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16. Abstract

This report documents the development, construction, and subsequent first year's operation of the North Freeway (I-45N) Transitway in Houston, Texas. The facility and its immediate predecessor, the North Freeway Contraflow Project, are described. A detailed discussion of the problems and unique solutions encountered during the construction and contraflow-to-transitway transition process are also described. Impacts to mainlane traffic, both in the peak and in the off-peak direction, are assessed through an analysis of travel times and speeds, vehicle and passenger flow rates, and freeway accident rates. Transitway operation is assessed through an analysis of HOV demand volumes and peaking characteristics, park-and-ride volumes, travel time savings, occupancy rates, violation rates, disabled vehicle incident rates, and a variety of other performance measures. Comparisons of corridor operations during the contraflow operating period, during the construction period, and during the transitway operating period are discussed and evaluated. Finally, projected facility direct benefits and costs are provided and analyzed.

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METRIC CONVERSION FACTORS

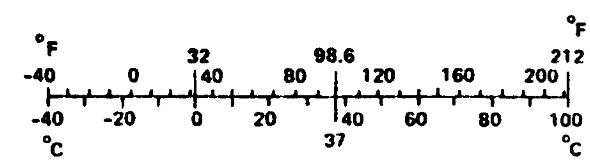
Approximate Conversions to Metric Measures

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

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

Approximate Conversions from Metric Measures

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



The North Freeway Transitway:
Evaluation of the First Year of Barrier-Separated Operation

Prepared by

Nana M. Kuo
Engineering Research Associate

Research Report 339-9

Improving Urban Mobility Through Application
of High Occupancy Vehicle Priority Treatments
Research Study Number 2-10-84-339

Sponsored by

Texas State Department of Highways and Public Transportation
in Cooperation with the
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Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

February 1987

ABSTRACT

This report documents the development, construction, and subsequent first year's operation of the North Freeway (I-45N) Transitway in Houston, Texas. The facility and its immediate predecessor, the North Freeway Contraflow Project, are described. A detailed discussion of the problems and unique solutions encountered during the construction and contraflow-to-transitway transition process are also described. Impacts to mainlane traffic, both in the peak and in the off-peak direction, are assessed through an analysis of travel times and speeds, vehicle and passenger flow rates, and freeway accident rates. Transitway operation is assessed through an analysis of HOV demand volumes and peaking characteristics, park-and-ride volumes, travel time savings, occupancy rates, violation rates, disabled vehicle incident rates, and a variety of other performance measures. Comparisons of corridor operations during the contraflow operating period, during the construction period, and during the transitway operating period are discussed and evaluated. Finally, projected facility direct benefits and costs are provided and analyzed.

SUMMARY

In the last week of November 1984, the North Freeway (I-45N) Transitway officially began operating behind barriers within the median of the freeway from downtown Houston to a distance 9.6 miles north, near North Shepherd Drive. This event was preceded by approximately 10 months of construction and more than 4 years of contraflow operation. The contraflow project was an immense success. The project began operating in August 1979 with less than 1,500 passenger-trips being served in a typical peak period of operation. By September 1983, the project was handling more than 8,000 passenger-trips in an average peak period. However, due to high traffic growth in the off-peak direction, particularly in the afternoon period, operation of the contraflow project was causing undesirable levels of congestion in the off-peak direction, and continuation of the contraflow project could not be justified beyond the mid-1980's. Consequently, plans were initiated to replace the contraflow project with a reversible transitway facility to be located within the median of the freeway (thus no longer removing a lane from off-peak direction use) and to be protected by concrete barriers on either side (thus increasing the safety of operation for both transitway and mainlane vehicles). Median construction progressed from January through November 1984. Although adverse impacts both to mainlane and to contraflow traffic operations were observed during construction, most of the impacts were not permanent. Speeds and flow rates have returned to preconstruction levels in the peak direction, and speeds have continued to improve in the off-peak direction since the discontinuation of contraflow operation. Furthermore, accident rates over both freeway directions have dropped to a level even lower than that which existed before construction began.

Transitway demand has been stable over the first year of barrier-separated median operation. In an average day, the transitway carried more than 14,500 people in less than 825 vehicles (buses and vans). These transitway users were able to save an average of 9 minutes on every trip made in the transitway. Although total transitway demand remained more or less constant in the first year of operation, park-and-ride utilization has climbed by 14% over the same 12-month period. The increase in bus ridership

was offset by an equivalent decrease in vanpool ridership (likely the result of the discontinuation of vanpool sponsorship by various downtown companies resulting from the economic downturn).

Transitway peaking of demand is driven primarily by vanpool volumes. Bus volumes run on scheduled headways that do not vary much over the morning or the afternoon operating periods. Vanpool volumes, however, peak very sharply. More than 65% of peak period vanpools use the facility during a typical peakhour of operation, with 20% to 30% using the transitway in the peak 15-minutes. In the morning period, the peak 15-minutes of flow begins at 6:45 a.m. In the afternoon, vanpool volumes peak at two separate 15-minute time periods starting at 4:30 p.m. and at 5:15 p.m.

Transitway operating hours extend from 6:00 to 8:30 in the morning and from 3:45 to 6:30 in the afternoon. The facility is currently controlled manually by an on-site METRO (transit authority) crew. However, by 1987, the facility is expected to be fully automated with an integrated system of closed-circuit television surveillance and centralized computer controls. Over the first year of transitway operation, approximately 8.5 vehicles per month either became or were found disabled within the transitway. Less than 50% of these disabled vehicles had to be towed out of the facility. Accidents (including near misses and all other incidents involving any physical damage to vehicles or to facility equipment) occurred at a rate of 1.6 incidents per month. Finally, more than 112 unauthorized vehicles entered the transitway each month with a vast majority of these violations occurring in the afternoon period.

