Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-81/52+205-14		

4. Title and Subtitle	5. Report Date
Priority Treatment for High-Occupancy Vehicles on Interstate 10, El Paso	April 1982
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
William R. Stockton and Timothy J. Lomax	Research Report 205-14
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843	
	11. Contract or Grant No.
	Research Study 2-10-74-205
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas State Department of Highways and Public Transportation; Transportation Planning Division P.O. Box 5051 Austin, Texas 78763	Interim - September 1973 April 1982
	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with DOT, FHWA
Research Study Title: Priority Use of Freeway Facilities

16. Abstract

This report presents an evaluation of the need for priority treatments for high-occupancy vehicles on Interstate 10 in El Paso, Texas. The study addresses a 24.9-mile section of roadway from Americas Avenue (FM 375) on the east to Mesa Street (US 80, SH 20) on the west. Applicable priority treatments and the anticipated effectiveness of those treatments to the year 2000 were identitied.

17. Key Words	18. Distribution Statement
Priority Treatment, High-Occupancy Vehicles, Priority Entry, Exclusive Busways	No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

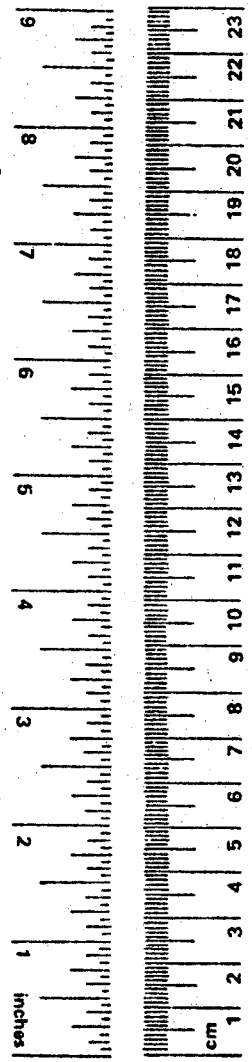
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

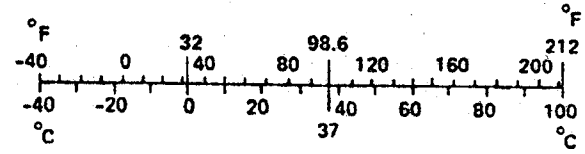
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
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^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°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
		LENGTH		
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
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
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^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°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.

PRIORITY TREATMENT FOR HIGH-OCCUPANCY VEHICLES ON INTERSTATE 10, EL PASO

A Feasibility Study

by

William R. Stockton
Assistant Research Engineer

and

Timothy J. Lomax
Engineering Research Associate

Research Report 205-14

Priority Use of Transportation Facilities

Research Study Number 2-10-74-205

Sponsored by

State Department of Highways and Public Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

April 1982

ABSTRACT

This report presents an evaluation of the need for priority treatments for high-occupancy vehicles on Interstate 10 in El Paso, Texas. The study addresses a 24.9-mile section of roadway from Americas Avenue (FM 375) on the east to Mesa Street (US-80, SH-20) on the west. Applicable priority treatments and the anticipated effectiveness of those treatments to the year 2000 were identified.

Key Words: Priority Treatment, High-Occupancy Vehicles, Priority Entry, Exclusive Busways.

SUMMARY

This study evaluates the need for priority treatment for high-occupancy vehicles (HOVs) on Interstate 10 in El Paso. Given present operating conditions, a need for priority measures does not exist at this time.

Level-of-Service (LOS) C conditions or better exist on both I-10 East and I-10 West for a significant portion of the peak period; LOS D conditions are experienced regularly on short sections of I-10 East, as well as occasional LOS E. The rapid growth of the last decade is expected to continue through the 1980s, and taper off somewhat during the 1990s. Traffic volumes approaching 150,000 vehicles per day (vpd) on I-10 East and 125,000 vpd on I-10 West are expected by the year 2000. No major freeway improvements are programmed.

By the late 1980s, a need for low-cost, short implementation time improvements is anticipated for both freeway sections. Priority entry for HOVs (buses, vanpools, and carpools) appears to be the preferred alternative. The suggested approach includes ramp metering with priority bypass at three locations on I-10 East and two locations on I-10 West. These improvements should cost $55,000-$70,000 per ramp and require about six months to implement.

In general, intermediate cost, intermediate implementation time HOV improvements begin to become effective when LOS E conditions exist for most of the peak hour. Although some LOS E conditions are expected on each freeway by the late 1990s, the duration of those conditions is not expected to be sufficient to justify an exclusive median HOV lane. This conclusion is further substantiated by utilization estimates that indicate that such an exclusive lane, if available, would serve only half as many person-trips in the peak hour as each of the non-priority lanes.

Due to the implementation times associated with the priority improvements

and the projected times until those improvements are needed, the Department does not need to take any immediate priority treatment actions. This report documents what improvements may be needed; sufficient time exists to allow the Department to wait to see if the need does, indeed, develop. If so, to the extent possible, provision of the HOV priority measures should be undertaken in conjunction with other improvements planned by the Department for Interstate 10.

IMPLEMENTATION STATEMENT

The intent of Project 205 has been to assist the Department in planning and implementing priority treatment on roadways in Texas. Historically, priority treatment has been considered as an alternative after the traffic situation has already become critical. The question then becomes what is there that can be done as quickly as possible.

In the Interstate 10 corridor, the situation is not yet critical. The opportunity exists to identify what improvements might be needed and at what point in time those improvements may be needed. With that information, high-occupancy vehicle improvements can be planned for, and coordinated with, other improvements planned by the Department. This report is intended to assist District 24 in that planning process.

DISCLAIMER

TABLE OF CONTENTS

INTRODUCTION

Since the inception of this project in 1974, the primary intent has been to assist the State Department of Highways and Public Transportation in planning for and implementing priority treatments for high-occupancy vehicles on roadways in Texas. As part of this assistance, the Institute has begun to perform feasibility studies concerning high-occupancy vehicle treatments for specific urban freeways in Texas.

The Project 205 Committee, comprised of 6 District Engineers and 3 Division Heads, has assisted the Institute in selecting the specific facilities to be evaluated. This feasibility study, which addresses Interstate 10 in El Paso, is the third of a series of such studies to be undertaken by Texas Transportation Institute. Figures 1 and 2 identify the Interstate 10 corridor study area. The study corridor extends 8.4 miles northwest of the central business district (CBD) to Mesa (US 80, SH 20) and 16.5 miles east of the CBD to Americas Avenue (FM 375). The cross section of Interstate 10 varies considerably throughout the study corridor as indicated on Figure 3. Because the freeway serves two separate segments of El Paso, the two sections will be referred to as Interstate 10 East (I-10E) and Interstate 10 West (I-10W).

The intent of the feasibility studies is to identify what priority treatments, if any, should be considered for the time and funding levels listed below.

- Short implementation time, low cost. Priority measures such as signal preemption and priority entry for high-occupancy vehicles are representative of this type of improvement.
- Intermediate implementation time, intermediate cost. Priority measures in this category would include contraflow lanes and one-lane median busways.

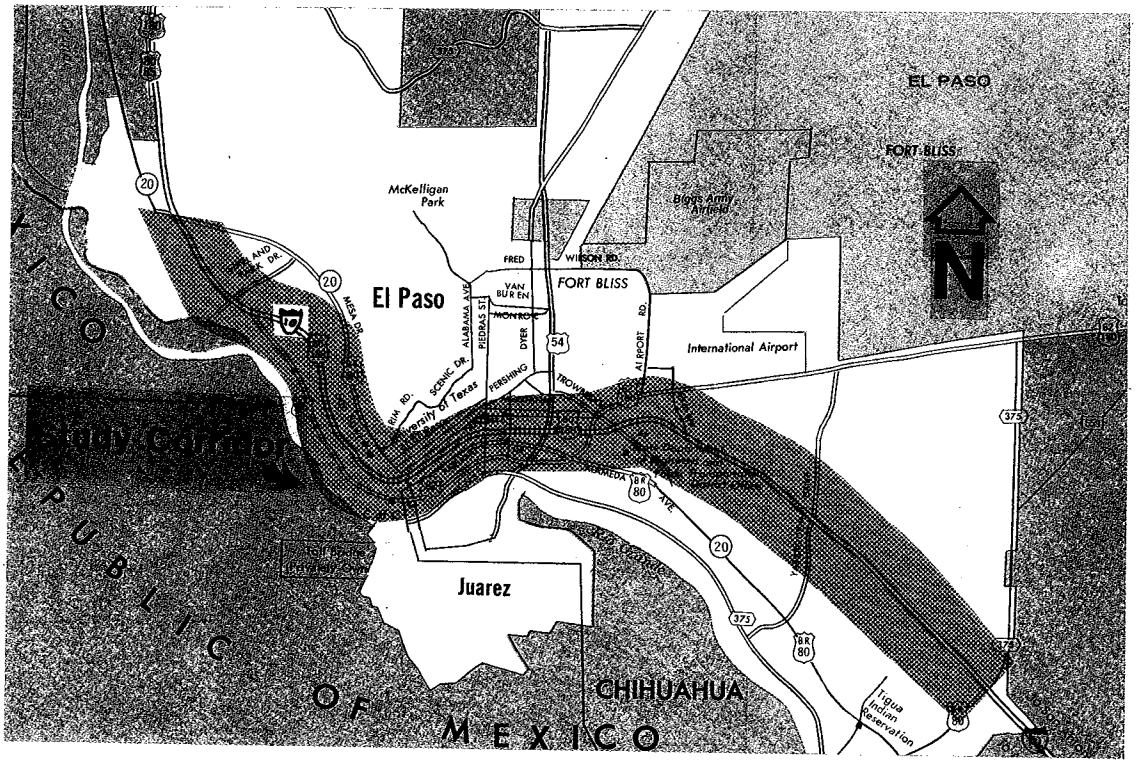


Figure 1. General Location of Interstate 10 Study Corridor

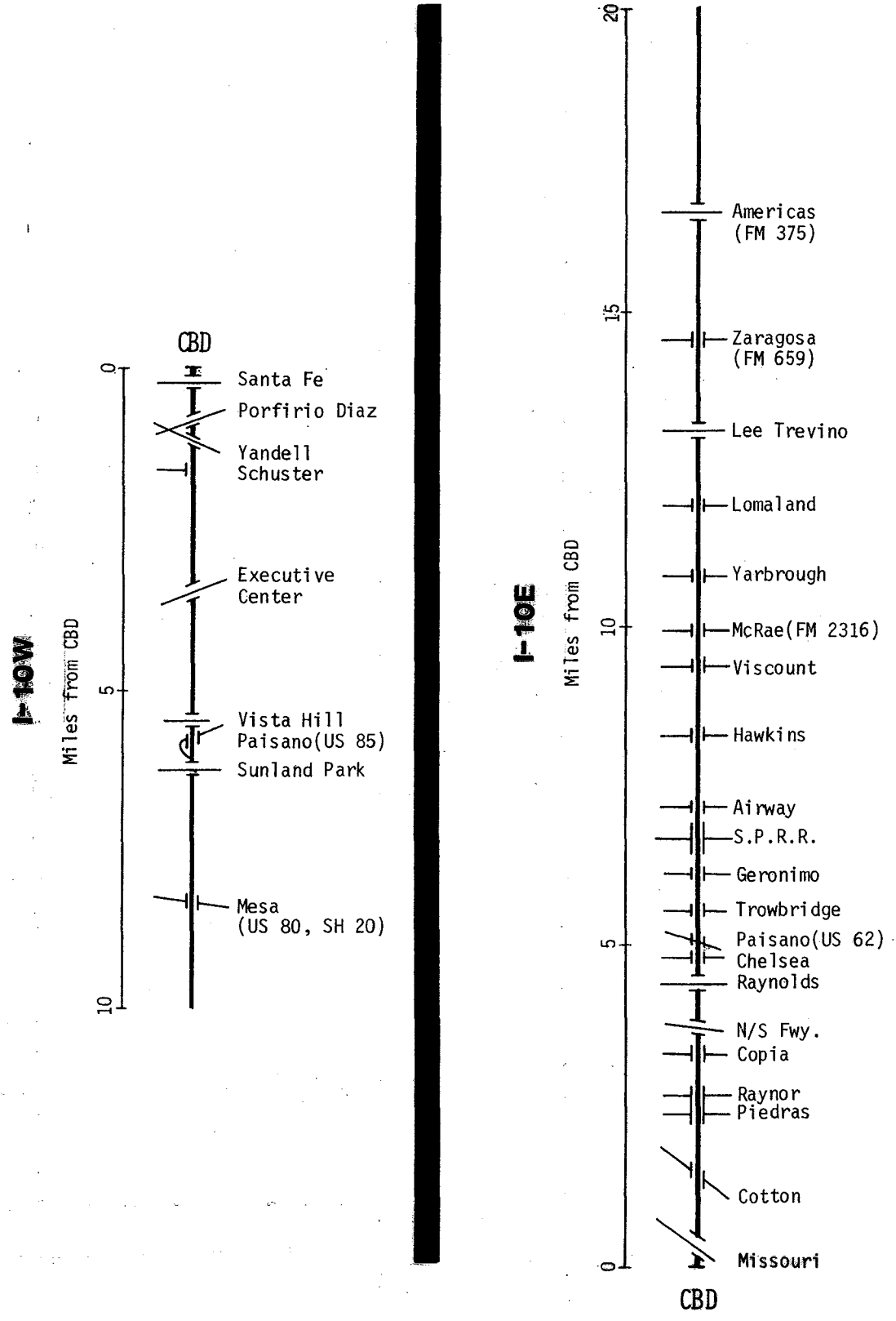


Figure 2. Interstate 10 Study Corridor and Major Intersections

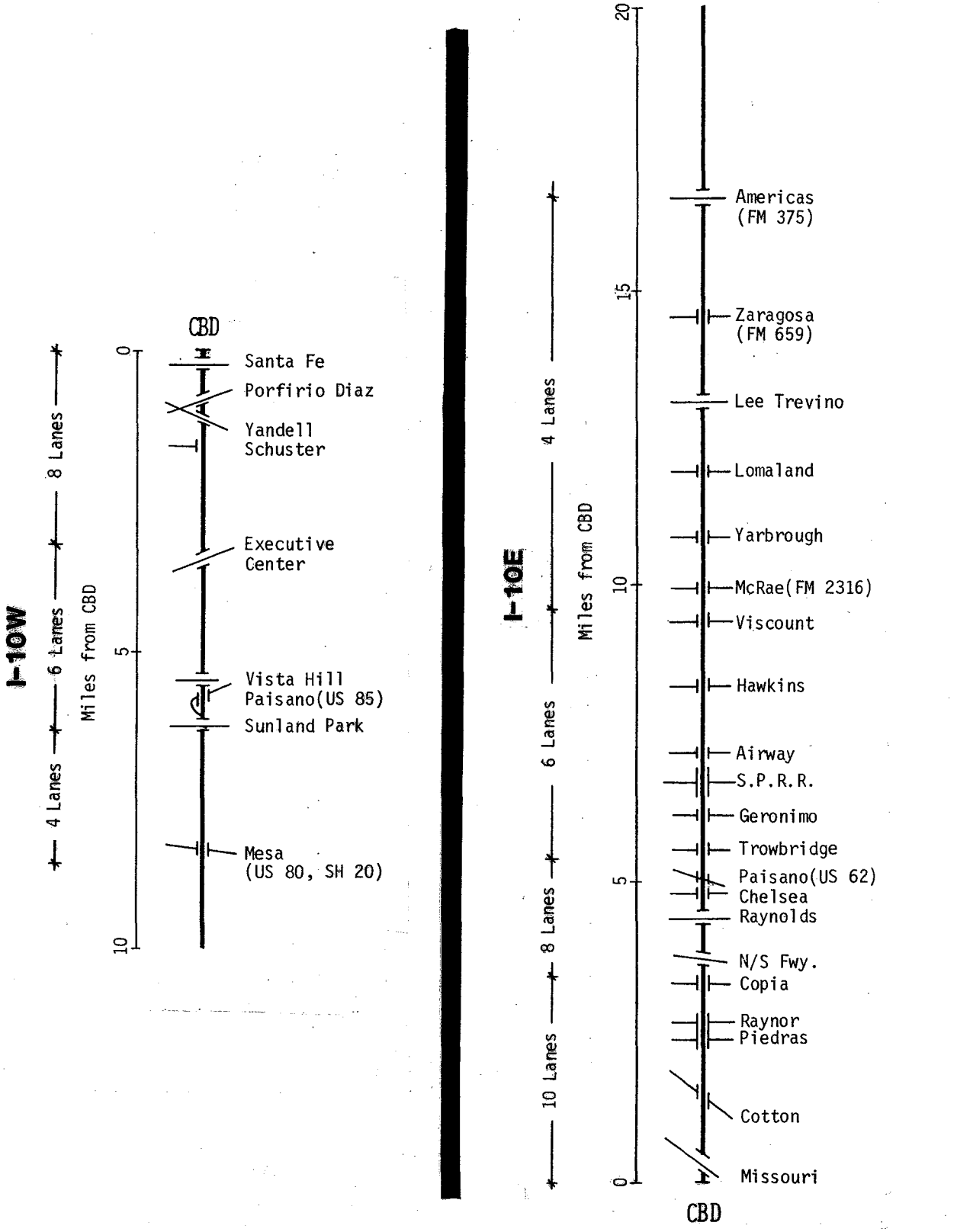


Figure 3. Cross Section Configuration in the Interstate 10 Study Corridor

- Long implementation time, very high cost. Multilane HOV facilities would be representative of this type of improvement.

Each of these time and funding levels is considered in this research project.

In addition to this introductory section, this report is presented in five sections. The initial section defines the extent and characteristics of both existing and projected traffic congestion in the Interstate 10 study corridor and the implications this traffic congestion has concerning priority treatment. The second section reviews available priority treatments and identifies those that appear applicable, based on physical design and traffic operating patterns, for implementation in the study corridor. The third section identifies the number of high-occupancy vehicles that can be expected to use the priority treatment and estimates the effectiveness of candidate treatments based on the anticipated utilization. The fourth section presents conceptual designs for the improvements; cross sections and renderings of both existing and possible future conditions are presented. The final section presents the major study findings and recommendations.

TRAFFIC CONSIDERATIONS

Interstate 10 is the major east-west route in El Paso. It provides access to the central business district (CBD) from both directions, as well as serving some of the Fort Bliss demand and a substantial amount of both commercial and industrial development along I-10.

Traffic volumes approaching 110,000 vehicles per day (vpd) on the east side and 60,000 vpd on the west are typical of existing operation. A recent report (Research Report 205-7) developed preliminary congestion indices for 19 radial freeways in Texas. In the two separate indices I-10E was rated the 14th and 15th most congested freeway, and I-10W the 19th most congested freeway. Based on these indices, congestion in the study corridor does not appear critical.

However, in the mid 70's, traffic on Interstate 10 grew at a faster rate (43 percent in 5 years) than on other freeways in Texas[1]*. Though it is unlikely that this growth rate will be sustained, congestion could be significant in the not-too-distant future. A substantial lead time exists between the time an improvement is identified and the implementation of that improvement. Thus, if anticipated future conditions indicate that some type of priority treatment will be needed, it is appropriate at this time to identify the nature of those needs. In this manner any other improvements made in the corridor can incorporate necessary provisions for future priority treatments, thereby minimizing unnecessarily expensive retrofitting.

For the purposes of this study, I-10E and I-10W are analyzed separately. I-10E varies in cross section from four to ten lanes. I-10W varies in cross section from six to eight lanes approaching the CBD. Any evaluation of either corridor must consider conditions and alternatives for each of the configurations shown in Figure 3.

---

*Indicates reference number at end of text.

Previous research[2,3] has indicated that low capital, short implementation time alternatives begin to become effective when peak-period travel volumes result in level of service (LOS) D. Intermediate cost, intermediate implementation time alternatives should begin to be effective as LOS E is reached. To be effective, HOV improvements must serve a significant portion of the person-trips through the corridor. It has been found that the conditions noted above (LOS D and E) would need to exist over an extended section of freeway and last throughout the peak hour for the treatments to represent a significant attraction.[3] Such improvements can then provide significant travel time advantages for high-occupancy vehicles (HOVs), as well as increase effective roadway capacity. If the intermediate range improvements cannot accommodate the projected travel demands, consideration needs to be given to long-range, high-cost alternatives. This does not preclude the need for implementation of other operational improvements prior to the evidenced need for priority treatment.

