical Problem	97	4.0%
Vehicle Fire	4	0.2%
Locked Out	2	0.1%
Abandoned	154	6.3%
Debris Removal	43	1.8%
Mechanical Problem	512	20.9%
Rollover	6	0.2%
Unknown/Other	286	11.7%
Total	2,446	100.0%

Table 2.5: FSP-Assists, Type of Vehicle Assisted

Type of Vehicle Assisted	Count	Percent
Auto	1,477	55.3%
Van	558	20.9%
Pickup	20	0.7%
Truck < 1 ton	411	15.4%
Truck > 1 ton	120	4.5%
Motorcycle	87	3.3%
Total	2,673	100.0%

Table 2.6: FSP-Assists, Assisted Vehicle Location

Vehicle Was Located	Count	Percent
In Fwy Lanes	209	7.8%
On Left Shoulder	84	3.1%
On Right Shoulder	2,071	77.5%
Ramp/Connect	266	10.0%
Other	19	0.7%
Unable to Locate	16	0.6%
In HOV Lane	4	0.1%
Check Call Box	2	0.1%
Total	2,671	100.0%

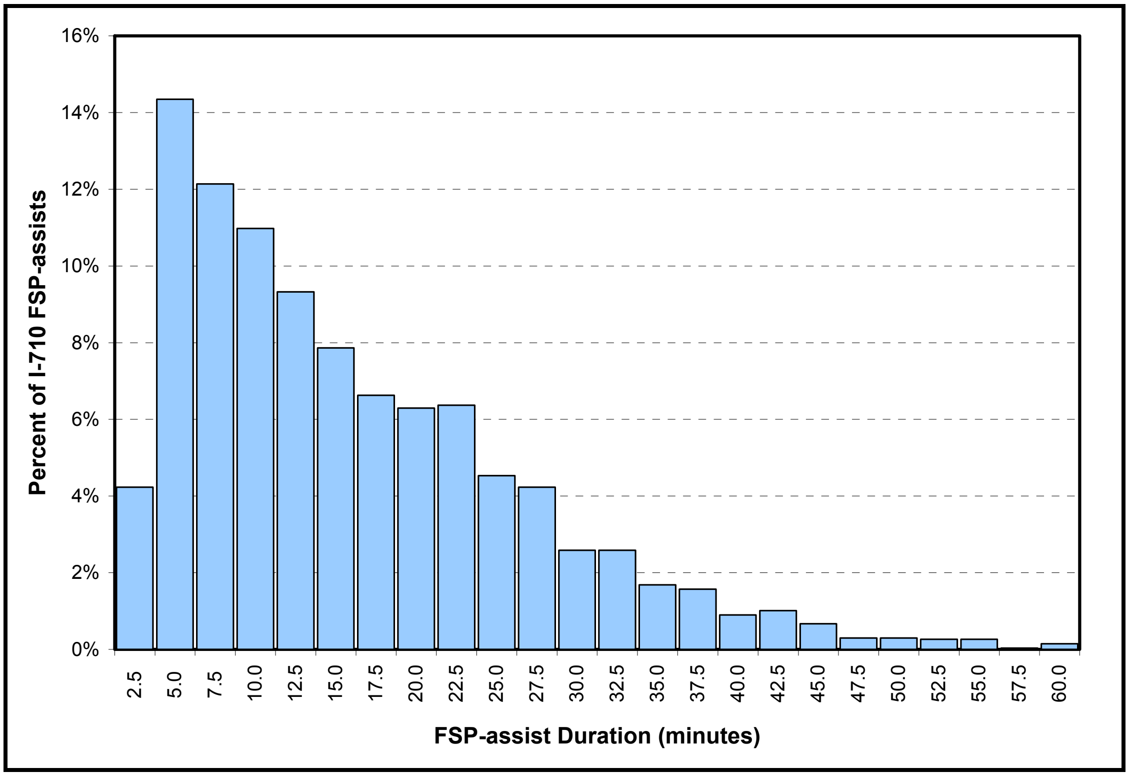


Figure 2.5: FSP-assist Durations

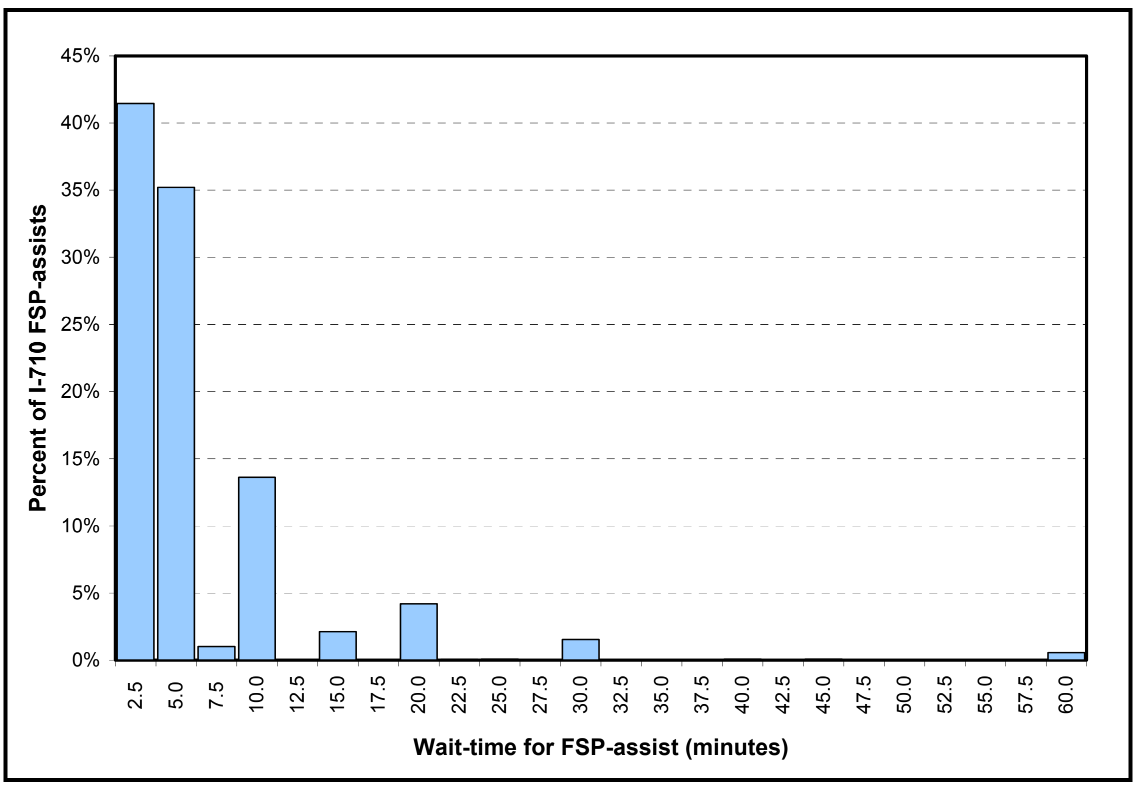


Figure 2.6: Motorist's Wait-times for FSP-assists

2.1.3 PeMS Archived CHP Incidents

The freeway Performance Measurement System (PeMS) is a real-time data archival system. It collects and stores loop detector data from all freeways in the State, about 2GB/data per day [10]. PeMS was jointly developed by Caltrans and the Partners for Advanced Transit and Highways (PATH) at the University of California, Berkeley. PeMS provides easy-to-access historical and real-time traffic data, and it is accessed via a standard Internet browser. PeMS contains several built-in analytical capabilities to support a variety of uses for managers, engineers, and planners, and provides traffic information to the public through Value Added Resellers [11].

PeMS also collects and stores incident data from the CHP incident web pages. PeMS has been collecting and archiving CHP incident data from the reports on their Traffic Incident Information Page (http://cad.chp.ca.gov/) since March 20, 2000. The CHP reported incidents archived in PeMS contain data on incident date and time, description, severity, location, and duration. There is one log entry each and every time an incident's status is updated by LACC. As such, major incidents may have multiple entries, e.g. one for when the incident is first called in, one for when a CHP officer arrives on the scene, one for when an ambulance arrives, etc.

There were 1,232 CHP loggings during April and May 2005 on Interstate 710. About 7% of the entries were incomplete, and did not contain direction of travel, post-mile, or adequate location description to match the incident to Caltrans post-miles. As such, 7% of the CHP incidents could not be mapped in the time-space plane to be matched to observed traffic delays. The other 93%, 1,143 of the 1,232 logged incident entries contained sufficient information to be located.

Even though, the official Pre-Demonstration data collection period was April – May 2005, a larger sample (January – June 2005) was used to create incident density plots and to obtain descriptive summary statistics. Larger samples produce more reliable estimators of incident densities, incident frequencies, and more reliable distributions (i.e. histograms) of incident durations. Bubble plots showing incidents in the time-space plane are shown in Figures 2.7 and 2.8 for the I-710 Northbound and Southbound direction, respectively. The bubble size is correlated to incident durations; longer lasting incidents are depicted as larger bubbles. The largest bubble shown on Figure 2.7 is for an incident lasting 960 minutes (16 hrs). Likewise, the longest lasting southbound incident plotted was 680 minutes.

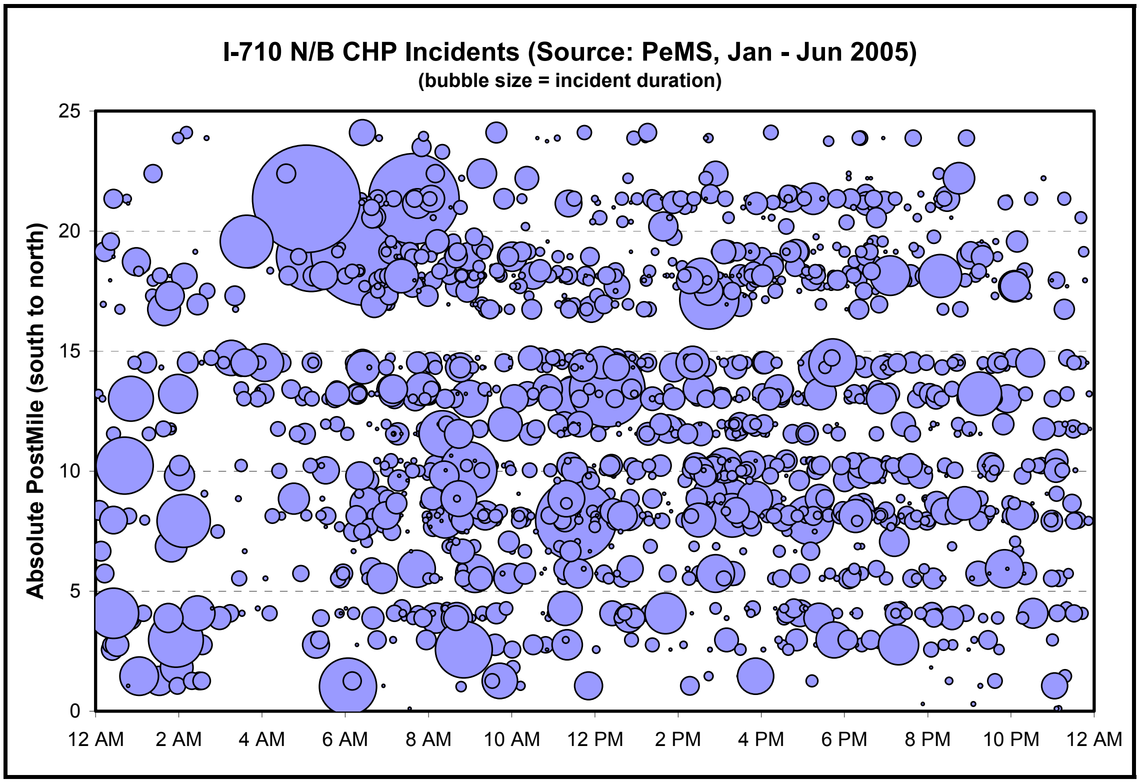


Figure 2.7: Spatial Distribution of CHP Incidents on I-710 Northbound

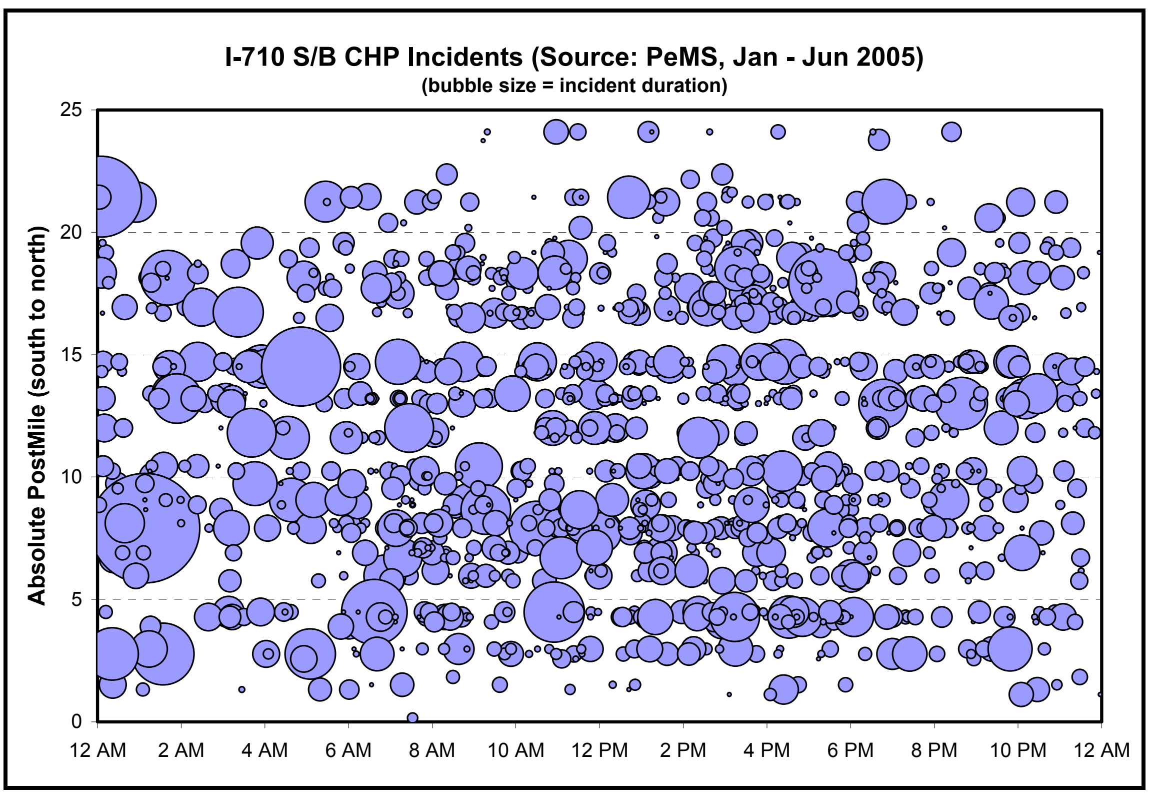


Figure 2.8: Spatial Distribution of CHP Incidents on I-710 Southbound

2.2 DATA ON TRAFFIC CONDITIONS

Vehicular speed and flow data were extracted from PeMS and analyzed for April – May 2005, separately for the I-710 northbound and southbound traffic. There were 42 non-holiday weekdays in April and May 2005, 21 in April and 21 in May. For the weekend/holiday analyses, 19 weekend & holiday days were used (9 in April and 10 in May). The Caltrans vehicle detector locations for Interstate 710 Northbound are shown in Figure 2.9(a). Figure 2.9(b) shows the same for I-710 Southbound. On average, traffic flows were the highest on Fridays and lowest on Sundays. Table 2.7 lists the average daily traffic observed on I-710 by weekday. Using the detector data, the basic performance measures, vehicle miles of travel (VMT), vehicle-hours-of-travel (VHT) and vehicle hours of delay were estimated.