Overall, corridor-wide traffic operation has progressively improved since the implementation of the median transitway. Passenger through put (total, freeway plus transitway) has increased from less than 18,600 passenger-trips in a typical 3-hour peak period to more than 19,500 passenger-trips in the same 3-hour period, more than 34% of which was carried by the transitway. Occupancy rates have climbed from 1.5 passengers per vehicle to 1.7 passengers per vehicle.

Based upon average transitway volumes in the first year of transitway operation, transitway users cumulatively realized an average travel time savings of almost 2,200 person-hours per day over parallel freeway mainlane travelers. These travel time savings translate into a benefit of almost $4.3 million each year. Combining these travel time savings with reduced bus operating cost savings, a total present value direct benefit of $42.0 million over a 20-year period may be obtained. With direct construction and operating costs of $15.2 million, the transitway confirms its cost-effectiveness with a benefit to cost ratio of almost 3:1.

IMPLEMENTATION STATEMENT

This study was sponsored by the Texas State Department of Highways and Public Transportation as part of an overall effort entitled "Improving Urban Mobility Through Application of High Occupancy Vehicle Priority Treatments" (Research Study Number 2-10-84-339). An objective of this research is to evaluate for the Department the implementation of high occupancy vehicle priority treatment projects. An intent of these evaluations is to develop guidelines for planning, designing, and operating transitways on Texas freeways. This is the first evaluation report on the North Transitway.

DISCLAIMER

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INTRODUCTION

The North Freeway (I-45N) in Houston is a major interstate highway serving travel demands from northern Harris and Montgomery Counties to various parts of Houston (Figure 1). Extensive residential and commercial development has occurred along this corridor. In the Greenspoint vicinity alone, more than 10 million square feet of commercial space has been completed or committed. The population within the corridor has been estimated to grow by 38% between 1980 and 1995, resulting in a population of around 88,000 people in the area by 1995 (1). This development and population growth has led to progressively worse levels of traffic congestion throughout the corridor. Average daily traffic volumes in 1984 were already greater than 194,000 vehicles in an 8-lane section. Even in 1983, peak direction speeds averaged less than 30 mph in the afternoon peak hour and less than 25 mph in the morning peak hour. The North Freeway has been one of Houston's more congested freeways for many years.

As early as 1979, the Texas State Department of Highways and Public Transportation (SDHPT) and the Metropolitan Transit Authority of Harris County (METRO) cooperated to bring a 9.6 mile contraflow lane into operation on the North Freeway between downtown Houston and North Shepherd Drive (Figure 2). This joint project was an interim measure designed to relieve some of the corridors congestion by providing some additional peak direction capacity. This peak direction capacity was obtained without extensive roadway construction. A lane was "borrowed" from off-peak direction flow and dedicated to registered high-occupancy vehicles (HOVs) traveling in the peak direction. Since the project began in 1979, utilization increased steadily from approximately 2900 daily passengers in September 1979 to more than 16,500 daily passengers (its highest utilization rate) in September 1983 (1). Because of the high occupancy rates of the vehicles utilizing the contraflow lane, as well as the high peaking characteristics of contraflow vanpools, the contraflow lane was serving more passenger trips during a typical peak hour of operation than two adjacent freeway lanes.

