Title

The Los Angeles Freeway Service Patrol (FSP) Evaluation: Site Selection and Database Development

Authors
Bertini, Robert
Petty, Karl
Skabardonis, Alexander
et al.

Publication Date
1997-05-01

CALIFORNIA PATH PROGRAM
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

The Los Angeles Freeway Service Patrol (FSP) Evaluation: Site Selection and Database Development

Robert Bertini, Karl Petty,
Alexander Skabardonis, Pravin Varaiya

California PATH Working Paper
UCB-ITS-PWP-97-16

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department Transportation, Federal Highway Administration.

May 1997

ISSN 1055-1417

ACKNOWLEDGMENTS

This study is being performed as part of the California PATH (Partners for Advanced Transit and Highways) Program at the Institute of Transportation Studies **(ITS),** University of California at Berkeley. Professor Pravin P. Varaiya serves as Principal Investigator and Alexander Skabardonis serves as Principal Researcher.

This project has been made possible with the generous assistance and cooperation of many individuals. Diane Perrine of **LAMTA** has contributed significant funding, expertise and support to the project. Joe Palen, Andrew Lee, and Larry Jellison of the California Department of Transportation (Caltrans) Division of New Technology and Research have provided unparalleled guidance and support throughout the study. Randy Ronning and Don Howe of the Caltrans Headquarters Division of Traffic Operations has also been a critical member of the FSP team. Peter Wong, Mohammed Kalbasi, and Sue King of Caltrans District 7 have generously provided their time and expertise in the provision of freeway loop data. Hassan Safari and Freddie Guerrero of the Caltrans District 7 Office of Traffic Management, Freeway Service Patrol division have assisted greatly in providing supporting data and field liaison.

The California Highway Patrol, including Lieutenant Bill Pasley, Marghi Davidson and Sharlene Turner (Los Angeles) and Lieutenant Mike Farrell, Twanna Turner and Cynthia De Leon, have assisted greatly with the retrieval of CAD data. In the Bay Area, Ron Ho of District 4 assisted with a tach vehicle test run and Sergeant Paul Congi and Duane Potts of the CHP Golden Gate District have assisted with understanding the CAD system.

ABSTRACT

The Los Angeles Freeway Service Patrol (FSP) Evaluation project is measuring the effectiveness of the FSP program on a specific freeway site in Los Angeles. This report describes the site selection and database development phases of the project. From an initial list of ten possible sites, detailed analysis was performed in order to rank the sites according to specific parameters developed by the study team. Site selection was based on congestion levels, average travel speeds, shoulder width, number of in-lane FSP assists, average daily traffic, directionality and the density of functional loop detectors. The site selected was FSP Beat **8,** which is located on Interstate Route 10, between Eastern Avenue and Santa Anita Avenue.

Once the site was selected, a detailed, comprehensive, computerized database was developed. This database completely describes the traffic conditions along Beat 8 for 32 weekdays, for a total of six hours each day. This 192-hour database includes detailed descriptions for 1,560 incidents, tach vehicle travel time traces for 3,619 runs (at 5.7 minute headways), and loop detector data (30-second flow and occupancy) from 240 loop detectors. Finally, the CHP has provided electronic CAD logs for the entire study period. Further to the documentation included in this report, preliminary incident analysis is included in PATH Working Paper 97-18 and the methodology and preliminary evaluation results are included in PATH Working Paper 97-17.

EXECUTIVE SUMMARY

As a key component in the development of California's Advanced Transportation Management and Information Systems (ATMIS), Freeway Service Patrol (FSP) is an incident management measure designed to assist disabled vehicles along congested freeway segments and relieve peak period non-recurrent congestion through quick detection, verification and removal of accidents and other incidents on freeways. The program is jointly administered by the California Department of Transportation (Caltrans), the California Highway Patrol (CHP) and the local Metropolitan Planning Organizations (MPOs), and has been implemented on many freeway sites (beats) across the state.

The Los Angeles County Metro Freeway Service Patrol is a partnership program jointly implemented by Caltrans, the Los Angeles County Metropolitan Transportation Authority (LAMTA), CHP and 20 private towing contractors. As of April 1, 1996, the Los Angeles program was comprised of 149 tow trucks patrolling 40 beats covering 404 centerline miles of freeway in Los Angeles County with an annual budget of approximately $24 million. Historically there have been approximately 1,000 assists per day performed by FSP tow truck operators. The continuously patrolling tow trucks provide complimentary services such as: changing a flat tire, refilling a radiator, taping a leaking hose, providing one gallon of gasoline, and removing stalled vehicles from the freeway when they cannot be restarted.

A study conducted as part of the PATH Program evaluated the effectiveness of FSP on a section of the **1-880** freeway. Extensive data on incidents and traffic characteristics were collected "before" and "after" the implementation of FSP, using specially instrumented probe vehicles and information from loop detectors in the roadway. The evaluation of the benefits based on delay savings, fuel consumption and air pollution reduction indicated that the FSP is a cost-effective measure at the specific site. The results of the **1-880** study on the FSP effectiveness would apply to locations with similar characteristics as the specific beat that was studied. There is a need, however, to have performance estimates from other beats in the state to permit a thorough evaluation of the FSP program in California. A more comprehensive understanding is needed between the relationship of delay savings from quick FSP response to incidents and benefit-cost relationships.

The objective is to evaluate the benefits and costs of FSP at a specific freeway section in Los Angeles. The scope of work includes:

- Development of study methodology.
- Selection of the test site.
- Field data collection and processing.
- Data analysis and evaluation.

This report describes the test site selection and database development tasks. From an initial list of ten possible sites, detailed analysis was performed in order to rank the sites according to specific criteria developed by the study team. Site selection was based on site congestion, travel speeds, shoulder width, number of in-lane FSP assists, average daily traffic, presence of directionality and the density of functional loop detectors. The evaluation was performed using both historical data and new data collected by the study team. The site selected was **FSP** Beat **8,** which is located on Interstate Route 10, between Eastern Avenue and Santa Anita Avenue.

Once the site was selected, seven probe vehicles were specially instrumented and were dispatched at approximately 5 minute headways, six hours per day, for 32 days to collect speed data and detailed incident reports. In addition 30-second freeway loop detector data was collected for the same time periods. Both data sets were automatically transferred from Los Angeles **to U.C.** Berkeley, where software was developed to integrate the data sets. Subsequent to data collection, a detailed, comprehensive, computerized database was developed. This database completely describes the traffic conditions along Beat **8** for the 32 weekdays. This 192-hour database includes detailed descriptions for 1,560 incidents, tach vehicle travel time traces for 3,619 runs (at 5.7 minute headways), and loop detector data (30-second flow and occupancy) from **240** loop detectors.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

As a key component in the development of California's Advanced Transportation Management and Information Systems (ATMIS), Freeway Service Patrol (FSP) is an incident management measure designed to assist disabled vehicles along congested freeway segments and relieve peak period non-recurrent congestion through quick detection, verification and removal of accidents and other incidents on freeways. The program is jointly administered by the California Department of Transportation (Caltrans), the California Highway Patrol (CHP) and the local Metropolitan Planning Organizations (MPOs), and has been implemented in several freeway sites (beats) across the State.

A study conducted by the University of California at Berkeley, sponsored by Caltrans through the PATH Program evaluated the effectiveness of FSP on **a** section of the **1-880** freeway, Bay Area Beat **3** *(1)*. Extensive data on incidents and traffic characteristics were collected "before" and "after" the implementation of FSP, using specially instrumented probe vehicles and information from loop detectors in roadway. The data were processed, verified and integrated into a computerized database. This database is perhaps the largest database on freeway operations created to date. A methodology was developed to estimate the incident-specific delays. The evaluation of the benefits based on delay savings, fuel consumption and air pollution reduction indicated that the FSP is a cost-effective measure at the specific test site.

The results of the **1-880** study on the FSP effectiveness would apply to locations with similar characteristics as the specific beat which was studied. There is a need, however, to have performance estimates from other beats in the state to permit a thorough evaluation of the FSP program in California, and to develop a method for Statewide evaluation of FSP based on data commonly available to Caltrans operations staff. **A** more comprehensive understanding is needed between the relationship of delay savings from quick FSP response to incidents and benefit-cost relationships.

1.2 Objective of the Study

The objective of this study is to evaluate the benefits and costs of the Freeway Service Patrol (FSP) at a specific freeway section in Los Angeles.

1.3 Project Overview

This study is being conducted by the Institute of Transportation Studies **(ITS)** as part of the Partners for Advanced Transit and Highways (PATH) program (MOU-172 and MOU-264). Wiltec Associates served as a subcontractor for field data collection.

The work under the first phase of the project (MOU-172) consists of the following major tasks:

- **Development of Evaluation Methodology:** An evaluation methodology has been developed based on the status of the FSP program in Los Angeles. Because all of the potential freeway sites in Los Angeles currently have FSP service, the service cannot be temporarily suspended for collecting "before" data due **to** liability concerns. Also, a freeway beat with temporarily suspended FSP service is not exactly the same as a beat without service, because in the former case stranded drivers would expect the FSP to assist them and may not immediately call for other service. Therefore, the study workplan and evaluation methodology has been developed to account for the lack of "before" field data.

- **Test Site Selection:** A rigorous test site selection process has been undertaken, which has included site ranking, site visits, travel time runs and detailed analysis of loop detector data.

- **Develop Database:** Field data collection to develop a comprehensive database on incidents and freeway operating conditions at a Los Angeles freeway section. This database will be fully computerized and integrated similar to the 1-880 database

- **Analysis and Evaluation:** Data analysis and evaluation of the effectiveness of the FSP service at the test site.

The detailed evaluation of the FSP will be performed under the second phase of the project (MOU-264). This report, the first formal deliverable for MOU-172, summarizes the extensive effort undertaken during the test site selection process, data collection and development of the computerized database. Chapter 2 provides some background and describes the Los Angeles FSP program. Chapter **3** describes the test site analysis and evaluation procedures, along with the research team's final site recommendation. Chapter **4** includes a detailed analysis of the data collection and processing efforts in the development of the database. Two other deliverables have been submitted. PATH Working Paper UCB-ITS-PWP-97-X describes the analysis of incident data and PATH Working Paper UCB-ITS-PWP-97-X describes the study methodology and results of the preliminary evaluation.

CHAPTER 2

THE LOS ANGELES FSP PROGRAM

The Los Angeles County Metro Freeway Service Patrol, begun in July **1991,** is a partnership program jointly implemented by Caltrans, the Los Angeles County Metropolitan Transportation Authority (LAMTA) and CHP. As of April 1, **1996,** the Los Angeles program was comprised of **149** tow trucks from **20** towing contractors patrolling **40** beats covering **404** centerline miles of freeway in Los Angeles County with an annual budget of approximately **$24** million. Historically there have been approximately **1,000** assists per day performed by FSP tow truck operators. The continuously patrolling tow trucks provide complimentary services such as: changing a flat tire, refilling a radiator, taping a leaking hose, providing one gallon of gasoline, and removing stalled vehicles from the freeway when they cannot be restarted.

The Los Angeles FSP program essentially began in **1978,** when Caltrans began operating a service patrol for the 42-mile Downtown Loop (formed by the Santa Monica, San Diego and Harbor Freeways) as a component of the Los Angeles Area Freeway Surveillance and Control Project (LAAFSCP). In November, **1990,** Los Angeles County voters approved Proposition C, a half-cent sales tax for transportation improvements, now administered by the LAMTA. Revenues from Proposition C are used for a variety of transportation programs, including incident management programs such as FSP. The Los Angeles Freeway Service Patrol Program was initiated in July, **1991.** In **1992,** Assembly Bill **3346** (Katz) authorized funding for the initiation of FSP statewide.

Figure **2-1** shows the FSP service area and Figure **2-2** shows the beat locations. Table **2-1** shows the status of each FSP beat as of April **1, 1996.** Of particular note on Table **2-1** is the length, number of trucks and the time periods (a.m. and p.m.) covered on each beat. Not including the temporary Traffic Management Plan (TMP) beats associated with construction projects, the average beat length is **9.8** centerline miles. The average number of trucks per beat is **3.6.** The number of trucks per beat is generally determined such that a motorist will have to wait no longer than ten minutes for service. Also from Table **2-1,** one can see that the average number of service hours per beat is **7.8,** and the average cost per hour per beat is **$146.25,** which translates into an average of **$40.63** per truck hour. Given that there are approximately **1,120** truck hours per day **(312** service hours per beat **x 3.6** trucks per beat), in **1995** there were thus approximately **0.88** assists per truck hour over the entire year.

Table **2-2** shows the monthly evolution of the numbers of total assists provided from **1991** through **1996.** As shown in Table **2-2,** in **1995** there were a total of **257,463** responses on the **43** Los Angeles beats. This meant that each beat averaged ***5988*** assists over **1995.**

In order to display how the numbers of total assists are distributed among the beats, Figure **2-3** shows a sample histogram **of** the number of assists per beat for the year **1995.** As shown, Beat **23** had the largest number of assists at **2,716,** and Beat **51** had the smallest number of assists at **230.**

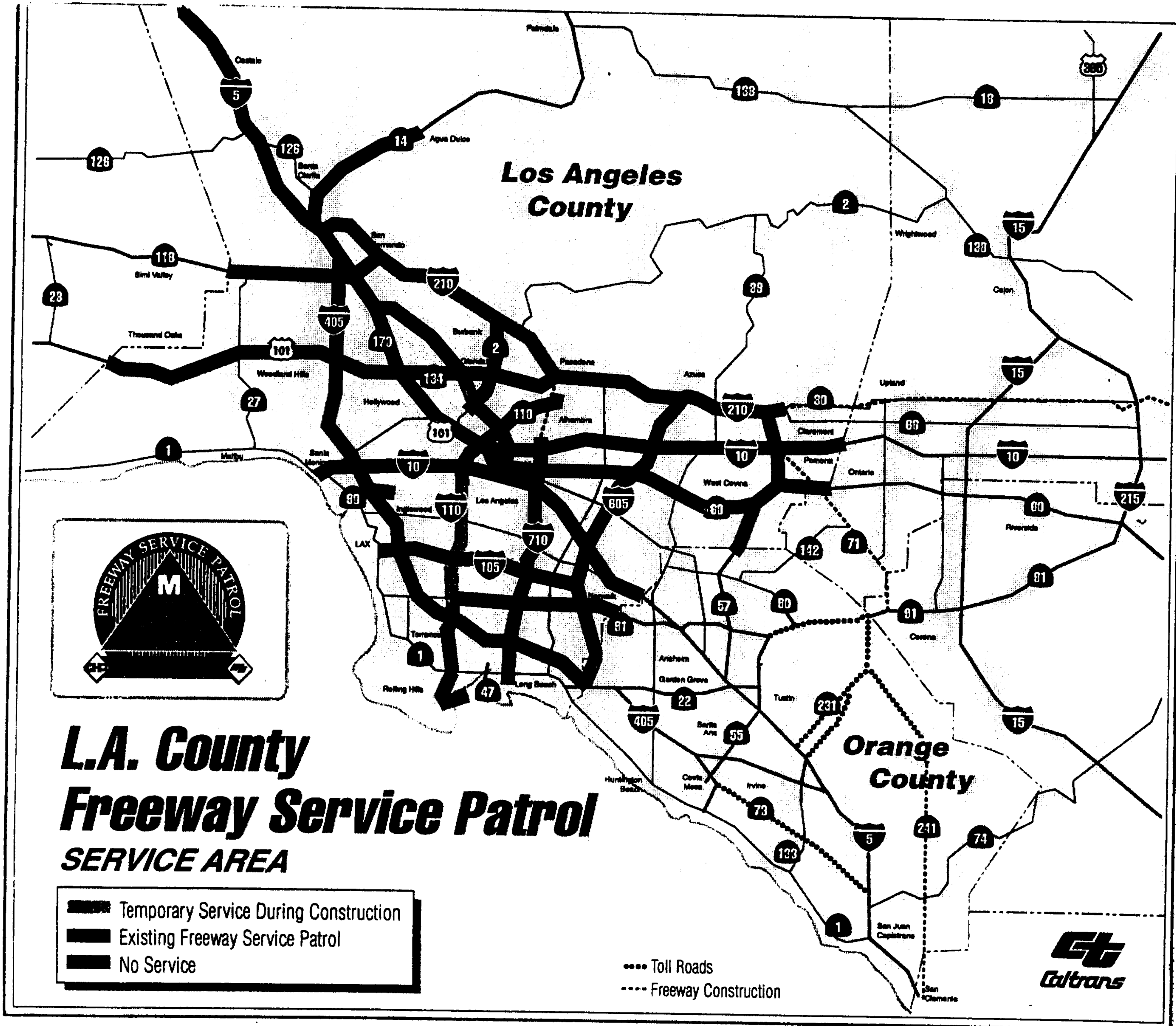


FIGURE 2-1 LOS ANGELES COUNTY METRO FREEWAY SERVICE PATROL SERVICE AREA MAP

FIGURE 1A. FREEWAY SERVICE PATROL AREA MAP

FIGURE 2-2 LOS ANGELES COUNTY METRO FREEWAY SERVICE PATROL BEAT MAP

TABLE 2-1 FSP BEAT STATUS

Dist	Beat	Rte	CO	Limits	Cost/Hr	CL Miles	# of Trucks	Tot Cost/hr	Start Date	AM Shift	AM Hrs	PM Shift	PM Hrs	Total
7	1	110	LA	Martin LutherKing to Avenue 43	$39.00	7.62	5	195	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	2	101	LA	Vermont to I-5 at Euclid 1Rte 10 at EasternAve	$35.75	9.07	4	143	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	3	10	LA	Vermont to Rte 60 at 3rd Street	$45.00	6.71	4	180	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	4	5	LA	Stadium Way/Riverside to Garfield	$45.00	11.06	5	225	7/1/91	5:45-9:45	4.0	2:45-6:45	4.0	8.0
7	5	405	LA	Mulholland to Venice/Washington	$40.00	9.08	4	160	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	6	405	LA	Venice/Washington to Imperial	$39.00	6.73	3	117	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	7	101	LA	Reseda to 101/134 interchange	548.00	9.60	4	192	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	8	10	LA	Eastern to Santa Anita	$39.19	7.83	3	118	7/1/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	9	405	LA	Imperial Hwy. to Normandie	$40.00	7.40	4	160	7/1/91	6:00-10:00	4.0	2:30-6:30	4.0	8.0
7	10	405	LA	Devonshire to Mulholland	$40.00	9.21	3	120	8/5/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	11	210	LA	Orangegrove to Santa Anita	$38.50	7.30	3	116	8/5/91	6:00-10:00	4.0	2:30-6:30	4.0	8.0
7	12	10	LA	Santa Anita to Grand	$43.00	9.84	3	129	8/5/91	6:00-10:00	4.0	300-700	4.0	8.0
7	13	60	LA	3rd Street to Crossroads Pkwy	$38.42	10.04	5	182	8/5/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	14	605	LA	Telegraph Rd. to Orange County Line	$37.50	10.25	3	113	8/5/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	15	91	LA	Cherry to Orange County Line	$37.51	7.65	3	113	8/5/91	5:30-9:30	4.0	2:30-6:30	4.0	8.0
7	16	5	LA	L A County line 1Artesia to Garfield	$45.00	10.88	4	180	8/5/91	6:00-9:30	3.5	230700	4.5	8.0
7	17	10	LA	Bundy to Vermont	$44.70	9.30	4	179	9/2/91	6:30-10:00	3.5	2:30-7:00	4.5	8.0
7	18	10	LA	Grand to LA County Une / Milk Avenue	$34.87	9.76	4	139	9/2/91	530-900	3.5	230-700	4.5	8.0
7	19	405	LA	Normandie to L A County Line	$43.75	13.56	5	219	9/2/91	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	20	60	LA	Crossroads Pkway to Fairway	$43.00	8.85	3	129	9/2/91	5:30-9:00	3.5	2:30-7:00	4.5	8.0
7	21	60	LA	Fairway to S B County Unr / Rte 57 OC line to Temple	$34.87	15.15	4	139	9/2/91	5:30-9:00	3.5	230-7m	4.5	8.0
7	22	134	LA	Jct St 170 North to Pacific Ave.	$39.75	6.57	3	119	9/2/91	6:30-10:00	3.5	2:30-7:00	4.5	8.0
7	23	710	LA	Firestone Blvd. to Valley Blvd.	$39.19	8.95	3	118	9/2/91	6:00-10:00	4.0	300-700	4.0	8.0
7	24	14	LA	San Fernando (Rte. 126) to Agua Dulce Rd.	$50.00	12.82	2	100	9/2/91	5:00-9:00	4.0	300-700	4.0	8.0
7	25M	Var	LA	Downtown loop, Midday service	$39.00	26.70	6	234	1/19/93	10:00-Noon	2.0	Noon-300	3.0	5.0
7	26	91	LA	Vermont to Cherry	$44.75	7.08	3	134	1119/93	6:00-10:00	4.0	2:30-6:30	4.0	8.0
7	27	101	LA	Vermont to Rte 170 at Magnolia	$45.00	4.33	4	180	1/19/93	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	28	210	LA	Santa Anita to Sunflower	$43.00	11.28	4	172	1/19/93	5:30-9:30	4.0	3:00-7:00	4.0	8.0
7	29	101	LA	Reseda to Las Virgines Road	$42.00	10.00	4	168	2/1/93	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	30	710	LA	willow to Firestone	$39.00	10.55	4	156	2/1/93	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	31	5	LA	HollywoodWay to Stadium Way	$38.75	10.49	4	155	2/1/93	6:00-9:30	3.5	230-700	4.5	8.0
7	32	110	LA	Avenue 43 to Glenam St	$40.98	4.79	2	82	2/1/93	6:30-10:00	3.5	230-700	4.5	8.0
7	33	118	LA	Rocky Peak Road to Rte 210 at McClay	$42.00	16.76	4	168	2/1/93	6:00-9:00	3.0	3:30-6:30	3.0	6.0
7	34	5	LA	Roxford to Hollywood Way	$39.75	10.30	4	159	3/1/93	5:30-9:30	4.0	300700	4.0	8.0
7	35	134	LA	Pacific to Orange Grove	$38.75	6.39	3	116	3/1/93	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	36	170	LA	Sheldon to Magnolia	$38.75	4.73	2	78	3/1/93	6:30-9:30	3.0	3:30-6:30	3.0	6.0
7	37	605	LA	Huntington Drive to Telegraph	$37.50	15.76	4	150	3/1/93	6:00-10:00	4.0	2:30-6:30	4.0	8.0
7	38	210	LA	Sunflower to Rte 30 at Foothill and 57/Temple	$43.00	9.60	2	86	3/1/93	6:00-9:00	3.0	4:00-7:00	4.0	7.0
7	39	105	LA	California Street to Central Avenue	$37.50	8.90	3	113	10/14/93	6:00-10:00	4.0	300-700	4.0	8.0
7	40	105	LA	Central Avenue to Studebaker Road	$38.00	10.00	3	114	10/14/93	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	53	110	LA	Martin Luther King to 405	$39.00	11.50	3	117	8/3/95	6:00-10:00	4.0	3:00-7:00	4.0	8.0
7	53M	110	LA	Martin Luther King to 405	$39.00	11.50	1	39	8/3/95	10:00-Noon	2.0	Noon-3:00	3.0	5.0
				(Not incl. TMP Beat 53 & 53M)		392.89	144							
					Total	404.39	148							