Table 2.7: Average Daily Travel on Interstate 710

Day of Week	Northbound	Southbound
Monday	88,129	85,497
Tuesday	91,319	88,243
Wednesday	92,772	86,928
Thursday	93,213	88,075
Friday	98,057	91,198
Saturday	72,103	68,661
Sunday	58,904	53,913
Weekday Avg	92,698	87,988

Figures 2.10 and 2.11 display the time-of-day traffic flow profiles for northbound I-710 traffic flows measured on weekdays near Martin Luther King Junior (MLK) and Firestone Boulevards. Figures 2.12 and 2.13 show the same weekday traffic flow profiles measured for southbound I-710 near Imperial Highway and Olympic Boulevard. Saturday's time-of-day flow traffic profiles are shown in Figures 2.14 and 2.15 for I-710 northbound near MLK and Firestone Boulevard. Figures 2.16 and 2.17 show Saturday's time-of-day flow traffic profiles for southbound near Imperial Highway and Olympic Boulevard. Figures 2.18 through 2.21 display Sunday's time-of-day profiles on the same four locations. These traffic flow profiles clearly show the variations in the observed traffic flows by direction, time-of-day, and by location along the freeway. A part of the observed variations is due to incidents. Other contributing factors to the variations in traffic flows and speeds are weather (i.e. fog, rain), random variations in travel demand, and construction related lane closures, etc.

From the recorded traffic speeds archived in PeMS, I-710 travel-times (in minutes) were estimated. Figures 2.22 thru 2.27 display the I-710 travel-times. Northbound and southbound travel-times are shown in separate plots for the non-holiday weekdays, Saturdays, and Sundays, created using the April – May 2005 data. Combining traffic speed (or travel-times) with measured vehicular flows, produces VMT, VHT and delay estimates. The average VMT by day-of-week are displayed in Figure 2.28. Figures 2.29 and 2.30 show the daily VMT and VHT for April and May 2005 for traffic observed on I-710.

Post mile	Vds_id	Cross street name
6.04	717962	DEL AMO 2
7.17	717966	LONG BEACH
8.33	717968	ATLANTIC
9.14	761734	ALONDRA
9.42	718488	COMPTON
9.94	717770	ROSECRANS 1
10.14	718102	ROSECRANS 2
10.34	718492	S OF 105
10.94	717977	KING 1
11.14	717660 716856	FM RT 105
11.54	716857	KING 2
11.90	718151	IMPERIAL 1
12.05	717983	IMPERIAL 2

Direction of traffic

Post mile	Vds_id	Cross street name
13.42	717992	FIRESTONE 1
13.51	717995	FIRESTONE 2
14.76	718147	FLORENCE 2
17.14	718320	ATLANTIC 2
17.15	718010	WASHINGTON
18.16	763468	S OF 5
18.50	718014	OLYMPIC
18.58	765597	
19.43	718016	THIRD

Direction of traffic

Figure 2.9(a): Caltrans Vehicle Detector Locations on I-710 Northbound

Post mile	Vds_id	Cross street name
	717960	DEL AMO
6.93	717963	LONG BEACH
8.15	716847	N OF 91
8.87	717970	ALONDRA
9.42	761851	COMPTON
9.77	717975	ROSECRANS 1
10.05	717972	ROSECRANS 2
10.29	761761 717960	FM RTE 105
10.34	718493	S OF 105
10.94	717978	KING 1
11.92	717980 717979	IMPERIAL 1
11.98	761776	IMPERIAL 2

Direction of traffic ↑

Post mile	Vds_id	Cross street name
13.42	717986	FIRESTONE 1
13.51	717989	FIRESTONE 2
14.59	718002	FLORENCE 2
16.88	718008	ATLANTIC 2
17.53	718012	WASHINGTON
18.16	716891	S OF 5
18.47	718321	OLYMPIC
18.50	718285	OLYMPIC BLVD
18.71	716875 716876	EASTERN
19.54	718017	THIRD
19.89	718018	BROOKLYN