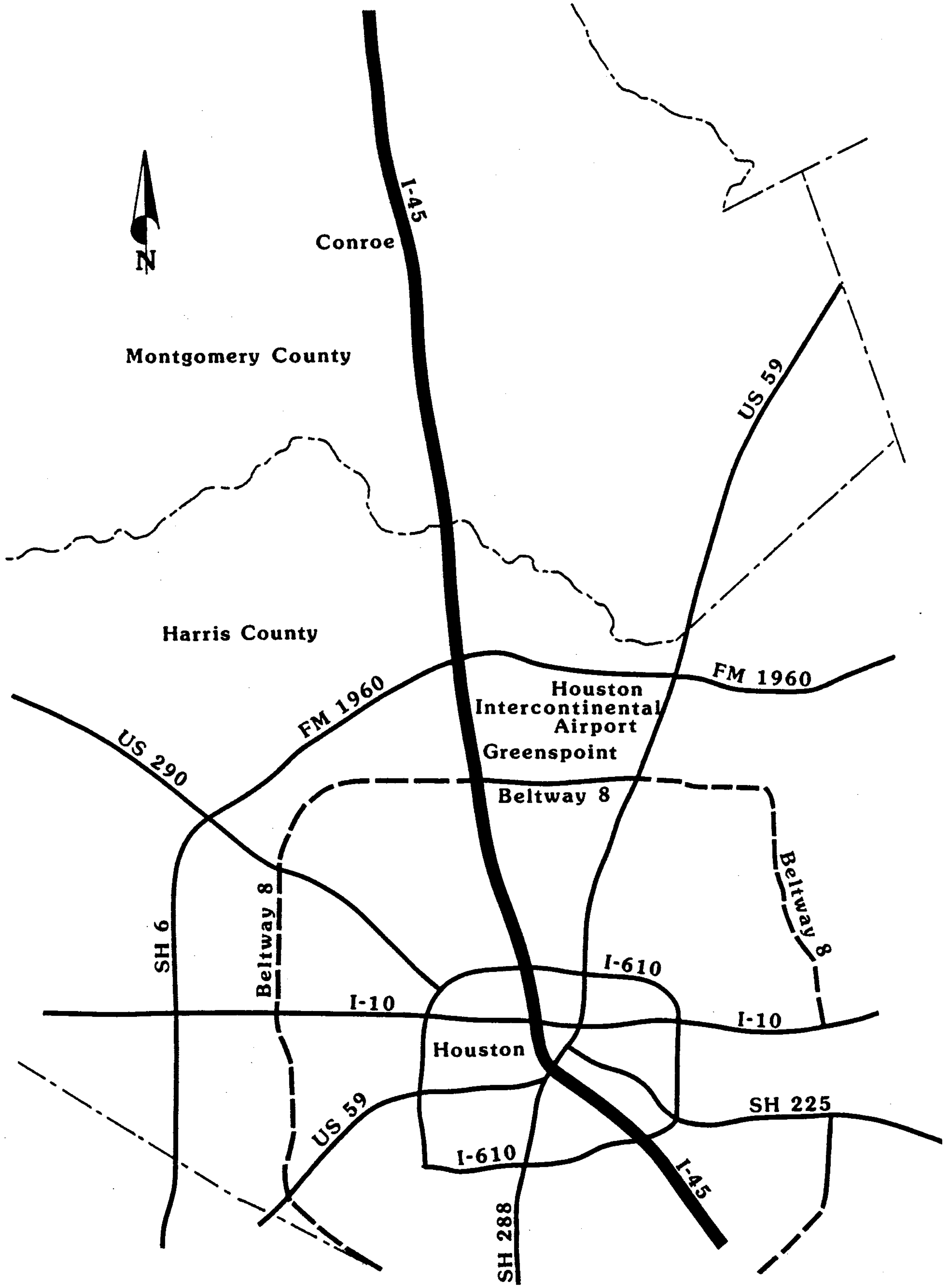


Figure 1. North Freeway (I-45N) Service Corridor

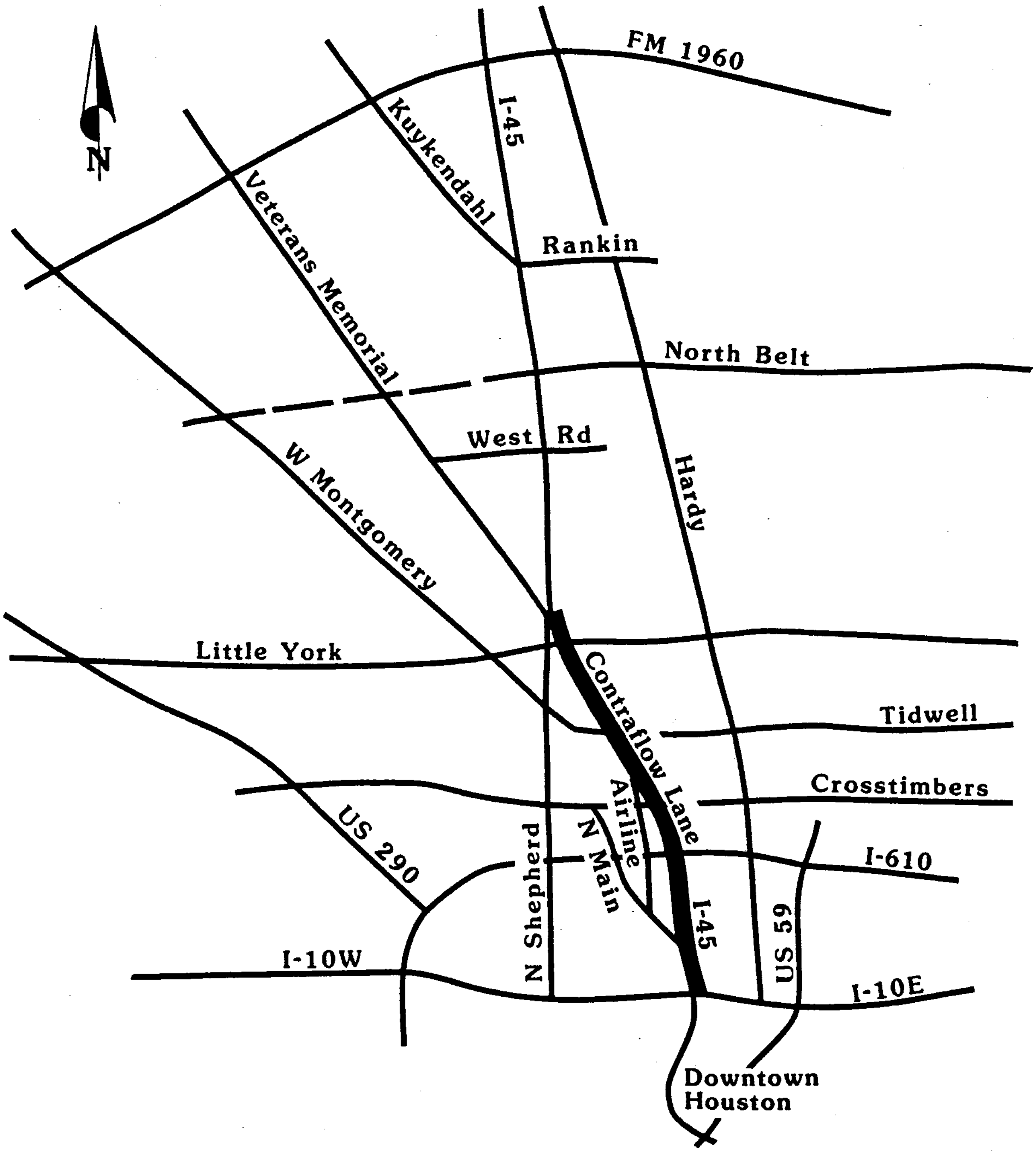


Figure 2. North Freeway Contraflow Project Limits

Unfortunately, the contraflow project could be considered only an interim solution to the corridor's need for additional capacity. Due to increases in the off-peak direction traffic volumes, a lane could not continue to be borrowed from the off-peak direction beyond the mid 1980's without increasing off-peak direction congestion to unacceptable levels. The critical point in time was imminent. Although the continuation of the contraflow project was no longer desirable, neither was it economically nor physically feasible to provide enough additional lanes to satisfy even existing peak period travel demand let alone projected future demand levels. The need for a transitway was clear; moreover, the construction of a transitway within a relatively short time frame was critical in order to preserve the express transit benefits and the resulting transit ridership levels that were derived from the availability of the contraflow lane.