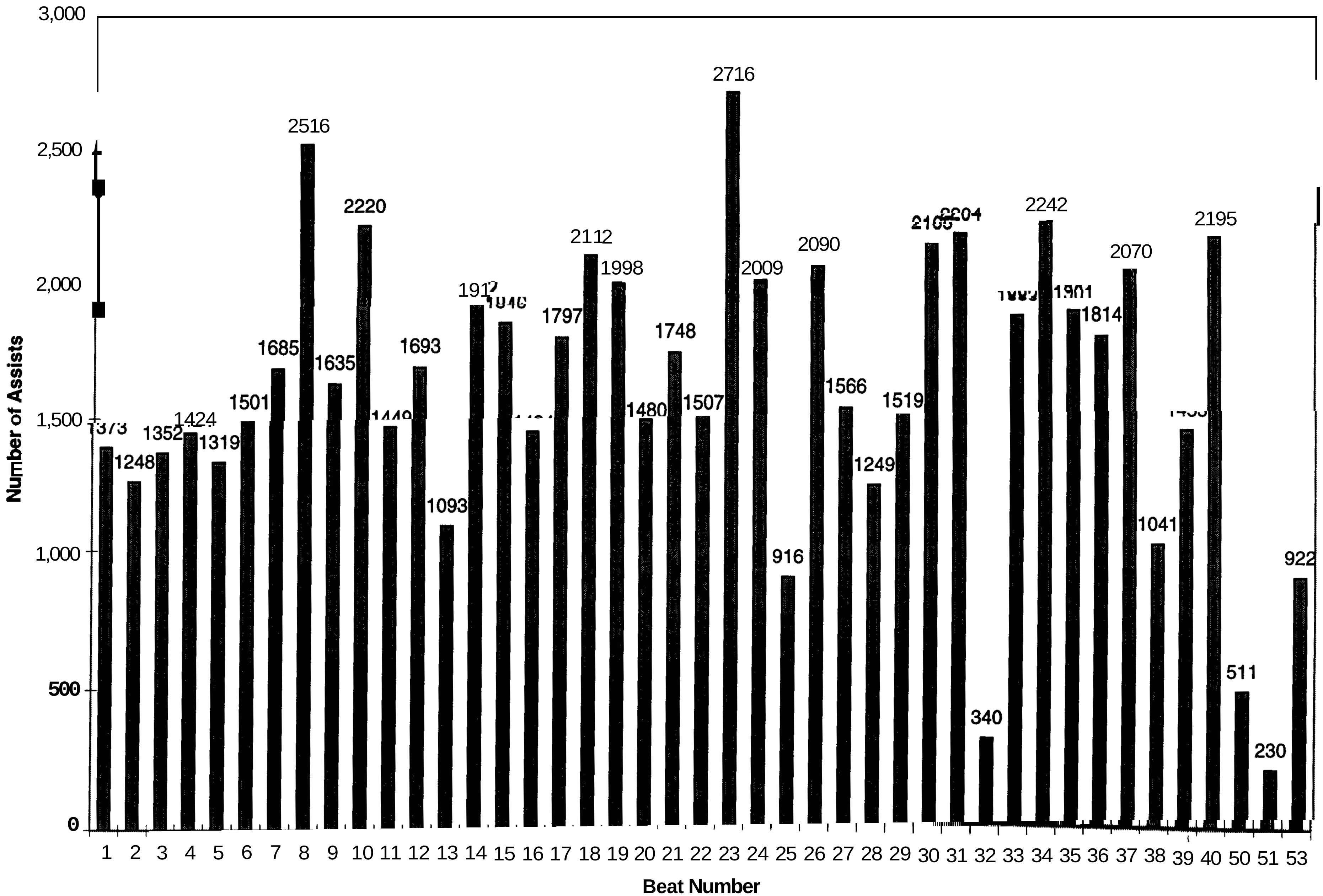
Note: A Maximum of 141 trucks are on patrol during any one shift

Information updated 8/8/95 by D-07 Rita Allan

TABLE 2-2 METRO FREEWAY SERVICE PATROL SUMMARY OF ASSISTS

Month	1991	1992	1993	1994	1995	1996
January		13163	17295	19383	18789	21498
February		13488	19387	18476	17933	25154
March		16294	28009	22327	22693	24888
April		13849	25586	20676	18537	28050
May		14469	24045	21543	21714	
June		16433	27066	23271	26239	
July	4872	17929	22547	19367	24988	
August	10231	16841	23873	24633	27156	
September	12651	16729	23077	21693	22425	
October	14477	15733	22276	20080	22175	
November	12882	15216	22517	18413	19398	
December	11020	14888	17551	15982	15416	
TOTAL	66133	185032	273229	245844	257463	99590

Figure 2-3 Los Angeles County Metro Freeway Service Patrol Assists 1995



As an example of some typical statistics, second quarter **1995** data is used below to present characteristics of the FSP service. This data is recorded on *Scantron* forms filled out by each FSP driver after each assist.

During the second quarter of **1995,** data were extracted from the Scantron reports in order to develop a picture of what incident characteristics would be reported. First, looking at towing activity, **74% of** the incidents did not require towing, **2%** were towed to the shoulder, and **24%** were towed off the freeway. Most of the incidents did not require additional assistance beyond the **FSP** operator's capabilities **(72%** No, **28%** Yes). Most vehicles had mechanical problems **(24%),** followed by flat tires (20%), and out of gas **(12%).** Furthermore, most of the vehicles assisted were autos (64%), followed by pickups **(16%).**

In terms of detecting the incident, 85% of the FSP-assisted incidents were located by the FSP driver, and **13%** were identified by the CHP dispatcher. Disabled vehicles were predominantly located on the right shoulder **(78%)** at the time the **FSP** arrived, while **10%** were located in the freeway lane. Drivers report their estimated speed prior to assist. Most drivers reported that their speed was greater than **40** miles per hour **(78%).** The FSP program primarily serves California drivers (96%). Finally, drivers report their waiting time for FSP service. Most drivers **(72%)** report that they waited less than five minutes, and **18%** of drivers report that they have waited between six and ten minutes. Only **10%** of drivers report that they wait more than 11 minutes for FSP service.

The present study is an effort to build upon past evaluation efforts with a minimum of assumptions and pure empirical data. **A** detailed analysis of the Los Angeles County Metro Freeway Service Patrol was conducted in **1992** and is described in Finnegan **(6).** Caltrans also evaluated the FSP service in **1992** and found that the program reduced response times by 15 minutes **(4).** The program's effectiveness was then calculated based on estimated total delay savings. The approach at that time used simplified assumptions and historical incident characteristics. Also, capacity reduction and demand level assumptions resulted in useful, but relatively coarse results. It is hoped that the results of the present evaluation project will validate and further solidify past evaluation approaches.

CHAPTER 3

TEST SITE SELECTION

This chapter describes the process for selection of the freeway section for the **FSP** evaluation. The test site should meet several criteria for the successful completion of the study as well as the concerns of all interested parties.

3.1 Proposed Test Sites

Staff from Caltrans District 7, LAMTA and CHP prepared a list of potential sites for the field experiment that satisfy the following criteria (listed in order of importance):

- Functional surveillance system: loop detectors in place that provide reliable data on traffic volumes. Speed and occupancy data are also needed but their accuracy is limited by the existing surveillance system
- Congestion levels: traffic volumes close to or at capacity during the peak periods. Avoid congested locations because of bottlenecks outside the study beat
- Incident frequency: high frequency of incidents/accidents
- Geometrics: narrow (or no) shoulders, mixed lanes (no HOV lane) no construction

The list of proposed sites and the degree they satisfy the above criteria was submitted to Caltrans Headquarters and ITS for review. The proposed sites were then ranked based on the above criteria and the top two sites were selected for more detailed evaluation

3.2 Test Site Evaluation Procedure

One of the objectives of this report is to document the procedure used to determine the preferred site for further detailed evaluation. The detailed evaluation will consist of the following steps:

1. Collection of data on the freeway section geometrics, lane configurations and detector locations from Caltrans District 7 as-built plans and records.

2. Sample tach car runs will be performed to assess the suitability of the test site for field data collection. Suitable vehicle assembly areas, tach car calibration area and efficient on/off ramp connections will be mapped.

3. Sample loop detector data for the proposed site will be transferred from District **7's** Modcomp system and checked for consistency and integrity.

4. Video recording will be performed at the proposed site for comparison with loop detector data in order to assess accuracy of loop data.

3.3 Test Site Proposals

Staff from Caltrans District 7, LAMTA and the CHP prepared a priority list **of** potential sites for the field experiment. The priority list for ten sites is shown in Table 3-1 below.

The primary criteria considered for selecting the beat are:

- High volumes
- High incident frequency
- Narrow/no shoulders
- Relatively high detection density and high percentage of working loops
- Don't discard any beat for HOV or construction, but consider impacts on incident characteristics and impacts on congestion.

The above criteria are not prioritized. The beat which has the best combination of all criteria will be selected. As an additional check on the procedure used to evaluate potential evaluation sites, the FSP database was sorted by Beat using "number of lane blocking incidents" **as** the primary sort field. This information was then put in the category of "number of lane blocking incidents per centerline mile." One year of data were provided by District 7 staff for the short list, including:

- Beat Number
- Beat length (miles and described by Post Mile)
- Beat - hours of operations
- Number of FSP trucks on beat
- Number of in-lane incidents
- Number **of** incidents for beat
- Number of travel lanes
- Volume/hour/lane
- Percentage of loops active
- Loop spacing
- Average speed or speed contours

Based on the data provided in Table 3-1, three candidate sites were ultimately chosen for further detailed analysis (Beat 23, Beat 17, and Beat **8).** After the first tier of additional analysis, Beat **17** was discarded. Subsequent to the final tier of site analysis, Beat 23 was discarded, and Beat **8** was selected **as** the site for the **FSP** Evaluation.

TABLE 3-1 TEST SITE PROPOSALS

BEAT EVALUATION

BEAT	FWY	POST MILES	DESCRIPTION	MILES	NO. OF TRUCKS	AM SHIFT	PM SHIFT	TOTAL ASSIST	TOTAL ASSIST INLANE
5,6	405	27.9-37.0	Mulholland to Imperial	9.1	3 + 4	6:00-10:00	3:00-7:00		
17	10	R4.5-13.8	Bundy Dr. to Vermont Ave.	9.3	4	6:30-10:00	2:30-7:00		
7	101	11.6-21.3	SR 134 to Reseda Blvd.	9.7	5	6:00-10:00	3:00-7:00		
16	5	6.8-13.8	1-605 to Eastern Ave.	7.0	4	6:00-9:30	2:30-7:00		
1	110	19.5-27.1	Martin Luther King Blvd. to Ave. 43	7.6	5	5:00-10:00	3:00-7:00	6866	1568
4	5	10.9-21.9	Garfield to Stadium Way/Riverside Dr.	11.1	5	5:45-9:45	2:45-6:45	7476	1215
8	10	20.9-28.7	Eastern Ave. to Santa Anita Ave.	7.8	3	6:00-10:00	3:00-7:00	8287	1008
19	405	0.30-13.8	Normandy Ave. to Orange County Line	13.6	5	6:00-10:00	3:00-7:00	9991	1046
23	710	18.4-27.4	Firestone Blvd. to Valley Blvd.	9	3	6:00-10:00	3:00-7:00	8873	1037
2*	101	4.4-0.00	Vermont Ave. to Jct 10/101 Sep.	9.1	4	6:00-10:00	3:00-7:00	5298	951

TABLE 3-1 TEST SITE PROPOSALS (CONTINUED)

BEAT EVALUATION

BEAT	FWY	POST MILES	DESCRIPTION	NO. LOOP STATIONS	% ACTIVE LOOPS	LOOPS /MILE	TRAFFIC VOLUME (AADT)
5,6	405	27.9-37.0	SR 187 to Mulholland Dr.	21	77.0	0.80	284,000
17	10	R4.5-13.8	Bundy Dr. to Vermont Ave.	29	93.0	0.25	248,000
7	101	11.6-21.3	SR 134 to Reseda Blvd.	17	100.0	1.63	290,000
16	5	6.8-13.8	1-605 to Eastern Ave.	16	85.0	0.75	267,000
1	110	19.5-27.1	Martin Luther King Blvd. to Ave. 43	9	64.2	1.30	289,000
4	5	10.9-21.9	Garfield to Stadium Way/Riverside Dr.	34	75.6	0.70	247,000
8	10	20.9-28.7	Eastern Ave. to Santa Anita Ave.	49	87.6	0.34	249,000
19	405	0.30-13.8	Normandy Ave. to Orange County Line	37	55.4	0.74	240,000
23	710	18.4-27.4	Firestone Blvd. to Valley Blvd.	16	73.6	0.91	193,000
2*	101	4.4-0.00	Vermont Ave. to Jct 10/101 Sep.	16	86.1	0.61/0.39	237,000

Notes:

1. AADT is Annual Average Daily Traffic from the 1994 Traffic Volumes on California State Highways.
2. Loops Active is an estimate of loop condition estimated from Modcomp.
3. Number of Loops is total number of northbound and southbound detector stations.
4. Beat 2* covers Routes 101, 5 & 10:
   101 = PM 4.4 to PM 0.0, Vermont Ave. JCT 10/101 Sep.
   101 = PM 1.3 *to* PM 0.0, JCT 10/101 Sep. St 10/5 Sep. 53-1367L
   5 = PM 16.9 to 16.1, JCT 5/10/101 Sep. 53-1367 - Euclid Ave.
   10 = PM 20.9 to PM 18.3, Eastern Ave. - JCT 10/5/101 Sep.

TABLE 3-1 TEST SITE PROPOSALS (CONTINUED)

BEAT EVALUATION

			AM OPERATION		PM OPERATION		TOTAL	
BEAT	FWY	DIR	HOURS OF CONGESTION	AVG SPEED	HOURS OF CONGESTION	AVG SPEED	HOURSOF CONGESTION	AVE SPEED
5,6	405	N/B	0715-1000 (2:45)	31	1530-1915 (3:45)	26	6:30	28
		S/B	0615-1000 (3:45)	31	1515-2000 (4:45)	22	8:30	26
17	10	E/B	0700-0945 (2:45)	26	1645-1945 (3:00)	33	5:45	27
		W/B	0715-0915 (2:00)	27	1645-1945 (3:00)	30	5:00	29
7	101	N/B	0745-0900 (1:15)	37	1445-1930 (4:45)	22	6:00	18
		S/B	0700-0945 (2:45)	26	1500-1915 (4:15)	27	7:00	26
16	5	N/B	0630-0900 (2:30)	32	--	X	2:30	32
		S/B	--	X	1545-1930 (3:45)	30	3:45	30
1	110	N/B	0630-1000 (3:30)	29	1500-1915 (4:15)	21	7:45	25
		S/B	0645-0930 (2:45)	'27	1500-1915 (4:15)	25	7:00	26
4	5	N/B	0615-1000 (3:45)	24	1500-1830 (3:30)	27	7:15	26
		S/B	0700-0845 (1:45)	27	1615-1845 (2:30)	31	4:15	28
8	10	E/B	--	X	1615-1915 (3:00)	26	3:00	26
		W/B	0630-0915 (2:45)	26	--the	X	2:45	26
19	405	N/B	0630-0900 (2:30)	42	--	X	2:30	42
		S/B	--	X	1545-1915 (3:30)	29	3:30	29
23	710	N/B	0645-0915 (2:30)	31	1645-1845 (2:00)	36	4:15	33
		S/B	--	X	1615-1830 (2:15)	29	2:15	29
2*	101	N/B	0630-0915 (2:45)	20	1645-1845 (2:00)	19	4:45	19
		S/B	0645-0900 (2:15)	32	1645-1900 (2:45)	19	5:00	25

Notes:
1. Hours of congestion are estimated from 1994 HICOMP Report.
2. X means not congested.

3.4 Test Site Congestion and Speeds

Since the congestion level is an important characteristic for the sites in question, the 1994 Statewide Highway Congestion Monitoring Program (HICOMP) Report was consulted next in order to get a general sense of average speeds during morning and afternoon peak congested periods. These speeds are shown in Table 3-1. The data summarized in Table 3-1 will now be evaluated in order to make a preliminary recommendation of a specific site for further evaluation.

3.5 Preliminary Site Evaluation

According to the evaluation criteria described above, a process of comparison and elimination has been undertaken in order to arrive at a preliminary recommendation of sites for detailed evaluation. Table 3-1 is the primary source of information relating to the suitability of the ten candidate sites. Table 3-2 has also been prepared in order to summarize the assessments of the sites.

The Bay Area FSP Evaluation was conducted on Route 880 in Alameda County. The following discussion includes some level of comparison of the Los Angeles sites to the Bay Area sites.

Functional Loop Detectors

In concert with the critical nature of the real time loop data, Beat 7 and Beat 1 were eliminated from further consideration due to the relatively large loop spacings (greater than one mile in both cases). Also, the estimate that only 67% of the loops on Beat 1 also results in the elimination of Beat 1. The "functional density" for the remaining Beats can now be calculated. For this analysis, the functional density is simply the distance between loops multiplied by the estimated percentage of active loops. Functional density for the remaining beats is shown in Table 3-2,

Therefore, from strictly a "functional loop density" standpoint, Beats 8 and 17 appear to be the optimal choices. In addition, Beats 5, 6, and 19 were discarded primarily due to a "functional loop density" less than one per mile. As a means of comparison to the Bay Area FSP study, the functional loop density for Route 880 is 2.90, which compares most closely with Beats 8 and 17 in Los Angeles.

