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16. Abstract

This report documents a review of the travel impacts of six urban freeway reconstruction projects throughout the United States and analysis of the travel impacts of five projects in Texas. The review includes projects in Chicago, Pittsburgh, Boston, Seattle, Detroit, and Milwaukee. The five projects in Texas include I-35 in Austin, US-75 in Plano, I-45 North Freeway in Houston, I-35W in Fort Worth, and I-10 in El Paso. The traffic control plans for the projects in Texas were similar: the same number of freeway lanes as existed before reconstruction were maintained, but there were minor freeway capacity reductions associated with off-peak lane closures, reductions in lane and shoulder widths, ramp closures, frontage road lane closures, and detours within the right-of-way. None of the five projects in Texas had serious adverse impacts on traffic patterns or travel times either on the freeway or elsewhere in the corridor. However, the projects in Plano and Fort Worth, where access to the freeway was restricted by frontage road lane closures and ramp closures, respectively, did cause some diversion of traffic away from the freeway.

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TRAVEL IMPACTS OF URBAN FREEWAY RECONSTRUCTION PROJECTS IN TEXAS

by

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Research Report 1108-3
Research Study Number 2-8-87/1-1108
"Traffic Pattern Assessment and Road User Delay Costs Resulting from Roadway Construction Options"

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha
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lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

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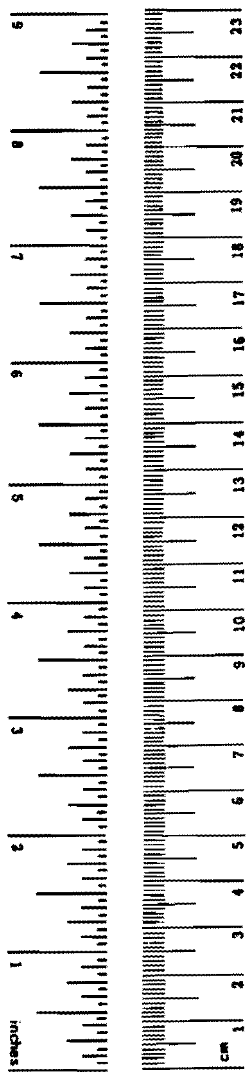
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

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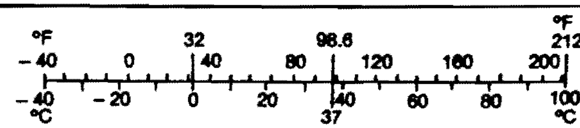

These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

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SUMMARY OF FINDINGS

This report documents a review of the travel impacts of six urban freeway reconstruction projects throughout the United States and an analysis of the travel impacts of five projects in Texas. The review included projects in Chicago, Pittsburgh, Boston, Seattle, Detroit, and Milwaukee. These projects represented a range of capacity reductions including the total closure of one directional roadway at a time on the Lodge Freeway in Detroit; long-term lane closures in Chicago, Pittsburgh, Seattle, and Milwaukee; and lane closures only during off-peak periods in Boston. The five projects in Texas that were analyzed included I-35 in Austin, US-75 in Plano, I-45 North Freeway in Houston, I-35W in Fort Worth, and I-10 in El Paso.

The major findings of the review of previous experiences at projects throughout the United States were as follows:

- o The percentage reduction in average daily traffic volumes was approximately equal to the percentage reduction in capacity at reconstruction zones on heavily traveled urban freeways.
- o Traffic volumes on the freeway varied considerably during the first several weeks of reconstruction while motorists experimented with alternative routes and adjusted their travel patterns.
- o Among those motorists who changed their travel patterns, diversion to another route in the corridor was much more common than diversion to another mode (mass transit, ridesharing).
- o Some discretionary trips during off-peak periods were cancelled during reconstruction.
- o Little change in total corridor-wide traffic volumes was observed at projects where complete screen lines were monitored.
- o Changes in corridor-wide traffic conditions were relatively minor at some projects (Boston and Milwaukee) but were fairly substantial at others (Pittsburgh and Detroit).

At all of the five projects in Texas that were analyzed, the same number of freeway lanes as existed before reconstruction were maintained. There were minor freeway capacity reductions associated with off-peak lane closures, reductions in lane and shoulder widths, and detours within the right-of-way. In addition, at US-75 in Plano there were long-term frontage road lane closures and at I-35W in Fort Worth there were long-term ramp closures which restricted access to the freeway.

In general, none of the five projects had serious adverse impacts on traffic patterns or conditions either on the freeway or elsewhere in the corridor. However, in Plano and Fort Worth where access to the freeway was restricted, some diversion of traffic away from the freeway occurred.

The observed impacts at the five projects in Texas can be summarized as follows:

- The I-35 project in Austin had little impact on traffic patterns or travel times. Traffic volumes were actually higher than expected (given normal seasonal volume patterns) on the freeway and throughout the corridor as a whole. Travel times on freeway, frontage roads, and alternative arterial routes before and during reconstruction were not significantly different.

- The US-75 project in Plano affected traffic volumes but caused little change in travel times. Traffic volumes on the freeway and throughout the corridor were generally lower than expected. Freeway volumes were 15,000 vpd (15 percent) lower than normal during reconstruction, and total corridor volumes were 23,000 vpd (12 percent) lower. Travel times through the corridor before and during reconstruction were not significantly different.

- The I-45 North Freeway project (Phase II) in Houston had little impact on traffic patterns or travel times. There were only minor changes in peak period traffic volumes on the freeway and frontage roads, although some shifting of traffic between the freeway and frontage roads was observed early in the project. Travel times on the freeway, frontage roads, and two alternative arterial routes before and during the project were about the same.

- The I-35W project in Fort Worth affected the volume and pattern of traffic entering and exiting the freeway, but had little effect on total corridor-wide volumes. Ramp volumes in the reconstruction zone decreased 11 percent during Phase I (when 12 of the original 30 ramps were closed) and 31 percent during Phase II (when 20 of the original 30 ramps were closed).

- The I-10 project (Phases II and III) in El Paso had little effect on travel times in the corridor. Travel times on I-10 were generally lower during reconstruction. The fact that only small changes in travel times were observed on the alternative routes in the corridor suggests that there was little diversion to these routes from the reconstruction zone.

IMPLEMENTATION STATEMENT

The findings of this study should be useful to the State Department of Highways and Public Transportation when planning future urban freeway reconstruction projects. The results suggest that the traffic control plans typically used by the Department effectively minimize the adverse travel impacts resulting from the projects. The minor capacity reductions associated with narrowing lane and shoulder widths and detouring traffic within the right-of-way in order to maintain the same number of freeway lanes as before reconstruction, have little effect on traffic volumes and travel times in the freeway corridor. However, when access to the freeway is restricted due to ramp closures and/or lane closures on the frontage road, some diversion of traffic away from the freeway is likely to occur. The Department should determine the availability of excess capacity on other routes in the corridor when considering traffic control options that would significantly reduce freeway, frontage road, or ramp capacity.

The traffic monitoring plan and statistical analysis methodology developed and used in this study proved to be effective. Its use is recommended for future monitoring efforts.

DISCLAIMER

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1. INTRODUCTION

Reconstruction projects are either underway or being planned on a number of major urban freeways throughout Texas and the United States. When planning a project, a balance must be reached between two conflicting objectives: (1) maximizing the safety and efficiency of the reconstruction activity, and (2) minimizing the adverse impacts on motorists and nearby communities. In seeking an acceptable balance, highway agency officials must be able to estimate the travel impacts of reconstruction options. Research Study 2-8-87/1-1108 was undertaken to provide the Texas State Department of Highways and Public Transportation (SDHPT) with a comprehensive data base and sound analytical approach for estimating these impacts.

An extensive data collection effort was undertaken to document the travel impacts of urban freeway maintenance and reconstruction projects in Texas. Field studies were conducted before and during three long-term freeway reconstruction projects (I-35 in Austin, US-75 in Plano, and US-59 Southwest Freeway in Houston) to monitor the changes in travel patterns and traffic conditions. For three additional projects that were underway when Study 1108 began (I-35W in Fort Worth, I-10 in El Paso, and I-45 North Freeway in Houston), traffic data that had been collected previously by or for the SDHPT were also obtained. The objective of this report is to summarize the data for five of these projects. (The US-59 Southwest Freeway project is still underway and will be documented after all field studies are completed.)

The data base being developed also includes accident data. An analysis of the accident experience at five of the projects (all but the US-59 Southwest Freeway project) has been documented in Report No. FHWA/TX-90/1108-2.

One final component of the data base relates to short-term freeway maintenance work zone lane closures. More than 40 capacity studies have been conducted to improve the existing data base on work zone lane closure capacity. In addition, diversion studies have been conducted at 11 work zones to compile data on why, when, where, and how much traffic diverts in response to work-zone-related delays. These studies will be documented in separate reports.

This report is divided into nine chapters. Chapter 2 summarizes the travel impacts of selected urban freeway reconstruction projects elsewhere in the United States. Chapter 3 summarizes the plan for developing the data base. Chapters 4 through 8 document the travel impacts of the five reconstruction projects in Texas. Chapter 9 provides a summary of findings about the travel impacts of reconstruction projects in Texas.

2. SUMMARY OF PREVIOUS EXPERIENCES

The first task in Study 1108 was to review available literature on the travel impacts of highway reconstruction projects. Documentation is available on a number of major urban freeway reconstruction projects throughout the United States. This chapter summarizes the reported travel impacts of these projects as a basis for comparison with the impacts measured at projects in Texas.

Several summaries of projects have already been compiled. Krammes et al. (1) documented the corridor traffic management planning efforts at five projects. Ullman et al. (2) synthesized the cost and effectiveness of the traffic management techniques that were employed at 12 projects. Scott (3) compiled abbreviated case studies of traffic management during major highway reconstruction in 17 cities. The proceedings of the National Conference on Corridor Traffic Management for Major Highway Reconstruction (4) also included a number of case studies.

This chapter focuses on the travel impacts observed at six projects where changes in traffic patterns and conditions were monitored and documented. These projects (listed in chronological order) are:

- I-94 Edens Expressway in Chicago,
- I-376 Penn-Lincoln Parkway East in Pittsburgh,
- I-93 Southeast Expressway in Boston,
- I-5 Ship Canal Bridge in Seattle,
- US-10 John C. Lodge Freeway in Detroit, and
- I-94 Menomonee Valley Bridge in Milwaukee.

Table 1 summarizes the capacity reductions and travel impacts associated with each project. The projects represent the full range of possible capacity reductions through the reconstruction zone (from the total closure of one direction of the freeway to no long-term lane closures). During the Lodge Freeway project, one directional roadway at a time was reconstructed and all traffic in that direction was diverted to alternative routes. At the Edens Expressway, Parkway East, Ship Canal Bridge, and Menomonee Valley Bridge projects, long-term lane closures were implemented. At the Southeast Expressway project, lane and shoulder widths were reduced, but the same number of travel lanes were maintained as before reconstruction. The experiences at these projects suggest that, at freeways where traffic volumes are near capacity much of the day, the percentage of traffic that diverts from the freeway is approximately equal to the percentage reduction in the traffic-handling capacity of the reconstruction zone.

TABLE 1. Summary of Reconstruction Project Travel Impacts

Project	Dates	Number of Lanes in Each Direction Peak/Off-Peak		Freeway ADT Before Reconstruction (1000 vpd)	% of Reduction in Freeway AADT
		Before	During		
Chicago	1978-80	3/3	2/2	135	30
Pittsburgh	1981-82	2/2	1/1	84	56
Boston	1984 1985	4/3 4/3	4/2 4/2	160	8 0
Seattle	1984 1985	4/4 4/4	4/2 2/2	210	38 40
Detroit[a]	1986 1987	3/3 3/3	3/2 0/0	150	19 100
Milwaukee	1987	4/4	2/2	120	45

[a] In 1987, one directional roadway at a time was closed and all traffic in that direction was forced to leave the freeway.

I-94 EDENS EXPRESSWAY IN CHICAGO

The Edens Expressway is a six-lane freeway serving the north shore suburbs of Chicago. Figure 1 illustrates the corridor. Traffic volumes on the Expressway ranged from 135,000 vehicles per day (vpd) at its southern terminus with the I-94 Kennedy Expressway to 57,000 vpd at the Lake-Cook county line (5). During the reconstruction of the Expressway, the number of travel lanes was reduced from three to two per direction (5). The changes in traffic patterns during reconstruction were monitored using data from the freeway surveillance system in the Chicago area.

With respect to traffic patterns, Ziejewski (5) reported the following:

- The Edens Expressway handled more than 70 percent of its normal weekday traffic volumes during reconstruction, although less than two-thirds of the normal capacity was available for use.

- The percentage diversion during peak periods was up to 5 percent higher than the 24-hr average.

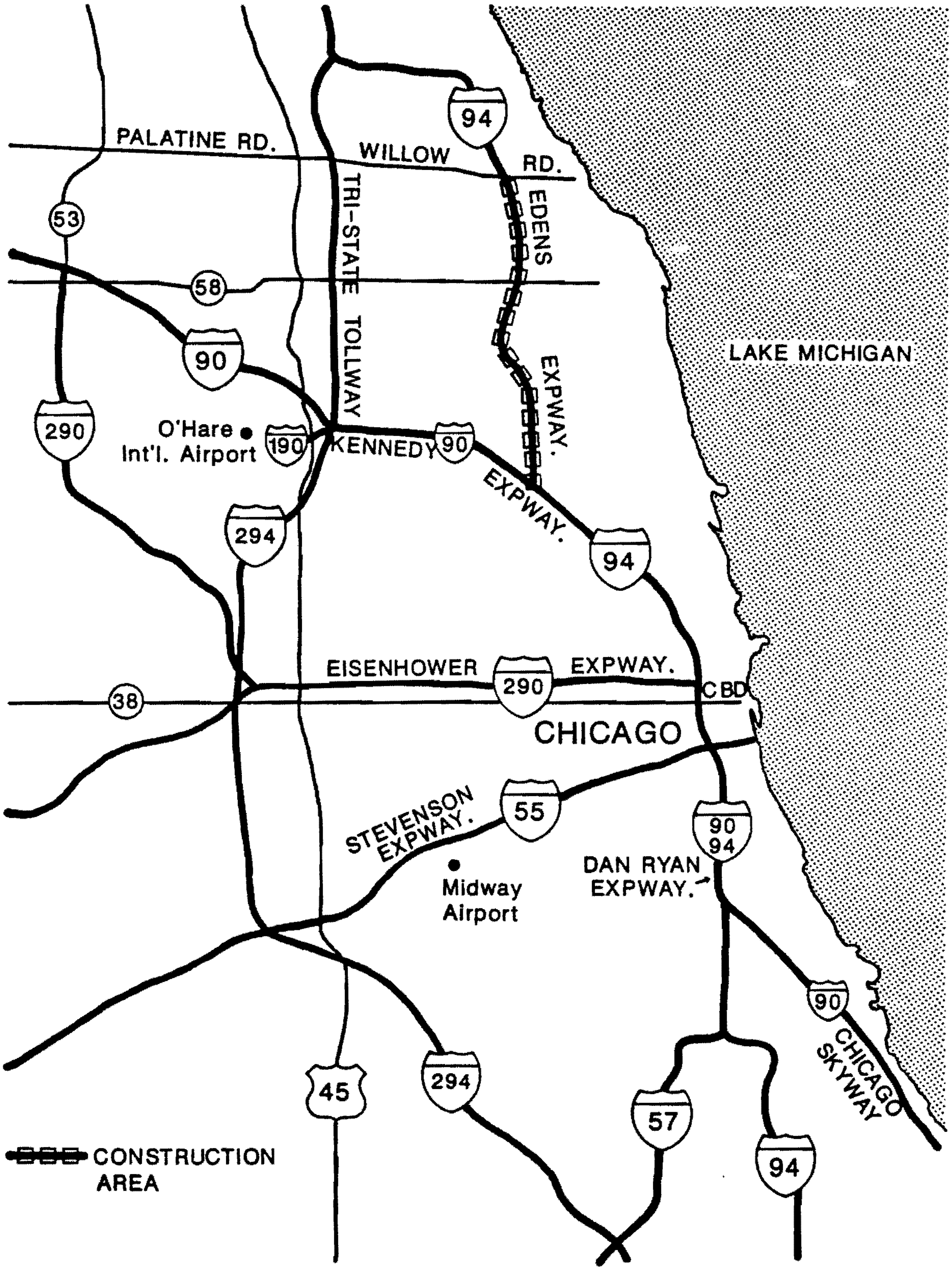

Figure 1. I-94 Edens Expressway in Chicago.

- o There was more peak-period diversion and less congestion on Edens during the first few weeks of the project than later in the project, while motorists experimented with alternative routes and established new traffic patterns.

- o Of the daily trips diverted, 40-50 percent were traced to the Kennedy Expressway west leg. There was less peak-period congestion on the Kennedy Expressway southeast of the Edens Expressway junction, and additional peak-period congestion on the Kennedy Expressway west leg.

- o Considerably less truck traffic was observed on the Edens Expressway, combined with noticeable increases on the Tri-State Tollway (a parallel route approximately 6 mi west of Edens Expressway).

- o The 35 mph speed limit established through the reconstruction zone resulted in a 10 mph reduction in speeds.

About half of the traffic that diverted from the Edens Expressway was traced to the Kennedy Expressway, which was considered the principal alternative route. Ziejewski (5) speculated that the remainder of the traffic reduction on the Edens Expressway could be attributed to some combination of the following factors:

- o Many arterial routes handled some diverted traffic without serious degradation of traffic conditions.

- o Some through traffic, including long-haul truckers and interstate drivers, avoided the Edens completely by using I-294, I-290, or combinations thereof.

- o Some longer-distance commuters shared rides or diverted to public transportation or both, taking advantage of commuter rail feeder buses and extra trains provided by Regional Transit Authority.

- o Many drivers cancelled trips or avoided using the Edens Expressway for discretionary trips. The energy crisis, which began in April 1979, also encouraged motorists to reduce travel, due to the cost and availability of fuel.

Ziejewski (5) concluded:

> The Edens reconstruction project illustrates that proper traffic planning will help establish public awareness of the project and the expected impacts. The fact that the predicted traffic chaos never resulted demonstrates that the planning and implementation of the overall traffic program was most effective.

I-376 PENN-LINCOLN PARKWAY EAST IN PITTSBURGH

The Parkway East, illustrated in Figure 2, is the only east-west freeway connecting the Pennsylvania Turnpike (I-76) and eastern suburbs with downtown Pittsburgh. This four-lane freeway carries about 84,000 vpd at the Squirrel Hill Tunnel, and a total of 132,000 vpd entered the zone prior to reconstruction. During reconstruction, one directional roadway at a time was closed and one travel lane for each direction, separated by a buffer lane, was maintained on the other roadway. The entrance ramps within the reconstruction zone were closed, and the entrance ramp nearest each end of the zone was restricted to high-occupancy vehicle (HOV) use only. A large package of improvements to alternative routes and modes in the corridor and an extensive public information program were implemented.

Changes in traffic patterns and conditions were monitored through screen line counts, travel time runs, and surveys of travelers (motorists, carpoolers, and transit users) in the corridor. The travel impacts have been thoroughly documented (6, 7).

Hendrickson et al. (6) and Anderson et al. (7) reported the following impacts:

- Relatively few motorists switched modes to carpools, vanpools, or transit.

- Large volumes of traffic diverted from the Parkway East to alternative routes in the corridor during reconstruction. The route diversion was concentrated on the arterial streets closest to the Parkway. Daily traffic volumes through the Squirrel Hill Tunnel decreased by 58 percent and morning peak-period, peak-direction volumes by 68 percent. Daily traffic volumes entering the reconstruction zone decreased by 60 percent.

- Total corridor volumes at a screen line that cut through the Squirrel Hill Tunnel and all major alternative routes decreased by only 1 percent.

- Average travel times generally increased on the Parkway and throughout the corridor. In the westbound (inbound) direction weighted average travel times throughout the corridor increased by 5 min (16 percent) during the A.M. peak, by 1 min (4 percent) during the off-peak, and by 3 min (12 percent) during the P.M. peak. In the eastbound (outbound) direction average travel times increased by 6 min (37 percent) during the A.M. peak, by 11 min (52 percent) during the off-peak, and by 13 min (57 percent) during the P.M. peak.

- Travelers in the corridor responded to the increases in travel time by departing earlier for work. Average departure time was 20 min earlier during the reconstruction.

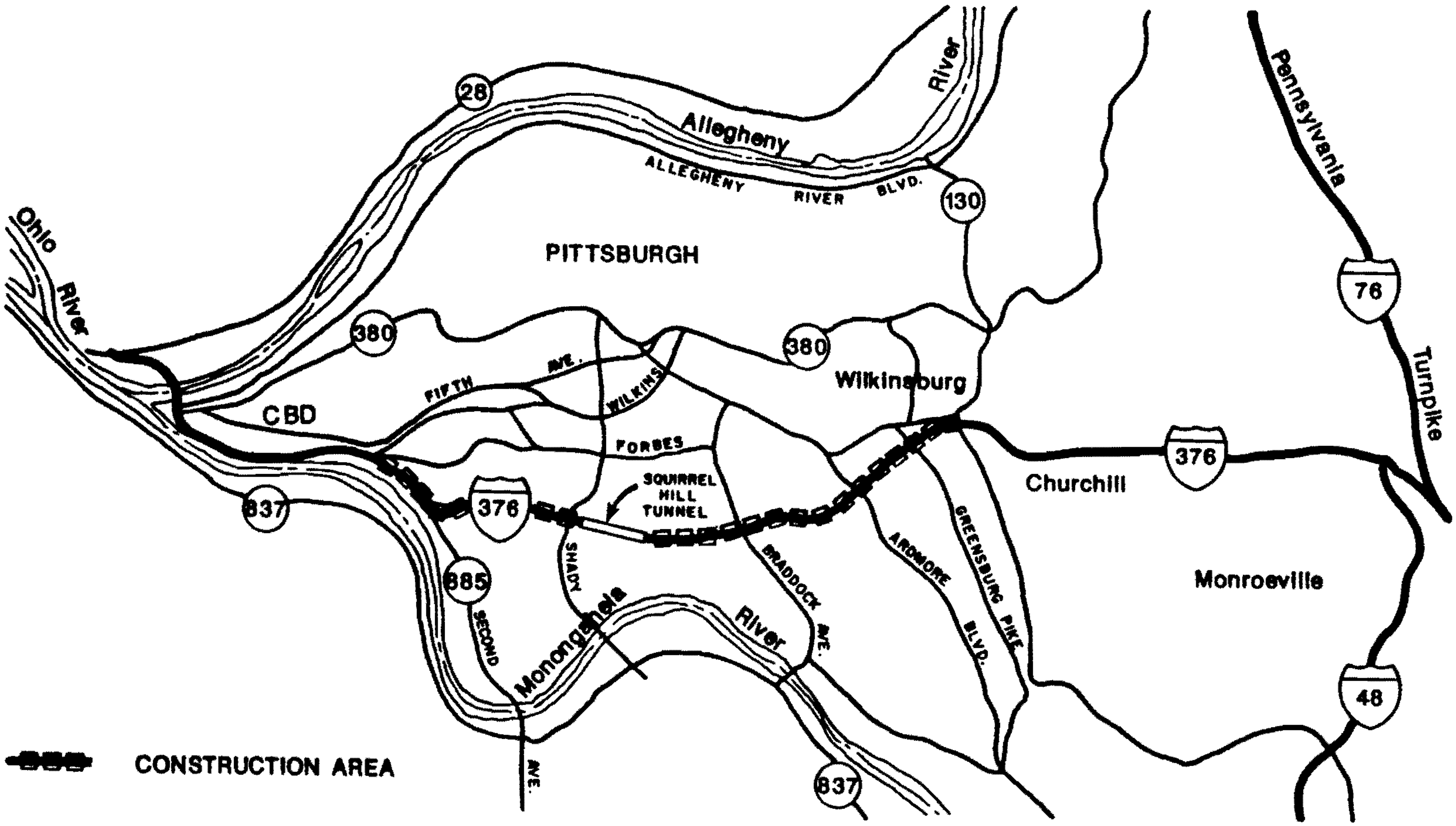

Figure 2. I-376 Penn-Lincoln Parkway East in Pittsburgh.