Traffic Volumes

Because the cross section of I-10 varies, a level-of-service analysis based on ADT per lane is used to permit comparisons of expected conditions irrespective of cross section. To ensure that projections of LOS D and E represent long-duration conditions, a conservative approach was taken in the computation of the ADT/lane that would generate each level-of-service (i.e., peak hour factor= 1.00 and directional distribution = 50/50). If other conditions are assumed, different time frames will result. Peak hour level-of-service D operation is characterized by volumes approaching 1800 vehicles per hour per lane; 2000 vehicles/hour/lane is the upper limit of LOS E operation. An expansion of these peak hour values using K=8 (i.e., peak hour = 8% of daily traffic) indicates that long-duration LOS D conditions can be expected when the ADT/lane reaches 22,500, and LOS E when the volumes reach 25,000 ADT/lane. A peak-hour factor

of K=10 would reduce the LOS D and E capacity values by 20 percent (i.e., 18,000 and 20,000 vpd, respectively). A peak-hour factor range of K=8 to K=10 could be used by the District for determining when to implement low cost priority treatments. Figure 4 shows estimated ADT/lane for 1980 and 2000 at selected locations. Historical and projected volumes for each freeway section are shown in both forms (total ADT and ADT/lane) in the following portions of this report

References to LOS D and E conditions will be made throughout this report. Unless noted otherwise, these estimated levels-of-service are based on the conservative approach explained above and relate to long-duration conditions. Some of the illustrations used could be misconstrued as indicating that neither LOS D nor E will be experienced in El Paso until late in this decade. Both LOS D and E are experienced sporadically now, though the frequency, length of freeway affected, and the duration are not adequate to justify priority treatments. LOS D and E as used in this report refer to the long-duration (at least one hour) conditions under which priority treatments are effective.

Interstate 10 East (I-10E)

The expected future increases in traffic volumes on I-10E are relatively modest, perhaps because much of the growth on the east side of El Paso has already occurred. Short-duration level-of-service D is a reality, or at least imminent, on many sections of I-10E. Historical and projected volumes for the various sections of I-10E are shown in Figure 5.

The projected volumes shown in Figures 5 and 6 are based on traffic assignments for the years 1985 and 2000. Projections may be low because of adjustments of impedance in the modelling process to force a distribution of traffic to other arteries in the corridor other than I-10. If the model proves invalid (i.e., higher I-10 volumes than projected), then the magnitude and anticipated time frame of future problems may be underestimated.

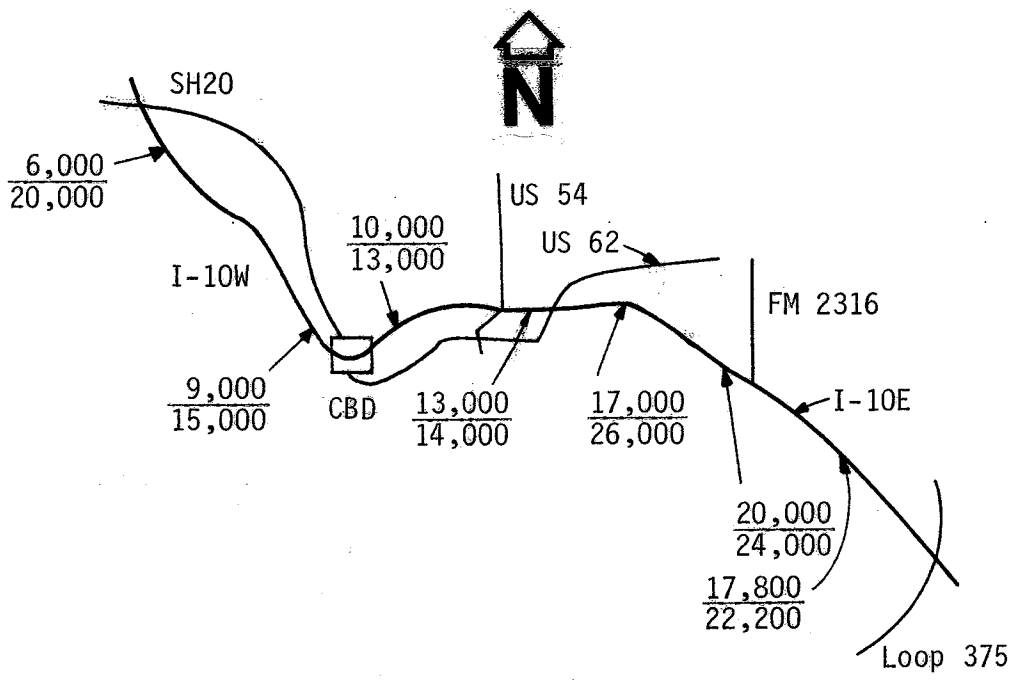
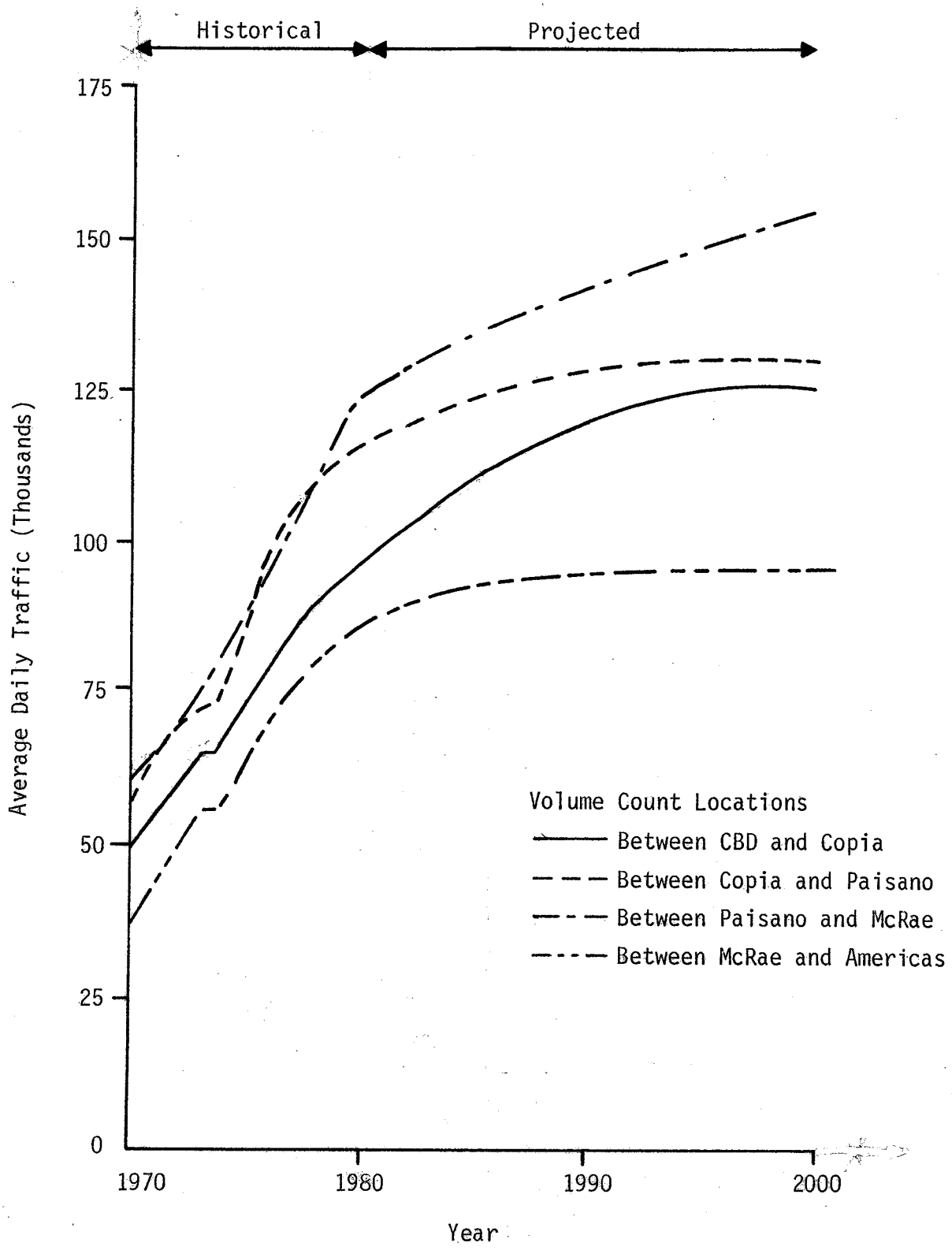
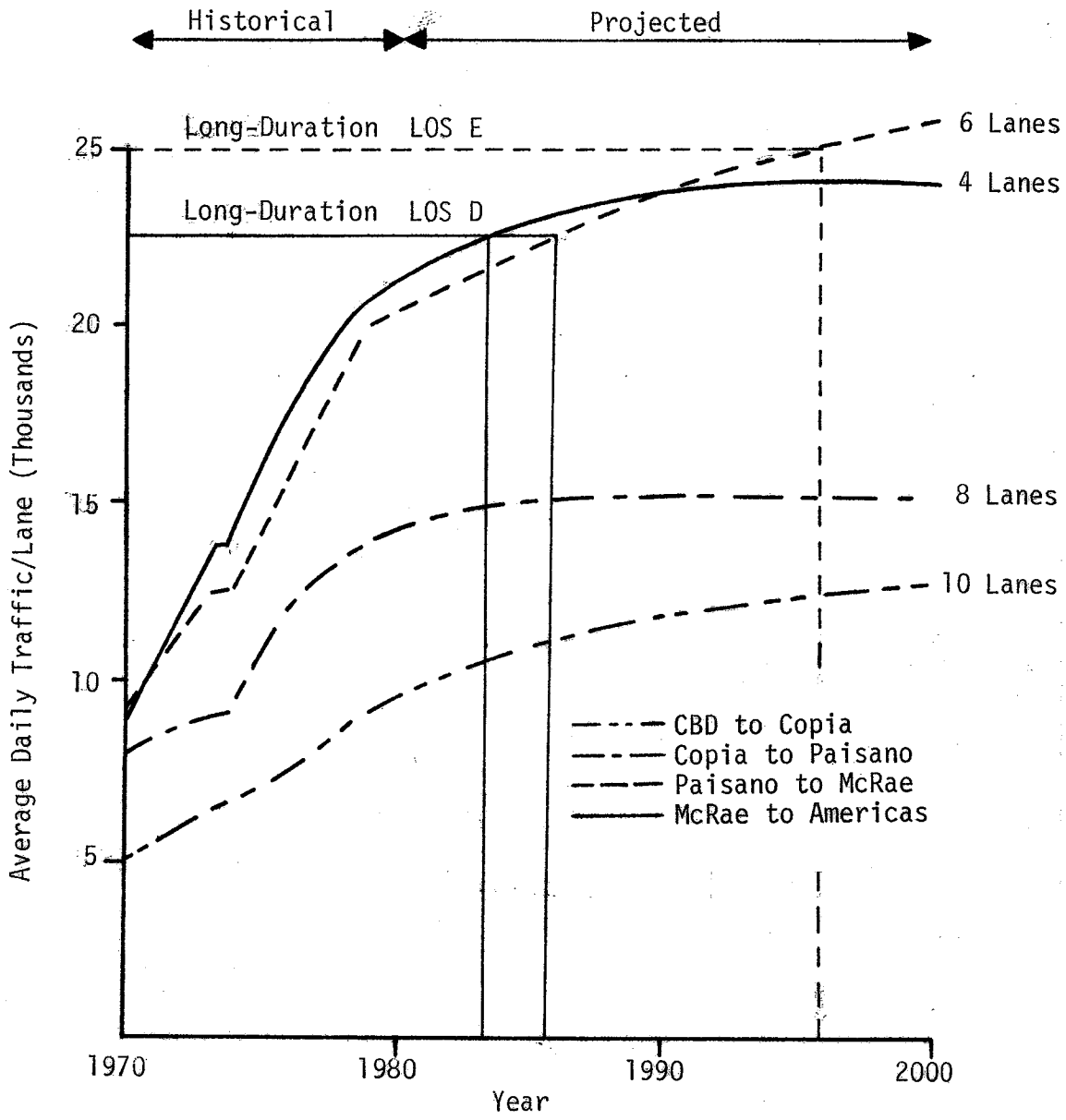


Figure 4. Estimated Average Daily Traffic per Lane, 1980 and 2000.



Source: State Department of Highways and Public Transportation

Figure 5. Historical and Projected Average Daily Traffic--Interstate 10, East, El Paso



Source: State Department of Highways and Public Transportation

Figure 6. Historical and Projected ADT/Lane--Interstate 10 East, El Paso

Americas Avenue to McRae Blvd.

A fairly steady increase in volume is expected in this 4-lane section until the mid 1980s; thereafter, a much slower growth rate is anticipated. Figure 6 shows that LOS D conditions should be anticipated by the mid 1980s, but that volume increases for the remainder of the century should not produce LOS E operation.

McRae Blvd. to Paisano Dr.

This six-lane section has also experienced significant growth in the last decade. Growth in volumes should continue at a fairly constant pace until 2000, but at a somewhat lower rate than in recent years. LOS D conditions should be evident by the late 1980s (Figure 6), with the onset of LOS E conditions anticipated in the late 1990s.

Paisano Dr. to CBD

Traffic volumes on these 8- and 10-lane sections will also increase, but at much lower rates than the two eastern sections. Long-duration LOS D conditions are not expected during the next two decades.

Priority Treatments for I-10E

The anticipated time frame for the onset of levels of service D and E are shown in Table 1. This summary indicates that some priority treatments may be appropriate from Lomaland to Paisano within this decade. The need for low-cost priority treatments by the mid 1980s is indicated for the four-lane section of I-10E. Low cost priority treatments should be applicable to the six-lane section from McRae to Paisano by late in the decade. A slow growth rate in traffic on sections west of Paisano, as is projected, indicates that no programming of priority treatments is necessary.

Table 1. Estimated Time Frame for Low and Intermediate Cost Priority Treatments on I-10E, El Paso

Roadway Section	Low-Cost Treatments Applicable	Intermediate-Cost Treatments Applicable
Americas Ave to McRae Blvd (4 Lanes)	mid 1980's	None Applicable[1]
McRae Blvd to Paisano Dr. (6 Lanes)	late 1980's	late 1990's
Paisano Dr to Copia St. (8 Lanes)	None Applicable[2]	None Applicable[1]
Copia St to CBD (10 Lanes)	None Applicable[2]	None Applicable[1]

[1] LOS E operation not anticipated this century.

[2] This section should experience only intermittent and isolated operation at LOS D through the 1990s.

Interstate 10 West (I-10W)

Figure 7 shows total historical and projected traffic volumes for the I-10W corridor. The relatively modest growth to date is expected to increase significantly in the 1980s and 1990s. This projected growth in traffic is consistent with the expected residential development northeast of the I-10W corridor. The Chaparral Park area is expected to produce more CBD trips than any other area of the city by 2000.[4] Many of these trips would enter I-10W near the end of the study area.

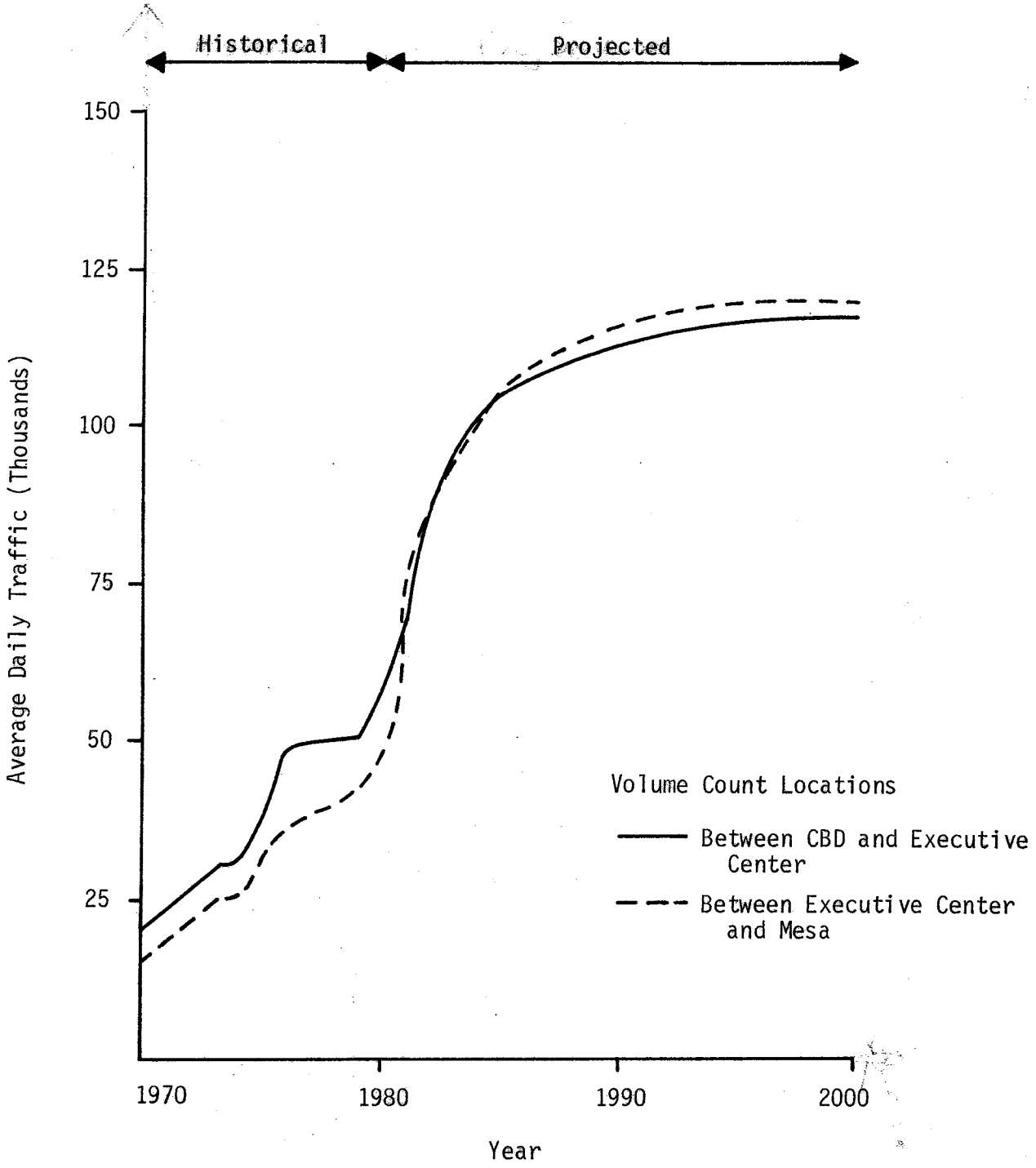
Projections of the anticipated onset of LOS D and E operation are shown in Figure 8. Estimates for K-factors of 8 and 10 are shown to indicate the possible range of conditions. Present peaking characteristics result in a K-factor near 10. If that characteristic is sustained, then a lower total daily traffic (18,000 ADT/lane) would produce LOS D operation in the peak.

Mesa St. to Executive Center Blvd.

Based on the estimates shown in Figure 8, the earliest that LOS D operation could be anticipated in this six-lane section would be the late 1980s. If that estimate is borne out, then LOS E conditions could be expected by the mid-to-late 1990s. This estimate assumes that peak period traffic will continue to account for 10 percent of total daily traffic. It is more likely that LOS D conditions will develop in the mid-1990s with no LOS E conditions of significant duration (i.e., at least one hour in length) prior to the end of the century.

Executive Center Blvd. to CBD

Ample capacity exists in this eight-lane section to accommodate traffic at LOS C or better through the 1990s.



