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16. Abstract A considerable amount of time and effort are being spent by Department personnel to prepare Traffic Control Plans (TCPs). Thus, there is a need to evaluate TCP procedures and identify needed improvement. In addition, the complexity of reconstruction work zones requires that a variety of traffic handling approaches both standard and innovative be utilized.  Toward these ends, data were collected by a series of visits to several work zone sites in Texas, interviews with numerous District personnel, review of several TCPs for worksites in Texas and several field studies. Also, the study staff worked with District 12 (Houston) in organizing a Special Traffic Handling Crew, and in developing and implementing work zone traffic management strategies.  This is the third and final report in a 3-report series. The other reports are listed below											
<table border="1"> <thead> <tr> <th>Report</th> <th>Title</th> </tr> </thead> <tbody> <tr> <td>321-1</td> <td>Catalog of Traffic Control Strategies and Devices</td> </tr> <tr> <td>321-2</td> <td>Guidelines for Preparing Work Zone Traffic Control Plans (Unpublished)</td> </tr> </tbody> </table>						Report	Title	321-1	Catalog of Traffic Control Strategies and Devices	321-2	Guidelines for Preparing Work Zone Traffic Control Plans (Unpublished)
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EVALUATION OF TRAFFIC CONTROL PLANS  
AT RECONSTRUCTION SITES

by

Conrad L. Dudek

and

Stephen H. Richards

Research Report 321-3F  
Research Study Number 2-18-82-321  
Evaluation of Traffic Control Plans at Reconstruction Sites

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January 1986

TEXAS TRANSPORTATION INSTITUTE  
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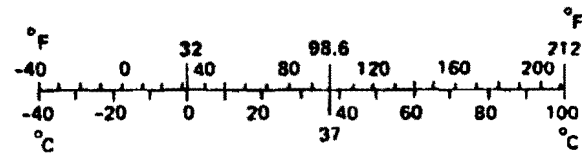
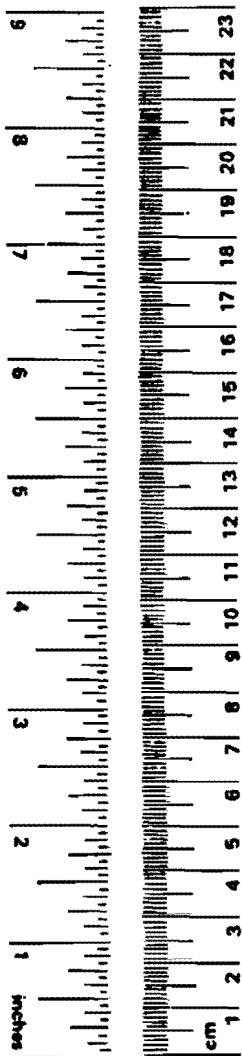
## METRIC CONVERSION FACTORS

### Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
<b>VOLUME</b>				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

### Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	35	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



\* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10:286.



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The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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## 1. INTRODUCTION

In October 1978, the Federal Highway Administration adopted a policy (FHPM 6-4-2-12) requiring a formal Traffic Control Plan (TCP) be developed for all federal-aid highway construction projects (1). In response to FHPM 6-4-2-12, the SDHPT adopted a consistent policy on work zone TCPs (2). The Department policy, however, goes beyond the federal requirements. It requires a TCP on all construction projects, not just federal-aid projects. The policy also states that a TCP should be utilized on all maintenance activities. A considerable amount of time and effort are being spent by the Districts to prepare TCPs. Thus, there is a need to evaluate TCP procedures and identify needed improvements.

Traffic control is particularly critical at highway reconstruction work zones. The complexity of reconstruction work zones requires that a variety of traffic handling approaches, both standard and innovative, be utilized. The effectiveness of these traffic handling approaches needs to be evaluated and documented so that the best techniques can be readily adopted.

### Objectives

The primary objectives of Study 321 were as follows:

1. Identify innovative traffic management approaches being used at work zones in Texas,
2. Evaluate the effectiveness of some aspects of TCPs and develop recommendations and guidelines for developing and implementing effective TCPs at reconstruction projects,
3. Identify improved ways of transferring new information on traffic management techniques to Resident Engineers in Texas,
4. Determine a more effective means of developing and implementing traffic management strategies for planned and emergency work zones.

Information for the first 3 objectives was obtained by a series of visits at several work zone sites in Texas, interviews with numerous District personnel, review of several TCPs for worksites in Texas and several field studies. For the fourth objective, the Study staff worked with District 12 in organizing a Special Traffic Handling Crew, and in developing and implementing work zone traffic management strategies.

This Final Report is divided into four chapters in addition to Chapter 1. Chapter 2 is a catalog of several traffic control strategies and devices appropriate for freeway work zones. Chapter 3 summarizes current District practices regarding TCPs, District problems in preparing TCPs and possible solutions, and recommendations for improved procedures, methods and guidelines for preparing TCPs. Chapter 4 summarizes the results of field studies conducted at 3 major reconstruction projects in Texas. Chapter 5 discusses the development of a Special Traffic Handling Crew in District 12 (Houston).

## 2. CATALOG OF TRAFFIC CONTROL STRATEGIES AND DEVICES

### Introduction

This chapter summarizes Report 321-1 (3), which is a catalog of several traffic control strategies and devices appropriate for freeway work zones. The strategies and devices were identified during field studies and interviews conducted at numerous freeway work zones in Houston, Dallas, Fort Worth, San Antonio, Austin and Amarillo, and reviews of several TCPs prepared by various Districts. The reader is encouraged to review Report 321-1 for details.

A total of 21 strategies and devices were identified, and a brief description of each one is presented in the following sections. The 21 strategies/devices, grouped by major topic area, are listed below for reference:

#### Innovative Traffic Management Strategies

- Short-Term Total Freeway Closure
- Traffic Splitting

#### Supplemental Traffic Management Strategies

- Shoulder Use
- Speed Control
- Temporary Entrance Ramp Closures
- Narrow Lanes
- Load Zoning

#### Motorist Information Devices

- Arrowboards
- Portable Changeable Message Signs
- Highway Advisory Radio
- Special Lane-Blocked Sign
- Special Word Message Pavement Marking

## Traffic Control Services

- Flagging
- Law Enforcement

## Safety Hardware

- Portable Roadside Barriers
- Crash Cushions
- Temporary Lighting

## Implementation

- Corridor Management Team
- Special Traffic Handling Crew
- Advance Notification
- Photographic Documentation

## **Short-Term Total Freeway Closure**

Certain types of maintenance activities (e.g., bridge joint repair, overhead sign work, pavement repairs, etc.) and construction must be performed across several lanes which may require short-term total freeway closures. Total closures may also be used to perform several maintenance activities simultaneously.

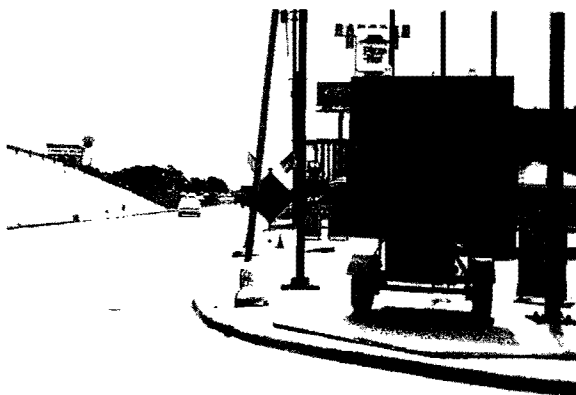
Freeway closures have been implemented in several cities with success. Success, however, depends on proper scheduling, good coordination, advance notification and adequate traffic control on the freeway and along the detour route.

## **Traffic Splitting**

When work is required on the middle lane of a three-lane section, generally both the middle lane and one of the exterior lanes are closed. This traffic control strategy greatly reduces work zone capacity and, thus, can result in severe congestion when traffic volumes are heavy.



Freeway Closure



Traffic Splitting

Figure 1. Innovative Traffic Management Strategies

If there are shoulders at the worksite, a shoulder-use strategy may be used to increase the capacity of the work zone. However, if there are no shoulders or the shoulders are too narrow, traffic splitting may be considered. Using this approach, the left lane is first closed in order to move traffic into two lanes, and then traffic is "funnelled" or "split" to both sides of the resulting island work zone.

Using the traffic splitting strategy, work zone capacities up to 3000 vehicles per hour have been observed. This is approximately double the capacity of a conventional two-lane closure.

Based on studies conducted in Houston, traffic splitting can be accomplished safely if proper traffic control is used. It is recommended, however, that the strategy be used only at relatively short work zones so that drivers entering and exiting at ramps are not tempted to weave through the closed middle lane.

### **Shoulder Use**

Generally, when maintenance work is performed in a middle (or interior) freeway lane, both the middle lane and one of the exterior lanes are closed. This provides a large protected workspace, but the multilane closure greatly reduces capacity. Severe congestion can occur when traffic volumes are heavy.

If there are shoulders present at the work zone, they may be utilized temporarily as a travel lane in order to increase work zone capacity. Shoulder-use, as it is called, is most applicable to long work zones where congestion would develop if two lanes were closed.

Shoulder-use has been used successfully at several maintenance work zones in Houston and Los Angeles. Studies have shown that, with the proper traffic





Shoulder Use



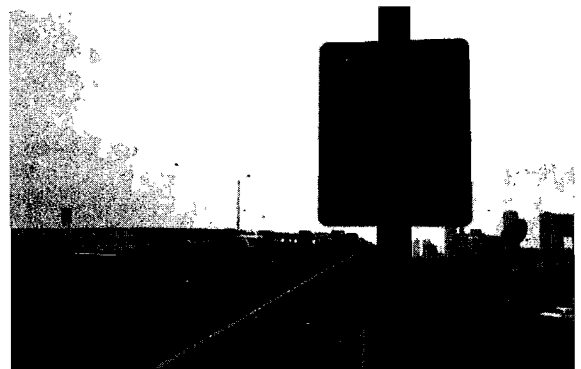
Speed Control



Entrance Ramp Closures



Narrow Lanes



Load Zoning

Figure 2. Supplemental Traffic Management Strategies

control, drivers will begin using the shoulder whenever minor congestion occurs. As traffic demand volumes increase, more and more drivers will move to the shoulder. Under heavy flow conditions, a 10-foot shoulder can carry up to 1500 vehicles per hour, thus greatly increasing work zone capacity. Shoulder-use may be encouraged by a flagger directing motorists' attention to the signs.

### **Speed Control**

Excessive speeds at freeway work zones can adversely effect the safety of the work crew and motorists. Studies have shown that standard regulatory and advisory speed signs generally do not slow work zone speeds, thus some type of active speed control may be needed in the interest of safety.

Active control refers to techniques which restrict movement, display real-time dynamic information, or enforce compliance to a posted speed limit. Active speed control techniques include: flagging, changeable message signs (CMSs), law enforcement, and lane width reduction.

Every effort should be made to design work zones to safely accommodate traffic at normal speeds. When it is impossible or impractical to accomplish this goal, safe, effective and economical means should be used to reduce speeds to the appropriate level. At urban freeway work zones, maximum speed reductions of 5 to 10 mph can be expected.

Speed reductions should be aimed at decreasing the number and severity of work zone accidents, or the potential for accidents at sites where speed-related hazards exist. The overuse, prolonged use, or misuse of speed control techniques will damage their credibility and reduce their general effectiveness.

### **Temporary Entrance Ramp Closures**

Entrance ramps in a freeway work area may be closed to protect the work crew and facilitate the work activity. At freeway work zones with insufficient capacity, entrance ramps at and upstream of the work zone may also be closed to decrease mainlane traffic flow, and thus reduce congestion.

A ramp should be closed only as long as needed (i.e., while the work activity occupies the ramp area or demand volumes on the mainlanes exceed the work zone capacity). Changes in work and traffic conditions should be constantly monitored so that ramps can be opened and closed at the critical time. If ramps are left closed too long or too many ramps are closed at one time, severe congestion may develop on the frontage road.

Whenever an entrance ramp closure is anticipated, motorists should be notified in advance of the closure. Special signing may be installed at the ramp as the most direct means of advance notification. Newspaper releases and radio reports are also effective.

### **Narrow Lanes**

At freeway reconstruction work zones, it is sometimes difficult to provide the necessary work space and still keep enough lanes open to prevent serious congestion. In these situations, the use of narrow lanes may be considered. Lanes between 10 and 11 feet have been used at several freeway reconstruction work zones. Lanes as narrow as 9 1/2 feet have been used on I-45 in downtown Houston. Since the prolonged use of narrow lanes must be approved by FHWA, adequate justification should accompany the request or TCP as appropriate.

Studies have shown that drivers slow down as they travel through narrow sections; however, only moderate speed reductions (i.e., up to 5 mph) can be expected. In addition, speed variance increases in narrow lane sections.

The capacity of narrow lane sections will depend upon the location of the work crew and work zone geometry, capacities up to 1800 vehicles/hour/lane have been observed at long-term reconstruction sites.

### **Load Zoning**

It may be desirable to prohibit large and/or heavy vehicles from traveling through some freeway reconstruction work zones. This may be effectively accomplished by "load zoning" the work area. Load zoning simply means that vehicles of a certain size or weight are restricted from using a stretch of roadway (i.e., these vehicles must use another route).

There are many work zone situations which may warrant load zoning. Some of the most common ones are cited below:

1. If normal traffic demand exceeds work zone capacity, the level of service at the work zone may be improved by encouraging larger trucks to use other routes.
2. Some work zones may not have sufficient pavement strength to handle heavy trucks and buses (e.g., work zones where traffic is diverted to the frontage road or onto a temporary bypass).
3. Some work zones may possess severe design limitations (e.g., narrow lanes, steep grades, no shoulders, etc.). Traffic safety and operations at these sites may be improved by prohibiting large vehicles.

Load zoning must be enforced to be effective. Thus, it is essential that any load zoning effort be coordinated with the appropriate law enforcement agency. The permit office in the District may have additional requirements

and needs to coordinate Truck Routings given by D-18P in order to fully assist the load zone designer in checking alternate routes.

Load zoning has been used very effectively at freeway reconstruction work zones in Houston and near Beaumont. Compliance rates of 97 to 99 percent were achieved. When trucks or other traffic are diverted, detour signing should be installed on the entire stretch of the detour route so that the affected drivers have sufficient information to navigate the route.

### **Arrowboards**

Arrowboards are one of the most effective devices for closing lanes at freeway work zones. They are interpreted by drivers to mean that a lane closure is ahead.

Arrowboards encourage drivers to leave a closed lane sooner than the normal complement of signs and channelizing devices. They are highly visible and can be seen from great distances, making them particularly appropriate for high-speed and high-density conditions.

There are two common types of arrowboards: 1) flashing arrow and 2) sequential arrow. Although they may be used interchangeably, only one type should be used on a given project. In addition, both types can operate in a warning mode (i.e., the four corner lights are flashed as a general warning).

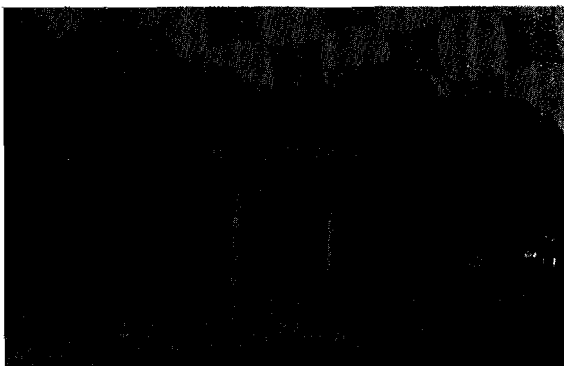
Arrowboards are generally used for day or night lane closures and slow-moving maintenance and construction activities. Guidelines for the use of arrowboards in these situations are presented in Sections 6E-7 through 6E-9 in the Texas MUTCD and on BC (6)-82.



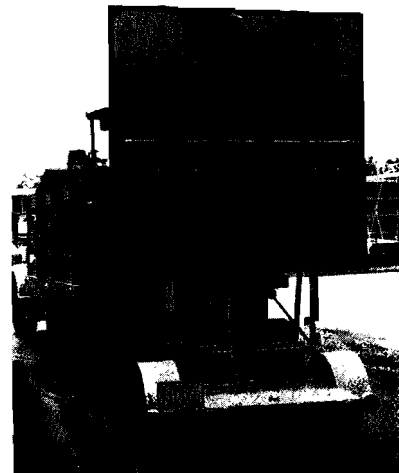
Arrowboards



Portable Changeable Message Signs



Highway Advisory Radio



Special Lane-Blocked Sign

Figure 3. Motorist Information Devices

Arrowboards are intended to supplement other work zone traffic control devices. They will not solve difficult traffic problems by themselves, but can be very effective when properly used to reinforce signs, barricades, cones, and other traffic control devices.

### **Portable Changeable Message Signs**

CMSs refer to those signs capable of displaying different messages in response to changing conditions. Types of CMSs include: bulb matrix, disk matrix, rotating drum, tri-color and scroll.

In recent years, CMSs have been made portable by placing them on trailers or pickup trucks. Portable CMSs provide the flexibility to display highlighted information at critical locations in work zones.

Bulb matrix signs are the most commonly used CMSs at freeway work zones. Currently, one-line and three-line portable bulb matrix signs are commercially available. One-line signs are well suited where messages containing 4 words or less will be displayed. Three-line signs can display more information to drivers, and therefore have greater flexibility and utility.

CMSs can perform a critical role at urban freeway work zones by furnishing drivers with real-time warnings of problems and unexpected conditions, and advising them of the best course of action. CMSs are especially useful in the following work zone situations:

1. New detours.
2. Change in detours.
3. Introduction of a lane drop where a continuous lane once existed.
4. Special speed control measures.
5. Periodic use of flaggers, and

6. Location where sight distance is restricted and congestion occurs due to a lane closure.

### **Highway Advisory Radio**

HAR is a special radio tool that can be used to give motorists up-to-the minute travel information via their AM radios. Work zone warnings, advisories and route directions can be broadcast. HAR messages are transmitted from low-power roadside transmitters. An advance highway sign advises drivers where to set the tuning dial to receive the message.

HAR should supplement, not replace, standard traffic control devices used in freeway work zones. HAR should be used for the unusual situations that occur which cannot be handled by the static traffic control devices (e.g., intermittent presence of traffic queues, changing requirements for diversion, etc.).

All HAR installations must be licensed by the Federal Communication Commission (FCC).