In 1982, SDHPT and METRO agreed to develop a transitway in the median of the North Freeway as part of a corridor wide improvement project which included widening bridges and providing better paving, more efficient and safer lighting, and better drainage, as well as expanding the number of lanes to add capacity along a 9 mile segment of the freeway from the North Loop (I-610) to the North Belt (Beltway 8). This report documents the development, construction and subsequent first year of operation of this transitway within the North Freeway Corridor.

NORTH FREEWAY CONTRAFLOW PROJECT

In 1974, soon after the City of Houston purchased the local bus system from a private operator, discussions regarding express, preferential treatments for Houston's transit vehicles were initiated with the Texas State Department of Highways and Public Transportation (SDHPT). In January 1975, the North Freeway (I-45N) corridor was identified as a potential candidate for the implementation of one particular type of preferential treatment -- contraflow operation.

The contraflow concept is a means to utilize existing freeway capacity more fully. The excess capacity which is usually available in the off-peak direction on radial freeways is siphoned off for peak-flow use. The median, innermost freeway lane is 'borrowed' from the off-peak flow and dedicated for use by high-occupancy vehicles traveling in the peak-flow direction. A prerequisite for this 'borrowing' to be tenable, is that traffic flow must be so unevenly distributed between the peak and the off-peak directions of flow that the off-peak direction traffic will not be pushed into forced flow operation once a lane is removed for contraflow use. At the time the contraflow concept was initially suggested as being an idea which could be applied on the North Freeway, the directional split on the North Freeway was as high as 70/30 at some locations in the peak direction during morning peak-hour operation. The directional split in the afternoon was also heavily distributed towards the peak flow direction, but steady gains in the off-peak direction traffic volumes were already eroding the extremity of this directional imbalance. Consequently, selective off-peak direction ramp metering and ramp closures were considered in concert with the contraflow project to improve off-peak direction traffic flow (2).

Extensive feasibility and operational studies were completed in the 3 years after the concept was first suggested. Federal funding for a demonstration project was obtained from the Urban Mass Transportation Administration and construction for the project was begun in February 1978. In 1979, the Metropolitan Transit Authority of Harris County (METRO) was created and assumed the city's responsibilities in regard to this project. Sixteen months after construction began, the project was completed, and the Houston I-45 Contraflow Lane (CFL) was subsequently brought into operation in August 1979 (2).

The North Freeway CFL extended from downtown Houston to a distance 9.6 miles north (Figure 2). The project 'borrowed' the innermost traffic lane (i.e. the lane closest to the median) from the off-peak flow direction and used the lane for registered buses and vanpools traveling in the peak direction during each of the peak periods. Emergency shoulders located next to the median throughout most of the project's length allowed contraflow vehicles to bypass disabled vehicles or minor incidents within the contraflow lane. Figure 3 illustrates a typical freeway cross-section within the CFL project limits.

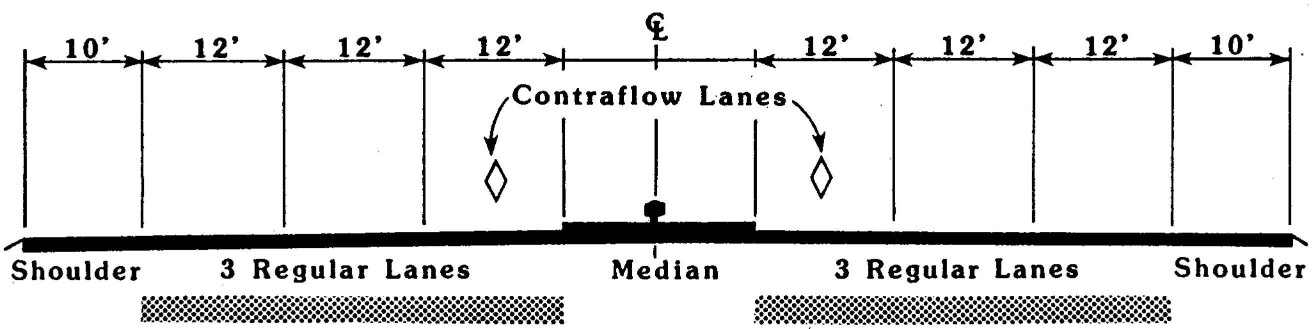


Figure 3. Typical Freeway Contraflow Cross-Section, I-45N Houston

At the northern terminus of the CFL near North Shepherd, morning access to the CFL was obtained either from a concurrent flow freeway lane north of the project or from a primary arterial (Stuebner-Airline Road) serving the nearby North Shepherd park-and-ride lot through a special 'button-hook' ramp. In the afternoon, the same button hook ramp was used to exit the CFL onto Stuebner-Airline; otherwise, vehicles were directed across the median to merge back into mixed flow freeway traffic on the left-hand side. The northern terminus and its operation are illustrated in Figure 4.