Hendrickson (6) concluded:

> Despite a large reduction in the effective capacity of the Parkway East and a large diversion of traffic in the corridor, the overall traveler impacts and responses to the reconstruction were small. Changes in route choice and somewhat earlier departure times were the primary responses.
>
> The changes in trip characteristics were also relatively small, with a reported increase of roughly 7 min in travel time and 1.3 km (0.8 mile) in travel distance for work trips. These travel time increases were not significant enough to induce more extensive changes in route, departure time, or modal choice.

I-93 SOUTHEAST EXPRESSWAY IN BOSTON

The Southeast Expressway is the major freeway connecting Boston with southeastern Massachusetts. The section highlighted in Figure 3 was reconstructed in 1983 and 1984. The six-lane freeway, with a discontinuous breakdown lane in each direction used as a travel lane during peak hours, carried more than 160,000 vpd before reconstruction. The reconstruction zone was divided into four two-lane segments separated by concrete median barrier. Work was performed in one segment at a time. One segment was provided for each direction, and the remaining segment was used as reversible, express lanes. Thus, four travel lanes were available in the peak direction (the same as before reconstruction), and two lanes in the off-peak direction (one less than before reconstruction).

A corridor-wide traffic management plan was implemented. The plan included traffic engineering improvements on alternative routes; increases in commuter rail, boat, and bus service, ridesharing programs and park-and-ride lots; and a public information and community liaison program.

The travel impacts of the project have been well documented (8, 9). The traffic monitoring program included screen line counts and travel time runs.

Meyer (8) and Steffens et al. (9) reported the following impacts on traffic patterns:

- Expressway traffic volumes declined during the first year of reconstruction (1984), but returned to and slightly exceeded pre-reconstruction levels during the second year (1985). Volumes between 6:00 A.M. and 7:00 P.M. decreased by approximately 9,000 vehicles (8 percent) during the first year, and increased by less than 0.2 percent during the second year.

- The traffic volume increase on the alternative routes exceeded the decrease on the Expressway during the first year of reconstruction. A.M. peak period traffic actually increased slightly during reconstruction, which suggested that the volume decrease was due to the diversion of mid-day trips.

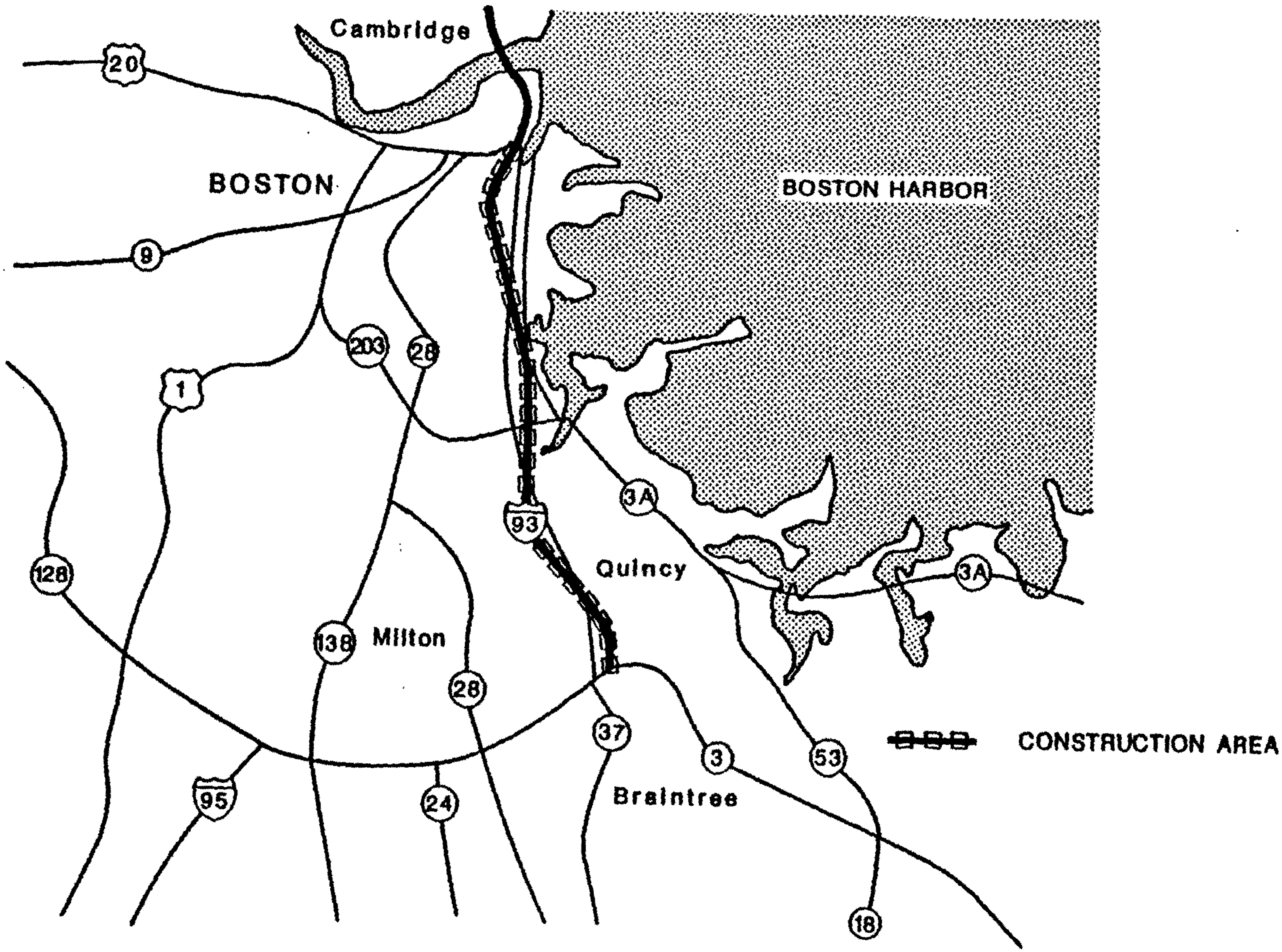

Figure 3. I-93 Southeast Expressway in Boston.

- o There were considerable fluctuations in traffic volumes during the first few weeks of the reconstruction project. Daily traffic on the Expressway during the first week of reconstruction was 7,000 vpd lower than during preceeding weeks, which resulted in much improved traffic flow on the Expressway. By the third week of reconstruction, this improvement in traffic flow (and extensive media attention) began to attract large numbers of vehicles back to the Expressway.

With respect to travel times in the corridor, Meyer (8) and Steffens et al. (9) reported:

- o Peak-period travel times on both the Expressway and alternative routes were lower during the first year of reconstruction than before reconstruction and returned to pre-reconstruction levels during the second year.

- o The 3-4 min reduction in peak-period travel times on the Expressway during the first year was attributed to (1) the reduction in traffic volumes on the Expressway, and (2) the added capacity associated with the express lanes and closure of certain entrance and exit ramps. The express lanes offered through traffic improved operating conditions since trucks were prohibited and the turbulence due to entrance and exit ramps was eliminated. Furthermore, the closure of certain ramps also reduced turbulence on the lanes for local traffic. Therefore, even though the same number of lanes was maintained, the capacity was effectively increased.

- o Travel times on the alternative routes generally decreased during the first year. This decrease, in spite of the increase in traffic volumes on most of the routes, was attributed to the traffic engineering improvements that were made on the routes.

With respect to public transportation in the corridor, Steffens (9) observed:

- o Travel time/capacity improvements during the morning peak hours kept operational improvements on feeder bus and rapid transit services from successfully capturing market share during the first year of reconstruction.

- o Despite increases in bus service, ridership decreased by 1 percent overall, although significant increases were observed on some routes.

- o The 100 percent increase in the frequency of peak period commuter rail service on the two lines in the corridor produced a 360-420 passenger per day (10 percent) increase in ridership.

- o The increases in vanpooling were about what would have been expected in the absence of the reconstruction project.

Meyer (8) concluded:

> The results of the evaluation effort showed that commuters responded quite dramatically to the media attention on the anticipated disruption of the reconstruction. The most important means of alternate travel was an alternative route, and the most-used mass transit option was commuter rail. The perceived success of the Expressway project was greatly influenced by a comprehensive public information and media effort that provided extensive information on the project and on alternative means of travel.

I-5 SHIP CANAL BRIDGE IN SEATTLE

I-5 is the major north-south freeway running through Seattle, as illustrated in Figure 4. It includes an eight-lane freeway and a separate two-lane reversible roadway. The reversible roadway runs north from the cental business district for 8 mi and serves as express lanes. The average weekday traffic on this section of I-5 was 210,000 vpd. The Washington State Deprtment of Transportation undertook a project to resurface the mainlanes of the Ship Canal Bridge and the Lakeview/Galer Viaduct on I-5. A 1-mi section of the northbound (outbound) mainlanes was resurfaced during the summer of 1984, and a 2-mi section of the southbound (inbound) mainlanes was resurfaced during the summer of 1985. Mieras (10) and Bockstruck (11) have summarized the travel impacts of the project.

The resurfacing of the northbound lanes in 1984 was conducted in three phases. First, preparatory work was performed in two-lane segments on weeknights and weekends; lane closures were installed and removed nightly. During the day, all lanes were open, but traffic was slowed by the rough surface. Second, two lanes at a time were closed for placing and curing the 1.5-in concrete overlay. Traffic was maintained on two 11-ft lanes with a 1-ft left shoulder and a 1.5-ft right shoulder. Finally, lanes were closed during weeknights and weekends while cleanup operations were performed. A review of this traffic management strategy led project officials to conclude that the daily traffic control setup not only caused the project to take longer than expected but also confused the driving public because of the frequent changes in traffic patterns. Therefore, during the resurfacing of the southbound lanes in 1985, a temporary median barrier was used to close two lanes at a time through the length of the project while preparatory work and paving were completed in those lanes. This traffic control plan was considered superior because it allowed the contractor to work more efficiently (as evidenced by the fact that the southbound work was completed in less time than the northbound even though the length resurfaced southbound was greater) and it provided a more stable driving environment.

A coordinated effort was undertaken to reduce the volumes on I-5 and to minimize the adverse impacts on motorists. The strategy was to take advantage of (1) the express lanes as an alternative route and (2) the strong mass transit and carpool/vanpool organizations in Seattle. An extensive public information program was also implemented.

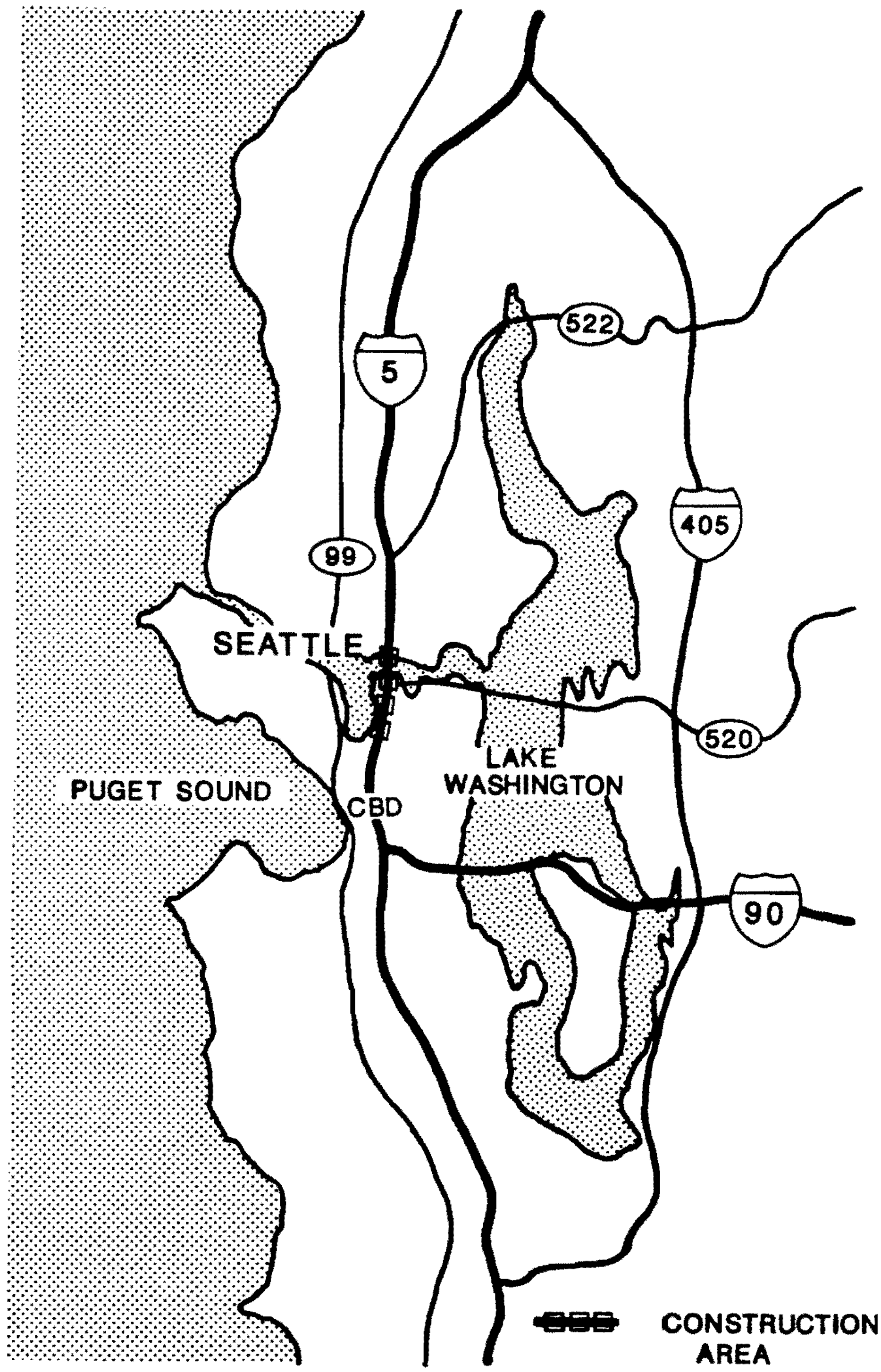

Figure 4. I-5 Ship Canal Bridge in Seattle.

Mieras (10) and Bockstruck (11) reported the following changes in travel patterns:

- o During 1984, weekday traffic volumes on northbound I-5 decreased 32,000 vpd (38 percent) through the project area. During the 1985 project, weekday traffic volumes were reduced 40 percent.

- o Of the 32,000 vpd that diverted from I-5 in 1984, about 13,000 vpd (41 percent) were traced to city streets, and 13,000 vpd (41 percent) to the express lanes. The remaining 6,000 vpd (18 percent) diverted to still other routes, changed modes, or were not made.

With respect to changes in mass transit and vanpooling, Mieras (10) and Bockstruck (11) reported the following findings:

- o Three new bus routes that were added during 1984 produced an increase of about 50 passengers per day, and one route was canceled because of lack of ridership.

- o In the summer of 1985, bus ridership figures showed an increase of 10 percent over those for a usual summer.

- o Requests for ride matching increased 33 percent in July and 47 percent in August of 1984, and 56 percent in August 1985 compared to August 1983.

Mieras (10) concluded:

> All of these diversions contributed to the lack of congestion. Motorists even went so far as to curtail many discretionary trips in an effort to cooperate in reducing congestion.
>
> No severe congestion was found on the alternate routes. Overall congestion was much less than anticipated because of good traffic control measures and motorists' shifting travel patterns. People changed travel patterns not as a reaction to congestion, but because of the advance information provided. The aggressive, comprehensive public information plan allowed them to plan ahead in anticipation of construction.

US-10 JOHN C. LODGE FREEWAY IN DETROIT

The Lodge Freeway is a six-lane freeway connecting downtown Detroit and its northwestern suburbs. AADTs prior to reconstruction were approximately 125,000 vpd at the maximum load point. In 1986 and 1987, the 8.4-mi section of the freeway between I-75 and Meyers Avenue (highlighted in Figure 5) was reconstructed.

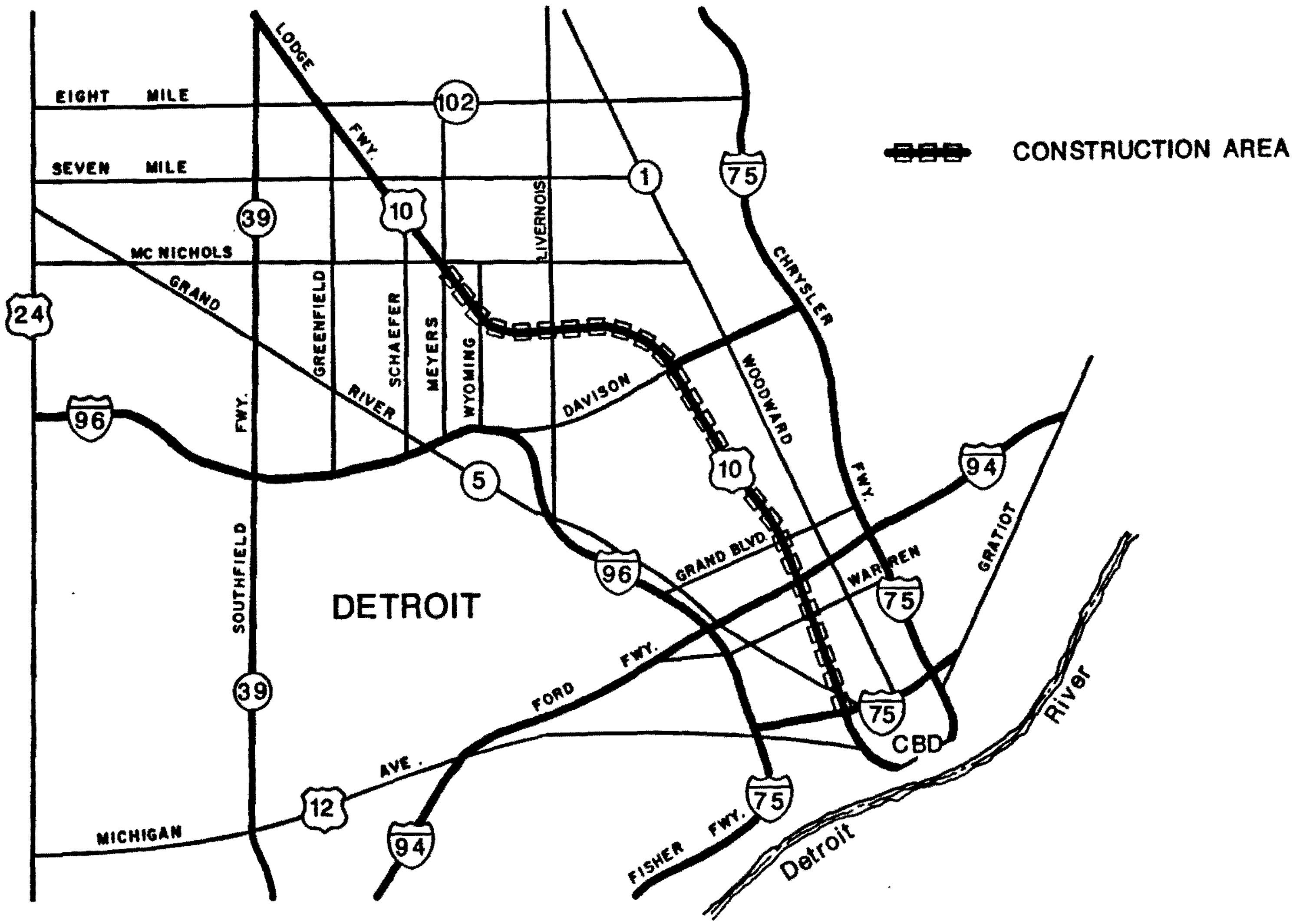

Figure 5. US-10 John C. Lodge Freeway in Detroit.

Project planners estimated that there was adequate capacity elsewhere in the corridor to permit the total closure of the freeway, which would enable the project to be completed in one construction season. However, public opposition to this approach led to a reformulation of the sequence of work over a two-year period. The work performed during 1986 did not directly involve the travel lanes and, therefore, the traffic control plan allowed the outside lanes only to be closed during off-peak periods. The travel lanes and the median shoulders were narrowed in order to provide a 6-ft right shoulder. Ramps could be closed, but no two consecutive entrance or exit ramps at a time. A 45-mph speed limit was posted through the reconstruction zone, as required by Michigan law.

During 1987, the pavement in both directions was removed and replaced. The traffic management plan involved the total closure of one direction at a time with one-way traffic maintained in the open direction. The corridor traffic management plan included improvements to alternative routes, increases in ridesharing programs, supplemental bus service, and an extensive public information program.

A traffic monitoring program was implemented to count traffic at 48 locations in the Lodge Freeway corridor. Scott (3) and Tadi (12) reported the following findings:

- o During the 1986 construction season, traffic volumes on the freeway decreased by 24,000 vpd (19 percent).

- o In a research poll conducted between the 1986 and 1987 reconstruction phases, 85 percent of the motorists stated that they experienced little or no inconvenience.

- o During 1987 when one directional roadway at a time was closed, traffic volumes on surface streets in the corridor increased by approximately 25 percent in the direction of the closures.

- o When the southbound (inbound direction) of the Lodge Freeway was closed, average speeds inbound during the A.M. peak on the three suggested alternative routes decreased between 23 and 31 percent. Average speeds on I-75/I-96/M-39 decreased 13 mph (31 percent), on Grand River decreased 8 mph (25 percent), and on Woodward Ave. decreased 6 mph (23 percent).

- o When the northbound (outbound) direction of the freeway was closed, average speeds outbound during the P.M. peak decreased 12 mph (25 percent) on I-75/I-96/M-39 but were not significantly different from before reconstruction on Grand River or Woodward Ave.

- o Traffic flowed smoothly on the alternative routes in spite of the volume increases due to signal coordination and special signing.

I-94 MENOMONEE VALLEY BRIDGE IN MILWAUKEE

I-94 is the principal route from the south into downtown Milwaukee. In 1987, the Wisconsin Department of Transportation replaced the 4,000-ft long deck of the Menomonee Valley Bridge, which connects I-94 with the downtown area, as the first year of a three-year reconstruction project. In 1988 and 1989, the 5-mi section of freeway between the bridge and I-894 to the south was resurfaced and rehabilitated. The project limits are highlighted in Figure 6.

The bridge consists of two independent structures, one for each direction of traffic. There were four travel lanes per direction. The average weekday traffic volumes on the bridge are 125,000 vpd. The traffic control plan was divided into two stages, each of which involved closing one structure and maintaining two lanes of traffic per direction on the other structure. Certain ramps in the I-94/I-43/I-794 interchange were also closed during each stage. The corridor traffic management plan for the project included traffic operations improvements on alternative routes, transit service improvements and carpooling promotions, school crossing and pedestrian safety programs, extra police enforcement and towing service, and a public information program.

Sonntag (13) documented the travel impacts of the 1987 project. Traffic conditions were monitored using screen line counts across the Menomonee River valley and travel time runs on I-94 and alternative routes. Sonntag reported the following impacts:

- During the first stage of the project, volumes across the bridge decreased 58,000 vpd (45 percent). Of this total, 6,000 vpd (10 percent) were traced to the only marked detour (I-794 to Becher St.), 3,000 vpd (5 percent) to I-894, and 33,000 (57 percent) to local streets.