Direction of traffic ↑

Figure 2.9(b): Caltrans Vehicle Detector Locations on I-710 Southbound

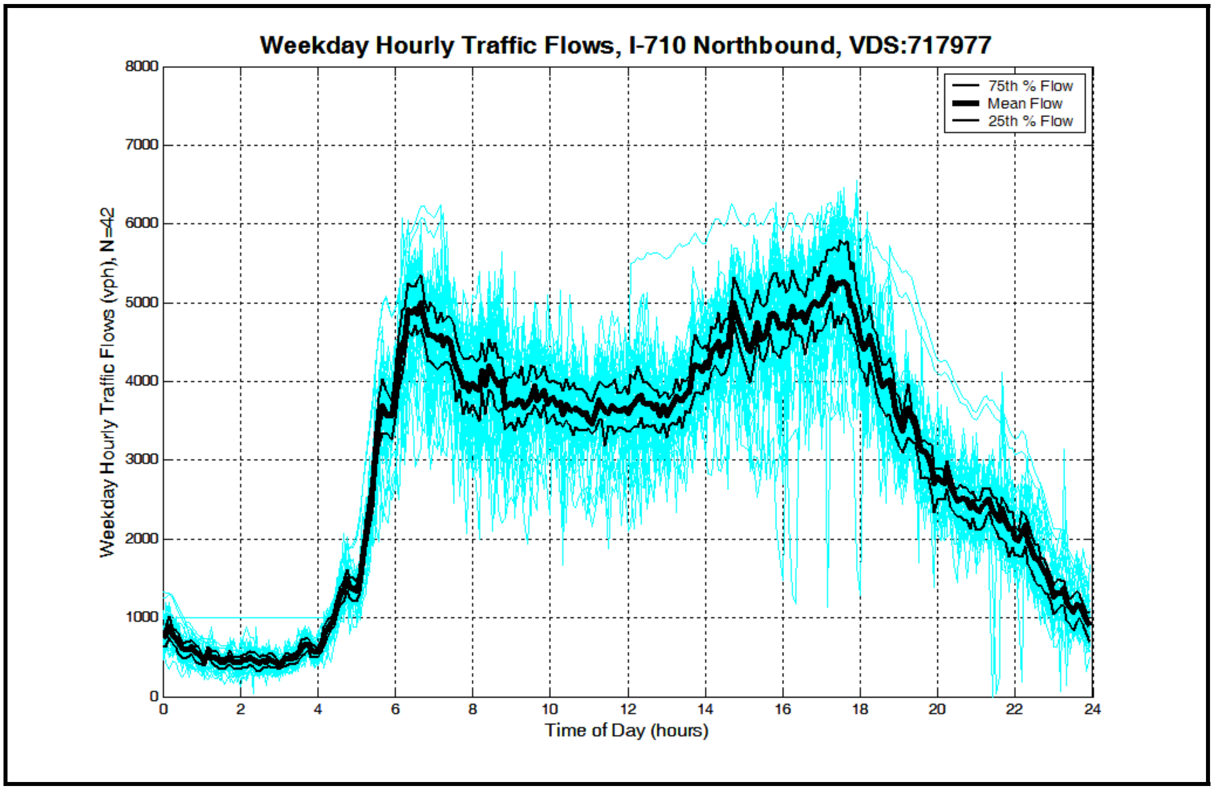


Figure 2.10: Weekday Hourly Vehicle Flows I-710 North near MLK Blvd. in LA

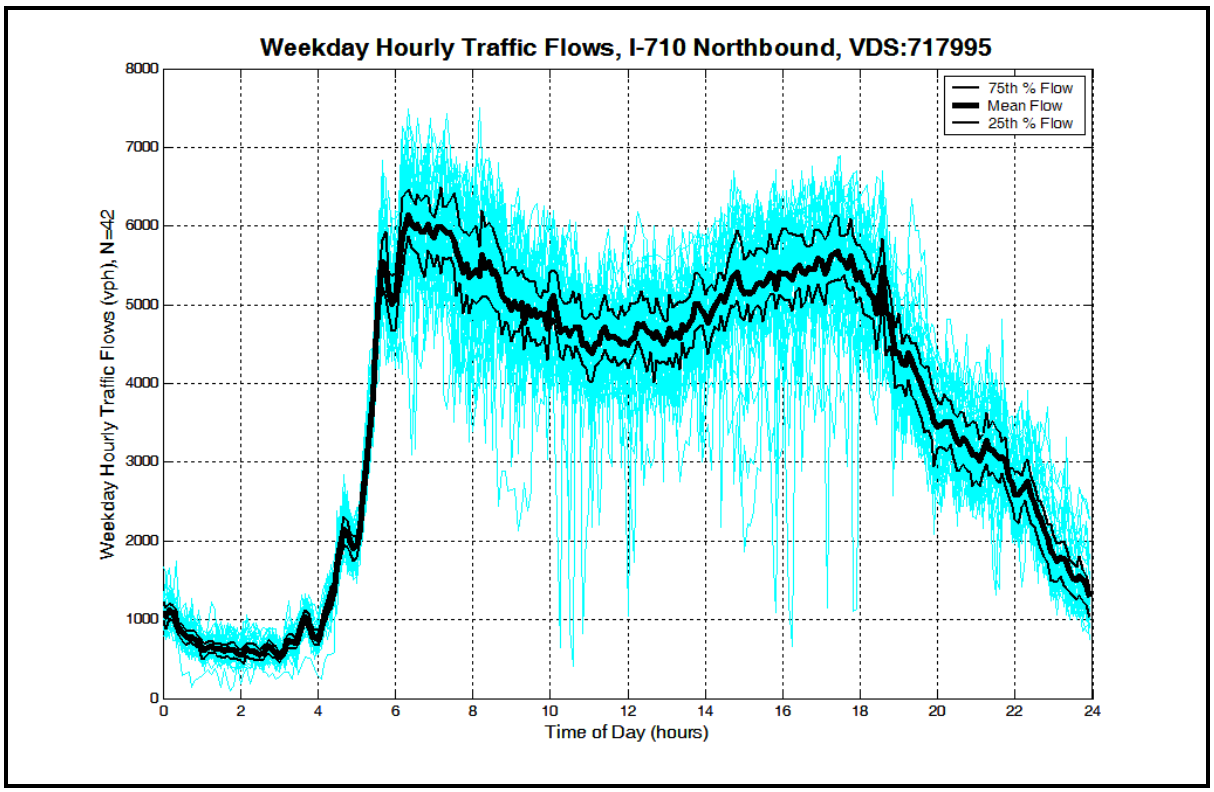


Figure 2.11: Weekday Hourly Vehicle Flows I-710 North near Firestone Blvd. in LA

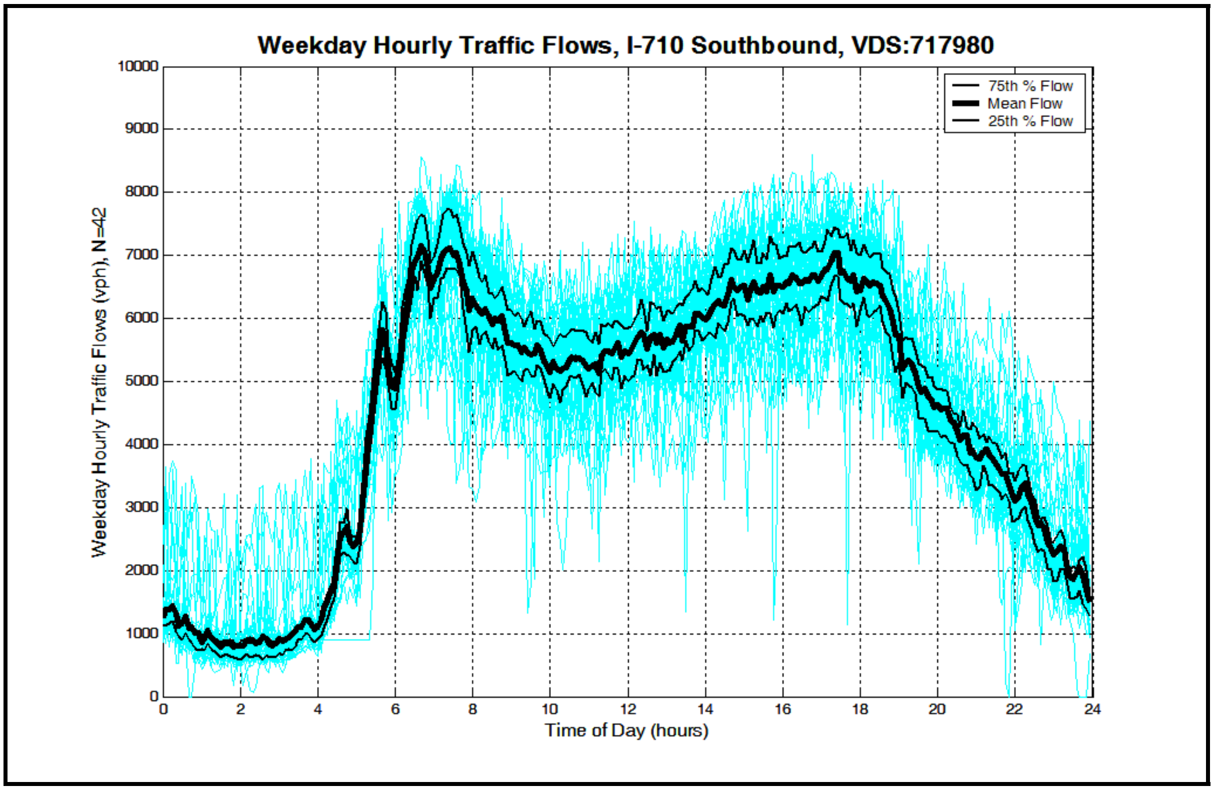


Figure 2.12: Weekday Hourly Vehicle Flows I-710 South near Imperial Hwy in LA

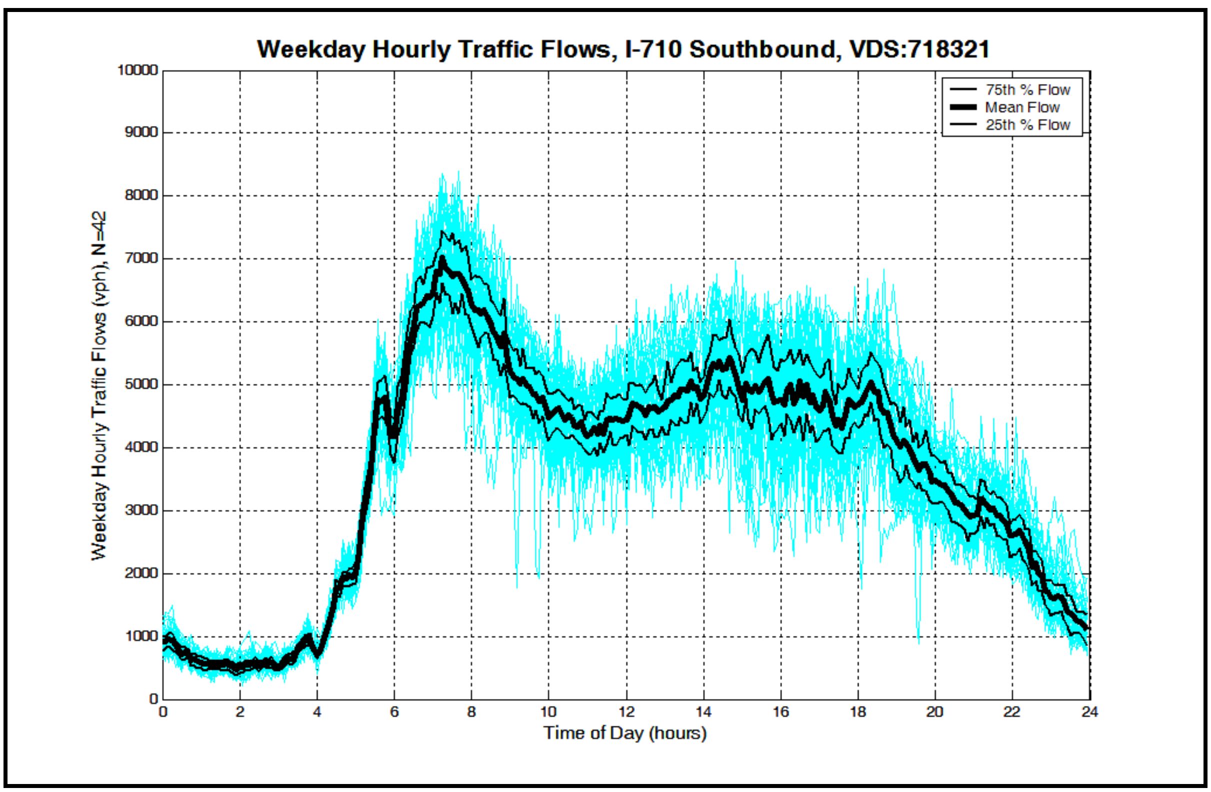


Figure 2.13: Weekday Hourly Vehicle Flows I-710 South near Olympic Blvd. in LA

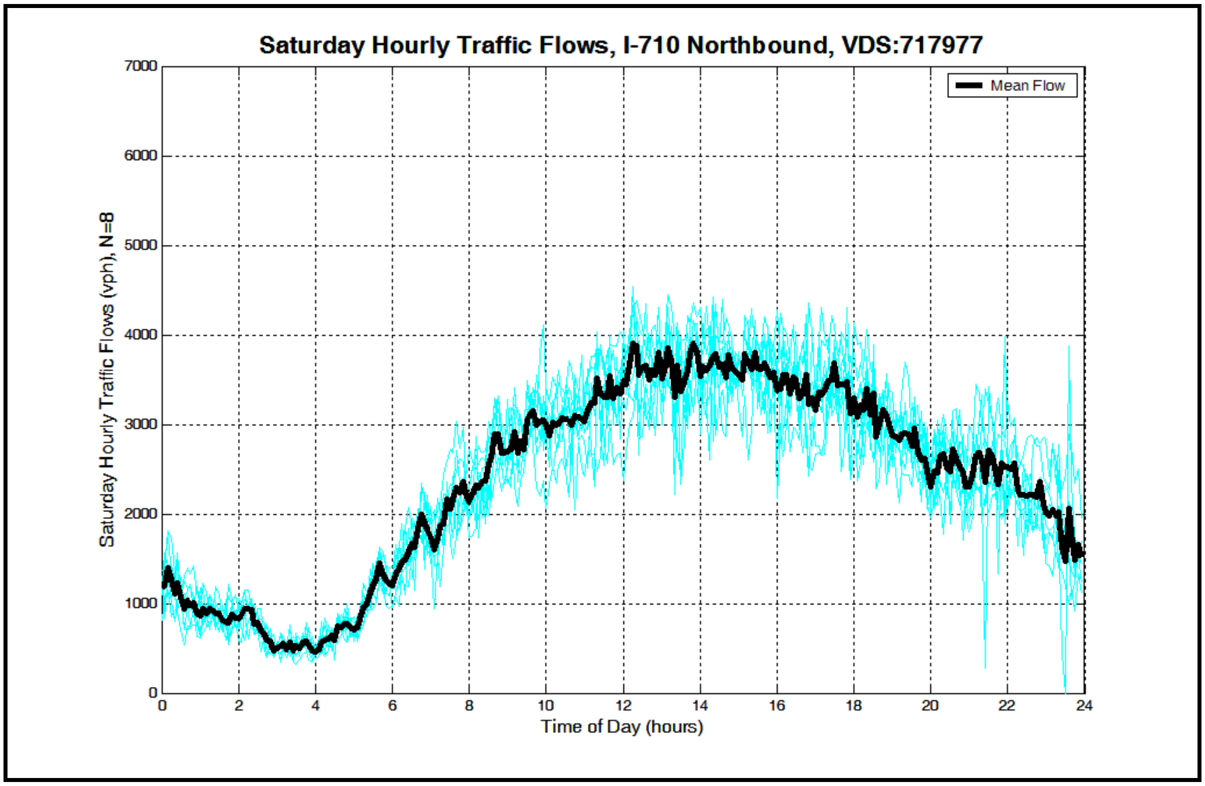


Figure 2.14: Saturday Hourly Vehicle Flows I-710 North near MLK Blvd. in LA

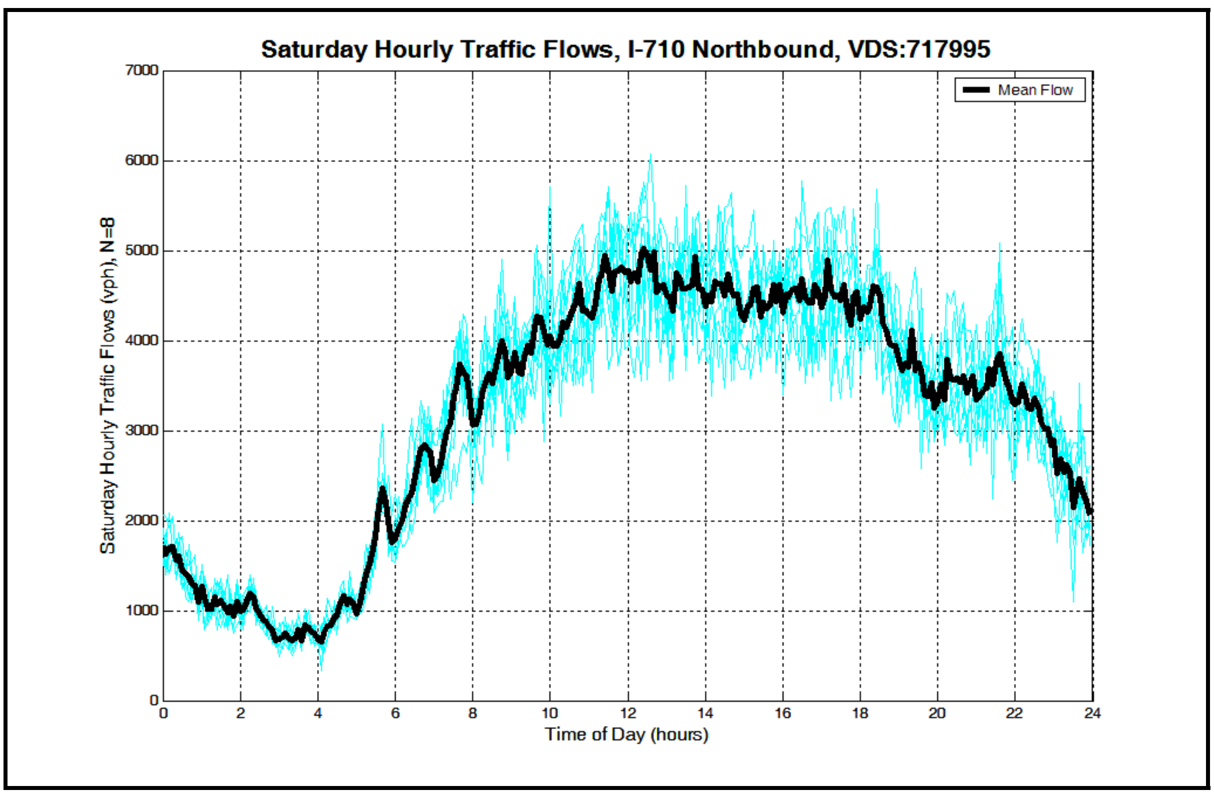


Figure 2.15: Saturday Hourly Vehicle Flows I-710 North near Firestone Blvd. in LA