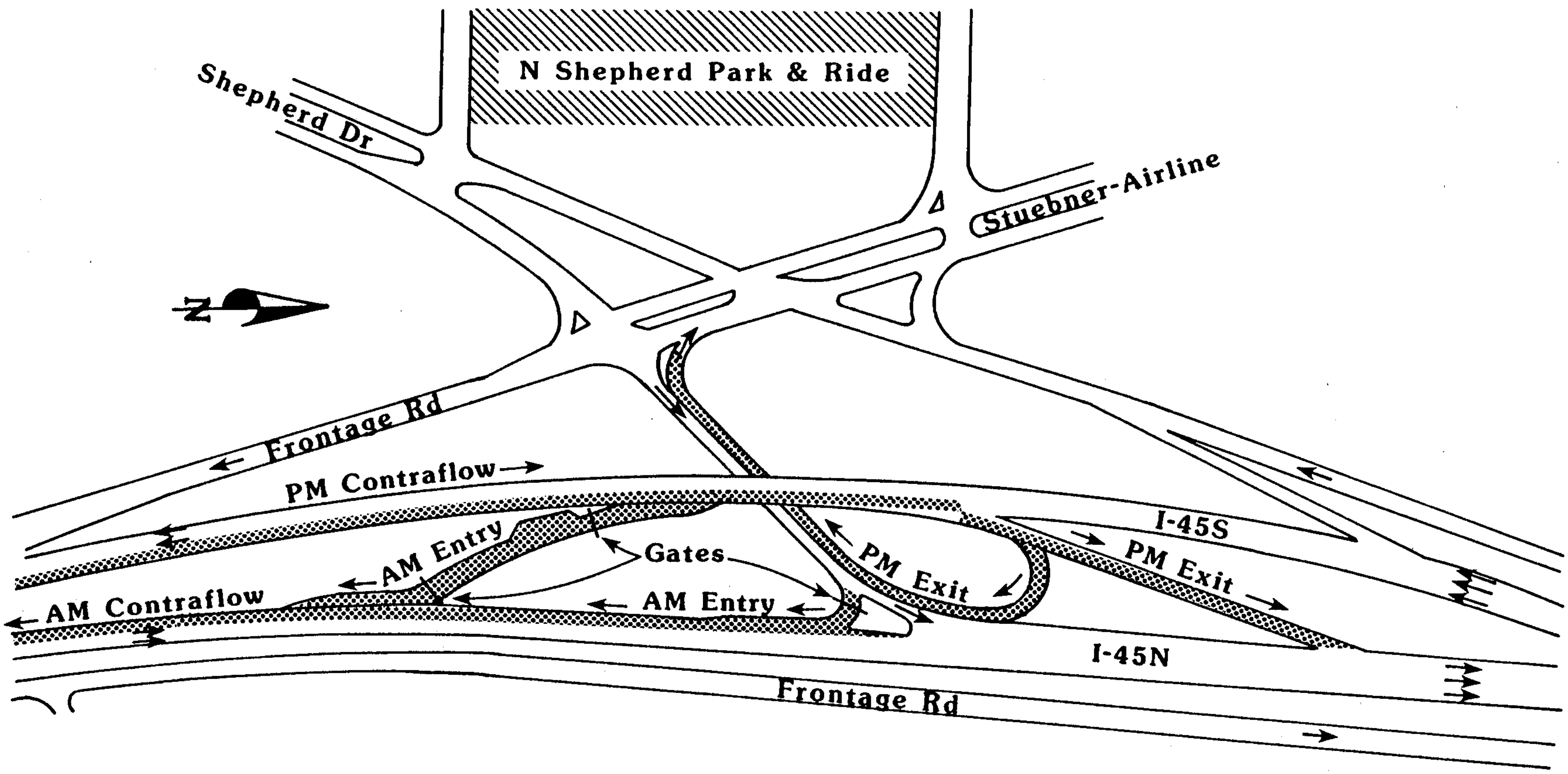


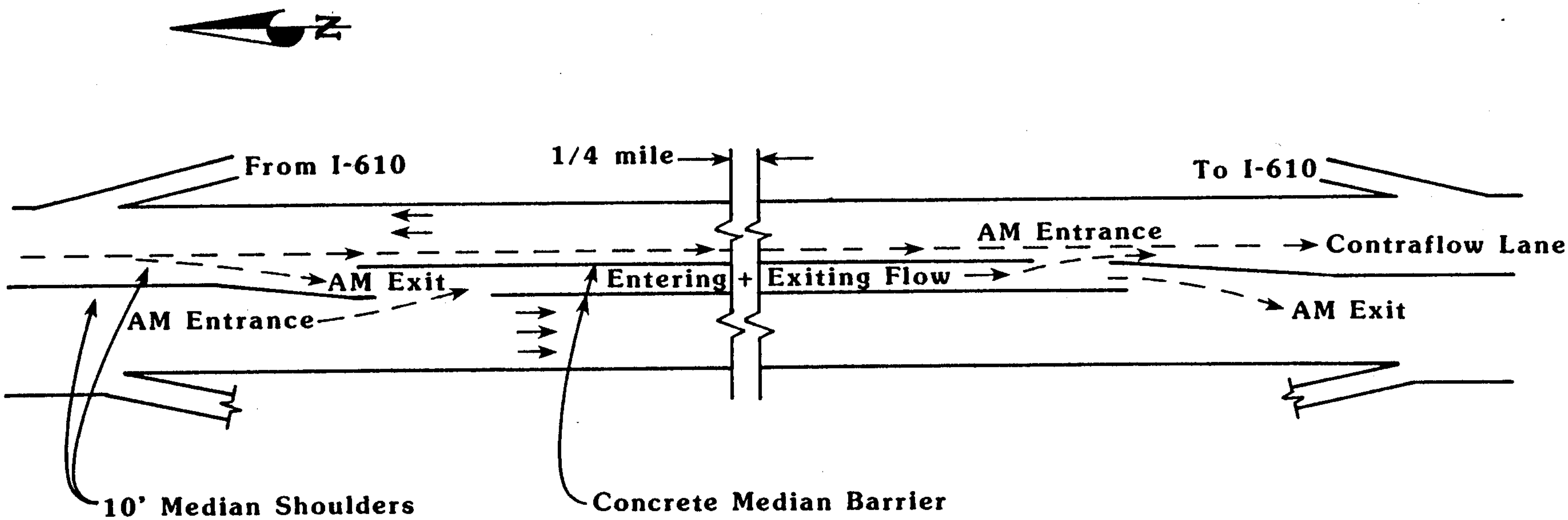
Figure 4. Contraflow Terminus at North Shepherd

About halfway through the lane, near the North Loop (I-610), a crossover location was implemented to provide a means for emergency diversion onto the mainlanes should an incident block the lane downstream. The crossover was designed with staggered openings and was separated from freeway traffic by concrete median barriers on both sides (Figure 5).