The only documented use of HAR at a work site in Texas was at reconstruction work on I-10 near Beaumont in Chambers County. Some of the findings on a questionnaire survey were as follows:

1. Only 30% of the drivers reported they tried to tune to the HAR station.
2. Approximately 49% of the drivers who did not tune to the station did not see the advance signing for the HAR.
3. Nearly 20% of the drivers said they were very familiar with the work zone and simply did not desire to tune to the HAR broadcasts.

The advance sign is very critical to a successful HAR system. It must be very visible and have large letters. It must not be "lost" in the middle of



other construction zone signs. Two advance signs may be used where room permits.

### **Special Lane-Blocked Sign**

Drivers need advance warning of lane closures or temporary blockages so they can move into an open lane prior to the point of closure or blockage. On multilane facilities (e.g., freeways, frontage roads and arterial streets) having up to three lanes per direction, the conventional Advance Lane Closed Sign (CW 20-5) can be used for left and right lane closures. Closure of the center lane is more difficult to communicate. With the increased use of the "traffic split" traffic control technique there is a need to effectively describe the center lane closure to drivers.

The communication problem is compounded when there are four or more lanes per direction. Word descriptors like LEFT, CENTER and RIGHT are ambiguous to drivers in designating lane closures in these cases, therefore, signing can become a problem.

The need for advance warning of lane closures also exists for moving maintenance operations on freeways. Generally, no advance notification of a lane blockage is given. On urban freeways, advance notification of which lane is closed could minimize operational problems.

A special lane-blocked sign was developed by TTI and SDHPT and built by District 12 to more effectively communicate lane closures or blockages to drivers. The sign identifies the number of lanes and specifically illustrates which lanes are closed or blocked with a large "X" mounted under the lane number. The lane numbers and Xs are removable to provide flexibility regardless of the number of lanes on the facility and the number of lanes

closed. The sign was developed based on national human factors studies of driver understanding of lane closure messages. It has been approved for use in Texas on an experimental basis on sections where three or more lanes exist in the direction of work.

### **Special Word-Message Pavement Marking**

At major freeway reconstruction work zones, there are typically many detours, lane closures, ramp closures and other complicated driving conditions. Conventional signing and channelizing devices are used to warn motorists of these conditions and guide them safely through the work zone. However, it is often difficult and/or impractical to place enough signing channelizing devices at the ideal locations within the cluttered work zone environment. In these situations, special word-message pavement markings may be used to supplement the conventional signing and channelization.

Word and symbol markings on the pavement may be used for the purpose of guiding, warning or regulating traffic at freeway work zones. Requirements and limitations on the use of these markings are presented in Section 3B-17 of the Texas MUTCD. Wide stripes have been used successfully at gore areas to enhance traffic operations.

District 15 used special word-message pavement markings at the Fratt Interchange reconstruction work zone in San Antonio. The word-message markings were installed at major decision points (e.g., in advance of freeway-to-freeway connector ramps) to designate the exit lanes versus the thru lanes. These markings were particularly helpful since the work activity made it

impossible to place overhead guide signing in the most desirable locations. The markings were apparently very effective, but they did require frequent maintenance.

### **Flagging**

At urban freeway work zones, flaggers may perform a variety of critical and somewhat unique traffic control functions, including the following:

1. Control traffic at frontage road intersections and along detour routes.
2. Close entrance and exit ramps.
3. Direct traffic through complicated work zones, onto shoulders, or at ramps within the work area.
4. Prevent illegal freeway access.
5. Alert traffic to special signing (and enhance motorist response to the signing).
6. Speed control.

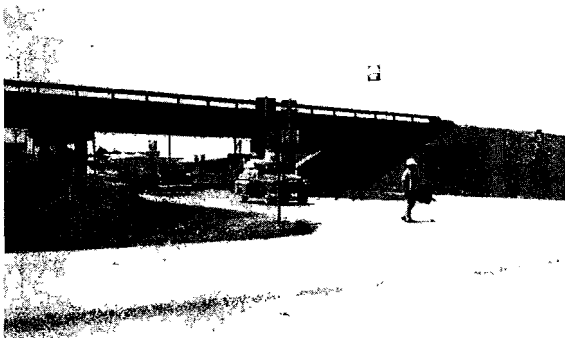
Normally, flaggers are best utilized at ramps and frontage road and detour route intersections. Flaggers should be used on the mainlanes only in special situations (e.g., for speed control), since they have difficulty conveying messages to high-speed traffic in several freeway lanes.

### **Law Enforcement**

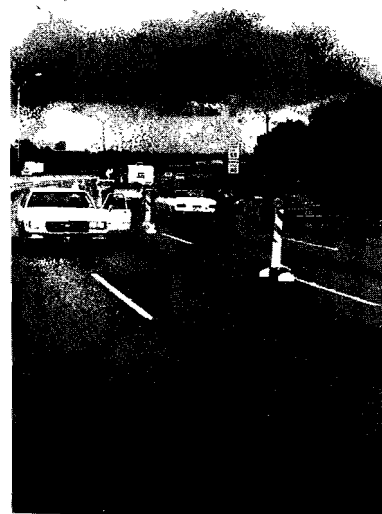
The presence of law enforcement personnel can have positive effects on traffic safety and flow at freeway work zones. Uniformed officers can perform a variety of useful services ranging from work site security patrol to manual traffic control. They can be particularly useful in performing the following traffic management duties:

1. Enforcement of work zone speed limits, load zones and frontage road parking prohibitions.
2. Control of illegal freeway access.
3. Ramp closures.
4. Manual traffic control at intersections and ramps.
5. Removal of accidents and stalls from the mainlanes and accident investigation.
6. Active speed control (e.g., radar enforcement or manual traffic control).

Law enforcement personnel should be enlisted to perform specific traffic control functions, (e.g., those listed above), and that they not be asked to merely "be present" at a work zone.



Flagging



Law Enforcement

Figure 4. Traffic Control Services

## **Portable Roadside Barriers**

Portable roadside barriers made of concrete or metal, are designed to contain and redirect errant vehicles. They may be used at freeway work zones to:

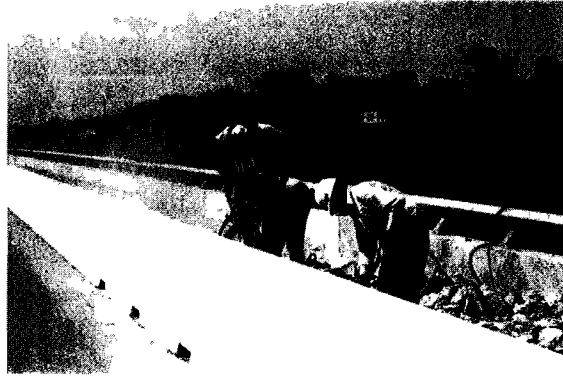
1. Keep traffic from entering work areas, excavations or material storage sites.
2. Provide positive protection for workers.
3. Separate two-way traffic, and
4. Protect construction such as falsework for bridges and other exposed objects.

At freeway reconstruction work sites, portable barriers are particularly valuable since they alleviate the need for additional buffer zones between traffic lanes and the work crew and equipment. Thus, more lanes can be kept open and the work zone capacity increased. The use of barriers also allows work to continue during the peak periods and at night if desired.

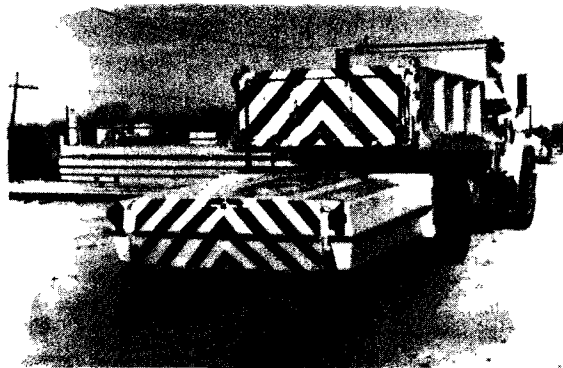
The effects of the portable roadside barriers on accidents have not been fully documented. An analyses of accidents at the Fratt I Interchange reconstruction project in San Antonio indicated that while the portable concrete barriers which were used extensively on this project may have resulted in a higher accident occurrence, the death and injury rates were reduced.

## **Crash Cushions**

Crash cushions are devices designed to absorb the energy of an impacting vehicle in a controlled manner such that the impact forces on the passengers are tolerable. Crash cushions can be used at freeway work zones to protect traffic from point hazards such as exposed barrier ends, bridge parapets and



Portable Roadside Barriers



Crash Cushions



Temporary Lighting

Figure 5. Safety Hardware

piers, falsework, etc. Crash cushions may also be mounted on work vehicles to protect the work crew, or on a shadow vehicle to shield a moving maintenance work activity.

There are several types of crash cushions available. Sand-filled plastic barrels, steel drums, or a "Guard Rail Energy Absorbing Terminal" are commonly used in work zones to protect point hazards.

Crash cushions should be designed to meet the needs of the particular location. The type and design will depend on the type, length, and width of the hazard. Crash cushion location and design should be incorporated into the Traffic Control Plan.

### **Temporary Lighting**

Most urban freeways have continuous roadway lighting. On reconstruction projects (e.g., freeway widening or transitway construction), the existing lighting units often must be turned off and relocated. During the time when the permanent lighting is inoperative, temporary lighting may be needed to minimize the nighttime accident potential. In fact, a study conducted in Austin on I-35 found that nighttime accidents may increase by more than 50 percent when urban freeway lighting is turned off.

Currently, there are no guidelines available on when or how to use temporary lighting at urban freeway work zones. The Texas MUTCD does, however acknowledge that such lighting may be beneficial.

Where temporary lighting is used, every effort should be made to provide the minimum lighting levels required for permanent lighting installations. In addition, the lighting units should be protected from vehicle impact by placing them behind temporary barriers or locating them at least 30 feet from

the travel lanes. If the units cannot be placed behind barriers or off the roadway, then break-away bases should be used.

District 15 used temporary lighting extensively on the Fratt Interchange reconstruction project in San Antonio. On this project, luminaires were mounted on wooden poles in the median. Power was supplied to lighting units by overhead wiring, and the units were protected from traffic by portable concrete barriers.

### **Corridor Management Team**

Major work activities on urban freeways can disrupt police, fire and emergency medical services, as well as local transit operations. They can also prompt more traffic to use the local street system resulting in severe congestion. It is therefore essential that freeway work activities be coordinated with the many local agencies which may be affected. The Corridor Management Team (or Traffic Management Team) provides an excellent means to achieve the needed coordination.

Several cities in Texas have established Corridor Management Teams. As of this writing, Corridor Management Teams are active in Beaumont, Corpus Christi, Fort Worth, Houston, Lubbock, Midland-Odessa, San Antonio, and Wichita Falls. Austin is in the process of forming a team. These teams consist of representatives from the city transportation department, SDHPT, District office, local police agencies, transit agencies and other groups involved in local transportation. The Corridor Management Team functions through formal meetings and informal channels to coordinate metropolitan traffic and transportation activities.



The Corridor Management Team, by discussing planned work activities, can anticipate potential problems and solve them before the work even begins. The team approach also allows the various agencies to coordinate their activities and to pool resources if necessary.

### **Special Traffic Handling Crew**

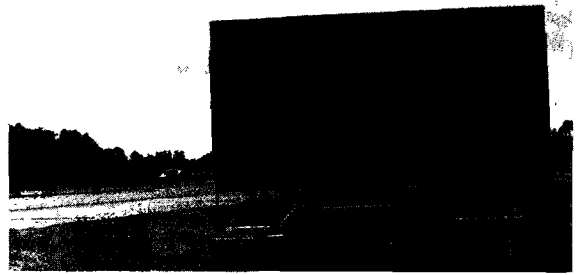
Freeway work zones can result in serious congestion and traffic safety problems unless special attention is given to work zone traffic management. This special attention can be provided by a Special Traffic Handling Crew. Members of this Crew are specially trained and equipped to install and actively manage traffic at freeway work zones.

Typically, a Crew will consist of a minimum of 4 members, including the Crew supervisor. The duties of the Crew may include: 1) installing, maintaining and removing work zone traffic control devices, 2) coordinating the activities of flaggers and law enforcement personnel, 3) implementing special traffic management strategies (e.g., ramp closures, shoulder usage, frontage road diversion, etc.), and 4) responding to emergency situations (e.g., accidents).

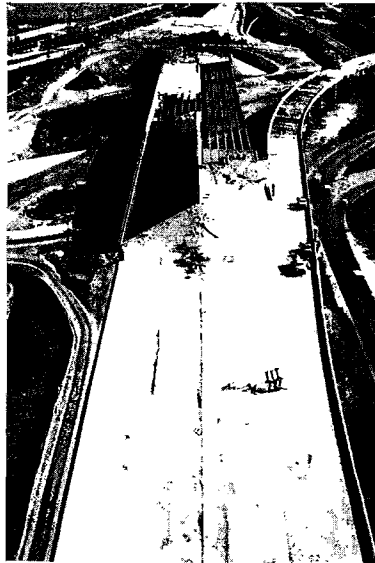
The Special Traffic Handling Crew approach offers several benefits. Because of their special training and equipment, the Crew can use the most effective strategies and devices for the particular work zone situation. Thus, congestion and accidents can be minimized. The Crew can also continually monitor work zone conditions and quickly modify the traffic control as needed. This is referred to as active traffic management.



Special Traffic Handling Crew



Advance Notification



Photographic Demonstration

Figure 6. Implementation

Using a Special Traffic Handling Crew also "frees up" the work force from having to worry about traffic control. This may increase worker productivity and efficiency.

### **Advance Notification**

Freeway reconstruction activities can have a very negative effect on the motoring public, especially if long delays result. To help minimize the negative effects and improve public relations, motorists should be notified of work activities in advance whenever possible. Motorists will then have the opportunity to use different routes or postpone their trips. They may also be more alert and less frustrated as they travel through the work zone.

Advance notification is desirable for all work activities; however, it is most critical for those activities which result in detours, ramp closures, and/or long delays, or performed at unusual time (e.g., night work or weekend work).

Motorists can be given advance notification of a planned work activity in many ways, including the following:

1. Newspaper articles and news releases.
2. Radio and television news broadcasts and spot announcements.
3. Billboards and special advance signs posted along the roadway or in places where large groups of people gather who are likely to be affected by the project.
4. Press conferences.
5. Pamphlets, detour maps, letters, programs, and flyers sent directly to motorists.
6. Door-to-door or telephone contact.
7. Meetings with civic associations, Chambers of Commerce, and other groups.

Advance notification should be coordinated through a single office and directed by a single individual (e.g., the District Public Affairs Officer). This will help assure that the proper information about all work is disseminated in a timely and appropriate manner.

### **Photographic Documentation**

Freeway work zones are typically very complex and constantly changing. It would be virtually impossible to remember or keep a detailed written record of every traffic control device, detour, ramp closure, etc., throughout the project life. It is recommended, therefore, that some type of photographic record of the work zone be kept. This documentation, which may consist of photologging, video taping and/or aerial photographs, will provide a permanent record of the traffic control and work status, and may be used to evaluate problem locations and as support evident in tort claims suits.

District 15 used a combination of photographic techniques to document the reconstruction of the Fratt Interchange in San Antonio. Every time a new detour was opened or a new work phase initiated, the entire Fratt work zone was photologged. In this manner, signing and barricade changes were documented, and potential traffic control deficiencies were observed and recorded.

During the project, aerial photography was used extensively as a traffic control and construction monitoring tool. Color aerial photographs were taken of the work zone at 3-5 month intervals. The photographs were enlarged and placed under plastic. The photos were studied to check work progress, traffic

control alternatives, traffic control and detour deficiencies, etc. The plastic coverings over the photos allowed detour alternatives to be sketched directly onto the existing conditions.



### 3. GUIDELINES FOR PREPARING WORK ZONE TRAFFIC CONTROL PLANS

#### **Background**

A previous study (4) investigated how the Department's policy on TCPs compares with other states' policies. The study found that Texas is ahead of many states in implementing a comprehensive work zone traffic safety program. It also revealed that Districts are devoting a considerable amount of time and manpower to TCPs. Thus, it would be beneficial to identify and implement methods, procedures and guidelines to improve and expedite the TCP development process.

Recognizing the need to optimize the TCP development process, a study was conducted to: 1) identify current District practices with regard to TCPs, 2) gather District input on problems and potential problem solutions, and 3) develop improved procedures, methods and guidelines for preparing and implementing TCPs. The results of the study are documented in Report 321-2 (5). The findings and recommendations are summarized in this chapter of the Final Report.

#### Structure Interviews

To gather information concerning the Department's TCP procedures, structured interviews were conducted with SDHPT personnel from D-18T, Districts 2, 4, 12, 15, 17 and 18 (including District office and Residency staff), and the Houston Urban Office. Approximately forty Department personnel participated in the interviews, and each participant was involved in one or more aspects of TCP administration, development, preparation, review and/or implementation. The interviews were conducted in the participants'

offices by one or two specially trained researchers, and each interview took approximately 2 1/2 hours to complete.

### Data Analyses

The data gathered during the surveys were grouped into 3 major topic areas for analysis: 1) Transfer of Information, 2) TCP Development and 3) TCP Implementation. The results of the analyses are presented in the following 3 sections corresponding to these major topic areas.

### **Transfer of Information**

#### Training

The Department's work zone training program is one of the most comprehensive programs of its type in the country (4). However, the interviews revealed that the existing training courses do not satisfy all of the Districts' training needs. The existing courses do not provide a "total" training package. For example, in the survey, 55% of those interviewed had never attended any work zone training course. Several reasons for non-attendance were cited by the survey participants:

1. The present courses are normally taught in the Spring and Summer, during the peak of the construction/maintenance season. It is difficult for many District personnel to be away from their jobs for 2 or 3 days during this time.
2. New employees must often wait months before a course is offered in their locale.
3. It is impractical for some groups of employees (e.g., striping crews, freeway maintenance crews, etc.) to be away from their job for 2 or 3 days at a time.



The survey participants identified the following training voids:

1. The existing courses cover a wide range of topics which are not necessarily relevant to all individuals. Due to their general nature, the courses fail to provide the specialized instruction needed by some personnel (e.g., striping crews, overlay and seal coat crews, freeway maintenance crews, etc.).
2. The existing courses become outdated after a couple of years.
3. The existing courses are not well-suited for refresher training since many employees do not have time to repeat an entire course at regular intervals.