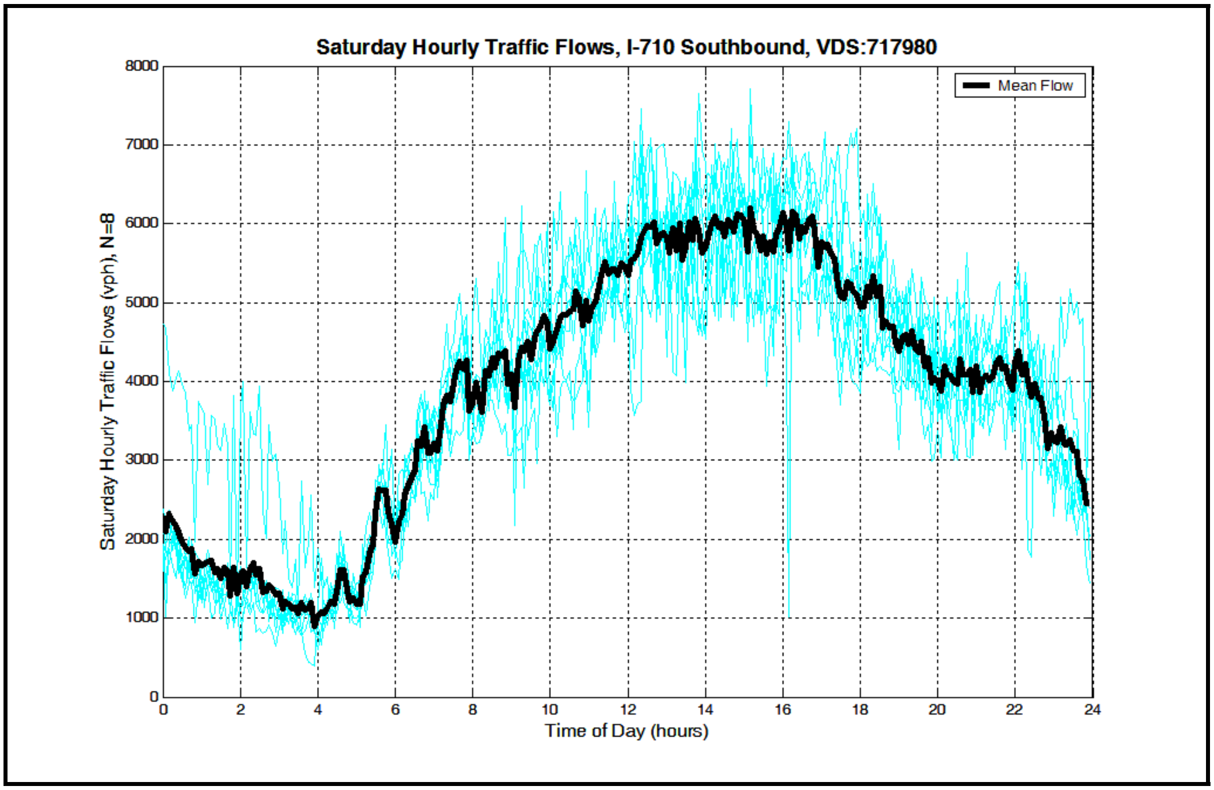


Figure 2.16: Saturday Hourly Vehicle Flows I-710 South near Imperial Hwy in LA

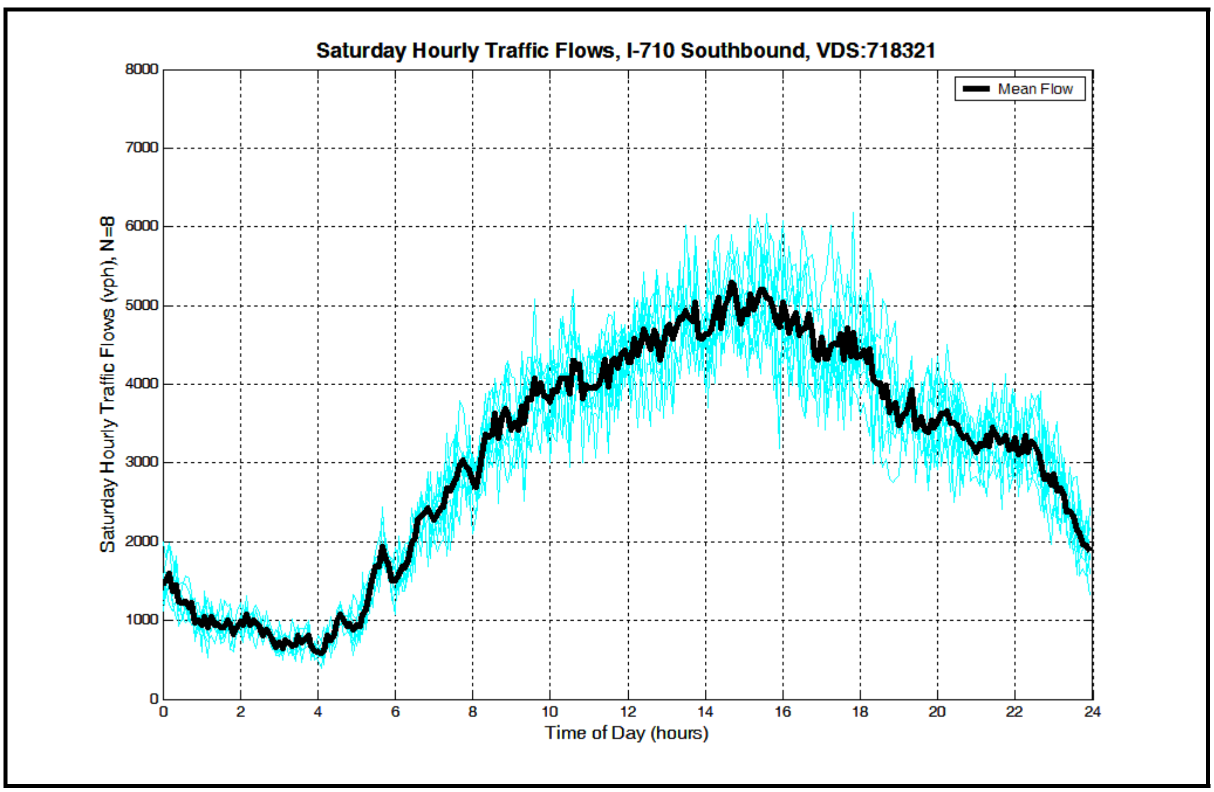


Figure 2.17: Saturday Hourly Vehicle Flows I-710 South near Olympic Blvd. in LA

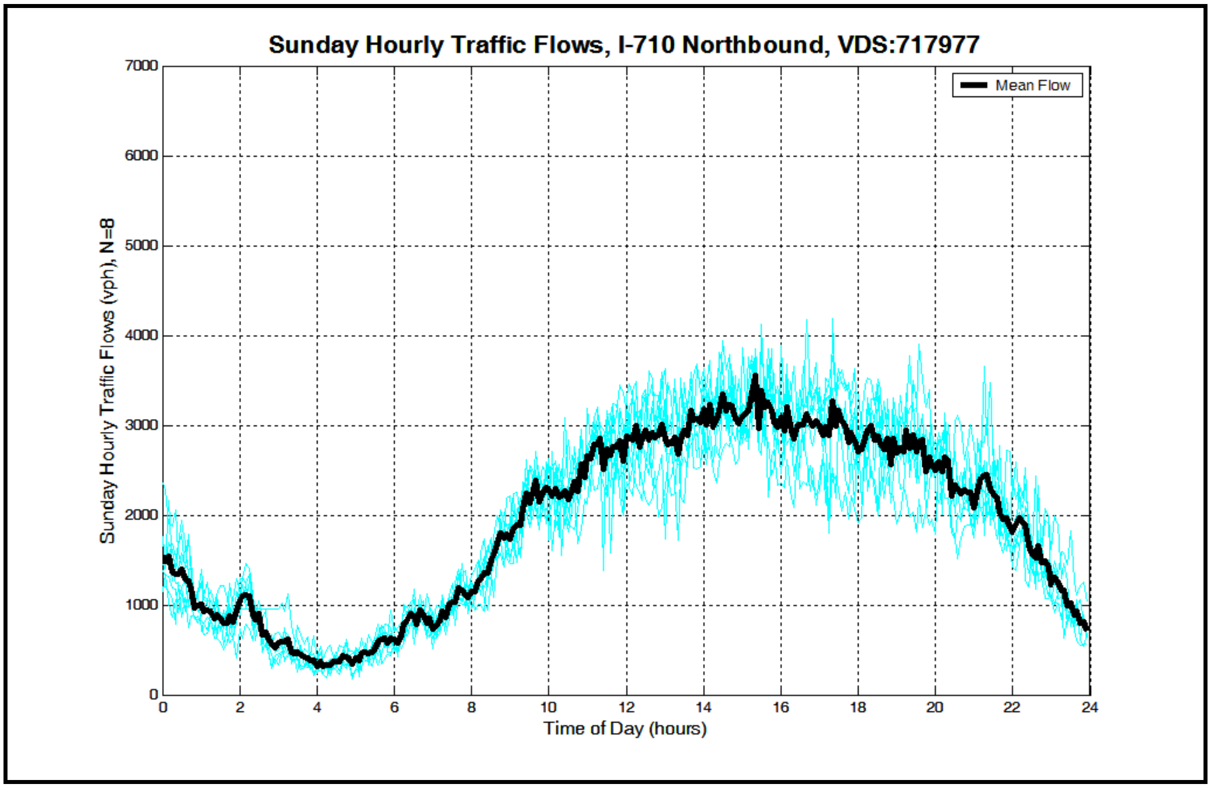


Figure 2.18: Sunday Hourly Vehicle Flows I-710 North near MLK Blvd. in LA

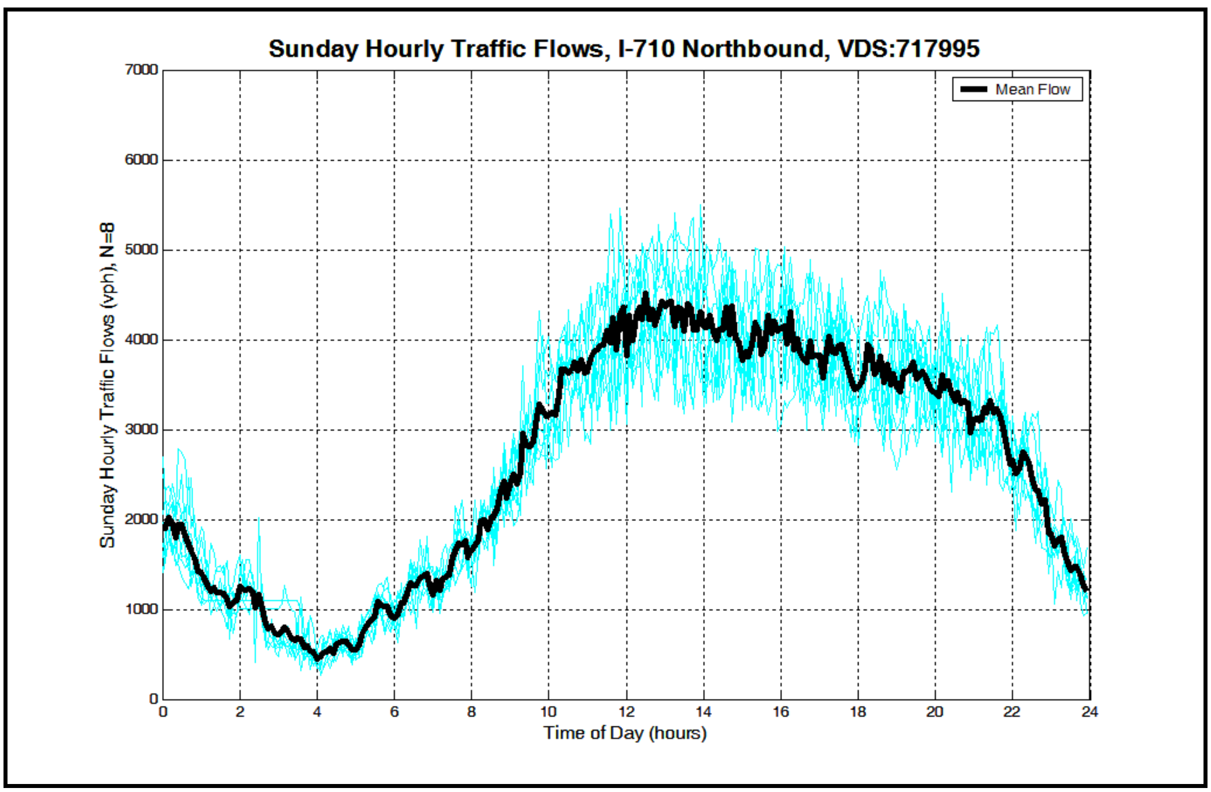


Figure 2.19: Sunday Hourly Vehicle Flows I-710 North near Firestone Blvd. in LA

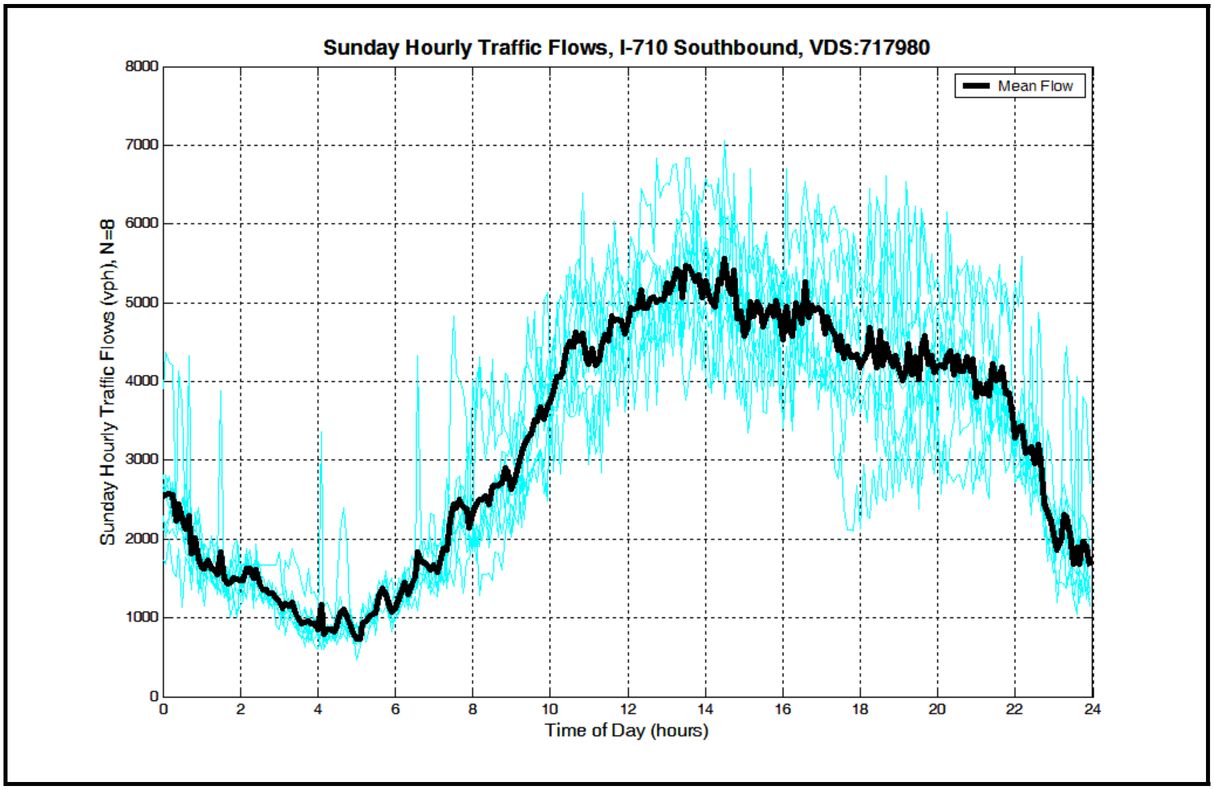


Figure 2.20: Sunday Hourly Vehicle Flows I-710 South near Imperial Hwy in LA

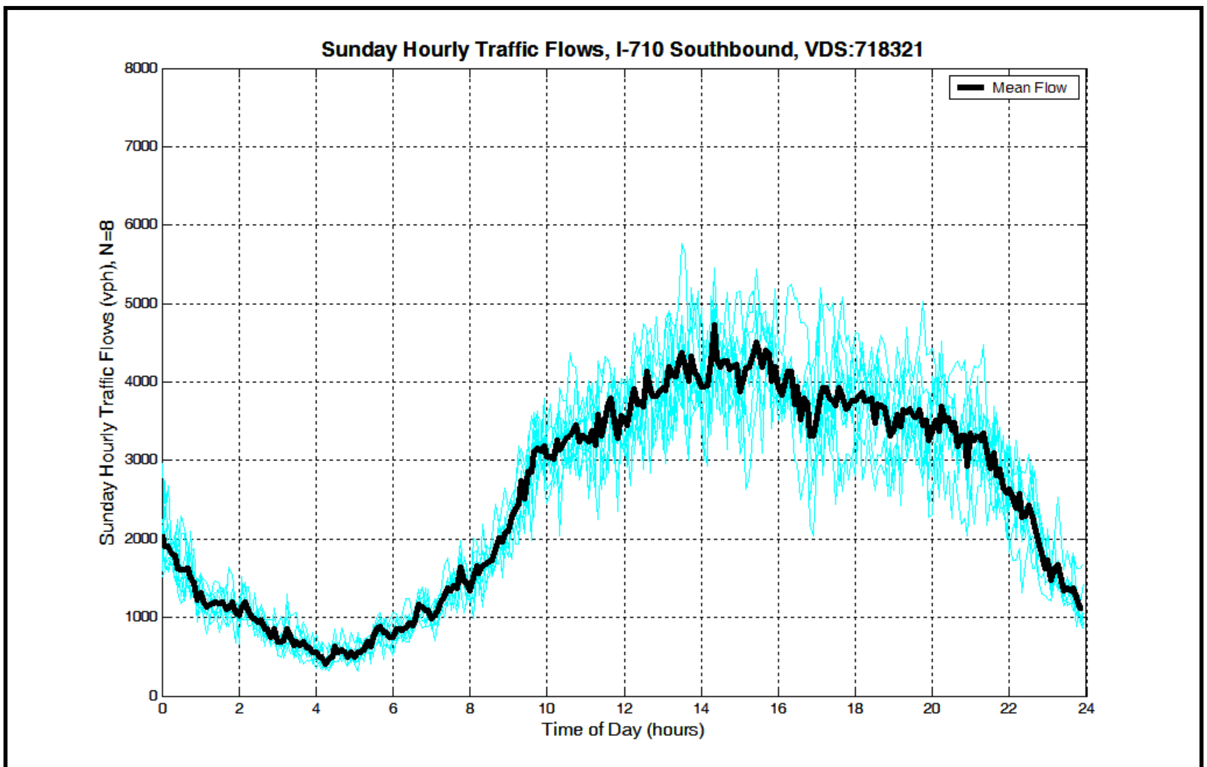


Figure 2.21: Sunday Hourly Vehicle Flows I-710 South near Olympic Blvd. in LA

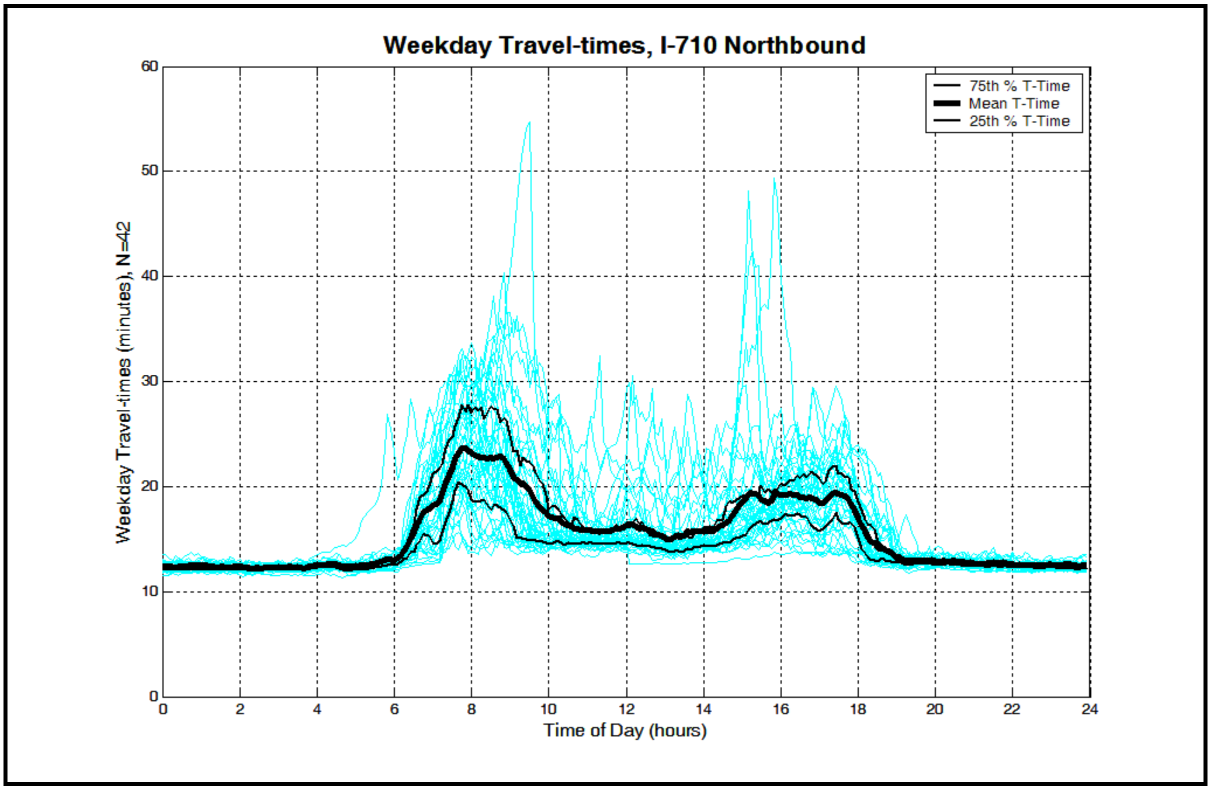


Figure 2.22: Northbound Weekday Travel-times through I-710

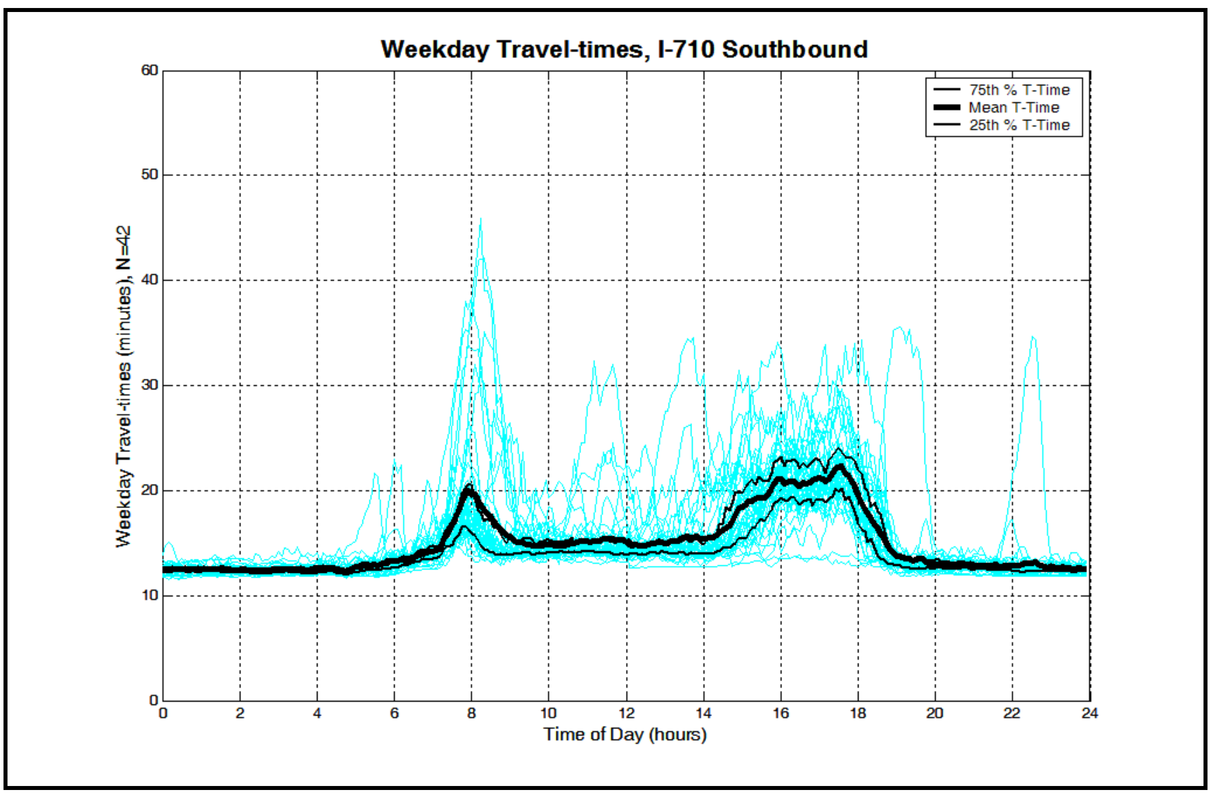


Figure 2.23: Southbound Weekday Travel-times through I-710

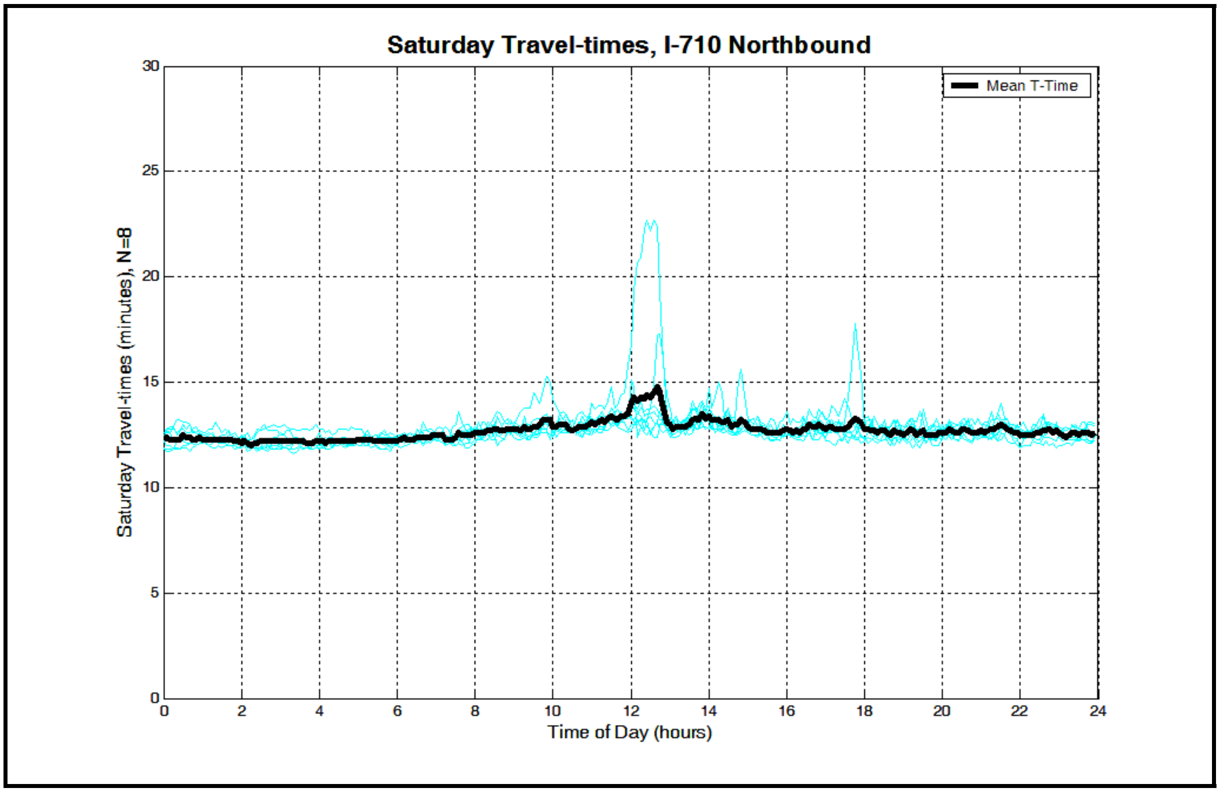


Figure 2.24: Northbound Saturday Travel-times through I-710

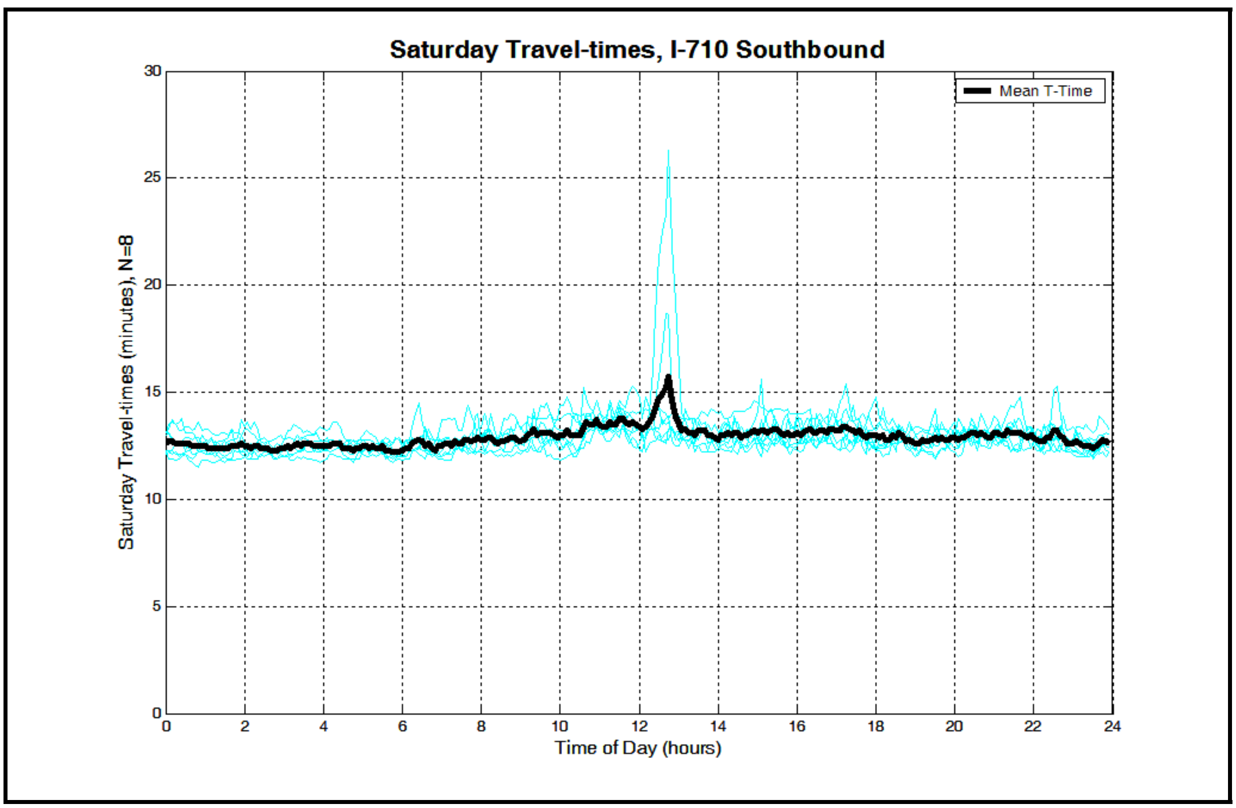


Figure 2.25: Southbound Saturday Travel-times through I-710

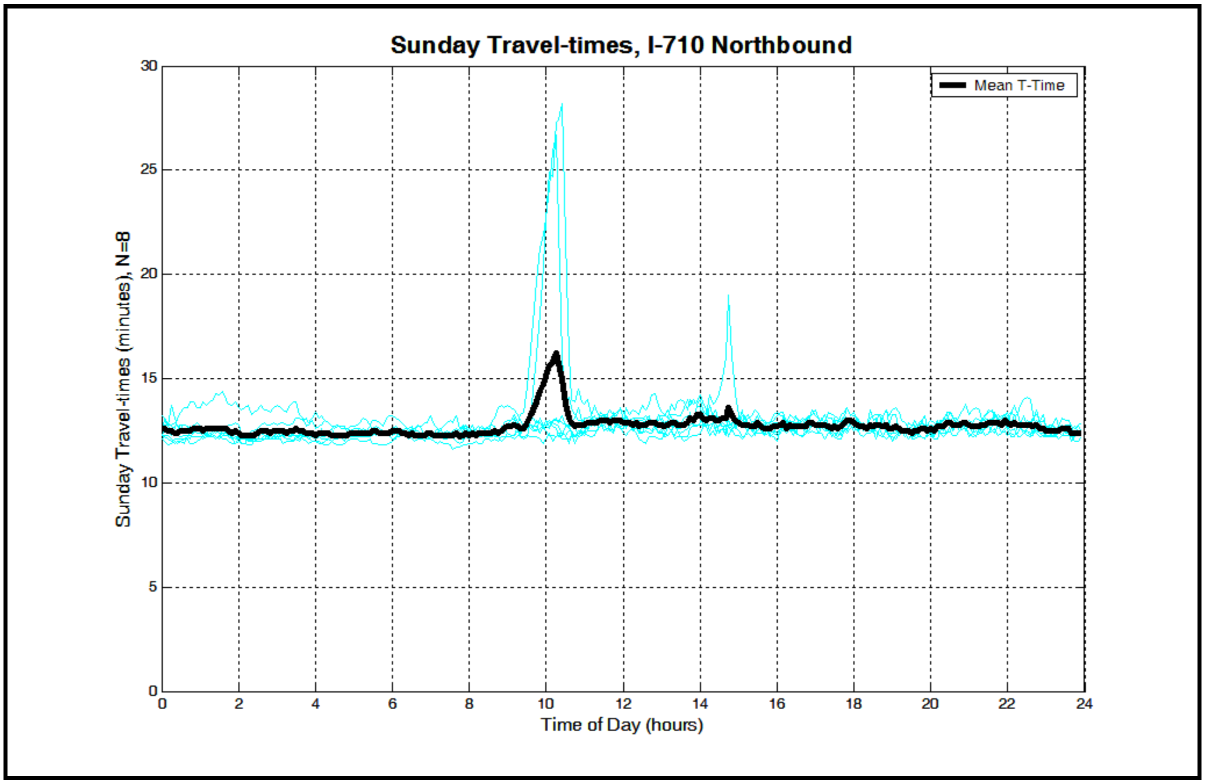


Figure 2.26: Northbound Sunday Travel-times through I-710

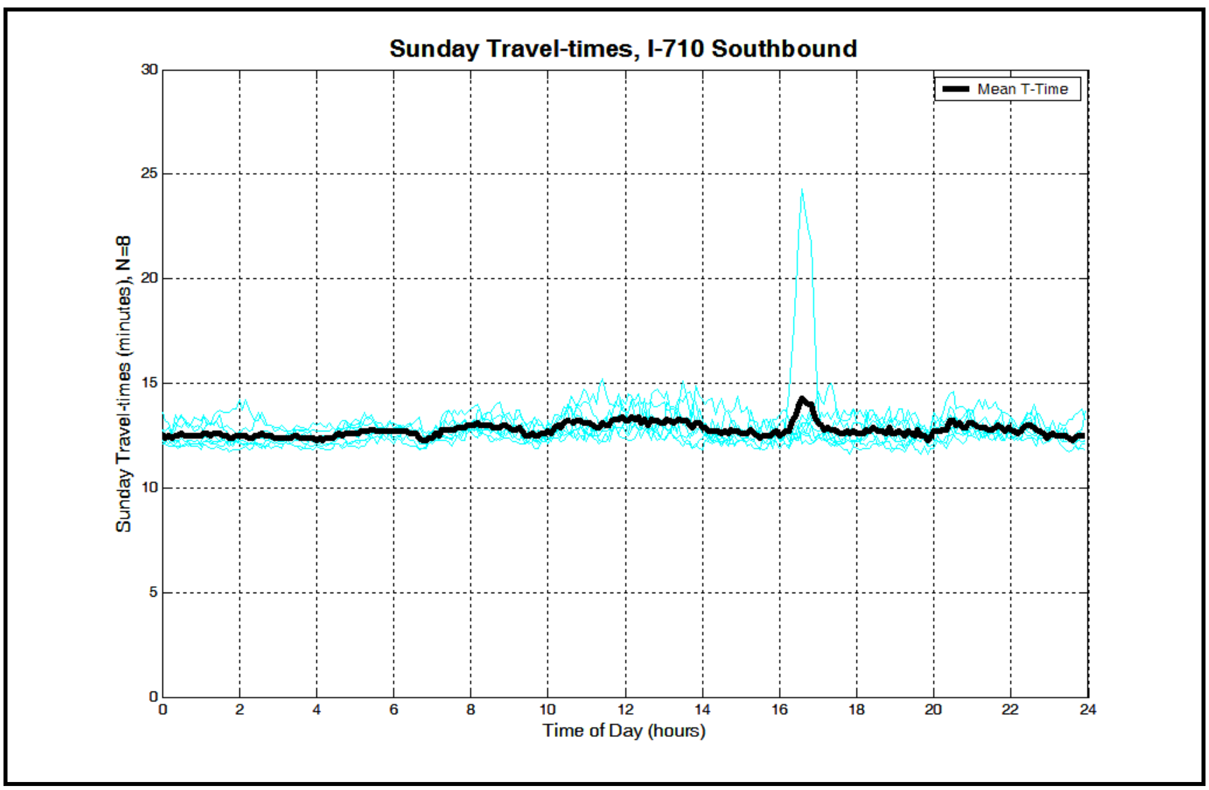


Figure 2.27: Southbound Sunday Travel-times through I-710

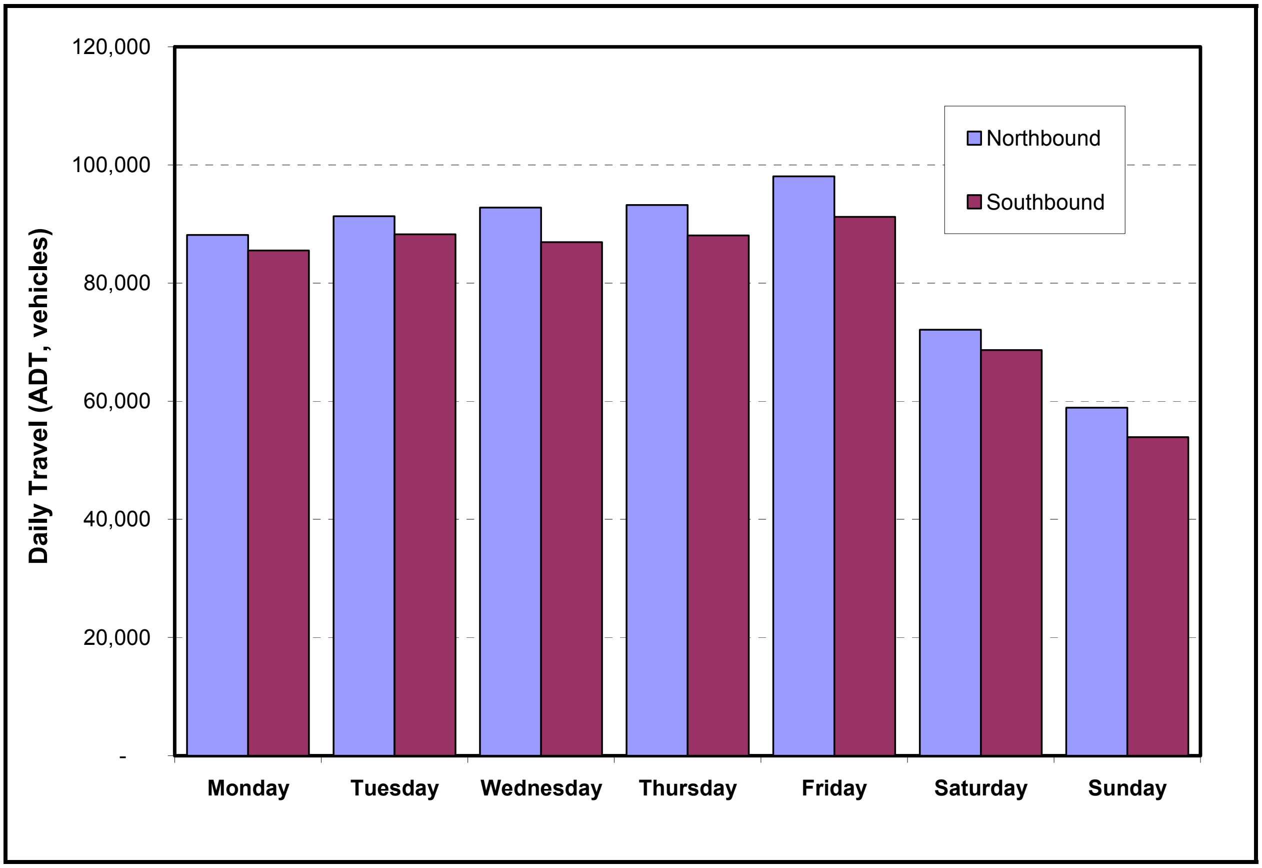


Figure 2.28: Vehicle Miles of Travel (VMT) on I-710

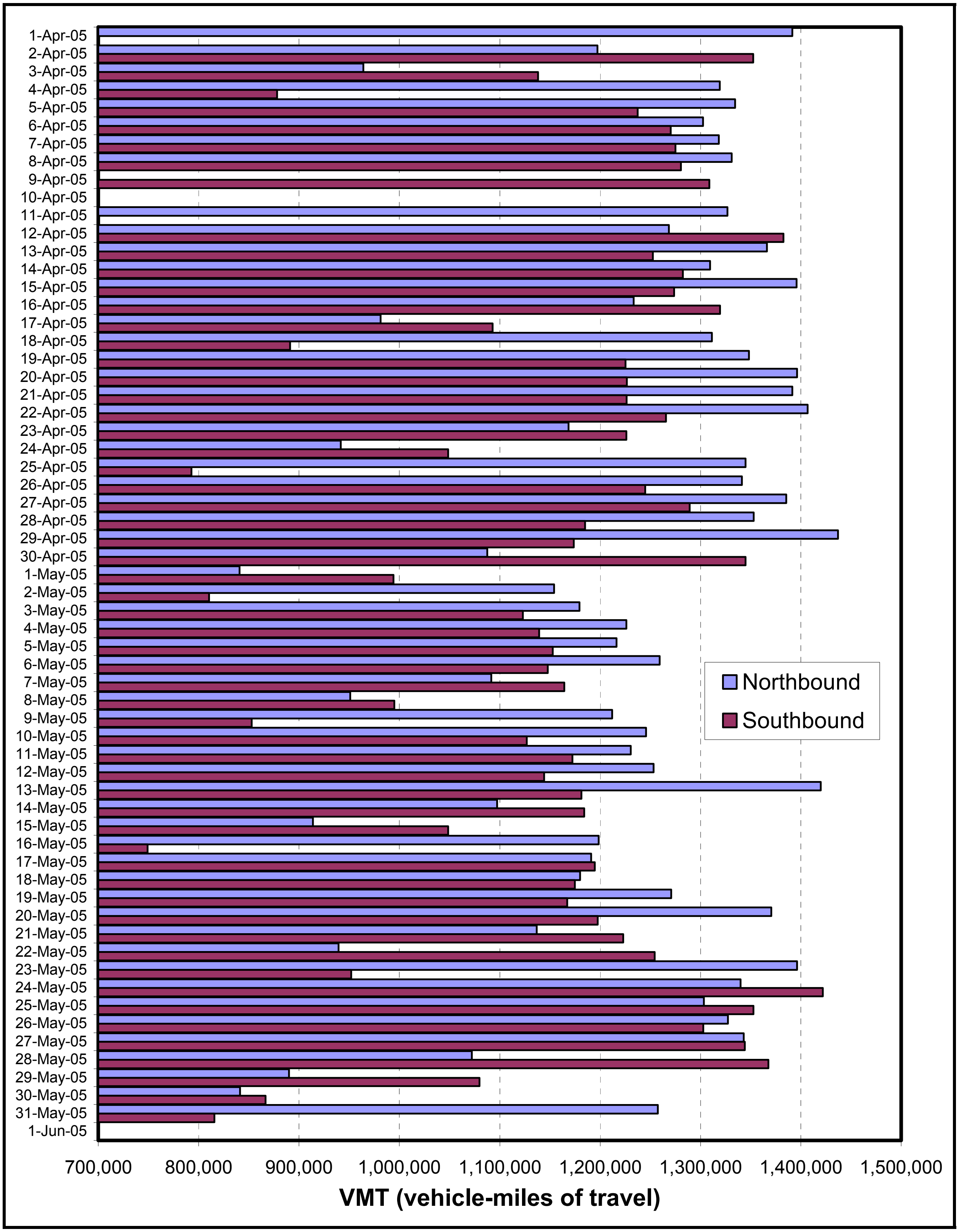


Figure 2.29: Vehicle Miles of Travel (VMT) on I-710

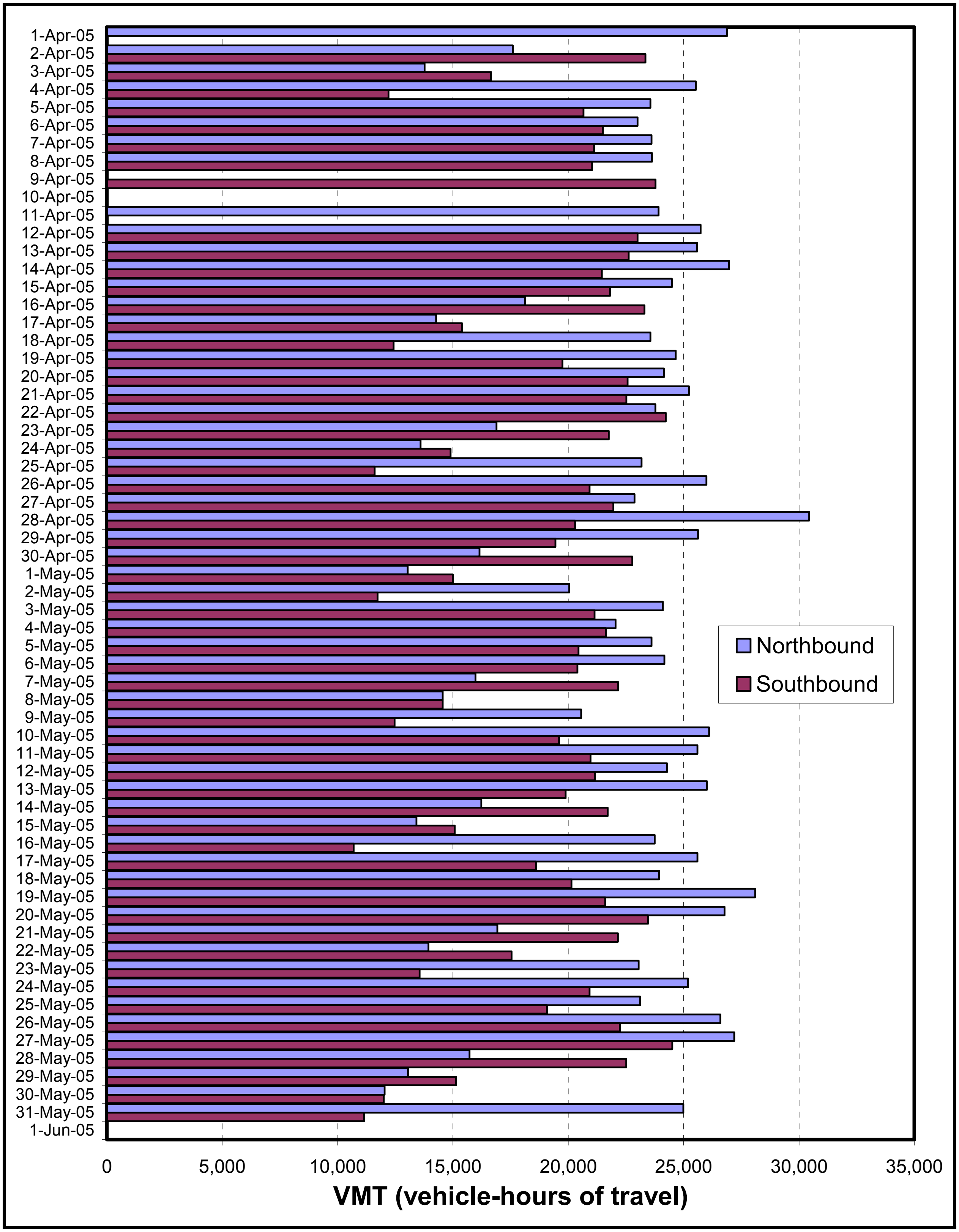


Figure 2.30: Vehicle Hours of Travel (VHT) on I-710

CHAPTER 3
EVALUATION

3.1 RESEARCH APPROACH

The FSP I-710 Big-rig Demonstration Program's evaluation consists of three main phases:

1) Conduct technical analyses to evaluate the effectiveness of the FSP big-rig demonstration, based on reductions in response times, incident delay savings, and benefit/cost ratio, based on empirical data on incident patterns and freeway operating conditions. The evaluation will be performed in three phases as described in Section 1.4 of the report:
    a) Pre-demonstration evaluation,
    b) Mid-demonstration evaluation, and
    c) Post-demonstration evaluation.

2) Collect and process traffic data, big-rig incident data, and FSP assist data throughout the duration of the Big-rig FSP demonstration project.

3) Assess the effectiveness of the I-710 Big-rig demonstration to determine whether this strategy would be effective on other heavily truck traveled freeway corridors. Identify and recommend modifications for improvement of FSP big-rig service, and develop implementation guidelines.

3.2 BIG-RIG INCIDENTS

Viewing the temporal distributions of big-rig incidents provide valuable information as to when big-rig incidents tend to occur, which can be used as a decision making tool for determining the Big-rig FSP hours of operation. During the 42 workdays in April and May 2005, CHP logged 102 big-rig incidents on I-710, 69 of which were also coded as "lane blocking". This equates to 2.4 big-rig incidents per workday, and 1.5 lane-blocking big-rig incidents per day. Table 3.1 lists big-rig incidents, and big-rig incidents that were coded as "lane blocking" estimated for an average workday from the I-710 April & May 2005 CHP logged incidents. Figure 3.1 displays the temporal distributions along with average workday VMT for I-710.

The relation between big-rig incidents and VMT is relatively weak, yet it is reasonable to expect a correlation between VMT and total incidents. The plausible lack of this expected relation is in the details. The VMT in Figure 3.1 is the vehicle miles of travel for all vehicles (e.g. autos, vans, busses, and trucks) while the incidents displayed are only big-rig incidents. The correlation between VMT and incidents would probably be much stronger if big-rig truck VMT data were available and plotted against big-rig incidents. Unfortunately, big-rig (or truck) count data were not available in sufficient detail to obtain reliable truck-VMT estimates.