The southern terminus of the CFL fed directly into the downtown local street system. In the morning, near the I-10/I-45 interchange, CFL vehicles crossed over the median to a reversible-flow lane which was delineated on the inside shoulder of the southbound lanes. This reversible-flow shoulder lane was then connected with an exclusive, barrier-separated reversible median lane which subsequently fed the CFL traffic onto another contraflow segment operating along an outbound ramp connector from the downtown street network. In the afternoon, operation was reversed, and outbound CFL vehicles accessed the facility directly from outbound mixed-flow traffic. The design and operation of the CFL's southern terminus is illustrated in Figure 6.

METRO field crews were responsible for manually setting up and taking down the lane as well as for operating the entrance ramp gates that controlled entry into the CFL (Figure 7). Transit police, (city police in the early years) were also stationed at the entry points to enforce authorized use of the facility. A combination of stationary signs with flashing yellow beacons, lane control signals placed over the CFL and adjacent lanes at critical locations, white diamond pavement markings designating the reserved lane, various fixed and changeable message signs near the approach to the CFL project, and yellow plastic pylons which were inserted into holes in the pavement at 40-foot intervals (20-foot intervals within critical freeway sections) were used to provide adequate warning, guidance, and general information to CFL and non-CFL motorists alike. These treatments are illustrated in Figures 8 through 12.

The I-45 Contraflow Lane operated in the morning from 6:00 am to 8:30 am, and in the afternoon from 4:00 pm to 6:30 pm. Set-up (including clearing out the innermost off-peak direction freeway lane) and take-down (including reopening the innermost lane for mixed flow use) procedures each required approximately 1.5 hours for completion. This effectively extended the hours



Note: This crossover was not used during normal operation. It provided a means of diverting traffic in the event of a contraflow incident.