Based on the survey results, the following improvements to the Department's work zone training program are recommended:

1. **More training courses should be offered during the winter months when construction and maintenance work loads are reduced.**
2. **Every effort should be made to train new employees as soon as practical (i.e., within 1 or 2 months).**
3. **Since it is impractical for some employees or groups of employees to be away from their jobs for 2 or 3 days at a time, "in-house" training modules (e.g., slide-tape or video cassette modules) should be developed for District use.**
4. **Training courses should be updated at regular intervals (e.g., every 2 years) to include new technology and standards.**
5. **Specialized training should be developed for striping crews, freeway maintenance crews, seal coat and overlay crews, and other employees who are involved in unique work zone traffic control situations.** Since it would be impractical to take these personnel away from their jobs for extended periods, "in-house" training modules would be desirable.
6. **Refresher training should be provided at regular intervals.** Again, "in-house" training modules could be used for this purpose.

## Standards and Guidelines

The survey participants identified the following concerns relating to use of the Texas MUTCD (6) and B-C Standards (7):

1. Over 70% of the TCP preparers reported that the primary source of input for preparing TCPs were TCPs previously prepared for similar jobs. The old TCPs may or may not have performed effectively (generally, the TCP preparer does not know this), and the old TCPs may or may not be consistent with the current Manual and B-C Standards.
2. Many District personnel complained that the standards in the Texas MUTCD and B-C Sheets and even the typical layouts, are too generalized. They said that it was very difficult and time-consuming to combine the general guidelines into an acceptable TCP.
3. The Manual and B-C Standards may be revised several times between the time that a major project is designed (i.e., the plans are prepared) and work is completed. The contractor and Department personnel have difficulty knowing which edition of the Texas MUTCD and B-C Standards to follow.

The following recommendations for improving the use of guidelines and standards were presented:

1. **A set of acceptable sample TCPs for various work zone situations should be assembled and distributed to the Districts.** The distribution of sample TCPs should encourage the transfer of information among Districts, reduce TCP preparation time and promote uniformity in TCP content, style and level of detail.
2. **Typical traffic control layouts should be removed from the D-8 and D-18 operating manuals unless provisions are made to update the layouts every time revisions are made in the Texas MUTCD and/or B-C Standards.**
3. **The version of the Texas MUTCD and B-C Standards used in preparing a TCP should be documented on the TCP.**

## Reference Materials

Although there has been considerable research conducted in the area of work zone traffic safety and control in recent years, the research findings

are very slow in reaching TCP preparers. The survey revealed that only about 20% of the TCP preparers have ever read any of the recent reports.

Guidelines presented for improving the use of reference materials are as follows:

1. **Each District should establish and maintain a library which includes work zone research reports, reference books, manuals, etc.** The library should be organized and accessible, and it should be updated at frequent intervals. District staff should be informed of the availability of the library and how to use it.
2. **D-18T should annually circulate an updated list of the most useful reference sources on work zone traffic control so that Districts may update their libraries.**
3. **Provisions should be made in each District to circulate copies of pertinent work zone research reports to TCP preparers (i.e., the potential user).**
4. **The Department needs to encourage its staff to seek out and use all available sources of information including Short Course Notes and research reports.** Currently, many TCP preparers are relying solely of the Texas MUTCD.
5. **Research reports should devote more emphasis to implementation of the research findings, and they should be written in a "user friendly style."** This will encourage their use at the District level.

## **TCP Development**

### Organization

In recent years, more and more Districts have centralized the development of all or some work zone TCPs (i.e., TCPs are developed by a specialized section in the District Design Office). If TCPs are developed in a central office, the following practices are recommended to achieve the best results:

1. **TCP developers should obtain as much local input as possible in developing the TCP.** In particular, the TCP developer should talk with the Resident Engineer, Project Engineer and candidate contractors, and he/she should visit the work zone site.

2. **Ample time should be provided for local review of centrally prepared TCPs.**
3. **The central office which prepares TCPs should have sufficient staff to gather necessary work zone traffic data.**

If TCPs are prepared locally, the following practices are recommended:

1. **Provisions should be made to fully coordinate the traffic control at nearby and overlapping projects.**
2. **The resources and expertise of the District Traffic Section should be utilized as much as possible, and particularly when traffic problems are anticipated.**
3. **Local personnel involved in TCP development should receive special training in work zone traffic control and safety.**
4. **TCP uniformity should be encouraged statewide.** This may be accomplished through the distribution of "typical TCPs" for various work situations.

#### Classification of TCPs

According to one TCP preparer interviewed, projects are often treated as numbers, and there is no formal recognition that some projects may have a much greater impact on traffic operations and safety than others. As a result, the critical projects from a traffic standpoint do not always get the special attention they need. They are developed and reviewed in the same manner and with the same level of effort as routine minor projects.

To assure that critical projects get the special traffic handling attention they justify, **TCPs should be classified according to their complexity and potential impact on traffic.**

#### Pre-Design Meeting

In order to assure that construction/maintenance work is designed and sequenced to permit safe and efficient traffic flow, traffic handling should

be considered throughout the project design. However, in the survey over 60% of the TCP developers interviewed said that the TCP was the last item prepared in assembling a set of construction plans. Several of those interviewed commented that traffic handling was not usually addressed until the end of the design process except when the TCP affected construction-related bid quantities. **To assure that traffic handling gets the proper attention, traffic control requirements and alternatives should be discussed during a Pre-Design Meeting.**

#### Team Approach

The District personnel interviewed estimated that it took approximately 1 man-month of professional effort to develop a TCP for a typical construction project. For large, complicated projects, they estimated that it took up to 3 man-months of professional effort. The TCP developers agreed that the most time-consuming task in the development process was deciding what traffic control approach to use. **It is recommended that a team approach be utilized.**

#### Data Gathering

A TCP should be tailored to the conditions at a particular work zone. This means that the TCP preparer should have recent traffic operation and safety data from the site. Most TCP preparers, however, do not have easy access to such data.

TCP quality can be improved if TCPs are developed using recent and accurate traffic and accident data. The following recommendations are offered to enhance data collection and use by TCP preparers:

1. **Personnel should be better trained in the importance and benefits of using traffic and accident data in developing TCPs.** The advance level short course recently developed by TTI addresses work zone data needs.
2. **TCP preparers should have the capability and resources to gather traffic and accident data.** One approach is to make arrangements for the District Traffic Section to supply needed data upon request.

### Contractor Input

Contractor input is seldom used in developing TCPs, despite the fact that over 90% of the TCP preparers interviewed said that contractor input would be desirable or very desirable. The survey also revealed that contractors rarely submit their own TCP even though Department policy allows them to do so.

To increase the amount of contractor input into TCPs, the following practices are recommended:

1. **The Department should consider providing monetary incentives to contractors submitting an improved TCP.**
2. **TCP preparers should be encouraged to seek contractor input on work zone traffic control techniques and strategies.** One approach would be to invite interested contractors to an annual traffic control "de-briefing" meeting at which the contractors could voice their concerns and opinions.

### Manpower Requirements

Most of the TCP developers said that manpower resources for TCP preparation were adequate and preparation time was adequate; however, the District personnel recognized some needed improvements. They offered the following recommendations related to manpower allocations:

1. **TCPs should be developed by a team.** It is beneficial to consult with other staff members; this will encourage more technical input and speed the development process.
2. **TCP preparers should have a broad background in traffic, construction and design.** Most of those interviewed also recommended field experience in construction and/or maintenance.
3. **TCP preparation should not be rushed by the letting schedule.** The TCP preparer should be consulted when the letting schedule is set and updated.
4. **Newer, inexperienced employees tend to "copy" previous TCPs, and also lack confidence in their planning abilities.** It was suggested that an experienced engineer closely supervise new employees' work to build their planning skills.

### Time Savings

As part of the survey, District personnel were asked what the most time-consuming part of TCP preparation was. The survey participants gave the following responses:

1. One-half of the participants said that determining a proper sequence of work was the most time-consuming aspect of preparing a TCP.
2. Approximately one-fourth said that drafting or drawing the plan was the most time-consuming task.
3. The remaining one-fourth said that selecting and documenting a sign layout was most time-consuming.

The participants were then asked what could be done to reduce the time involved in preparing TCPs. They responded with the several recommendations listed below:

1. **A set of typical, acceptable TCPs for various work zone situations should be assembled and distributed to the Districts.**
2. **TCP preparers should have design and construction experience.**
3. **TCP preparers should receive feedback from the field on which techniques and strategies are working and which are not.**

4. **Interactive graphics should be utilized to reduce drafting and sign layout time.**
5. **Complicated TCPs should be prepared by a central office specializing in TCP development.**
6. **The Project Engineer should be given more flexibility to make changes to the TCP.**

#### District Review

All Districts have established procedures for reviewing work zone TCPs internally before they are submitted to the Division offices. Although these procedures differ from one District to the next, the survey revealed that there are some common problems shared by many of the Districts:

1. Oftentimes, the TCP preparer is not familiar with the internal review process, nor does he/she receive any feedback on the results of the review (i.e., changes resulting from the review are made in the District office and the TCP preparer is never notified). Thus, certain mistakes, omissions, use of outdated technology, etc. are repeated over and over again by the uninformed TCP preparer.
2. Internal review of TCPs is sometimes rushed to meet a letting date. Apparently, this problem is not uncommon since almost 70% of the District personnel interviewed said that more review time was desirable. In fact, several of those interviewed said that they usually only had time to check to see if all the pages were included and if the quantities were totalled correctly.
3. Some Districts use a routing system for TCP review (i.e., one set of plans is routed to several individuals for review). The routing approach is inefficient since a set of plans may sit idle on one person's desk for several days if that person is out of the office or busy on another job. Other reviewers then may not have adequate time to review the plans.
4. In some Districts where plans are prepared in a central office, the Resident Engineer and Project Engineer who will supervise the work are not provided an opportunity to review the plans before they are submitted. In some other Districts, the Resident Engineer and Project Engineer only have one day to review an entire set of plans before it is submitted. During the surveys, the Residency and field office staff pointed out that many TCPs could be improved by more local input.



5. In some Districts, the District Traffic Engineer or his staff does not review work zone TCPs except in special problem situations. Traffic engineering input into TCPs is very desirable, however.

Based on the results of the survey, the following improved procedures are recommended for internal review of TCPs:

1. **The TCP preparer should be notified of any changes in a TCP resulting from internal review.** This will prevent mistakes, omissions and the use of outdated technology from being repeated.
2. **TCP preparers should be familiar with internal review procedures (i.e., who is involved and how long it takes).** This will encourage the transfer of technology and information, and will help the TCP preparer to schedule his/her time.
3. **Plenty of time should be provided for TCP review (e.g., one day per person just for the TCP).** If time is critical, it is suggested that a special meeting be held to review the TCP. This will assure that everyone has an opportunity to critique the plan, yet it can be accomplished in an hour or so.
4. **The routing approach should not be used for internal review of TCPs.** Multiple copies of the TCP should be distributed.
5. **It is strongly recommended that all TCPs be reviewed by the District Traffic Engineer or his/her staff.**
6. **The Resident Engineer and Project Engineer should have the opportunity to review TCP prepared in a central office.** Ample time (i.e., several days) should be provided for this local review.
7. **It is suggested that complicated or problem TCPs be circulated and reviewed separately from the remainder of the construction plans.** This will help assure that they are given the special attention they deserve during the review.
8. **Some Districts require that TCPs for major projects be formally presented and discussed at a meeting of the District Safety Review Team.** This practice appears to be very helpful.

#### Division Review

Interviews were conducted with several D-18T personnel who review work zone TCPs at the Division level. District personnel were also questioned about their involvement with the Division review process. Based on the

findings of the survey, the following deficiencies in Division review procedures were identified:

1. Typically, all plans scheduled for a certain letting will arrive at D-18T on or very near the deadline (i.e., approximately 1 month before letting). The plans are assigned by area of the state to a reviewer. Each reviewer has up to 15 or so TCPs to review before the letting date. The schedule and workload often do not permit a thorough review of all the TCPs. Even more important, if a problem is found in a TCP, it is very difficult to make the necessary changes in time for the letting.
2. Oftentimes, the TCP preparer is unaware of problems, mistakes, omissions, etc. uncovered in the Division review. The required changes are handled by the Division or District office and the TCP preparer in the Residency is not informed.
3. District personnel, in general, know very little about the Division review process, and they tend to have a negative attitude toward it. In the survey, over 40% of the District personnel did not know who reviewed the TCPs or how long it took. Many of those interviewed stated that the Division reviewers could not make appropriate decisions since they were unfamiliar with conditions at the worksite.

#### Recommended Improvements to Division Review Procedures

1. **Some Districts send draft TCPs to D-18T for early review.** This allows time for thorough Division review and for changes to be made if necessary. This practice is especially appropriate for complicated or problem TCPs.
2. **Some D-18T reviewers make routine visits to the Districts to review TCPs which are in preparation and to observe the performance of implemented TCPs.** This practice encourages communication and information transfer between the field personnel and Division staff.
3. **The TCP preparer should be notified whenever a TCP is changed as a result of Division review.**
4. **More time and/or manpower should be allocated to review work zone TCPs at the Division level.** This will require that additional staff be assigned to the review task and/or TCPs be submitted earlier.

## **TCP Implementation**

The success of a TCP depends on how it is implemented and maintained throughout the life of the project. As part of the Study 321 survey, TCP implementation was investigated. This investigation resulted in several recommended improvements in current implementation practices. These improvements are identified and discussed in the following sections.

### Field Visits

The survey revealed that approximately two-thirds (62%) of the TCP preparers interviewed are never present on the site when their TCPs are first installed. Almost 40% said they seldom or never inspect work zones to see if their TCPs are implemented as intended. These data are alarming since they indicate that the designer's input often stops when the plans leave his/her drafting table. They also suggest that the TCP preparer is missing an opportunity to gain insight into how practical and effective his/her TCPs really are.

Based on these findings, the following recommendation is offered:

- 1. TCP preparers should make visits to selected work zones to gain insight into how well their TCPs are performing.**

### Inspections

Department policy requires that formal daytime and nighttime inspections be made at every work zone at least once a month. The results of the monthly inspections are documented on a standard report form(9).

In the survey, over 70% of the District personnel interviewed said that more inspections were needed. In discussing this concern with field personnel (e.g., inspectors and Project Engineers), it was revealed that the number of

inspections is probably adequate. The problem stems from the lack of documentation of informal inspections. **In light of the potential for tort liability suits involving work zone traffic accidents, it would be beneficial to keep a written record of daily inspections either in the project diary or on a separate report form.**

#### Feedback to TCP Preparers

Two-thirds of the TCP preparers interviewed said that they seldom or never get any feedback from the field on how well their TCPs are working, and almost 90% (13 of 15) said that more feedback would be very desirable. Based on these findings, the following practice is recommended:

1. **The TCP preparer should be notified whenever there is a significant problem with his/her TCP, or whenever a field change is made.**

#### Field Changes

All of the District personnel interviewed (100%) said that more flexibility should be given to the Project Engineer or Department Responsible Person to make TCP field changes in the interest of traffic safety. According to most of those interviewed, field changing a TCP is currently very time-consuming. They reported that it takes from 3 to 6 months for a field change approval. As a result, many beneficial field changes are not attempted due to the lengthy waiting time.

**Thus, there is a need to reassess the current approach to implementing traffic control field changes.** The new approach must take into account both time and legal issues.

### Current Policy on TCP Field Changes

Department policy states that ..."when conditions warrant, minor or emergency changes to the TCP may be authorized immediately by the Department's responsible person. If substantial changes are made, the changes should be documented and submitted for review." According to almost all of the District personnel interviewed, this policy needs to be clarified with respect to the following:

1. **What is a minor change vs. a substantial change?**
2. **What constitutes an emergency situation?**
3. **What level of documentation is required for field changes and what constitutes approval of a field change.**



#### 4. RECONSTRUCTION PROJECTS

##### Background

Field studies were conducted at three major freeway reconstruction projects to evaluate the effectiveness of some of the aspects of TCPs at selected projects in Texas. The reconstruction projects were:

1. Fratt I Interchange (IH-30 and IH-410) in San Antonio.
2. Katy Freeway (IH-10) in Houston.
3. North Freeway (IH-45) in Houston.

The Fratt I Interchange project was the first phase of a 3-phase \$125 million reconstruction project at the IH-35 and IH-410 interchange. Federal discretionary funds were used for the \$63 million Fratt I project, which was the largest single dollar volume contract let by the Texas SDHPT. The construction plans, with over 600 sheets, were completed in 5 months.

The project included several unique design and construction features. These included reinforced earth retaining walls; new 13-inch continuously reinforced concrete pavement; 832-ft plate girder bridge with 7-ft deep beams with span lengths up to 235 ft. Precast portable concrete barriers (PCBs) were used initially for protection in detours, and then re-used as median barriers on the completed mainlane section. Temporary lighting and changeable message signs (CMSs) were also used extensively throughout the project. Traffic was shifted about 30 times in the course of the project.

The Katy Freeway (IH-10) in Houston is currently under construction for the installation of an Authorized High-Occupancy Vehicle Lane (AVL) into the median section of the freeway. This project is the first of a 72-mile network

of transitways to be retrofitted into an existing high volume freeway cross-section in Houston. The project involved TCPs which had multiple phases and a variety of cross-sections.

To allow retrofit construction of the transitway, work areas were developed in the median and to the inside and outside areas of the freeway mainlanes. Traffic was then routed around the work areas, depending on location, in narrow lanes varying from 10 to 11 feet in width with no shoulders on either the inside or the outside. Temporary PCBs were used extensively to protect and separate the work areas from freeway traffic.

The transitway was designated to be developed and operated in two major phases. Construction of Phase I began in May 1983 between Post Oak (near IH-610) and Gessner, a distance of five miles, and will be completed in October 1984. Phase II will extend the transitway another five miles from Gessner to SH 6.

The North Freeway (IH-45) is currently under construction for the replacement of an existing contraflow transitway with a separate median transitway (AVL). The construction activities are more complex due to the need to maintain existing AVL traffic as well as normal freeway traffic. Traffic control techniques similar to those on the Katy Freeway are being used on the North Freeway.

Three principal types of data were collected and analyzed in Study 321 for the Katy and North Freeways: speeds, volumes (capacity) and lane distributions. The data were supplemented by data collected on the Katy Freeway as part of Study 339 entitled, "Improving Urban Mobility Through



Application of High-Occupancy Vehicle Priority Treatments" (8). Study 339 included Katy Freeway accident data and analyses.

### **Fratt I Interchange (IH-35 and IH-410)**

Several discussions were held with the District 15 Project Engineers for the Fratt I Interchange reconstruction project in San Antonio. Field studies and evaluations were also conducted to evaluate selected traffic control strategies. In addition, an accident analyses was made to assess the safety impacts of the traffic control strategies and devices. Hard-copy accident reports from the Fratt I reconstruction project, which were provided by District 15, were reviewed and pertinent data were input into a computer storage file. The data were reduced and analyzed using SAS. Results of the studies are summarized in Reports 321-1 and 321-2 (5, 3). The following sections summarize the findings.