Table 3.2 shows the CHP logged incidents by day-of-week. There were only eight big-rig incidents on weekends, indicating that weekend big-rig FSP service might not be cost-effective. Therefore, for the pre-demonstration Big-rig FSP evaluation, delay estimation was conducted only for non-holiday weekdays; weekend/holiday evaluations were not performed.

Table 3.1: Big-rig Incidents Vs Time-of-day (Average Workday)

Average April-May 2005 Workday, Big-rig Incidents		
Time-of-Day	CHP/LACC Incidents (count)	Average Duration (minutes)
Midnight - 1 AM	-	-
1 - 2 AM	0.02	398.0
2 - 3	0.05	386.5
3 - 4	0.05	224.0
4 - 5	-	-
5 - 6	0.02	57.0
6 - 7	-	-
7 - 8	0.02	1,422.0
8 - 9	0.02	50.0
9 - 10	0.07	1,258.3
10 - 11	0.19	209.8
11 - Noon	0.21	174.4
Noon - 1PM	0.24	311.9
1 - 2 PM	0.21	172.2
2 - 3	0.21	39.0
3 - 4	0.33	83.1
4 - 5	0.33	281.9
5 - 6	0.17	148.6
6 - 7	0.07	22.3
7 - 8	0.07	581.7
8 - 9	-	-
9 - 10	0.02	106.0
10 - 11	0.07	465.7
11 - Midnight	0.02	89.0
Total:	2.4	
Average:		242.6

Average April-May 2005 Workday, Big-rig & Lanes-Blocked Incidents		
Time-of-Day	CHP/LACC Incidents (count)	Average Duration (minutes)
Midnight - 1 AM	-	-
1 - 2 AM	-	-
2 - 3	0.05	386.5
3 - 4	0.02	151.0
4 - 5	-	-
5 - 6	0.02	57.0
6 - 7	-	-
7 - 8	0.02	1,422.0
8 - 9	-	-
9 - 10	0.07	1,258.3
10 - 11	0.07	56.3
11 - Noon	0.12	80.8
Noon - 1PM	0.12	337.6
1 - 2 PM	0.19	187.9
2 - 3	0.12	44.2
3 - 4	0.17	143.1
4 - 5	0.24	382.9
5 - 6	0.10	226.3
6 - 7	0.05	23.0
7 - 8	0.07	581.7
8 - 9	-	-
9 - 10	0.02	106.0
10 - 11	0.05	342.5
11 - Midnight	0.02	89.0
Total:	1.52	
Average:		290.2

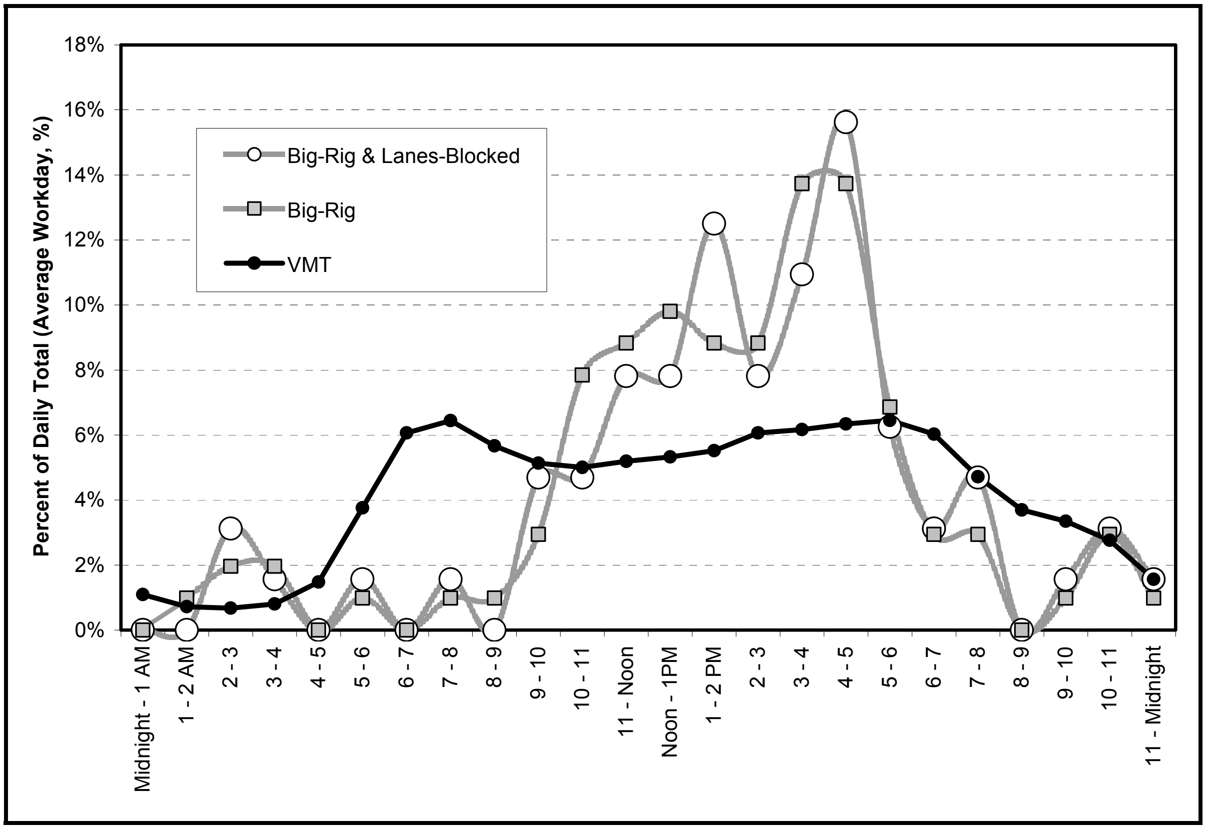


Figure 3.1: I-710 Big-rig Incidents and VMT

Table 3.2: CHP Logged Incidents by Day-of Week (I-710, April and May 2005)

Day of Week	CHP Incidents	CHP Big-rig Incidents
Monday	102	13
Tuesday	103	19
Wednesday	90	18
Thursday	108	25
Friday	111	27
Saturday	72	3
Sunday	67	5

The incident's locations were matched to the Caltrans post-miles to facilitate the analysis of the impacts of incidents with respect to their location along I-710. Figure 3.2 displays the relative frequency (as a percent of all big-rig incidents) with respect to Caltrans post miles. The table included with Figure 3.2 lists several arterial streets and their respective Caltrans post-mile location (as a convenience for the reader). The highest incident density was between Caltrans post-mile 12 and 14; the area of Long Beach Boulevard, Artesia Boulevard, Atlantic Avenue, or the Route 91 junction. Also, there were higher than normal northbound incidents near Firestone Avenue/Florence Avenue (post mile range 18-20).