Figure 5. Contraflow Crossover at I-610

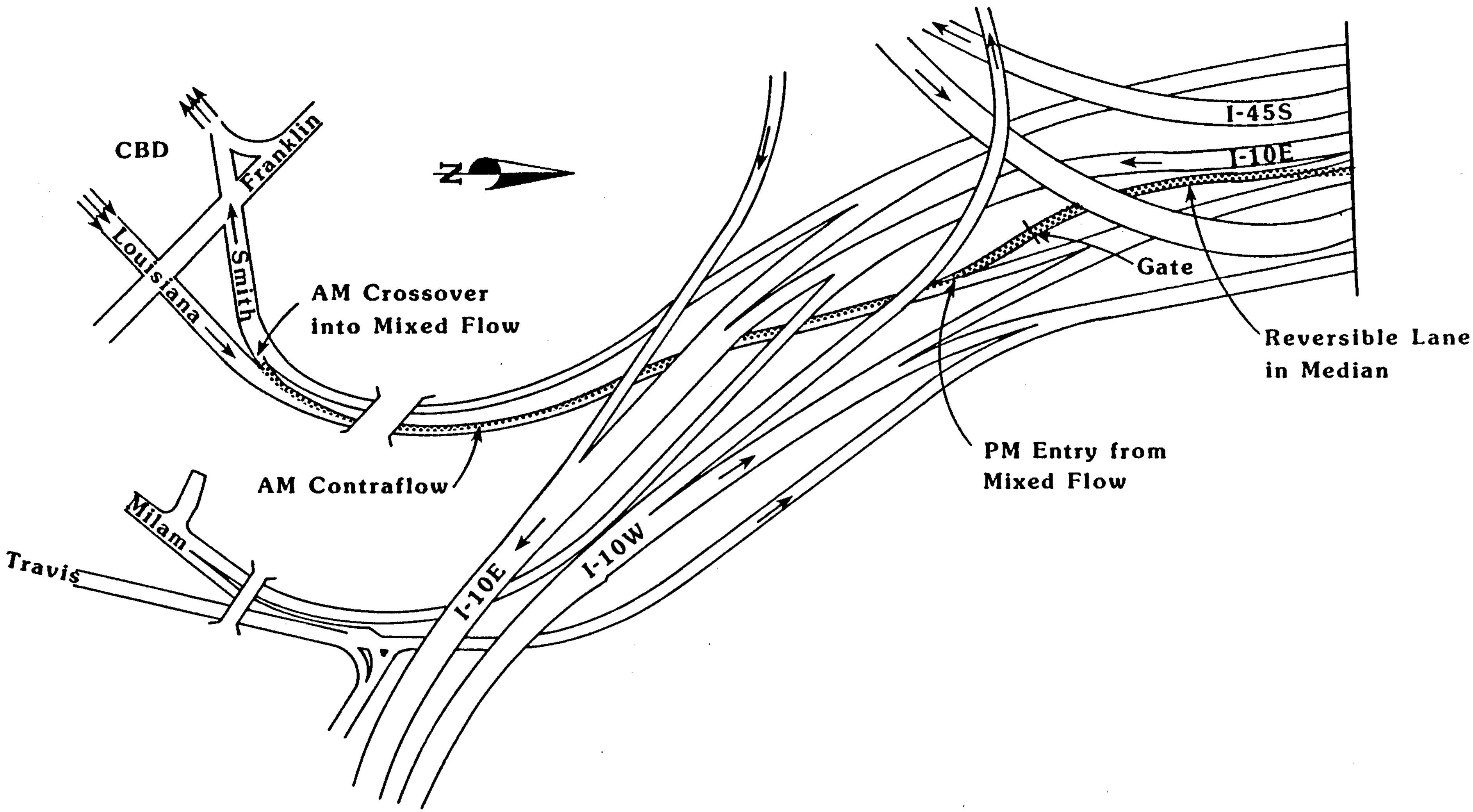


Figure 6. Downtown Contraflow Terminus

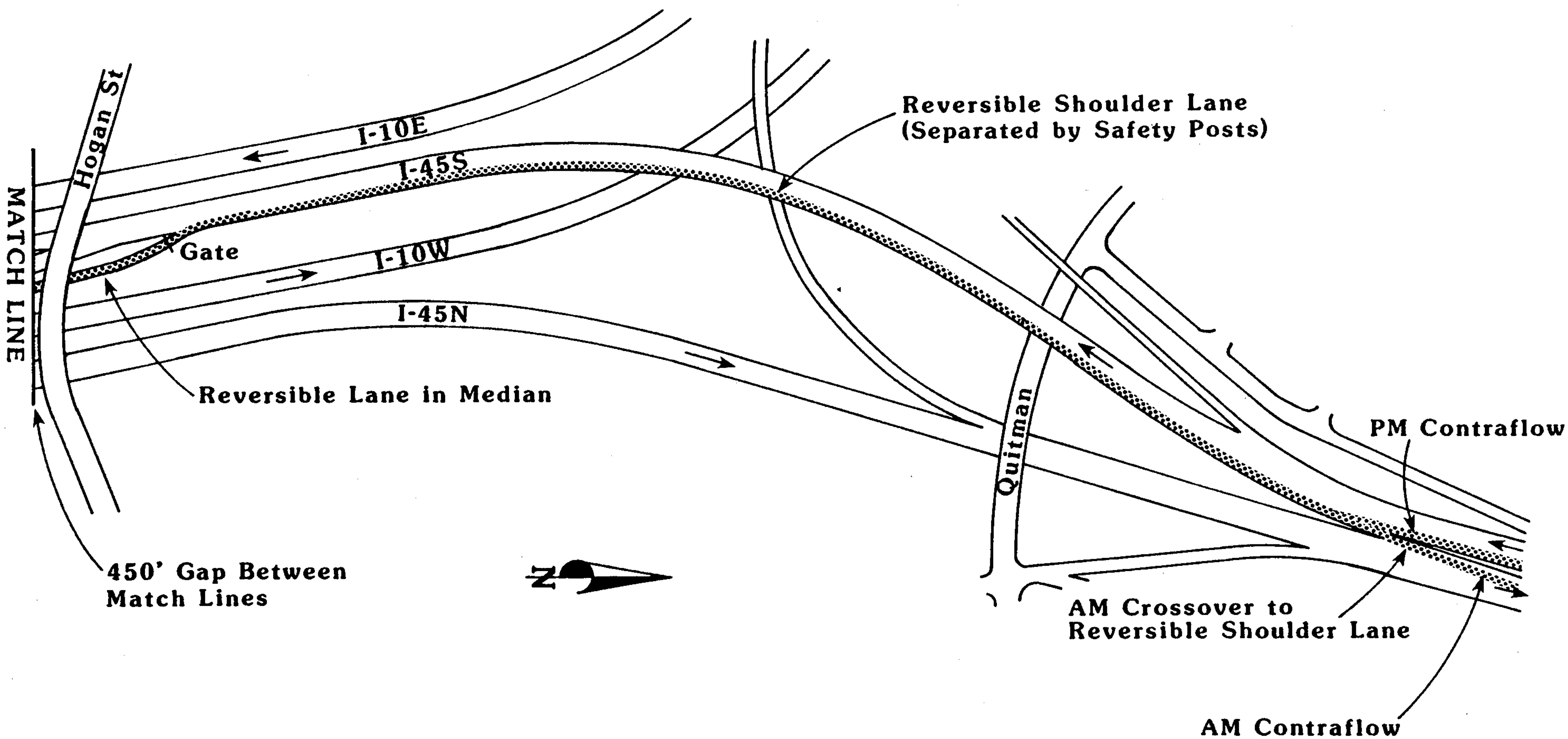


Figure 6. Downtown Contraflow Terminus (Continued)

Figure 7. Contraflow Set-Up and Take-Down

Figure 8. CFL Stationary Signs with Flashing Yellow Beacons

during which the innermost off-peak direction traffic lane was not available to mixed-flow traffic to 4:30 am to 10:00 am and 2:30 pm to 8:00 pm. The setup of the contraflow lane was accomplished with the flow of traffic, and the take-down was accomplished against the flow of traffic in order to minimize traffic disruption while protecting the CFL operating crew performing the setup and takedown tasks.

During the first 18 months of operation, operating costs for the contraflow lane were covered equally by METRO and UMTA (through a Service and Methods Demonstration (SMD) grant). These costs averaged approximately $50,200 per month, or $602,400 annually, during the demonstration period. After the demonstration period ended, METRO assumed the CFL's entire operating cost which, in 1984, averaged approximately $600,000 annually (3).