#### Flexibility and Cooperation

Freeway reconstruction is complex, costly and potentially hazardous to motorists and workers. To increase the chances for success on a major reconstruction project, it was recommended that all the parties involved need to promote an atmosphere of flexibility and cooperation. This includes the State, FHWA, contractor, city, business community and motoring public. In addition, the project staff should constantly be looking for innovative and more effective approaches to managing the project. The project staff should always be on the look-out for ways to improve traffic flow, increase worker and motorist safety, minimize adverse effects of the work on the business community, and reduce the overall construction time.

### Plan Complexity

It was stated that the work sequence in the Fratt I construction plans was very complex. No suggestion on how to simplify the plans were presented, but an idea on how to better present the sequencing was offered. It was suggested that each separate work phase be color coded. This allows one to quickly determine which lanes are open and which detours are being used during a particular phase.

### Critical Path Method

The contractor performed Critical Path Method analyses to plan and schedule the Fratt I project.

### Work Force

During peak construction periods, the contractor mobilized an average work force of 300 workers. On some days there were up to 330 men working on the job. Despite this large work force and the complexity of the TCP, there were no traffic-related deaths or injuries to the work force during the entire 4-year project duration.

The Department had up to 15 men working on the job during peak construction periods. Most of the Department employees were field inspectors. One individual was assigned the responsibility to oversee all detours. The Project Engineer spent about 10% of his time on traffic control matters.

### Safety Inspector

The contractor employed a full-time safety inspector for the Fratt job. The inspector was a licensed Emergency Medical Technician with training in occupational safety. He inspected all areas of the job on a daily basis

attempting to identify and correct potential safety hazards. He worked closely with the Project Engineers to correct apparent traffic control deficiencies.

#### Traffic Volumes

During the construction period, traffic volumes increased by approximately 4,000 vehicles per day.

#### Aerial Photographs and Photologging

During the project, aerial photography was used extensively as a traffic control and construction monitoring tool. Color aerial photographs were taken of the work zone at 3-5 month intervals. The photographs were enlarged and placed under plastic. The photos were studied to check work progress, traffic control alternatives, traffic control and detour deficiencies, etc. The plastic coverings over the photos allowed detour alternatives to be sketched directly into the existing conditions.

Every time a new detour was opened or a new work phase initiated, the entire Fratt work zone was photologged by the District 15 Traffic Section. In this manner, signing and barricade changes were documented, and potential traffic control deficiencies were observed and recorded. During the early stages of the project, an attempt was made to document signing changes with a color video. The video pictures, however, lacked the needed clarity and detail.

#### Isolation of the 3-Level Interchange

The original construction plans called for building a 3-level bridge structure with traffic passing through and under the work. In order to

accomplish the plans, several short-term detours and lane closures were required. Once the project began, however, a safer and more efficient traffic management approach was discovered.

Instead of attempting to maintain traffic through the work area, all traffic was detoured completely around the bridge construction area utilizing the existing westbound lanes of IH-410 which had been abandoned earlier and were to be removed. This approach permitted the work to be greatly accelerated. It was estimated that this revision reduced the total project time by 6 months.

#### Modification of Detour

Although there was no formal field change, one of the several detours was modified to completely remove traffic from a mainlane work area. The modification allowed the uninterrupted construction of a major mainlane bridge. The change made it possible to complete the bridge ahead of schedule and return traffic to the mainlanes.

#### Traffic Control Field Changes

On the Fratt job, there was only one formal traffic control field change (i.e., isolation of the 3-level bridge construction). It took several months to gain FHWA approval of this field change due to the complex nature of the TCP and the extensive ramifications that could result from the change.

Subsequent changes in the TCP, because of their urgency, were made without going through the formal field change procedure. However, this was possible only because project personnel involved the FHWA representative in the planning of these changes, and also because the local FHWA representative

shared the same goals and objectives as the planning team, (i.e., to protect the interests of the traveling public and the adjacent business community). It should be noted that, though these changes provided significant improvements in the TCP and work sequence, they involved only minor adjustments in quantities and locations. Otherwise, the formal field change procedure could not have been avoided.

Traffic Control Costs

It was estimated that traffic control for the 48-month project cost a total of \$4.25 million. This cost includes signing and barricades, temporary striping, construction of detours, and temporary concrete barriers. It represents 6.7% of the total job cost of \$63.5 million.

The following unit bid costs were used in estimating traffic control costs:

<u>Item</u>	<u>Unit Cost</u>
Signing & Barricades	\$54,000/mo.
Detour Construction*	\$7,000/Station
Temporary Striping	\$3.50/l.f.
Temporary Concrete Barrier	\$2.70/ft.(Install and Remove)

\*Note: There were more than 135 detour stations constructed (13,500 feet).

It was reported that the temporary striping on this job and many others was greatly underestimated. The problem appears to result from TCP preparers not realizing the extensive striping required at gore areas (e.g., up to 3,000 feet of striping per gore area).

### Temporary Portable Concrete Barriers

The Project Engineers commented that temporary PCBs were proven to be very valuable at freeway reconstruction work zones. They alleviate the need for buffer zones between traffic lanes and the work crew and equipment. Thus, more lanes can be kept open and work zone capacity increased. The use of barriers also allow work to continue during peak periods and at night if desired.

Some problems were experienced with placing PCBs on both sides of the travel lanes (e.g., no shoulder). The problems resulted from having no place for emergency parking.

It was recommended that lane widths be at least 11 feet and that PCBs be placed at least 1 foot from the edge of narrow lanes. Drivers will straddle the lane line if barriers are placed too close to narrow lanes.

### "Soft" Detours

The original construction plans called for several detours with relatively sharp curves (e.g.,  $8^{\circ}$  or greater). Subsequent detours were modified to a maximum curvature of  $6^{\circ}$ . These "soft" detours performed much better.

### Temporary Latex Paint Markings

At the beginning of the project, temporary tape markings were used on the detours. The tape would not stay down on "green" concrete surfaces, however,

and so the traffic control subcontractor experimented with latex paint markings. After several trials, the subcontractor developed a latex paint with glass beads which was very effective. In fact, it has been used on all subsequent Fratt detours.

The latex paint is applied with a standard striping machine, and glass beads are sprinkled on top of the fresh paint. The latex striping has a relatively long life (e.g., 6 months with a 70,000 ADT), and it can be removed with minimum scarring with a water or water-sand jet.

#### Special Word Message Pavement Markings

There were a number of complicated detours, lane closures, lane shifts, and ramp changes during the project. Every effort was made to use conventional signing to warn and direct motorists in these situations, but it was difficult and/or impractical to locate enough proper signing in the cluttered work zone environment.

To supplement the conventional signing, special word message pavement markings were used extensively. These markings were apparently very effective, but they did require frequent maintenance.

#### Changeable Message Signs

Three CMSs were purchased and used on the Fratt job. The signs were most effective when used to warn motorists of new detours. Whenever a new detour was opened, a CMS was positioned upstream of the detour displaying a warning message and speed advisory. The sign was left in place for up to 2 weeks.

### Advisory Speed Signing

In an effort to encourage reduced speeds, District 15 installed advisory speed signs with "odd-ball" speeds at several detour curves. The signs displayed speeds such as "26 MPH" and "17 MPH". It was reported that the signs were noticed by drivers and prompted much motorist feedback; however, they did not slow drivers down to the posted speeds. According to the Project Engineers, the signs were a good idea, but the posted speeds were lower than the maximum safe speed and, thus, the signs quickly lost their credibility. It was speculated that for the "odd-ball" sign to be effective, the speed posted must be close to the maximum safe speed for the particular curve.

### Appropriate Standards

Large projects take several years to complete (e.g., Fratt I was a 4-year project). During such extended projects, major revisions to the MUTCD and Standard B-C Sheets often occur. As a result, there is some confusion and possibly legal concerns over which guidelines apply. These issues need to be resolved. It was suggested that the project plans state that "the current MUTCD (at the time of letting) shall govern, but the contractor may upgrade to new standards with approval from the Engineer." A similar note would be added concerning B-C standards.

### Level of Service

Although there is no supporting data, it is the belief of the construction project staff that the level of service through the Fratt Interchange was actually higher during construction than before construction (except during



temporary lane closures). This belief is based on the observation that congestion and queues were reduced during construction, even though traffic volumes increased.

### Accident Study

Hard-copy reports were used in lieu of the State's computerized accident record system because of a problem of locating the accidents within the construction project boundaries. The roadway system continuously changed during construction, and with the numerous detour routes, accidents could not be correlated with mile markers in this special instance. Attempts were also made to use hard-copy records of accidents prior to construction for before and during construction comparisons, however, the difficulty and cost of obtaining and analyzing these files caused the researchers to explore other alternatives. The most accessible work zone accident statistics were available in a report prepared as part of Study 263 (9). The report, published by the Department, contained Texas work zone accident statistics for 1977.

The Fratt Interchange accident data were, therefore, compared with work zone accidents in Texas during 1977. In addition, the data were also compared with all accidents occurring in Texas in 1977, when applicable. During accidents were collected and analyzed between March 1980 through June 1983 (i.e., for 3 1/3 years).

Number of Accidents -- There were 878 accidents recorded within the Fratt I reconstruction boundaries during the 3 1/3-year period.

Accident Severity -- Of the 878 accidents that occurred, 77% were property damage only, 23% resulted in injuries, and less than 1% involved a fatality (Table 1).

The results in Table 2 show that the accident severity rates during the reconstruction project were lower than for all 1977 work zones in Texas, and lower than the severity rates for all 1977 Texas accidents. This indicates that the attention devoted to traffic control during the Fratt project resulted in a safer driving environment.

The injury rate was 3,087 injuries per 10,000 accidents, which was 14% lower than the rate of 3,600 for all 1977 work zone accidents in Texas, and 17% lower than the rate of 3,705 for all 1977 accidents in Texas.

The fatality rate of 57 deaths per 10,000 accidents was 37% lower than the rate of 90 for all 1977 work zone accidents, and 51% lower than all 1977 accidents in Texas.

Alcohol Involvement -- Further testimony to successful traffic control is exemplified in the fact that 9% of the accidents during the study period were alcohol related. This is a very high percentage compared with 1% alcohol related accidents for all Texas work zone accidents and for all Texas accidents in 1977. It would be expected that the higher alcohol involved accidents would have resulted in increased accident severity.

Barrier Involvement -- Since the Fratt I Interchange was one of the first major reconstruction projects in Texas where temporary PCBs were used extensively to separate traffic from the work crews and separate opposing lanes of traffic, it was of interest to investigate accidents involving PCBs.

TABLE 1. ACCIDENT SEVERITY AT FRATT INTERCHANGE

	Number of Accidents	Percent of Accidents
Property Damage	675	77
Injuries	198	23
Fatalities	<u>5</u>	<u>&lt;1</u>
	878	100

TABLE 2. COMPARISON OF ACCIDENT SEVERITY RATES

	Fratt	1977 Work Zones	All 1977
Injuries/10,000 Accidents	3,087	3,600	3,705
Deaths/10,000 Accidents	57	90	117

Table 3 summarizes the frequency of accidents at the Fratt Interchange as related to PCB involvement. Although PCBs were used extensively throughout the reconstruction site, only 9% of the accidents involved the barriers. The 1977 study indicated that only 3% of the accidents at work zones involved PCBs. Although this percentage is lower, it must be noted that most work zones do not use PCBs. Also, PCBs were not used extensively at major reconstruction projects until the early 80's.

Table 3 also shows that 7% of all injury and fatality related accidents involved PCBs. Looking at the data in a different perspective, it is seen that 40% of all PCB related accidents involved an injury or fatality, compared to 22% of all non-PCB related accidents involving an injury or fatality.

The findings should not be interpreted to mean that the PCBs result in higher severity rates. Barriers do not necessarily cause the accidents. They are generally located at high risk areas. Also, many collisions with PCBs may be secondary collisions following severe vehicle/vehicle accidents (although this factor was not evaluated). The barriers most likely prevented more serious injuries by protecting both the vehicle occupants and construction workers.

Types of Accidents -- Table 4 presents the frequency and percentage of accidents by type. Also shown is the percentage breakdown for the 1977 Texas work zone accidents.

The results reveal no unusual pattern of accident types at the Fratt Interchange. The most common type of accident was the rear-end (42%) followed by single vehicle (25%) and sideswipe (21%) accidents. The percentages of rear-ends and single vehicle accidents compare favorably to all Texas work

TABLE 3. COMPARISON OF ACCIDENT SEVERITY RELATED TO PORTABLE CONCRETE BARRIERS AT FRATT INTERCHANGE

	Accidents		Injury & Fatality		% of Accidents Involving Injury or Fatality
	No.	%	No.	%	
Non-PCB Related	802	91	629	93	22
PCB Related	<u>75</u>	<u>9</u>	<u>45</u>	<u>7</u>	40
	877	100	674	100	

TABLE 4. COMPARISON OF ACCIDENTS BY TYPE

	Percent	
	Fratt	1977 Work Zones
Rear-End	42	40
One Car	25	24
Sideswipe	21	10
Right-Angle	7	15
Head-On	<1	8
Others	<u>&lt;5</u>	<u>3</u>
	100	100

zone accidents. The percentage of sideswipes were higher, but the percentage of right-angle and head-on accidents were lower.

Vehicle-Type -- The results shown in Table 5 reveal that there were no unusual patterns of accidents by vehicle type. Although the truck involvement was much higher than all Texas accidents in general, it was no different from all Texas work zone accidents in 1977.

Weather -- Eighty-eight percent of all 1977 accidents and 88% of all 1977 work zone accidents in Texas occurred during dry weather conditions. In contrast, 84% of the accidents at the Fratt Interchange occurred during dry weather conditions.

Time of Day -- Table 6 shows the percentage of accidents classified according to daylight and nighttime. The results show that 32% of the accidents at the Fratt Interchange occurred at night. Although this percentage is about the same as for all 1977 accidents, it does represent an increase over the 1977 work zone accidents in which 27% occurred at night.

Vehicle-Type -- The results indicated that 6% of the accidents involved large trucks. This compares favorably with the 1977 work zone accident data which showed a 7% truck involvement. However, both values are larger than the 3% truck involvement for all 1977 accidents. The results indicate that the extensive use of PCBs at the Fratt Interchange project did not affect the percentage of truck accidents in comparison to other work zones in Texas.

TABLE 5. COMPARISON OF ACCIDENTS BY VEHICLE TYPE

	Percent		
	Fratt	1977 Work Zones	All 1977
Cars, Small Trucks	93	91	94
Large Trucks	6	7	3
Others	<u>1</u>	<u>2</u>	<u>3</u>
	100	100	100

TABLE 6. COMPARISON OF ACCIDENTS BY TIME OF DAY

	Percent		
	Fratt	1977 Work Zones	All 1977
Daylight	68	73	69
Night	<u>32</u>	<u>27</u>	<u>31</u>
	100	100	100

## **Katy Freeway (IH-10)**

### Sequence of Work and Cross Section

Figure 7 is a schematic of the Katy Freeway sequence of work. The work zone consists of five segments (sections) with each segment involving up to four steps. Figure 8 illustrates the planned cross-section for each step. The study locations and actual cross-sections are shown schematically in Figure 9. These locations (Antoine, Wirt, Campbell and N. Wilcrest) are referenced in subsequent figures and tables. The North Wilcrest location is outside the construction zone and is used for comparison purposes.

### Accidents

Accident experience (fatal and injury accidents) was evaluated within the limits of the construction project by segment for equal comparison time periods prior to and during construction. The results indicated that the overall accident rate between pre and during construction increased by 0.5 accidents per million vehicle miles and was statistically significant. However, the increase is not considered practically significant.

Further analyses revealed that none of the construction steps indicated a statistically significant change in accident rates. The overall conclusion to be drawn is that the various types of cross-sections did not greatly affect accident rates.