Congestion Levels

In terms of AADT, all Los Angeles freeway segments have AADT greater than 200,000 vehicles per day, ranging from 205,000 to 284,000 vehicles per day. As shown in Table 3-1, congestion levels (as represented by speeds) vary significantly over the segments under consideration, as does the directionality of congestion. Several segments are highly directional, while portions of others are congested during both peak periods. This is especially true for segments that include major bottlenecks such as freeway-to-freeway interchanges. Beats 1, 5, 6, 7 and 19 were eliminated from consideration due to the unfavorable loop detector functionality. Therefore, Beats 2, 4, 8, 16, 17 and 23 will be assessed from the perspective of AADT and congestion. The term "directionality" is used to indicate whether there is only congestion on the particular segment in the peak direction. Table 3-2 shows the AADT for each route, along **with an** assessment of the "directionality" of congestion.

From this analysis, it appears that Beats 17, 4, and 2 would be most desirable for analysis, since there is some level of congestion in both directions during both peak periods. From a strictly volume perspective, it is noted that Beats **16, 8, 17,** and **4** have the highest daily estimated volumes, near 250,000 vehicles per day in all cases. We note that Route 880 had an AADT of approximately 180,000 vehicles per day, ***so*** all segments meet the criterion of having higher volume.

Assisted Incident Frequency

Several data series from Table 3-1 were next converted to provide the total number of assisted in-lane incidents per mile. This was done by dividing the total number of in-lane assists by the length of the beat in miles. The results for all ten beats under consideration are shown in Table 3-2. **As** shown, Beat **8** and Beat 23 have the highest numbers of in-lane assists since inception of the **FSP** program.

Geometrics

By studying the shoulder ratings in Table 3-2, it is noted that there is not an excessive variation in shoulder characteristics. **A** lower weight has been assigned to the shoulder width **as** an evaluation criterion, since all segments have at least a 3.5-foot shoulder. In terms of comparison to Route 880, it is noted that the Bay Area segment has relatively good shoulders (minimum **8** feet) for most of the segment. **A** potential disadvantage of Beat 17 are the "continuous"auxiliary lanes and weaving maneuvers for most of the segment length. Beat 23 is also characterized by good, wide shoulders for the majority of its length, **as** is Beat **8.** Beat **8** is somewhat complicated by the presence of the El Monte **HOV** facility, which includes one **HOV** lane in each direction.

3.6 Preliminary Summary

Based on the above discussion, the key criteria are summarized in Table 3-2:

TABLE 3-2 SUMMARY TABLE

Beat	Route	Shoulder Rating	In-Lane Assists per mile	AADT	Directionality	Functional Loop Density
Bay Area	*880*	*8*		*180,000*	*Yes*	*2.90/mile*
5,6	405	8		284,000	AM Yes PM No	0.97
17	10	8		248,000	No	3.80
7	101	5		290,000	Mixed	0.61
16	5	4		267,000	Yes	1.14
1	110	4.5	206	224,000	No	0.59
4	5	7	109	247,000	No	1.09
8	10	8	129	249,000	Yes	2.58
19	405	8	77	240,000	Yes	0.75
23	710	5	115	205,000	Yes	1.30
2	101	3.5	105	237,000	No	1.72

As discussed above, Beats 1, 4, 5, 6, 7, and 19 were discarded due to the undesirable working loop density (due primarily to large loop spacing). It has also been said that Beats 17, 8 and 23 appear to exhibit desirable congestion characteristics, particularly in comparison with Route 880 and consistent with the objective of studying a freeway segment with high AADT. Next, the incident rates (per mile) of the candidate beats have been compared to and it has been found that Beats 8 and 23 have favorable numbers. As shown on the HICOMP maps (Figures 3-1 and 3-2), much of Beat 23 is uncongested (south of Route 105). However, within Beat 23, Route 710 peak period speeds are relatively close to those on Beat 8 and Beat 17. However, the congestion on Beat 23 may be influenced by other freeways. Based on the above analysis it is proposed to look more closely at Beats 17, 23 and 8.

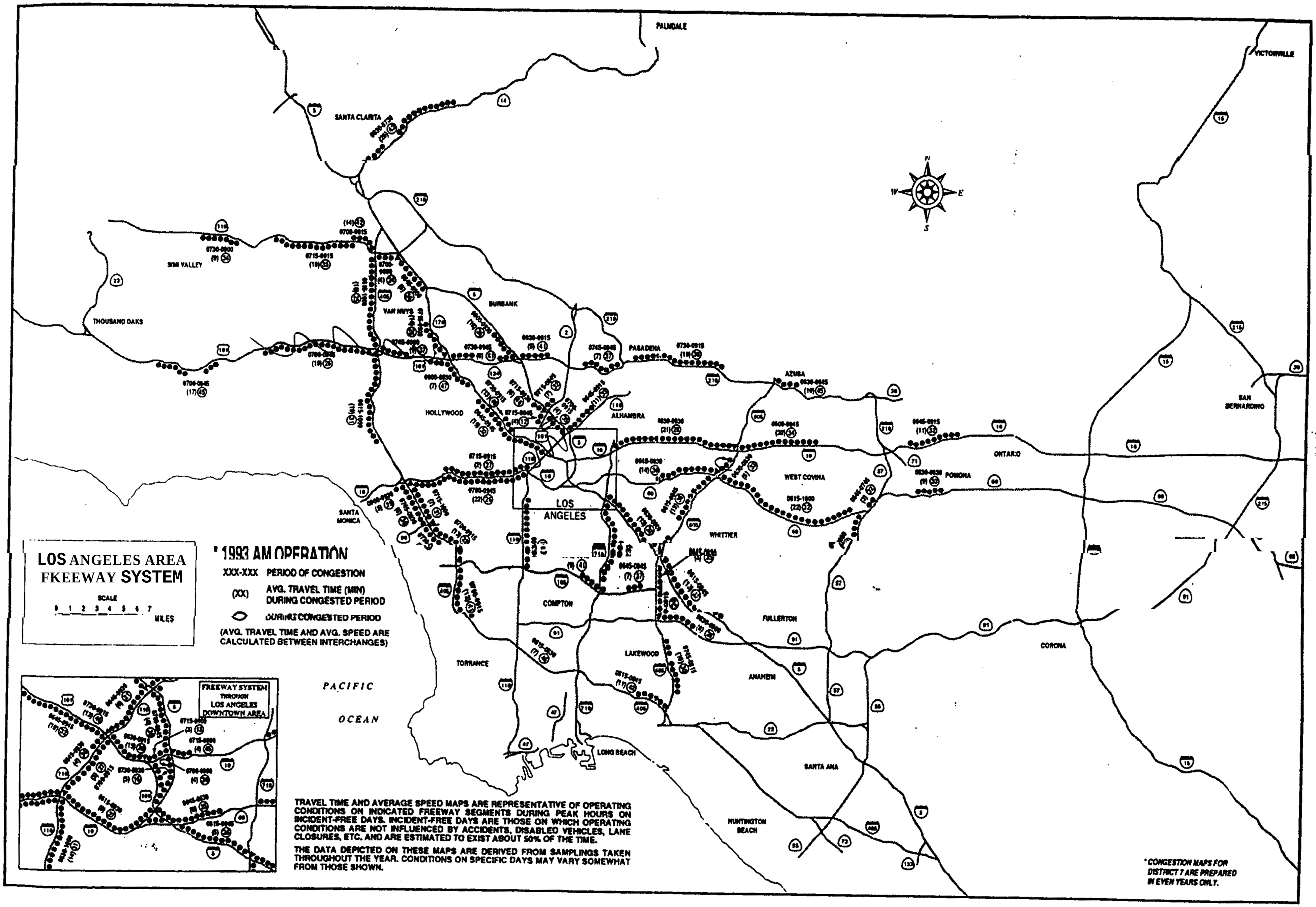
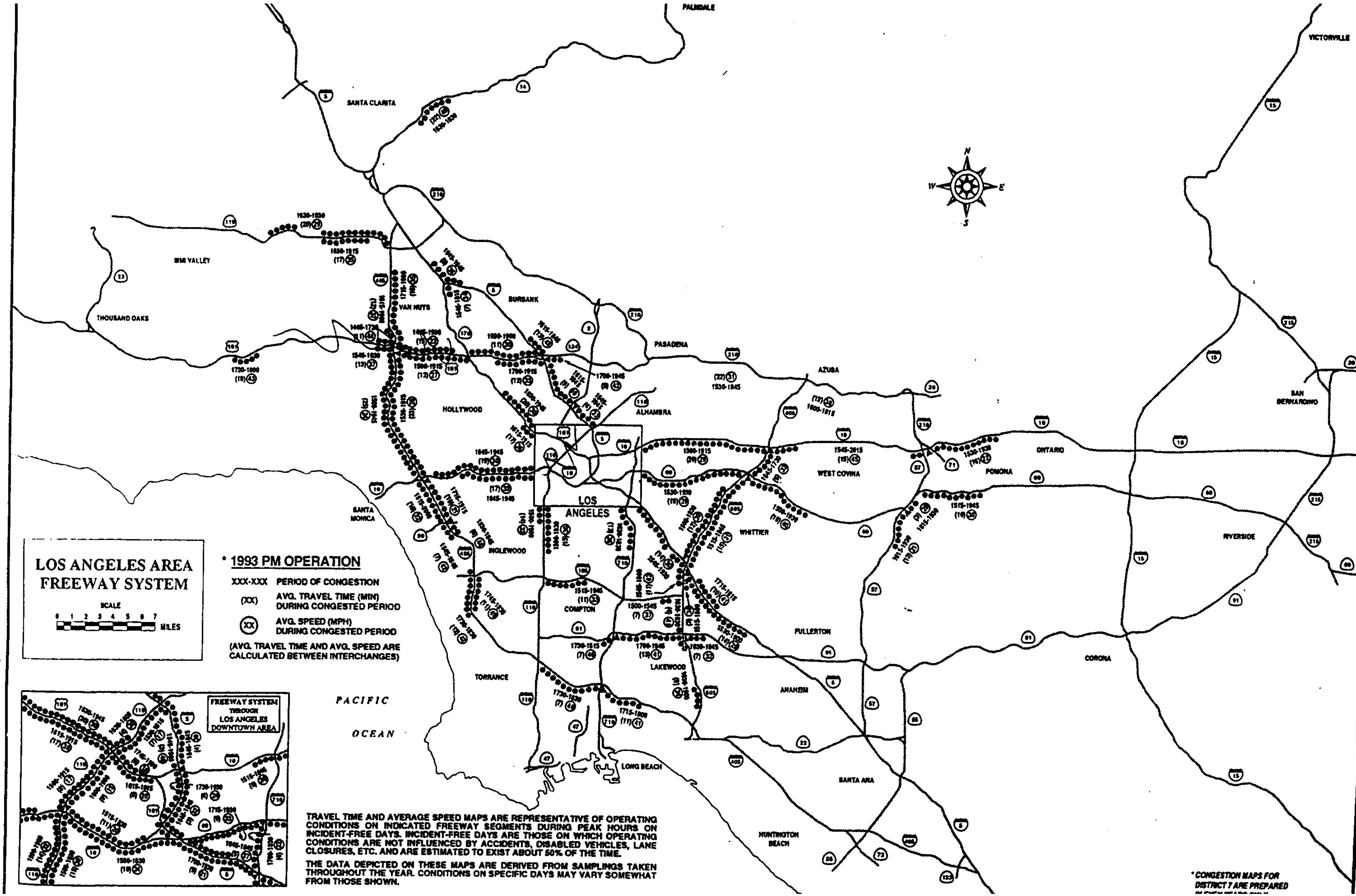


FIGURE 3-1 LOS ANGELES AREA FREEWAY SYSTEM AM CONGESTION MAP

LOS ANGELES AREA FREEWAY SYSTEM PM CONGESTION MAP



3.7 Detailed Test Site Evaluation

Wiltec has been retained for the traffic data collection efforts. In order to verify the congested speed estimates for Beat 23 and Beat 17, Wiltec performed some travel time and speed runs along the freeways on Tuesday, December 5, 1995, during the A.M and P.M. peak periods. Beat 8 was not subjected to this travel time test since the site is near Beat 17.

This preliminary survey was very simple, but has provided some valuable information. A summary of the data collected appears in Table 3-3. Results of these travel time surveys are shown in Figures 3-3 and 3-4.

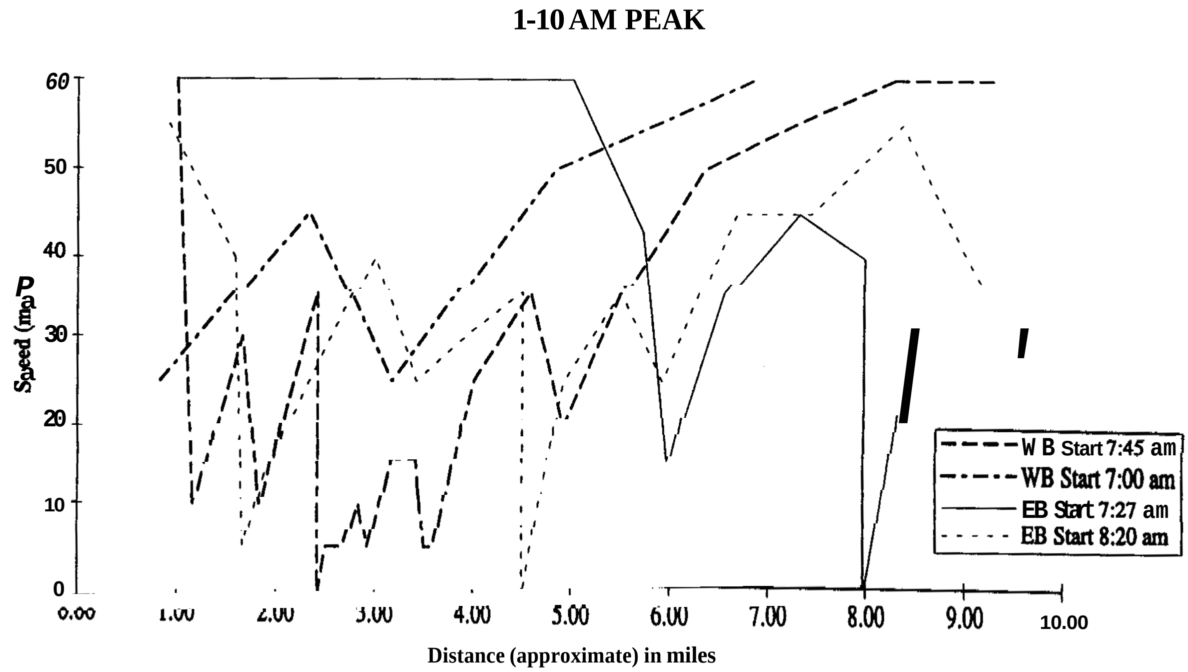
On Beat 23, in general higher speeds are more prevalent. In fact, for the A.M. peak there is tight bunching of speeds between 50 mph and 60 mph in the southbound direction. Northbound A.M. peak traffic exhibits stop-and-go characteristics. The P.M. peak exhibits higher variability, with some stretches of up to 70 mph travel.

On Beat 17, the average speeds are also relatively high. However, there are several periods of very low speeds, with many more fluctuations. Opposite to Beat 23, Beat 17 exhibits greater variability during the P.M. peak period.

TABLE 3-3 SUMMARY OF TRAVEL TIME RUNS - DECEMBER 5,1995

Beat 17	Start Time	9.29 Miles	Time (min)	Average Speed
AM	7:00	W	10	56
	7:27	E	12	46
	7:45	W	23	24
	8:20	E	17	33
PM	4:00	W	9	62
	4:14	E	9	62
	4:29	W	11	51
	5:03	E	10	56
	5:18	W (Acc.)	16	35
	5:43	E	12	46
Beat 23	**Start Time**	**19.59 Miles**	**Time (min)**	**Average Speed**
	7:00	S	19	62
	7:26	N	33	36
	8:03	S	20	59
	8:33	N	20	59
	4:00	S	25	47
	4:27	N	29	41
	4:58	S	32	37

FIGURE 3-3 1-10 A.M. AND P.M. PEAK



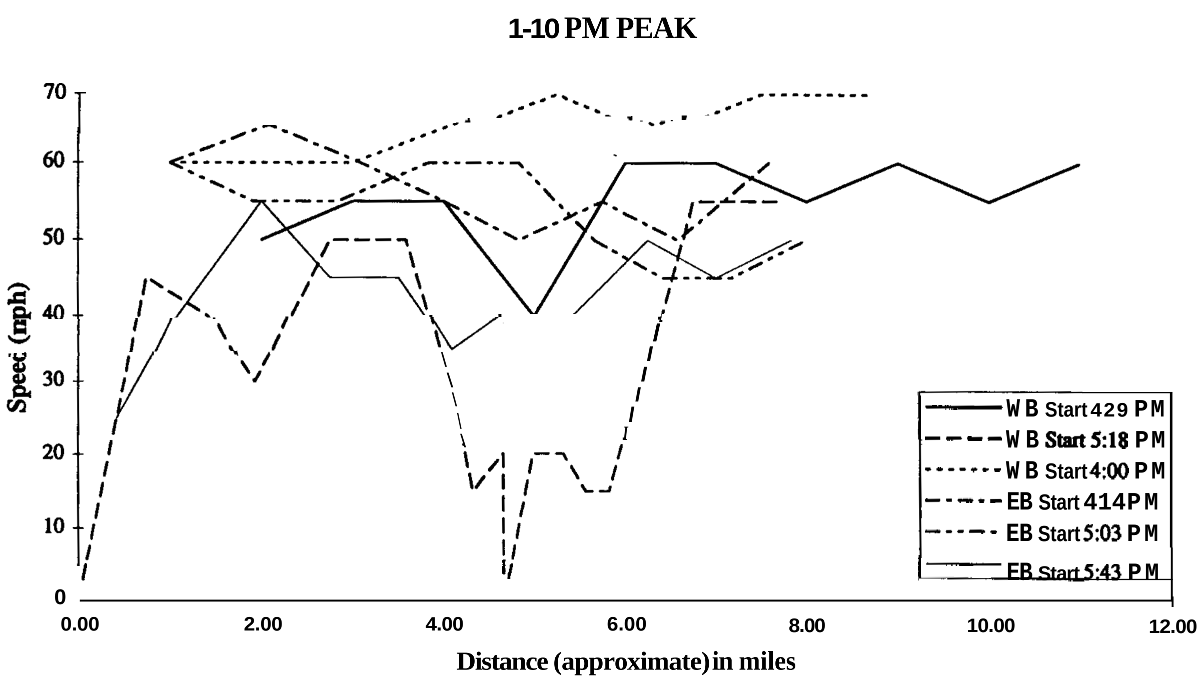
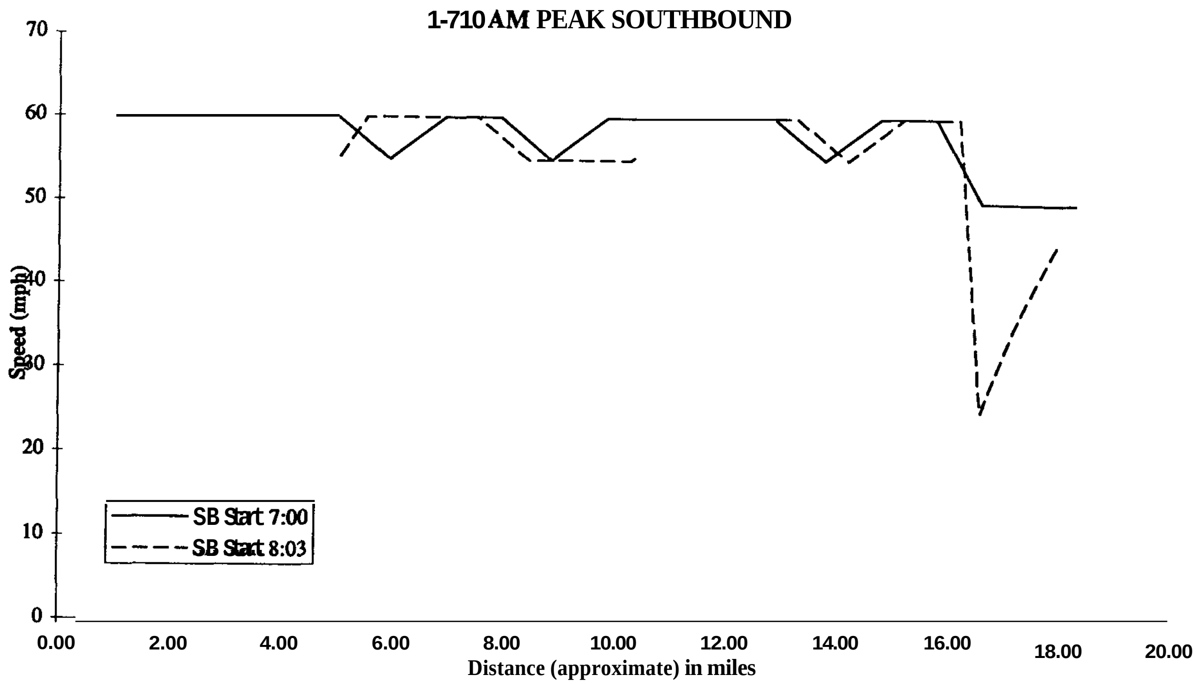
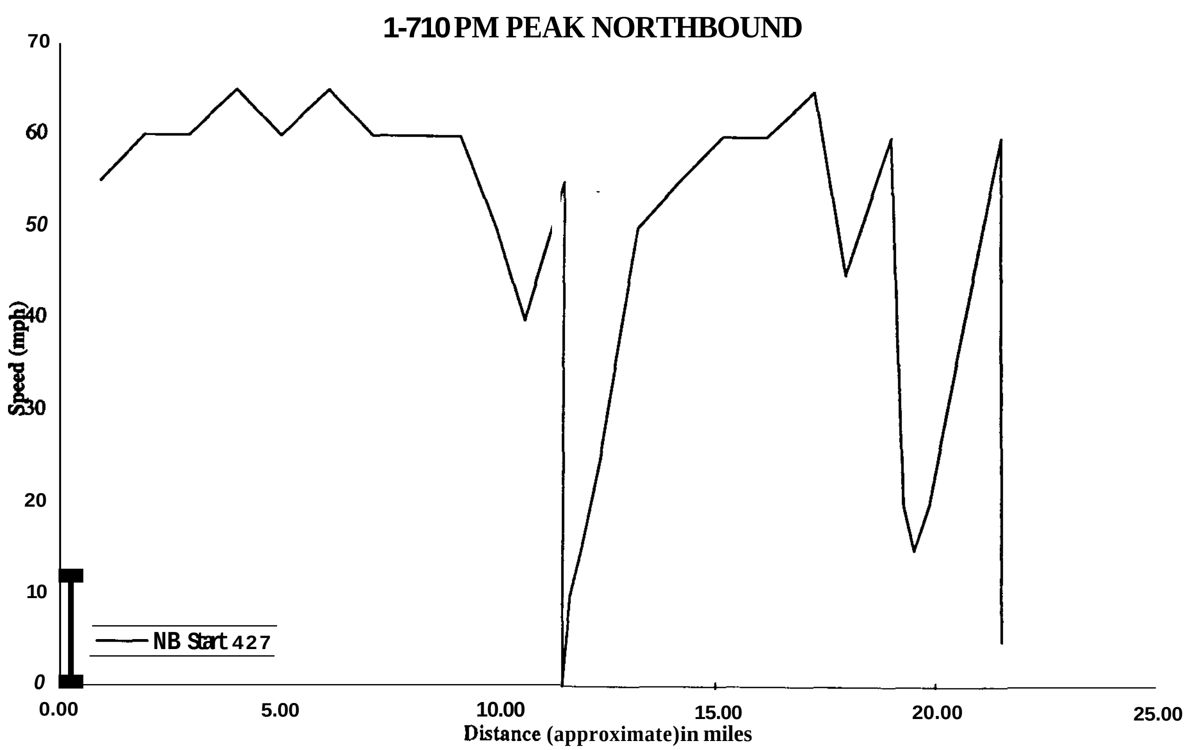