Source: State Department of Highways and Public Transportation

Figure 7. Historical and Projected Average Daily Traffic--Interstate 10 West, El Paso

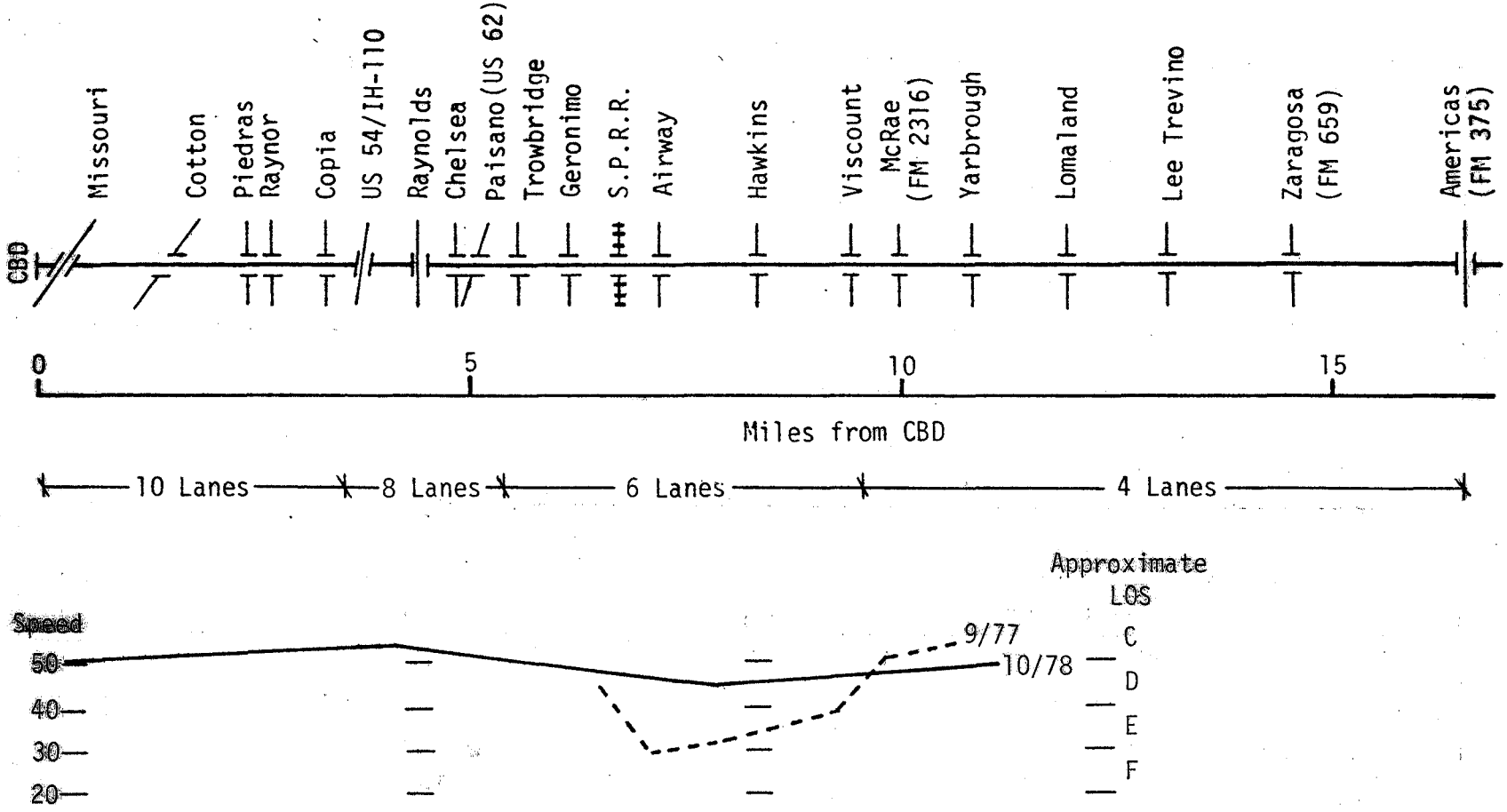
Priority Treatments for I-10W

Table 2 lists the approximate time frame in which LOS D and E operation can be anticipated for the two cross sections of I-10W. Two caveats are issued with this interpretation of volume projections. First, the anticipated rapid growth in northwest El Paso will be very sensitive to numerous economic variables, such as housing cost and availability, fuel availability and the continued economic prosperity of the city in general. It would be unwise to commit a large investment on such a high and sensitive projected growth rate at this time. Second, the projected onset of LOS D and E does not assure that such a level of service will exist for a substantial duration each day. One hour of operation at the designated level of service is generally assumed to be the minimum duration for which HOV improvements are warranted[3]. Recent estimates by the SDHPT[5] and on-site observations indicate that LOS E conditions occasionally exist downstream of the Sunland Park entrance ramp during 15-20 minutes of the AM peak. However, depending on the arrival distribution, LOS D is common. Such short and sporadic congestion is not conducive to effective priority treatment utilization.

Travel Speeds

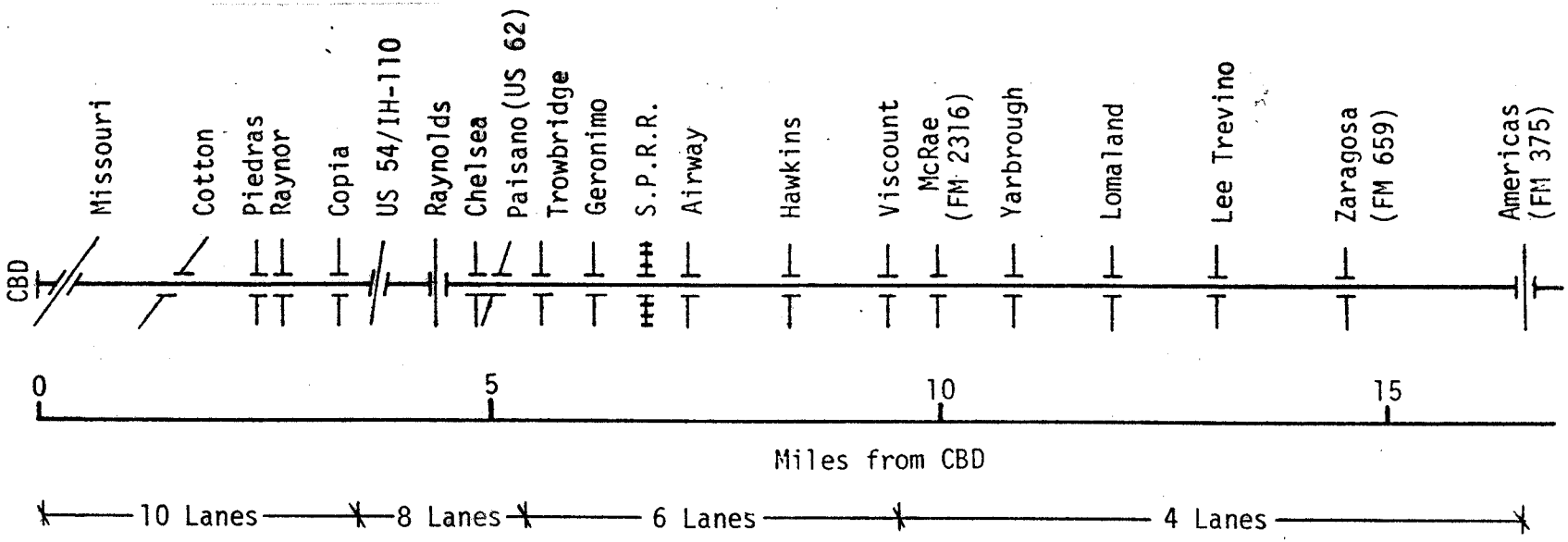
Peak period travel speed data were collected by the State Department of Highways and Public Transportation on I-10E in 1977[5] and 1978[6]. Speed profiles prepared from those data are shown in Figures 9 and 10 for morning and afternoon peaks, respectively.

The morning peak speed profile, shown as a solid line in Figure 9, indicates a relatively high level of service provided during the October 1978 data collection period. The Highway Capacity Manual[7] indicates that operating speeds above 50 mph are characteristic of LOS C, 40-50 mph of LOS D, and 30-40



Source: State Department of Highways and Public Transportation

Figure 9. AM Peak Operating Speeds, I-10E



Source: State Department of Highways and Public Transportation

Figure 10. PM Peak Operating Speed, I-10E

Table 2. Estimated Time Frame for Low and Intermediate Cost Priority Treatments on I-10W, El Paso

Roadway Section	Low-Cost Treatments Applicable	Intermediate-Cost Treatments Applicable
Mesa St. to Executive Center Blvd. (6 Lanes)	late 1980s	late 1990s
Executive Center Blvd. to CBD (8 Lanes)	None Applicable[1]	None Applicable[2]

[1] This section should experience only intermittent and isolated operation at LOS D through the 1990s.

[2] LOS E operation not anticipated this century.

mph of LOS E. From this base, LOS D is indicated for the section from McRae to Paisano in 1978. This finding is consistent with those based on traffic volumes (Table 1). However, the duration of LOS D operation at present is less than 30 minutes, generally from 7:20 to 7:50. A short section from Geronimo to Hawkins occasionally experiences short-duration LOS E conditions, as shown by the dashed line in Figure 9.

The effects of eastbound PM peak congestion are shown in Figure 10. The congestion indicated by the short-duration low speeds from the North-South Freeway to Geronimo is due to a capacity reducing bottleneck section downstream of the Trowbridge exit ramp, where one eastbound lane is dropped. Operating conditions downstream of the bottleneck rapidly resume LOS C+ speeds. The only entrance ramp in the affected section eastbound is at Raynolds. This ramp is on an elevated structure, and therefore not easily adapted to an HOV bypass lane.

No operating speed data were collected for I-10W because existing conditions permit virtually free speed operation.

OVERVIEW OF APPLICABLE PRIORITY TREATMENTS

In evaluating the potential for priority treatment on Interstate 10, a number of alternative improvements justify consideration. The primary issue addressed in this report concerns what priority treatments, if any, should be considered for incorporation into the facility. The intent of this section of the report is to screen the available priority treatment techniques, and to identify those priority treatments that appear to be technically feasible.

Previous research reports (205-1, 205-8, and 205-10) have identified and reviewed alternative priority techniques as those techniques relate to specific Texas freeways. Those preliminary evaluations have identified the general types of improvements that appear to be applicable in the Interstate 10 Study Corridor.

The applicability of the following five priority treatments to Texas freeways was considered in previous reports.

1. Exclusive Busway - lanes that are physically separated from other traffic;
2. Contraflow Lane - a lane reserved for buses on the left-hand side of the median barrier;
3. Reserved Lane-Concurrent Flow - a lane reserved for high-occupancy vehicles in the normal direction of flow that is not physically separated from other lanes;
4. Freeway Control with Priority Entry - a situation where total freeway traffic volumes are controlled by traffic signals at entry ramps, with high-occupancy vehicles provided special entry ramps; and
5. Use of Frontage Roads - the use of signal preemption, reserved lanes, or other devices to expedite the movement of buses along freeway frontage roads or other surface streets.

Each of these techniques requires a different set of design and operational characteristics in order to be applicable to a specific freeway. A set of design

and operational characteristics considered critical to the implementation of each of the five techniques was developed as part of previous research. In developing those characteristics, the underlying assumptions set forth below were utilized. If different underlying assumptions are considered, different guidelines will result.

1. Negative effects on existing traffic capacity available to the general public should be minimized.

   a. To be effective and enforceable, all of the techniques implemented must have the support of the general public. An episode similiar to the Los Angeles "Diamond Lane" controversy would be highly undesirable.

   b. Removal of emergency parking shoulders would probably be acceptable as would narrowing of lane width along short sections of roadway. Removal of an existing lane of travel in a congested portion of freeway problably would not be acceptable.

2. The application of priority treatment to any segment of freeway should result either in improved HOV travel speeds or in improved bus schedule reliability.

   a. Priority treatment along portions of freeways that are operating at 45 mph or better in mixed flow would yield little, if any, benefit. Such projects could not be justified unless there is strong evidence that the "free-flow" conditions will be short-lived, and that early implementation of priority treatment would be beneficial. This is an especially critical consideration in the study of Interstate 10 since, at present, mixed flow operating speeds during the peak hour are frequently in the range of 45 mph or better.

   b. No consideration is given to trying to force a reduction in Vehicle-Miles-of-Travel (VMT) through the implementation of priority treatment. The primary objective of priority treatment techniques is to increase the effective capacity of the existing facilities and also to permit improved transit schedule reliability.

Design and Operational Characteristics

For each type of priority improvement, the design and operational characteristics of a freeway which are critical to implementation of that technique are presented in this section. It should be noted that these characteristics are divided into two sets: those considered to be "Required Attributes," and those

considered to be "Desired Attributes." If a specific freeway does not meet all of the "Required Attributes" for a certain priority treatment technique, then that particular technique is considered technically infeasible for application to the freeway being evaluated. The "Desired Attributes" are to be considered only if all "Required Attributes" are satisfied. If all desired characteristics are not met, the improvement may be undesirable but not necessarily infeasible.

Exclusive Busway

Different types of exclusive busways might be considered. One type might consist of an elevated guideway with adequate lane and shoulder widths to assure optimal operation. This might be considered as a long implementation time, very high cost alternative. The other type might be considered more of an "intermediate" range improvement: a busway that might be implemented primarily at-grade in the median. Such an improvement would require less implementation time than would an entirely grade-separated, multilane, high-occupancy vehicle facility. It is recognized that several design and operational aspects of this latter design, although "workable," may not be optimal.

Required Attributes

The following attributes are considered essential for application of an exclusive busway to an existing freeway.

- Continuous wide median section (∿20 feet wide) available along most of the critical segment.
- Buses are able to reach the exclusive lane expeditiously.
- No left-hand entrances or exits that cannot be grade-separated within available right-of-way.
- No existing underpasses with center columns that cannot be negotiated through restriping lanes or some device other than eliminating the columns.

Desired Attributes

The following attributes are considered desirable for application of an exclusive busway to an existing freeway.

- Minimum median clutter requiring relocation (luminaire supports, sign structures, drainage inlets, etc.)
- Minimum grade differentials between roadways on each side of the median.
- Continuous median shoulders across existing overpass structures.

Contraflow Lane

Contraflow lanes have generally been applied as remedial measures for freeways with critical congestion problems. As discussed previously, congestion on Interstate 10 is not expected to reach such a critical level for several years, allowing ample opportunity to plan for long-range improvements. Although contraflow should not be summarily ruled out, it is unlikely that this technique would be planned as a long-range improvement.

Required Attributes

The following attributes are considered absolute requirements for applicability of a contraflow lane.

- Minimum of three lanes in the off-peak direction.

  Note: At least two remaining travel lanes must be available to the general public in the off-peak direction for the roadway to continue to function as a freeway.

- A directional split high enough that the resulting flow rates in the off-peak direction will not exceed 1700 vehicles per hour per lane after the lane is removed.

  Note: Flow rates exceeding 1700 vehicles per hour per lane can result in level-of-service E (speeds of 30-40 mph) and can easily deteriorate into level-of-service F (Stop-and-Go).

- No left-hand entrance and exit ramps without bypass opportunities.

  Note: Obviously, these ramps would cause traffic conflict problems.

- An opportunity to design a safe entrance to, and exit from, the contraflow lane on each side of the congested portion.

  Note: Safety considerations include sufficient sight distance, adequate weaving opportunity, and opportunity for police to enforce the restrictions.

Desired Attributes

The following attributes are considered desirable for a contraflow lane.

- A directional split such that the resulting flow rates in the off-peak directions would be less than 1500 vehicles per hour per lane after the lane is removed.
- An available median shoulder over most of the route for stalled vehicles.
- Acceptable sight distance along the freeway for safe operation during periods of infrequent bus traffic.
- Continuous freeway lighting over the entire contraflow segment.
- Opportunities for designing intermediate entries to, and exits from, the contraflow lane, thereby increasing the flexibility of operations.

  Note: This attribute probably requires a wide median (at least 20 feet wide) in those locations where entry and exit points are desired.

Reserved Lane - Concurrent Flow

Evaluation of problems encountered concerning safety, public acceptance, operation, and enforcement of concurrent flow lanes have led to a recommendation against further implementation of this technique when that implementation involves taking a lane away from the general traffic.[3] If a new lane is added to the facility to function as the concurrent flow, this treatment becomes less unattractive although probably not as desirable as other priority treatments that might be implemented if the space were available to add an extra lane. However, short segments of concurrent flow lanes, designed to connect with, and provide transitions to, other forms of treatment, may represent a means of greatly enhancing the flexibility associated with new freeway

construction, as well as the effectiveness of the other priority treatments; for example, a short section of concurrent flow lane is being used as an approach to the I-45 contraflow lane in Houston. As a result, this is not considered as a separate technique for evaluation. Reference 12 provides an extensive discussion of the ramifications of concurrent flow lanes.

Freeway Control and Priority Entry

Required Attributes

The following attributes are considered to be absolute requirements for implementing this priority technique.

- Capability to control the total volume of traffic on the freeway sufficiently to assure no worse than level-of-service D in the critical segment.

  Note: It is considered highly undesirable if freeway-to-freeway traffic must be reduced sufficiently to back the queue onto the other freeway in order to meet this requirement. Some difficulties of this nature could conceivably arise in the vicinity of the North-South Freeway interchange.

- Adequate queueing space available at each control location.

  Note: If isolated ramps fail to meet this criterion, they should either be closed completely, dedicated totally to high-occupancy vehicles (HOVs), or not used as priority entry locations.

- Available HOV entry ramp locations to permit HOVs to bypass queued vehicles to enter the freeway.

Desired Attributes

The following attributes are considered desirable for implementation of freeway control with priority entry.

- Continuous frontage roads--at least to an intersection with a suitable arterial street that could be used as a diversionary route.

  Note: This feature would permit cars to enter the ramp queue and remain long enough for the drivers to estimate how long it would require to enter the freeway and then divert to the frontage road if they so desire.

- The ability to control the traffic without obviously placing more severe restrictions on traffic entering at certain ramps.

  Note: Such cases of obvious discrimination may result in intense protests from those neighborhoods affected. However, selective control may be feasible if adequate alternatives exist for non-HOV traffic.

Use of Frontage Roads

Required Attributes

The following attributes are considered to be absolute requirements for implementing this priority technique.

- Continuous frontage roads over the length of the critical segment (or a combination of frontage roads and suitable parallel surface arterial streets).
- Adequate capacity at the frontage road/arterial street intersection to enable the intersection to rapidly recover operationally after a preemption.
- The ability to clear the queue ahead of the bus whenever signal preemption is used.

Desired Attributes

The following attribute is considered desirable for implementation of priority treatment on frontage roads.

- At least three approach lanes to each high volume intersection so that the buses will not be impeded by turning movements.

Applicability to Interstate 10 East

Research Report 205-8 compared the guidelines presented previously in this section to the design and operational features of Interstate 10. The conclusions, as set forth in Research Report 205-8, are documented in this section. Additional information concerning the applicability of these priority measures to Interstate 10 East is also presented.

This section of freeway includes the lowest level of service found in the study corridor. Peak-period level of service is frequently LOS D between Yarbrough Drive and the North-South Freeway. Between the North-South Freeway and the CBD, traffic is generally free flow except where it enters the CBD. Therefore, any consideration of HOV priority treatment should concentrate on improving operations east of the North-South Freeway.

Exclusive HOV Lane

The following analysis summarizes the applicability of a 22-foot wide (center of median barrier to center of median barrier) exclusive HOV lane for I-10E.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Wide Median	6.6 miles of ∿48' median 5.7 miles of ∿20' median 3.7 miles of 20-25' median	
Entry Locations	Yes (Difficult west of N-S Fwy)	Yes
Left-hand Ramps	None	None
Center Columns	4 locations (Americas Ave., Lee Trevino, Raynolds, N-S Fwy interchange)	
Desired		
Median Clutter	Some luminaires, sign supports	
Grade Differential	Not Significant	
Median Shoulders	Continuous	

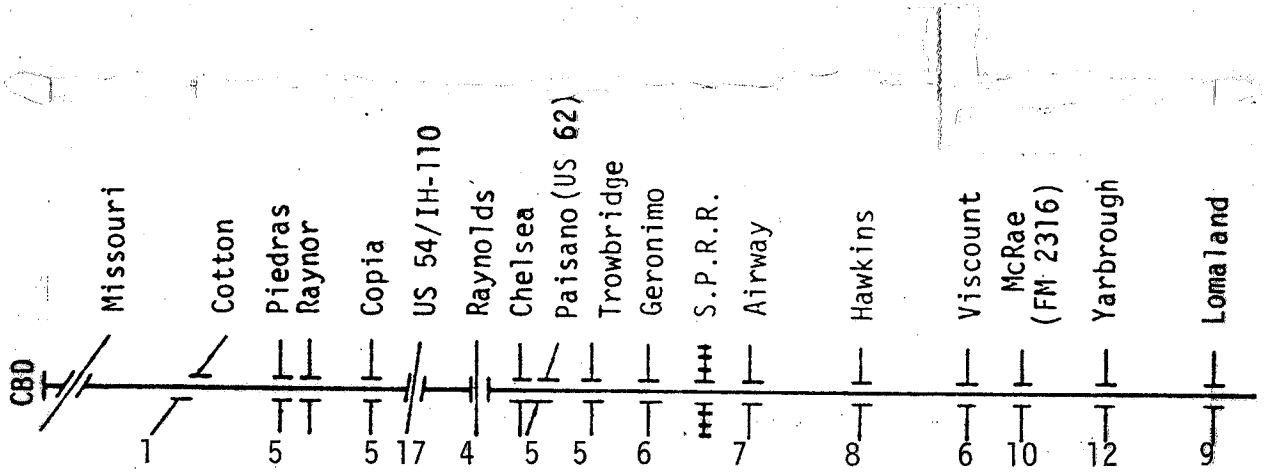
An exclusive lane is technically feasible although, as shown later, not necessarily needed or desirable. The inside shoulders of the section west of McRae would have to be removed and the mixed traffic lanes narrowed to 11 feet to provide for such a lane within the existing cross section. The most significant deterrent to the construction of the exclusive lane is the requirement of providing structural support for a median lane at the 11 locations where separate bridges are presently provided for the eastbound and westbound lanes. Assuming that this type of construction cost $60/sq.ft., the cost of this portion of the construction is estimated at approximately $2.0 million.[8] Construction of the exclusive lane is estimated to cost $1.1 million per mile[9], including removal of obstructions, preparation of subgrade and base, paving and installation of barriers. The total cost of a 6.8-mile exclusive lane from Yarbrough to the N-S Freeway is estimated at $9.5 million.