- During the second stage, there was a 53,000 vpd (41 percent) decrease in volumes across the bridge; of which 11,000 vpd (21 percent) were traced to the marked detour, 5,000 vpd (9 percent) to I-894, and 18,000 vpd (34 percent) to local streets.

- The 16,000 vpd during the first stage and 19,000 vpd during the second stage that were not traced to these routes "may have used alternate routes well beyond the immediate corridor, elected to eliminate optional trips, or changed their mode of travel to use public transit or carpooling."

Despite the reduction in capacity on the bridge and increase in traffic volumes on alternative routes in the corridor, Sonntag (13) reported little change in travel times:

- Average travel time on the local streets in the corridor increased between one and two minutes.

- The travel time on the freeway through the reconstruction zone remained virtually unchanged.

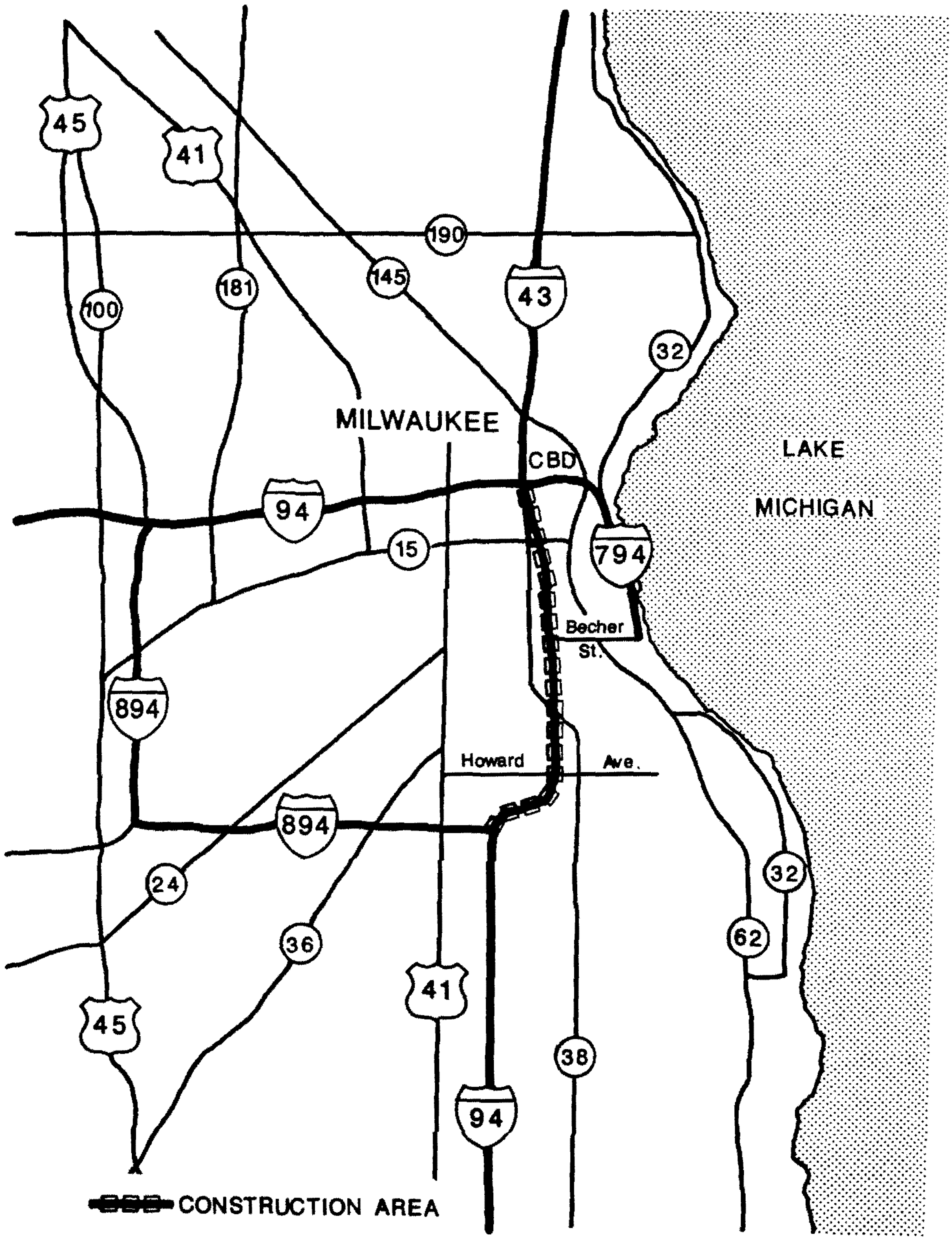

Figure 6. I-94 in Milwaukee.

SUMMARY OF EXPERIENCES

The major findings of the review of previous experiences are summarized below:

- The percentage reduction in average daily traffic volumes was approximately equal to the percentage reduction in capacity. In Chicago, the number of lanes on the Edens Expressway was reduced by 33 percent, and there was a 30 percent reduction in average daily traffic. In Pittsburgh, Seattle, and Milwaukee, where the number of lanes through the reconstruction zone was reduced by 50 percent, the reduction in average daily traffic ranged from 38 to 56 percent. In Boston, where the same number of lanes as before reconstruction were maintained during peak periods but one of three lanes was closed during off-peak periods, the reduction in average daily traffic was 8 percent during the first year and 0 percent during the second year.

- Considerable fluctuations have been reported in traffic volumes through the reconstruction zone during the first several weeks of projects. A common pattern (in Chicago, Pittsburgh, and Boston, for example) has been for traffic volumes to be low enough during the first week of a project (as a result of extensive media attention) that traffic conditions are reasonably good. When motorists learn what conditions are actually like, they migrate back to the freeway. It takes several weeks for motorists to experiment with alternative routes and adjust their travel patterns before a new equilibrium is established.

- Among those motorists who changed travel patterns during reconstruction, diversion to an alternative route in the corridor was much more common than diversion to an alternative mode.

- Some, but not a large amount of, diversion to alternative modes was reported in Chicago, Pittsburgh, Boston, Detroit, and Milwaukee. In Seattle, however, a 10 percent increase in bus ridership and 33-56 percent increase in requests for ride matching were reported.

- In Pittsburgh and Boston, where fairly complete screen lines through the corridor were monitored, little change in total corridor-wide traffic volumes were reported. However, in Chicago, Seattle, and Milwaukee, where less complete screen lines were monitored, not all of the decreases in traffic volumes in the reconstruction zone could be explained by increases elsewhere in the corridor.

- Evidence of the cancellation of discretionary trips during off-peak periods was reported at most of the projects.

- Changes in traffic conditions were reportedly fairly minor in Boston and Milwaukee. In Pittsburgh, increases in corridor-wide average travel times ranged from 1 to 13 min (4 to 57 percent); and in Detroit, increases in average speed on the three suggested alternative routes ranged from 0 to 13 mph (0 to 31 percent), depending on the time of day and direction of travel.

3. PLAN FOR DEVELOPING DATA BASE

The plan for developing a data base on the travel impacts of urban freeway reconstruction projects in Texas involved the collection and analysis of data from two sources: one obtained from "existing" projects and one from "new" projects. "Existing" refers to projects that were underway when Study 1108 began, and "new" refers to projects that started after Study 1108 had started. This chapter documents that data collection plan for both the existing and new projects.

DATA COLLECTION FOR NEW PROJECTS

Traffic conditions were monitored before and during three long-term urban freeway reconstruction projects:

- o I-35 in Austin,
- o US-75 in Plano, and
- o US-59 Southwest Freeway in Houston.

This report documents only the projects on I-35 in Austin and US-75 in Plano. The US-59 Southwest Freeway project continues into 1992 and will be documented in another report after all data collection is completed.

The same basic data collection plan was implemented at both the I-35 and US-75 projects. Traffic volume, travel time, and speed data were collected before and during reconstruction. Every effort was made to conduct identical data collection efforts each time. Data were collected during the same weekdays at the same times of day and at the same locations.

Traffic Volume Data

The traffic volume data included screen line, automatic traffic recorder (ATR) station, and vehicle classification counts. Partial screen lines were aligned perpendicular to the freeway and were positioned at locations where changes in travel patterns were most likely to be observed. In locating the screen lines, consideration was given to the characteristics of the reconstruction zone, the origins and destinations of freeway users, and the location of major cross streets. Counts were taken at least on the freeway, frontage roads, and one parallel arterial street. Directional volumes were collected using machine counters. Data were collected during the midweek (Tuesday through Thursday).

ATR stations in the urban area that were not affected by the reconstruction project were selected as control locations. The ATR station data were used to seasonally adjust the screen line counts, so that the changes attributable to the reconstruction project could be isolated from normal seasonal and daily variations.

Vehicle classification counts were taken during peak and off-peak periods. Vehicles were classified as passenger cars (any two-axle vehicle including pickup trucks and vans) or trucks (any vehicles with three or more axles including passenger cars towing trailers).

Travel Time and Speed Data

Travel times were measured on the freeway, frontage roads, and at least one parallel alternative route. The floating car technique was used in which the driver of a test vehicle attempts to operate at the median speed on the route by passing as many vehicles as pass the test vehicle (14). Travel time runs were performed inbound in the morning (during both peak and off-peak periods) and outbound in the afternoon (both peak and off-peak). Runs were made only during the midweek (Tuesday through Thursday). The frequency of runs was higher on the freeway than on the frontage roads or parallel alternative routes. Freeway runs were performed at ½-hr intervals during peak periods and at hour intervals during off-peak periods. Runs on the frontage roads and parallel alternative routes were made at ½- to 1 ½-hour intervals. The same schedule of start times was used before and during reconstruction. Times were recorded at the beginning and end of the routes, as well as at intermediate cross streets common to all of the routes.

The total length of the route and the distance between cross streets were measured using vehicle-installed distance-measuring instruments. Average travel speeds were estimated by dividing the length of the route by the travel time.

DATA COLLECTION FOR EXISTING PROJECTS

Data were obtained for three existing projects:

- o I-45 North Freeway in Houston,
- o I-35W in Fort Worth, and
- o I-10 in El Paso.

At these projects, traffic volume and/or travel time data had been collected previously either by or for the Department. For example, the Houston office of the Texas Transportation Institute (TTI) collected traffic volume and travel time data before and during the North Freeway reconstruction project. The Fort Worth district office of the SDHPT collected ramp volume data before and during reconstruction on I-35W, and the El Paso district office performed travel time runs on the freeway and on several alternative routes before and during the I-10 reconstruction project. These data were obtained and analyzed. No original data collection was performed by the Study 1108 research team at these projects.

STATISTICAL ANALYSIS METHODOLOGY

For both the existing and new projects, descriptive statistics were tabulated to summarize average volumes, travel times, and speeds before and during reconstruction. For the new projects, analyses were also performed to test the statistical significance of the differences in traffic volumes and travel times before and during reconstruction. It was not possible to perform such tests on the data from the existing projects.

Traffic Volume Data

An analysis procedure described by Griffin (15) was used to test the statistical significance of the changes in traffic volumes along the screen lines. Analyses were performed separately by route, direction, and time period. The time periods included the entire day, as well as A.M., off, and P.M. peaks.

The procedure involves before-after comparisons at a study segment with a control location. Ullman and Krammes (16) used the procedure previously in Study 1108 to analyze changes in accident frequencies at the same reconstruction projects discussed herein. Tyer (17) has described the procedure's application to traffic volumes at reconstruction projects.

The procedure was used to test the statistical significance of the observed change in volumes at the routes along the screen lines relative to the control location. One or more ATR stations in the urban area were used as the control location. The changes in volumes at the screen line relative to the control location (i.e., seasonally adjusted percentage change in volumes attributable to the reconstruction project) were computed. The z-test was used to determine whether the percentage change was significantly different from zero at a 0.05 significance level. This procedure provided an objective basis for isolating the volume changes attributable to the reconstruction project and for testing whether the changes were statistically significant.

Travel Time Data

Travel times before and during reconstruction were compared on the mainlanes, frontage roads, and alternative routes. Data were analyzed separately by time period (a.m., off, and p.m. peaks). In an attempt to isolate the effect of the reconstruction projects on normal travel times, data affected by accidents or other incidents or by rain and wet pavements were not included in the analysis.

Since the same schedule was used for the travel time runs before and during reconstruction, it was possible to use a paired t test to analyze the statistical significance of the differences between travel times on each route before and during reconstruction. The travel times before and during reconstruction were paired according to the start time of the runs. Pairing the travel times by start time helped control for the effect of hourly volume patterns on travel times and, thereby, isolate the changes in travel time attributable to the reconstruction project. The paired t test was used to determine whether the mean of the differences between the travel times at each start time was significantly different from zero at a 0.05 significance level or, in other words, whether the changes in travel times attributable to the reconstruction project were statistically significant.

4. I-35 IN AUSTIN

PROJECT DESCRIPTION

I-35 is the major north-south freeway running through Austin and is being reconstructed in several segments. This study focused on the travel impacts of the segment reconstructed: a 5.7-mi segment through northern Austin from US-290 north to Yager Lane. Figure 7 highlights the limits of the study segment. South of US-290, I-35 is an eight-lane freeway. The cross section between US-290 and US-183 included a six-lane freeway with a median consisting of paved shoulders and concrete median barrier, and three-lane, one-way frontage roads. The cross section north of US-183 included a four-lane freeway with a depressed grass median and two-lane, one-way frontage roads.

The primary alternative routes to this segment of I-35 are Lamar Blvd. and Dessau/Cameron Roads. Lamar Blvd. is an arterial street with a four or five lane (four lanes with a center left turn lane) cross section. Dessau Rd. is a two-lane highway north of Rundberg. Cameron Rd. south of Rundberg is a four-lane arterial.

The project began in November 1986 and was completed in August 1988. Reconstruction activities included widening, replacing structures, repaving, illumination, and pavement markings and signing. The mainlanes were widened to six lanes from US-183 to Yager Lane, and the frontage roads were widened to three lanes in each direction from US-183 to Rundberg Lane. The bridge structures over Walnut Creek, Rundberg Lane, and US-183 were widened, and the St. Johns structure was replaced.

The traffic control plan for the project maintained two freeway lanes in each direction. The segment north of US-183 remained two lanes in each direction, but the segment south of US-183 was reduced from three to two lanes in each direction for part of the project. Lane closures were allowed on the freeway, frontage roads, and cross streets during off-peak periods.

In May 1987 when data were being collected during reconstruction, only two freeway lanes in each direction were open between St. Johns and US-183. Work was being conducted in the median between US-183 and Braker Lane. A temporary concrete barrier was placed near the edge of the existing travel lanes to separate traffic from the work activity. Therefore, the cross section between US-183 and Braker Lane consisted of the existing travel lanes and outside shoulders but narrow (approximately 1-ft wide) inside shoulders.

In addition to the I-35 reconstruction, roadwork was being conducted on Dessau and Cameron Roads in May 1987. Alternating one-way traffic was being maintained on one open lane for a short distance north of Yager Lane.

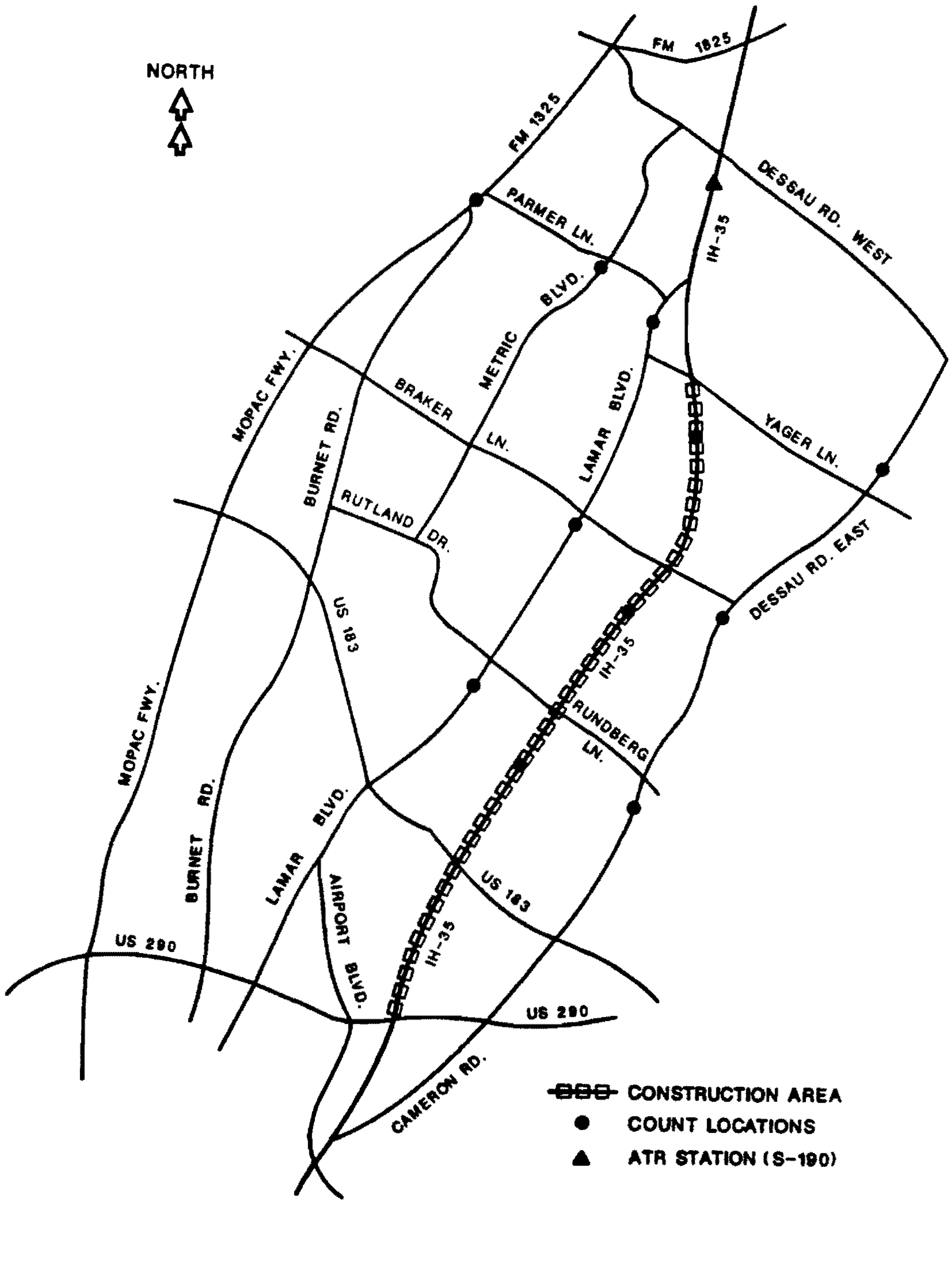

Figure 7. I-35 Travel Corridor in Austin

DATA COLLECTION

Traffic Volume Data

Traffic volume data were collected on the freeway, frontage roads, and major alternative routes at three screen lines: Yager Lane, Braker Lane, and Rundberg Lane. Figure 7 illustrates the count locations. At all locations, except those on Dessau/Cameron Roads, directional counts were obtained. On Dessau Rd., which is a two-lane roadway, bidirectional counts were obtained. Average daily traffic volumes were obtained from the ATR station on I-35 north of the reconstruction zone in order to evaluate hourly, daily, and seasonal variations in traffic patterns. The location of the ATR station is also indicated on Figure 7.

Travel Time and Speed Data

Travel time data were collected on the freeway, frontage roads, and two major alternative routes (Lamar Blvd. and Dessau/Cameron Roads). Figure 8 highlights the travel time routes. The schedule of travel time runs is summarized in Table 2. Travel times were collected on the freeway and frontage roads at 15-min intervals over three days (i.e., runs started every 45 min and start times were staggered by 15 min each day). Runs on the alternative routes followed the same schedule but alternated between the two routes so that travel times were collected on each route at 30-min intervals over the three days. The length of each run and the distance between each major cross street was measured so that average speeds could be computed from the travel times.

TABLE 2. Schedule of Travel Time Runs: I-35 Corridor in Austin

Direction	Beginning Times of Travel Time Runs		
	Tuesday	Wednesday	Thursday
Southbound (Inbound)	6:00 A.M.	6:15 A.M.	6:30 A.M.
	6:45 A.M.	7:00 A.M.	7:15 A.M.
	7:30 A.M.	7:45 A.M.	8:00 A.M.
	8:15 A.M.	8:30 A.M.	8:45 A.M.
	9:00 A.M.	9:15 A.M.	9:30 A.M.
	9:45 A.M.	10:00 A.M.	10:15 A.M.
	10:30 A.M.	10:45 A.M.	11:00 A.M.
Northbound (Outbound)	3:00 P.M.	3:15 P.M.	3:30 P.M.
	3:45 P.M.	4:00 P.M.	4:15 P.M.
	4:30 P.M.	4:45 P.M.	5:00 P.M.
	5:15 P.M.	5:30 P.M.	5:45 P.M.
	6:00 P.M.	6:15 P.M.	6:30 P.M.
	6:45 P.M.		

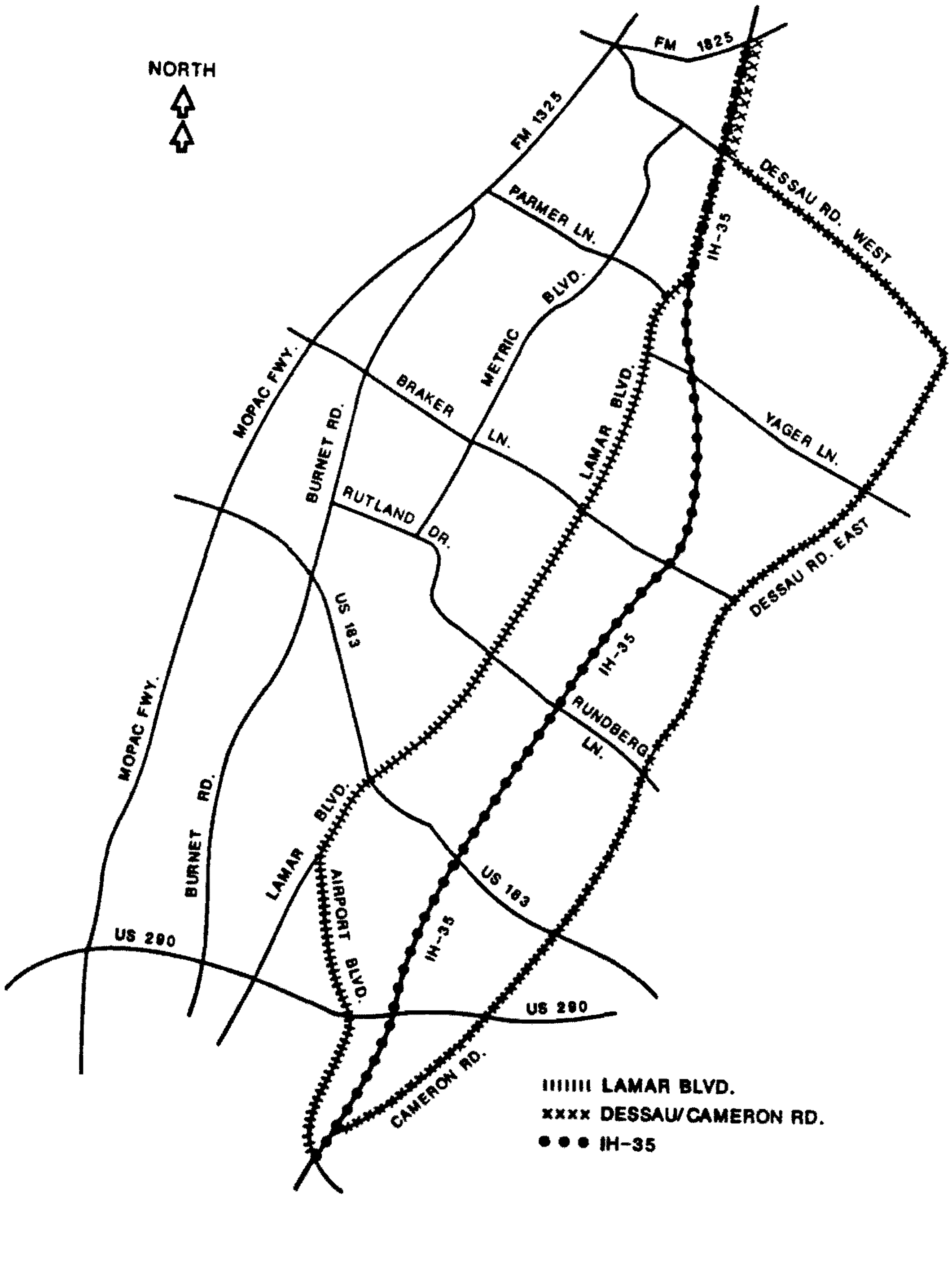

Figure 8. Travel Time Routes in the I-35 Corridor in Austin.