FIGURE 3-4 I-710 A.M. AND P.M. PEAK





3.8 Refinement of Sites for Further Analysis

Subsequent to the travel time runs on Beat 17, and based on discussions with Caltrans, CHP and the LAMTA, Beat 17 was eliminated as a candidate site. The presence of continuous auxiliary lanes was a major determinant in making this decision. It was felt that the presence of auxiliary lanes would mask the potential congestion reduction benefits achieved with the implementation of the FSP program. This meant that only Beat 23 and Beat 8 were subjected to the final stage of site selection analysis, as described below.

3.9 Beat 23 (Route 710) Loop Data Assessment

The preliminary site selection analysis has led to the performance of further detailed analysis on the Route 710 (Long Beach Freeway) site, approximately between the Junction with Pacific Coast Highway in Long Beach (PM 7.887) and just north of the Gravois Avenue Overcrossing in Alhambra, approximately one mile north of the Route 10 Junction (PM 27.387). This corresponds to FSP Beats 23 and 30.

From the Caltrans/Maxwell ***Laboratories Southern*** *California' Only* ***Online Real-Time Traffic Reports*** page on the World Wide Web (http://www.scubed.com/caltrans/transnet.html), a list of "sensor locations'' was also obtained which provide real time traffic speed data over the Internet. There are 24 Southbound "sensors" listed and 20 Northbound "sensors," for a total of 44. Each of these sensors appears to be producing a reasonable speed range indicator; for 35 MPH, 20-35 MPH, and c 20 MPH. These ranges are indicated by green, yellow and red dots, respectively. This provides some level of preliminary confidence that loop detectors are working out in the field and providing data to the Modcomp computer.

District 7 also provided an Ordered Freeway Printout from Modcomp covering this portion of Route 710 listing data for 25 Southbound and 25 Northbound loop detector zones, for a total of 50. These data are summarized on the attached Table 3-4 and Table 3-5 for Northbound and Southbound Route 710. It is noted that there are seven "zones" which do not appear as "sensor locations" on the Internet, and there is one sensor location that appears twice. This accounts for the difference of 6 (50 - 44) which was observed.

TABLE 3-4 NORTHBOUND ROUTE 710 ZONES

NORTHBOUND ROUTE 710

Roadway 31

postmile	Cross Street	Zone	Up Zone	Down Zone	Modem No.	Controller Number	Field 170 Loc. No.	0 Installed	1 Operational	2 Mainline Detectors	3 On Ramp Detectors	4 Metered	5 Instrumented	6 Off Ramp	7 Instrumented	8 Coll/Dist	9 Instrumented	A Opp. Side Detectors	B Secondary Side	C Zone Diverge	D Zone Converge	E Zone Converge	F Unused
9.72	Pacific	123	0	151	9	2	450	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
10.69	Del Amo 1	151	123	126	9	16	451	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
11.00	Del Amo 2	126	151	264	9	17	452	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
12.13	Long Beach	264	126	715	24	5	453	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
13.25	Atlantic	715	264	401	24	6	454	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
14.10	Alondra	401	715	1607	24	13	455	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
14.38	Compton	1807	401	403	24	1	2209	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No
14.90	Rosecrans 1	403	1807	404	6	17	456	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
15.10	Rosecrans 2	404	403	1804	6	18	457	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
15.30	Sof 105	1804	404	1647	6	15	2647	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No
15.90	King 1	1647	1804	720	24	7	450	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No
16.10	Fm Rt 105	720	1647	1650	24	16	2902	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	No	No	No	Yes	No	No
16.50	King 2	1650	720	405	24	20	2210	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	No	No	No	No
16.90	Imperial 1	405	1650	130	24	15	462	Yes	Yes	Yes	Yes	Yes	No	NO	No	No	No	No	No	No	No	No	No
17.05	Imperial 2	130	405	399	24	16	463	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
18.42	Firestone 1	399	130	400	16	12	464	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
18.51	Firestone 2	400	399	154	16	13	465	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
19.50	Florence 1	154	400	132	16	2	466	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
19.76	Florence2	132	154	661	16	1	467	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
22.14	Atlantic 2	661	132	663	16	20	695	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No·
22.54	Washington	663	661	900	16	16	468	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
23.16	S of 5	900	663	133	16	11	312	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	No	No	No	No	No
23.50	Olympic	133	900	897	16	5	469	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
24.31	S of 60	897	133	134	23	4	2359	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
24.43	Third	134	897	0	23	6	470	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No

TABLE 3-5 SOUTHBOUND ROUTE 710 ZONES

SOUTHBOUND ROUTE 710

Roadway 32								0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
			Up	Down	Modem	Controller	Field 170	installed	Opera-	Mainline	On Ramp		instru-	Off	Instru-		Instru-	Opp. Side	Secondary	Zone	Zone	Zone	
postmile	Cross Street	Zone	Zone	Zone	No.	Number	Loc. No.		tional	Detectors	Detectors	Metered	mented	Ramp	mented	Coll/Dist	mented	Detectors	Side	Diverge	Converse	Converge	Unused
24.85	Brooklyn	139	0	140	23	8	472	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
24.54	Third	140	139	896	23	9	473	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No
24.30	S of 60	896	140	822	23	5	2539	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No	No	No	No
23.71	Eastern	822	896	143	23	10	2255	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No	No	No	No	No	No
23.47	Olympic	143	822	1900	18	6	474	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No
23.16	S of 5	1900	143	407	16	11	312	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	No	No	No	No
22.53	Washington	407	1900	408	16	17	475	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
21.95	Atlantic 2	408	407	145	16	18	476	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
19.76	Florence 2	145	408	161	16	3	478	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
19.50	Florence 1	161	145	410	16	4	479	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No
18.51	Firestone 2	410	161	411	16	14	480	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
18.42	Firestone 1	411	410	146	16	15	481	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
16.98	Imperial2	146	411	147	24	17	482	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
16.92	Imperial 1	147	146	635	24	14	483	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
16.50	King 2	635	147	634	24	20	2210	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No
15.90	King 1	634	635	1004	24	7	458	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No
15.30	S of 105	1004	634	719	6	15	2647	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	No	No	No	No	No
15.25	Fm Rt 105	719	1004	797	6	19	2901	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
15.01	Rosecrans 2	797	719	796	24	11	459	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
14.73	Rosecrans 1	796	797	1007	24	8	460	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
14.38	Compton	1007	796	152	24	1	2209	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	No	No	No	No	No
13.83	Alondra	152	1007	962	24	12	461	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
13.11	N of 91	962	152	367	24	3	2313	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No
11.89	Long Beach	367	962	153	24	4	88	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
10.95	Del Amo 1	153	367	0	9	18	84	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No

Preliminary Loop Data Analysis

This is a preliminary analysis of the loop detector data received from Caltrans for the Los Angeles area. This analysis is being conducted for two reasons. The first is to make sure that the loop data are being read and interpreted correctly. There was some initial concern about matching zones to loop detectors or matching up lanes with offsets in each data record. The second reason that this analysis has been done is to verify what loop detectors are working correctly. If there is a discrepancy in what loops appear to be working then a clear understanding is necessary.

The data that were provided by Caltrans District 7 are for two days, November **6** and 7, 1995. The zone to loop detector mapping was also provided by Caltrans District 7. The program written by Cheu, Prosser and Ritchie (UC Irvine) and the mapping provided by Caltrans were **used** to extract the data from the tapes. (7) To automate the loop data verification process a small analysis program was written to read in the occupancy files and generate some statistics. The statistics were generated for every detector site and every lane. Hence, for each direction there were **22** detectors **x 4** lanes **= 88** numbers per day. Note that zone **634** in the southbound direction could not be found on the tapes. The statistics that we choose to generate were:

- Number of data points above 50% occupancy.
- Number of data points between 50% and 0% occupancy.
- Number of data points below 0% occupancy.
- Mean of the occupancy.
- Standard deviation of the occupancy.

The value of 50% occupancy was chosen **as** a threshold based on experience with the **1-880** 30-second data. These statistics were used to look for things in the data that were visibly not valid, such **as** a case where the output was always **32.** Note that these tests are only detailed enough to determine if the data is not being reported. More detailed tests will be needed to determine if the thresholds are set correctly and if the detectors are over- or under-counting. ***An*** example of the output for the southbound direction for lane **2** is given in Table **3-6.** In this table, **an** example **of** a loop detector that is not valid is in zone #1007. Here the output is always below 0 which indicates that there are no data for these time periods. If, for example, a loop detector is deemed not valid if the mean occupancy is less than zero, then from this table it turns out that on November 7, 1995 there were 9 invalid loop detectors in lane 2.

TABLE 3-6 SAMPLE STATISTICS FOR NOVEMBER 7,1995, SB LANE 2

Zone#	#Points	#Pts > 50	50≥#Pts≥ 0	0 > #Pts	Mean	Std Dev
139	2341	0	2191	150	6.3	3.86
140	2341	0	2300	41	4.4	3.17
896	2341	0	0	2341	-1.0	0.00
822	2341	59	2089	193	11.9	12.02
143	2341	43	2297	1	10.2	11.23
1900	2341	114	1898	329	15.3	18.45
407	2341	62	2278	1	11.5	14.88
408	2341	0	0	2341	-1.0	0.00
145	2341	0	0	2341	-1.0	0.00
410	2341	0	2337	4	-0.0	0.04
411	2341	2	2335	4	10.8	5.69
147	2341	0	2279	62	-0.0	0.16
635	2341	0	2022	319	4.7	3.58
1004	2341	0	2290	51	7.1	3.87
719	2341	0	2321	20	7.0	3.73
797	2341	0	1852	489	-0.1	1.54
796	2341	0	2312	29	-0.0	0.11
1007	2341	0	0	2341	-1.0	0.00
152	2341	0	2136	205	9.5	6.50
962	2341	0	2340	1	5.9	3.23
367	2341	0	2339	2	-0.0	0.03
153	2341	0	2338	3	6.8	5.36

To determine if a loop detector was not providing proper data, the mean occupancy was first examined. If this was less than zero then the loop detector was automatically labeled invalid. If the occupancy was reasonable then the standard deviation was examined to make sure there was some variance around the mean. In cases that seemed odd (like the variance was very low or very high) plots of the occupancy versus time were constructed to verify what was occurring. ***So*** while most of the analysis was determined by only looking at the means and variances, there were some cases where it was determined that the detectors were invalid from studying the actual occupancy plots. The findings are summarized in Table 3-7. These tables list the total number of invalid detectors in each lane in each direction. ***So,*** on November 7, 1995 there were a total of 51 invalid loop detectors out of 176 leaving only 71% of the detectors working. This results in a functional loop density of approximately 1.1 loops per mile.

Perhaps something worth knowing is which loops are invalid on both days (instead of those that are periodically questionable). These would probably correspond to loop detectors that are definitely in need **of** repair. Table **3-8** is a list of the loop detectors that were found to be invalid on both days.

TABLE 3-7 INVALID LOOPS

November 6,1995

	Lane Number				
Direction	**1**	**2**	**3**	**4**	**Total**
North	4	4	5 7	2	0
South	6	9	7 7	2	9
Total	10	13	12	14	49

November 7,1995

	Lane #				
Direction	**1**	**2**	**3**	**4**	**Total**
North	4	4	5	7	20
South	6	9	9	7	31
Total	10	13	14	14	57

TABLE 3-8 INVALID ON BOTH DAYS

	Lane #			
Zone	**1**	**2**	**3**	**4**
North				
1807	x	x	x	x
404	x	x	x	x
1647				x
405	x	x	x	x
132	x	x	x	x
897				x
134				x
South				
896	x	x	x	x
1900				x
408	x	x	x	x
145	x	x	x	x
410		x		
147	x	x	x	
797	x	x	x	x
796	x	x	x	
1007	x	x	x	x
367		x		x

Subsequent to this analysis there were some concerns, particularly whether the loops listed in Table **3-8** were definitely invalid. It was **also** observed that some loops seem to sporadically ***go*** out on some days, and it was hoped that there would be some opportunity to repair some detectors prior to commencing the data collection effort.

3.10 Beat 8 (Route 10) Loop Data Assessment

Based on the test site proposals, it was determined that Beat 8 along Route 10 should **be** given the same level of scrutiny **as** Beat 23 along Route 710. Therefore, an extensive site analysis for Beat 8 **was** also performed. Beat 8 is located on Route 10 from PM 20.9 to PM **28.7.** The list of good loop detectors is provided in Table 3-9. The list **of** invalid detectors for December 7, 1995 is given in Table 3-10 **below.** An **X** marks a nonfunctioning loop detector.

TABLE 3-9 NUMBER OF GOOD LOOPS FOR DECEMBER 7,1995

Direction	Lane Number				Total
	1	2	3	4	
East	11/25	10/25	7/25	10/25	38/100
West	10/25	10/25	11/25	10/25	41/100
Total	21/50	20/50	18/50	20/50	79/200

A sample **of** the statistics for December 7, 1995 for lane **4** for the eastbound and then the westbound loops are given in Tables 3-11 and 3-12 below.

TABLE 3-10 INVALID LOOPS BEAT 8

Eastbound December 7,1995

	Lane			
Zone	1	2	3	4
942	x	x	x	x
941	x	x		
940				x
968	x	x	x	x
998	x	x	x	x
752	x	x	x	x
972	x	x	x	x
483	x	x	x	x
484	x	x	x	x
486				
485				
1581	x	x	x	x
482				
481				
436				
444				
449				
445				
446				
440	x	x	x	x
447	x	x	x	x
448	x	x	x	x
1653	x	x	x	x
450	x	x	x	x
452	x	x	x	x

Westbound December 7,1995

	Lane			
Zone	1	2	3	4
451				
1585		x	x	x
453	x	x	x	x
1594	x	x	x	x
454	x	x	x	x
455	x	x	x	x
456	x	x	x	x
458				
457				
437				
438				
466				
472				
996			x	
476			x	
474			x	
473	x	x	x	x
475	x	x	x	x
997	x	x	x	x
751	x	x	x	x
971	x	x	x	x
818	x	x	x	x
1565	x	x	x	x
1573	x	x	x	x
1566	x	x	x	x

TABLE 3-11 SAMPLE STATISTICS FOR DECEMBER 7, 1995, EASTBOUND LANE 4

Zone	No. Points	#>50	50>#>0	0>#	Mean	Std. Dev.
942	2341	0 (0.00)	1154 (0.49)	1187 (0.51)	-0.5	0.50
941	2341	36 (0.02)	1118 (0.48)	1187 (0.51)	4.8	10.95
940	2341	0 (0.00)	623 (0.27)	1718 (0.73)	-0.3	1.42
968	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
998	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
752	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
972	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
483	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
484	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
486	2341	4 (0.00)	1146 (0.49)	1191 (0.51)	2.9	5.95
485	2341	5 (0.00)	1146 (0.49)	1190 (0.51)	***5.8***	8.60
1581	2341	1154 (0.49)	0 (0.00)	1187 (0.51)	55.2	57.01
482	2341	4 (0.00)	1146 (0.49)	1191 (0.51)	***5.6***	8.66
481	2341	7 (0.00)	1141 (0.49)	1193 (0.51)	3.6	6.89
436	2341	9 (0.00)	1144 (0.49)	1188 (0.51)	4.0	7.44
444	2341	5 (0.00)	1147 (0.49)	1189 (0.51)	6.0	9.07
449	2341	13 (0.01)	1141 (0.49)	1187 (0.51)	4.1	7.97
445	2341	3 (0.00)	1151 (0.49)	1187 (0.51)	4.7	7.88
446	2341	12 (0.01)	1142 (0.49)	1187 (0.51)	5.9	10.06
440	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
447	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
448	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
1653	2341	0 (0.00)	11 (0.00)	2330 (1.00)	-1.0	0.07
450	2341	4 (0.00)	1148 (0.49)	1189 (0.51)	4.5	8.11
452	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00

TABLE 3-12 SAMPLE STATISTICS FOR DECEMBER 7, 1995, WESTBOUND LANE 4

Zone	No. Points	#>50	50>#>0	0>\#	Mean	Std. Dev.
451	2341	2 (0.00)	1152 (0.49)	1187 (0.51)	3.6	6.29
1585	2341	0 (0.00)	1152 (0.49)	1189 (0.51)	-0.5	0.50
453	2341	11 (0.00)	0 (0.00)	2330 (1.00)	-0.5	6.91
1594	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
454	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
455	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
456	2341	1154 (0.49)	0 (0.00)	1187 (0.51)	48.8	50.50
458	2341	21 (0.01)	1131 (0.48)	1189 (0.51)	4.9	9.63
457	2341	36 (0.02)	1118 (0.48)	1187 (0.51)	5.5	11.39
437	2341	3 (0.00)	1150 (0.49)	1188 (0.51)	5.4	9.28
438	2341	0 (0.00)	1153 (0.49)	1188 (0.51)	4.9	7.67
466	2341	28 (0.01)	429 (0.18)	1884 (0.80)	2.2	9.66
472	2341	59 (0.03)	1095 (0.47)	1187 (0.51)	2.9	12.20
996	2341	12 (0.01)	1142 (0.49)	1187 (0.51)	5.3	9.29
476	2341	21 (0.01)	1130 (0.48)	1190 (0.51)	4.0	8.94
474	2341	7 (0.00)	1146 (0.49)	1188 (0.51)	5.7	9.56
473	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
475	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
997	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
751	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
971	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
818	2341	0 (0.00)	0 (0.00)	2341 (1.00)	-1.0	0.00
1565	2341	0 (0.00)	623 (0.27)	1718 (0.73)	1.0	3.74
1573	2341	0 (0.00)	1154 (0.49)	1187 (0.51)	3.6	5.52
1566	2341	0 (0.00)	1154 (0.49)	1187 (0.51)	-0.5	0.50

Caltrans District 7 undertook a maintenance effort to improve the validity of the **loop** data for Beat **8.** Following that effort, new data were retrieved and analyzed for several days in May **1996.** Table **3-13** lists the number **of** good loop detectors for May **14, 1996.** The list of invalid detectors is given in Table **3-14** below. An X marks a broken loop detector.