In a 1979 study prepared District 24, the State Department of Highways and Public Transportation estimated the cost of one additional lane in each direction from Paisano to Yarbrough at $15.4 million.[6,8]

Conclusions Regarding an Exclusive HOV Lane

It is technically feasible to construct a median HOV lane on I-10E from Yarbrough to the N-S Freeway. However, the loading of CBD-bound traffic onto I-10E is very evenly distributed (See Figure 11). Therefore, significant demand would need to be generated beyond the eastern terminus to produce adequate utilization. As will be shown in subsequent sections of this report, the necessary level of utilization is not anticipated before the end of the century.

The provision of priority treatments for HOVs typically has not significantly improved the operation of mixed flow lanes. Preliminary estimates of projected growth indicate that deteriorated operation of this section should be expected.



Source: State Department of Highways and Public Transportation

Figure 11. Distribution of Entering Volumes -- Westbound Interstate 10 East, El Paso

If the proposed lanes are constructed, the level of service provided will be adequate for all traffic and obviate the need for extensive priority treatments for the rest of the century.

Contraflow Lane

The following analysis summarizes the applicability of a contraflow lane to I-10E.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Minimum of 3 lanes	West of Viscount	
Flow Rate per lane in off-peak direction <1700	∿2,000*	∿2,000*
Left Hand Ramps	None	None
Safe Ends	Yes	Yes
Desired		
Flow Rate <1500	No*	No*
Median Shoulder	Yes, will require some paving of loose gravel	
Sight Distance	Good to Poor	
Lighting	Continuous except on outer portions	
Intermediate entries	Difficult, but possible at locations with a wide median	

*Based on a 60/40 directional distribution and a K factor of 10. (Applies to a 6-lane section).

Conclusions Regarding a Contraflow Lane

Based on existing design, per lane flow rates in the off-peak direction are too high to permit successful implementation of this concept. Therefore, a contraflow lane is not considered feasible for this freeway segment.

Freeway Control with Priority Entry

The following analysis summarizes the applicability of freeway control with priority entry to I-10E.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Total Control	Would require control of interchange with N-S Fwy.	
Queueing Space	Yes	Yes
HOV Ramps	Yes, except at Trowbridge and Raynolds	Yes, except at Raynolds
Desired		
Continuous Frontage Roads	Yes, except thru N-S Fwy.	East of Eucalyptus
Nondiscriminatory Metering	Yes	Yes

Conclusions Regarding Priority Entry

A 1978 analysis conducted by District 24, the State Department of Highways and Public Transportation[5], showed that significant benefits could be derived from an overall ramp metering project on I-10. That analysis showed that the most significant restrictions in entering traffic would be necessary for the westbound entrance ramps from Lomaland to Geronimo. Several of the ramps considered could be utilized for priority entry.

Generally, the most effective approach to priority entry involves control of all entering traffic to assure an acceptable level-of-service on the main lanes and combines that with preferential entry for high-occupancy vehicles. Total control from the east end of the corridor to the CBD would require freeway-to-freeway metering at the North-South Freeway which is generally considered undesirable. However, freeway operation west of the N-S Freeway is generally at LOS C or better, and does not justify priority entry control.

For the AM peak (westbound traffic), "total" control could be effected from Lomaland to Raynolds. Priority entry at some of these ramps appears to be a viable approach.

If all westbound ramps were controlled, the Department estimates that as many as 1100 vehicles would be diverted to other facilities during the peak hour[5]. Although the frontage roads have adequate capacity to handle this amount of diversion, this would only serve to shift congestion to other locations. Thus, it is likely that drivers would shift to parallel arterials. According to a 1978 study prepared for the City of El Paso[10], Alameda Avenue would be an attractive alternative because it is operating at a volume/capacity (v/c) ratio of less than 0.8; however, it may be difficult to utilize Alameda due to limited access along Delta Drive, a feeder arterial (See Figure 12). On the north side of I-10E, Montana Avenue is available for east-west travel. The most significant deterrent to using Montana is a severe capacity deficiency at its intersection with Geronimo Drive. All of the frontage road intersections east of Geronimo have v/c ratios of less than 0.8[10]. If every second or third entrance ramp were metered, the non-HOVs could divert to uncontrolled ramps downstream to avoid delay at the priority entry location. Non-priority traffic at the Geronimo entrance ramp could divert downstream on the frontage road to the Trowbridge entrance ramp or along Montana and Paisano to the Paisano entrance ramp.

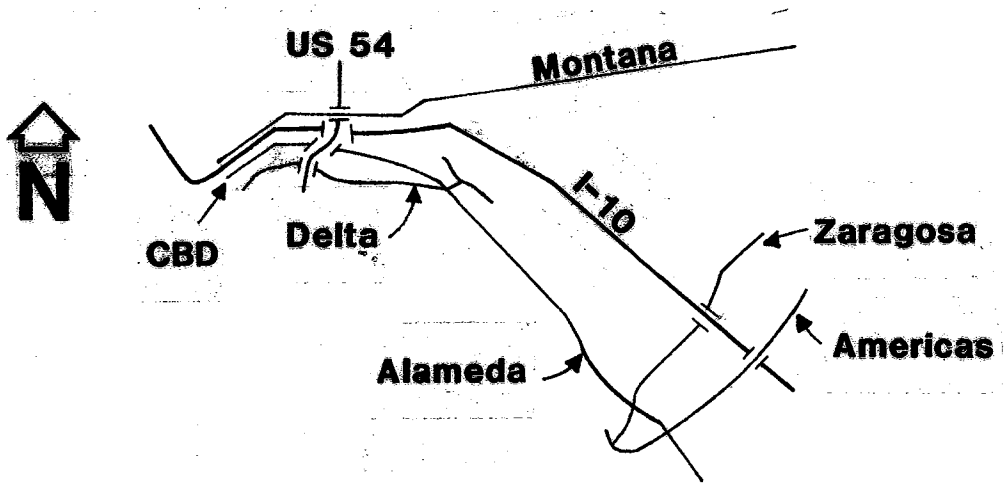


Figure 12. Alternate Routes in the Interstate 10 East Corridor

Use of Frontage Roads

The following analysis summarizes the applicability of using frontage roads as a priority treatment technique on I-10E.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Continuous	Discontinuous at N-S Fwy.	East of Eucalyptus
Clear Queue	Yes	Yes
Desired		
3 Lanes at Intersections	Most Locations	

Conclusions Regarding Use of Frontage Roads

Westbound frontage road discontinuity at the N-S Freeway interchange virtually precludes the use of this technique as an AM peak priority treatment. However, frontage road usage in the PM peak is technically feasible, since the frontage roads are continuous east of Eucalyptus. Traffic from the CBD would have to enter the freeway, then exit at Piedras to take advantage of the continuous eastbound frontage. Such routing is less than desirable.

Signal preemption systems benefit buses and, quite possibly, disadvantage general traffic. As is shown in subsequent sections of this report, in considering HOV improvements in El Paso, buses represent a very small percentage of total high-occupancy vehicles; in El Paso, HOV improvements should be designed to also serve carpools. Because the intersecting arterials are carrying high volumes of traffic, if significant bus volumes did use the frontage roads and had preemption capabilities, serious disruption of traffic

flow on major cross streets might result. Priority entry appears considerably more desirable than signal preemption on the frontage road.

Findings Concerning Applicable Priority Treatments for Interstate 10 East

Congestion on I-10E is primarily concentrated in a 5-mile section between Trowbridge and Yarbrough. Although localized congestion exists at other merge points, this freeway section represents the most significant impediment to both AM and PM peak traffic.

Previous portions of this section have addressed numerous technical features that affect the applicability of the various priority treatments to I-10E. Some additional considerations are summarized in Table 3.

Low-cost, short implementation time alternatives considered in this section included priority entry and priority use of frontage roads. Of those two choices, priority entry appears the most desirable. Unlike priority use of frontage roads, it offers benefits to all high-occupancy vehicles (a very important consideration in El Paso where bus volumes are relatively low) and does not disrupt traffic on major cross streets. Also, all HOVs benefit regardless of their destination, an important point in El Paso since CBD employment is relatively low. Total freeway metering is feasible east of the N-S Freeway and possible, though undesirable, throughout the I-10E corridor. Priority entry is a viable concept as long as the main lanes operate at about LOS D or better, which should be attainable by metering selected westbound ramps east of the N-S Freeway. In subsequent years, increasing the number of entrance ramps under control (including the entrance from the N-S Freeway) could aid in sustaining LOS D operation through increased diversion of traffic.

As intermediate cost, intermediate implementation time improvements, this section considered contraflow lanes and a one-lane, reversible, median busway.

Table 3: Comparison of Alternative Priority HOV Improvements[1]

Parameter	Alternative HOV Improvements			
	1-lane Median Busway	2-lane Elevated Busway[2]	Use of Frontage Roads	Freeway Control w/Priority Entry
Quality of bus Service				
Avg. Speed, mph	50	50	30	40[3]
Schedule Reliability	Excellent	Excellent	Poor	Good-Fair
Carpools Included	No/Yes[4]	Yes	No	Yes
Impact on Other Traffic	Minor	Minor	Major	Moderate-Major
Cost, Thousands/Mile[5]	$2,000	$9,000	$130	$400
Maximum Capacity				
Buses, Veh./Hr.	400[6]	400[6]	60[8]	200[9]
Carpools, Veh./Hr.	0	800[7]	0	400[9]
Total, Persons/Hr.	20,000	24,000	3,000	12,000

[1]Based on a similar table presented in "Cost-Effectiveness Analysis of Alternatives for Gulf Freeway Busway," Prepared by Houston Urban Office, June 11, 1979.
[2]For numerous reasons listed previously in this section, this does not appear to represent a needed improvement in the I-10E corridor. As considered in this matrix, this facility would operate with one-lane in each direction.
[3]Attainable only with sufficient enforcement to control ramp violation rates.
[4]Operationally, it may be undesirable to allow carpools onto a facility one-lane wide without continuous shoulders. Realistically, it may be necessary to allow carpool utilization to generate an "Acceptable" level of total vehicular utilization. Continuous shoulders greatly reduce this potential problem.
[5]Does not include costs required to provide "support" facilities such as park-and-ride lots.
[6]This value based on the flow volume that could return in mixed flow in the off-peak direction. At this flow level, carpools would be undesirable on the one-lane busway since they would adversely impact schedule reliability for the high bus volume.
[7]Sufficient carpools added to obtain level-of-service D.
[8]At 60 buses per hour, every cycle would be preempted by buses, destroying the capability of cross streets to serve traffic demands.
[9]This capacity is a function of the volume of traffic the freeway can serve. It is assumed in this table that no more than half the capacity of one freeway lane will be available for HOV use.

Given a choice between operating on an exclusive HOV lane or a contraflow lane, the exclusive lane represents a preferable alternative for the reasons listed below.

- Penalty to Off-Peak Traffic. An exclusive lane would not penalize traffic moving in the off-peak direction through removal of a travel lane. The high volume movements in the off-peak direction virtually prohibit the implementation of a contraflow lane.
- Operational Cost. It is costing the Metropolitan Transit Authority in Houston $2000 to $3000 per day to set up, take down, and enforce the contraflow lane on I-45N. Costs of operating a busway would be a small fraction of that cost.
- Positive Separation of Flow. An exclusive HOV lane would allow median barriers to continue to provide a positive separation of traffic flow during all times of day.
- Eligible Vehicles. The exclusive HOV lane would permit less concern to occur over the types of vehicles and drivers eligible to use the lane. Again, this is a major consideration in El Paso.

Thus, the following priority measures warrant more comprehensive evaluation.

- Low Cost, Short Implementation Time. Priority entry at selected high-volume ramps.
- Intermediate Cost, Intermediate Implementation Time. A one-lane, reversible, median HOV lane. Because the feasibility of this treatment is questionable, it is investigated further under the section on utilization.
- Very High Cost, Very Long Implementation Time. A need for this type of improvement is not identified for the time period evaluated in this study (20-year planning horizon).

Applicability to Interstate 10 West

Available data indicate that there are no significant problems with congestion at present. There are some isolated weaving section (e.g., eastbound between Sunland Park and U.S. 85) that experience occasional LOS D operations. However, significant growth is anticipated in this corridor. Such growth could result in the need for HOV priority treatments before the end of the

century. This section investigates the feasibility of the various treatments on I-10W.

Exclusive HOV Lane

The following analysis summarizes the applicability of a 22-foot wide exclusive HOV lane for I-10W.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Wide Median	5.6 miles of 20-24' median 2.1 miles of ∿48' median	
Entry Locations	Yes, on outer end; difficult at CBD	
Left-hand Ramps	None	None
Center Columns	7 locations (Porfirio Diaz, Yandell, Asarco Plant, Executive Center, Vista Hill, Paisano, Sunland Park)	
Desired		
Median Clutter	Lights, signs, barriers	
Grade Differentials	Severe grade differentials	
Median Shoulders	Yes	Yes

There are some significant deterrents to constructing an exclusive median lane on I-10W. The severe grade differentials between the eastbound and westbound lanes from Schuster to Executive Center Blvd. make the construction of a median facility expensive. An exclusive lane could be constructed on the same grade as either roadway using a retaining wall to support either the HOV lane or the side slope (See Figure 13). The cost of constructing the structural support is estimated at about $2.2 million[9]. Construction of 7.2 miles of

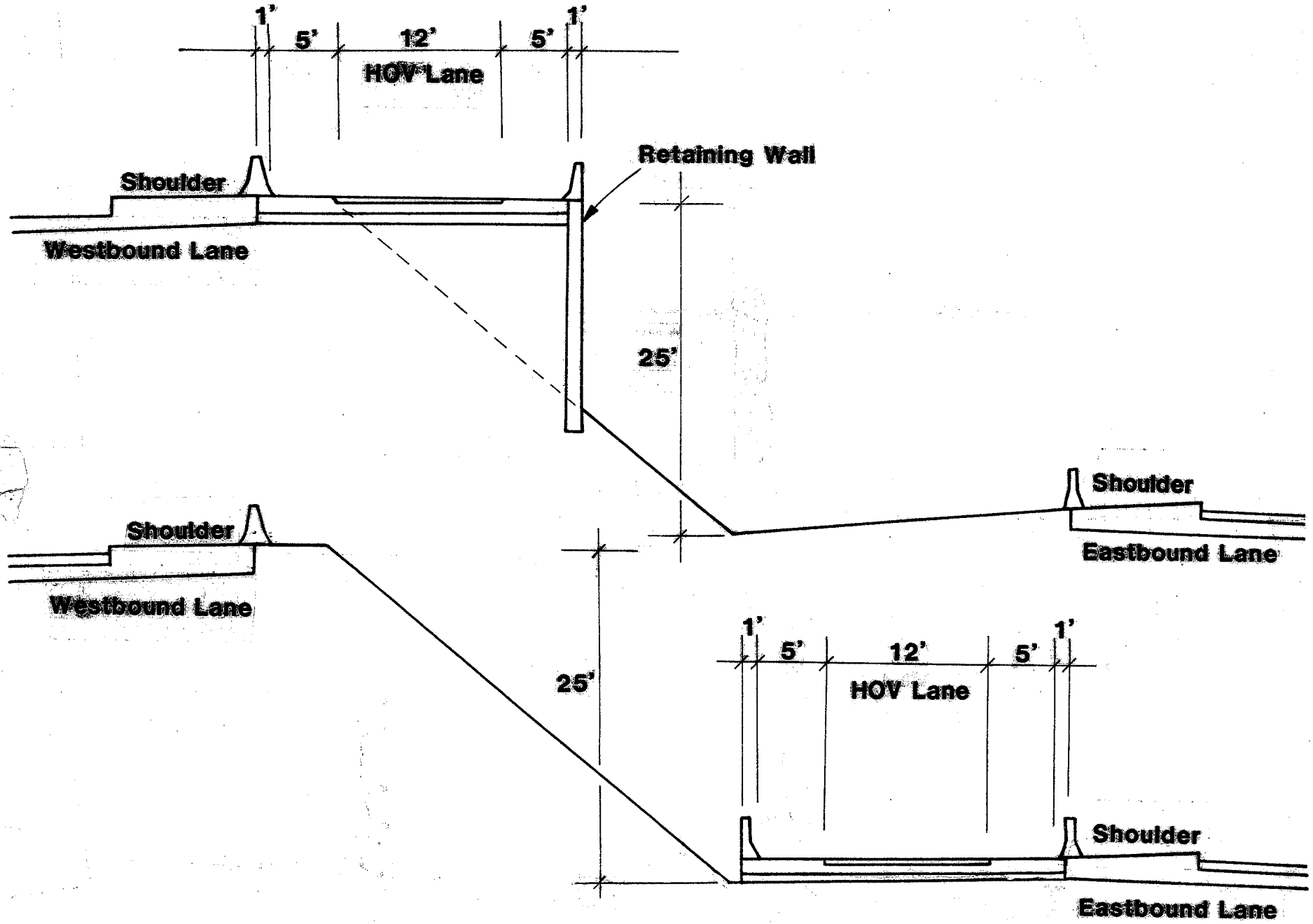


Figure 13. Alternate Median HOV Lane Configurations--Interstate 10 West

HOV lane at a cost of $1.1 million/mile runs the total estimated cost to about $10.1 million. In addition to the expense of such construction, the bypassing of center columns at seven location will result in undesirable geometrics.

Conclusions Regarding an Exclusive HOV Lane

An exclusive HOV lane is technically feasible throughout the I-10W corridor. However, as shown in subsequent sections of this report, such a facility would not be needed or desirable this century.

Contraflow Lane

The following analysis summarizes the applicability of a contraflow lane to I-10W.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Minimum of 3 lanes	Yes	Yes
Flow Rate <1700	1000	1000
Left-Hand Ramps	None	None
Safe Ends	Yes, on outer portions; difficult near CBD	
Desired		
Flow Rate <1500	Yes	Yes
Median Shoulder	Yes	Yes
Sight Distance	Poor	Poor
Lighting	Not Continous	
Intermediate Entry Points	Difficult, but possible east of Sunland Park	

Conclusions Regarding Contraflow

A contraflow lane is technically feasible on I-10W. Generation of additional traffic in the off-peak direction could result from continued growth in the northwest. The operational costs of a contraflow lane must be considered when evaluating this concept relative to other priority treatments. Therefore, although technically feasible, a contraflow operation for I-10W is not considered desirable.

Freeway Control with Priority Entry

The following analysis summarizes the applicability to freeway control with priority entry for I-10W.

Attributes	Peak Period	
	A.M.	P.M.
Required		
Total Control	Yes	Yes
Queueing Space	Yes	Yes
HOV Ramps	Yes	Yes
Desired		
Continuous Frontage Roads	No	No
Nondiscriminatory Metering	No	No

This segment is well suited to virtually total control without the adverse effects resulting from the metering of freeway-to-freeway traffic. So little traffic is generated west of Mesa St., that metering at the Mesa St., Sunland Park Dr., and Executive Center Blvd. entrance ramps would provide virtually total control.

Mesa Street offers a reasonable alternative for travel to the CBD for non-priority vehicles. A 1978 report[10] revealed no capacity deficiencies

on inbound Mesa St. that would preclude its use as an alternate route. Capacity deficiencies at the Mesa St. and Sunland Park Dr. entrance ramps could be compounded by the metering of entering traffic. However, the planned connection of Resler Dr. to I-10W between Mesa St. and Sunland Park Dr. (See Figure 14) should be adequate to accommodate both priority and non-priority vehicles.

Conclusions Regarding Freeway Control with Priority Entry

This priority treatment is a feasible and desirable technique. It should provide adequate control to sustain LOS D operation on the main lanes of I-10W, as well as providing adequate service to HOVs through the 1990s.

Priority Use of Frontage Roads

The absence of frontage roads on I-10W precludes the consideration of this priority treatment.

Findings Concerning Applicable Priority Treatments for Interstate 10 West

Congestion on I-10W is not a major concern at this time. As indicated previously (See Table 2), conditions warranting low-cost priority treatments for I-10 W may develop between Mesa St. and Executive Center Blvd. late in this decade. The only low-cost, short implementation time technique that is applicable is freeway control with priority entry. This technique could be easily implemented at a relatively low cost considering the small number of entrance ramps (five) between Mesa St. and the CBD.