OBSERVED TRAVEL IMPACTS

The reconstruction activities underway and traffic control plan in effect when data were collected in May 1987 had little impact on traffic conditions or travel patterns in the I-35 corridor. Traffic volumes on the freeway and throughout the corridor as a whole were actually higher than expected during reconstruction (given normal seasonal volume patterns). Travel times were not significantly different before and during reconstruction on the freeway, frontage roads, or alternative routes.

Traffic Volumes

Traffic volumes before and during reconstruction were compared for the day as a whole as well as by time of day. Time periods were defined as follows: A.M. peak (6:00-9:00 A.M.), off peak (9:00 A.M.-4:00 P.M.), and P.M. peak (4:00-7:00 P.M.). The changes observed in daily traffic volumes and during each peak period were similar.

In addition to the screen line traffic volume counts, A.M. peak hour capacity was counted on southbound I-35 immediately south of the Rundberg Lane entrance, which was the bottleneck before and during reconstruction. The volumes were very similar to those observed by Urbanik (18) before reconstruction, suggesting that the loss of the inside shoulder and the proximity of temporary concrete barrier to the travel lane had little effect on the capacity of the bottleneck.

Changes in Total Daily Screen Line Traffic Volumes

Table 3 summarizes the changes in total daily screen line traffic volumes during reconstruction. Volumes were 3-4 percent higher than normal in May 1987 at all three screenlines. The freeway carried the majority of traffic in the narrowly defined corridor (consisting of the freeway, frontage roads, Lamar Blvd., and Dessau/Cameron Roads): 70 percent at Yager Lane, 66 percent at Braker Lane, and 63 percent at Rundberg Lane.

Changes in Daily Traffic Volumes by Route

Southbound Traffic. Table 4 summarizes the daily southbound traffic volumes on each route before and during reconstruction. Traffic volumes on the freeway were higher than expected, whereas on the frontage road they were lower.

Northbound Traffic. Table 5 summarizes the daily northbound traffic volumes. Northbound volumes were higher than normal during reconstruction on most of the routes in the corridor.

TABLE 3. Total Daily Screen Line Traffic Volumes: I-35 Corridor in Austin

Screen Line	Direction	Before (November 1986)	During Reconstruction Volumes (May 1987)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ
Yager Ln.	Northbound[c]	70,403	72,682	74,947	2,265	3
	Southbound[c]	68,218	70,064	72,056	1,992	3
	Total[d]	132,946	136,902	141,795	4,893	4
Braker Ln.	Northbound[c]	63,730	65,790	68,205	2,415	4
	Southbound[c]	61,336	62,998	66,453	3,455	5
	Total[d]	119,118	122,663	126,228	3,565	3
Rundberg Ln.[e]	Northbound	74,008	76,421	83,113	6,692	9
	Southbound	78,143	80,237	79,545	-692	-1
	Total	152,151	156,658	162,658	6,000	4

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Combined direction volumes are included in both the north and southbound data for the Yager Ln. and Braker Ln. screen lines on Dessau/Cameron Rd.
[d]Combined direction volumes are only included once in the total volume data.
[e]Volume data (before and during) for Cameron Rd. were not included since a resurfacing project did not allow before volumes to be collected.

TABLE 4. Southbound Daily Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	32,045	32,904	35,993	3,089	9	8.41
	Frontage Rd.	2,046	2,101	1,614	-487	-23	-7.73
	Mopac Fwy.	15,209	15,617	16,985	1,368	9	6.27
	Metric Blvd.	5,009	5,143	3,742	-1,401	-27	-13.92
	Lamar Blvd.	8,234	8,455	8,514	59	1	.41
	Dessau Rd.[d]	5,675	5,844	5,208	-636	-11	-5.79
Braker Ln.	Freeway	37,723	38,734	40,431	1,697	4	4.16
	Frontage Rd.	2,748	2,822	2,802	-20	-1	-.25
	Lamar Blvd.	14,917	15,317	14,790	-527	-3	-2.54
	Cameron Rd.[d]	5,948	6,125	8,430	2,305	38	18.03
Rundberg Ln.	Freeway	49,162	50,480	51,495	1,015	2	2.05
	Frontage Rd.	10,013	10,281	9,459	-822	-8	-5.16
	Lamar Blvd.	18,968	19,476	18,591	-885	-5	-3.66
	Cameron Rd.[e]	--	--	11,411	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha=0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

TABLE 5. Northbound Daily Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	33,800	34,902	35,758	856	2	2.29
	Frontage Rd.	1,138	1,175	1,356	181	15	3.50
	Mopac Fwy.	15,797	16,312	17,260	948	6	4.26
	Metric Blvd.	3,062	3,162	3,781	619	20	7.04
	Lamar Blvd.	10,931	11,287	11,584	297	3	1.70
	Dessau Rd.[d]	5,675	5,844	5,208	-636	-11	-5.79
Braker Ln.	Freeway	40,288	41,601	40,684	-917	-2	-2.18
	Frontage Rd.	2,427	2,506	3,562	1,056	42	12.86
	Lamar Blvd.	15,067	15,558	15,529	-29	0	-0.14
	Cameron Rd.[d]	5,948	6,125	8,430	2,305	38	18.03
Rundberg Ln.	Freeway	43,894	45,325	50,997	5,672	13	11.98
	Frontage Rd.	10,697	11,046	12,095	1,049	10	5.98
	Lamar Blvd.	19,417	20,050	20,021	-29	0	-0.11
	Cameron Rd.[e]	--	--	9,501	--	--	--

[a] Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b] Δ = Observed - Estimated.
[c] Percentage change (%Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.
[d] Volumes are for combined directions.
[e] Resurfacing project did not allow before volumes to be collected.

Changes in Traffic Volumes by Time of Day

Similar analyses were performed for the A.M., off, and P.M. peaks. The results are summarized in Tables A-1 through A-9 in Appendix A. In general, the changes by time period did not differ dramatically from the overall changes for the day as a whole.

Travel Times and Speeds

Travel times and average travel speeds were measured along the routes highlighted in Figure 8. Tables 6 through 8 summarize the sample size, average travel time, and average travel speed before and during reconstruction for the A.M., off, and P.M. peaks, respectively. Table 9 summarizes the paired t test statistics. The results of the paired t tests indicated that there were no significant differences in travel times on any of the routes in either direction during any of the peak periods.

LESSONS LEARNED

The traffic restrictions in effect in May 1987 (lane reduction between St. Johns and US-183, narrow median shoulders between US-183 and Braker Lane, work activity in the median and adjacent to the frontage roads) did not adversely affect traffic volumes or travel times in the I-35 corridor. Volumes were higher on the freeway and lower on the frontage roads. Total corridor-wide volumes were higher than expected during reconstruction in May 1987. The traffic control plan appeared to do a very good job at accommodating traffic during reconstruction.

TABLE 6. A.M. Peak Period Travel Times and Speeds: I-35 Corridor in Austin

Route	Direction	Distance (mi)	Sample Size[a]	Average Travel Time (min)		Average Travel Speed (mph)	
				Before (Nov 1986)	During (May 1987)	Before (Nov 1986)	During (May 1987)
I-35 Mainlanes	NB	9.60	10	10.1	10.1	57	57
	SB	9.79	11	16.0	12.1	37	48
Frontage Rd.	SB	10.36	8	19.8	19.1	31	33
Lamar Blvd.	SB	10.28	3	20.4	20.3	30	30
Cameron/Dessau Rd.	SB	11.44	3	20.8	20.2	33	34

[a]Number of travel time runs during each study period.

TABLE 7. Off Peak Period Travel Times and Speeds: I-35 Corridor in Austin

Route	Direction	Distance (mi)	Sample Size[a]	Average Travel Time (min)		Average Travel Speed (mph)	
				Before (Nov 1986)	During (May 1987)	Before (Nov 1986)	During (May 1987)
I-35 Mainlanes	NB	9.60	9	10.1	9.9	57	58
	SB	9.79	9	10.7	10.2	55	57
Frontage Rd.	SB	10.36	9	18.2	16.3	34	38
Lamar Blvd.	SB	10.28	3	18.2	18.5	34	33
Cameron/Dessau Rd.	SB	11.44	4	19.0	20.5	36	33

[a]Number of travel time runs during each study period.

TABLE 8. P.M. Peak Travel Times and Speeds: I-35 Corridor in Austin

Route	Direction	Distance (mi)	Sample Size[a]	Average Travel Time (min)		Average Travel Speed (mph)	
				Before (Nov 1986)	During (May 1987)	Before (Nov 1986)	During (May 1987)
I-35 Mainlanes	NB	9.60	10	13.1	13.8	44	42
	SB	9.79	9	10.7	10.4	55	57
Frontage Rd.	NB	10.34	11	21.7	23.2	29	27
Lamar Blvd.	NB	10.20	5	22.7	22.8	27	27
Cameron/Dessau Rd.	NB	11.54	6	23.4	23.1	30	30

[a]Number of travel time runs during each study period.

TABLE 9. Paired t-Test Results for Changes in Travel Time: I-35 Corridor in Austin

Route	Direction	A.M. Peak			Off Peak			P.M. Peak		
		df	Calculated t-value	Critical t-value	df	Calculated t-value	Critical t-value	df	Calculated t-value	Critical t-value
I-35 Mainlanes	NB	9	0.01	2.26	8	-.10	2.31	9	.05	2.26
	SB	10	-.24	2.23	8	-.11	2.31	8	-.24	2.31
Frontage Rd.	NB	--	--	--	--	--	--	10	.08	2.23
	SB	7	-.06	2.36	8	-.75	2.31	--	--	--
Lamar Blvd.	NB	--	--	--	--	--	--	4	.08	2.78
	SB	2	-.04	4.30	2	.25	4.30	--	--	--
Cameron/ Dessau Rd.	NB	--	--	--	--	--	--	5	-.05	2.57
	SB	2	-.25	4.30	3	1.05	3.18	--	--	--

Note: Change in travel time is significant at $\alpha = 0.05$ if |calculated t-value| > critical t-value.

5. US-75 IN PLANO

PROJECT DESCRIPTION

The US-75 North Central Expressway extends north from the central business district through the northern suburbs of Dallas. The reconstruction of an 18.3-mi section from Spur 366 near downtown Dallas to SH 121 in McKinney will be completed over an 11-year period at a cost of more than $500 million. The effort will be divided into at least 10 construction segments. The work north of the LBJ Freeway began in 1986 and is scheduled for completion in 1993. The work to the south began in 1990 and will be completed in 1997.

The segment highlighted in Figure 9 between FM 544 and Spring Creek Parkway in Plano was the focus of this study. Prior to reconstruction, this segment of the expressway had four mainlanes and two-lane, one-way frontage roads. The mainlane cross section consisted of two 12-ft travel lanes in each direction, 10-ft right shoulders, and a 30- to 60-ft grass median. The median edge of the travel lanes was curbed.

The reconstruction project included widening the existing roadway, reconstructing two major cross-street underpasses/overpasses, and installing new signs, markings, and illumination. The freeway was expanded to six mainlanes with three-lane, one-way frontage roads, and to eight lanes at the southern end of the segment.

The reconstruction was performed in four phases. During phase one, temporary pavement was constructed in the median to function as a traffic detour during later phases of the project. In addition, reconstruction began on the northbound frontage road. During phase two, the northbound mainlanes and the outside lane of both the northbound and southbound frontage roads were reconstructed. During phase three, work was primarily concentrated on the southbound mainlanes and frontage road. Finally, the median was reconstructed after the northbound and southbound travel lanes had been completed.

Reconstruction began in June 1987 and was completed in September 1989. Traffic data were collected before reconstruction in early June 1987 and during reconstruction in October 1987 and again in June 1988.

During the data collection in October 1987, phase two was underway. The northbound mainlanes and the outside travel lane of the northbound and southbound frontage roads were being reconstructed. Work was also underway on the northbound portion of the FM 544 overpass structure. The specific activities included the removal of concrete pavement on the existing northbound travel lanes, excavation and earth-fill between the mainlanes and frontage roads, placement of retaining walls, and placement of lime subgrade and asphalt on the northbound frontage road.

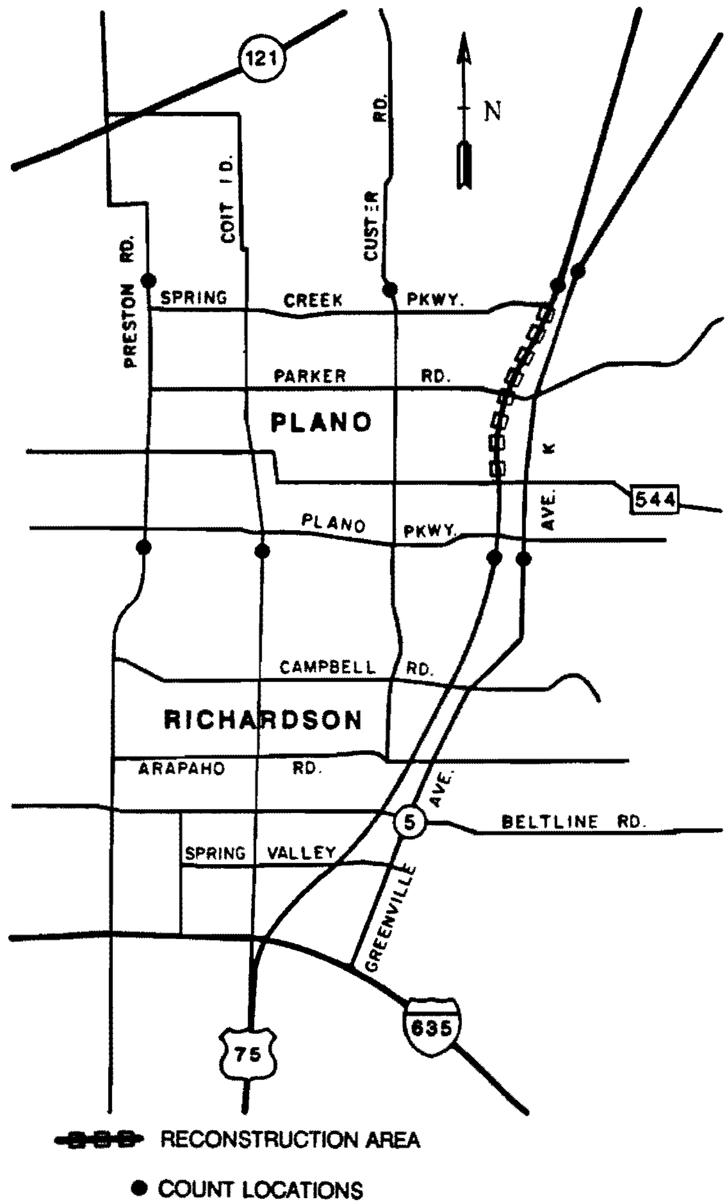

Figure 9. US-75 North Central Expressway Corridor in Plano.

In October 1987, the northbound mainlane traffic was detoured into the median. The detour, which had been implemented one week before data collection, began just south of FM 544 and continued to north of Parker Rd., a distance of approximately 2.6 mi. Portable concrete barriers were used to separate the northbound and southbound traffic and to provide safety to workers on the outside of the traveled way. The cross section included two 10- to 12-ft mainlanes in each direction and a right shoulder that varied from 2 to 8 ft. For most of the project's length, the frontage roads were reduced to one traffic lane.

During the data collection in June 1988, the northbound traffic remained on the median detour; however, the detour was extended north of Spring Creek Parkway to the end of the reconstruction project to allow for the reconstruction of the northbound portion of the Spring Creek Parkway overpass structure. Work activities consisted of concrete paving operations on the northbound mainlanes and the southbound frontage road. For the most part, the northbound frontage road included three travel lanes. However, only one lane was open on the southbound frontage road.

Long-term lane closures were not permitted; however, temporary lane closures during the off-peak period (from 9:00 A.M. to 3:30 P.M.) were allowed. Although the traffic control plan provided the same number of mainlanes as existed prior to reconstruction, the capacity of the Expressway may have been restricted by the narrow lanes (10- to 12-ft) and minimal lateral clearances (2 to 8 ft) during reconstruction.

DATA COLLECTION

Traffic Volume Data

Traffic volume data were collected on the mainlanes, frontage roads, and major alternative routes at two screen lines: Spring Creek Parkway, which lies at the northern limit of the project, and Plano Parkway, which is located just south of the project limits. The count locations are shown in Figure 9. The Spring Creek Parkway location was selected to detect changes in traffic with origins or destinations north of Plano, and the Plano Parkway location was selected to detect changes in the pattern of trips originating or terminating within Plano.

Volume data were obtained from ten ATR stations in the Dallas metropolitan area in order to investigate hourly, daily, and seasonal variations in traffic patterns. Two of the stations, S-121 and S-169, are located on the North Central Expressway approximately 10 mi north and 20 mi south of the reconstruction project, respectively, and were used as control locations.

Travel Time and Speed Data

Travel time data were collected on the mainlanes, frontage roads, and three major alternative routes. Travel times were measured from Spring Creek Parkway in Plano to the I-635 LBJ Freeway in Dallas, a distance of approximately 10 mi. The travel time routes are highlighted in Figure 10.

The major north-south alternative routes in the corridor are Greenville Ave./Ave. K to the east of the Expressway, and Coit and Preston (SH 289) Roads to the west. Although a short segment of Greenville Ave./Ave. K just north of the LBJ Freeway consists of six lanes, it is mostly a two-lane facility with 35-45 mph speed limits. Coit Rd., however, is mainly a six-lane divided roadway with 40-45 mph speed limits, although four-lane segments exist north of FM 544 in Plano. Preston Rd. is primarily a four-lane facility with 40-50 mph speed limits; however, the segment of the roadway between Plano Parkway and Spring Creek Parkway had only two lanes. A widening project on this segment was in progress during all three data collection periods.

The times at which travel time runs began are shown in Tables 10 and 11. Travel time runs were performed on the Expressway and frontage road on 1½-hour intervals during a three-day period (Tuesday, Wednesday, and Thursday). The beginning times for the runs each day were staggered by ½-hour increments to achieve full coverage of peak and off-peak periods. As Table 11 indicates, travel time runs were made on a different alternative route each day.

TABLE 10. Schedule of Travel Time Runs on the Expressway and Frontage Roads: US-75 Corridor in Plano

Direction	Beginning Times of Travel Time Runs		
	Tuesday	Wednesday	Thursday
Southbound (Inbound)	6.00 A.M. 7:30 A.M. 9:00 A.M.	6:30 A.M. 8:00 A.M. 9:30 A.M. 10:30 A.M.	7:00 A.M. 8:30 A.M. 10:00 A.M. 11:00 A.M.
Northbound (Outbound)	3:00 P.M. 4:30 P.M. 6:00 P.M.	2:00 P.M. 3:30 P.M. 5:00 P.M. 6:30 P.M.	2:30 P.M. 4:00 P.M. 5:30 P.M. 7:00 P.M.

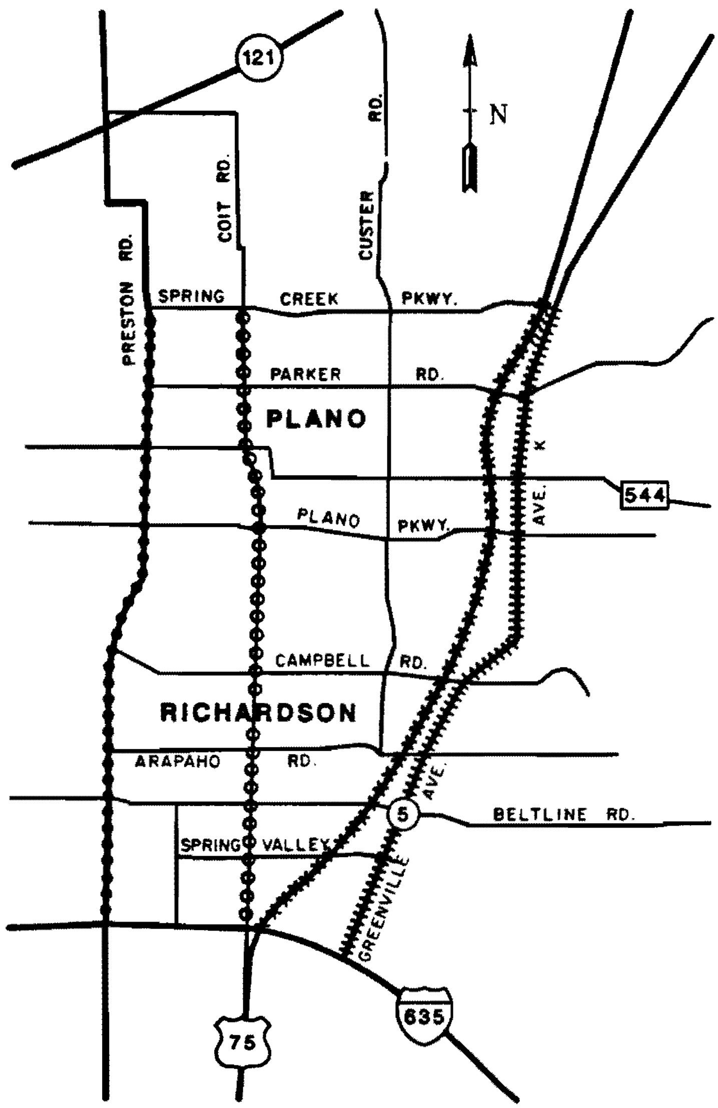

Figure 10. Travel Time Routes in the US-75 North Central Expressway Corridor in Plano.

TABLE 11. Schedule of Travel Time Runs on the Alternative Routes: US-75 Corridor in Plano

Direction	Beginning Times of Travel Time Runs		
	Tuesday (Preston Rd.)	Wednesday (Greenville Ave.)	Thursday (Coit Rd.)
Southbound (Inbound)	6:30 A.M. 7:30 A.M. 9:00 A.M.	6:30 A.M. 7:30 A.M. 9:00 A.M. 10:30 A.M.	6:30 A.M. 7:30 A.M. 9:00 A.M. 10:30 A.M.
Northbound (Outbound)	2:00 P.M. 3:30 P.M. 5:00 P.M. 6:30 P.M.	2:00 P.M. 3:30 P.M. 5:00 P.M. 6:30 P.M.	2:00 P.M. 3:30 P.M. 5:00 P.M. 6:30 P.M.