TABLE 3-13 NUMBER OF VALID LOOPS FOR BEAT 8 MAY 14,1996

Direction	Lane Number				Total
	1	2	3	4	
East	24/25	23/25	24/25	23/25	94/100
West	18/25	21/25	17/25	19/25	75/100
Total	42/50	44/50	41/50	42/50	169/200

TABLE 3-14 INVALID LOOPS BEAT 8

Eastbound May 14,1996

	Lane			
Zone	1	2	3	4
942				
941				
940			x	
968				
998				
752	x			
972				
483				
484				
486				
485				
1581				
482				
481				
436				
444				
449				
445				
446				
440				
447				
448	x			
1653	x	x	x	
450				
452				

Westbound May 14,1996

	Lane			
Zone	1	2	3	4
451				
1585	x		x	x
453	x	x	x	x
1594				
454	x	x	x	
455				
456	x	x	x	x
458				
457				
437				
438				
466				
472		x		
996		x		
476	x			
474				
473				
475				
997				
751	x	x	x	x
971				
818	x	x	x	x
1565				
1573				
1566				

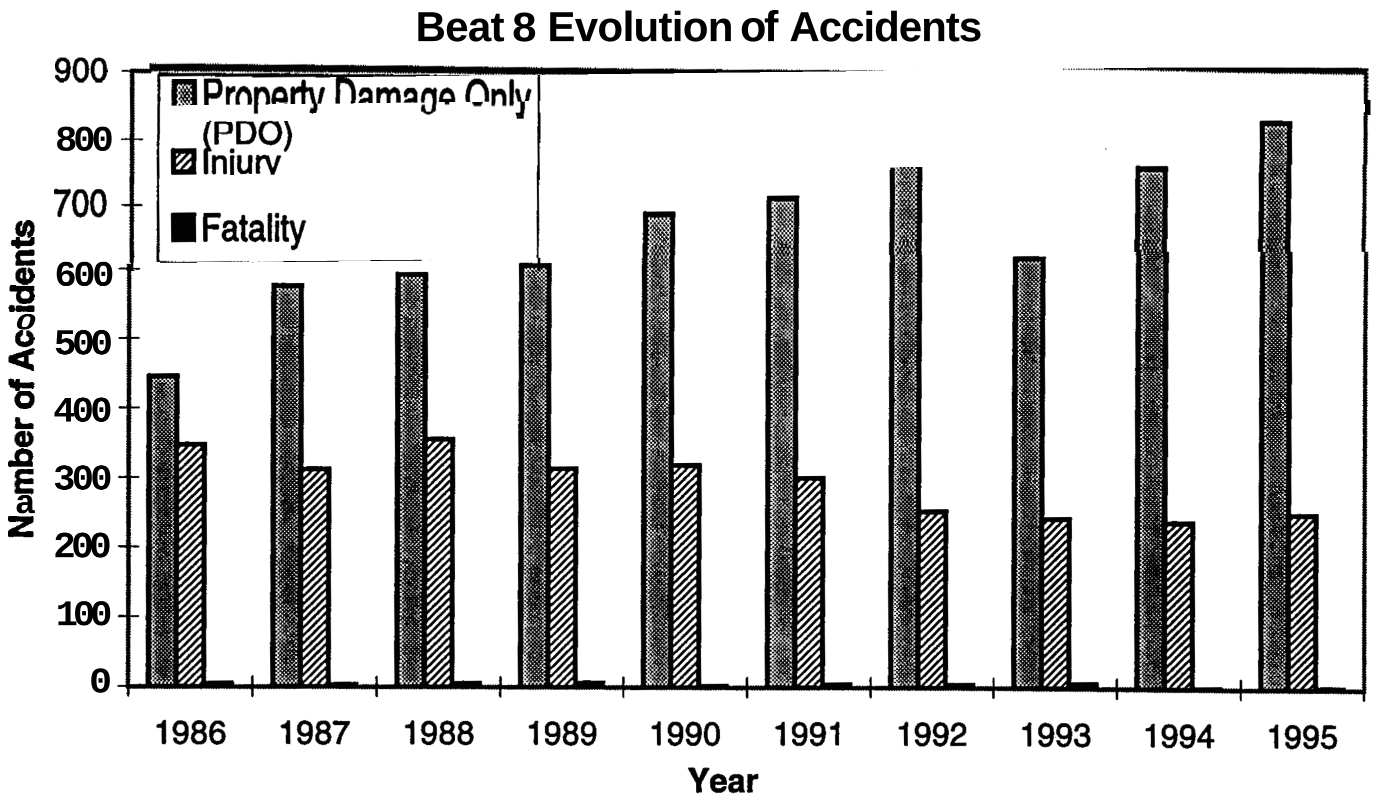
3.11 Accident Analysis

Accident data from Beat **8** and Beat 23 were retrieved from the Caltrans Traffic Accident Surveillance and Analysis Selective (TASAS) Record Retrieval system and analyzed over a ten-year period. Figures 3-5 and 3-6 show the results of this analysis. FSP tow trucks currently patrol this site with three trucks for eight hours per day (6:00 - 10:00 a.m. and 3:00 to 7:00 p.m.). Historical accident data for Beat **8** shows that the number of property damage only (PDO) accidents has steadily increased over the last ten years (from **450** to ***850*** per year), while the number of injury accidents has decreased (from 350 to ***250*** per year). Accident analysis also shows that approximately ***50%*** **of** the accidents occur during **peak** periods.

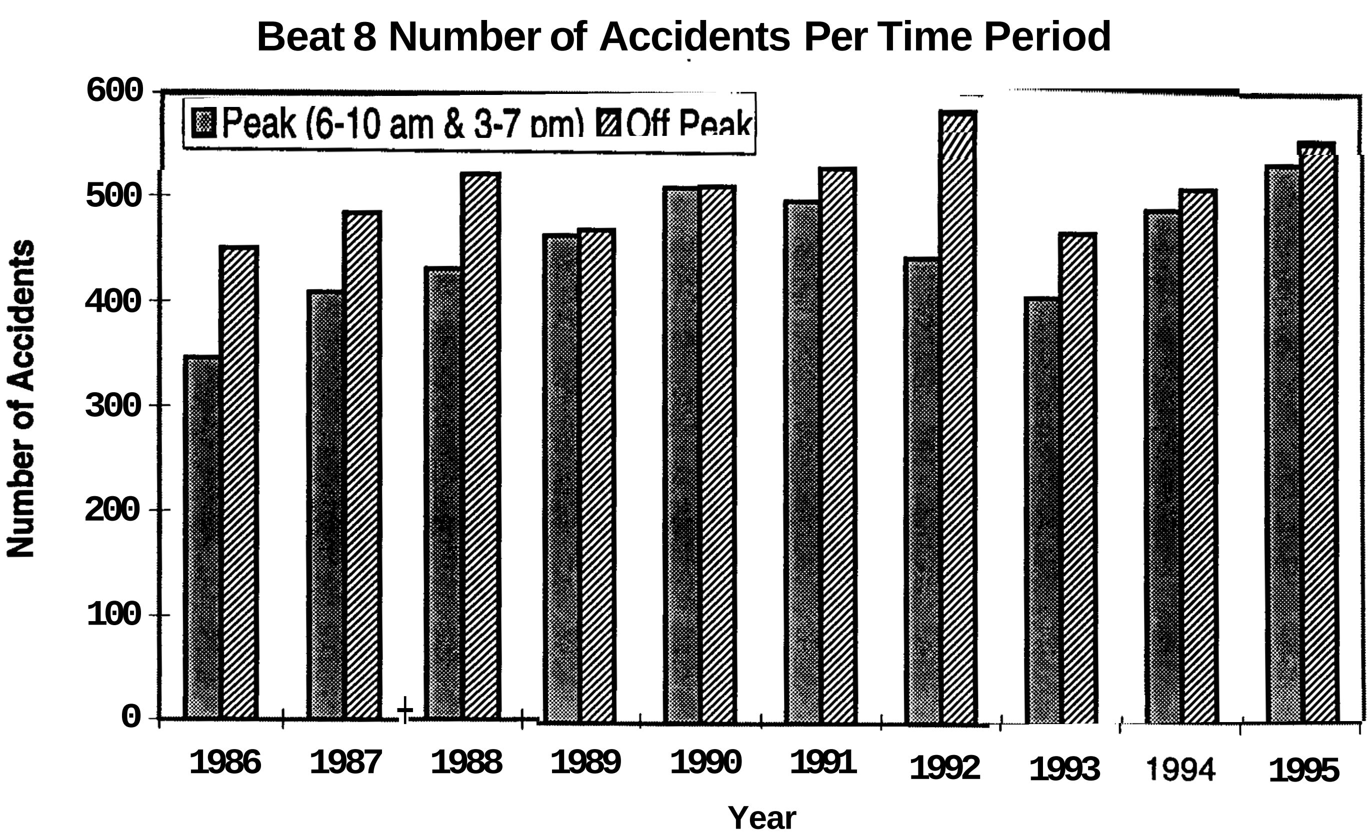
To the extent that the numbers of property damage only (PDO) accidents have steadily increased, it may be the case that PDO reporting has improved with the introduction of the FSP service, and improved auto safety devices may have led to the reduced injuries.

In looking at the numbers of accidents during the peak periods, it is shown that on Beat **8,** clearly ***50%*** of the accidents do occur during the peak **8** hours of the day. On Beat ***23,*** however, it seems that more accidents have occurred during the off-peaks, at least through 1993.

FIGURE 3-5

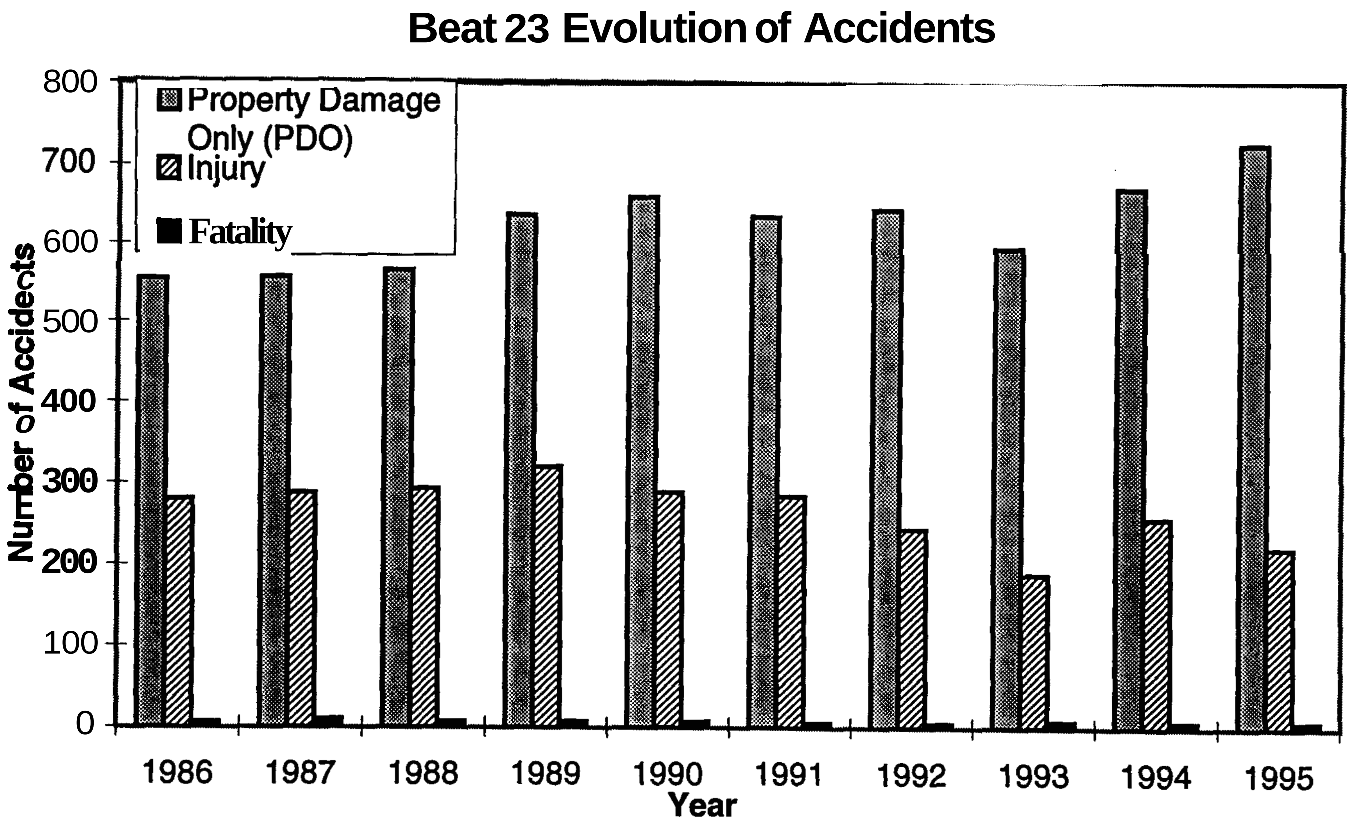


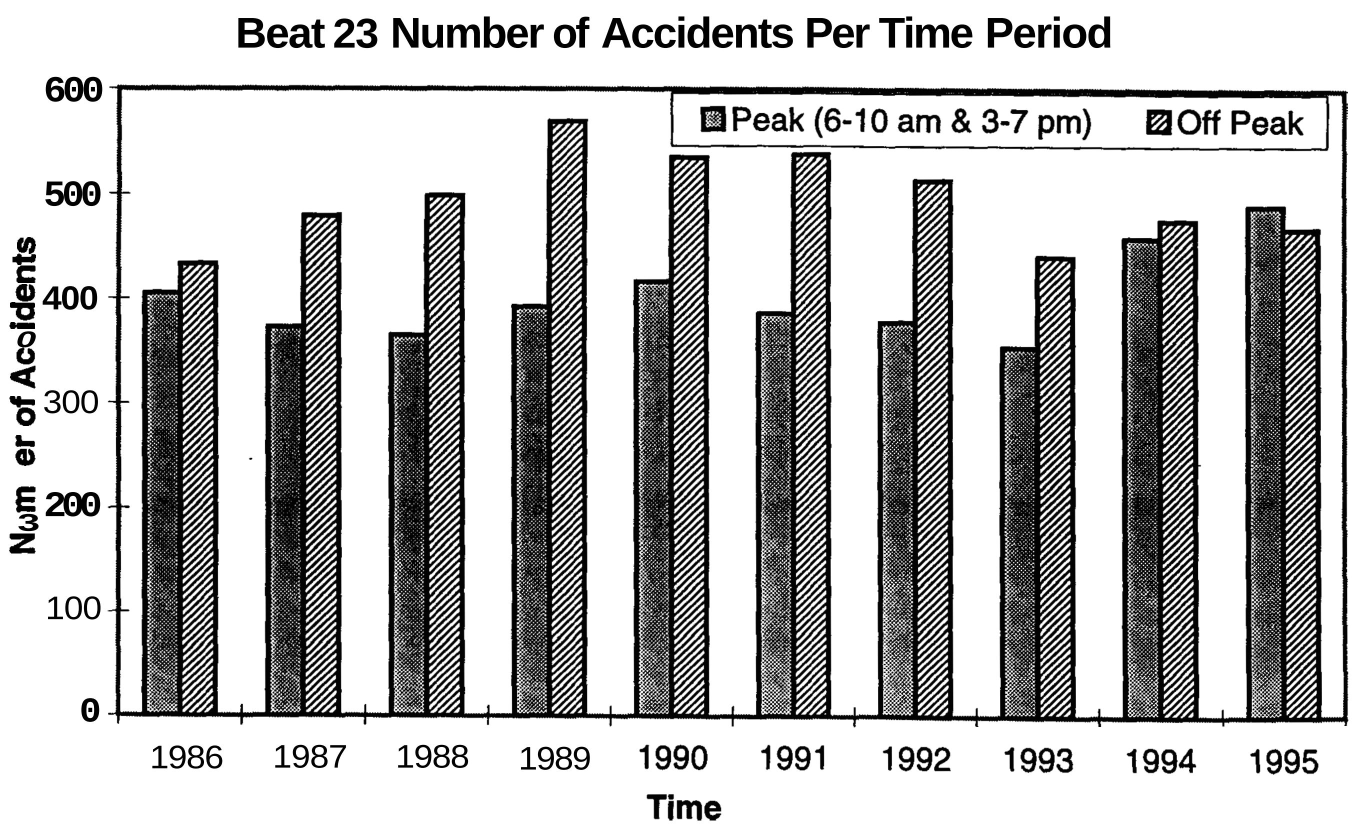
Beat 8 Evolution of Accidents
Property Damage Only (PDO)
Injury
Fatality
Number of Accidents
900
800
700
600
500
400
300
200
100
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year



Beat 8 Number of Accidents Per Time Period
Peak (6-10 am & 3-7 pm)
Off Peak
Number of Accidents
600
500
400
300
200
100
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year

FIGURE 3-6


Beat 23 Evolution of Accidents
800
700
600
500
400
300
200
100
0
Number of Accidents
Property Damage Only (PDO)
Injury
Fatality
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year


Beat 23 Number of Accidents Per Time Period
600
500
400
300
200
100
0
Number of Accidents
Peak (6-10 am & 3-7 pm)
Off Peak
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Time

3.12 Final Site Selection Recommendation

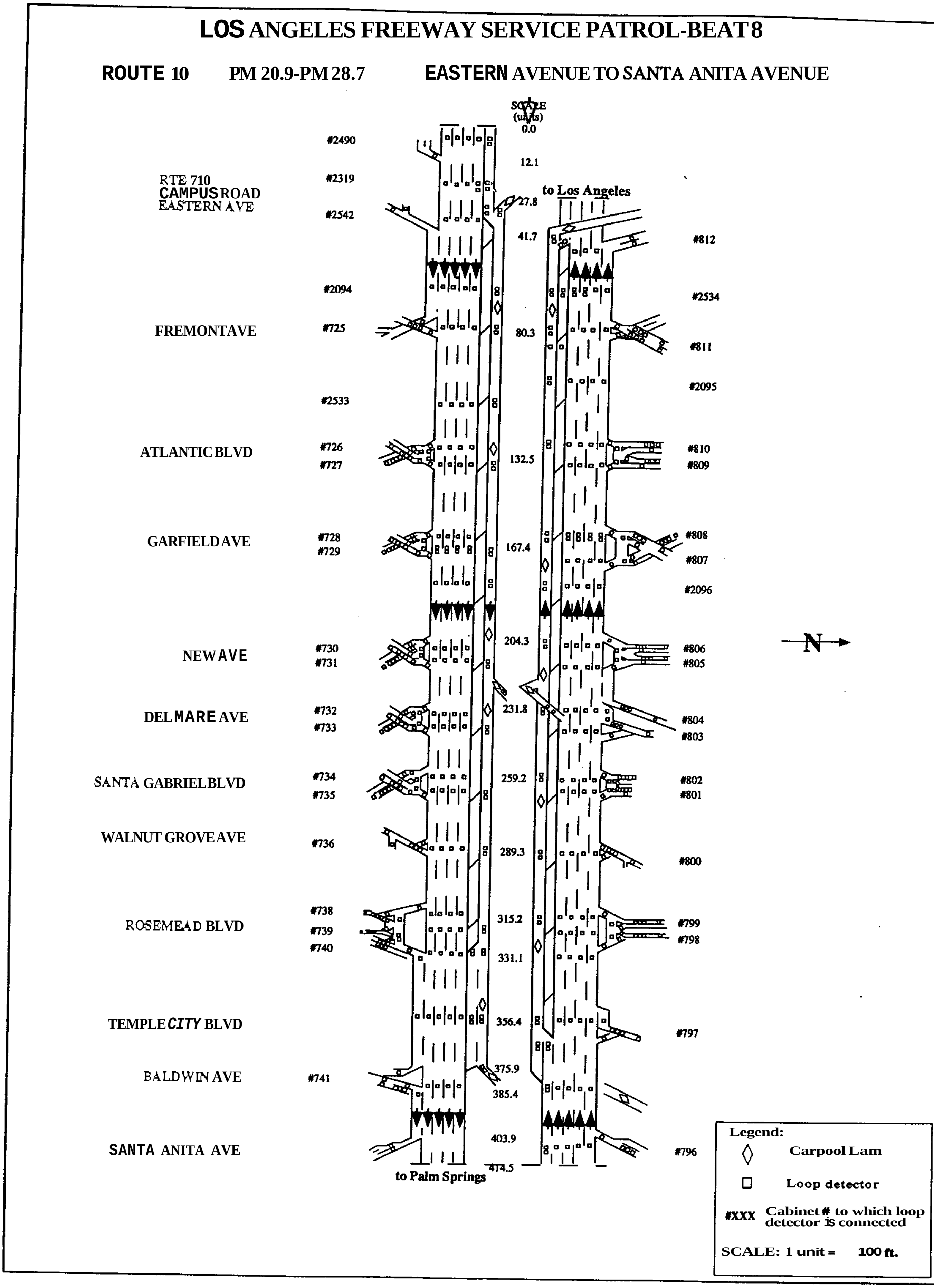
Table **3-15** shows the final comparison between Beats **8** and **23.** Due primarily to the richness of the loop data and satisfactory compliance with the other evaluation criteria, it is recommended that data collection proceed on Beat **8.** A schematic of the geometrics on this beat are shown in Figure **3-7.** Beat **8,** located on **1-10,** was selected based on its exceptionally high loop density rating, **as** well **as** its high ADT, large number of total assists, and large number of in-lane assists.