Two intermediate cost, intermediate implementation time priority treatments were considered -- exclusive HOV lane and contraflow. Both techniques are feasible, though the need for such extensive improvements is not expected this century. An exclusive median HOV lane from Mesa St. to the CBD would be very expensive because of the severe grade differentials between Executive

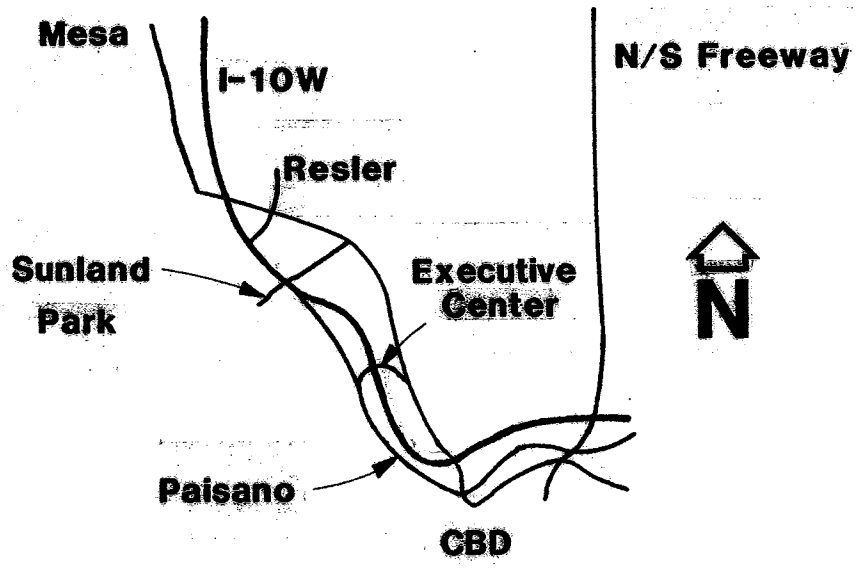


Figure 14. Alternate Routes in the Interstate 10 West Corridor

Center Blvd. and Schuster. Such a facility could serve to bypass congestion between Mesa St. and Executive Center Blvd., the section expected to reach critical congestion earliest. For the reasons cited in the I-10E evaluation (operational cost, positive separation of flow, and vehicle eligibility), contraflow is not recommended for further consideration.

Thus, the following priority measures warrant more comprehensive evaluation.

- Low Cost, Short Implementation Time. Priority entry at selected high-volume ramps.
- Intermediate Cost, Intermediate Implementation Time. A one-lane reversible, median HOV lane. Because the feasibility of this treatment is questionable, it is investigated further in the following section.
- Very High Cost, Very Long Implementation Time. A need for this type of improvement is not identified for the time period evaluated in this study (20-year planning horizon).

UTILIZATION AND COST OF PRIORITY MEASURES

Two alternative priority measures, priority entry and a one-lane, reversible median HOV lane were identified in the previous section as warranting more extensive evaluation. This section presents estimates of the number of HOVs that would utilize the improvements as well as the benefits that would accrue to those vehicles. Design aspects of the priority measures are discussed in the succeeding section of this report.

Analysis Data

Extensive traffic and design data collected by the Department were made available as part of this study. As necessary to evaluate the need for priority treatment, other pertinent data were developed during the course of the study.

Vehicle Occupancy

A 1980 occupancy study conducted by District 24[11] showed the average peak-period vehicle occupancy to be approximately 1.3 persons per vehicle and the following vehicle occupancy distribution.

- Single occupant 74%
- Two occupants 20%
- Three occupants 5%
- Four or more occupants 1%

Ramp Entry Data

As part of a feasibility study on control and surveillance measures for the Interstate 10 freeway, the Department collected peak hour volume counts for the entrance and exit ramps[5]. Peak hour entry volumes at I-10E ramps in the study corridor for 1980 are shown in Table 4. Volumes for I-10W ramps are shown in Table 5.

Table 4. 1980 Peak Hour Traffic Volumes on Ramps Entering Westbound Interstate 10 East.

Ramp Location	Hourly Volume	Percent of Total	Cumulative Percent
Lomaland	1250	9	9
Yarbrough	1650	12	21
McRae	1290	10	31
Hunter	870	6	37
Hawkins	1050	8	45
Airway	950	7	52
Geronimo	750	6	58
Trowbridge	710	5	63
Paisano	610	5	68
Raynolds	520	4	72
N/S Freeway	2330	17	89
Copia	700	5	94
Piedras	700	5	99
Cotton	200	1	100
	13,580		

Table 5. 1980 Peak Hour Traffic Volumes on Ramps Entering Eastbound Interstate 10 West.

Ramp Location	Hourly Volume	Percent of Total	Cumulative Percent
Mesa	1450	22	22
Sunland Park	1550	24	46
US 85	620	10	56
Executive Center	1520	23	79
Schuster	1360	21	100
	6500		

Downtown Travel Estimates

As mentioned previously, I-10E serves a variety of activity centers. Although the CBD is not the attraction for a majority of I-10E traffic, the employment in the CBD is the most dense, and therefore the primary attraction for high-occupancy vehicles. Thus, to estimate the effectiveness of an HOV improvement, an estimate of work trip patterns to the CBD is needed.

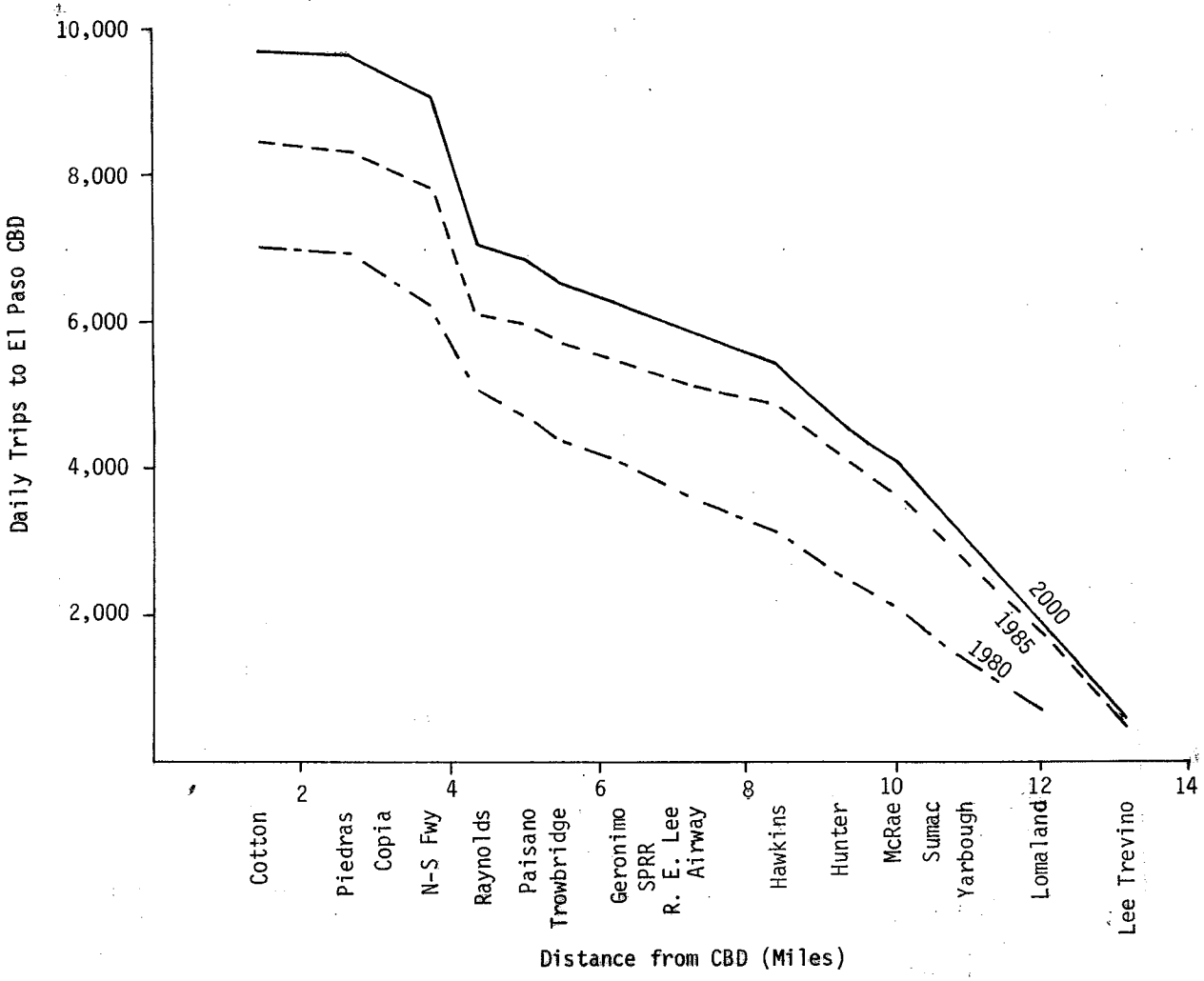
Detailed origin-destination data are not available for use in such an estimate. As a consequence, secondary data developed by the Department were used to estimate work trip patterns on Interstate 10. The results of the estimates for I-10E and I-10W are shown in Figures 15 and 16, respectively. The procedures used to develop these estimates are documented in Appendix A.

The trips shown in Figures 15 and 16 represent daily auto work trips to the CBD that use I-10E and I-10W, respectively. It is assumed that approximately 50 percent of those trips occur during the peak hour.

Utilization of Priority Entry

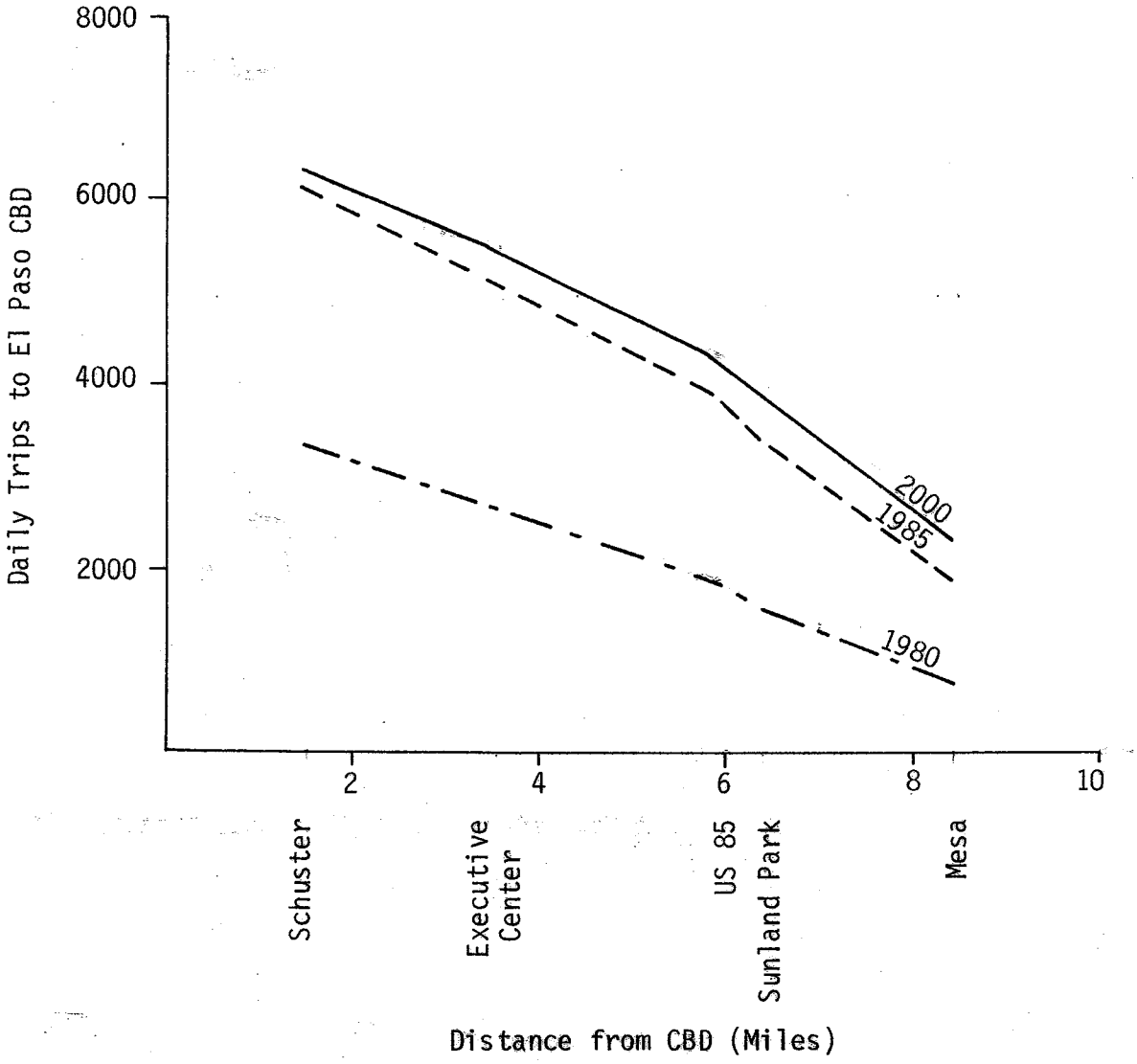
Based on analyses presented previously in this report, it appears that some form of low-cost, short implementation time priority measure might be needed on I-10E and I-10W by the mid-to-late 1980s. It also appears that priority entry represents the most desirable form of low-cost priority treatment for Interstate 10.

Priority entry, in conjunction with freeway metering, can be considered in two manners. In the first, which is similar to the operation of certain Los Angeles freeways, all freeway ramps are metered to help assure a satisfactory operating condition on the main lanes. In addition, at some ramp locations high-occupancy vehicles are provided with preferential entry ramps to allow those vehicles to bypass the queue at the metered ramp.



Source: State Department of Highways and Public Transportation

Figure 15. Estimated Daily Auto Work Trips to the El Paso CBD on I-10E



Source: State Department of Highways and Public Transportation

Figure 16. Estimated Daily Auto Work Trips to the El Paso CBD on I-10W

The second approach involves taking actions such as have been taken in Dallas on I-30 at Ferguson Road. With this approach, certain high-volume ramps are identified and ramp metering installed; priority entry for high-occupancy vehicles is provided at those locations. Other freeway ramps are not metered. Thus, this second approach appears applicable to Interstate 10 as a low-cost, short implementation time action.

Impact of Priority Entry Ramps

Most of the experience with priority entry has been in Los Angeles. Nearly 150 bypass ramps are operational in that city. In Texas, 4 bypass ramps are presently operational (2 on Southwest Freeway in Houston, 1 on North Central Expressway in Dallas, 1 on I-30 in Dallas). The Los Angeles ramps are used by both buses and carpools; with the exception of the I-30 ramp in Dallas, all the Texas ramps are for buses and/or vans only. Fewer than 20 buses per hour would use a priority system on Interstate 10; as a result, carpools should be allowed to use a priority entry approach. For this type of operation, a carpool is defined as 2 or more persons per vehicle.

Selected data for the Los Angeles operation are shown in Table 6. The utilization and effectiveness of these lanes can be expected to be somewhat higher than will be experienced in El Paso. The Los Angeles freeways are typically operating at capacity, while it is anticipated that Interstate 10 will be at LOS D when priority entry is provided. A travel time savings of 2 minutes will not result in El Paso; indeed, on I-30 in Dallas, the travel time savings on the bypass ramp were 3 seconds. As a result, the values for El Paso that are shown in Table 6 are assumed to be approximately half of the corresponding Los Angeles values. A 20 percent increase in carpools in El Paso will result in about a 5 percent increase in average occupancy at those locations where priority entry is provided.

Table 6. Effects of Priority Entry in Los Angeles and Estimated Impacts in El Paso.

City	Avg. Travel Time Savings	Percentage Increase in Carpools	Violation Rate[1]
Los Angeles	2 minutes	38%	35%
El Paso	<1 minute	20%	25%

[1] The percentage of vehicles using the priority ramp that are not eligible to do so.

Priority bypass ramps would not be provided at each ramp location. Los Angeles provides such facilities on about every second ramp. On Interstate 10 it would appear appropriate to provide priority bypass at selected high-volume entry locations. The following discussion identifies the proposed priority entry locations and anticipated utilization for I-10E and I-10W, respectively.

Interstate 10 East

Based on the data presented in Table 4, priority entry might be considered initially at three locations -- Yarbrough, Hawkins and Geronimo. Twenty-six percent of the traffic entering I-10E enters at those ramps. Such improvements could be phased in to evaluate the effectiveness and public acceptance; if that approach is used, the Yarbrough entrance ramp would appear to be the best location for initial development due to both its high volume and distance from downtown.

If ramp metering with priority entry is provided at the three locations identified previously, assuming that the priority entry is provided in 1985, peak-hour utilization of the priority entry facility is estimated in Table 7. Based on the values in Table 7, approximately 30 percent of the peak-hour vehicles would use each priority lane; those vehicles would move 43 percent

Table 7. Estimated 1985 Peak Hour Usage of Priority Entry Ramps on Interstate 10 East.

Ramp Location	Est. Volume Without Priority Entry	Est. Volume With Priority Entry[1]	
		Non-Priority Lane	Priority Lane[2]
Yarbrough	1800	1330	560
Hawkins	1180	875	370
Geronimo	840	620	260

[1] It is estimated that carpools will increase by 20 percent (See Table 6) and total ramp volume will increase by 5 percent as a result of the priority measure.

[2] Vehicles with 2 or more occupants.

of the persons. The average occupancy in the priority ramp lanes would be 2.26 persons per carpool.

Interstate 10 West

Priority entry might be considered initially at Mesa St. and Executive Center Blvd. These locations more nearly lend themselves geometrically to the accommodation of a priority bypass lane than does Sunland Park Drive. These two ramps account for about 45 percent of the entering traffic on I-10W (Table 5). Mesa appears to be the best location for initial implementation because of its distance from the CBD and its proximity to the anticipated growth centers.

The estimated peak-hour utilization of these two priority entry locations, assuming a 1985 time frame, is shown in Table 8.

Table 8. Estimated 1985 Peak Hour Usage of Priority Entry Ramps on Interstate 10 West.

Ramp Location	Est. Volume Without Priority Entry	Est. Volume With Priority Entry[1]	
		Non-Priority Lane	Priority Lane[2]
Mesa	2000[3]	1480	625
Executive Center	2000[3]	1480	625

[1] It is estimated that carpools will increase by 20 percent (See Table 6) and total ramp volume will increase by 5 percent as a result of the priority measure.

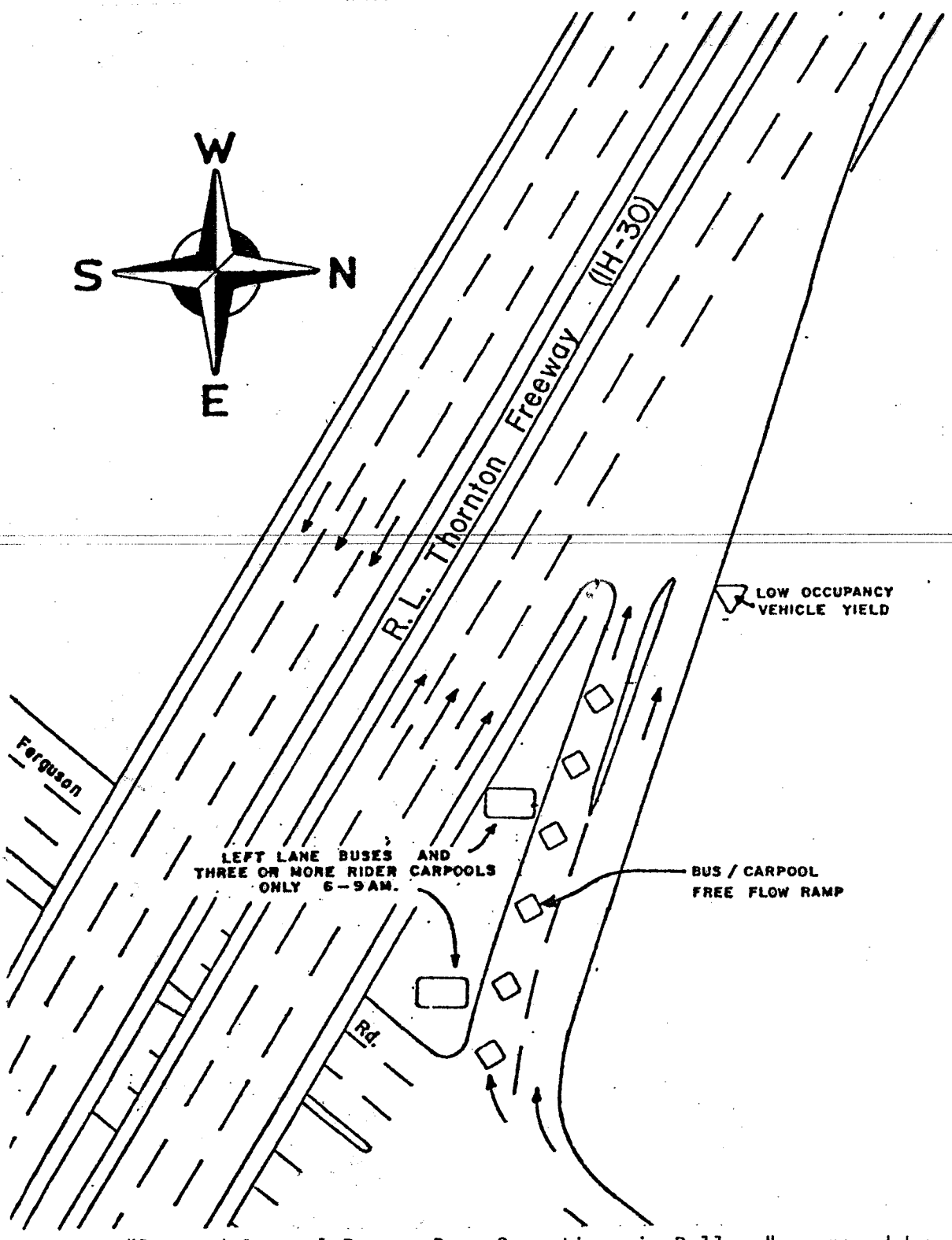
[2] Vehicles with 2 or more occupants.