OBSERVED TRAVEL IMPACTS

The analysis suggests that traffic volumes through the corridor were significantly affected by the reconstruction project on US-75 in Plano. Traffic volumes through the corridor during reconstruction were generally lower than expected. However, travel times on most of the routes monitored did not change significantly.

Traffic Volumes

Total daily screen line traffic volumes during reconstruction were lower than expected. The percentage reduction in volumes was fairly uniform throughout the A.M., off, and P.M. peaks. Volumes decreased significantly on the mainlanes and frontage roads as well as on Preston Rd., which was also being reconstructed. Volume increases on other routes in the corridor did not account for all of the traffic that diverted from the routes under construction. The volume reductions at the Plano Parkway screen line (immediately south of Plano and the reconstruction zone) were greater than at the Spring Creek Parkway screen line (immediately north of Plano and the reconstruction zone).

Changes in Total Daily Screen Line Traffic Volumes

Table 12 summarizes the changes in total daily screen line traffic volumes during reconstruction on US-75 in Plano. Overall, volumes during reconstruction were lower than expected. Volume reductions were greater at the Plano Parkway screen line than at the Spring Creek Parkway screen line and were greater in October 1987 than in June 1988.

TABLE 12. Total Daily Screen Line Traffic Volumes: US-75 Corridor in Plano

Screen Line	Direction	Before (June 1987)	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	Estimated[a]	Observed	Δ[b]	% Δ
Plano Pkwy.	SB	92,214	97,655	86,103	-11,552	-12	98,577	91,487	-7,090	-7
	NB	96,153	100,192	88,794	-11,398	-11	102,595	95,716	-6,879	-7
	Total	188,367	197,847	174,897	-22,950	-12	201,172	187,203	-13,969	-7
Spring Creek Pkwy.	SB	51,486	54,524	52,316	-2,208	-4	55,039	53,235	-1,804	-3
	NB	48,760	50,809	50,074	-735	-1	52,027	54,918	2,891	6
	Total	100,246	105,333	102,390	-2,943	-3	107,066	108,153	1,087	1

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

Corridor-wide volumes at the Plano Parkway screen line were 12 percent lower than expected in October 1987 and 7 percent lower in June 1988. The total daily volumes at the Spring Creek Parkway screen line were 3 percent lower than normal in October 1987 and 1 percent higher in June 1988. The decreases at the Plano Parkway screen line were about equal in the northbound and southbound directions. Whereas, at the Spring Creek Parkway screen line there was a greater reduction in the southbound direction than in the northbound direction.

The screen line traffic analysis indicates that almost twice as many vehicles crossed the Plano Parkway screen line as crossed the Spring Creek Parkway screen line. It is estimated that at least 47 percent of the Plano Parkway screen line traffic originated or terminated within Plano. Because only minor changes in corridor-wide traffic occurred at the Spring Creek Parkway screen line, it appears that motorists making long trips continued to travel in the corridor during reconstruction. The reduction in total traffic at the Plano Parkway screen line suggests that trips having origins and/or destinations within Plano were most affected by the reconstruction project on the Expressway.

There are three possible explanations for the decrease in total daily traffic at the Plano Parkway screen line: (1) cancellation of trips in the corridor or change in trip destinations away from the corridor, (2) diversion to minor routes not monitored, and (3) shift in transportation mode and/or vehicle occupancy. The analysis suggests that some trips were either canceled or diverted to routes not monitored (either in or out of the corridor). Bus ridership and vehicle occupancy were not monitored as part of the data collection efforts. Therefore, no conclusions can be drawn about modal shifts.

Changes in Daily Traffic Volumes by Route

Southbound Traffic. Table 13 summarizes the daily southbound traffic volumes on each route before and during reconstruction. Table 14 summarizes the z-test statistics. The Expressway carried approximately half of the total screen line traffic. Frontage road volumes were relatively small. Preston Rd. was a major long-distance alternative route, carrying approximately 20 percent of the traffic at each screen line. Coit Rd., which primarily served traffic between Plano and points south, was also a major route at the Plano Parkway screen line.

There were greater reductions in traffic volumes on the Expressway and frontage road at the Plano Parkway screen line than at the Spring Creek Parkway screen line, and there were greater reductions in October 1987 than in June 1988. These findings suggest that trips originating or terminating in Plano were more affected by the reconstruction project than the longer trips originating or terminating north of Plano.

There were no major differences in the southbound cross section between October 1987 and June 1988. Therefore, the lesser impact in June 1988 may indicate that motorists became better able to cope with the project over time.

TABLE 13. Southbound Daily Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	46,899	49,666	42,106	-7,560	50,135	45,828	-4,307
	Frontage Rd.	2,299	2,435	1,927	-508	2,458	2,061	-397
	Ave. K	7,662	8,114	7,664	-450	8,191	7,756	-435
	Coit Rd.	18,947	20,065	24,165	4,100	20,254	22,598	2,344
	Preston Rd.	16,407	17,375	10,241	-7,134	17,539	13,244	-4,295
Spring Creek Pkwy.	Expressway	26,534	28,100	26,939	-1,161	28,365	28,819	454
	Frontage Rd.	2,668	2,825	3,048	223	2,852	2,865	13
	Ave. K	5,631	5,963	6,064	101	6,020	5,128	-892
	Custer Rd.	5,519	5,845	6,747	902	5,900	7,678	1,778
	Preston Rd.	11,134	11,791	9,518	-2,273	11,902	8,745	-3,157

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE 14. Z-Test Statistics for Changes in Daily Traffic Volumes: US-75 Corridor in Plano

Screen Line	Route	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Southbound		Northbound		Southbound		Northbound	
		% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]
Plano Pkwy.	Expressway	-15	-17.50	-15	-16.89	-9	-9.61	-15	-17.30
	Frontage Rd.	-21	-7.41	-41	-18.17	-16	-5.67	-12	-4.72
	Ave. K	-6	-3.29	0	0.18	-5	-3.13	-5	-2.68
	Coit Rd.	20	15.76	-3	-2.65	12	9.21	4	3.25
	Preston Rd.	-41	-37.13	-11	-8.33	-24	-20.90	7	5.04
Spring Creek Pkwy.	Expressway	-4	-3.90	-9	-8.15	2	1.47	1	1.23
	Frontage Rd.	8	0.76	2	0.16	0	0.16	48	4.19
	Ave. K	2	0.83	15	7.85	-15	-7.85	1	0.68
	Custer Rd.	15	7.41	18	8.68	30	13.97	45	20.42
	Preston Rd.	-19	-13.87	-5	-3.07	-27	-19.56	-5	-3.24

[a]Percentage change between the estimated and observed during volumes.
[b]Percentage change (% Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.

Southbound traffic on the Expressway decreased 15 percent (7560 vpd) at the Plano Parkway screen line in October 1987, which may be due in part to the narrow lanes and shoulders that adversely affected the driving environment and traffic handling capacity, and in part to the lane closure on the frontage road that restricted access to the Expressway. Southbound frontage road traffic at the Plano Parkway screenline decreased 21 percent (508 vpd) due to the reduction in the number of lanes from 2 to 1 throughout most of the reconstruction area. Significant volume reductions also occurred on Preston Rd. at both the Plano Parkway and Spring Creek Parkway screen lines. Preston Rd. was also under reconstruction and the number of southbound lanes had been reduced from 2 to 1 lanes at the Plano Parkway screen line. The traffic volume increases on Coit Rd. and Custer Rd. are probably the result of diversion from both the Expressway and Preston Rd. In summary, volumes decreased on all three routes that were being reconstructed (Expressway, frontage road, and Preston Rd.). The increases in traffic volumes on the alternative routes that were monitored were less than the decreases on the routes being reconstructed and, therefore, there was a net reduction in total screen line traffic volumes.

Northbound Traffic. Table 15 summarizes the daily northbound traffic volumes on each route before and during reconstruction. Table 14 summarizes the z-test statistics.

The most important changes in the northbound direction are the 15 percent (7726 vpd) decrease on the Expressway at the Plano Parkway screen line and the 9 percent (2424 vpd) decrease at the Spring Creek Parkway screenline in October 1987. In June 1988, northbound Expressway volumes remained 15 percent below normal at the Plano Parkway screen line but returned to near normal levels at the Spring Creek Parkway screen line, in spite of the fact that the northbound mainlane detour had been extended further north between October 1987 and June 1988. At the Plano Parkway, screenline frontage road volumes in October 1987 were 41 percent (1,397 vpd) lower than normal due to the reduction from 2 to 1 lanes throughout the reconstruction area. In June 1988 frontage road volumes were less affected, only 12 percent (400 vpd) lower, since by that time the majority of the northbound frontage road reconstruction was complete and three traffic lanes were open. Northbound frontage road volumes at the Spring Creek Parkway screen line were very low (less than 200 vpd) before reconstruction and, therefore, the 48 percent increase in June 1988 represents an actual volume increase of less than 100 vpd. On Preston Rd. the reconstruction activity had less impact on northbound traffic since only one lane was open during the entire study period (June 1987 through June 1988). The net effect of the changes on the individual routes was a 7 percent decrease in total northbound screen line volumes at the Plano Parkway screen line, but a 6 percent increase at the Spring Creek Parkway screen line.

TABLE 15. Northbound Daily Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	51,123	53,270	45,544	-7,726	54,548	46,530	-8,018
	Frontage Rd.	3,253	3,390	1,993	-1,397	3,471	3,071	-400
	Ave. K	7,562	7,880	7,903	23	8,069	7,702	-367
	Colt Rd.	19,358	20,171	19,529	-642	20,665	21,478	823
	Preston Rd.	14,857	15,481	13,825	-1,656	15,852	16,935	1,083
Spring Creek Pkwy.	Expressway	27,208	28,351	25,927	-2,424	29,031	29,428	397
	Frontage Rd.	185	193	196	3	197	293	96
	Ave. K	6,799	7,085	8,141	1,056	7,255	7,347	92
	Custer Rd.	5,861	6,107	7,189	1,082	6,254	9,040	2,786
	Preston Rd.	8,707	9,073	8,621	-452	9,290	8,810	-480

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

Changes in Traffic Volumes by Time of Day

Table 16 summarizes the percentage of total daily screen line traffic volume before reconstruction and the percentage of the total reduction in screen line volumes during reconstruction. The A.M. and P.M. peaks accounted for 45 percent of the total daily volume before reconstruction but only 35 percent of the decrease in volumes during reconstruction, whereas the midday and nighttime off peaks accounted for 55 percent of the total volume before reconstruction and 65 percent of the decrease during reconstruction. The volume reductions were proportionately greater during the nighttime than during any other time of day. This reduction in corridor-wide traffic primarily occurred on the Expressway and frontage roads, suggesting that motorists may have canceled trips or changed their destinations to avoid the reconstruction zone at night.

TABLE 16. Volume Changes by Time of Day at the Plano Parkway Screen Line: US-75 Corridor in Plano

Period	Time	% of Total Daily Screenline Volumes Before Reconstruction	% of Total Decrease in Daily Screenline Volumes During Reconstruction
A.M. peak	6:00 A.M.-9:00 A.M.	20	15
Midday off peak	9:00 A.M.-4:00 P.M.	35	25
P.M. peak	4:00 P.M.-7:00 P.M.	25	20
Nighttime	7:00 P.M.-6:00 A.M.	20	40
Total		100	100

Analyses were also performed separately for the A.M., off, and P.M. peaks. Tables B-1 through B-12 in Appendix B summarize the results for each time period. As expected, larger changes occurred in the peak direction than in the off-peak direction during the A.M. and P.M. peaks. In general, the changes by time period were consistent with the overall changes for the day as a whole.

Travel Times and Speeds

Travel times did not change significantly on most of the routes. Tables 17 and 18 summarize the average travel times and speeds for the A.M. and P.M. peaks, respectively. Table 19 presents the paired t test results. Data were collected during the off peak, but the number of usable travel time runs (i.e., not affected by incidents or rain) was too small to obtain reliable estimates.

TABLE 17. A.M. Peak Period Southbound Travel Times and Speeds: US-75 Corridor in Plano

Route	Distance (mi)	Sample Size[a]	Average Travel Time (min)			Average Travel Speed (mph)		
			Before (Jun 1987)	During (Oct 1987)	During (Jun 1988)	Before (Jun 1987)	During (Oct 1987)	During (Jun 1988)
US-75 Mainlanes	10.4	4	13.9	16.6	14.2	45	38	44
Frontage Rd.	10.6	4	18.8	24.4	25.9	34	26	25
Greenville Ave.	10.6	1	32.8	29.8	28.4	19	21	22
Coit Rd.	9.1	2	19.5	19.8	26.1	28	28	21
Preston Rd.	9.1	1	15.3	17.6	14.1	36	31	39

[a]Number of travel time runs during each study period.

TABLE 18. P.M. Peak Period Northbound Travel Times and Speeds: US-75 Corridor in Plano

Route	Distance (mi)	Sample Size[a]	Average Travel Time (min)			Average Travel Speed (mph)		
			Before (Jun 1987)	During (Oct 1987)	During (Jun 1988)	Before (Jun 1987)	During (Oct 1987)	During (Jun 1988)
US-75 Mainlanes	10.4	4	14.4	14.3	12.4	43	44	50
Frontage Rd.	10.2	5	26.3	32.6	28.4	24	20	22
Greenville Ave.	10.6	2	24.7	28.5	26.4	25	22	24
Coit Rd.	9.2	2	19.2	23.1	23.6	29	24	23
Preston Rd.	9.1	1	18.4	21.4	21.8	30	26	25

[a]Number of travel time runs during each study period.

TABLE 19. Paired t-Test Results for Changes in Travel Time: US-75 Corridor in Plano

Route	A.M. Peak Period (Southbound)						P.M. Peak Period (Northbound)					
	During (October 1987)[a]			During (June 1988)[a]			During (October 1987)[a]			During (June 1988)[a]		
	df	Calculated t-value	Critical t-value	df	Calculated t-value	Critical t-value	df	Calculated t-value	Critical t-value	df	Calculated t-value	Critical t-value
US-75 Mainlanes	3	2.63	3.18	3	0.32	3.18	3	-0.12	3.18	3	-1.30	3.18
Frontage Rd.	3	2.13	3.18	3	4.15	3.18	4	1.59	2.78	4	1.24	2.78
Greenville Ave.	--	--	--	--	--	--	1	13.85	12.71	1	0.61	12.71
Coit Rd.	1	1.06	12.71	1	5.71	12.71	1	5.86	12.71	1	4.98	12.71
Preston Rd.	--	--	--	--	--	--	--	--	--	--	--	--

[a]Compared to before reconstruction (June 1987) peak period travel times.

Note: Change in travel time is significant at $\alpha=0.05$ if $|\text{calculated t-value}| >$ critical t-value.

A.M. Peak

As indicated in Table 17, the Expressway had the highest average speed both before and during reconstruction. The largest decrease in speeds was on the frontage road. The paired t test results indicate that the only statistically significant difference between travel times before and during reconstruction was a 7.2 min increase on the frontage road in June 1988.

P.M. Peak

As indicated in Table 18, the Expressway also had the highest average speed during the P.M. peak. Speeds on the Expressway were actually slightly higher during reconstruction which may have been due to the decrease in traffic volumes through the reconstruction zone. Speeds decreased slightly on the other routes. The only statistically significant change in travel times was a 3.7 min increase on Ave. K in October 1987.

LESSONS LEARNED

Total corridor-wide traffic volumes were lower than normal during reconstruction on US-75 in Plano. The volume reductions were greater at the Plano Parkway screen line immediately south of Plano and the reconstruction zone than at the Spring Creek Parkway screen line immediately north of Plano and the reconstruction zone, which suggests that trips originating/terminating in Plano were more significantly affected than trips originating/terminating north of Plano. The cross section through the reconstruction zone (and particularly on the frontage roads) was more restricted and, correspondingly, the volume reductions were greater in October 1987 than in June 1988. Daily volumes on the Expressway during reconstruction decreased as much as 15 percent at the Plano Parkway screen line. This decrease was probably due in part to the narrow lanes and shoulders on the Expressway and in part to the lane closure on the frontage roads. The volume decreases throughout the corridor were proportionately greater during the nighttime than during the day, suggesting that motorists may have avoided the reconstruction zone particularly at night.

There were small increases in travel times and decreases in average speeds on most of the routes during reconstruction. For the most part, however, there was not sufficient evidence to indicate that the changes were statistically significant.

Comparisons of the experiences at the US-75 project in Plano and the I-35 project in Austin provide important insights about the travel impacts of reconstruction activities. The traffic restrictions, and the resulting travel impacts, at the US-75 project were more severe than at the I-35 project. In Plano, some segments had narrow travel lanes, temporary concrete barrier near the median edge of the travel lanes, and narrow outside shoulders. Furthermore, traffic was detoured onto temporary travel lanes in the median, and the frontage roads were reduced to one lane. In Austin, by contrast, the principal traffic restriction through the bottleneck section at the time of data collection was the loss of the inside shoulder and the placement of temporary concrete barrier near the median edge of the travel lanes. There were no detours during the data collection period, and two-lane frontage roads were maintained. These differences are probably largely responsible for the fact that traffic volumes on US-75 in Plano were 15 percent lower than normal during reconstruction, whereas volumes on I-35 in Austin were slightly higher than normal.

6. I-45 NORTH FREEWAY IN HOUSTON

PROJECT DESCRIPTION

The I-45 North Freeway is the major north-south freeway connecting downtown Houston and its northern suburbs. Figure 11 illustrates the corridor.

Reconstruction on the North Freeway is being conducted in four phases. Phase I, which was completed in 1984, extended from downtown Houston to North Shephard Drive and involved the installation of a narrow (16-ft) barrier-separated transitway lane in the median of the freeway. Phase II, which was underway from July 1985 to May 1987, affected the same section but involved the widening of the freeway for additional lanes, frontage road improvements, and the widening of the transitway to approximately 20 ft. Phase III involves extending the transitway from North Shephard to Beltway 8, and Phase IV will extend the transitway from Beltway 8 to FM 1960.

This study focused on Phase II. The traffic control plan for Phase II specified that the number of lanes available to peak-period, peak-direction traffic must be the same during reconstruction as existed before reconstruction. Detours were used in various sections to shift freeway traffic within the right-of-way in order to allow work to proceed in the medians or shoulders. In some sections, the travel lanes were reduced to 10-11 ft and shoulders were narrowed or eliminated. The traffic control plan allowed frontage road lane closures, off-peak and nighttime freeway lane closures, and ramp closures.

Because the reconstruction activities were expected to cause some delay and inconvenience to motorists, the SDHPT and Metropolitan Transit Authority of Harris County (METRO) contracted with the TTI-Houston office to monitor traffic conditions through the Phase II reconstruction period.

DATA COLLECTION

Travel time and traffic volume data were collected before and during Phase II. Data were collected only during the A.M. (6:00-9:00) and P.M. (3:30-6:30) peaks.

Traffic Volume Data

Peak-period, peak-direction traffic volume data were collected at three locations on the freeway: the North Shepard overpass, the HB&T Railroad overpass, and the Link Road Overpass. Data were collected for one day per month between June 1985 and January 1986. In addition, 24-hour volume counts were collected at several ramp and frontage road locations. Two of these locations were monitored on a monthly basis: the I-45 northbound Tidwell exit and frontage road before the exit, and the I-45 southbound Tidwell entrance and frontage road after the entrance. Additional ramp and frontage road data were collected intermittently at other locations.

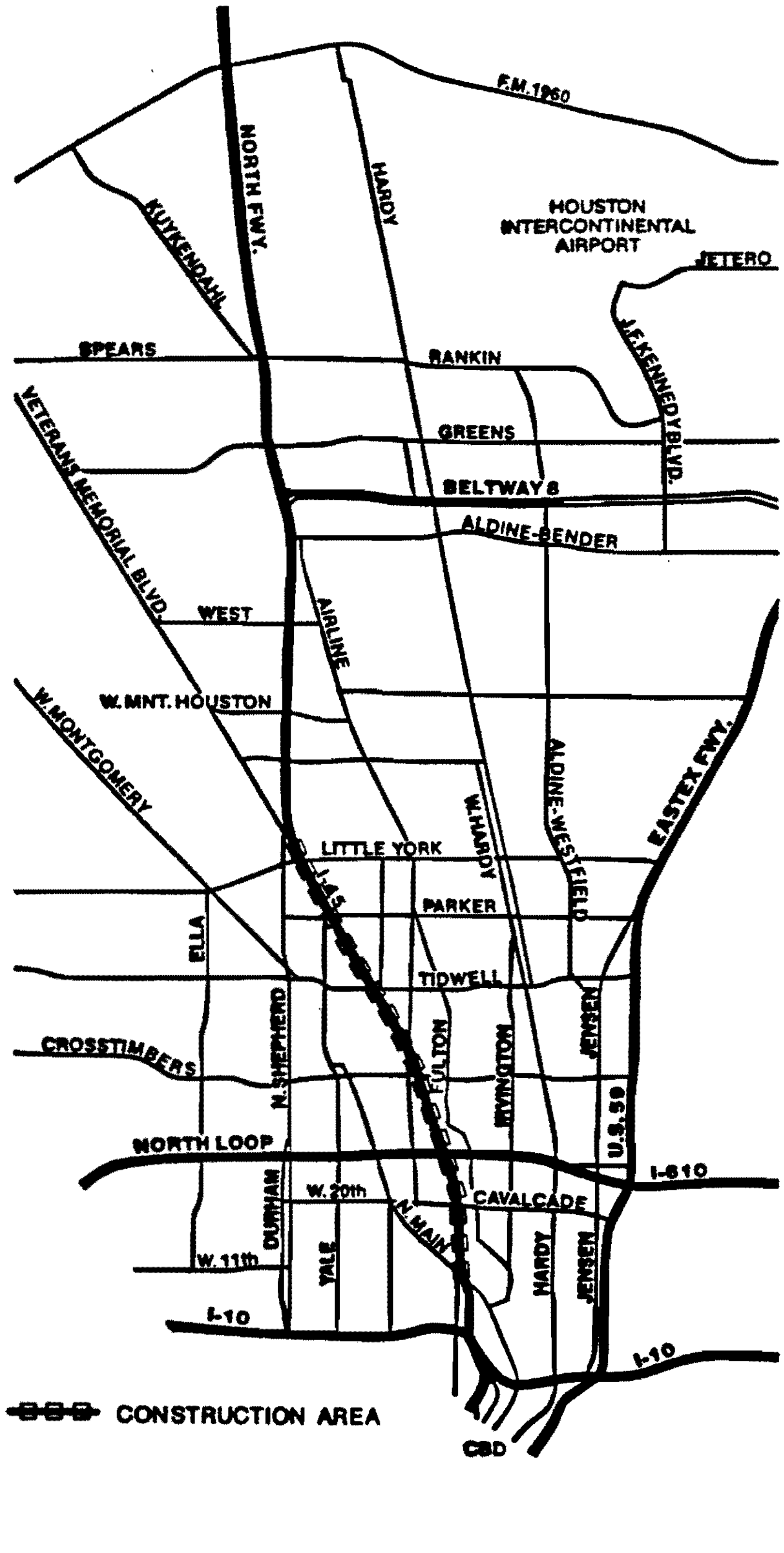

Figure 11. I-45 North Freeway Corridor in Houston.

Travel Time Data

Travel time data were collected by the floating-vehicle method at 1-hr intervals on the freeway and frontage road during the peak periods. Data were collected for one weekday each month between April 1985 and March 1986. Some off-peak travel time data were also collected. Travel time data for several alternative routes (Airline, North Shepard, and 43rd/Crosstimbers) were also collected, although not as systematically or frequently as for the freeway and frontage roads. Travel time runs began at the same time and location each day data were collected. Travel times influenced by weather or incidents were discarded during data processing. The travel times collected during each period (A.M, off, and P.M. peaks) were averaged by route and direction of travel.