Beat **8** is a **12.5 km** (7.8-mile) segment **of 1-10,** the San Bernadino Freeway, between Eastern Avenue and Santa Anita Avenue, in the cities of El Monte and Alhambra , in Los Angeles County, California. Beat **8** is characterized by **an** AADT of **249,000** (compared to **I-880's** AADT of approximately **180,000).** There are **49** loop detector stations equipped with Type 170 controllers, **with** a total of **203** single loop detectors, of which approximately **88%** are active. This translates into one active loop station every **0.57** km **(0.34** mile). The controllers collect flow and occupancy data every **30** seconds, and then feed these data via telephone lines to the Caltrans Modcomp computer. The Modcomp system then generates data for the Traffic Management Center (TMC). These data are also disseminated via local cable television and over the World Wide Web **(http://www.scubed.com/caltrans/transnet.html/).**

TABLE 3-15 SITE SELECTION RECOMMENDATION

Parameter	Beats	
	Beat 8	*Beat 23*
In-lane assists per truck	336	346
Total assists **per** truck	2,762	2,958
AADT	249,000	193,000
Loop density **(1/mi.)**	0.34	*0.905*
Ave. response rate, min.	22	26
Hours of congestion	7.25	3.00
Slowest directional speed	26	29

FIGURE 3-7 SELECTED STUDY AREA - FSP BEAT 8

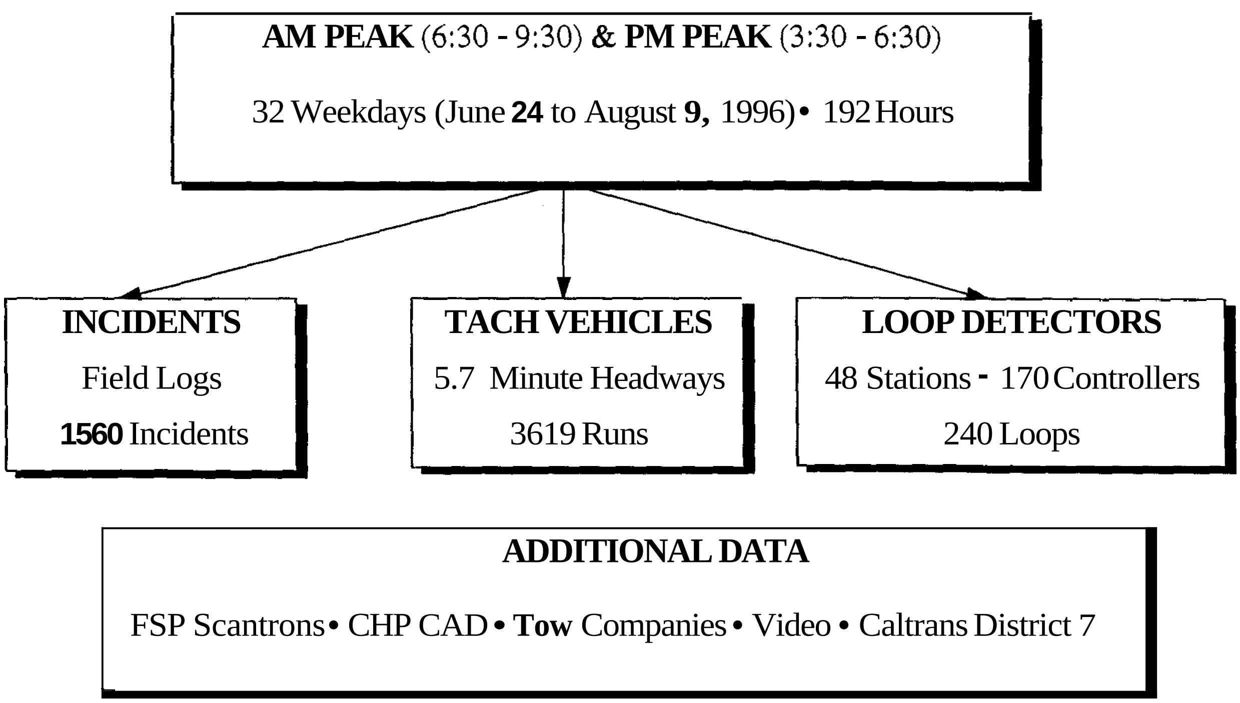


CHAPTER 4.

DATA COLLECTION AND DATABASE DEVELOPMENT

This chapter describes the data collection procedures, and summarizes the methods used for incorporating the various data into one comprehensive, computerized database describing all of the traffic characteristics of the freeway segment being studied. The data were collected over a five-week period, in order to develop a database consisting of a minimum 25 days. The data collection effort began on June 24, 1996 and continued through August 9, 1996. This provided 32 weekdays of data. On each day, data were collected between 6:30 and 9:30 a.m. and between 3:30 and 6:30 p.m. Figure 4-1 shows an overview of the data collection and processing effort. Incident report data from the 32 analysis days (64 shifts between June 26 and August 9, not including the days surrounding the July 4th holiday weekend) have also been analyzed.

FIGURE 4-1 DATA COLLECTION OVERVIEW



4.1 Preparation for Data Collection

The procedures developed for the 1-880 study have served as the basic guide for the field data collection and analysis. However, it was recognized early that procedures used in the 1-880 study would not be directly transferable to the Los Angeles study. Therefore, Caltrans District 4 provided a tach vehicle, laptop computer, and data collection hardware and software. ITS and Wiltec staff performed trial runs on 1-80 in Berkeley to confirm that the software and hardware configurations would be appropriate for the Los Angeles study. The software and hardware arrangements appeared to be satisfactory and provided the team with sample data for analysis and practice. Wiltec explored the marketplace and found a rental car agency which rented vehicles to Wiltec for tach vehicle instrumentation.

In order to gain a full understanding of the interactions among CHP, FSP and Caltrans staff, in October 1995 an ITS researcher visited the California Highway Patrol's Bay Area Traffic Control Center in Vallejo and rode with a Freeway Service Patrol during a peak period.

Subsequent to renting the vehicles and properly instrumenting them, training was conducted to familiarize the probe vehicle drivers with test driving procedures and incident reporting. The training of drivers was performed by U.C. Berkeley researchers and Wiltec managers in cooperation with the CHP and Caltrans staff.

A one-week pilot study was undertaken, including complete data collection and processing. Sample floating car data from the pilot study has been processed and the few problems found were quickly corrected. Sample loop data were also checked to verify that the loop detectors provide accurate data.

4.2 Loop Detector Data

The loop detector data were collected to measure flow and occupancy on the selected study site. The District 7 Modcomp system gathered and preprocessed the 30-second data and transferred it directly to U.C. Berkeley via modem on an almost real-time basis (twice per day). This is in contrast to the I-880 study, when researchers and Caltrans staff were required to download the data directly from the controller cabinets in the field. Caltrans District 7 staff wrote an innovative, custom program which automated the data transfer process. After receiving the loop data via modem, U.C. Berkeley researchers were able to review the data within hours of the end of each peak period.

4.3 Probe Vehicle Data

Probe vehicles recorded detailed incident data as well as speed traces. Seven vehicles were used for the floating car runs, with one additional vehicle serving as back-up. The test cars (1995 Ford **Escorts)** were selected based on experience and suggestions of the Caltrans Transportation Laboratory to maximize the use of existing resources and minimize the possibility of equipment failures. Several test runs were performed to calibrate the in-vehicle equipment, and to verify that accurate and reliable data are provided.

The test vehicles were rented and subsequently instrumented with commercially available speedometer transducers. Caltrans provided custom-made wiring harnesses which were fed from the transducer, through the vehicle firewall, and into the glove compartment. These harnesses include a serial connection for a laptop computer and a **12** volt power supply connection. Various Caltrans district offices provided laptop computers for use during the data collection effort. **A** Caltrans data collection program called "Congest" was used in the laptops. Information on probe vehicle trajectories is automatically gathered through the in-vehicle instrumentation.

A system for probe vehicle data downloading and transmission to U.C. Berkeley was established, including a PC computer, disk loader and high speed modem, facilitating almost real-time data transfer (twice per day). Figure **4-2** shows an automatically-generated probe vehicle report which was produced by a U.C. Berkeley custom program after each peak period data transfer. Summaries for each probe vehicle were automatically posted on a restricted access World Wide Web page for review by the researchers. Problems could easily be noted, and corrected by the data collection team during the next peak period.

Figure **4-3** shows the distributions and statistics for the arrival and departure headways of the probe vehicles. The headways were estimated by measuring the difference between the arrival and departure times of two adjacent vehicles. **It** is noted that there was some variability in the clocks on the computers in each probe vehicle. This contributes to the variability that is displayed on the figure. The mean headway was **5.7** minutes and the standard deviation was approximately **3.7** minutes. Some of the longer headways were due to one probe vehicle breakdown and severe congestion on some days during the data collection period.

4.4 Incident Data

Incident data were gathered through direct observations of probe vehicle drivers traveling at approximate **3** minute headways. The test cars were equipped with two-way radios. The drivers reported the following incident data:

- Incident type (accident, breakdown, debris).
- Severity (number of lanes affected)
- Description of the vehicles involved (color, type)
- Location (direction, postmile location, lane/shoulder)
- Presence of rotational tow or FSP, CHP, or other emergency vehicles.

This incident information is transmitted via radio to the field test supervisor at the site and is also registered by the drivers **as** a location flag on the on-board laptop computer. The incident logs recorded by the supervisor are sent twice per day via fax to U.C. Berkeley and entered into a database for analysis. The quality of radio transmission was thoroughly tested to ensure that the incident information is accurately transmitted. Figure **4-4** shows a sample incident field log.

4.5 Supplementary Incident Data

Incident reports "before" and during the field data collection are being obtained from the Los Angeles CHP/CAD system. This data is stored as FoxPro database entries, and is archived on Panasonic double sided WORM optical disk cartridges with a storage capacity of 1.4 GB (Panasonic LM-W1400A). Through a unique procedure arranged with the CHP, this data will be loaded onto a hard drive for transfer to U.C. Berkeley computers. CHP/CAD data will be analyzed to determine incident response and clearance times for non-FSP conditions, and derive estimates of the reduction in incident durations due to the FSP service. The CAD data will be analyzed to provide information related to major freeway incidents, accidents, debris, and other non-ticketing CHP involved incidents. The CHP/CAD database includes records of all calls directed to the CAD center and information for each incident involving a CHP officer. The detection of these incidents are from CHP calls, cellular 911 calls, Call Boxes, other public agencies' calls and FSP drivers' calls. The CAD incident logs include the call source/time, incident type and severity (accident, stall, breakdown, number of lanes affected), description of the vehicles involved (license plate number, color, type), location (direction, lane, upstream/downstream to the nearest exit), and reporting and clearance times (CHP, FSP if any, tow truck call, arrival and departure).

Additional data will be collected from tow truck companies (rotating tow companies and the California State Automobile Association). Such data may be used to explain the long response times observed for some incidents.

The Caltrans Traffic Accident Surveillance and Analysis Selective (TASAS) Record Retrieval files will also provide a complementary source for accident data.

The FSP tow truck drivers fill out an assist form each time they assist a motorist, as shown in Figure 4-5. These forms include information on type and location of the incident, type of assistance provided, and arrival and departure times of the FSP unit. The data from these forms are entered into a spreadsheet by Caltrans District 7 staff for further analysis. District 7 has provided the FSP log spreadsheets for use by the researchers.

4.6 Database Development

As indicated above, there are three main data sources: probe vehicles, loop detectors, and incident logs. The probe vehicles provide travel times, speeds (leading to speed contour maps), and incident flags. The loop detectors provide volumes and occupancies. Finally, the incident logs provide detailed information about each incident observed. The combination of these data have provided a comprehensive database which fully describes traffic conditions and incidents for the 32 days of the study period.

Significant software modifications were required in order to complete the database development. The probe vehicle reports were sent via modem to U.C. Berkeley, and a custom program was developed to convert the CONGEST reports for each probe vehicle into a comprehensive report for all vehicles for each shift. In addition, software was developed to analyze each shift's loop detector data (30-second aggregation).

By virtue of the data transfer processes put into place, a daily effort was undertaken to review and analyze the probe vehicle speed data, incident reports and loop detector data. In addition, probe vehicle reports were generated twice a day, and loop data have also been undergoing continuous review. Some preliminary findings are presented in the following sections.

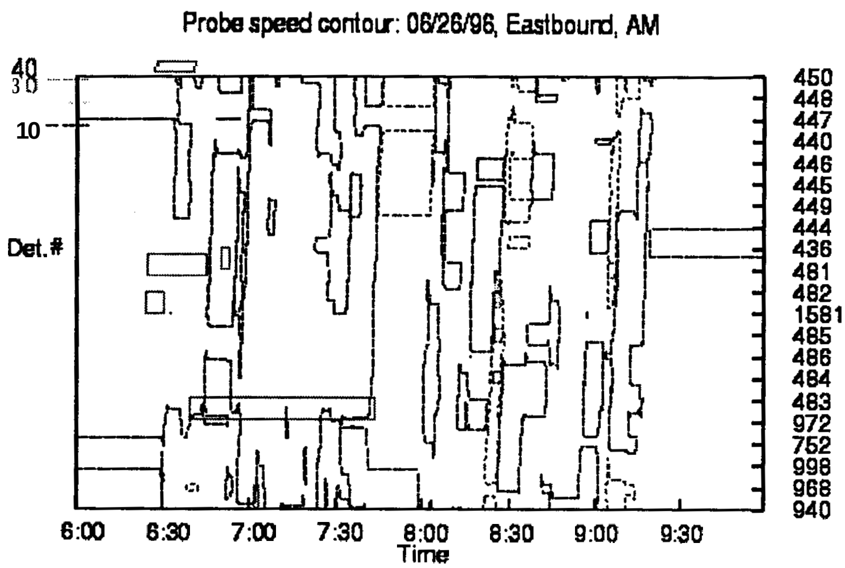
Figure 4-6 shows an example of a speed contour diagram created directly from the speed data provided by the probe vehicle on-board computers. Superimposed on the contours are the "incident flags,'' generated by the probe vehicle drivers' computer key presses **as** they pass each incident. It can be clearly seen that a delay-causing incident was observed at approximately mile 7.0 a total of six times, and resulted in a reduction in freeway speed. This speed reduction means that drivers experienced incident delay. A backward moving shockwave can be visualized from the **speed** contours, **as** can the growth of the queue. Coincident with the last "x" representing the last time the incident was observed by Car 1, a forward moving shock appears, and the queue diminishes shortly afterward. By subsequently reviewing the incident logs for July 24, it turns out that this particular incident was a car fire at mile 7.0, **as** indicated on Figure 4-6.

Figure 4-6 shows the data provided by the probe vehicle laptop computers, including the speed profile and the incident flags. Figure 4-7 shows a loop detector occupancy contour diagram for the same day and direction. These data came directly from the Caltrans Modcomp system, and seem to confirm the information that was provided by the probe vehicles. The favorable comparison shown in this example provides confidence that the methodology outlined here will successfully provide the necessary data for the evaluation of the FSP program at this site.

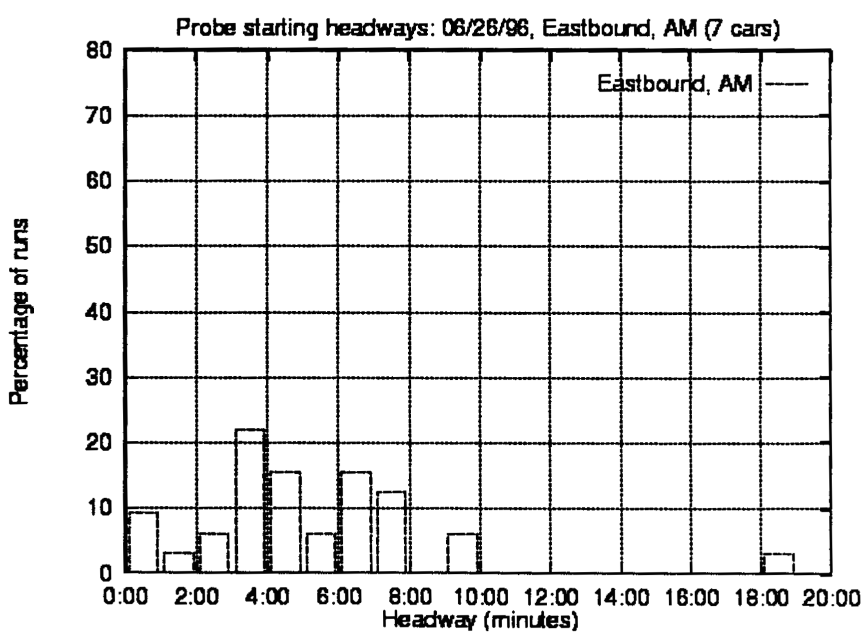
To summarize, a comprehensive database has been developed which completely describes the traffic conditions along Beat 8 for 32 weekdays, for a total of six hours each day. This 192-hour database includes detailed descriptions for 1,560 incidents, tach vehicle travel time traces for 3,619 runs (at 5.7 minute headways), and loop detector data (30-second flow and occupancy) from 240 loop detectors. Finally, the CHP has provided electronic CAD logs for the entire study period. Further to the documentation included in this report, preliminary incident analysis is included in PATH Working Paper 97-X and the methodology and preliminary evaluation results are included in PATH Working Paper 97-X.