[3] Estimated capacity flow, though demand estimates considerably higher.

General Considerations

The bypass ramp in Dallas (Figure 17) is similar to the type of treatment that might be implemented along Interstate 10. That installation cost approximately $50,000. Cost estimates developed recently for priority entry ramps in San Antonio ranged from $80,000 to $180,000, including ramp metering. Therefore, it is reasonable to assume that per ramp costs in El Paso should be approximately $65,000-$75,000. Consideration needs to be given to queueing space, as it will not be unusual at some ramps for 20 to 30 cars to be queued at the ramp meter during the height of the peak period. The high violation rate (Table 6) also makes enforcement a major concern; personnel need to be available (on random basis after the first several weeks of operation), and procedures must exist to permit the identification and safe apprehension of violators.

However, of equal concern is the problem of being able to efficiently



Source: "Bus and Carpool Bypass Ramp Operations in Dallas," prepared by Office of Transportation Programs, City of Dallas, July 1979

Figure 17. Priority Entry Ramp on East R.L. Thornton at Ferguson Road, Dallas

meter ramp volumes in excess of 900 vehicles per hour. Previous research[3] has indicated that 720 vph (12 vehicles per minute) is a practical maximum metering rate, with 900 vph (15 vehicles per minute) being a virtually absolute maximum. Beyond that volume (i.e., 25 vpm to accommodate 1500 vph) the ramp meter cycle time is so short that the lead vehicle cannot move up and reach a full stop before the next green indication. When main lane operations reach long-duration LOS D conditions, a combination of the following three actions by the motorists is likely: a) extension of the peak at the ramp beyond the peak hour, b) increased diversion to alternate routes, and c) increased utilization of HOVs. Since traffic volumes on alternate routes will also be increasing, effective diversion to alternate routes will likely be short-lived, especially for the extreme locations on I-10W, where Mesa St. is the primary option. Therefore, extension of the peak and increased HOV utilization, possibly beyond that estimated, are likely.

Utilization of a Median HOV Lane

If Interstate 10 remains in its present cross section, information presented previously suggests that by the late 1990s an exclusive median HOV lane may be applicable for I-10E, with some possible need for an exclusive lane on I-10W. Such an improvement provides considerable gains in capacity, travel speeds and schedule reliability over priority entry improvements, provided that long-duration LOS E conditions exist in mixed flow. This section develops estimates of 2000 utilization of a median HOV lane for both I-10E and I-10W.

The estimates are based on the data shown in Figures 15 and 16 and assume that the exclusive lanes would be used by buses, vanpools and carpools (for this type of treatment, carpools are defined as 3 or more persons per vehicle) and that this lane would provide service to the CBD.

Interstate 10 East

Bus Usage

Information supplied by the Public Transit Administration, City of El Paso, indicates that 10 peak hour buses are expected to use I-10E, east of the N-S Freeway by the year 2000.

Carpool Usage

Data shown in Figure 15 are used to estimate carpool usage of a median HOV lane. Based on discussions presented previously, an exclusive lane on I-10E would serve to bypass congestion between the McRae/Yarbrough vicinity and the North-South Freeway. Therefore, all loading of the HOV lane would occur near the eastern end of this sector.

To be effective, an exclusive HOV lane must extend beyond the anticipated congestion (in this case, to about Yarbrough Drive). Even though daily westbound volumes are expected to exceed 40,000 vehicles, only about 3000 are bound for the CBD (Figure 15). If half of these trips occur during the peak, and 6 percent of those trips are eligible carpools (3+ occupants for exclusive lanes), then only 125 carpools would initially use the HOV lane. If an increase in carpools of 70 percent was generated by the availability of an exclusive lane (as suggested from previous research [3]), then up to 215 carpools could be expected to use the facility in 2000.

Total Usage

Initial operation in the year 2000 should include approximately 225 vehicles in each peak period (215 carpools, 10 buses). Approximately 1100 persons would be served by the HOV lane during the peak hour, compared to about 2500 persons per hour in each of the mixed flow lanes. Thus, the

exclusive lane would carry about 15-18 percent of the total person throughput in the peak direction.

Effectiveness

Several measures can be used to estimate the potential effectiveness of an exclusive lane. The previously cited research for FHWA[3] concludes that a travel time saving of 1 minute per mile of improvement is necessary for successful operation. Thus, overall speeds of non-priority lanes must not exceed 28 mph. Since conditions on I-10E are expected to approach LOS E (30-40 mph) in the late 1990s, it is reasonable to assume that non-priority traffic will be operating at speeds above 28 mph for a large portion of the peak hour.

Another measure considered is the proportion of person throughput carried by the HOV lane. Generally the HOV lane should carry a higher proportion of person-flow than non-priority conditions. As noted above, an exclusive HOV lane on I-10E would only carry about half as many persons per hour as each of the non-priority lanes.

Although a detailed benefit-cost analysis was not performed for an I-10E HOV lane, some inferences can be drawn from a previous analysis performed by TTI[12]. Table 9 shows the present value of costs and benefits for exclusive lane and priority entry treatments considered in San Antonio. The B/C ratio for the HOV lane under LOS E conditions is based on utilization by 60 buses and 660 carpools, producing a throughput of 4940 persons per hour. In the year 2000, one-sixth of that number of buses, one-third that number of carpools, and less than one-fourth that person-flow could be expected on an I-10E exclusive HOV lane. Thus, since the expected direct costs should not be significantly different from that shown in Table 9, and since the benefits should be less than half that shown, it is concluded that the costs of an exclusive HOV lane on Interstate 10 East would considerably exceed the expected benefits.

Table 9: Present Value of Direct Costs and Direct Benefits for Typical HOV Improvement Measures; 20 Year Analysis Period, 10% Discount Rate

Alternative HOV Measure	Freeway LOS Prior to Provision of HOV Measure	
	D	E
Reversible HOV Median Lane		
Costs Per Mile (20 yr.)		
Construction	$4,000,000	$4,000,000
Operation & Maint.	170,000	170,000
Total	$4,170,000	$4,170,000
Benefits Per Mile (20 yrs.)		
Travel Time Savings		
HOV Traffic	$ 510,000	$1,590,000
Mixed-Flow Traffic	640,000	2,060,000
Fuel	1,060,000	1,970,000
Accident Reduction	890,000	1,530,000
Total Benefits	$3,100,000	$7,150,000
B/C Ratio	0.7	1.7
Priority Entry Ramp		
Cost Per Ramp (20 yr.)	$ 50,000	$ 50,000
Operation & Maint. (20 yr.)	90,000	90,000
Total Cost	$ 140,000	$ 140,000
Benefits Per Ramp (20 yr.)		
HOV Travel Time Savings	$ 70,000	$ 140,000
Fuel	100,000	160,000
Total Benefits	$ 170,000	$ 300,000
B/C Ratio	1.2	2.1

Source: "Priority Treatment for High-Occupancy Vehicles in San Antonio, Texas," Texas Transportation Institute, June 1981.

Interstate 10 West

Bus Usage

The Public Transit Administration estimates I-10W will be used by 15 buses in the morning peak by 2000.

Carpool Usage

An exclusive lane for I-10W, if needed during this century, would serve to bypass congestion between Mesa St. and Executive Center Boulevard. Again, to serve its intended purpose an exclusive HOV lane would need to extend beyond anticipated congestion to a terminus somewhere between Sunland Park and Mesa. Data from Figure 16 indicate that about 2400 daily CBD work trips will originate west of Sunland Park. Assuming that half of these trips occur in the peak (1200) and that 6 percent would be eligible for an exclusive lane, about 70 carpools would use the lane initially. Assuming a short-term increase of 70 percent, approximately 120 carpools would use an exclusive lane in the year 2000.

Total Usage

HOV lane utilization by 140 vehicles (approximately 1050 persons) would be expected during each peak period.

Effectiveness

Utilization of an exclusive median HOV lane on I-10W should be even less than that on I-10E. Following the same rationale presented for I-10E, it is concluded that the provision of an exclusive HOV lane on Interstate 10 West is not cost-effective this century.

Conclusions Regarding Utilization/Capacity

There should be adequate utilization of all recommended priority entry locations. In fact, ramp capacity will probably be a limiting factor at several locations. In the event that the priority bypass ramps cannot accommodate the HOV demand generated, it may be necessary to provide for priority entry at additional locations, or to consider redefining carpools as vehicles with 3+ occupants instead of 2+ occupants. On-site occupancy studies should indicate the desirability of such actions.

Adequate utilization of an exclusive lane is not expected in either corridor this century.

Cost and Implementation Time

It is estimated that implementation of priority entry will require 6-12 months once a decision is made. The minimum cost of a typical priority bypass lane is $55,000. There are indications that, depending on the magnitude of construction, costs could approach $70,000 per ramp.

CONCEPTUAL DESIGN AND OPERATION OF PRIORITY MEASURES

Previous sections have determined that priority entry ramps can be effectively utilized within the 20-year planning horizon on both I-10E and I-10W. This section primarily focuses on design and operational concerns associated with incorporating priority entry ramps at selected locations on Interstate 10. It appears that this method will provide sufficient capacity to accommodate the projected HOV travel needs until at least the late 1990s.

The design and operation of priority entry ramps are not extremely complicated, but there are several considerations that will be discussed in a general manner and related to specific ramps.

Compatibility with Department Plans

The Department has proposed an expansion (from 6 to 8 lanes) of the freeway section between Yarbrough and Paisano. Since the expansion will be accommodated on the outsides of the existing cross section, consideration should be given to locating ramp meters and raised medians (between priority and non-priority lanes) so that they will not conflict with future construction. No other major improvements that would affect these recommendations are planned.

Priority Entry Ramp Operations

Two priority entry concepts that can be incorporated into the existing freeway cross section are shown in Figures 18 and 19. The design shown in Figure 18 is preferred because the ramp for HOVs is completely separate from the non-priority ramp. This separation eliminates conflicts between priority and non-priority ramp traffic at the merge point. It also enhances a low violation rate by making it difficult for non-priority drivers to determine if police are present at the priority ramp. Non-priority traffic would utilize the left lane of the frontage road for storage in the ramp meter queue.

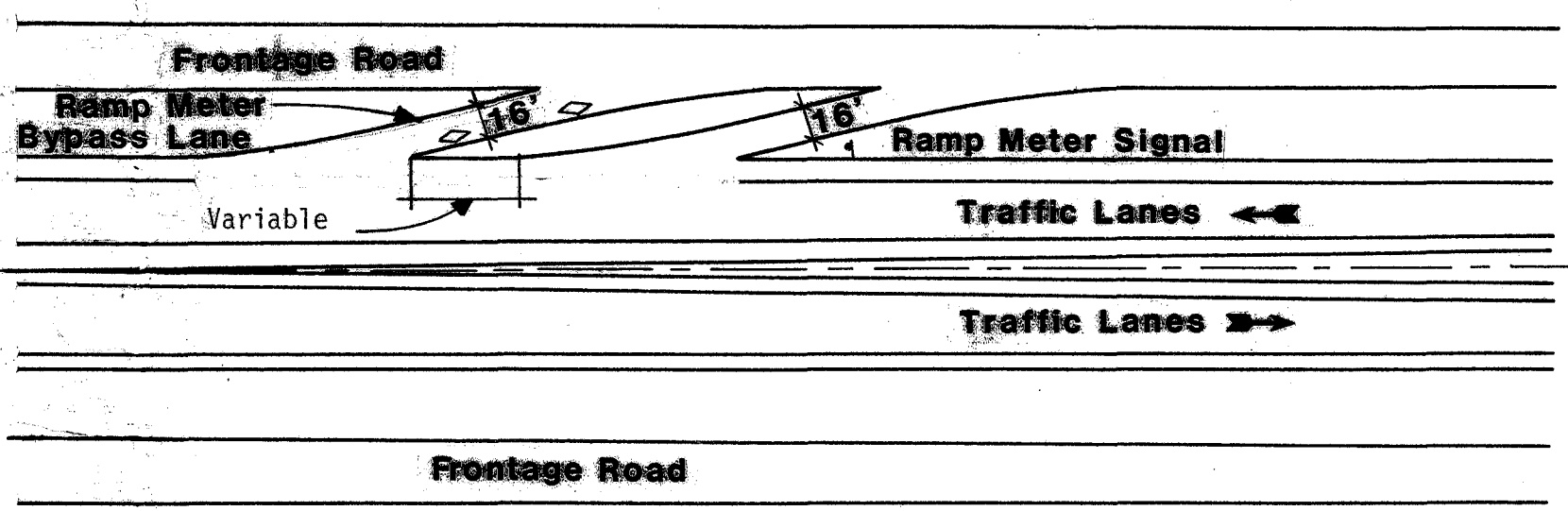


Figure 18. Priority Entry Ramp Located Downstream of Non-Priority Ramp

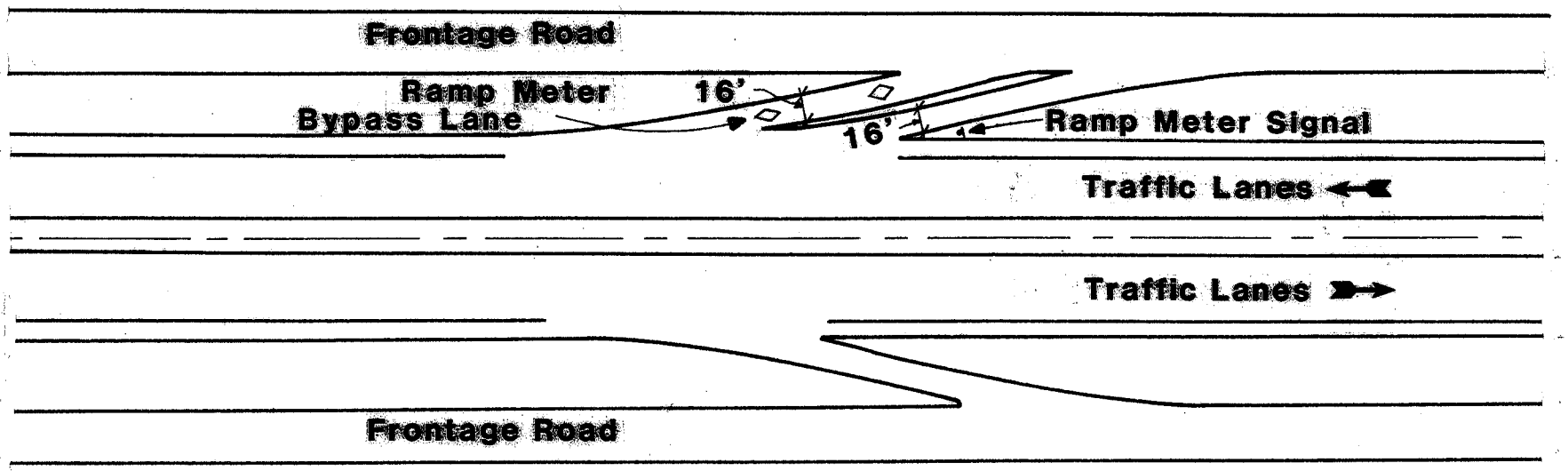


Figure 19. Priority Entry Ramp Located Adjacent to Non-Priority Ramp.

Eligible vehicles would bypass them in the next lane and proceed to the downstream ramp to enter the freeway.

Due to vertical curvature constraints or other geometric problems, some ramps may have to be built like the example shown in Figure 19. The existing ramp would be widened and a narrow raised median installed to separate the priority and non-priority vehicles. The HOVs would be forced to reduce their speed due to the possibility of lateral interference on the ramp approach and at the freeway merge point. All priority entry ramps on I-10E will, with minor modifications, fit these two general types.

The design of the existing ramps at the recommended priority entry locations on I-10W, Mesa St. and Executive Center Blvd., is generally compatible with the priority entry concept shown in Figure 19, except that there are no frontage roads on I-10W. Although the Sunland Park Dr. entrance ramp is not included in the initial priority entry recommendations, it is possible that traffic conditions may indicate the need for priority entry at that location. Therefore, one possible operational concept is a loop ramp with priority bypass as presented in Figure 20. This concept would require that the ramp be widened about eight feet on the inside of the loop to provide room for two separate lanes. The ramp meter signal would be located at the end of the raised median separation, about 150'-170' from the freeway intersection. Because the queues on westbound Sunland Park are already long, and should get longer, the right lane in the westbound direction would need to be reserved for HOVs.

Location of HOV Improvements

Interstate 10 East

Appendix A documents the peak-hour volumes of westbound entrance ramps on I-10E. Using these data, geometric considerations and analyses of impacts of metering on traffic, it has been determined that the entrance ramps at

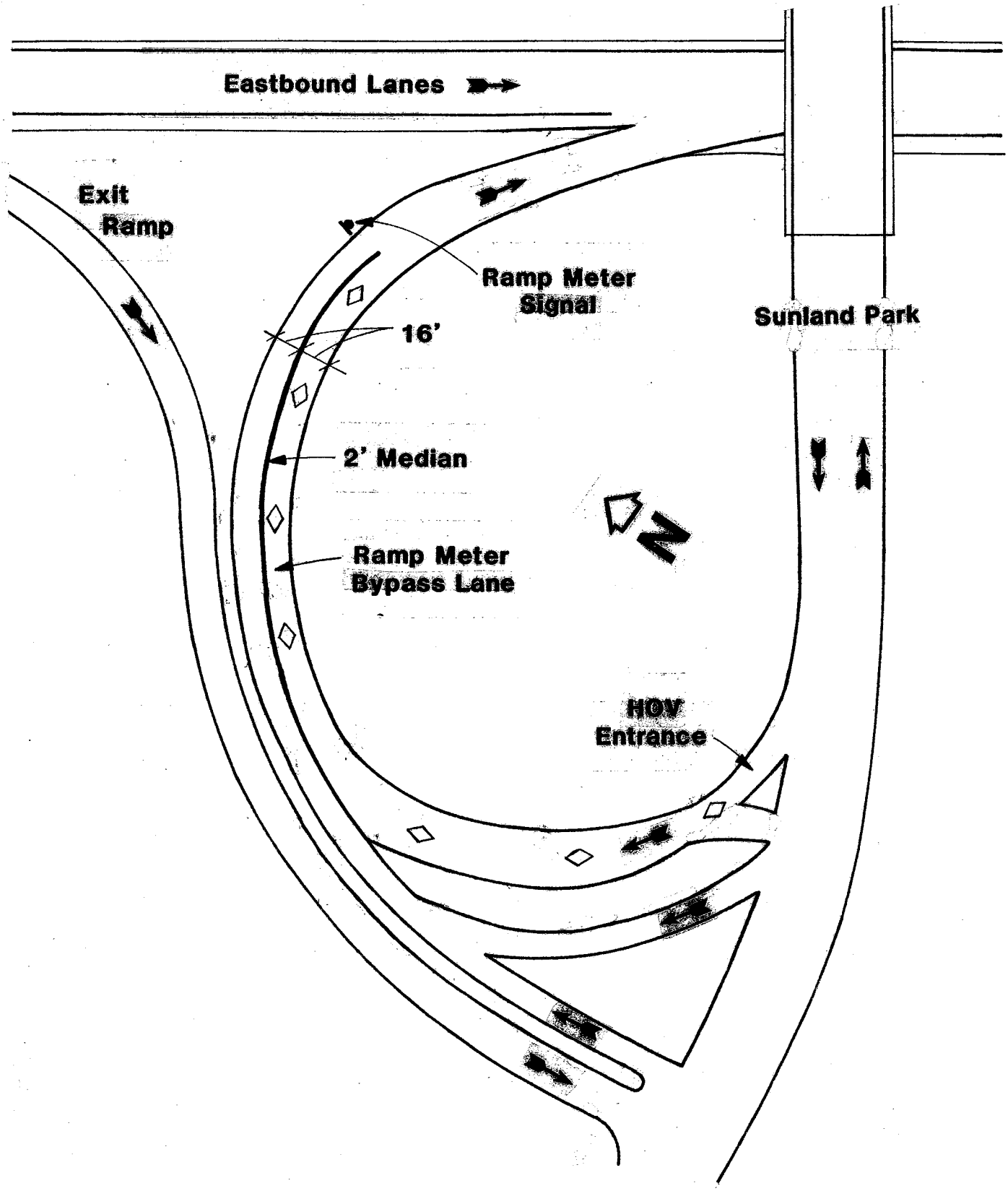


Figure 20. Conceptual Design of a Priority Entry Bypass Lane at Sunland Park Drive

Yarbrough, Hawkins and Geronimo would be the best three locations to initially install ramp metering with priority entry. Yarbrough was chosen because the ramp volume is the highest on I-10E. There is enough room to install a separate priority entry ramp inbound of the general traffic ramp at this location, as shown in Figure 21. The second highest volume in the area is at McRae; however, since this is the next ramp downstream of Yarbrough, and thus would be the primary diversion route for Yarbrough traffic, it should not be metered. The McRae ramp should operate well, even with the diverted traffic, since a main lane is added at this location for a total of three inbound lanes.