OBSERVED TRAVEL IMPACTS

The Phase II reconstruction project had little impact on traffic conditions and travel patterns. Traffic volumes remained stable during reconstruction. Peak period travel times through the corridor also remained about the same before and during reconstruction.

Traffic Volumes

Table 20 summarizes the average peak period volumes before and during reconstruction at the three freeway count locations. The count on June 26, 1985 represented conditions immediately before Phase II. In comparison with that count, southbound A.M. peak period volumes changed very little during the first 6 months of the project, and average northbound P.M. peak period volumes actually increased.

Some of the freeway and frontage road data at North Shepard were collected on the same days, which made it possible to examine the impacts of Phase II on the distribution of traffic between the freeway and frontage roads. Figures 12 and 13 summarize the distributions for the southbound A.M. peak and northbound P.M. peaks, respectively.

Figure 12 illustrates that the total southbound A.M. peak volume (freeway plus frontage road) remained almost constant through the early months of Phase II. In August and September 1985, however, there was a slight decrease in freeway volumes and a slight increase in frontage road volumes, which suggests that some drivers shifted from the freeway to frontage road. The data for November 1985 suggests that drivers shifted back to the freeway from the frontage road. The amount of data available and the changes observed are both too small to draw any strong conclusions, however.

Figure 13 indicates that northbound P.M. peak volumes on the freeway increased slightly during the first two months of Phase II but then decreased slightly over the next several months. The trend for the frontage road was the reverse. Again, the amount of data are small and the changes are slight, but the results suggest that traffic shifted between the freeway and frontage road due to the reconstruction activity.

TABLE 20. Peak Period Freeway Traffic Volumes: I-45 North Freeway in Houston

Freeway Count Location	AM Peak Period Southbound Volumes[a]				PM Peak Period Northbound Volumes[b]			
	Before (6/26/85)	During Average (7/31/85-1/30/86)	Δ	% Δ	Before (6/26/85)	During Average (7/31/85-1/30/86)	Δ	% Δ
North Shephard								
Peak Period	13,757	13,296	-461	-3.4	13,948	14,475	527	3.8
Peak Hour	4,896	4,857	-39	-0.8	4,707	5,243	536	11.4
HB&T Railroad								
Peak Period	18,653	19,031	378	2.0	1,598	17,141	1,153	7.2
Peak Hour	6,874	6,923	49	0.7	5,990	6,032	42	0.7
Link Road								
Peak Period	20,696	20,117	-579	-2.8	15,165	16,820	1,655	10.9
Peak Hour	7,617	7,497	-120	-1.6	5,726	6,079	6353	6.2

[a]6:00 - 9:00 A.M.
[b]3:30 - 6:30 P.M.

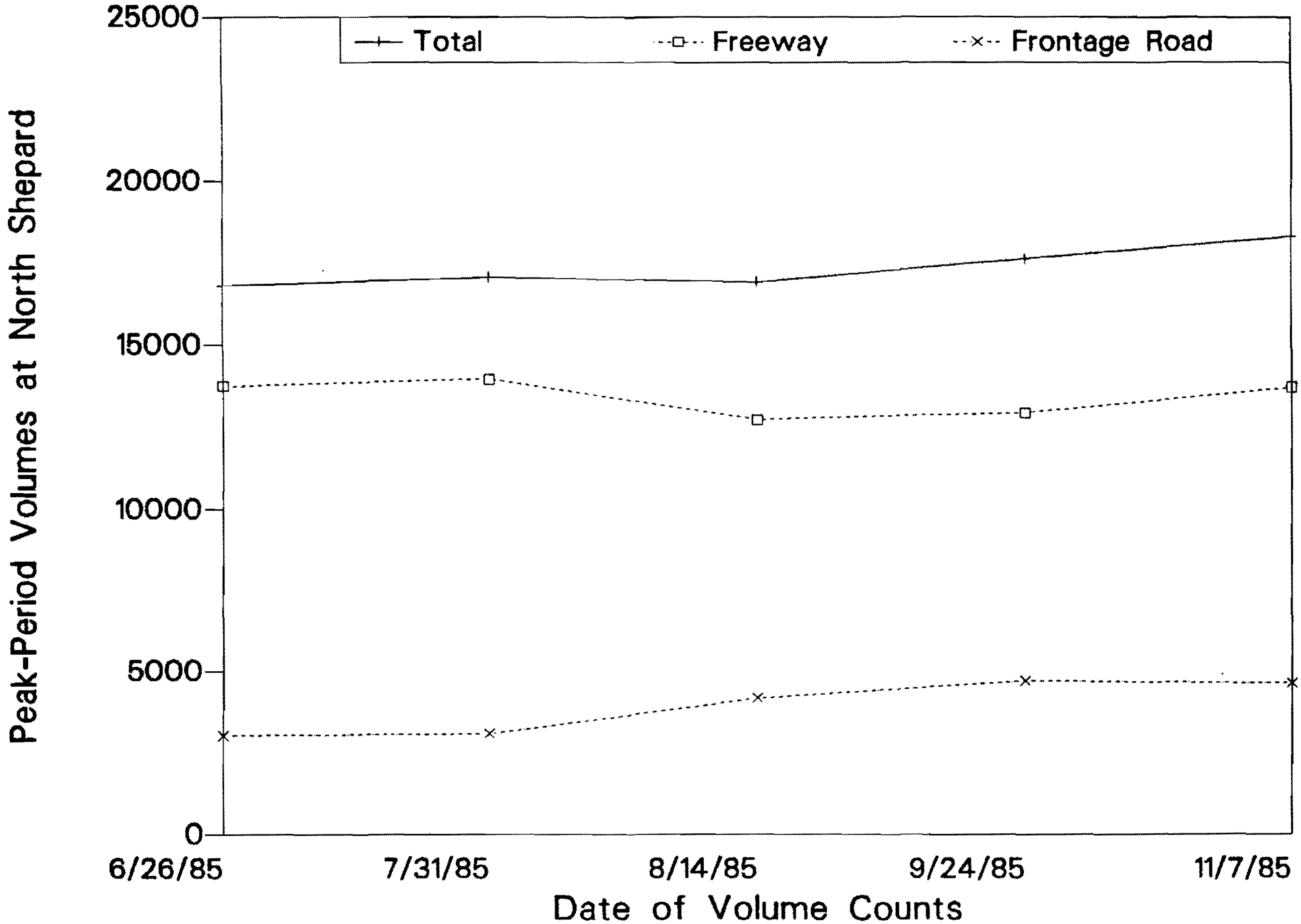

Figure 12. Southbound A.M. Peak Period Traffic Volumes:
I-45 North Freeway in Houston.

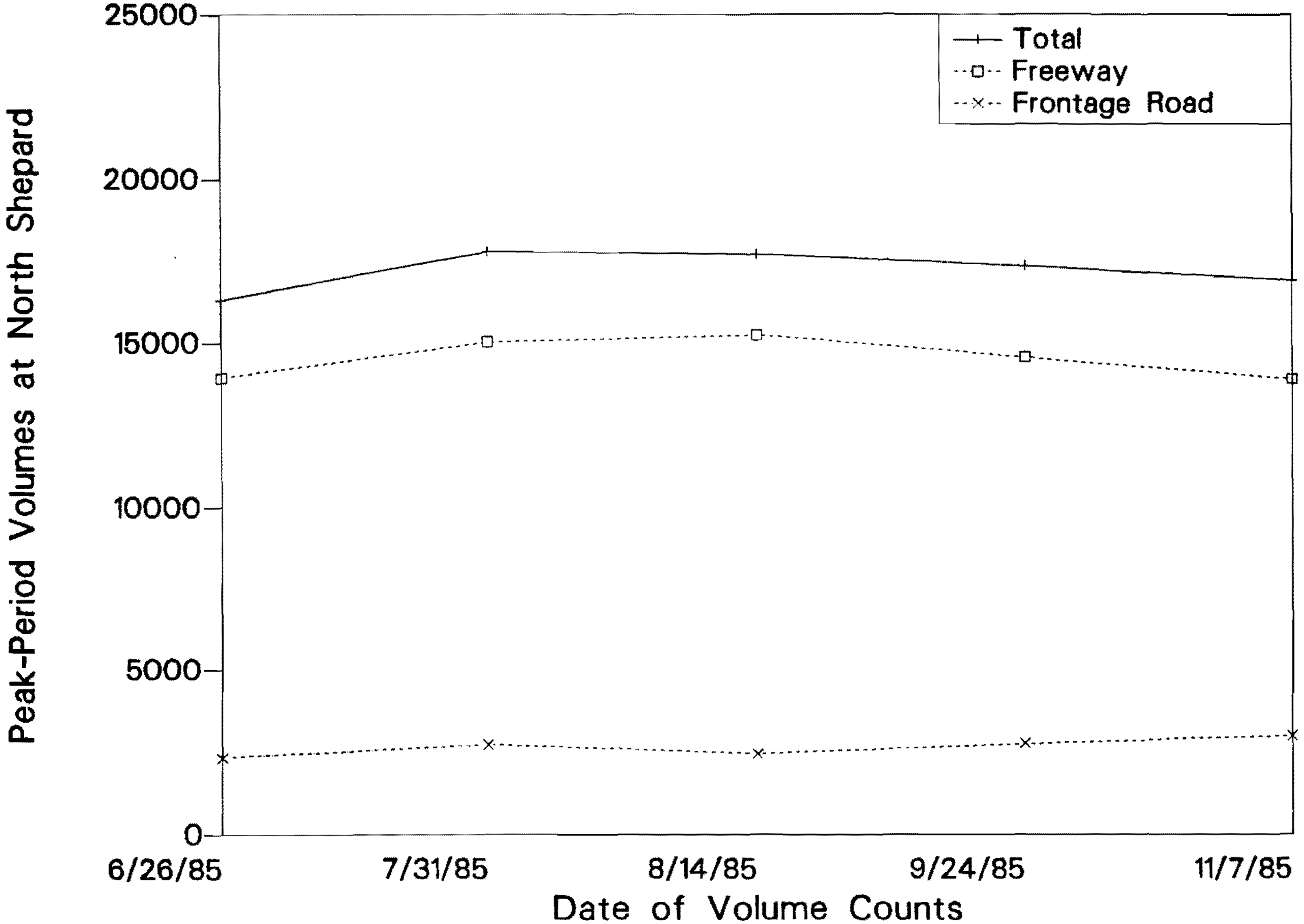

Figure 13. Northbound P.M. Peak Period Traffic Volumes:
I-45 North Freeway in Houston.

Travel Times

Table 21 summarizes peak period travel times before and during Phase II on the freeway, frontage road, and two alternative routes (North Shepard and Airline). The values reported are the averages of the travel times measured during the months identified in the table. Travel times changed very little during Phase II. Interestingly, southbound A.M. peak travel times on both the freeway and frontage roads were slightly lower during reconstruction. Whereas, northbound P.M. peak travel times on the freeway were somewhat higher.

LESSONS LEARNED

Overall, the traffic control plan during Phase II of reconstruction on the 1-45 North Freeway in Houston did not dramatically affect travel patterns or traffic conditions in the corridor. The restricted cross section (narrow lane and shoulder widths) did not have much affect on traffic volumes or travel times on the freeway. It does appear that some traffic shifted between the freeway and frontage roads early in the project. This phenomenon has been observed at other projects throughout the United States.

TABLE 21. Peak Period Travel Times: I-45 North Freeway Corridor in Houston

Route	Direction	Distance (mi)	Average Travel Time (min)			Average Travel Speed (mph)		
			Before (4/85-6/85)	During (7/85-1/86)	% Δ	Before (4/85-6/85)	During (7/85-1/86)	% Δ
Freeway	SB	7.8	14.0	13.1	-6.4	33	36	6.9
	NB	7.8	15.1	16.6	9.9	31	28	-9.0
Frontage Rd.	SB	6.6	14.6	13.3	-8.9	27	30	9.8
	NB	6.6	16.3	16.4	0.6	24	24	0.0
North Shepard	SB	6.7	18.5	18.0	-2.7	22	22	2.8
	NB	6.7	18.1	17.6	-2.8	22	23	2.8
Airline	SB	9.8	24.9	25.7	3.2	24	23	-3.1
	NB	9.8	28.3	25.9	-8.5	21	23	9.3

7. I-35W IN FORT WORTH

PROJECT DESCRIPTION

I-35W is the major north-south freeway through Fort Worth. This section is a link in the interstate system and, regionally, is the major arterial connecting southern Fort Worth with the central business district.

The reconstruction of a 6.4-mi segment of I-35W between I-20 Southeast Loop and the Fort Worth central business district has been conducted in two phases. The segment is highlighted in Figure 14. Phase I began in September 1984 and was completed in the summer of 1988. Phase II followed immediately. The cross section prior to reconstruction consisted of a four-lane freeway with two-lane, one-way frontage roads and will be upgraded to an eight lane freeway with three-lane, one-way frontage roads. In addition to the widening, improvements were made to ramp and acceleration/deceleration lane geometry.

The reconstruction activities during Phase I were concentrated on the construction of two additional lanes and right shoulder in each direction as well as ramp improvements. Traffic operated on the existing lanes. The typical cross section during Phase I consisted of two full-width lanes and 6-ft inside shoulders in each direction. A temporary concrete barrier separated traffic from the work activity on the outer portion of the freeway. In addition, 12 of the original 30 ramps in the segment were closed. The acceleration lanes at the entrance ramps that remained open were very short.

During Phase II traffic was routed onto the travel lanes constructed during Phase I, while the original four lanes, median barrier, and inside shoulders were reconstructed. The typical cross section consisted of two full width lanes and 6-ft shoulders in each direction. More ramps were closed during Phase II (20 of the original 30 ramps). Improved acceleration lanes were provided at the entrance ramps that remained open.

DATA COLLECTION

Traffic data were collected by the Fort Worth district office of the SDHPT and by the city of Fort Worth. The SDHPT collected 24-hour volume counts for each entrance and exit ramp within the reconstruction zone before reconstruction (September 13-20, 1984), during Phase I (June 14-24, 1988), and during Phase II (September 28-29, 1988).

In addition, traffic volume counts for I-35W and six parallel alternative routes in the corridor were extracted from data collected as part of the city-wide traffic count program in Fort Worth. The six routes included Eighth Avenue, Hemphill Street, South Main Street, Evans Avenue, Riverside Drive, and US-287. Data from 1983 were used to represent conditions before reconstruction, and data from 1987 were used for Phase I. Data for Phase II were not available. The counts provided by the city of Fort Worth for these routes were made throughout the year and were not seasonally adjusted.

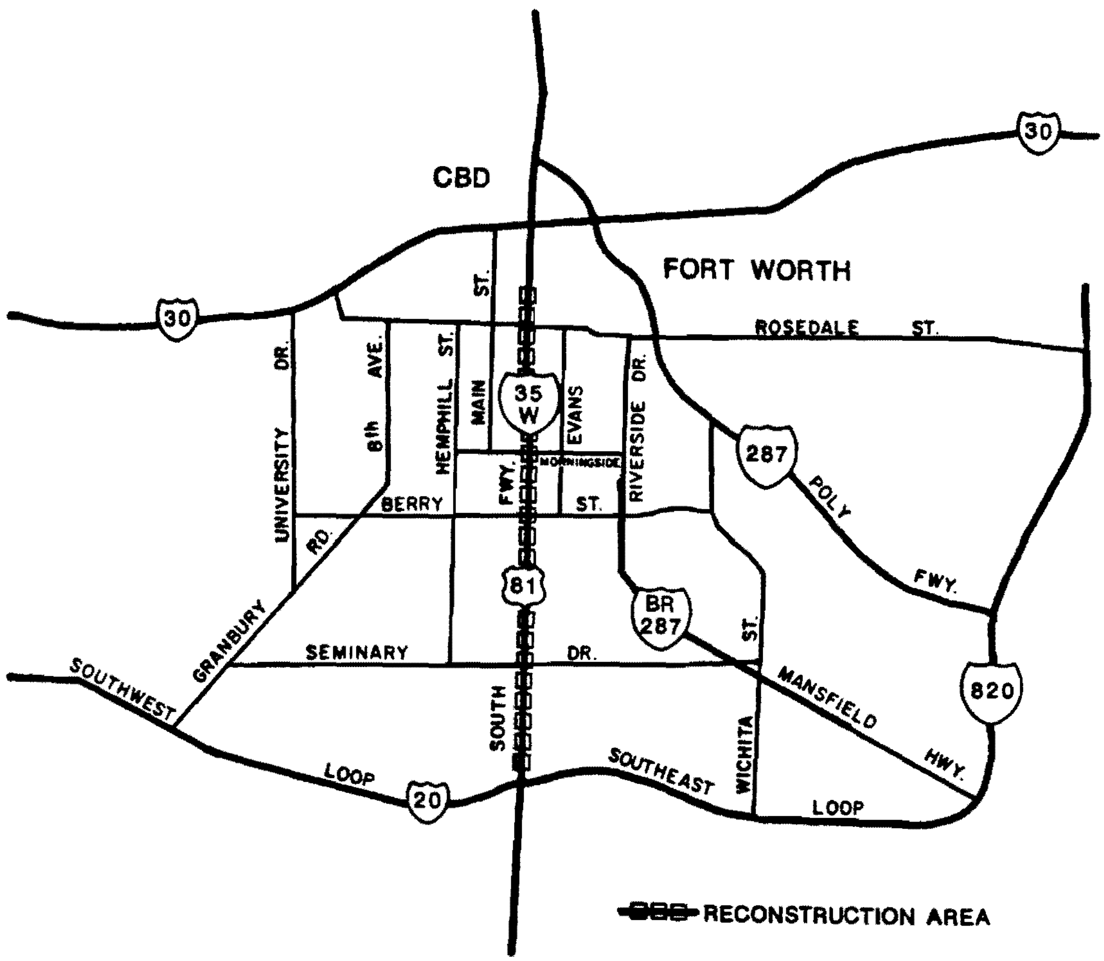

Figure 14. I-35W Corridor in Fort Worth.

OBSERVED TRAVEL IMPACTS

The reconstruction of I-35W impacted the corridor only to a small extent. Ramp closures impacted the volume and patterns of traffic entering and exiting the freeway. However, the screen line analysis suggests that little traffic diverted from I-35W to alternative routes in the corridor.

Ramp Volume Patterns

The ramp volume counts were tabulated to highlight the changes in traffic volumes and travel patterns during reconstruction. Tables 22 and 23 summarize the daily ramp volumes for the northbound (inbound) and southbound (outbound) directions, respectively. Ramp volumes are also reported as a proportion of the total entrance or exit ramp volume. Ramps are listed in order. Tables C-1 through C-6 summarize the results for A.M., noon, and P.M. peak periods.

Tables 22 and 23 show that the ramps remaining open absorbed most, but not all, of the entering/exiting volume displaced by ramp closures. Traffic seemed to shift to the nearest available upstream or downstream ramp. However, not all ramp traffic shifted to another ramp. Total entrance and exit ramp volumes within the reconstruction zone decreased 11 percent during Phase I and 31 percent during Phase II.

Screenline Volumes

Table 24 summarizes the I-35W corridor screen line analysis. Total screen line volumes increased by 7 percent from 177,250 vpd before reconstruction in 1983 to 189,400 vpd during Phase I in 1987. Traffic volumes on I-35W increased only 4 percent. Growth in traffic volumes on I-35W was probably constrained by both the capacity on and the access to the freeway. Most of the rest of the growth in traffic in the corridor was on US-287 which experienced a 27 percent increase. Overall, there was little change in the proportion of traffic carried by the routes in the corridor.

LESSONS LEARNED

The most unique feature of the traffic control plan for the I-35W reconstruction project was the closure of ramps. It appears that most of the ramp traffic adjusted by entering/exiting at the ramps immediately upstream or downstream. However, there was a decrease in the total ramp volume within the reconstruction zone, which may have constrained the growth in traffic volumes on I-35W. These results are consistent with experiences at projects elsewhere in the United States at which ramp closures were used effectively to control traffic demand in the reconstruction zone.

TABLE 22. Northbound Daily Ramp Volumes: I-35W in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
Entrances:								
Felix St.	2,261	0.07	0	0.00	-0.07	0	0.00	-0.07
Seminary Dr.	9,345	0.29	14,301	0.40	0.11	0	0.00	-0.29
Ripy St.	2,522	0.08	0	0.00	-0.08	0	0.00	-0.08
Berry St.	6,166	0.19	8,166	0.23	0.03	15,143	0.61	0.42
Morningside Dr.	3,212	0.10	0	0.00	-0.10	0	0.00	-0.10
Jessamine	908	0.03	0	0.00	-0.03	0	0.00	-0.03
Rosedale St.	3,971	0.12	8,987	0.25	0.13	9,771	0.39	0.27
Hattie St.	3,677	0.11	4,536	0.13	0.01	0	0.00	-0.11
Total	32,062	1.00	35,990	1.00	0.00	24,914	1.00	0.00
Exits:								
Felix St.	2,841	0.13	4,112	0.28	0.15	2,912	0.24	0.10
Seminary Dr.	4,143	0.20	3,116	0.21	0.02	3,156	0.26	0.06
Berry St.	7,119	0.34	4,920	0.34	0.00	6,303	0.51	0.17
Morningside Dr.	2,335	0.11	0	0.00	-0.11	0	0.00	-0.11
Rosedale St.	2,572	0.12	2,523	0.17	0.05	0	0.00	-0.12
Hattie St.	2,229	0.10	0	0.00	-0.10	0	0.00	-0.10
Total	21,239	1.00	14,671	1.00	0.00	12,371	1.00	0.00

Note: Proportions may not add to totals due to rounding.

TABLE 23. Southbound Daily Ramp Volumes: I-35W in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
Entrances:								
Hattie St.	2,198	0.09	0	0.00	-0.09	0	0.00	-0.09
Rosedale St.	4,870	0.19	6,112	0.33	0.14	0	0.00	-0.19
Morningside Dr.	2,424	0.10	0	0.00	-0.10	0	0.00	-0.10
Berry St.	5,015	0.20	6,335	0.34	0.15	8,811	0.61	0.41
Ripy St.	1,846	0.07	0	0.00	-0.07	0	0.00	-0.07
Seminary Dr.	5,319	0.21	6,002	0.33	0.11	5,556	0.39	0.18
Felix St.	3,616	0.14	0	0.00	-0.14	0	0.00	0.14
Total	25,288	1.00	18,449	1.00	0.00	14,367	1.00	0.00
Exits:								
Hattie St.	5,602	0.16	5,500	0.17	0.01	4,671	0.17	0.02
Rosedale St.	5,216	0.15	5,701	0.18	0.03	7,226	0.27	0.12
Jessamine St.	1,096	0.03	0	0.00	-0.03	0	0.00	-0.03
Morningside Dr.	2,203	0.06	2,567	0.08	0.02	0	0.00	-0.06
Berry St.	5,771	0.16	5,965	0.19	0.02	14,843	0.56	0.39
Ripy St.	1,618	0.05	1,378	0.04	0.00	0	0.00	-0.05
Bolt St.	3,107	0.09	0	0.00	-0.09	0	0.00	-0.09
Seminary Dr.	5,717	0.16	6,761	0.21	0.05	0	0.00	-0.16
Felix St.	5,047	0.14	4,141	0.13	-0.01	0	0.00	-0.14
Total	35,377	1.00	32,013	1.00	0.00	26,740	1.00	0.00

Note: Proportions may not add to totals due to rounding.