### Speed

Speed is perhaps, to the motorist, the most important of the three traffic characteristics. If traffic is moving at or above the speed limit, the motorist will likely perceive an acceptable level-of-service. At the



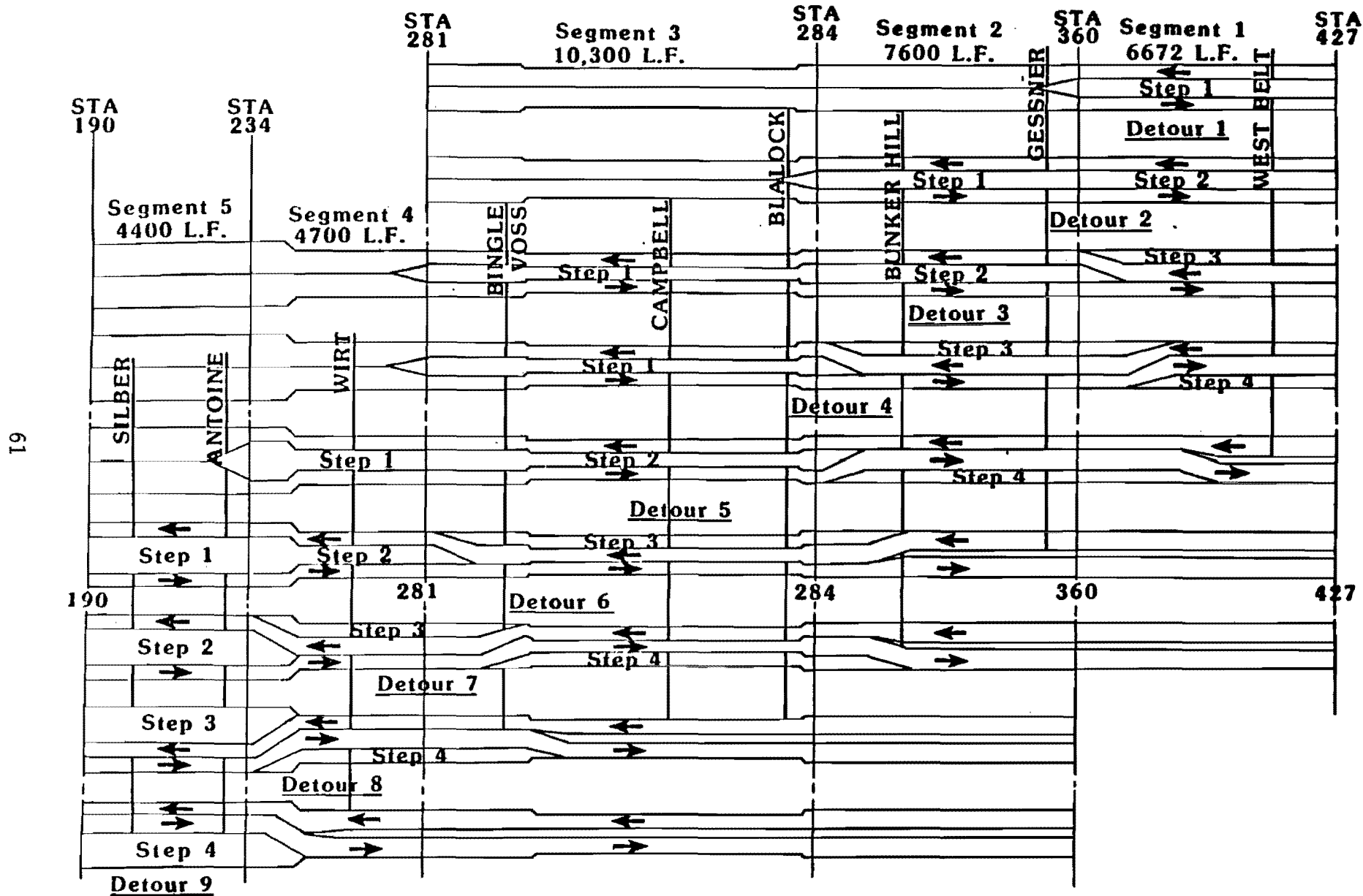


Figure 7. I-10 (Katy) Sequence of Work

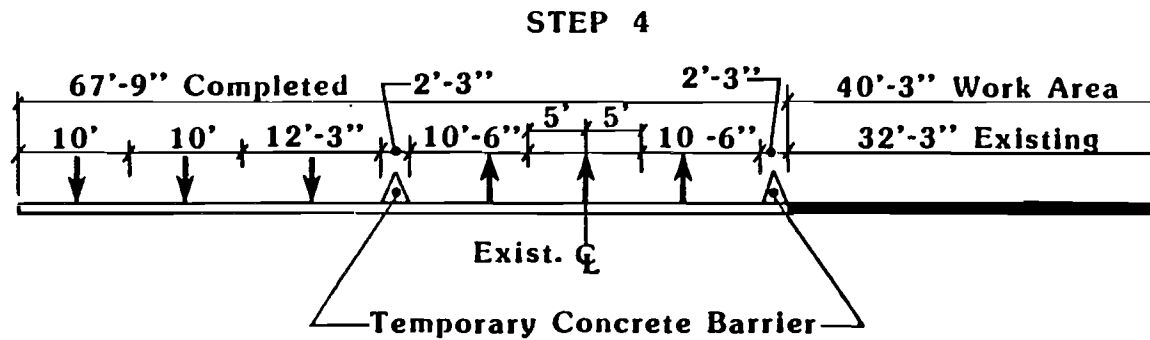
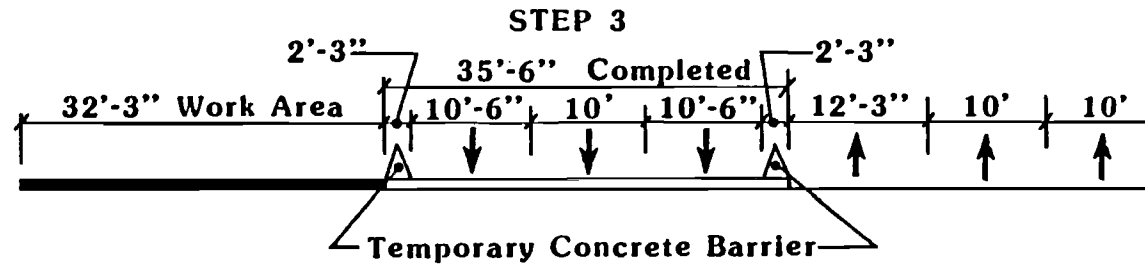
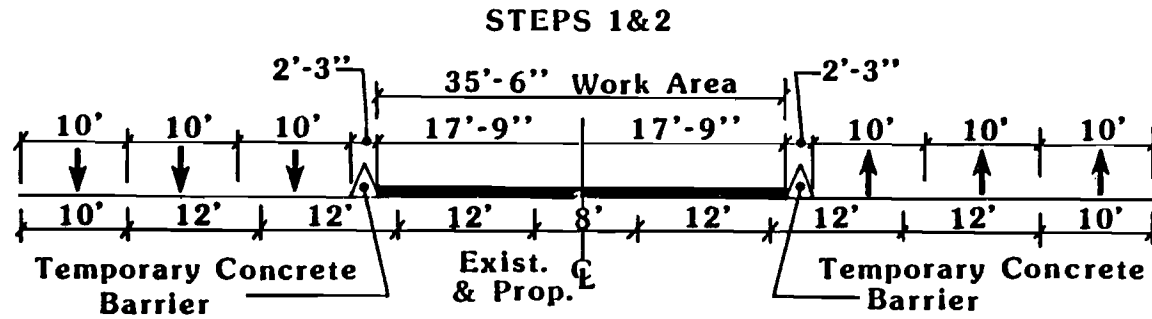


Figure 8. I-10 (Katy) Typical Cross Sections (Looking West) from Plans

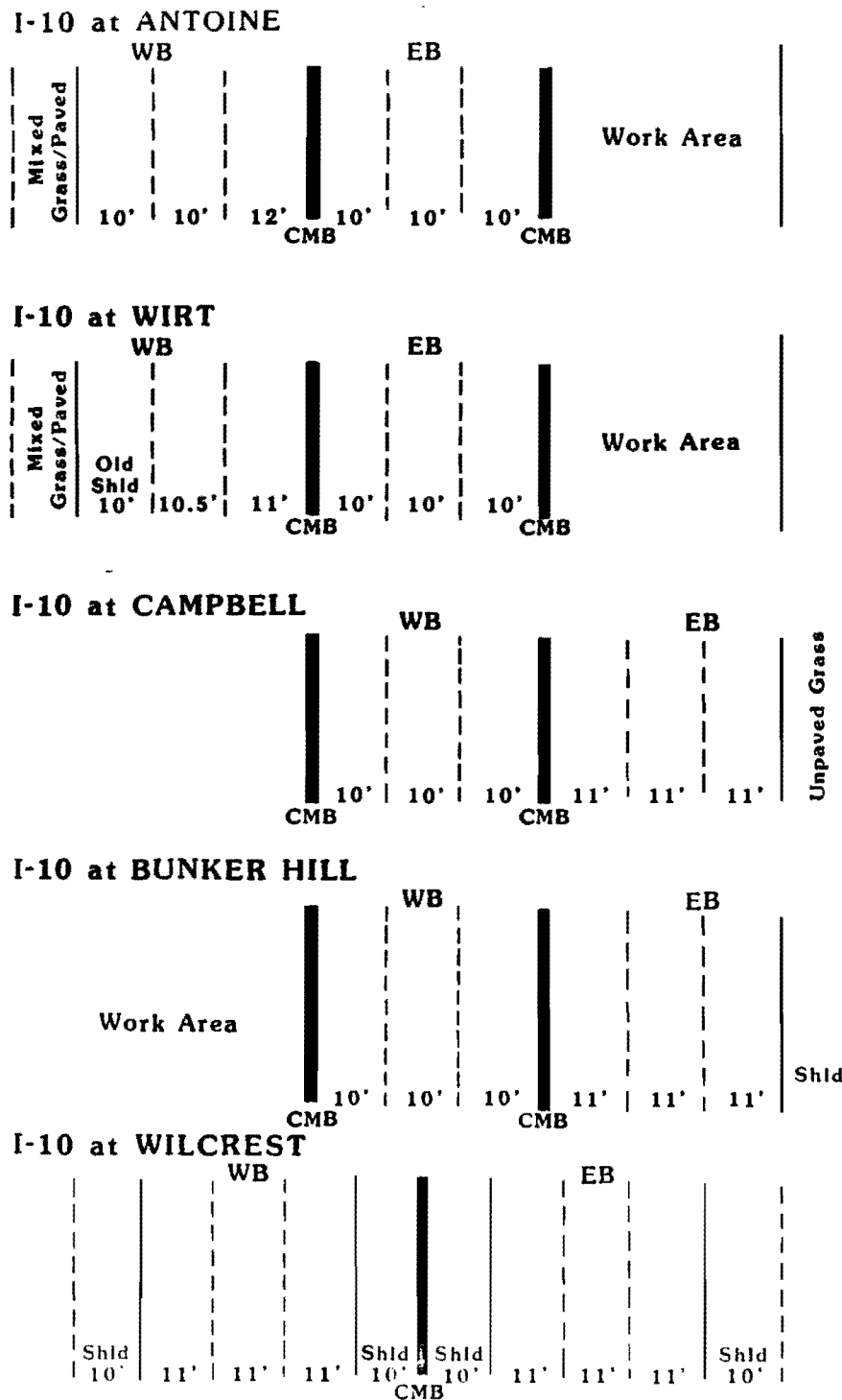


Figure 9. I-10 (Katy) Study Location Schematics

other extreme, low speeds under stop and go operation will likely be perceived as poor operation.

Data collected and analyzed indicated no practical decrease in speeds due to construction. The data for each segment under construction was compared to the data for each segment one year prior to construction. The changes were evaluated using a paired Student's "T" Test to establish the statistical significance of any observed differences between the "pre" and the "during" construction data. The results are summarized below. Speed profiles can be found in Appendix A.

The difference between speed profiles prior to and during construction was tested for statistical significance. The differences between the pre and during construction travel speeds for Segment 5 during the morning peak period was found to be significant at the 5% level. Segment 5 speeds decreased by almost 14 mph in the morning during construction as opposed to one year earlier. Overall, the morning eastbound speeds decreased by 3 mph during construction, however, this small decrease cannot be considered practically significant since the standard deviation associated with it is close to 6 mph.

Average peak period speeds during the first stages of narrow lane construction were compared to observations made during the later stages of narrow lane construction. As presented, none of the differences in operating speed in each segment or throughout the construction length was significant at the 5% level.

Finally, operating speeds prior to construction (with the full width lanes plus emergency shoulders) were compared to initial construction operating speeds as well as to later construction operating speed (both with

reduced lane widths and no emergency shoulders). Only one difference in operating speed between pre and beginning construction speeds was statistically significant at the 5% level. The difference in Segment 5 in the morning eastbound direction experienced an average decrease of more than 15 mph during the first stages of narrow lane construction. Overall, operating speeds did not change significantly during the initial institution of narrow lane work areas. As for the differences between pre and ending construction operating speeds, no negative speed differentials were statistically significant at the 5% level.

Volumes (Capacity)

Table 7 presents volume data by study location and time for the morning and afternoon peak periods. As shown in the table, peak hour volumes consistently exceeded 1700 vehicles per hour per lane (vphpl).

TABLE 7. KATY FREEWAY TRANSITWAY PROJECT OBSERVED WORK ZONE VOLUMES (VPHPL)

Location Site	Antoine	Wirt	Campbell
Lane Widths	10'-12'	10'-11'	10'-11'
Time Period			
AM Peak	1841	1686	1708
PM Peak	1747	1733	-

Figures 10 and 11 show volumes by lane separately for cars and trucks. Trucks are defined as vehicles with six or more tires. As can be seen, volumes during the peak periods reached as high as 1841 vphpl at Antoine and

**I-10 at ANTOINE**

		WB			EB				
4001		1347	1197	1457	1995	1670	1688		5353
329	Mixed Grass/Paved	120	154	55	36	76	59	Work Area	171
		10'	10'	12'	10'	10'	10'		
				CMB			CMB		

**I-10 at WIRT**

		WB			EB				
3908		1239	1217	1452	1878	1600	1422		4900
302	Mixed Grass/Paved	11	15	40	22	80	57	Work Area	159
	Old Shld	10'	10.5'	11'	10'	10'	10'		
				CMB			CMB		

**I-10 at CAMPBELL**

		WB			EB					
		3574		913	1265	1396	1670	1620	1682	
		263		64	150	49	19	77	57	Unpaved Grass
				10'	10'	10'	11'	11'	11'	153
				CMB		CMB				

**I-10 at BUNKER HILL**

		WB			EB					
		3436		965	1307	1164				
		253		30	175	48				
	Work Area			10'	10'	10'	11'	11'	11'	Shld
				CMB		CMB				

**I-10 at WILCREST**

		WB			EB				
3328		982	1175	1171		1351	1280	1402	4033
181		66	86	29		30	69	35	134
	Shld	11'	11'	11'	Shld	11'	11'	11'	Shld
		10'			10'				10'
					CMB				

AM PEAK CARS  
AM PEAK TRUCKS

Figure 10. I-10 Katy a.m. Volumes by Lane and Vehicle Type

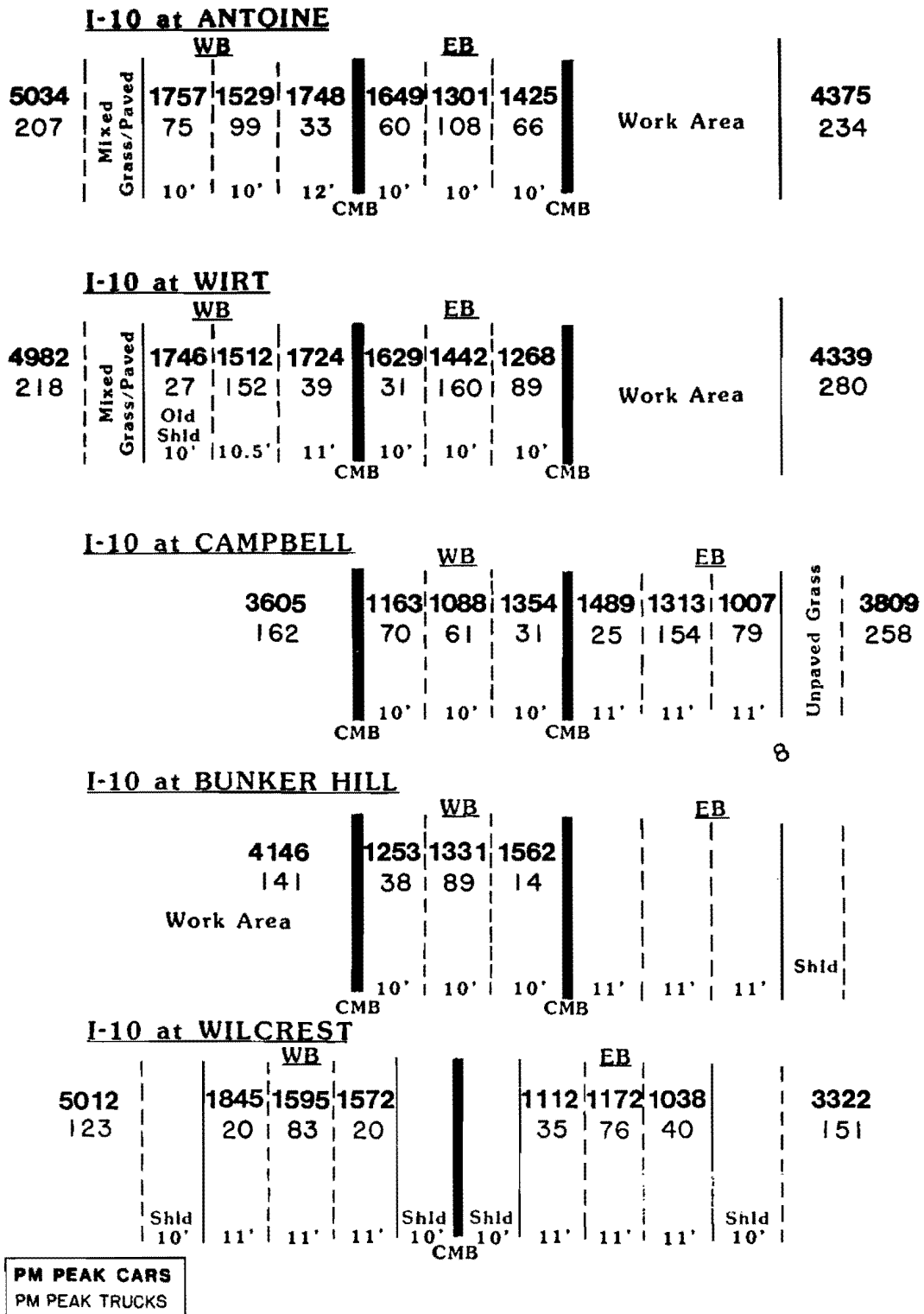


Figure 11. I-10 Katy p.m. Volumes by Lane and Vehicle Type

1686 vphpl at Wirt in the peak direction where three 10-ft lanes bounded by PCBs on each side were used. At Campbell, where 11-ft lanes were used with a PCB on the left and unpaved area on the right, volumes reached 1708 vphpl.

During the PM peak period, volumes in the peak direction (westbound) at Antoine and Wirt were 1747 and 1733 vphpl. Lane widths varied from 10 to 12 ft. at these locations (see Figure 9). A PCB was positioned on the right side of the travel lanes. At Wirt, where three 11-ft lanes were used, volumes reached 1712 vphpl.

It should be emphasized that the volumes presented represent a sample of counts made on two separate days, and is not a complete capacity study. The data represent volume data during typical peak periods; the flow at time may have been restricted by other factors (e.g., entrance and exit ramps). Nonetheless, the data indicate that volumes up to 1840 vphpl can be sustained on freeway sections with lanes as narrow as 10-ft on long-term construction projects where the traffic is physically separated from the work and opposing traffic by PCBs. On the average, it appears that the flow at the study sites was about 1750 vphpl. Considering the effects of trucks, this flow translates to about 1800 passenger cars phpl.

#### Lane Distribution

Although some interesting observations were made concerning lane distributions by type of vehicle during the AM and PM peak periods, the results were inconclusive because lane distribution data were not collected prior to construction. For example, the results revealed that there was a shift of approximately 20% from the inside lane to the middle lane by trucks



within the narrow lane construction cross-section over that observed in the full width cross-section. However, it is not known whether this trend existed prior to construction.

## **North Freeway (IH-45)**

### Cross-Section

Figure 12 illustrates the two forms of cross-section on the North Freeway reconstruction project at the time of the studies. Volume studies were conducted at Airline and N. Main Street. The measured cross-section at Airline consisted of three 10-ft lanes and a 10-ft paved shoulder in the southbound (inbound) direction and two 10-ft lanes, one 11-ft lane and an unpaved shoulder in the northbound (outbound) direction. At N. Main, the measured cross-section consisted of four 10-ft. lanes and an unpaved shoulder on the southbound direction, and three 10-ft lanes and one 11-ft lane in the northbound direction. The old shoulders in both directions were connected into 10-ft lanes.