The next metered ramp would be Hawkins, three entrances from Yarbrough. It has the third highest volume in the section and one of the longest storage lengths, over 1,000 feet. Airway, the next inbound ramp, will be used as the diversion for Hawkins. The typical design shown in Figure 18 is applicable at the Hawkins priority entry location.

The Geronimo ramp, just inbound of Airway, could be the next priority ramp due to its relatively high volume and few geometric constraints (See Figure 19 for typical layout). Diverted traffic could use the Trowbridge and Paisano entrances. Data from travel speed studies indicate an increase in speed inbound of Geronimo.

Providing priority entry at the Trowbridge ramp would be difficult due to the braided ramps at that location. The entrance ramp has some rather severe vertical curves, a less than desirable sight distance and inadequate width for expansion of the lane to include an HOV bypass. The Paisano ramp currently operates well due to low volumes and the addition of a main lane beginning with this ramp. Metering of upstream ramps should divert some traffic to this ramp.

Together, the three ramps proposed for metering and priority entry contribute 26 percent of the inbound I-10E traffic from Americas to the CBD, and

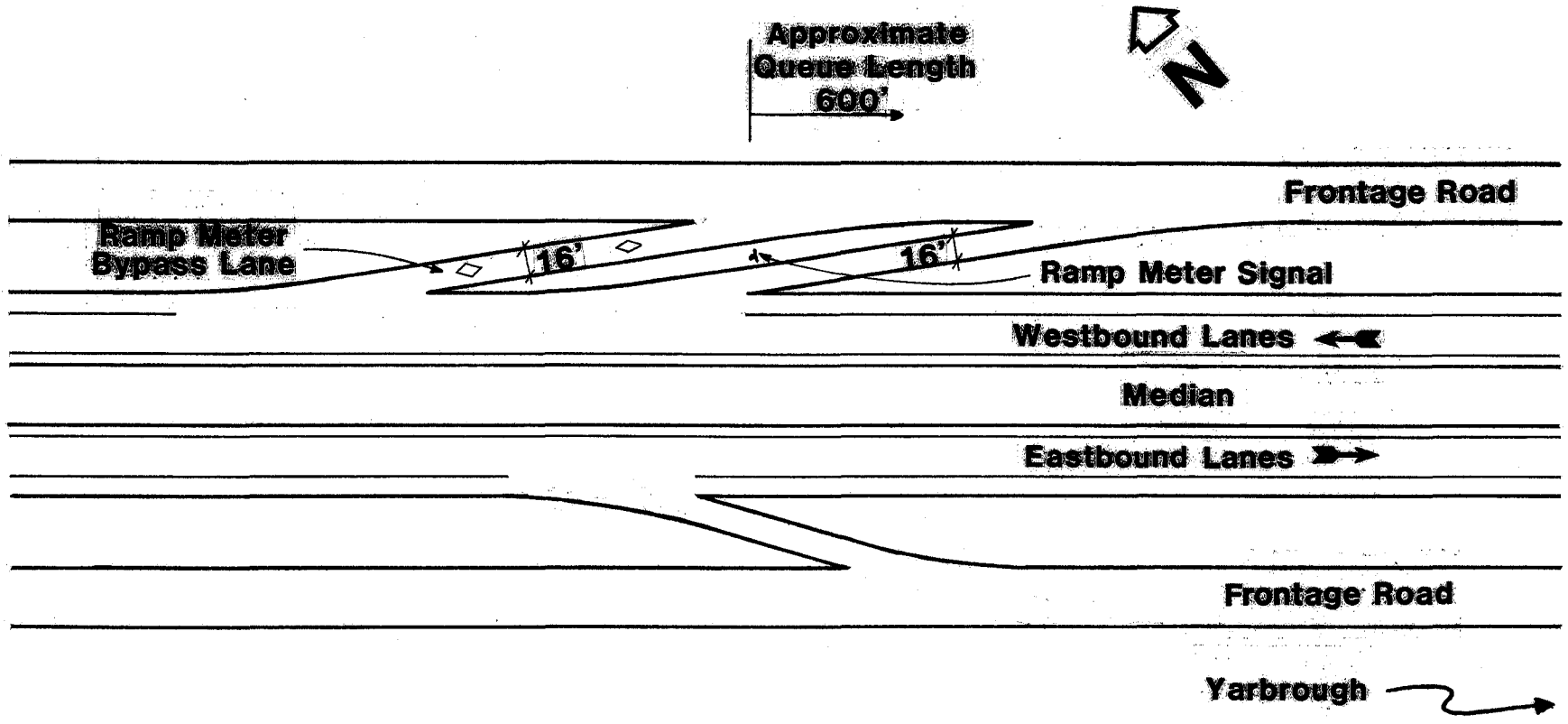


Figure 21. Conceptual Design of a Priority Entry Bypass Lane at Yarbrough Drive

37 percent of the traffic originating east of the N/S Freeway. The proposed project represents a good first step in managing congestion on this segment of freeway.

Interstate 10 West

The inbound ramps at Mesa St. and Executive Center Blvd. are the recommended locations for HOV priority treatment on I-10W. Recent widening of the Mesa St. ramp greatly minimizes the modification necessary to accommodate priority entry. Construction of a physical separation (a narrow, raised median) and the installation of a ramp meter signal are virtually all that would be required (Figure 22). Since dual left turns are permitted from Mesa St. onto the ramp, it would be desirable to reserve the rightmost of the two turning lanes for HOVs, thus minimizing lane changing on the ramp.

Executive Center Blvd. is the next location inbound at which initial priority entry should be considered. Construction of an HOV bypass lane similar to Figure 19 is recommended for late in this decade.

Freeway operating conditions inbound of Executive Center are expected to be at LOS C or better through the 1990s. Therefore no further improvements are recommended at this time.

Exclusive HOV Lane Operation

Interstate 10 East

While is does not appear that an exclusive reversible lane will be warranted before the year 2000, continued monitoring of the traffic situation may change current projections. Such a lane, however, is physically feasible and it is useful to examine the possible operation of a lane for any conflicts or problems that may be encountered.

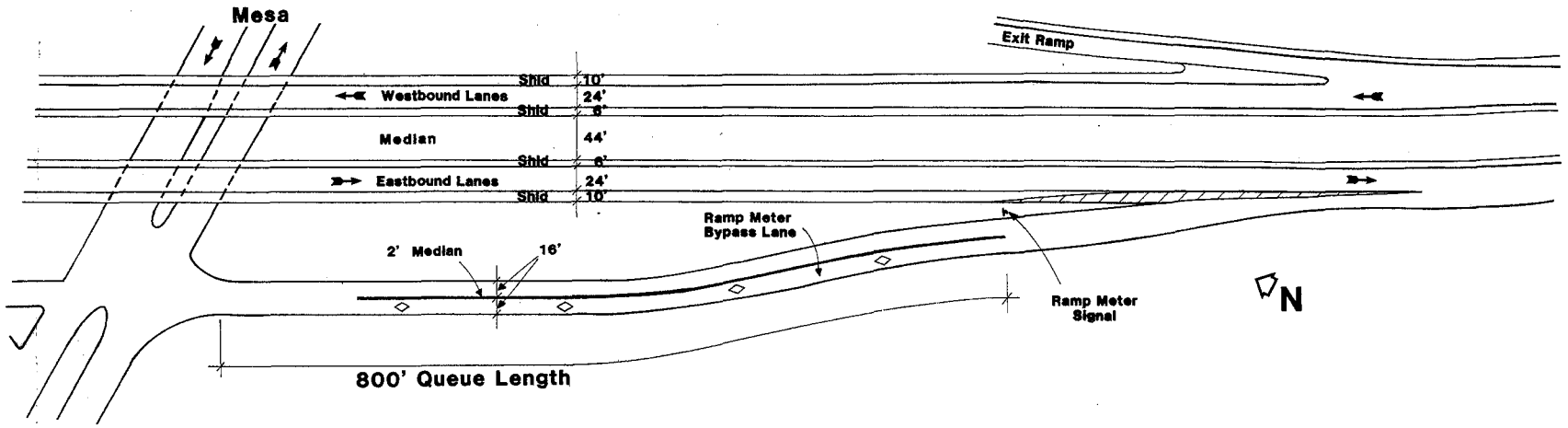


Figure 22. Conceptual Design of a Priority Entry Bypass Lane at Mesa Street

The lane would begin inbound of Yarbrough with concurrent-flow lanes being constructed on the inside shoulders, adjacent to the general traffic lanes. These concurrent-flow lanes would allow vehicles to make a smooth transition into the HOV lane in the morning and back into the general traffic in the evening. The concurrent-flow lanes would extend for 0.25 to 0.50 mile inbound to the beginning of the physically separated HOV lane. Figure 23 presents three different end treatments for a median HOV lane. These three concepts were developed as a part of a detailed feasibility study for Interstate 10 in San Antonio[12]. The directions and dimensions shown do not necessarily apply to El Paso. These are designed to minimize certain operational and safety problems. More study will be needed to identify the best of these or other alternatives, but the median opening has been successfully handled in other cases (e.g., I-70, Daniel Boone Freeway, St. Louis).

A typical cross section with and without a median HOV lane is shown in Figure 24 (a and b). The number of general traffic lanes is different in places, but the HOV lane and the inside shoulders will remain the same throughout most of the project. The cross section shown is 10 feet wider with the HOV lane than without. The only way a median HOV lane can be accommodated without widening the freeway is to eliminate one inside shoulder. HOV lane, main lane and shoulder widths will change near locations with median columns. The lane will be routed on one side of the columns, forcing a decrease in HOV lane, shoulder and main lane widths, as shown in Figure 25. A reduced operating speed will be required on the HOV lane in these sections.

Midpoint Entry Possibilities

The distance between Yarbrough and Raynolds (the anticipated limits of congestion) is approximately six miles. Thus, it would seem useful to provide some intermediate access points. Cielo Vista Mall, west of Hawkins,

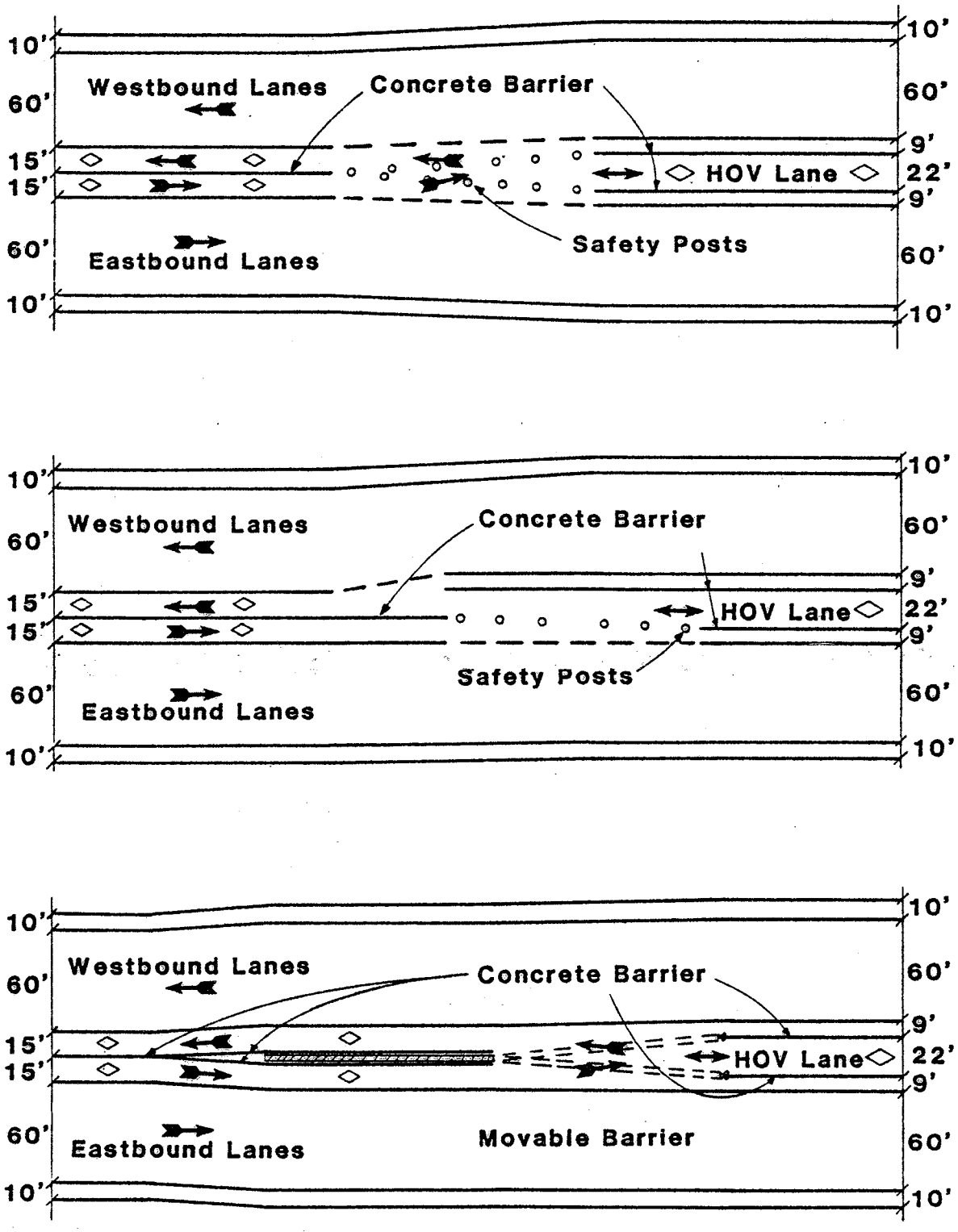


Figure 23. Alternative Median Treatements at the Outer Terminus of an HOV Lane, Possible Designs