Probe data: 06/26/96 AM shift

Eastbound contour plot:

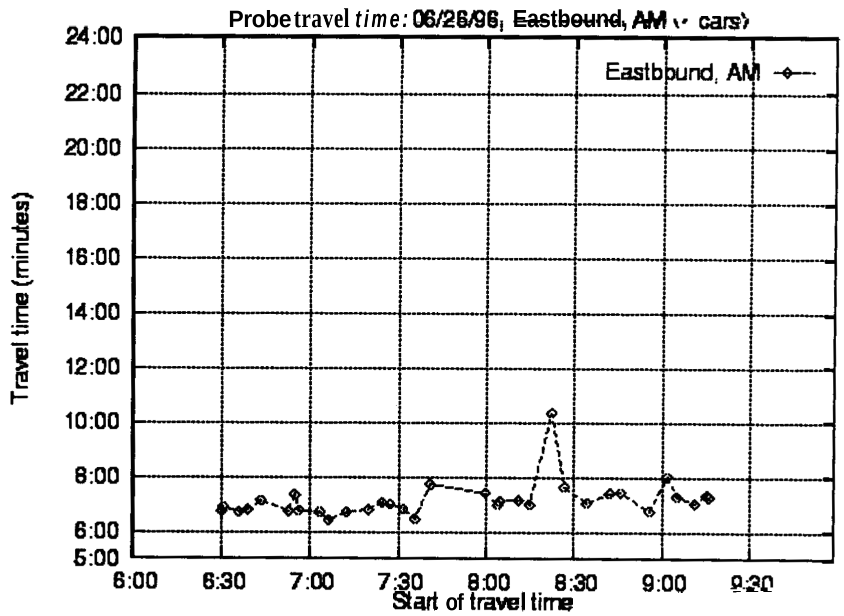


Eastbound headway distribution:

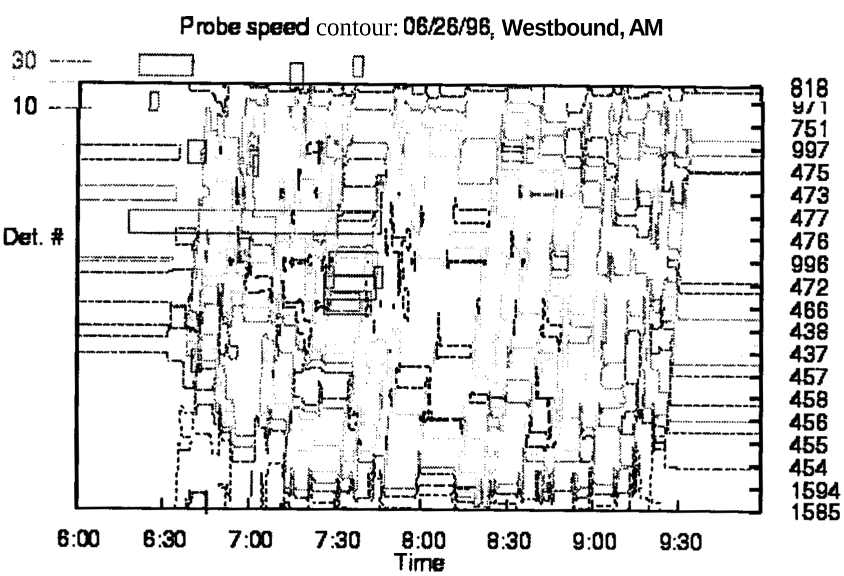


Eastbound travel time:

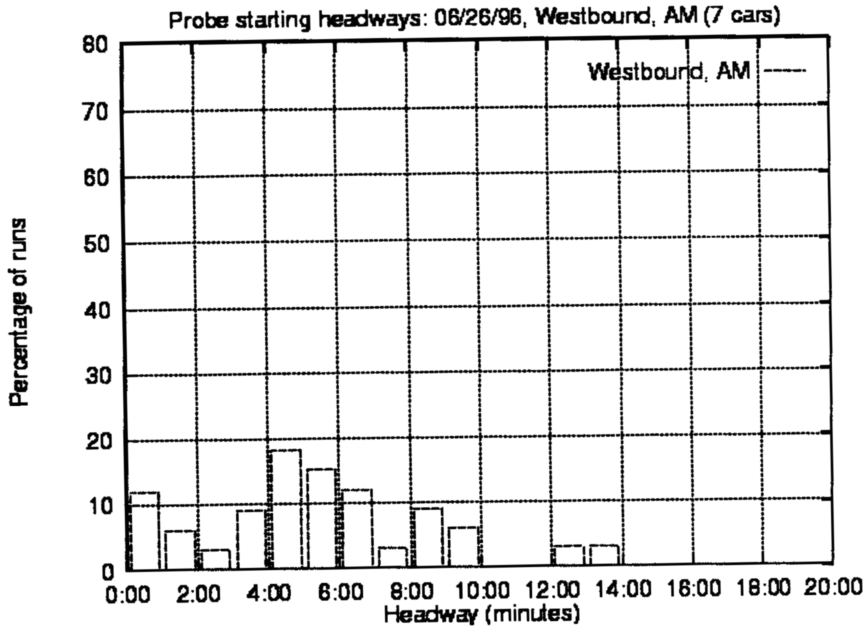
FIGURE 4-2 AUTOMATIC PROBE VEHICLE REPORT



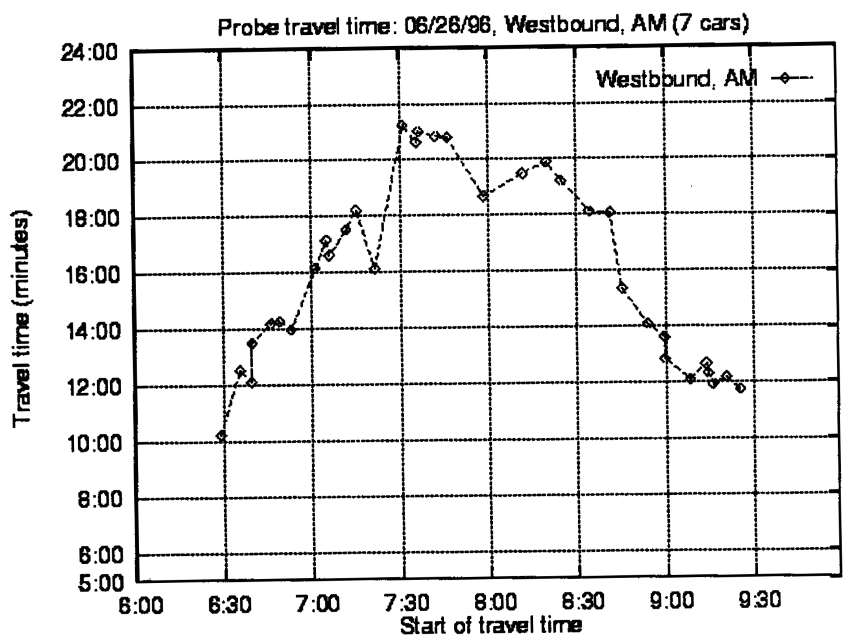
Westbound contour plot:



Westbound headway distribution:



Westbound travel time:



Detailed report of probe runs:

```
Summary for probe transfer Tran_6_26_96.b:
  Zip file seems intact
  Main zip file contains 7 files:
      file labeled 1 :  6/26 ->  car 1
      file labeled 2 :  6/26 ->  car 2
          WARNING: Multiple sub-directories (using 062696a2)
      file labeled 3 :  6/26 ->  car 3
      file labeled 4 :  6/26 ->  car 4
          WARNING: Multiple sub-directories (using 062696a4)
      file labeled 5 :  6/26 ->  car 5
      file labeled 6 :  6/26 ->  car 6
```

file labeled 7 : 6/26 -> car 7

Summary of probe vehicle activity:

Car	Date	Driver		Calibration	# Runs (# Incs) rt10-e	# Runs (# Incs) rt10-w
1	6/26	SANTIAGO	, ROBERT	0.820	5 (16)	7 (27)
2	6/26	SANTIAGO	, ISABEL	0.823	2 (2)	3 (5)
3	6/26	CASTILLO	, ANGIE	0.815	5 (12)	6 (19)
4	6/26	CUMMINGS	, MIKE	0.821	6 (6)	6 (12)
5	6/26	TORRES	, HECTOR	0.832	6 (5)	5 (5)
6	6/26	MCGREGOR	, DAX	0.835	6 (4)	5 (5)
7	6/26	ZELADA	, ANDY	0.882	4 (3)	4 (7)

Detailed summary of every run:

****

CAR: 1, SANTIAGO, ROBERT, 6/26

Run	Start time	Duration	Total Distance	Speed	#Incs	INCIDENTS Num	INCIDENTS Time	INCIDENTS Loc
rt10-e								
1	6:43:59	428 (0:07:08)	39237 (7.43)	62.5	3			
						1	179	16215
						2	213	19318
						3	417	38354
2	7:12:54	402 (0:06:42)	39199 (7.42)	66.5	2			
						1	195	19254
						2	377	37285
3	7:41:25	464 (0:07:44)	39270 (7.44)	57.7	5			
						1	81	7811
						2	99	9341
						3	210	19460
						4	265	24064
						5	437	37338
4	8:22:49	621 (0:10:21)	39279 (7.44)	43.1	4			
						1	5	389
						2	40	3182
						3	102	7791
						4	360	19244
5	9:02:26	481 (0:08:01)	39293 (7.44)	55.7	2			
						1	85	7714
						2	117	10712
rt10-w								
1	6:29:27	613 (0:10:13)	36030 (6.82)	40.1	2			
						1	345	22323
						2	597	35021
2	6:53:38	838 (0:13:58)	35979 (6.81)	29.3	2			
						1	492	22284
						2	824	35080
3	7:21:56	967 (0:16:07)	35995 (6.82)	25.4	5			
						1	212	11307
						2	285	14219
						3	316	15199
						4	549	22316
						5	951	35020
4	7:59:06	1120 (0:18:40)	36029 (6.82)	21.9	2			
						1	747	22331
						2	1101	34831
5	8:20:53	1 (0:00:01)	0 (0.00) B	0.0	7			
						1	0	0
						2	0	0
						3	0	0
						4	0	0
						5	0	0

Run	Start time	Duration	Total Distance		Speed	#Incs	Num	Time	Loc
							6	0	0
							7	0	0
6	8:41:47	1084 (0:18:04)	36054 (6.83)		22.7	5			
							1	555	16691
							2	596	17680
							3	616	18242
							4	670	19866
							5	790	23305
7	9:16:41	715 (0:11:55)	35977 (6.81)		34.3	4			
							1	310	17739
							2	312	17832
							3	349	19427
							4	407	22513

****

CAR: 2, SANTIAGO, ISABEL, 6/26

Run	Start time	Duration	Total Distance		Speed	#Incs	INCIDENTS Num	Time	Loc
rt10-e									
1	8:27:16	458 (0:07:38)	39217 (7.43)		58.4	1			
							1	93	9165
2	9:05:34	437 (0:07:17)	39256 (7.43)		61.2	1			
							1	120	10860
rt10-w									
1	8:04:26	1196 (0:19:56)	39414 (7.46)	B	22.5	2			
							1	690	22268
							2	1119	34409
2	8:45:49	921 (0:15:21)	35987 (6.82)		26.6	3			
							1	69	4903
							2	515	19073
							3	616	22446
3	9:15:00	738 (0:12:18)	36253 (6.87)		33.5	0			

****

CAR: 3, CASTILLO, ANGIE, 6/26

Run	Start time	Duration	Total Distance		Speed	#Incs	INCIDENTS Num	Time	Loc
rt10-e									
1	6:53:11	404 (0:06:44)	39584 (7.50)		66.8	2			
							1	172	16469
							2	383	37746
2	7:20:24	408 (0:06:48)	39581 (7.50)		66.1	1			
							1	81	8124
3	8:00:17	444 (0:07:24)	40417 (7.65)	H	62.1	4			
							1	8	672
							2	93	8221
							3	403	37771
							4	403	37771
4	8:34:59	423 (0:07:03)	39519 (7.48)		63.7	2			
							1	90	8218
							2	209	19575
5	9:11:58	422 (0:07:02)	39610 (7.50)		64.0	3			
							1	91	8151
							2	330	31355
							3	399	37727
rt10-w									
1	6:36:02	751 (0:12:31)	36037 (6.83)		32.7	2			
							1	426	22336
							2	687	32416
2	7:01:54	969 (0:16:09)	36054 (6.83)		25.4	2			
							1	531	22375
							2	749	28283
3	7:31:41	1274 (0:21:14)	36047 (6.83)		19.3	3			
							1	359	13912
							2	482	16729

Run	Start time	Duration	Total Distance	Speed	#Incs	Num	Time	Loc
						3	763	22309
4	8:12:25	1169 (0:19:29)	36031 (6.82)	21.0	3			
						1	543	18266
						2	726	22346
						3	1146	34541
5	8:54:31	844 (0:14:04)	36049 (6.83)	29.1	4			
						1	415	16706
						2	500	19504
						3	556	22387
						4	835	35494
6	9:21:04	730 (0:12:10)	36041 (6.83)	33.7	5			
						1	256	16703
						2	272	17780
						3	292	18445
						4	350	19484
						5	404	22381

****

CAR: 4, CUMMINGS, MIKE, 6/26

Run	Start time	Duration	Total Distance	Speed	#Incs	INCIDENTS Num	Time	Loc
rt10-e								
1	6:31:04	414 (0:06:54)	39150 (7.41)	64.5	0			
2	6:55:20	441 (0:07:21)	39168 (7.42)	60.6	1			
						1	179	16247
3	7:27:44	419 (0:06:59)	39221 (7.43)	63.8	1			
						1	89	8010
4	8:05:02	427 (0:07:07)	39234 (7.43)	62.6	2			
						1	16	1547
						2	89	7887
5	8:42:41	444 (0:07:24)	39169 (7.42)	60.2	1			
						1	91	7908
6	9:16:40	435 (0:07:15)	39285 (7.44)	61.6	1			
						1	85	7818
rt10-w								
1	6:39:54	727 (0:12:07)	35934 (6.81)	33.7	2			
						1	429	23252
						2	672	32240
2	7:06:40	996 (0:16:36)	36018 (6.82)	24.7	2			
						1	95	7781
						2	780	28162
3	7:36:54	1260 (0:21:00)	35929 (6.80)	19.4	1			
						1	673	20316
4	8:20:18	1193 (0:19:53)	35673 (6.76)	20.4	2			
						1	203	7845
						2	1165	34154
5	9:00:02	816 (0:13:36)	35937 (6.81)	30.0	3			
						1	363	16563
						2	389	17664
						3	807	35359
6	9:25:47	704 (0:11:44)	35862 (6.79)	34.7	2			
						1	309	18281
						2	584	29720

****

CAR: 5, TORRES, HECTOR, 6/26

Run	Start time	Duration	Total Distance	Speed	#Incs	INCIDENTS Num	Time	Loc
rt10-e								
1	6:30:28	404 (0:06:44)	39960 (7.57) H	67.4	1			
						1	21	2235
2	6:56:47	405 (0:06:45)	39969 (7.57) H	67.3	0			
3	7:25:00	423 (0:07:03)	39994 (7.57) H	64.5	1			
						1	89	8054
4	8:04:26	419 (0:06:59)	39961 (7.57) H	65.0	1			

Run	Start time	Duration		Total Distance			Speed	#Incs	Num	Time	Loc
									1	87	8048
5	8:46:25	446	(0:07:26)	39998	(7.58)	H	61.1	1			
									1	89	8010
6	9:15:44	441	(0:07:21)	40127	(7.60)	H	62.0	1			
									1	93	8019
rt10-w											
1	6:40:09	810	(0:13:30)	36645	(6.94)		30.8	0			
2	7:05:31	1028	(0:17:08)	36619	(6.94)		24.3	1			
									1	852	29084
3	7:36:07	1237	(0:20:37)	36621	(6.94)		20.2	1			
									1	660	20697
4	8:25:20	1153	(0:19:13)	36616	(6.93)		21.7	2			
									1	599	18596
									2	991	28894
5	9:00:13	770	(0:12:50)	36595	(6.93)		32.4	1			
									1	762	36078

****

CAR: 6, MCGREGOR, DAX, 6/26

Run	Start time	Duration		Total Distance			Speed	#Incs	INCIDENTS Num	Time	Loc
rt10-e											
1	6:36:24	402	(0:06:42)	38989	(7.38)		66.1	0			
2	7:03:42	402	(0:06:42)	38965	(7.38)		66.1	0			
3	7:32:14	409	(0:06:49)	39011	(7.39)		65.0	1			
									1	80	7705
4	8:11:46	429	(0:07:09)	38990	(7.38)		62.0	1			
									1	89	7934
5	8:56:09	405	(0:06:45)	38653	(7.32)	L	65.1	1			
									1	78	7805
6	9:24:11	398	(0:06:38)	37326	(7.07)	B	63.9	1			
									1	62	6113
rt10-w											
1	6:46:41	852	(0:14:12)	35728	(6.77)		28.6	0			
2	7:12:18	1050	(0:17:30)	35688	(6.76)		23.2	1			
									1	874	28369
3	7:42:43	1250	(0:20:50)	35806	(6.78)		19.5	1			
									1	1047	27880
4	8:35:03	1087	(0:18:07)	35730	(6.77)		22.4	2			
									1	488	16555
									2	682	20135
5	9:08:54	725	(0:12:05)	35754	(6.77)		33.6	1			
									1	343	19366

****

CAR: 7, ZELADA, ANDY, 6/26

Run	Start time	Duration		Total Distance			Speed	#Incs	INCIDENTS Num	Time	Loc
rt10-e											
1	6:39:28	408	(0:06:48)	39193	(7.42)		65.5	0			
2	7:06:45	385	(0:06:25)	39176	(7.42)		69.4	0			
3	7:36:11	388	(0:06:28)	39200	(7.42)		68.9	2			
									1	77	7727
									2	232	24029
4	8:15:19	419	(0:06:59)	39435	(7.47)		64.2	1			
									1	84	7776
rt10-w											
1	6:49:33	856	(0:14:16)	35926	(6.80)		28.6	1			
									1	460	22361
2	7:15:38	1092	(0:18:12)	35906	(6.80)		22.4	2			
									1	237	11317
									2	715	22284
3	7:46:44	1247	(0:20:47)	35923	(6.80)		19.6	2			
									1	550	18108
									2	1043	27966

4	9:14:18	758 (0:12:38)	36311 (6.88)	32.7	2			
						1	307	16628
						2	365	19084

Breakdown of distances (miles) for evaluation:

rt10-e:	bad	< 7.20 <	low	< 7.35 <	good	< 7.55 <	high	< 7.70 <	bad
rt10-w:	bad	< 6.60 <	low	< 6.75 <	good	< 6.95 <	high	< 7.10 <	bad

Evaluation of probe runs:

Car	Date	Driver	Calib.	Dir	#Runs	Bad	Low	Good	High
1	6/26	SANTIAGO, ROBERT	0.820	rt10-e	5	0	0	5	0
				rt10-w	7	1	0	6	0
2	6/26	SANTIAGO, ISABEL	0.823	rt10-e	2	0	0	2	0
				rt10-w	3	1	0	2	0
3	6/26	CASTILLO, ANGIE	0.815	rt10-e	5	0	0	4	1
				rt10-w	6	0	0	6	0
4	6/26	CUMMINGS, MIKE	0.821	rt10-e	6	0	0	6	0
				rt10-w	6	0	0	6	0
5	6/26	TORRES, HECTOR	0.832	rt10-e	6	0	0	0	6
				rt10-w	5	0	0	5	0
6	6/26	MCGREGOR, DAX	0.835	rt10-e	6	1	1	4	0
				rt10-w	5	0	0	5	0
7	6/26	ZELADA, ANDY	0.882	rt10-e	4	0	0	4	0
				rt10-w	4	0	0	4	0
TOTALS									
				rt10-e	34	1	1	25	7
				rt10-w	36	2	0	34	0
				TOTAL:	70	3	1	59	7