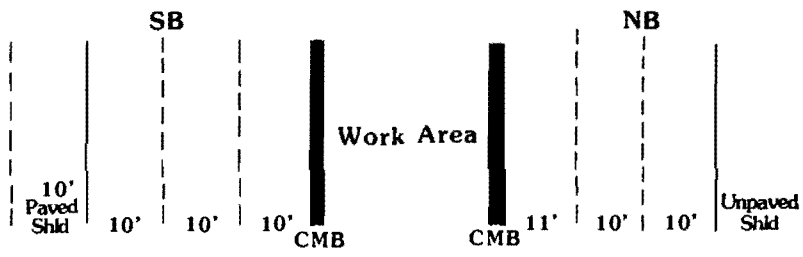
### Accidents

Accidents were not evaluated as of this writing because the reconstruction work had not progressed long enough to obtain sufficient data.

### Speed

Speed profiles for the North Freeway during typical AM and PM peak periods are shown in Appendix B.

**I-45 at AIRLINE**



**I-45 at N. MAIN ST.**

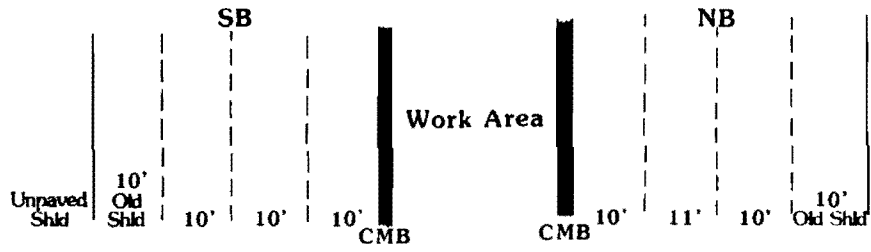


Figure 12. Schematic of I-45 (North) Study Sites

Volumes (Capacity) and Lane Distribution

Table 8 summarizes volume data by location for the AM and PM peak periods. As can be seen in Table 8 volumes were as high as 1757 vphpl, comparable to that experienced on the Katy Freeway. Considering the volume of trucks, this translates to about 1820 passenger cars phpl.

TABLE 8. NORTH FREEWAY TRANSITWAY PROJECT OBSERVED WORK ZONE VOLUMES (VPHPL)

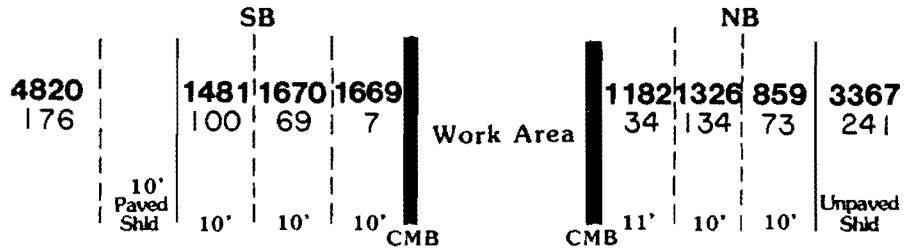
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Location Site	Airline	N. Main Street.
Lane Widths	10'-11'	10'-11'
Time Period		
AM Peak	1665	1757
PM Peak	1610	1592

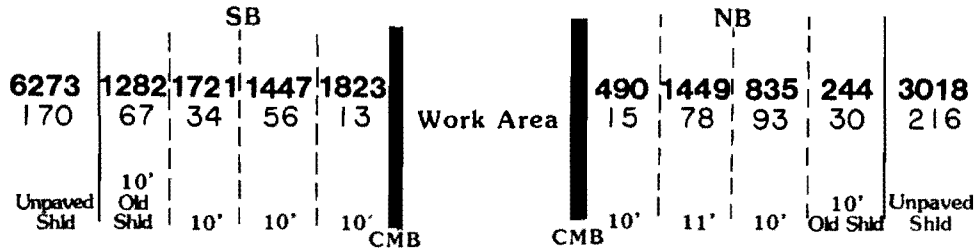
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Figures 13 and 14 show the volumes by lane and vehicle type during the AM and PM peak periods. No specific trends could be ascertained from the available data, with the exception of the following. When demand volumes are light, drivers prefer to travel on the regular traffic lanes. Use of the converted shoulder increases significantly as demand volumes approach or exceed the available capacity.

**I-45 at AIRLINE**



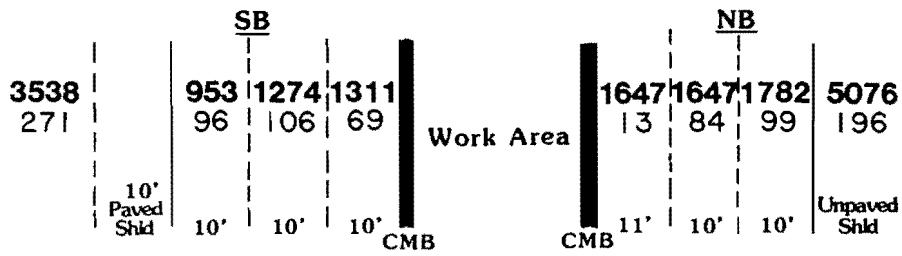
**I-45 at N. MAIN ST.**



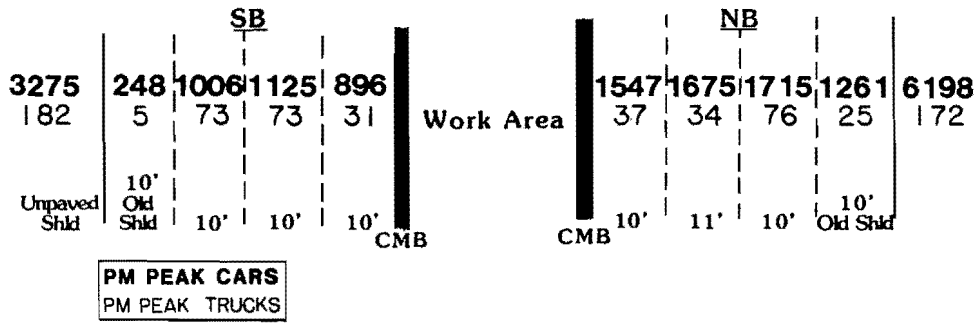
AM PEAK CARS  
AM PEAK TRUCKS

Figure 13. I-45 (North) A.M. Volumes by Lane and Location (Vehicles per Hour)

**I-45 at AIRLINE**



**I-45 at N. MAIN ST.**



**PM PEAK CARS**  
**PM PEAK TRUCKS**

Figure 14. I-45 (North) P.M. Volumes by Lane and Direction (Vehicles per Hour)



## 5. DISTRICT 12 SPECIAL TRAFFIC HANDLING CREW

### Introduction

During the late seventies and early eighties, performing major maintenance work on Houston's urban freeways degraded mobility to the extent that such maintenance operations were restricted to weekends and nights. The safety problems associated with nighttime work had further limited work to weekends, primarily on Sundays. However, the ever-increasing maintenance requirements of the freeway system meant that the needed repairs would take more time than was available on weekends. Therefore, the District 12 Maintenance and Traffic Operations staffs sought out methods that would allow repair work to be done during normal working hours.

The proposed approach was to apply proven work zone active traffic management techniques, such as shoulder usage and ramp control, to short-term maintenance activities. However, the implementation of active traffic control methods requires trained personnel, proper equipment, and adequate supervision. A Special Traffic Handling Crew was formed to provide a means of performing repair work safely on normal working days without unreasonable motorist delay. The Study 321 research staff assisted District 12 in organizing the Crew and developing and implementing work zone traffic control strategies.

This chapter summarizes the organization, function, needs, and success of the District 12 Special Traffic Handling Crew. It is not intended to provide a detailed account of active traffic management techniques. Rather, this chapter demonstrates how one District has implemented active traffic control and to provide some additional considerations in forming a crew.

## **Organization**

The Special Crew is part of the District 12 Traffic Management Section, which is responsible for freeway traffic operations. A crew could be housed in other sections; the important aspects are centralized administration of the crew and supervisors who are familiar with active work zone traffic control techniques. Centralized administration allows the crew to be assigned to local sections as needed and allows for maximum utilization of resources. Proper supervision insures that the crew is capable of actively managing traffic.

The District 12 crew is under the general direction of the traffic management supervisor, but the day-to-day supervision is provided by an assistant experienced in work zone traffic control. Scheduling work is accomplished by coordinating activities with local maintenance foremen and assistant foremen.

The crew itself consists of three Technician IIs. District 12 plans to hire a Technician III to function as a field foreman for the crew. This foreman will be a member of the crew, but will be trained to coordinate field activities in the absence of the traffic management supervisor's assistant. All crew members are trained in the basics of traffic operations through SDHPT sponsored short courses and practice sessions are held to train the crew in new procedures.

## **Duties**

The primary function of the crew is to manage traffic during major urban maintenance operations. However, this type of maintenance operation does not



necessarily occur every day. Therefore, the crew must have other duties so that the resources allocated to the team can be fully utilized.

The crew is also used to perform the traffic control set-up for routine maintenance jobs (i.e., those not requiring special active traffic management). Normally, a maintenance crew would set-up the traffic control themselves. Having the Special Crew perform this task allows the maintenance personnel to concentrate on the repair work. If the traffic control set-up does not require the special crew's attention, crew members can assist the maintenance personnel in the repair work.

The crew also participates in other secondary activities:

- 1) Delineator and mile post repair.
- 2) Traffic handling during major freeway incidents.
- 3) Assisting in sign repair.
- 4) Video taping of construction and maintenance projects.
- 5) Assisting in monitoring construction projects.
- 6) Collecting traffic operations data.

These activities could be supplemented from time-to-time, based on the needs of the District. Those given here are intended to demonstrate the range of possible functions.

### **Equipment**

The Special Traffic Handling Crew has some specialized equipment to facilitate their traffic control efforts. The equipment basically falls into one of the following categories: Vehicles, Communications, Signing, and General.

## Vehicles

The crew has three vehicles at its disposal: a cone-placement truck, a crew-cab pickup, and a pickup equipped with a one-line changeable message sign (CMS). The cone-placement truck, shown in Figure 15, was specially modified for quick placement and removal of cones. The truck was patterned after a vehicle which has been used successfully by Houston Metro transit to place tubular cones on the I-45 contraflow lane.

A crew-cab pickup (shown in Figure 16) is used to transport signs and sign supports.

The vehicle shown in Figure 17 is a pickup equipped with a one-line CMS. This CMS can be operated from the cab of the truck. Several pre-programmed messages are available and a keyboard can be used to program other messages. Additionally, the CMS can be programmed to function as an arrowboard. All vehicles are equipped with standard SDHPT two-way radios.

## Communications

Communication between crew members and supervisors is essential to the success of active traffic management. In District 12, the crew's vehicles are equipped with standard SDHPT radios; however, these radios are limited in their usefulness in active traffic management situations for two reasons: First, the degree of communication required for active traffic control tends to clutter the normal SDHPT radio frequency and limit the radio's usefulness for other SDHPT activities. Secondly, the crew members must be away from their vehicles at many times to manage traffic. Walkie-talkie type radios which operate on a frequency other than the SDHPT two-way radios are used by the District 12 crew during active traffic control situations.

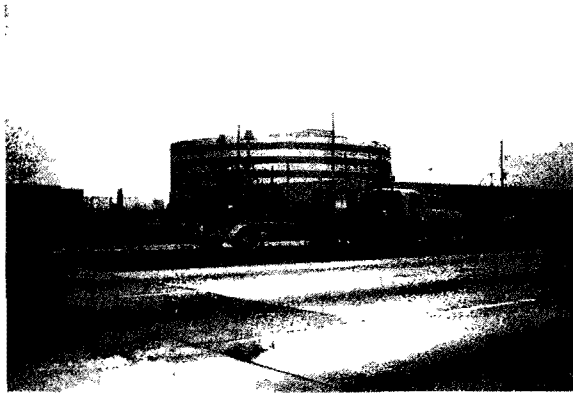


Figure 15. District 12 Special Traffic Handling Crew Cone Placement

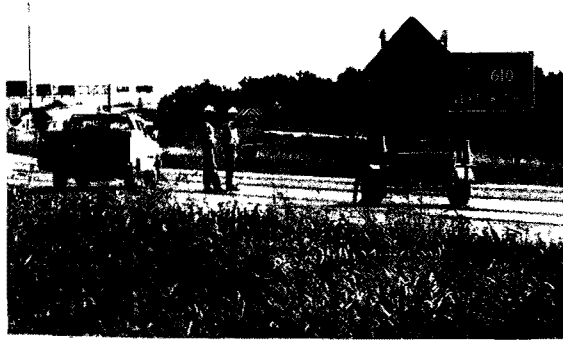


Figure 16. District 12 Special Traffic Handling Crew Sign Truck



Figure 17. District 12 Special Traffic Handling Crew CMS Truck

TABLE 9. RECOMMENDED EQUIPMENT FOR A SPECIAL TRAFFIC HANDLING CREW

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ESSENTIAL EQUIPMENT

- Cone Placement Vehicle
- Sign Vehicle
- Vehicle Equipped With Arrowboard<sup>a</sup>
- Full Complement of 48" x 48" Work Zone Warning Signs
- Adequate Number of Sign Supports
- Adequate Number of Cones
- Safety Vests
- Flags
- Hard Hats
- Jumper Cables

DESIRABLE EQUIPMENT

- Changeable Message Sign (Truck or Trailer-Mounted)<sup>b</sup>
- Temporary Striping
- Reserve Vehicle
- Shoulder Use Signs
- Supervisor's Vehicle

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<sup>a</sup>The Cone Placement or Sign Truck could be equipped with the arrowboard. A separate vehicle equipped with an arrowboard would be desirable.

<sup>b</sup>The trailer-mounted signs generally require a heavy-duty truck for towing. A truck-mounted sign may be more easily transported.

Effective communications are essential and the proper equipment is required to make that possible. Special emphasis should be placed on providing an effective field communications system. However, there is still a need for a standard SDHPT radio to provide a means of communicating with maintenance crews and headquarters.

### Signing

The crew is equipped with a full complement of 48" x 48" standard work zone signs and an adequate supply of sign supports. In addition to the standard signing, shoulder use and ramp closure signing is also carried. The crew may also help to install signs made specifically for certain maintenance or construction jobs.

### General

The crew is equipped with standard safety items such as reflective vests, hard hats and flags. The crew carries a substantial number of cones and more are available, if needed, from the District's supply.

### Recommended Equipment

Every Special Traffic Handling Crew might not need the same equipment used by the Houston crew; however, there are some items which are needed for effective traffic control. Table 9 is a recommended list of essential and desirable equipment for a Special Crew.

### **Benefits**

The primary advantage the Special Crew provides in Houston is the capability to do major freeway maintenance on weekdays. Before the formation

of the crew, weekday work on freeways was limited to emergency repairs. Weekends are still being utilized for maintenance work and the crew participates in some of these jobs; however, the ability to perform some of the work on weekdays has relieved the backlog of work.

The crew also allows maintenance work to be done more efficiently since regular maintenance personnel can concentrate on the repair without being concerned about the traffic control as well.

The use of a Special Crew also means that specialized training is not needed for every local section crew member. The Special Crew also becomes experienced in work zone traffic control and, therefore, able to handle unique situations. There is still a need for maintenance workers to be trained and capable in work zone traffic control since they will implement the traffic control plan for most repair jobs.

### **Additional Considerations**

The District 12 experience with the Special Crew has pointed out some areas where problems may occur. Districts considering the formation of such a crew should keep these in mind.

A primary consideration is finding qualified personnel. The Special Crew members must be able to manage traffic so that work zone safety, the efficiency of the repair work, and the efficiency of traffic movement are optimized.

Therefore, crew members must have some knowledge of safety and traffic operations and must also be able to adjust traffic control to suit the prevailing conditions. They must be able to cooperate with maintenance personnel to insure that the work can be performed safely, efficiently, and

without causing excessive delay for the motoring public. It has been suggested that special job classifications and pay scales be created for crew members to attract qualified personnel and to provide some continuity once the crew has been formed.

Another problem area can be vehicle breakdowns. District 12 has experienced some problems when a vehicle is disabled and no backup vehicle is available. The Special Crew depends on their vehicles to operate successfully and the loss of a vehicle has a great impact. It is recommended that when practical, a reserve vehicle be made available to a crew.

The crew also requires adequate supervision until the crew members gain experience in active traffic control. A good deal of support, effort, and time is required after the formation of a crew before benefits will be realized. However, with the cooperation of District administrative, operations and maintenance staffs, the crew can become a valuable asset to the District by providing safe and efficient traffic handling at major repair jobs.





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9. S.H. Richards and M.J.S. Faulkner. An Evaluation of Work Zone Accidents Occurring on Texas Highways in 1977. Texas Transportation Institute. Report No. FHWA/TX-81/44+263-3. July 1981.