TABLE 24. Daily Screen Line Traffic Volumes by Route: I-35W Corridor in Fort Worth

Route	Reconstruction Period			
	Before		Phase I	
	Volume	Proportion	Volume	Proportion
Eighth Avenue	21,800	0.12	21,500	0.11
Hemphill Street	19,500	0.11	19,500	0.10
S. Main Street	9,300	0.05	9,800	0.05
I-35 W	77,750	0.44	80,800	0.43
Evans Avenue	5,100	0.03	5,100	0.03
Riverside Dr.	10,800	0.06	10,800	0.06
US-287	33,000	0.19	41,900	0.22
Total	177,250	1.00	189,400	1.00

8. I-10 IN EL PASO

PROJECT DESCRIPTION

I-10 is the major east-west freeway through El Paso. Figure 15 illustrates the I-10 corridor in El Paso and highlights the 9-mi segment that was reconstructed. The segment extended from Chelsea St. in downtown El Paso eastward to Zaragosa Rd. The typical cross section before reconstruction was a six-lane freeway with three-lane, one-way frontage roads. The reconstruction project involved adding a freeway lane in each direction, widening structures, and reconstructing the frontage roads. The project was divided into four phases and was conducted from 1985 through early 1990. Table 8-1 summarizes the limits of the four phases. The focus of this study was on Phases II and III.

TABLE 25. Reconstruction Phases: I-10 Project in El Paso

Phase	Project Limits
I	McRae to Lomaland
II	Fort Bliss RR to McRae
III	Chelsea St. to Ft Bliss RR
IV	Lomaland to Zaragosa

Phase I involved widening existing roadway structures. Traffic was maintained on the three existing 12-ft lanes. Inside shoulders were narrowed and outside shoulders eliminated to accommodate the work zone. Phases II and III were conducted concurrently. In Phase II, traffic was shifted to the outside shoulder in order to maintain three 10.5-ft travel lanes with no shoulders on either side. In Phase III, traffic was shifted to the reconstructed inside shoulder and the cross section was three 10.5-ft travel lanes with no shoulders. A temporary concrete barrier separated traffic from the work area.

DATA COLLECTION

Travel time data were collected by the El Paso district office of the SDHPT. Travel times were measured on I-10 and five alternative routes in the corridor. Figure 16 highlights the travel time routes. The five alternative routes were North Loop/Delta Dr., Montana Ave., US-62 Paisano Dr., Loop 375 Border Highway, and SH-20 Almeda/Texas Ave. Data were collected during Phase I in February and March of 1986, and during Phases II and II in March, April, and May of 1987. The TRIDAQS system was used to collect travel time data in both eastbound and westbound directions during the A.M., off, and P.M. peaks.

Figure 15. I-10 Corridor in El Paso.

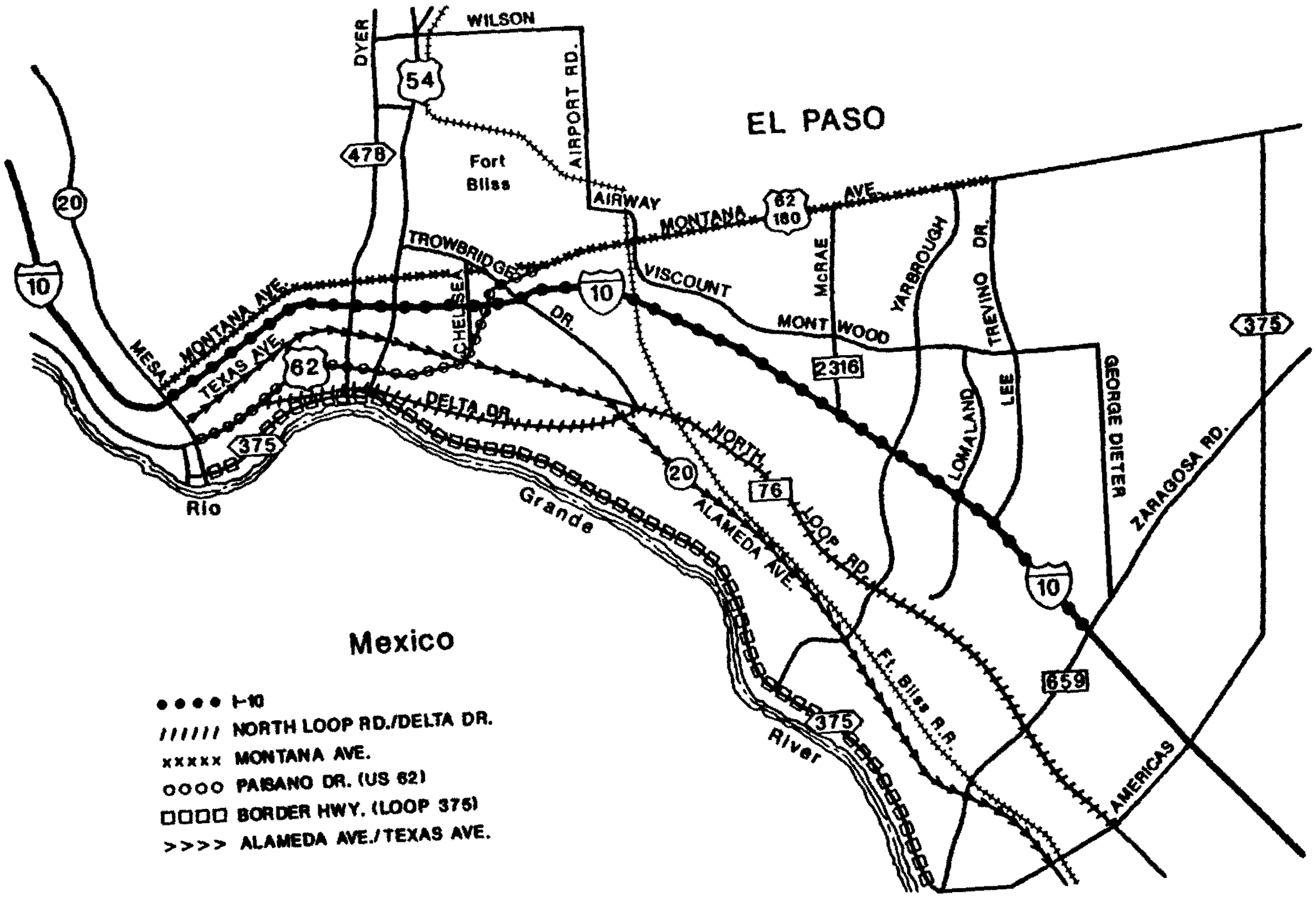

Figure 16. Travel Time Routes: I-10 Corridor in El Paso.

OBSERVED TRAVEL IMPACTS

The SDHPT reported that Phase I had little effect on traffic and considered the travel times during Phase I to be representative of before-reconstruction conditions. Therefore, the analysis focused on the changes in travel time from Phase I to Phases II and III. Tables 26 and 27 summarize the results of the analysis for the westbound (inbound) and eastbound (outbound) directions, respectively. The number of runs was too small for statistical analyses to be performed. Where multiple runs were made during a time period, the travel times were averaged.

The largest increases in travel time occurred on the Loop 375 Border Highway westbound during the A.M. peak and eastbound during the P.M. peak. These increases can be attributed to the reconstruction activities that were underway on that roadway at the same time as Phases II and III on I-10. Travel times on I-10 were slightly lower during Phases II and III than during Phase I. The only exception was in the eastbound direction during the P.M. peak when travel times increased 4.3 min (22 percent). This comparison is based upon one run during each phase and the difference is probably within the range of normal daily variations.

Overall, it was concluded that travel times on I-10 were not greatly affected by the reconstruction project. The fact that only small changes in travel times were observed on the alternative routes in the corridor suggests that there was little diversion to these routes from the reconstruction zone.

LESSONS LEARNED

Only a limited amount of data were collected. Therefore, it is not possible to draw strong conclusions. However, the results suggest that the traffic control plan in effect during Phases II and III of the reconstruction of I-10 in El Paso (narrow lanes, no shoulders, and detours to the shoulders) had little effect on travel times on I-10. No traffic volume data were collected, but the fact that there were only small changes in travel times on alternative routes in the I-10 corridor suggests that little traffic diverted from the reconstruction zone to these routes.

TABLE 26. Westbound Travel Times: I-10 Corridor in El Paso

Period	Route	Phase I		Phases II & III		Change in Travel Time (min)	Change in Travel Time (%)
		Number of Runs	Travel Time (min)	Number of Runs	Travel Time (min)		
A.M. Peak	I-10	2	18.4	1	16.9	-1.5	-8
	North Loop/Delta Dr.	1	30.8	1	31.1	0.3	1
	Montana Ave.	1	25.1	1	27.4	2.3	9
	Paisano Dr. (US-62)	2	11.9	1	11.3	-0.6	-5
	Border Hwy (Loop 375)	1	14.5	1	25.9	11.4	78
	SH-20 (Alameda/Texas)	1	36.0	1	35.8	-0.2	-1
Off Peak	I-10	2	13.7	1	13.6	-0.1	-1
	North Loop/Delta Dr.	1	29.0	1	25.0	-4.0	-14
	Montana Ave.	3	22.8	3	23.1	0.3	1
	Paisano Dr. (US-62)	2	11.9	1	11.2	-0.7	-6
	Border Hwy. (Loop 375)	2	15.4	2	16.8	1.4	9
P.M. Peak	I-10	1	14.0	1	13.8	-0.2	-1
	Paisano Dr. (US-62)	1	11.4	1	12.3	0.9	8
	Border Hwy. (Loop 375)	1	15.1	1	16.3	1.2	8

TABLE 27. Eastbound Travel Times: I-10 Corridor in El Paso

Period	Route	Phase I		Phases II & III		Change in Travel Time (min)	Change in Travel Time (%)
		Number of Runs	Travel Time (min)	Number of Runs	Travel Time (min)		
A.M. Peak	I-10	1	13.3	1	13.3	0.0	0
	North Loop/Delta Dr.	1	28.4	1	29.1	0.7	2
	Paisano Dr. (US-62)	1	12.5	1	12.9	0.4	3
	Border Hwy. (Loop 375)	1	14.8	1	15.4	0.6	4
Off Peak	I-10	1	13.4	1	13.2	-0.2	-2
	North Loop/Delta Dr.	2	29.7	2	26.9	-2.8	-9
	Montana Ave.	1	24.8	1	24.4	-0.4	-2
	Paisano Dr. (US-62)	1	11.8	1	13.4	1.6	14
	Border Hwy. (Loop 375)	2	15.3	2	16.8	1.5	10
P.M. Peak	I-10	1	19.5	1	23.8	4.3	22
	North Loop/Delta Dr.	1	32.9	1	33.8	0.9	3
	Montana Ave.	2	27.7	1	28.0	0.3	1
	Border Hwy. (Loop 375)	1	14.9	1	19.6	4.7	31

9. SUMMARY OF FINDINGS

This report documents an analysis of the travel impacts of five long-term urban freeway reconstruction projects in Texas. At two of the projects (I-35 in Austin and US-75 in Plano) original data were collected and analyzed. At the three remaining projects (I-45 North Freeway in Houston, I-35W in Fort Worth, and I-10 in El Paso) data collected previously by or for the SDHPT were analyzed. The impacts observed were similar to those reported for other projects elsewhere in the United States.

The major findings are as follows:

- None of five projects in Texas caused large changes in travel times either on the freeway being reconstructed or on the alternative routes in the corridor.
- The US-75 project in Plano was the only project at which there were significant decreases in traffic volumes on the freeway and throughout the corridor as a whole.
- The reductions in volumes during reconstruction on US-75 were primarily trips with local origins/destinations and were concentrated during the nighttime. These results are consistent with experiences elsewhere in the United States.
- Narrow lanes and shoulders during reconstruction did not significantly affect traffic patterns or travel times on the freeway. However, combinations of capacity reductions on the freeway (due to intermittent sections with narrow lanes and shoulders and to detours to temporary travel lanes) and restricted access to the freeway (due to lane closures on the frontage roads), such as during the US-75 project in Plano, did result in significant diversion from the reconstruction zone.
- Ramp closures within the I-35W reconstruction zone in Fort Worth resulted in a decrease in total ramp volumes and a smaller percentage increase in I-35W traffic volumes than for the corridor as a whole. These results are consistent with projects elsewhere in the United States at which ramp closures were effective at reducing the traffic volumes entering the reconstruction zone.
- Traffic shifted between the freeway and frontage roads during the early stages of Phase II reconstruction on the I-45 North Freeway in Houston. These results are consistent with experiences of shifting during the early stages of projects elsewhere in the United States.

Overall, the experiences at the five projects analyzed in this report suggest that the traffic control plans used during major urban freeway reconstruction projects in Texas do not cause significant changes in traffic volumes or travel times in the corridor. However, restricting access to the freeway either by ramp closures within the reconstruction zone or by lane closures on the frontage roads forces traffic to divert to other routes in the corridor. The experiences at the US-75 project in Plano suggest that the SDHPT should avoid concurrent capacity restrictions on the freeway and frontage road, unless adequate capacity exists to accommodate diverted traffic on alternative routes elsewhere in the corridor. The data from the I-45 North Freeway in Houston suggest that special attention should be paid to the information requirements of motorists in the early stages of reconstruction projects when they are deciding how to respond.

The traffic monitoring plan and statistical analysis methodology described in Chapter 2 proved to be effective and are recommended for use in future monitoring efforts. The paired t test, which controls for the starting time of travel time runs, is an appropriate technique for analyzing the changes in travel times during reconstruction projects. It is recommended that a larger sample of travel times runs than used herein be collected in order to obtain reliable results. With respect to volume data, the screen line analysis approach, the establishment of ATR stations as control locations, and the use of the before-after design with a control location and a check for comparability are recommended to analyze corridor-wide changes in travel patterns attributable to freeway reconstruction projects. In future monitoring efforts, multiple before reconstruction data collection periods are recommended in order to perform the check for comparability between the reconstruction zone and control location and thereby separate the effects of reconstruction from other factors that also cause changes in corridor-wide travel patterns and traffic conditions.

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APPENDIX A.

CHANGES IN TRAFFIC VOLUMES BY TIME OF DAY: I-35 PROJECT IN AUSTIN

TABLE A-1. A.M. Peak Period Total Screen Line Traffic Volumes: I-35 Corridor in Austin

Screen Line	Direction	Before (November 1986)	During Reconstruction Volumes (May 1987)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ
Yager Ln.	Northbound[c]	10,126	10,123	9,513	-610	-6
	Southbound[c]	18,012	18,915	19,517	602	3
	Total[d]	26,460	27,306	27,683	377	1
Braker Ln.	Northbound[c]	8,569	8,583	9,006	423	5
	Southbound[c]	15,093	15,841	16,295	454	3
	Total[d]	23,662	24,424	25,301	877	4
Rundberg Ln.[e]	Northbound	8,203	8,148	8,592	444	5
	Southbound	14,867	15,639	17,051	1,412	9
	Total	23,070	23,787	25,643	1,856	8

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Combined direction volumes are included in both the north and southbound data for the Yager Ln. and Braker Ln. screen lines on Dessau/Cameron Rd.
[d]Combined direction volumes are only included once in the total volume data.
[e]Volume data (before and during) for Cameron Rd. were not included since a resurfacing project did not allow before volumes to be collected.

TABLE A-2. A.M. Peak Period Southbound Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	6,600	6,943	8,316	1,373	20	8.30
	Frontage Rd.	1,379	1,451	925	-526	-36	-10.04
	Mopac Fwy.	4,813	5,063	5,038	-25	0	-.20
	Metric Blvd.	803	845	1,274	429	51	8.70
	Lamar Blvd.	2,739	2,881	2,617	-264	-9	-3.12
	Dessau Rd.[d]	1,678	1,732	1,347	-385	-22	-6.55
Braker Ln.	Freeway	8,146	8,569	9,277	708	8	3.82
	Frontage Rd.	1,192	1,254	1,135	-119	-9	-2.27
	Lamar Blvd.	3,923	4,127	3,719	-408	-10	-3.86
	Cameron Rd.[d]	1,832	1,891	2,164	273	14	3.99
Rundberg Ln.	Freeway	8,221	8,648	11,471	2,823	33	13.96
	Frontage Rd.	2,387	2,511	1,704	-807	-32	-11.16
	Lamar Blvd.	4,259	4,480	3,876	-604	-13	-5.50
	Cameron Rd.[e]	--	--	3,961	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

TABLE A-3. A.M. Peak Period Northbound Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	4,145	4,117	4,353	236	6	1.88
	Frontage Rd.	151	150	148	-2	-1	-.11
	Mopac Fwy.	1,653	1,642	1,774	132	8	1.95
	Metric Blvd.	1,157	1,149	581	-568	-49	-12.48
	Lamar Blvd.	1,342	1,333	1,310	-23	-2	-.40
	Dessau Rd.[d]	1,678	1,732	1,347	-385	-22	-6.55
Braker Ln.	Freeway	4,793	4,761	4,902	141	3	1.02
	Frontage Rd.	281	279	354	75	27	2.88
	Lamar Blvd.	1,663	1,652	1,586	-66	-4	-1.01
	Cameron Rd.[d]	1,832	1,891	2,164	273	14	3.99
Rundberg Ln.	Freeway	5,098	5,064	5,862	798	16	5.27
	Frontage Rd.	1,380	1,371	1,087	-284	-21	-5.12
	Lamar Blvd.	1,725	1,713	1,643	-70	-4	-1.05
	Cameron Rd.[e]	--	--	817	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha=0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

TABLE A-4. Off Peak Period Total Screen Line Traffic Volumes: I-35 Corridor in Austin

Screen Line	Direction	Before (November 1986)	During Reconstruction Volumes (May 1987)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ
Yager Ln.	Northbound[c]	25,950	26,105	26,925	820	3
	Southbound[c]	26,123	25,399	24,803	-596	-2
	Total[d]	52,073	51,504	51,728	224	0
Braker Ln.	Northbound[c]	24,170	24,311	24,975	664	3
	Southbound[c]	23,907	23,249	24,533	1,284	6
	Total[d]	48,077	47,560	49,508	1,948	4
Rundberg Ln.[e]	Northbound	30,306	30,521	33,417	2,896	9
	Southbound	32,341	31,410	31,661	251	1
	Total	62,647	61,931	65,078	3,147	5

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Combined direction volumes are included in both the north and southbound data for the Yager Ln. and Braker Ln. screen lines on Dessau/Cameron Rd.
[d]Combined direction volumes are only included once in the total volume data.
[e]Volume data (before and during) for Cameron Rd. were not included since a resurfacing project did not allow before volumes to be collected.

TABLE A-5. Off Peak Period Southbound Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	13,542	13,152	13,864	712	5	3.08
	Frontage Rd.	434	422	369	-53	-13	-1.85
	Mopac Fwy.	5,955	5,783	6,234	451	8	3.44
	Metric Blvd.	1,625	1,578	1,004	-574	-36	-10.79
	Lamar Blvd.	2,949	2,864	1,886	-978	-34	.26
	Dessau Rd.[d]	1,618	1,600	1,446	-154	-10	-2.73
Braker Ln.	Freeway	15,576	15,127	15,806	679	4	2.65
	Frontage Rd.	834	810	912	102	13	2.40
	Lamar Blvd.	5,772	5,606	5,594	-12	0	-.10
	Cameron Rd.[d]	1,725	1,706	2,221	515	30	7.94
Rundberg Ln.	Freeway	20,757	20,159	20,493	334	2	1.05
	Frontage Rd.	3,555	3,453	3,328	-125	-4	-1.36
	Lamar Blvd.	8,029	7,798	7,840	42	1	.27
	Cameron Rd.[e]	--	--	3,822	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

TABLE A-6. Off Peak Period Northbound Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	13,004	13,096	13,722	626	5	2.70
	Frontage Rd.	374	377	345	-32	-8	-1.16
	Mopac Fwy.	6,326	6,371	6,478	107	2	.77
	Metric Blvd.	835	841	1,132	291	35	6.30
	Lamar Blvd.	3,793	3,820	3,802	-18	0	-.18
	Dessau Rd.[d]	1,618	1,600	1,446	-154	-10	-2.73
Braker Ln.	Freeway	15,481	15,591	15,815	224	1	.86
	Frontage Rd.	930	937	1,000	63	7	1.39
	Lamar Blvd.	6,034	6,077	5,939	-138	-2	-1.05
	Cameron Rd.[d]	1,725	1,706	2,221	515	30	7.94
Rundberg Ln.	Freeway	17,225	17,347	20,822	3,475	20	11.47
	Frontage Rd.	4,380	4,411	4,212	-199	-5	-1.87
	Lamar Blvd.	8,701	8,763	8,383	-380	-4	-2.27
	Cameron Rd.[e]	--	--	3,208	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

TABLE A-7. P.M. Peak Period Total Screen Line Traffic Volumes: I-35 Corridor in Austin

Screen Line	Direction	Before (November 1986)	During Reconstruction Volumes (May 1987)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ
Yager Ln.	Northbound[c]	19,480	19,650	20,801	1,151	6
	Southbound[c]	13,384	13,590	13,253	-337	-2
	Total[d]	32,864	33,240	34,054	814	2
Braker Ln.	Northbound[c]	17,321	17,473	17,675	202	1
	Southbound[c]	11,754	11,933	13,101	1,168	10
	Total[d]	29,075	29,406	30,776	1,370	5
Rundberg Ln.[e]	Northbound	18,250	18,405	19,641	1,236	7
	Southbound	14,425	14,655	14,839	184	1
	Total	32,675	33,060	34,480	1,420	4

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Combined direction volumes are included in both the north and southbound data for the Yager Ln. and Braker Ln. screen lines on Dessau/Cameron Rd.
[d]Combined direction volumes are only included once in the total volume data.
[e]Volume data (before and during) for Cameron Rd. were not included since a resurfacing project did not allow before volumes to be collected.

TABLE A-8. P.M. Peak Period Southbound Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	5,866	5,959	6,357	398	7	2.56
	Frontage Rd.	167	170	183	13	8	.70
	Mopac Fwy.	2,372	2,410	2,834	424	18	4.93
	Metric Blvd.	1,782	1,810	747	-1,063	-59	.41
	Lamar Blvd.	1,609	1,635	1,631	-4	0	-.06
	Dessau Rd.[d]	1,588	1,606	1,501	-105	-7	-1.80
Braker Ln.	Freeway	6,727	6,834	7,123	289	4	1.69
	Frontage Rd.	376	382	395	13	3	.45
	Lamar Blvd.	2,979	3,026	2,884	-142	-5	-1.54
	Cameron Rd.[d]	1,672	1,691	2,699	1,008	60	14.17
Rundberg Ln.	Freeway	9,101	9,246	9,491	245	3	1.14
	Frontage Rd.	1,951	1,982	2,049	67	3	.92
	Lamar Blvd.	3,373	3,427	3,299	-128	-4	-1.27
	Cameron Rd.[e]	--	--	1,978	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

TABLE A-9. P.M. Peak Period Northbound Traffic Volumes by Route: I-35 Corridor in Austin

Screen Line	Route	Before (November 1986)	During Reconstruction Volumes (May 1987)				
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	z[c]
Yager Ln.	Freeway	8,832	8,907	8,869	-38	0	-.21
	Frontage Rd.	370	373	472	99	26	3.32
	Mopac Fwy.	4,718	4,758	5,035	277	6	2.30
	Metric Blvd.	574	579	1,316	737	127	15.81
	Lamar Blvd.	3,398	3,427	3,608	181	5	1.86
	Dessau Rd.[d]	1,588	1,606	1,501	-105	-7	-1.80
Braker Ln.	Freeway	10,521	10,610	9,289	-1,321	-12	-6.67
	Frontage Rd.	770	777	1,226	449	58	9.50
	Lamar Blvd.	4,358	4,395	4,461	66	2	.58
	Cameron Rd.[d]	1,672	1,691	2,699	1,008	60	14.17
Rundberg Ln.	Freeway	10,764	10,855	10,932	77	1	.36
	Frontage Rd.	2,943	2,968	3,823	855	29	8.97
	Lamar Blvd.	4,543	4,582	4,886	304	7	2.58
	Cameron Rd.[e]	--	--	3,486	--	--	--

[a]Volumes were estimated by seasonally adjusting November 1986 before volumes.
[b]Δ = Observed - Estimated.
[c]Percentage change (%Δ) is significant at $\alpha=0.05$ if $|z| > 1.96$.
[d]Volumes are for combined directions.
[e]Resurfacing project did not allow before volumes to be collected.