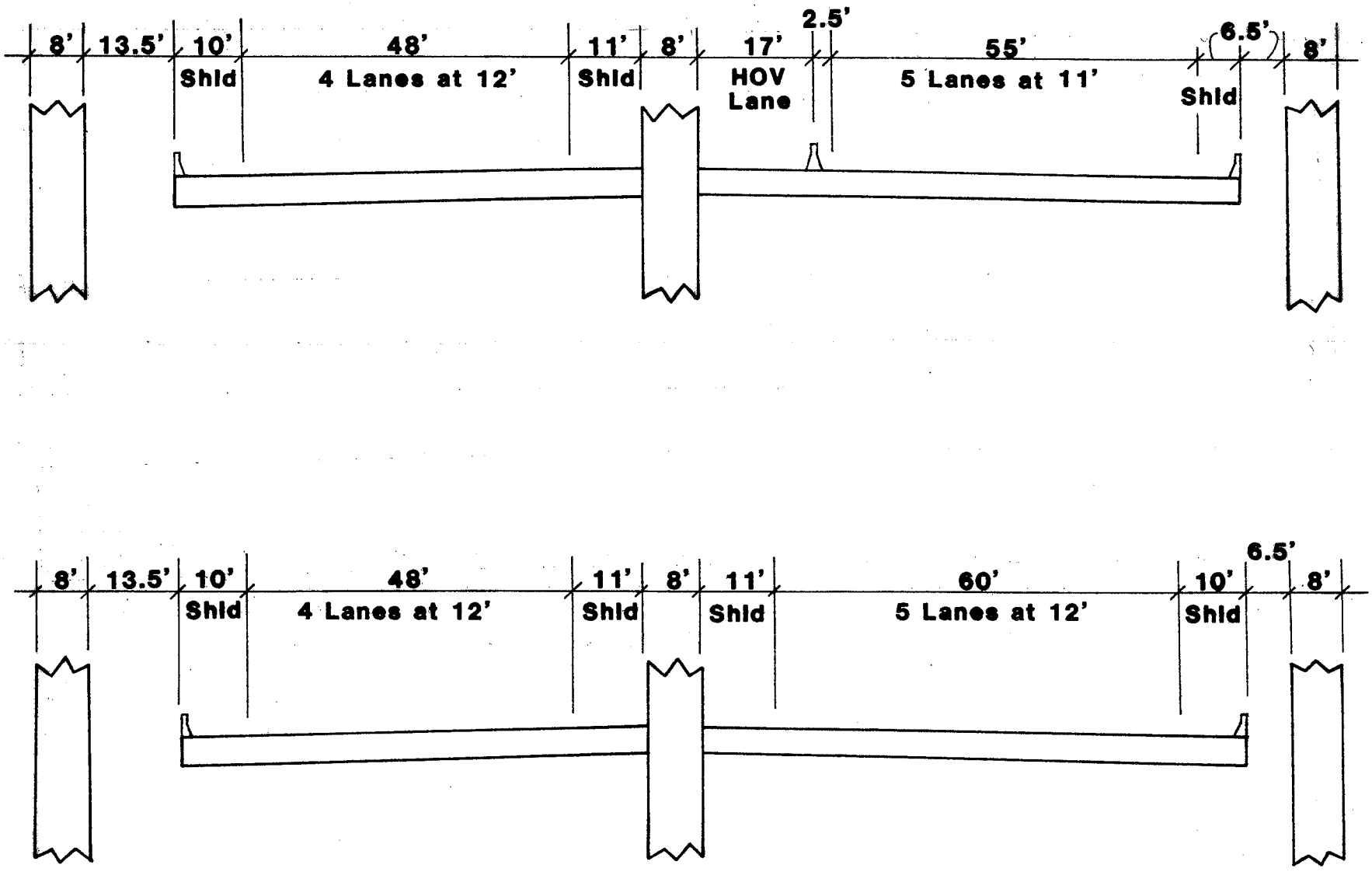


Figure 25. Typical Cross Sections at Locations with Median Columns

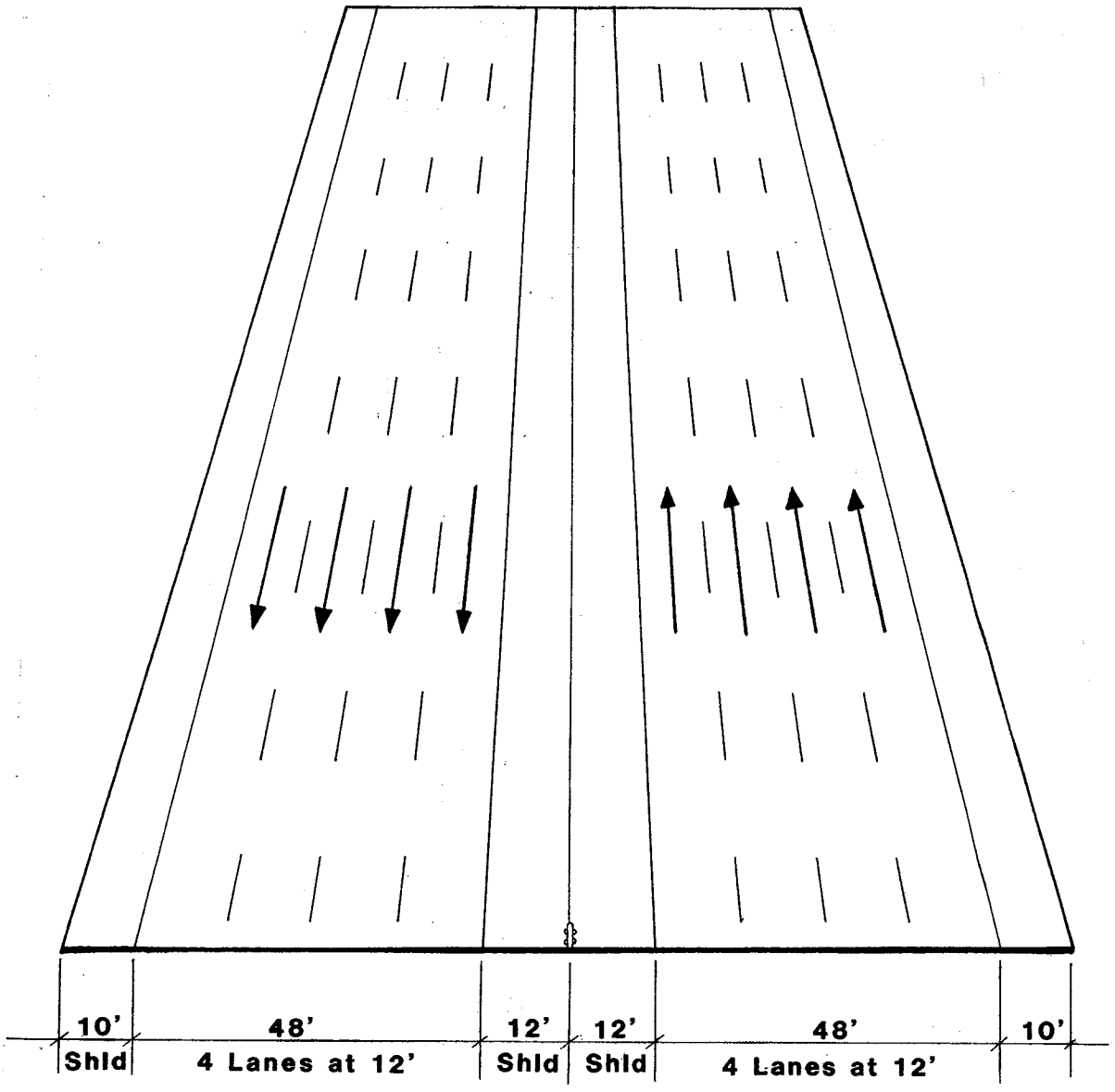


Figure 24a. Typical Cross Section without HOV Lane

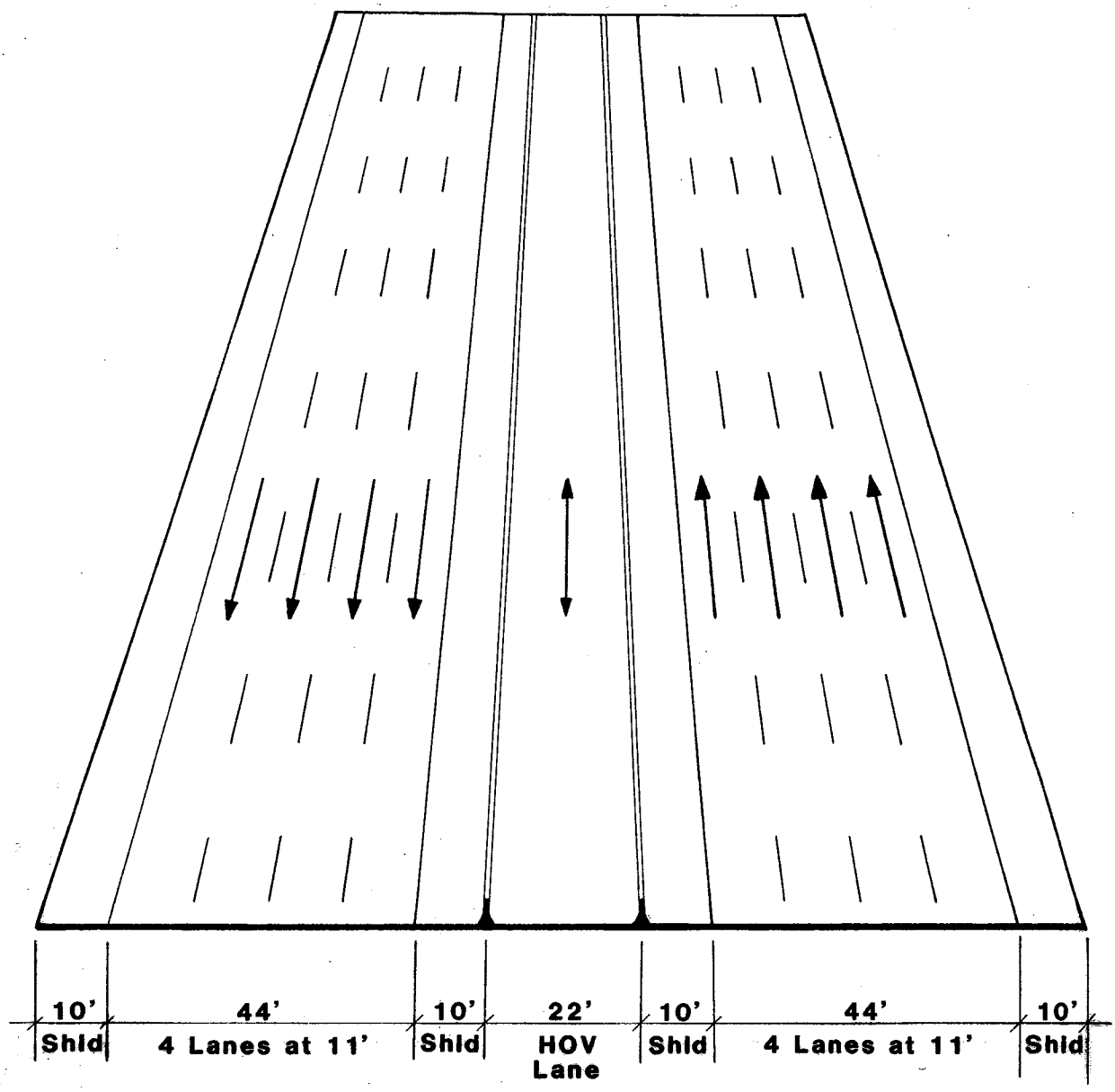


Figure 24b. Typical Cross Section with HOV Lane

is near the midway point of the congested section and the area around the mall may provide excellent opportunities for an elevated ramp to the median lane. A carpool staging area, and/or a Park-and-Ride lot, may also be incorporated in the design. By the time this lane is in the planning stages, land use in the area around the Mall may have drastically changed; therefore, no specific site planning is attempted at this time. These possibilities will need to be examined further at this and other locations.

Interstate 10 West

The need for an intermediate implementation time, intermediate cost high-occupancy vehicle improvement on I-10W was not identified.

CONCLUSIONS

This study evaluated the needs for priority treatment of high-occupancy vehicles for a 24.9-mile section of Interstate 10 in El Paso. This freeway serves both sides of the city and was evaluated as two separate facilities: Interstate 10 East (I-10E), which runs 16.5 miles from the CBD to Americas Avenue (FM 375), and Interstate 10 West (I-10W), which extends 8.4 miles to the Northwest to Mesa Street (US-80, SH-20). At present there is no immediate need to implement any priority measures. Level-of-service (LOS) C operations during the peak hours are typical on both facilities, with some short sections of I-10E experiencing short-duration LOS D conditions.

However, due to the lead time required to implement certain priority measures, the need for such improvements should be anticipated in order to permit the improvements to be operational by the time the need has developed. Interstate 10 East has experienced one of the fastest growth rates in the State in recent years, a trend that is likely to continue in some sections. Traffic volumes approaching 150,000 vehicles per day (vpd) are expected by the year 2000. Volumes are expected to more than double on I-10W by the mid-to-late 1980s, and approach 125,000 vpd by 2000. This growth suggests that the need for priority improvements may develop.

The needs, if any, for priority treatment were evaluated for the time and funding levels listed below.

- Short implementation time, low cost. Priority measures such as signal preemption and priority entry for high-occupancy vehicles are representative of this type of improvement.
- Intermediate implementation time, intermediate cost. Priority measures in this category would include contraflow lanes and one-lane median busways.

- Long implementation time, very high cost. Multilane HOV facilities would be representative of this type of improvement.

Due to the relatively low bus volumes in El Paso, any priority measure implemented should be capable of serving carpools.

Interstate 10 East

It was estimated that, given the present cross section of I-10E which varies from 4 to 10 lanes, a need for a low-cost, short implementation time improvements might develop late in this decade. Priority entry was identified as the most applicable technique. A need for an intermediate implementation time, intermediate cost improvement is not anticipated this century. Within the 20-year planning horizon considered in this study, a need for a long implementation time, very high cost priority improvement was not identified.

Priority Entry

Once freeway operating conditions approach long-duration LOS D, implementation of priority entry at selected locations should be considered. It is not intended that all ramps would be metered; however, if the Department elects to meter all ramps for operational purposes, then priority bypass lanes should be provided at all locations where geometrically feasible. Initially, priority entry should be considered at three locations -- Yarbrough, Hawkins, and Geronimo. Buses plus carpools (2 or more occupants) would be allowed to use the priority bypass lanes. It is estimated that, in 1985 nearly 1200 vehicles would use the three priority bypasses, representing 30 percent of the vehicles and 43 percent of the persons accommodated at the three locations.

Priority entry at the three locations would require a capital expenditure of approximately $150,000-$200,000 (1981 dollars). Implementation time for these treatments would be about six months; thus, no immediate action is needed at this time. Once the need for priority entry is evident, the improvements can

be implemented rather rapidly. Improvements in ramp construction or alignment made at any of these locations in the interim should include provisions for future implementation of priority bypass lanes. Enforcement is a major concern in planning and implementing this priority measure.

Interstate 10 West

Short implementation time, low cost improvements (priority entry) may be needed on this facility in the late 1980s. Within the 20-year planning horizon, a need for more extensive improvements was not identified.

Priority Entry

Priority bypass ramps should be considered initially at two locations--Mesa St. and Executive Center Boulevard. These locations appear best suited to low-cost measures because they will carry high volumes and require the least geometric modifications. Each of these two locations would provide priority entry for about 600 vehicles per hour and cost $55,000-$70,000.

Concluding Observation

Due to the implementation times associated with the improvements and the projected time until those improvements are needed, the Department does not need to take any immediate actions. This report documents what improvements may be needed, but sufficient time exists to allow the Department to wait to see if the need does, indeed, develop. If so, to the extent possible, provision of the HOV priority measures should be undertaken in conjunction with other improvements planned by the Department for Interstate 10.

REFERENCES

1. "Development of Preliminary Congestion Indices for Urban Freeways in Texas," Research Report 205-7, Texas Transportation Institute, June 1979.

2. "Preliminary Evaluation of Applicable Priority Treatment Techniques on Existing Urban Freeways in Texas," Research Report 205-8, Texas Transportation Institute, June 1979.

3. "Freeway High Occupancy Vehicle Lanes and Ramp Metering Evaluation Study," D. Baugh and Associates, U.S. Department of Transportation, Office of the Secretary, Washington, D.C., December 1979.

4. Sector Trip Production Summary, State Department of Highways and Public Transportation.

5. "Traffic Engineering Analysis -- Interstate Highway 10, El Paso (from Mesa Street Eastward to Lomaland Drive)," District 24, SDHPT, 1978.

6. "Engineering Analysis -- Interstate Highway 10, El Paso (from US Highway 62 to Yarbrough Drive)," District 24, SDHPT, 1979.

7. Highway Capacity Manual, Transportation Research Board, National Academy of Sciences, Washington, D.C., 1965.

8. Based on discussions with District 24, SDHPT personnel.

9. Cost estimates developed by District 15, SDHPT.

10. "Traffic Improvements and Safety Plan," Prepared for the City of El Paso by Pinnell-Anderson-Wilshire and Associates, Inc., 1978.

11. 1980 Vehicle Occupancy Study, District 24, SDHPT.

12. "Priority Treatment for High-Occupancy Vehicles in San Antonio, Texas," Texas Transportation Institute, June 1981.

APPENDIX A -- CBD WORK TRIP ESTIMATES

Estimating CBD Auto Work Trips Entering Westbound Interstate 10 East

This analysis is based on past research conducted by TTI in Houston and San Antonio. Three independent estimates are formulated, and the average used to estimate the number of auto work trips to the El Paso CBD via I-10E.

Work Trips, Estimate 1

It has been found that the work trips into the CBD can be estimated as between 6 and 12 percent of ADT count closest to the CBD (Table A-1). In Houston, the average proportion of CBD-bound traffic was 9.6 percent; whereas in San Antonio, approximately 6.2 percent of the traffic was destined for the CBD. The 1979 ADT on I-10E near Cotton Street is given as 97,600 vehicles (State Traffic Map). Using the non-weighted average of Houston and San Antonio data, the number of work trips on I-10E is determined as follows:

97,600 Vehicles x 7.9% auto work trips = 7710 auto work trips to CBD on I-10E.

Work Trips, Estimate 2

The City of El Paso estimated that 1980 CBD employment was 19,000 persons. Several factors are applied to this figure to arrive at an estimate for auto work trips to the CBD via freeways.

- Assume that, on any given workday, approximately 10 percent of the workers will be absent from work due to sickness, travel, vacation etc.
- Using information from TTI studies performed in Houston and San Antonio, it is estimated that 60 percent of the El Paso CBD workers arrive in downtown via the freeway system. (The corresponding value for Houston is 67 percent and for San Antonio is 80 percent).
- Auto occupancy for urban travel during the peak period is 1.27. This number was derived from auto occupancy studies conducted by the SDHPT in El Paso.

Table A-1: CBD Work Trips as Percent of ADT for Houston and San Antonio Radial Freeways.

Freeway	Auto Work Trips to CBD	ADT Closest to CBD	Work Trips as a Percent of ADT
Eastex (H)[1]	8,100	107,000	7.6%
Gulf (H)	13,800	165,000	8.4
Southwest (H)	15,800	134,000	11.8
Katy(H)	11,500	106,000	10.8
North (H)	11,200	120,000	9.3
I-35N (SA)[2]	10,800	152,000	7.1
US 281 (SA)	7,400	126,000	5.9
I-10W (SA)	12,200	200,000	6.1
US 90W (SA)	9,100	152,000	6.0
I-35S (SA)	6,800	114,000	6.0
Non-Weighted Average			7.9%

[1] Houston data is for 1975.

[2] San Antonio data is projected.

Therefore:

CBD Employment	x	Percent of workers on job any day	x	Percent of CBD workers using freeways	÷	Auto Occupancy	=	Auto Work trips to CBD via the freeways
19,000	x	90%	x	60%	÷	1.27	=	8079 trips

Using the Department Traffic Volume Maps, it was found that I-10E carried 65 percent of the total freeway volume entering the CBD (based on ADT values).

Trips to CBD	x	Percent of trips on I-10E	= Auto work trips on I-10E
8079	x	65%	= 5251

Work Trips, Estimate 3

A trip production matrix prepared by the SDHPT was used to estimate the number of CBD-bound work trips that are generated in the eastern sector. Table A-2 shows the sectors, the number of CBD work trips generated, and the proportion of those trips allocated to I-10E. The remainder of trips were assumed to use other routes, including the Border Highway and arterial streets.

The total number of work trips using I-10E is estimated as 8129.

Work Trips, Final Estimate

Estimates 1, 2, and 3 are averaged to obtain a value for use in this study.

	Total I-10E Work Trips
Estimate 1	7,710
Estimate 2	5,251
Estimate 3	8,129
Average	7,030

Table A-2. Work Trips to CBD Using I-10E, Based on Trip Production Summary

Sector #	Total# to CBD	x	% Using I-10E	=	Total on I-10E to CBD
13	569		80%		455
14	1089		80%		871
15	1894		30%		568
16	1701		35%		595
17	419		20%		84
18	1741		40%		696
19	923		70%		646
21	944		70%		661
22	834		80%		667
23	1531		40%		612
24	1356		90%		1220
25	259		60%		155
26	592		90%		533
27	421		50%		211
28	222		70%		155
				Total I-10 Traffic	8129

Distribution of 1980 Work Trips on I-10E

Knowing the number of vehicles entering the CBD on the I-10E freeway and given an estimate of the number of vehicles entering that freeway before Americas Avenue and destined for downtown, it is assumed that the remaining trips may be factored to the entrance ramps based on the overall ramp volume. From the trip production summary, it is estimated that 220 vehicles bound for the CBD enter the I-10E freeway upstream of Americas Avenue. Therefore, the number of trips to distribute to the ramps is:

Number of Total CBD Work Trips	-	CBD Work Trips originating before the Americas Avenue	=	Number of trips on I-10E West of Americas Avenue
7030	-	220	=	6810

The total of all entrance ramp volumes was computed, and then used to find the percentage of the total that each ramp represented. This percentage was applied to the number of work trips to achieve an estimate of the number of CBD work trips entering at each ramp. Table A-3 shows ramp volume by location.

Tables A-4 thru A-11 summarize the above computations performed for the years 1980, 1985 and 2000 for both I-10E and I-10W. The resulting values are used to develop the data shown in Figures 13 and 14.

Table A-3. Distribution of 1980 Entering Ramp Volumes for Westbound Interstate 10 East.

Ramp Location	Hourly Volume	Percent of Total	Cumulative Percent
Lomaland	1250	9	9
Yarbrough	1650	12	21
McRae	1290	10	31
Hunter	870	6	37
Hawkins	1050	8	45
Airway	950	7	52
Geronimo	750	6	58
Trowbridge	710	5	63
Paisano	610	5	68
Raynolds	520	4	72
N/S Freeway	2330	17	89
Copia	700	5	94
Piedras	700	5	99
Cotton	200	1	100
	13,580		

Table A-4. Estimate #1, CBD Work Trips on I-10 E and I-10 W for 1980, 1985, and 2000.

Freeway	Year	Estimated ADT	Percent Auto Work Trips	Estimated Auto Work Trips to CBD
I-10 E	1980	97,600	7.9	7710
	1985	111,600	7.9	8816
	2000	126,000	7.9	9954
I-10 W	1980	51,000	7.9	4029
	1985	92,100	7.9	7276
	2000	102,500	7.9	8098

Table A-5. Estimate #2, CBD Work Trips on I-10 E and I-10 W for 1980, 1985, and 2000.

Freeway	Year	CBD Empl.	Percent on Duty	Percent Using All Fwys.	Auto Occup.	Percent Using Spec. Fwy.	Est. Auto Work Trips
I-10 E	1980	19,000	90	60	1.27	65	5251
	1985	20,000	90	65	1.27	51	4698
	2000	21,300[1]	90	70	1.27	52	5494
I-10 W	1980	19,000	90	60	1.27	35	2828
	1985	20,000	90	65	1.27	49	4514
	2000	21,300	90	70	1.27	48	5072

[1] Source: City of El Paso, Department of Planning, Research and Development

Table A-6. 1985 Estimate #3, Work Trips to CBD Using I-10 E, Based on Trip Production Summary

Sector #	Total # to CBD	x	% Using I-10E	=	Total on I-10 E to CBD
13	1542		80%		1234
14	1762		80%		1410
15	2309		30%		693
16	1732		35%		606
17	397		20%		79
18	1852		40%		741
19	865		70%		606
21	1023		70%		716
22	850		80%		680
23	1972		40%		789
24	1286		90%		1157
25	1380		60%		828
26	1587		90%		1428
27	857		50%		429
28	829		70%		580
			Total I-10 E Traffic		11,976

Table A-7. 2000 Estimate #3, Work Trips to CBD Using I-10 E, Based on Trip Production Summary.

Sector #	Total # to CBD	x	% Using I-10E	=	Total on I-10 E to CBD
13	1794		80%		1435
14	2034		80%		1627
15	3070		30%		921
16	1822		35%		638
17	377		20%		75
18	1926		40%		770
19	1081		70%		757
21	1022		70%		715
22	1072		80%		858
23	2081		40%		832
24	1503		90%		1353
25	1435		60%		861
26	1696		90%		1526
27	815		50%		408
28	1689		70%		1182
			Total I-10 E Traffic		13,958

Table A-8. 1980 Estimate #3, Work Trips to CBD on I-10 W, Based on Trip Production Summary.

Sector#	Total # to CBD	x	% Using I-10W	=	Total on I-10 W to CBD
8	2475		40%		990
9	147		30%		44
10	965		50%		483
11	942		80%		754
12	1095		80%		876
	5624		Total I-10 Traffic		3,147

Table A-9. 1985 Estimate #3, Work Trips to CBD on I-10 W, Based on Trip Production Summary.

Sector #	Total # to CBD	x	% Using I-10W	=	Total on I-10 W to CBD
8	3320		40%		1328
9	109		30%		33
10	1255		50%		628
11	1563		85%		1329
12	2921		85%		2629
	9168		Total I-10 Traffic		5,801

Table A-10. 2000 Estimate #3, Work Trips to CBD on I-10 W, Based on Trip Production Summary.

Sector #	Total # to CBD	x	% Using I-10W	=	Total on I-10 W to CBD
8	3245		40%		1298
9	92		30%		28
10	1350		50%		675
11	1497		90%		1347
12	4014		90%		3613
	10198		Total I-10 Traffic		6,961

Table A-11. Summary of CBD Work Trip Estimates for I-10 E and I-10 W.

Freeway	Estimate #	Year		
		1980	1985	2000
I-10 E	1	7710	8816	9954
	2	5251	4698	5494
	3	8129	11976	13958
	Average	7030	8495	9800
I-10 W	1	4029	7276	8098
	2	2828	4514	5072
	3	3147	5801	6961
	Average	3335	5864	6710