APPENDIX A

KATY FREEWAY SPEED PROFILES  
Average Speed Between Roadways Obtained by Floating Car

KATY FREEWAY AVERAGE SPEEDS

DIRECTION=WESTBOUND PERIOD=AM PEAK

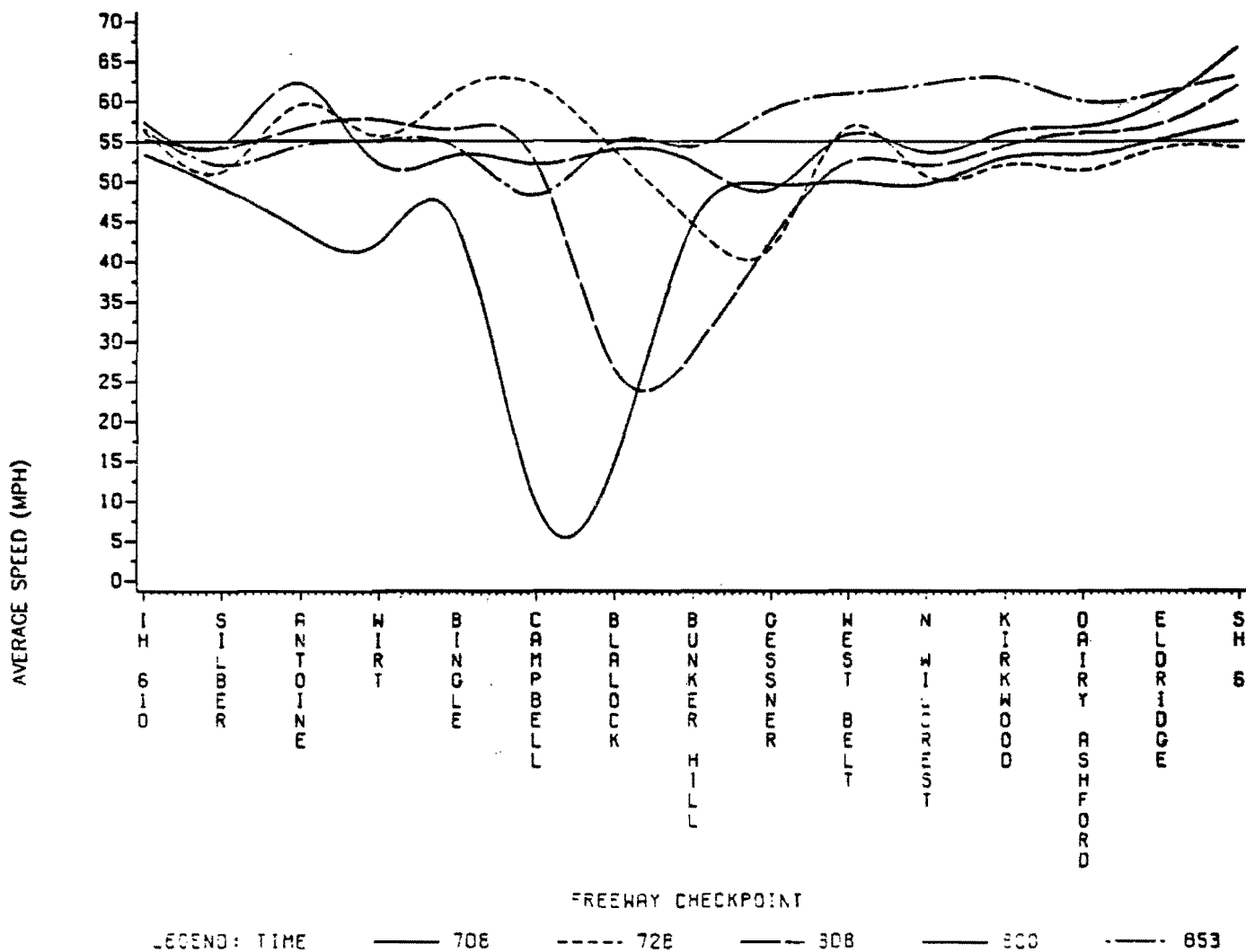


Figure 18.

# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=WESTBOUND PERIOD=NOON PEAK

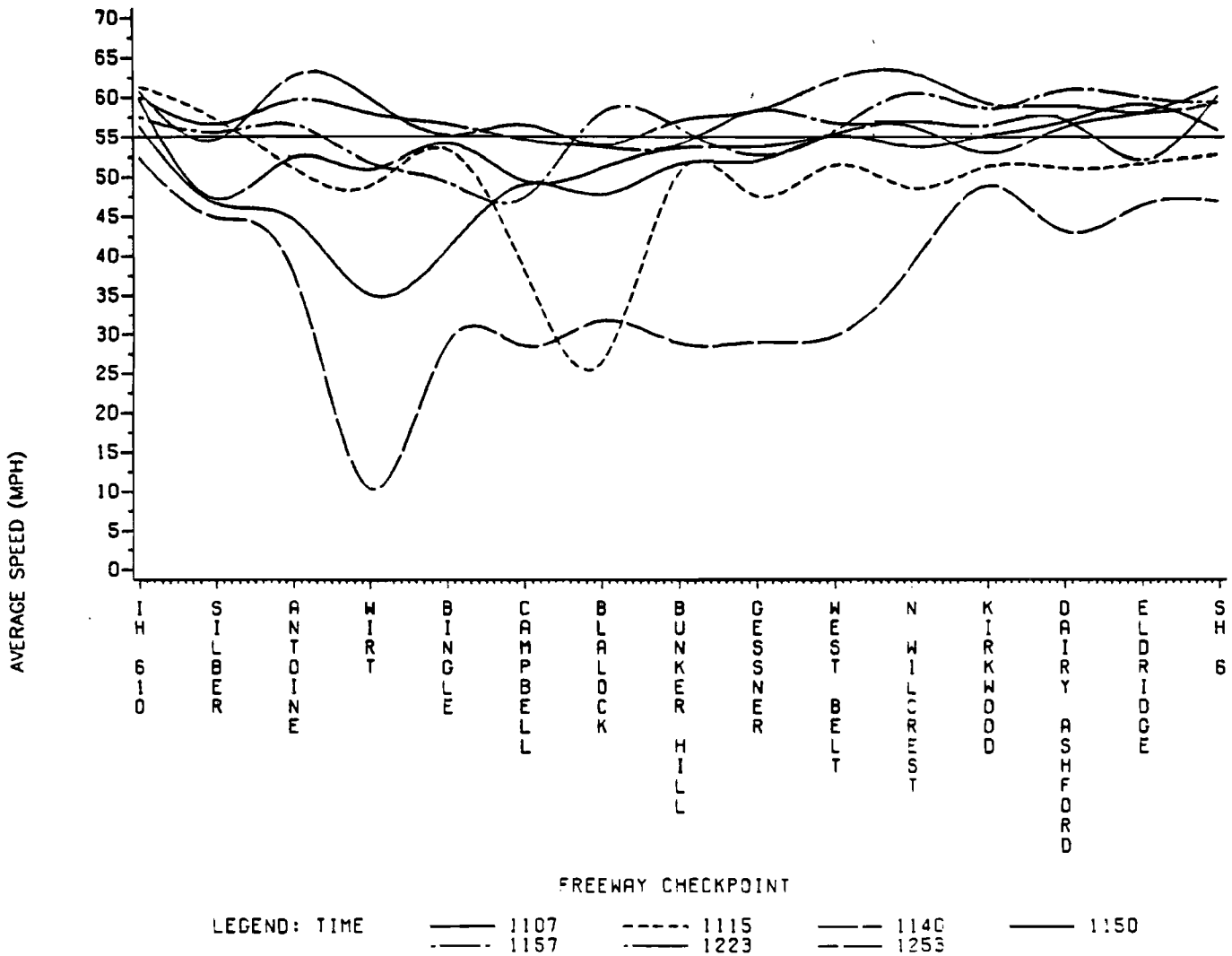


Figure 19.

# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=WESTBOUND PERIOD=PM PEAK

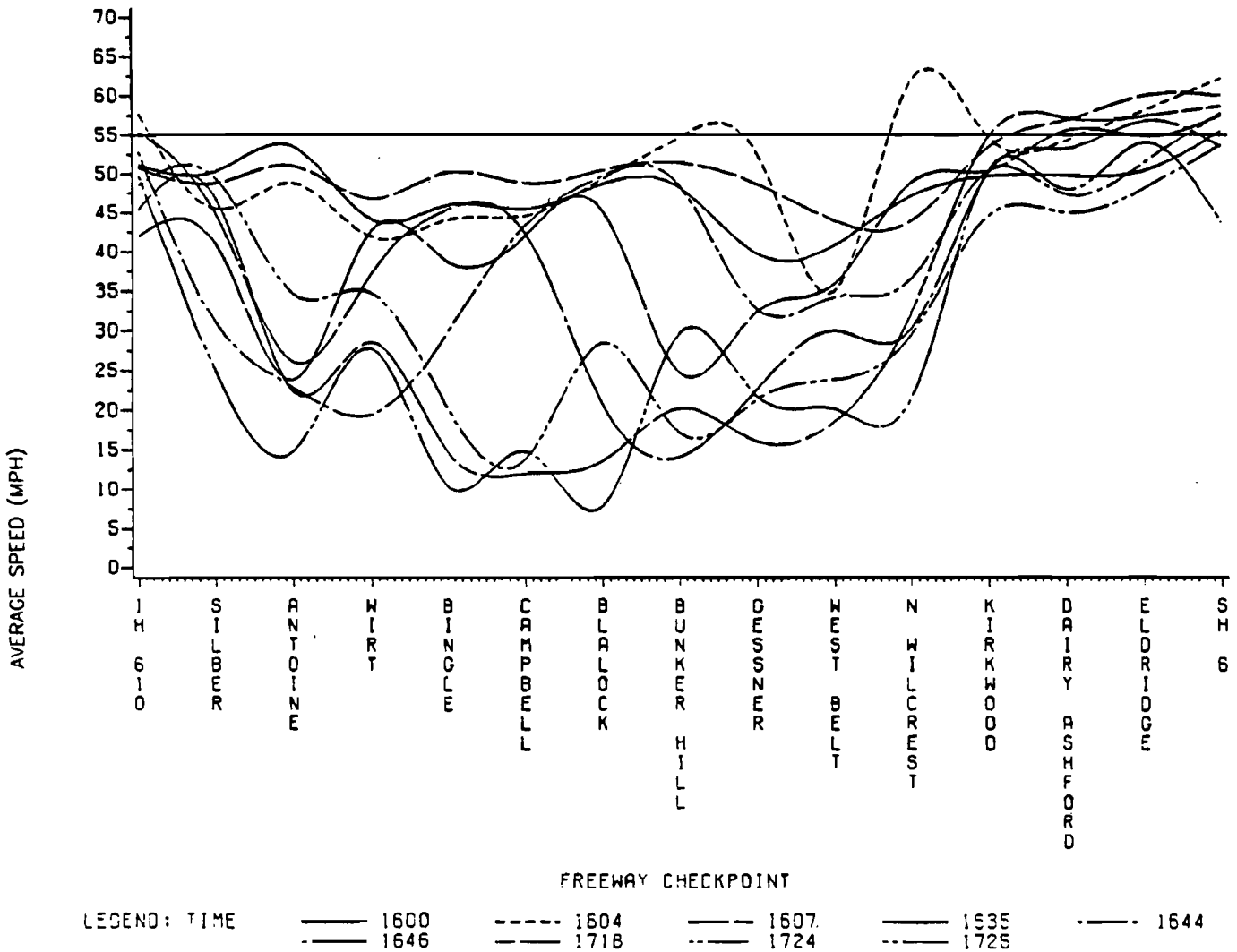


Figure 20.

# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=WESTBOUND PERIOD=NIGHT TIME

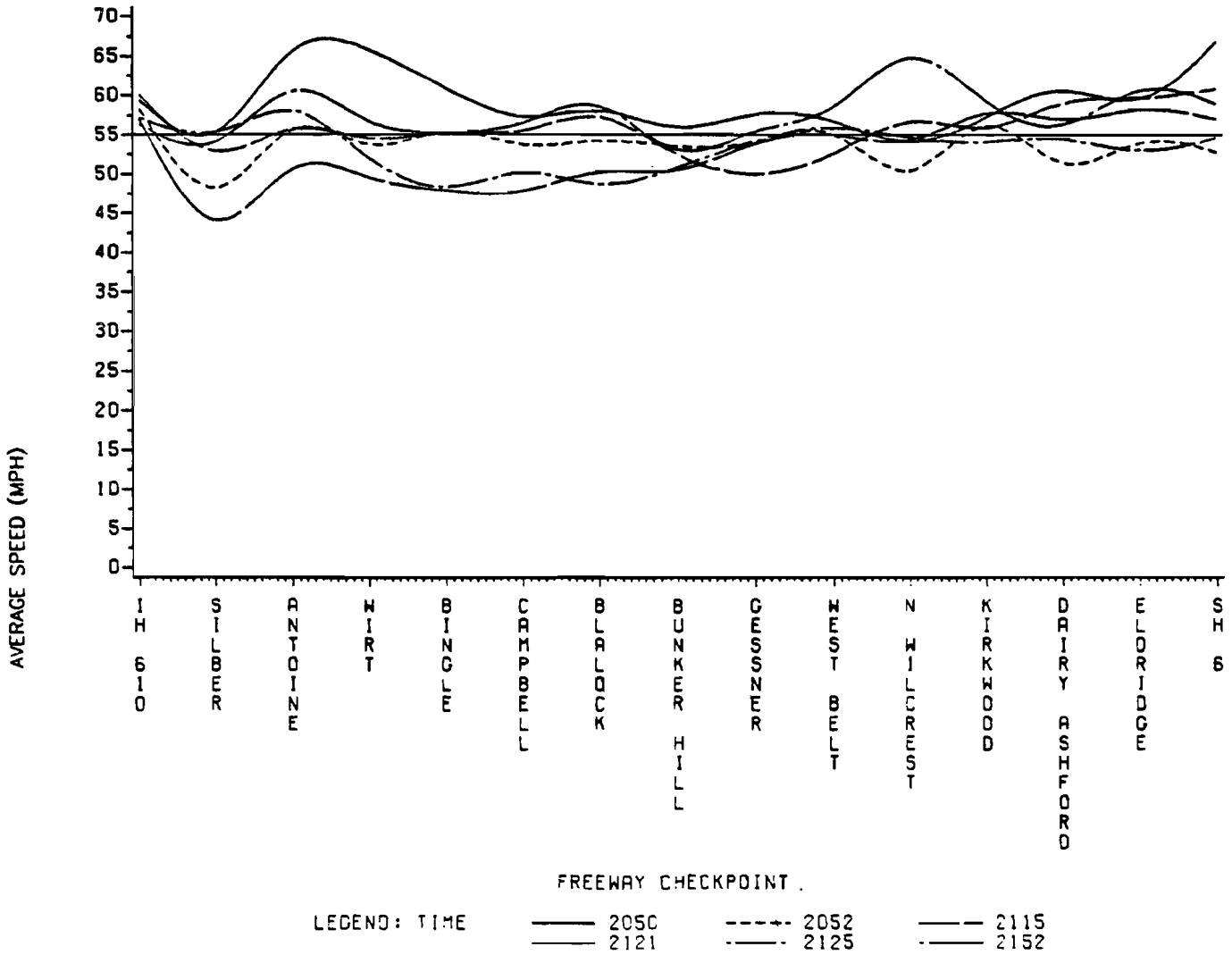


Figure 21.

# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=EASTBOUND PERIOD=AM PEAK

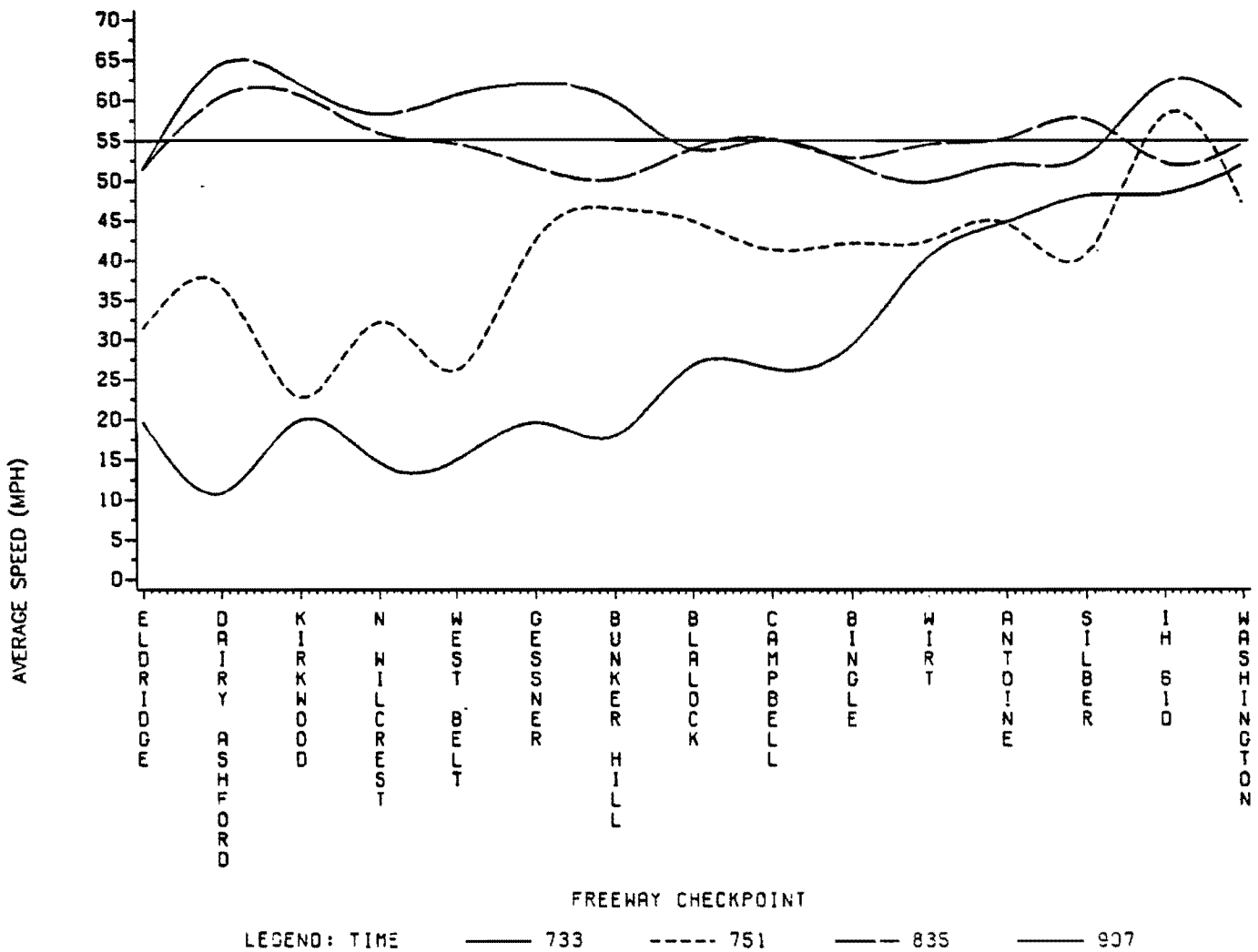


Figure 22.

# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=EASTBOUND PERIOD=NOON PEAK

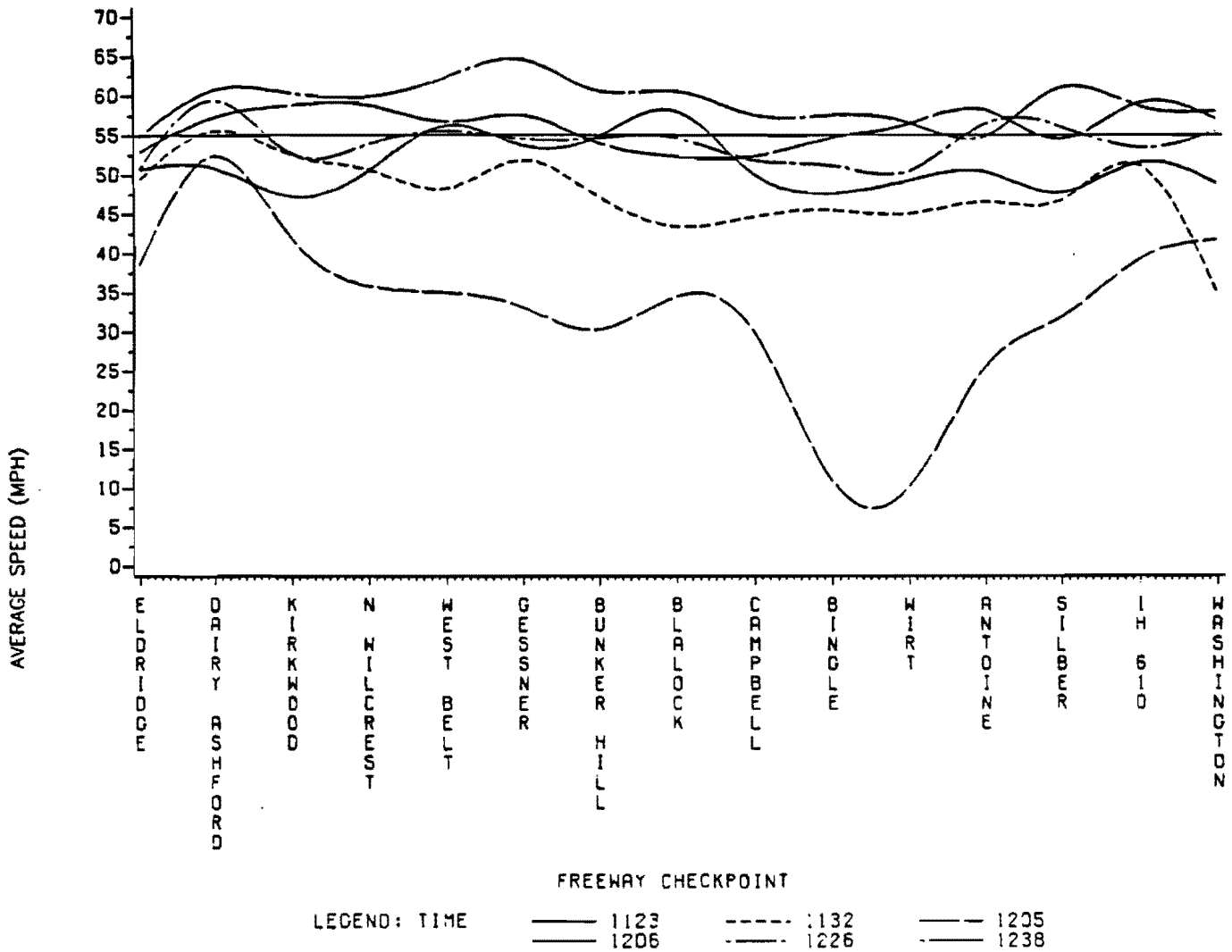


Figure 23.



# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=EASTBOUND PERIOD=PM PEAK

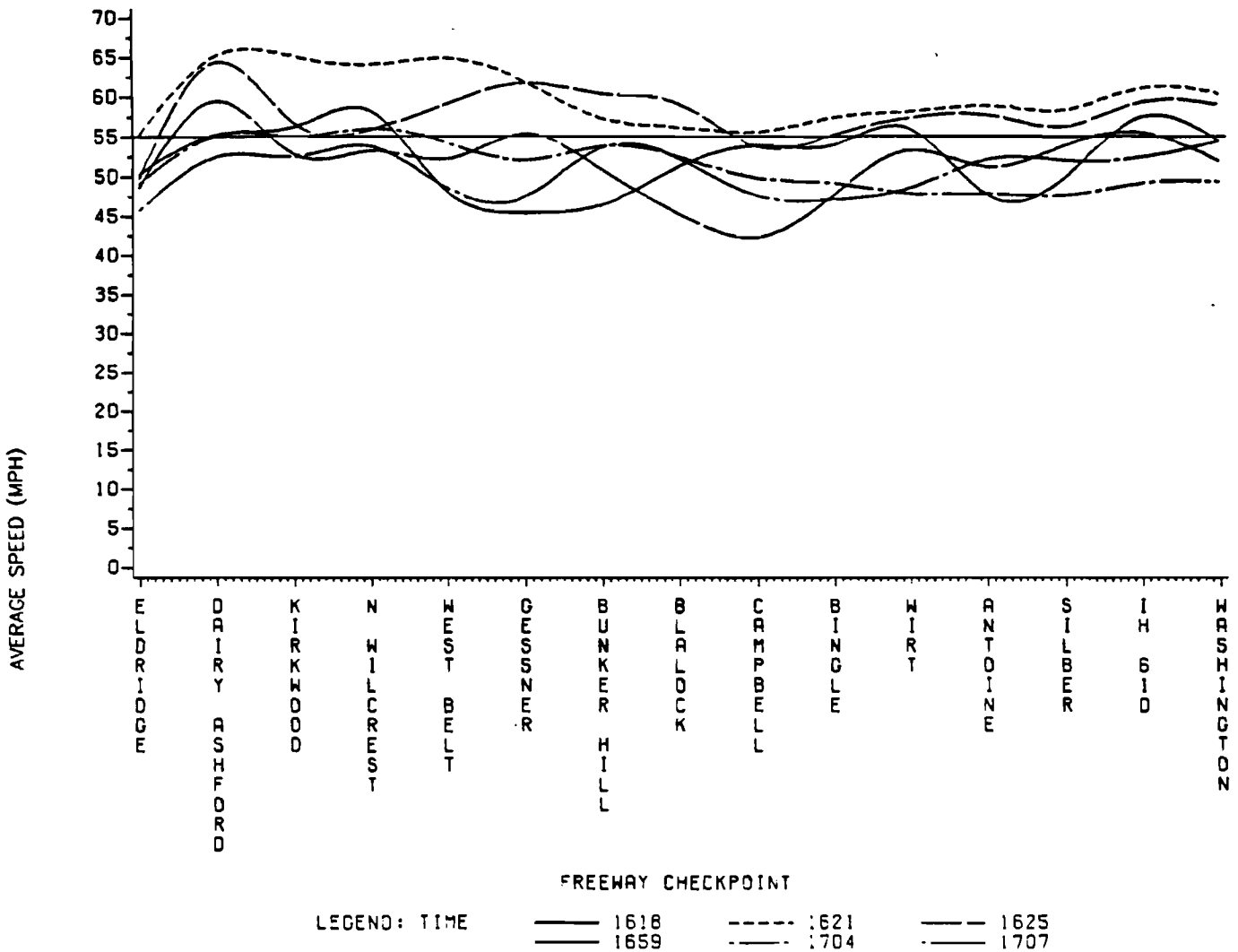


Figure 24.

# KATY FREEWAY AVERAGE SPEEDS

DIRECTION=EASTBOUND PERIOD=NIGHT TIME

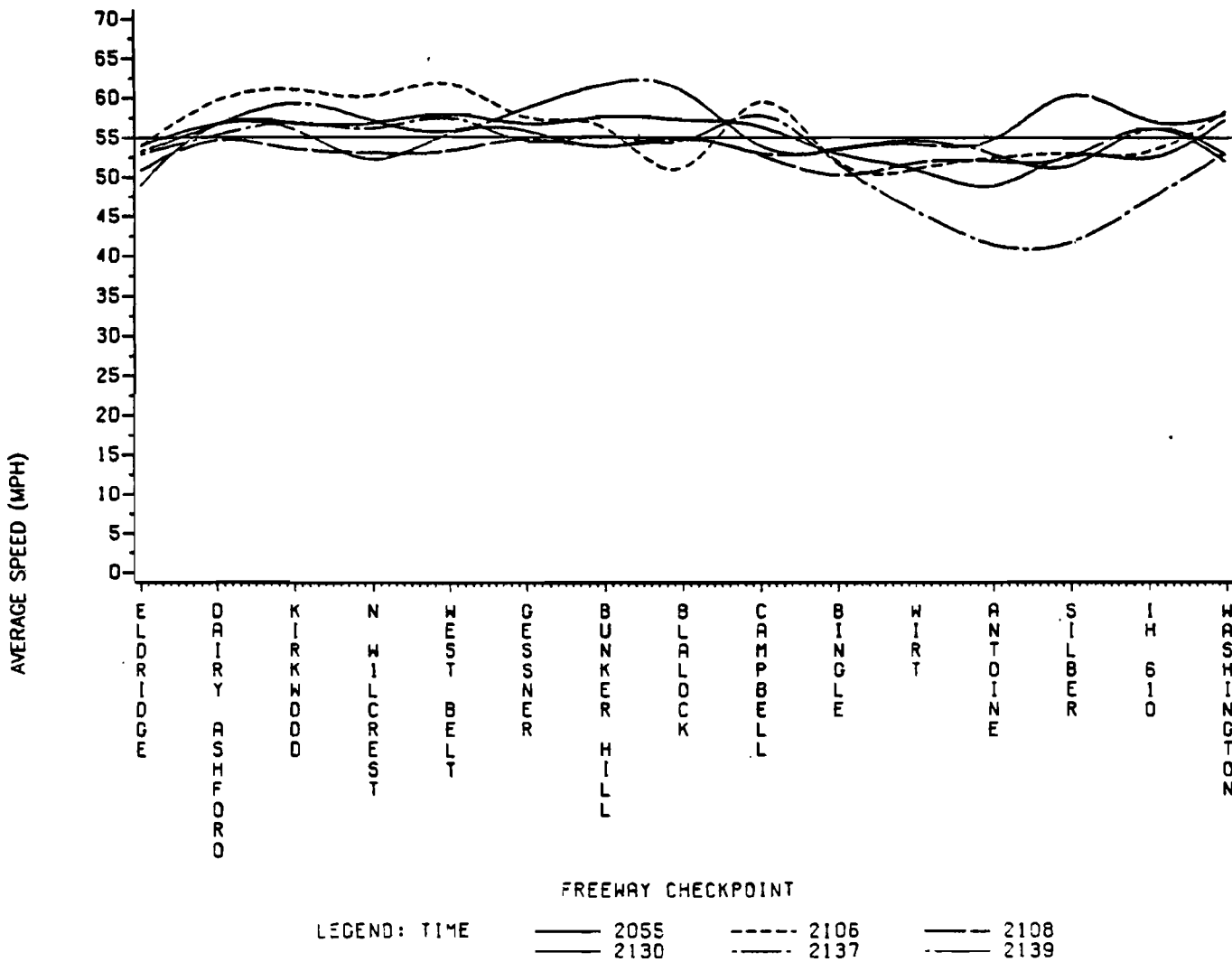


Figure 25.

APPENDIX B

NORTH FREEWAY SPEED PROFILES

NORTH FREEWAY AVERAGE SPEEDS

DIRECTION=NDRTHBOUND DATE=TUESDAY, MAY 22, 1984

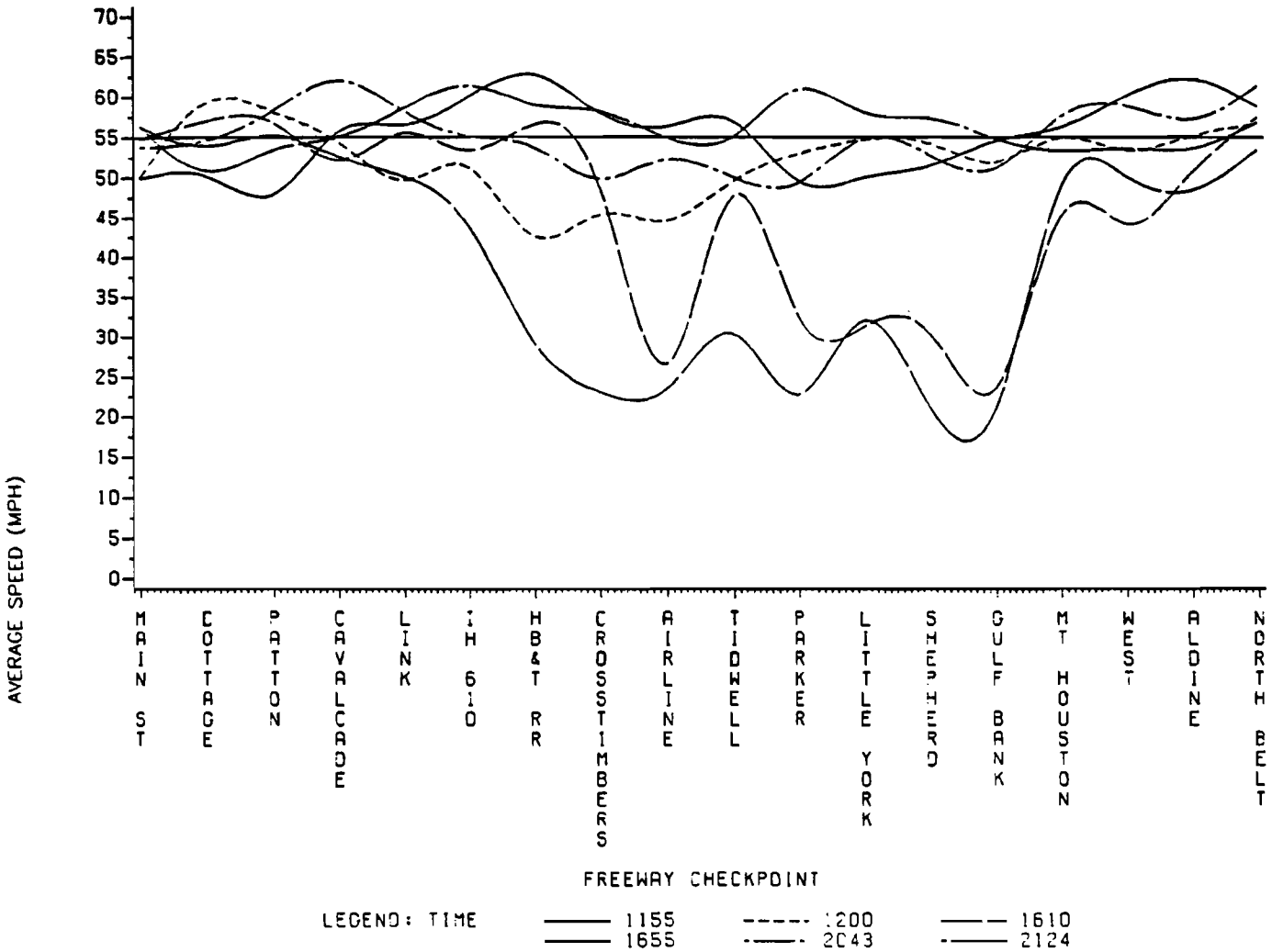


Figure 26.

**NORTH FREEWAY AVERAGE SPEEDS**  
 DIRECTION=SOUTHBOUND    DATE=TUESDAY, MAY 22, 1984

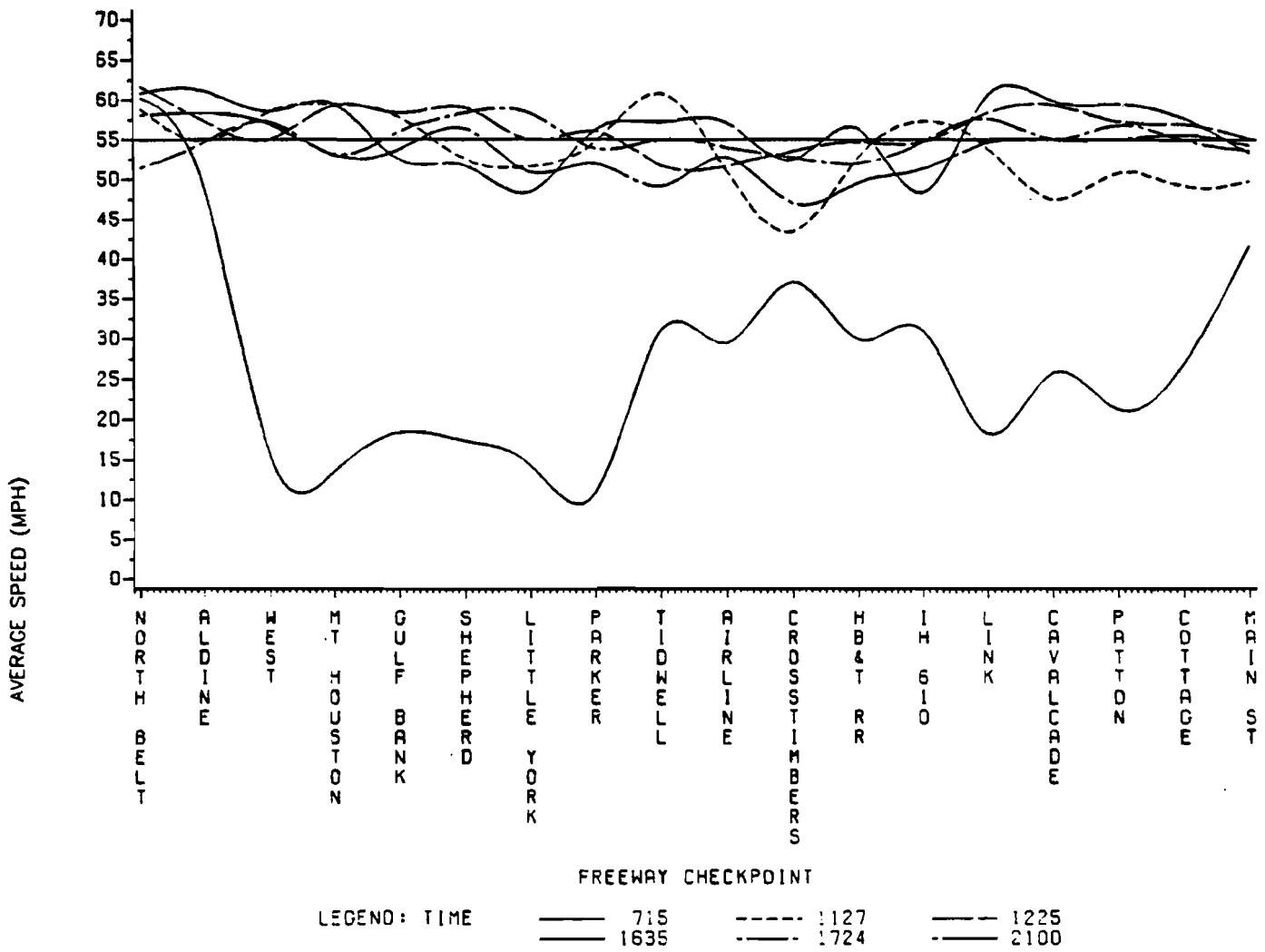


Figure 27.