APPENDIX B.

CHANGES IN TRAFFIC VOLUMES BY TIME OF DAY: US-75 PROJECT IN PLANO

TABLE B-1. A.M. Peak Period Total Screen Line Traffic Volumes: US-75 Corridor in Plano

Screen Line	Direction	Before (June 1987)	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	Estimated[a]	Observed	Δ[b]	% Δ
Plano Pkwy.	SB[c]	23,752	25,914	23,090	-2,824	-11	25,677	22,600	-3,077	-12
	NB	12,268	13,422	12,955	-467	-4	12,919	12,634	-285	-2
	Total	36,020	39,336	36,045	-3,291	-8	38,596	35,234	-3,362	-9
Spring Creek Pkwy.	SB[c]	12,494	13,632	13,298	-334	-2	13,506	12,661	-845	-6
	NB	8,014	8,767	8,603	-164	-2	8,438	7,993	-445	-5
	Total	20,508	22,399	21,901	-498	-2	21,944	20,654	-1,290	-6

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.
[c]Peak direction.

TABLE B-2. A.M. Peak Period Southbound Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	11,105	12,116	11,288	-828	12,005	11,354	-651
	Frontage Rd.	792	864	739	-125	856	613	-243
	Ave. K	1,898	2,071	1,817	-254	2,052	1,568	-484
	Coit Rd.	5,554	6,059	6,584	525	6,004	5,816	-188
	Preston Rd.	4,403	4,804	2,662	-2,142	4,760	3,249	-1,511
Spring Creek Pkwy.	Expressway	6,837	7,459	7,264	-195	7,391	7,623	232
	Frontage Rd.	386	421	483	62	417	347	-70
	Ave. K	1,599	1,745	1,823	78	1,729	1,402	-327
	Custer Rd.	1,160	1,266	1,642	376	1,254	1,587	333
	Preston Rd.	2,512	2,741	2,086	-655	2,715	1,702	-1,013

[a] Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b] Δ = Observed - Estimated.

TABLE B-3 A.M. Peak Period Northbound Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	7,351	8,042	7,133	-909	7,741	6,978	-763
	Frontage Rd.	130	142	163	21	137	162	25
	Ave. K	826	904	1,095	191	870	932	62
	Coit Rd.	2,049	2,242	2,404	162	2,158	2,490	332
	Preston Rd.	1,912	2,092	2,160	68	2,013	2,072	59
Spring Creek Pkwy.	Expressway	4,202	4,597	4,314	-283	4,425	4,571	146
	Frontage Rd.	62	68	96	28	65	94	29
	Ave. K	438	479	615	136	461	401	-60
	Custer Rd.	853	933	1,350	417	898	1,184	286
	Preston Rd.	2,459	2,690	2,228	-462	2,589	1,743	-846

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE B-4. Z-Test Statistics for Changes in A.M. Peak Period Traffic Volumes: US-75 Corridor in Plano

Screen Line	Route	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Southbound		Northbound		Southbound		Northbound	
		% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]
Plano Pkwy.	Expressway	-7	-3.61	-11	-5.25	-5	-2.87	-10	-4.50
	Frontage Rd.	-14	-2.94	15	1.14	-28	-6.01	18	1.42
	Ave. K	-12	-3.65	21	3.94	-24	-7.28	7	1.38
	Coit Rd.	9	3.60	7	2.06	-3	-1.37	15	4.25
	Preston Rd.	-45	-20.80	3	0.91	-32	-14.07	3	0.81
Spring Creek Pkwy.	Expressway	-3	-1.19	-6	-2.38	3	1.39	3	1.23
	Frontage Rd.	15	1.97	42	2.12	-17	-2.45	44	2.22
	Ave. K	4	1.19	28	3.87	-19	-5.34	-13	-1.97
	Custer Rd.	30	6.37	45	7.94	27	5.71	32	5.80
	Preston Rd.	-24	-8.30	-17	-5.68	-37	-13.56	-33	-11.27

[a]Percentage change between the estimated and observed during volumes.
[b]Percentage change (% Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.

TABLE B-5. Off Peak Period Total Screen Line Traffic Volumes: US-75 Corridor in Plano

Screen Line	Direction	Before (June 1987)	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	Estimated[a]	Observed	Δ[b]	% Δ
Plano Pkwy.	SB	35,186	36,840	34,200	-2,640	-7	36,593	34,485	-2,108	-6
	NB	36,151	37,272	33,432	-3,840	-10	37,814	35,838	-1,976	-5
	Total	71,337	74,112	67,632	-6,480	-9	74,407	70,323	-4,084	-5
Spring Creek Pkwy.	SB	19,208	20,110	19,421	-689	-3	19,976	20,105	129	1
	NB	17,544	18,088	18,196	108	1	18,352	20,045	1,693	9
	Total	36,752	38,198	37,617	-581	-2	38,328	40,150	1,822	5

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE B-6. Off Peak Period Southbound Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	18,469	19,337	15,690	-3,647	19,208	16,104	-3,104
	Frontage Rd.	787	824	640	-184	818	743	-75
	Ave. K	3,249	3,402	3,463	61	3,379	3,520	141
	Coit Rd.	6,851	7,173	10,131	2,958	7,125	8,921	1,796
	Preston Rd.	5,830	6,104	4,276	-1,828	6,063	5,197	-866
Spring Creek Pkwy.	Expressway	9,881	10,345	9,806	-539	10,276	10,311	35
	Frontage Rd.	1,078	1,129	1,290	161	1,121	1,163	42
	Ave. K	2,061	2,158	2,181	23	2,143	2,033	-110
	Custer Rd.	2,071	2,168	2,404	236	2,154	2,999	845
	Preston Rd.	4,117	4,310	3,740	-570	4,282	3,599	-683

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE B-7. Off Peak Period Northbound Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	18,670	19,249	16,176	-3,073	19,529	15,847	-3,682
	Frontage Rd.	944	973	796	-177	987	1,093	106
	Ave. K	3,801	3,919	3,716	-203	3,976	3,661	-315
	Colt Rd.	7,007	7,224	7,218	-6	7,329	8,300	971
	Preston Rd.	5,729	5,907	5,526	-381	5,993	6,937	944
Spring Creek Pkwy.	Expressway	9,666	9,966	9,222	-744	10,111	10,177	66
	Frontage Rd.	86	89	70	-19	90	132	42
	Ave. K	2,351	2,424	3,000	576	2,459	2,681	222
	Custer Rd.	2,014	2,076	2,485	409	2,107	3,410	1,303
	Preston Rd.	3,427	3,533	3,419	-114	3,585	3,645	60

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE B-8. Z-Test Statistics for Changes in Off Peak Period Traffic Volumes: US-75 Corridor in Plano

Screen Line	Route	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Southbound		Northbound		Southbound		Northbound	
		% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]
Plano Pkwy.	Expressway	-19	-13.81	-16	-11.41	-16	-11.70	-19	-13.72
	Frontage Rd.	-22	-4.66	-18	-4.08	-9	-1.86	11	2.21
	Ave. K	2	0.68	-5	-2.08	4	1.53	-8	-3.24
	Coit Rd.	41	18.32	0	-0.04	25	11.69	13	6.37
	Preston Rd.	-30	-15.66	-6	-3.06	-14	-7.08	16	7.00
Spring Creek Pkwy.	Expressway	-5	-3.02	-7	-4.27	0	0.18	1	0.35
	Frontage Rd.	14	3.14	-21	-1.46	4	0.84	47	2.76
	Ave. K	1	0.33	24	7.21	-5	-1.61	9	2.84
	Custer Rd.	11	3.25	20	5.64	39	10.86	62	15.99
	Preston Rd.	-13	-5.69	-3	-1.24	-16	-6.92	2	0.62

[a]Percentage change between the estimated and observed during volumes.
[b]Percentage change (% Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.

TABLE B-9. P.M. Peak Period Total Screen Line Traffic Volumes: US-75 Corridor in Plano

Screen Line	Direction	Before (June 1987)	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Observed	Estimated[a]	Observed	Δ[b]	% Δ	Estimated[a]	Observed	Δ[b]	% Δ
Plano Pkwy.	SB	16,498	17,652	15,998	-1,654	-9	17,208	16,674	-534	-3
	NB[c]	26,504	27,273	24,061	-3,212	-12	27,644	26,303	-1,341	-5
	Total	43,002	44,925	40,059	-4,866	-11	44,852	42,977	-1,875	-4
Spring Creek Pkwy.	SB	10,733	11,485	11,359	-126	-1	11,195	10,519	-676	-6
	NB[c]	13,324	13,711	13,303	-408	-3	13,897	14,863	966	7
	Total	24,057	25,196	24,662	-534	-2	25,092	25,382	290	1

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.
[c]Peak direction.

TABLE B-10. P.M. Peak Period Southbound Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	8,276	8,855	8,067	-788	8,632	8,193	-439
	Frontage Rd.	424	454	355	-99	442	374	-68
	Ave. K	1,477	1,580	1,454	-126	1,541	1,551	10
	Coit Rd.	3,560	3,809	4,737	928	3,713	4,310	597
	Preston Rd.	2,761	2,954	1,385	-1,569	2,880	2,246	-634
Spring Creek Pkwy.	Expressway	4,697	5,026	5,077	51	4,899	5,111	212
	Frontage Rd.	851	911	955	44	888	816	-72
	Ave. K	918	982	1,050	68	957	721	-236
	Custer Rd.	1,293	1,384	1,782	398	1,349	1,699	350
	Preston Rd.	2,974	3,182	2,495	-687	3,102	2,172	-930

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE B-11. P.M. Peak Period Northbound Traffic Volumes by Route: US-75 Corridor in Plano

Screen Line	Route	Before (June 1987)	During Reconstruction Volumes (October 1987)			During Reconstruction Volumes (June 1988)		
		Observed	Estimated[a]	Observed	Δ[b]	Estimated[a]	Observed	Δ[b]
Plano Pkwy.	Expressway	13,152	13,533	10,962	-2,571	13,718	11,838	-1,880
	Frontage Rd.	1,053	1,084	839	-245	1,098	1,470	372
	Ave. K	1,922	1,978	2,191	213	2,005	2,001	-4
	Coit Rd.	6,538	6,728	6,609	-119	6,819	6,631	-188
	Preston Rd.	3,839	3,950	3,458	-492	4,004	4,363	359
Spring Creek Pkwy.	Expressway	7,458	7,674	6,908	-766	7,779	8,001	222
	Frontage Rd.	24	25	13	-12	25	39	14
	Ave. K	2,261	2,327	2,634	307	2,358	2,291	-67
	Custer Rd.	1,624	1,671	2,012	341	1,694	2,576	882
	Preston Rd.	1,957	2,014	1,736	-278	2,041	1,956	-85

[a]Volumes were estimated by seasonally adjusting June 1987 before volumes.
[b]Δ = Observed - Estimated.

TABLE B-12. Z-Test Statistics for Changes in P.M. Peak Period Traffic Volumes: US-75 Corridor in Plano

Screen Line	Route	During Reconstruction Volumes (October 1987)				During Reconstruction Volumes (June 1988)			
		Southbound		Northbound		Southbound		Northbound	
		% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]	% Δ[a]	z[b]
Plano Pkwy.	Expressway	-9	-4.25	-19	-10.97	-5	-2.37	-14	-7.74
	Frontage Rd.	-22	-3.33	-23	-5.29	-15	-2.30	34	6.81
	Ave. K	-8	-2.08	11	2.97	1	0.18	0	-0.06
	Coit Rd.	24	8.11	-2	-0.80	16	5.46	-3	-1.25
	Preston Rd.	-53	-20.86	-12	-4.86	-22	-7.68	9	3.26
Spring Creek Pkwy.	Expressway	1	0.42	-10	-4.80	4	1.68	3	1.30
	Frontage Rd.	5	0.97	-47	-1.86	-8	-1.63	56	1.71
	Ave. K	7	1.41	13	3.87	-25	-5.44	-3	-0.88
	Custer Rd.	29	6.40	20	5.11	26	5.79	52	12.06
	Preston Rd.	-22	-7.80	-14	-4.14	-30	-11.08	-4	-1.22

[a] Percentage change between the estimated and observed during volumes.
[b] Percentage change (% Δ) is significant at $\alpha = 0.05$ if $|z| > 1.96$.

APPENDIX C.

CHANGES IN RAMP VOLUMES BY TIME OF DAY: I-35W PROJECT IN FORT WORTH

TABLE C-1 Northbound A.M. Peak Period Ramp Volumes: I-35W Reconstruction Zone in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
<u>Entrances:</u>								
Felix St.	175	0.05	0	0.00	-0.05	0	0.00	-0.05
Seminary Dr.	759	0.23	1,542	0.38	0.14	0	0.00	-0.23
Ripy St.	443	0.14	0	0.00	-0.14	0	0.00	-0.14
Berry St.	670	0.21	1,015	0.25	0.04	1,688	0.55	0.35
Morningside Dr.	460	0.14	0	0.00	-0.14	0	0.00	-0.14
Jessamine	148	0.05	0	0.00	-0.05	0	0.00	-0.05
Rosedale St.	339	0.10	1,244	0.30	0.20	1,355	0.45	0.34
Hattie St.	272	0.08	308	0.07	-0.01	0	0.00	-0.08
Total	3,266	1.00	4,109	1.00	0.00	3,043	1.00	0.00
<u>Exits:</u>								
Felix St.	679	0.19	429	0.22	0.03	353	0.17	-0.02
Seminary Dr.	575	0.16	446	0.22	0.06	480	0.23	0.07
Berry St.	1,136	0.32	682	0.34	0.02	1,250	0.60	0.28
Morningside Dr.	471	0.13	0	0.00	-0.13	0	0.00	-0.13
Rosedale St.	271	0.08	432	0.22	0.14	0	0.00	-0.08
Hattie St.	429	0.12	0	0.00	-0.12	0	0.00	-0.12
Total	3,561	1.00	1,989	1.00	0.00	2,083	1.00	0.00

Note: A.M. Peak Period is 7:00-9:00 A.M.
Note: Proportions may not add to totals due to rounding.

TABLE C-2 Southbound A.M. Peak Period Ramp Volumes: I-35W Reconstruction Zone in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
<u>Entrances:</u>								
Hattie St.	204	0.09	0	0.00	-0.09	0	0.00	-0.09
Rosedale St.	439	0.19	479	0.33	0.14	0	0.00	-0.19
Morningside Dr.	239	0.10	0	0.00	-0.10	0	0.00	-0.10
Berry St.	553	0.24	560	0.38	0.14	708	0.60	0.37
Ripy St.	195	0.08	0	0.00	-0.08	0	0.00	-0.08
Seminary Dr.	407	0.18	430	0.29	0.12	465	0.40	0.22
Felix St.	285	0.12	0	0.00	-0.12	0	0.00	-0.12
Total	2,322	1.00	1,469	1.00	0.00	1,173	1.00	0.00
<u>Exits:</u>								
Hattie St.	1,184	0.24	1,246	0.29	0.05	1,100	0.25	0.01
Rosedale St.	766	0.15	549	0.13	-0.03	1,209	0.27	0.12
Jessamine St.	79	0.02	0	0.00	-0.02	0	0.00	-0.02
Morningside Dr.	289	0.06	312	0.07	0.01	0	0.00	-0.06
Berry St.	827	0.17	829	0.19	0.03	2,180	0.49	0.32
Ripy St.	194	0.04	140	0.03	-0.01	0	0.00	-0.04
Bolt St.	342	0.07	0	0.00	-0.07	0	0.00	-0.07
Seminary Dr.	685	0.14	776	0.18	0.04	0	0.00	-0.14
Felix St.	618	0.12	434	0.10	-0.02	0	0.00	-0.12
Total	4,984	1.00	4,286	1.00	0.00	4,489	1.00	0.00

Note: A.M. Peak Period is 7:00-9:00 A.M.
Note: Proportions may not add to totals due to rounding.

TABLE C-3 Northbound Noon Peak Period Ramp Volumes: I-35W Reconstruction Zone in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
Entrances:								
Felix St.	188	0.05	0	0.00	-0.05	0	0.00	-0.05
Seminary Dr.	1,229	0.33	1,927	0.42	0.09	0	0.00	-0.33
Ripy St.	222	0.06	0	0.00	-0.06	0	0.00	-0.06
Berry St.	751	0.20	1,043	0.23	0.02	1,863	0.64	0.44
Morningside Dr.	282	0.08	0	0.00	-0.08	0	0.00	-0.08
Jessamine	89	0.02	0	0.00	-0.02	0	0.00	-0.02
Rosedale St.	515	0.14	1,001	0.22	0.08	1,045	0.36	0.22
Hattie St.	416	0.11	639	0.14	0.03	0	0.00	-0.11
Total	3,692	1.00	4,610	1.00	0.00	2,908	1.00	0.00
Exits:								
Felix St.	351	0.14	516	0.28	0.15	326	0.22	0.09
Seminary Dr.	612	0.24	442	0.24	0.00	400	0.27	0.04
Berry St.	821	0.32	555	0.30	-0.01	743	0.51	0.19
Morningside Dr.	249	0.10	0	0.00	-0.10	0	0.00	-0.10
Rosedale St.	295	0.11	318	0.17	0.06	0	0.00	-0.11
Hattie St.	255	0.10	0	0.00	-0.10	0	0.00	-0.11
Total	2,583	1.00	1,831	1.00	0.00	1,469	1.00	0.00

Note: Noon Peak Period is 11:00 A.M.-1:00 P.M.
Note: Proportions may not add to totals due to rounding.

TABLE C-4 Southbound Noon Peak Period Ramp Volumes: I-35W Reconstruction Zone in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
Entrances:								
Hattie St.	260	0.08	0	0.00	-0.08	0	0.00	-0.08
Rosedale St.	583	0.19	761	0.32	0.13	0	0.00	-0.19
Morningside Dr.	255	0.08	0	0.00	-0.08	0	0.00	-0.08
Berry St.	655	0.21	782	0.32	0.12	1,002	0.55	0.34
Ripy St.	232	0.07	0	0.00	-0.07	0	0.00	-0.07
Seminary Dr.	700	0.22	868	0.36	0.14	834	0.45	0.23
Felix St.	446	0.14	0	0.00	-0.14	0	0.00	-0.14
Total	3,131	1.00	2,411	1.00	0.00	1,836	1.00	0.00
Exits:								
Hattie St.	692	0.16	708	0.18	0.02	562	0.18	0.02
Rosedale St.	719	0.17	691	0.17	0.01	952	0.31	0.14
Jessamine St.	100	0.02	0	0.00	-0.02	0	0.00	-0.02
Morningside Dr.	194	0.05	289	0.07	0.03	0	0.00	-0.05
Berry St.	718	0.17	730	0.18	0.02	1,601	0.51	0.35
Ripy St.	138	0.03	120	0.03	0.00	0	0.00	-0.03
Bolt St.	389	0.09	0	0.00	-0.09	0	0.00	-0.09
Seminary Dr.	745	0.17	945	0.24	0.06	0	0.00	-0.17
Felix St.	577	0.14	480	0.12	-0.01	0	0.00	-0.14
Total	4,272	1.00	3,963	1.00	0.00	3,115	1.00	0.00

Note: Noon Peak Period is 11:00 A.M.-1:00 P.M.
Note: Proportions may not add to totals due to rounding.

TABLE C-5 Northbound P.M. Peak Period Ramp Volumes: I-35W Reconstruction Zone in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
<u>Entrances:</u>								
Felix St.	697	0.13	0	0.00	-0.13	0	0.00	-0.13
Seminary Dr.	1,311	0.24	1,746	0.32	0.08	0	0.00	-0.24
Ripy St.	381	0.07	0	0.00	-0.07	0	0.00	-0.07
Berry St.	935	0.17	1,223	0.22	0.05	2,283	0.55	0.38
Morningside Dr.	652	0.12	0	0.00	-0.12	0	0.00	-0.12
Jessamine	152	0.03	0	0.00	-0.03	0	0.00	-0.03
Rosedale St.	691	0.13	1,522	0.28	0.15	1,847	0.45	0.32
Hattie St.	682	0.12	1,016	0.18	0.06	0	0.00	-0.12
Total	5,501	1.00	5,507	1.00	0.00	4,130	1.00	0.00
<u>Exits:</u>								
Felix St.	354	0.13	562	0.30	0.17	439	0.27	0.13
Seminary Dr.	568	0.21	414	0.22	0.01	483	0.29	0.08
Berry St.	916	0.34	638	0.34	0.00	727	0.44	0.10
Morningside Dr.	310	0.12	0	0.00	-0.12	0	0.00	-0.12
Rosedale St.	255	0.10	245	0.13	0.04	0	0.00	-0.10
Hattie St.	273	0.10	0	0.00	-0.10	0	0.00	-0.10
Total	2,676	1.00	1,859	0.99	0.00	1,649	1.00	0.00

Note: P.M. Peak Period is 4:00-6:00 P.M.
Note: Proportions may not add to totals due to rounding.

TABLE C-6 Southbound P.M. Peak Period Ramp Volumes: I-35W Reconstruction Zone in Fort Worth

Ramp	Before Reconstruction		Phase I Reconstruction			Phase II Reconstruction		
	Volume	Proportion	Volume	Proportion	Change in Proportion	Volume	Proportion	Change in Proportion
Entrances:								
Hattie St.	510	0.10	0	0.00	-0.10	0	0.00	-0.10
Rosedale St.	820	0.17	1,011	0.31	0.14	0	0.00	-0.17
Morningside Dr.	627	0.13	0	0.00	-0.13	0	0.00	-0.13
Berry St.	774	0.16	1,122	0.35	0.19	1,783	0.63	0.47
Ripy St.	452	0.09	0	0.00	-0.09	0	0.00	-0.09
Seminary Dr.	955	0.19	1,107	0.34	0.15	1,053	0.37	0.18
Felix St.	766	0.16	0	0.00	-0.16	0	0.00	-0.16
Total	4,904	1.00	3,240	1.00	0.00	2,836	1.00	0.00
Exits:								
Hattie St.	613	0.12	566	0.13	0.02	422	0.11	0.00
Rosedale St.	836	0.16	978	0.23	0.07	1,168	0.31	0.15
Jessamine St.	221	0.04	0	0.00	-0.04	0	0.00	-0.04
Morningside Dr.	360	0.07	393	0.09	0.02	0	0.00	-0.07
Berry St.	714	0.14	761	0.18	0.04	2,187	0.58	0.44
Ripy St.	322	0.06	230	0.05	-0.01	0	0.00	-0.06
Bolt St.	578	0.11	0	0.00	-0.11	0	0.00	-0.11
Seminary Dr.	752	0.14	772	0.18	0.04	0	0.00	-0.14
Felix St.	867	0.16	542	0.13	-0.04	0	0.00	-0.16
Total	5,263	1.00	4,242	1.00	0.00	3,777	1.00	0.00

Note: P.M. Peak Period is 4:00-6:00 P.M.
Note: Proportions may not add to totals due to rounding.