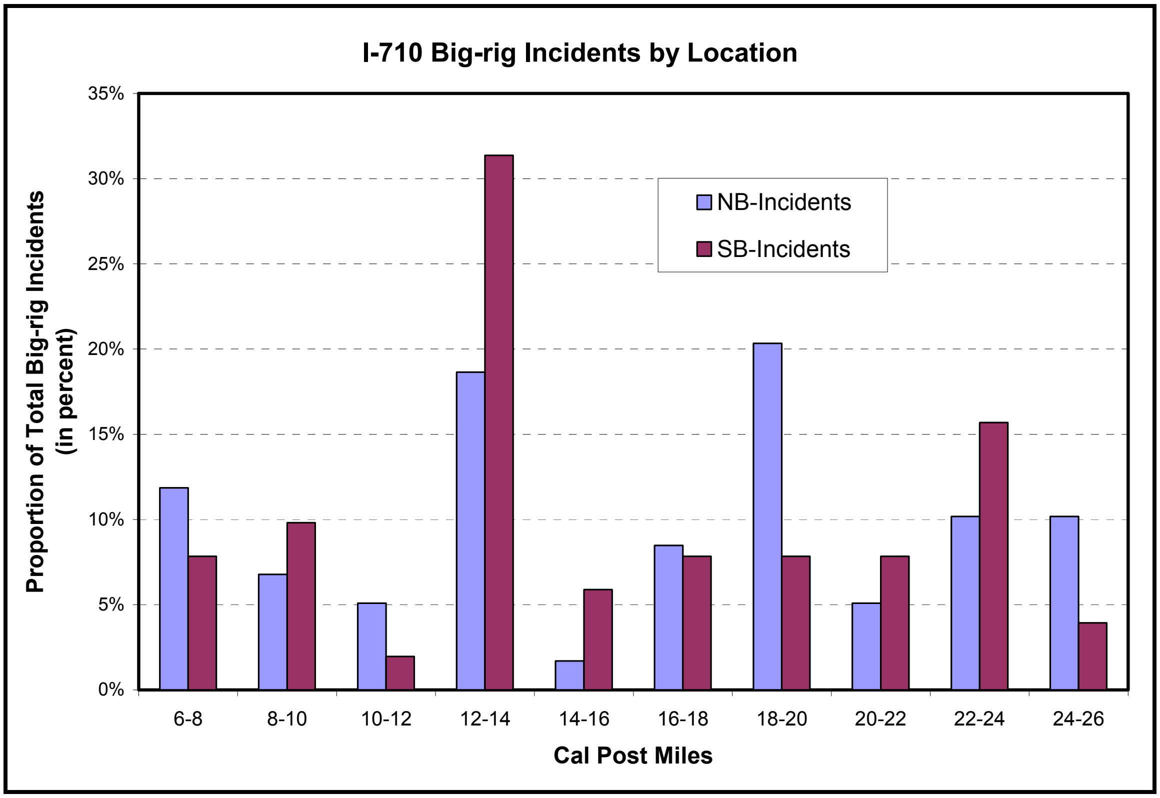


Figure 3.2: I-710 Big-rig Incidents by Caltrans Post-mile

Interstate 710 Cross Street Name	Caltrans Post-Mile
Begin Route	4.96
Pico Avenue	5.87
Shoreline Drive	6.08
Junction Rte 1 (PCH)	7.38
Junction I-405	9.52
Domingues Street	10.31
Del Amo Boulevard	10.83
Long Beach Boulevard	12.07
Artesia Boulevard	12.91
Atlantic Avenue	13.63
Alondra Boulevard	14.02
Rosecrans Avenue	14.97
Junction I-105	15.95
Firestone Avenue	18.59
Florence Avenue	20.00
Slauson Avenue	21.15
Bandini Boulevard	22.00
Washington Boulevard	22.46
Junction I-5	23.19
Whittier Boulevard	23.78
Humphreys Avenue	24.25
Junction Rte 60	24.63

3.3 ESTIMATING INCIDENT DELAYS

To gain insights into the relation between big-rig incidents and the traffic delays that they caused, regression analyses were conducted correlating the measured delays to big-rig and non-big-rig incidents. This model building exercise employed a database compiled from the I-710 traffic data (i.e. VHT, VMT, and delay) provided by PeMS and the incident data provided by FSP, CHP and PeMS. Table 3.3 lists the variables in the I-710 big-rig incident database. From the April – May 2005 database, the best delay estimating model (for non-holiday weekday) was:

$$Delay70 = 2337.87 \times \left(\frac{VMT}{1{,}000{,}000} \right)^{1.5} + 1040.68 \times (ChpdBrLb6a7p) + 355.85 \times \left(ChpdNonBrLb6a7p \right)$$

where:

Delay70 = average vehicular delay per day (in vehicle-hours-of-travel, VHT),

VMT = total daily vehicle-miles-of-travel,

ChpdBrLb6a7p = Number of CHP/LACC logged incidents coded as “Big-rig” and “Lane-blocking” incidents which occurred between 6AM and 7PM,

ChpdNonBrLb6a7p = Number of CHP/LACC logged incidents not coded as “Big-rig” and not coded as “Lane-blocking” which occurred between 6AM and 7PM.