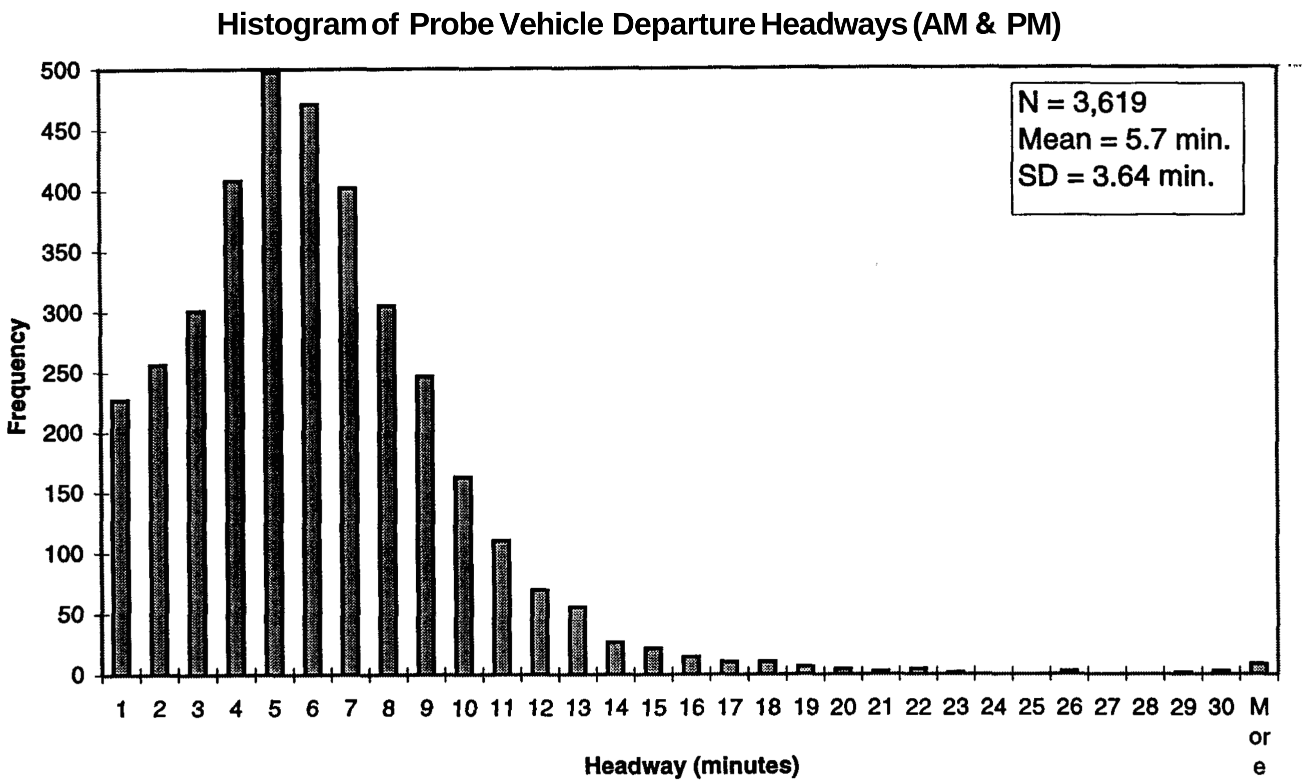
Starting headway statistics for this shift:

Date	Shift	Direction	Side	#Runs	Mean	Std Dev	Min	Max
6/26	Am	rt10-e	start	33	311.6	207.3	36	1132
6/26	Am	rt10-w	start	34	320.6	196.6	11	799

Ending headway statistics for this shift:

Date	Shift	Direction	Side	#Runs	Mean	Std Dev	Min	Max
6/26	Am	rt10-e	end	33	312.6	216.2	44	1112
6/26	Am	rt10-w	end	34	323.4	217.9	22	892

FIGURE 4-3


Histogram of Probe Vehicle Departure Headways (AM & PM)
N = 3,619
Mean = 5.7 min.
SD = 3.64 min.
Frequency
500
450
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 More
Headway (minutes)

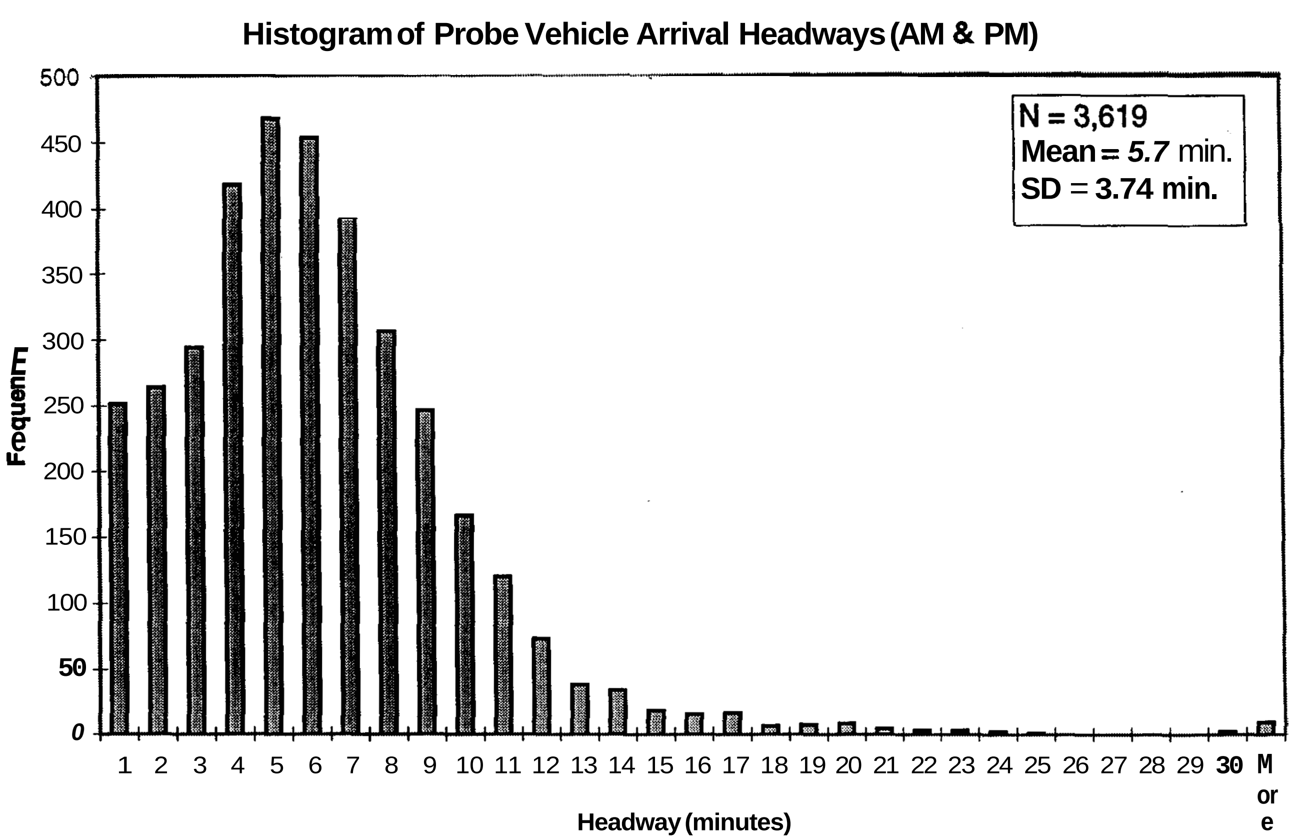

Histogram of Probe Vehicle Arrival Headways (AM & PM)
N = 3,619
Mean = 5.7 min.
SD = 3.74 min.
Frequency
500
450
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 More
Headway (minutes)

FIGURE 4-4 SAMPLE INCIDENT LOG

WILTEC - FSP SURVEY INCIDENT REPORT

BY: Andy DATE: 7-18-96 PERIOD: P.M. PAGE: 02/7

TIME	CAR NO	DIR	MILE NO	INCIDENT: DESCRIPTION	INCIDENT: VEHICLE	INCIDENT: ASSISTANCE	INCIDENT: REASON	INCIDENT: OTHER	INCIDENT: LOCATION
HR . MIN		E - EB W - WB		Color eg - Black White Blue, etc. Other eg - UPS RTA Ship Mark	MC - Motor Cycle Car Truck Van Semi - Semi Truck Bus	CHP POL - Other Police or Sheriff FT - Fire Truck FSP - Freeway Service Patrol PT - Private Tow AMB - Ambulance CT - CALTRANS	ACC - Accident BD - Break Down TKT - Ticket UNK - Unknown	PED - Pedestrian Debris Cones Flares Signs	HOV - HOV Lane DIV - HOV Divide Lane LS - Left Shldr Lane 1 Lane 2 Lane 3 Lane 4 RS - Right Shldr
410	06	WB	2.5	Blue	Car	FSP	BD		RS
410	06	WB	2.7			FSP			RS
413	10	WB	4.2	Brown	Toyota		Bd		RS
415	06	WB	5.5	Red	Truck		Study		RS
				Black	Truck				
				Red	Truck				
422	07	WB	2.5	Blue	Dodge		BD	1 Ped	RS
423	07	WB	4.1			FSP			RS
424	07	WB	4.8	White	Truck	FSP	BD	1 Ped	RS
425	07	WB	5.4	Red	Truck		Study		RS
				Black	Truck				
				Red	Truck				
428	02	EB	3.1	Grey	Mazda		BD		Lane 1
429	10	WB	4.1			FSP			RS
430	10	WB	5.4	Red	Truck		Study		RS

SAMPLE INCIDENT LOG

FIGURE 4-5 **FSP ASSIST FORM**

MOTORIST ASSIST FORM

Right / Wrong

DATE MO	DATE DAY	DATE YR	TIME ARRIVED	TIME DEPARTED	DRIVER ID	BEAT ID
		93				
		94				
		95				
		96				
		97				
		98				
		99				
		00				

USE MILITARY TIME

DISABLED VEHICLE LICENSE NO. — 1 California 2 Other

MOTORIST NAME

MOTORIST ADDRESS (optional)

LOCATION OF DISABLED VEHICLE

LOCATION DISABLED VEHICLE TOWED TO

How long did motorist wait for (you) the Freeway Service Patrol?

Fill in the number of minutes →

D'd you tow vehicle to:
Shoulder 2 Off Freeway 3 No Tow

Di the motorist need additional assistance?
Yes 2 No

At what speed was traffic traveling prior to this assist?
under 20 mph 2 21 to 30 mph 3 31-40 mph 4 above 40 mph

Problem with the vehicle-
54 Out of Gas Heated 57 Flat Tire 60 Accident
52 Electrical Problem 55 Vehicle Fire 58 Locked Out 61 Abandoned
53 Debris Removal 56 Mechanical Problem 59 Other 62 Unknown

Type of vehicle assisted:
1 Auto 2 Van 3 Pickup 4 Truck less than 1 ton 5 Truck more than 1 ton
6 Motorcycle 7 Big Rig 8 No assist due to oversize 9 Other

Vehicle location was:
Found By You 2 Dispatched By CHP 3 Dispatched By Caltrans

Disabled vehicle was:
1 In Freeway Lanes 2 On Left Shoulder
4 On A Ramp 5 Other 3 On Right Shoulder 6 Unable to Locate

TURN OVER TO COMPLETE

239734

DO NOT MARK IN THIS AREA

FIGURE 4-6 **PROBE VEHICLE SPEED CONTOURS**

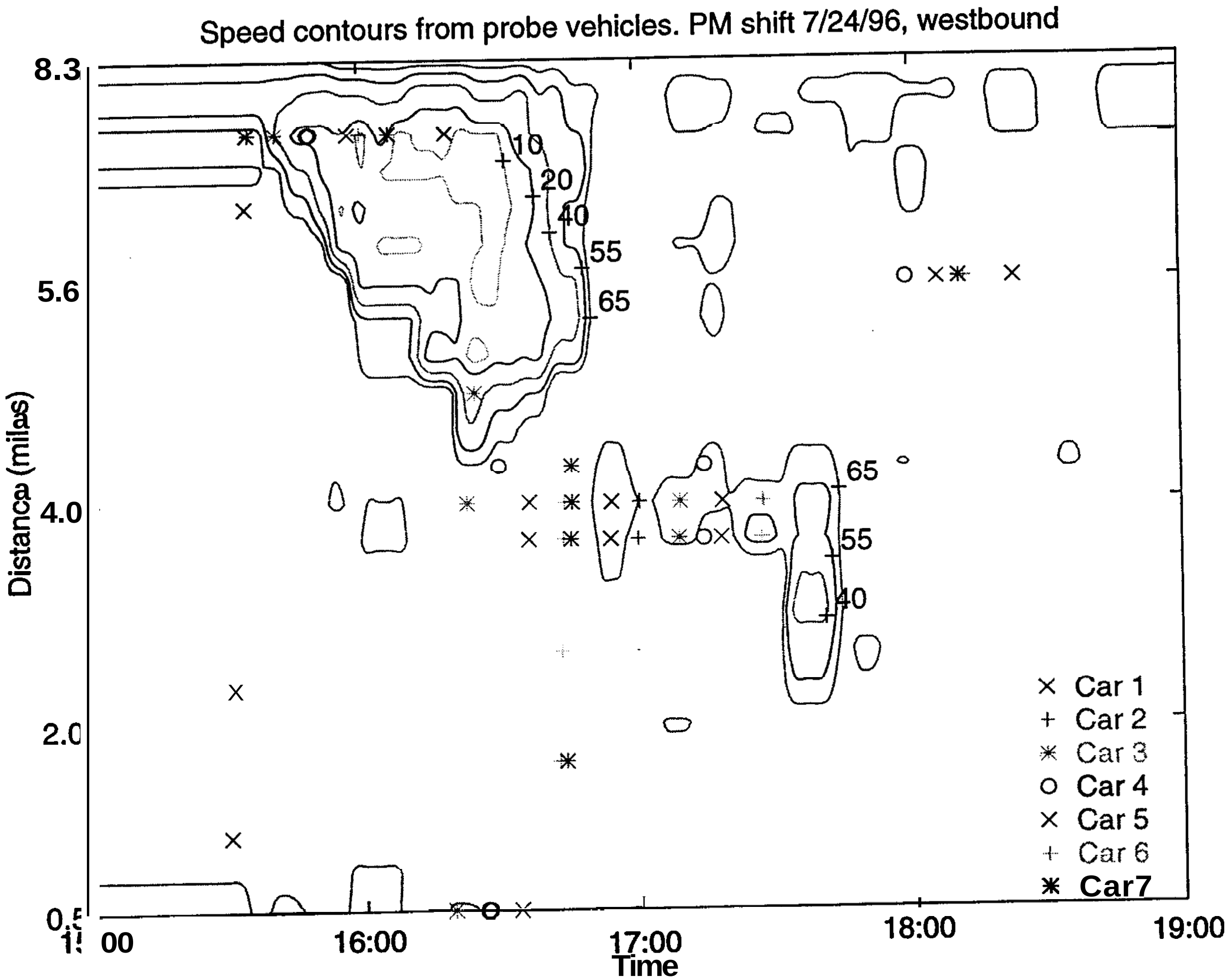
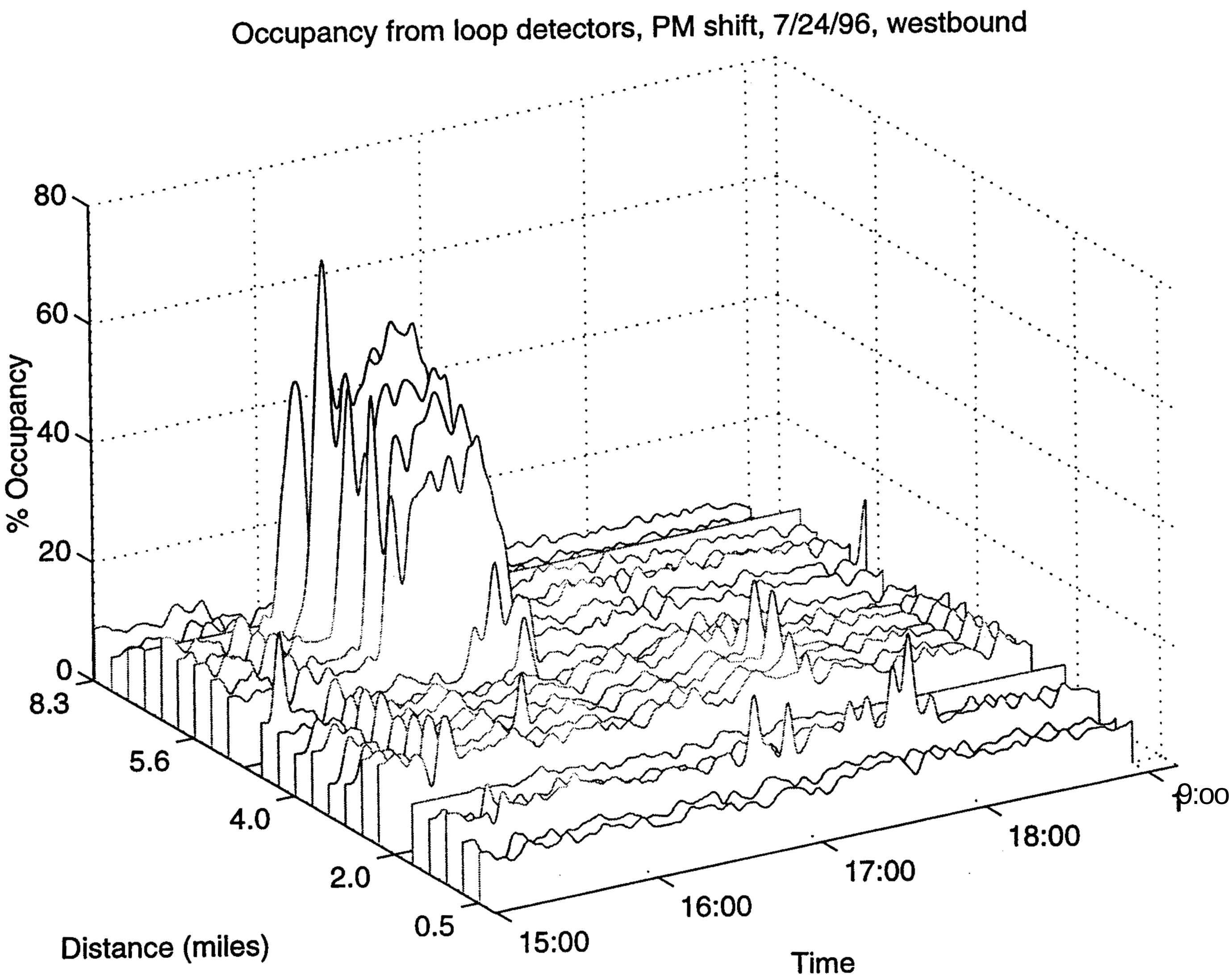


FIGURE 4-7 **LOOP DETECTOR OCCUPANCY**



REFERENCES

1. Skabardonis, A., H. Noemi, **K.** Petty, D. Rydzewski, P. Varaiya, and H. Al-Deek, 1995, "Freeway Service Patrol Evaluation," PATH Research Report, UCB-ITS-PRR-95-5, Institute of Transportation Studies, University of California at Berkeley.

2. Skabardonis, A., **K.** Petty, H. Noemi, D. Rydzewski, and P. Varaiya, 1996, "The I-880 Field Experiment: Database Development and Incident Delay Estimation Procedures,'' Transportation Research Record 1554, Washington D.C., 1995.

3. Skabardonis, A., K. Petty, R. Bertini, P. Varaiya, H. Noemi, and D. Rydzewski, 1997, "The 1-880 Field Experiment: Analysis of the Incident Data," Presented at the 76th Annual Meeting of the Transportation Research Board, Washington, D.C.

4. California Department of Transportation District 7, 1992, "Los Angeles County Metro Freeway Service Patrol 1992 Annual Report," Los Angeles.

5. **K.** Petty, A. Skabardonis, R. Bertini, "The Los Angeles Freeway Service Patrol Evaluation: Methodology and Preliminary Findings," California PATH Working Paper, UCB-ITS-PWP-97-X, University of California at Berkeley, 1997.

6. Finnegan, **S.,** "Estimating Freeway Service Patrol Assists," Master's Project, University of California, Los Angeles, 1992.

7. Cheu, R., N. Prosser, and **S.** Ritchie, **"A** User Guide to Reading Data Tapes From the **Los** Angeles Freeway System," **ITS** Irvine Special Report, University of California, Irvine, March 1992.

8. R. Bertini, L. Klieman, K. Petty, **A.** Skabardonis, "The Los Angeles Freeway Service Patrol Evaluation: Analysis of the Incident Data," California PATH Working Paper, UCB-ITS-PWP-97-X, University **of** California at Berkeley, 1997.