The model may be interpreted as:

- There are an additional 1,041 vehicle-hours of traffic delays for each big-rig lane-blocking incident that CHP responds to on non-holiday weekdays between 6AM and 7PM.
- There are an additional 356 vehicle-hours of delays for other (non-big-rig, and non-lane-blocking) incident that CHP responds to on non-holiday weekdays between 6AM and 7PM.

The incidents occurring between 7PM and 6AM (e.g. nighttime incidents) did not cause statistically significant traffic delays; that is, the average delay per nighttime incident was sufficiently small such that its delays could not reliably be distinguished from random variations in vehicle-hours of travel (VHT). Figure 3.3 shows the model parameters and goodness-of-fit statistics for the final weekday delay model.

During the model building exercise, several different models were developed and compared to determine the combination of available predictors that most completely explained the observed variations in traffic delays. Even though the final model does not include FSP-assists, and does not include any incident descriptors extracted from PeMS, these data sources provided valuable information and were included as potential predictors for all phases of model development.

Table 3.3: Variable Definitions, Weekday Delay & Incident Database

CHP/LACC data:

- **ChpdIncidents:** the total number of daily CHP logged incidents.
- **ChpdAvgDur:** the daily average incident duration (in minutes).
- **ChpdBigRig:** the total number of daily CHP logged Big-rig incidents.
- **ChpdNonBigRig:** ChpdNonBigRig = ChpdIncidents – ChpdBigRig.
- **ChpdSigAlert:** the total number of daily CHP logged incidents that were coded as being SigAlert incidents.
- **ChpdLnBlk:** the total number of daily CHP logged incidents that were coded as being "Lane Blocking" incidents.
- **ChpdLnBlkAvgDur:** the daily average incident duration for Lane-blocking incidents (in minutes).
- **ChpdBrLb:** the total number of daily CHP logged Big-rig incidents that were also coded as "Lane Blocking".
- **ChpdBrLbAvgDur:** the daily average incident duration for incidents coded as "Big-rig" and "Lane-blocking" (in minutes).
- **ChpdNonBrLb:** ChpdNonBrLb = ChpdIncidents – ChpdBrLb.
- **ChpdNonBrLbAvgDur:** the daily average incident duration for **ChpdNonBrLb** incidents (in minutes).
- **Chpd6a7p:** the number of **ChpdIncidents** incidents that occurred between the hours of 6AM and 7PM.
- **ChpdBrLb6a7p:** the number of **ChpdBrLb** incidents that occurred between the hours of 6AM and 7PM.
- **ChpdBrLb6a7pAvgDur:** the daily average incident duration for **ChpdBrLb6a7p** incidents (in minutes).
- **ChpdNonBrLb6a7p:** the number of **ChpdNonBrLb** incidents that occurred between the hours of 6AM and 7PM.
- **Chpd7p6a:** Chpd7p6a = ChpdIncidents – Chp6a7p.

PeMS data:

- **ChppIncidents:** the total number of daily CHP logged incidents.
- **VMT** is total (i.e. daily) measured vehicle miles of travel, estimated using the PeMS 5-minute traffic volumes.
- **VHT** is total (i.e. daily) measured vehicle hours of travel, estimated using the PeMS 5-minute traffic volumes and the PeMS 5-minute (mean) traffic speeds.
- **FfVht70** is the free flow VHT that would have occurred if all vehicles been able to travel at their desired speed (i.e. free flow speed), using 70 mph as free flow speed.
- **Delay70** is the difference between that actual (measured) VHT and free flowVHT. (Delay = VHT – FfVht70.)

```
Call: lm(Delay70~(-1)+I((VMT/1000000.)^1.5)+ChpdBrLb6a7p+ChpdNonBrLb6a7p,
         data = I710BigRig)

Residuals:
   Min    1Q Median    3Q  Max
 -3864 -1367 -291.5 892.1 5455

Coefficients:
                          Value Std. Error   t value  Pr(>|t|)
I((VMT/1000000.)^1.5) 2337.8749  203.0481    11.5139    0.0000
         ChpdBrLb6a7p 1040.6825  222.5672     4.6758    0.0000
      ChpdNonBrLb6a7p  355.8460   70.3324     5.0595    0.0000

Residual standard error: 1718 on 115 degrees of freedom
Multiple R-Squared: 0.8932
F-statistic: 320.6 on 3 and 115 degrees of freedom, the p-value is 0

Correlation of Coefficients:
                I((VMT/1000000.)^1.5) ChpdBrLb6a7p
   ChpdBrLb6a7p -0.2097
ChpdNonBrLb6a7p -0.7143               -0.2346
```

Figure 3.3: Incident Delay Estimation Model, Weekday Analysis (S-Plus Output)

Using the regression estimated 1,040 vehicle-hours of additional traffic delays per normal daytime lane-blocking big-rig incident (with mean duration of 50 minutes) and the theoretically accepted relation that traffic delays are proportional to the square of the incident duration [12], the relation between delays and incident duration becomes:

$$\textit{Traffic delays} = 1{,}500 \times T^2,$$
$$\text{where}: T = \text{daytime big-rig lane-blocking incident duration (in hours) and}$$
$$\textit{Traffic delays} \text{ are in units of vehicle-hours.}$$

For all other daytime incidents, the regression estimated 355 vehicle-hours of additional traffic delays per incident and a mean duration of 37 minutes equated to:

$$\textit{Traffic delays} = 936 \times T^2,$$
$$\text{where}: T = \text{daytime (other) incident duration, in hours, and}$$
$$\textit{Traffic delays} \text{ are in units of vehicle-hours.}$$

These calibrated functions relating incident durations to traffic delays were applied to the daytime (i.e. 6AM – 7PM) lane-blocking big-rig incidents, and to the daytime non-lane-blocking big-rig incidents, estimating the total traffic delays on I-710 from big-rig related incidents for April and May 2005. The resulting traffic delays totaled over 106,000 vehicle-hours of annual traffic delays attributable to big-rig related incidents on I-710.

3.4 ESTIMATING DELAY SAVINGS

Given that incident related traffic delays were quantified, the next steps were to estimate tow truck response times and response time savings from employing Big-rig FSP tow trucks on I-710. Next, these response time savings were combined with the delay estimates that were presented in Section 3.3 of this report to forecast Big-rig FSP delay savings.

The currently proposed I-710 Demonstration Project is funding two Class D tow trucks, which will provide assistance to incidents involving big-rigs from 5AM to 7PM on non-holiday weekdays. One truck will rove the 18.3 mile stretch of I-710 from Ocean Boulevard in Long Beach to the I-710 & I-5 interchange I-710 from 5AM to 4PM (with a one-hour lunch break). The second truck will rove from 8AM to 7PM (with a one-hour lunch). The contracted Big-rig FSP tow truck costs are $149.50 per truck-hour, totaling $2,990/day for the proposed 20 truck-hours per day [13].

For this two tow truck split-shift configuration, an expected average Big-rig FSP response-time of 17 minutes was calculated using a one-way beat length of 18.3 miles, and an average tow truck speed of 53 mph, which is the average observed traffic speed in the shoulder lane during hours of operation. Furthermore, it was presumed that the position of the big-rig tow trucks on the beat were not coordinated (i.e. the tow trucks were not necessarily equally spaced on the beat), and that the big-rig tow trucks were not busy at the time of a big-rig incident, thus were roving and available to respond to incidents. The closest big-rig tow truck would respond to an incident.

Response time savings is the difference between (1) the average response time by rotational big-rig tow trucks and (2) the average Big-rig FSP tow truck response time. That is, response time savings measures how much faster the Big-rig FSP tow trucks will get to a big-rig incident than rotational big-rig tow truck as dispatched via conventional services. Unfortunately, the rotational big-rig tow truck response times were not available in the CHP incident data. The CHP response times were provided (i.e. the time from when LACC dispatch was notified of an incident and when the first CHP officer arrived at the scene) but not the tow truck response times. Indicator data on whether or not a big-rig tow truck was dispatched to the incident was included, but the arrival times of the big-rig tow truck to the incident were not recorded. In lieu of empirically obtained rotational big-rig tow truck response times, the CHP policy response time of 30 minutes was used [14] as an absolute lower bound for rotational big-rig tow truck response times. Though, 45 minutes is a more realistic estimate for rotational big-rig tow truck response time because:

- The average CHP response time for big-rig incidents is 18 minutes (see Table 2.1), and the 30 minute policy response time starts when CHP requests assistance from a rotational tow truck provider. It does not start when LACC dispatch is notified of an incident. Accordingly, if a CHP officer arrives at the scene of an incident 18 minutes after LACC dispatch is notified of the incident and if the policy response-time for rotational tow trucks is 30 minutes, then the tow truck is required to be on scene 46 minutes after LACC dispatch was notified (18 minutes for CHP to arrive on scene plus and additional 30 minutes for the rotational tow truck to arrive on scene).

As such, the 45 minute estimated rotational tow truck response time was used for all subsequent estimates of traffic delay savings and to evaluate the cost effectiveness of the I-710 Demonstration Project.

Table 3.4 lists the expected delay savings for the Demonstration Project with a split-shift configuration operating from 5AM to 7PM on non-holiday weekdays, yielding a lower bound on the benefit-cost ratio of 2.6:1 (for a 30 minute rotational big-rig tow truck response time) and a more probable, yet conservative benefit-cost ratio of 4.9:1 (for a 45 minute rotational big-rig tow truck response time).

Table 3.4: Delay Savings from Big-rig FSP on I-710

Rotational Big-rig Tow Truck Response Time (minutes)	FSP Big-rig Response Time (minutes)	FSP Big-rig Response Time Savings (minutes)
45	17	28

Daily FSP Big-rig Costs	Daily FSP Big-rig Benefit	FSP Big-rig Benefit-Cost Ratio
$ 2,990	$ 14,651	4.9

CHAPTER 4
CONCLUSIONS

4.1 SUMMARY OF THE STUDY FINDINGS

A total of 102 big-rig incidents were reported along the I-710 freeway during the analysis period, of which 69 were blocking travel lanes. The median incident duration for big-rig lane-blocking incidents was 76 minutes. The median time between when a big-rig involved lane-blocking incident was called-in till traffic lanes were cleared, thus again available for use by motorist, was 58 minutes. On the average, a big-rig involved lane-blocking incident caused 1,050 vehicle-hours of delay to the traffic stream.

Some discussion is in order to put perspective on the impacts of big-rig incidents. It was just stated that the average big-rig incident which blocked traffic lanes lasted for 58 minutes and caused 1,050 vehicle hours of delay. Given that the capacity of a freeway lane is in the range of 2,000 vehicles per hour per lane, this is equivalent to saying that the average big-rig lane-blocking incident steals one lane worth of capacity for 30 minutes, or it steals the capacity of ½ of a freeway lane for an hour; additionally, an incident that causes 1,000 vehicle-hours of delay costs motorists $10,000 in lost time (assuming $10/hr as a value of time), or about $700,000 throughout the two month analysis period.

The currently proposed I-710 Big-rig FSP Demonstration provides two Class D type tow trucks delivering split-shift service from 5 AM to 7 PM on non-holiday weekdays, totaling 20 truck-hours of service per day at a cost of $149.50 per truck-hour or $2,990/day. The expected benefits are estimated to be $14,700/day with a benefit-cost ratio of about 5:1. These findings suggest that the benefits to motorists more than outweigh the costs for providing the big-rig FSP service along I-710.

Note that beginning July 1, 2005, the ports of Long Beach and Los Angeles are operating at night and on Saturdays [15]. With this, a 20% big-rig shift in service is expected to the new hours. This change in hours does not affect the findings of the preliminary evaluation. However, the mid- and post-demonstration project evaluations will take into account the effects of these changes especially if Saturday big-rig incidents increase significantly or if weekday truck traffic patterns change noticeably.

4.2 NEXT STEPS – CONTINUING WORK TASKS

This pre-demonstration evaluation completes the first phase of the research in support of the two-year Project. Ongoing and future tasks include:

- Assemble traffic data, incident data, and Big-rig FSP assist data, during the two year demonstration project
- Evaluate the effectiveness of the I-710 Big-rig FSP demonstration project approximately one year from the beginning of the project, using field data on FSP assists to update the delay savings and benefit-cost ratio estimates, and to refine the FSP service operation as appropriate

- Evaluate the I-710 Big-rig FSP Demonstration Project at the conclusion of the pilot project
- Develop recommendations and operational guidelines for extending FSP big-rig service to other freeway truck routes in the State

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