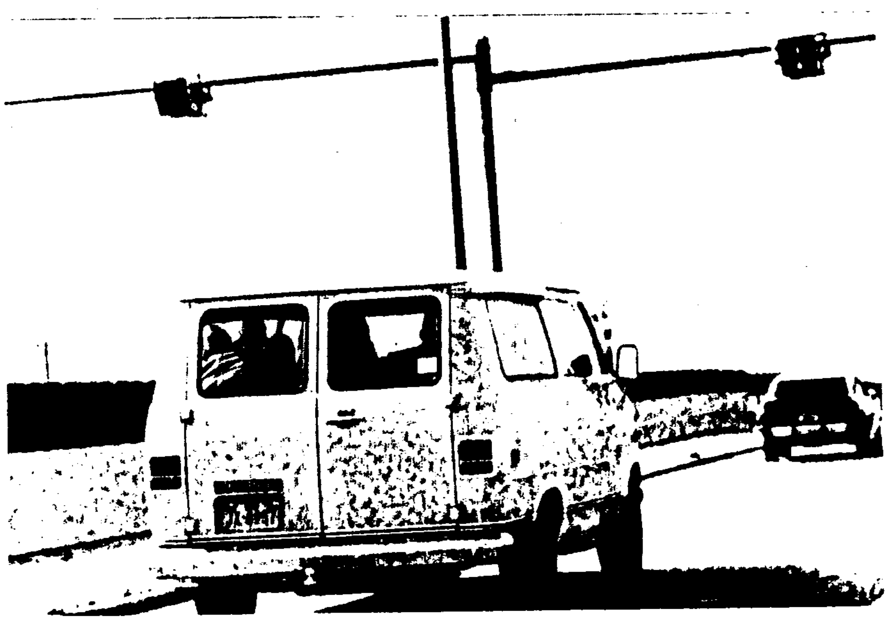


Figure 9. Contraflow Overhead Lane Control Signals

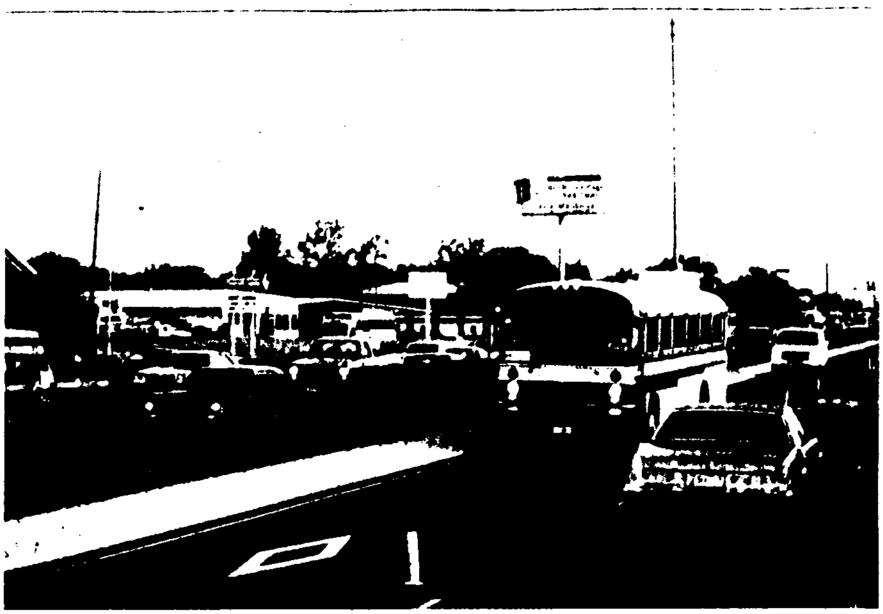


Figure 10. Contraflow Diamond Pavement Markings and Yellow Plastic Pylons

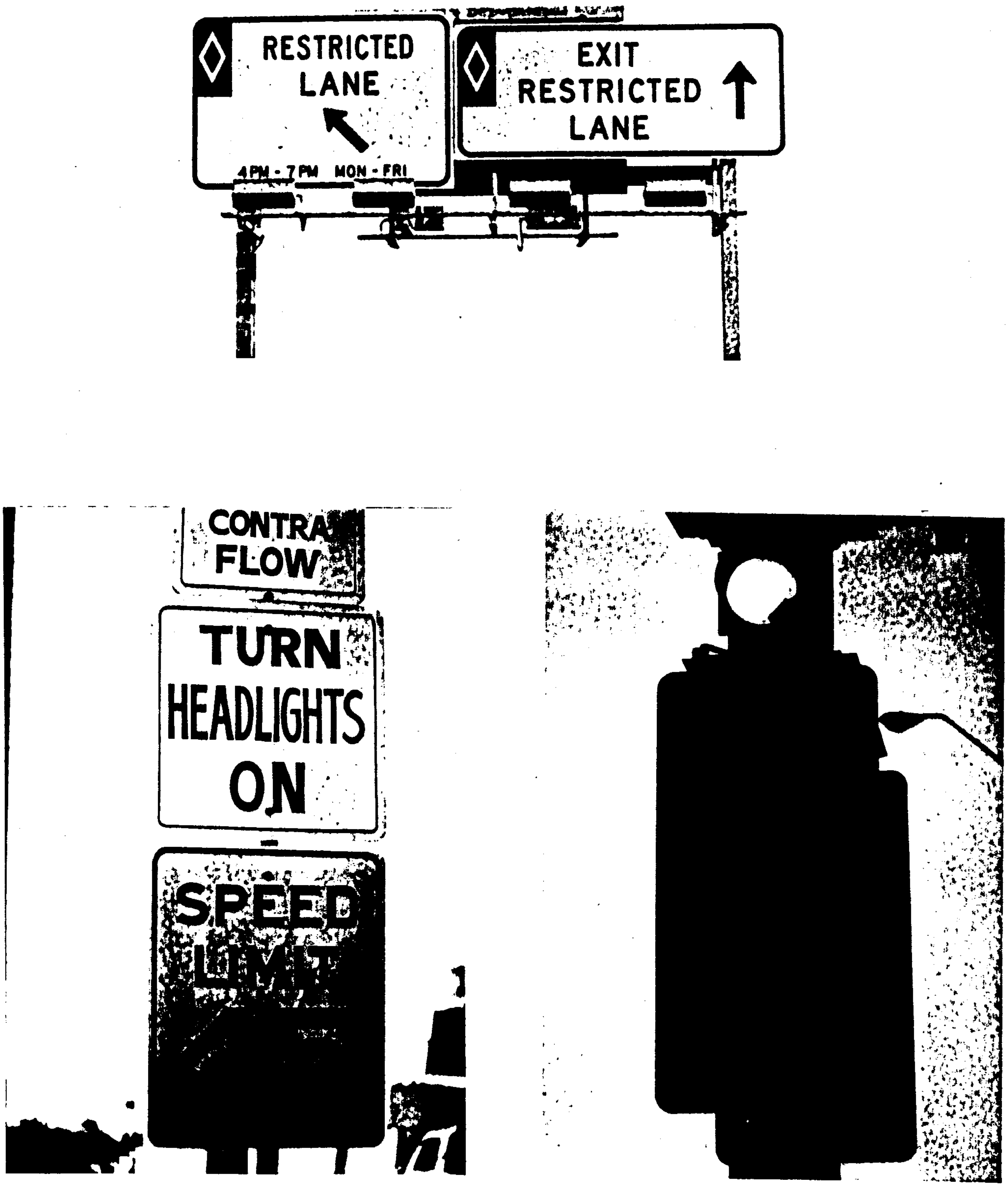


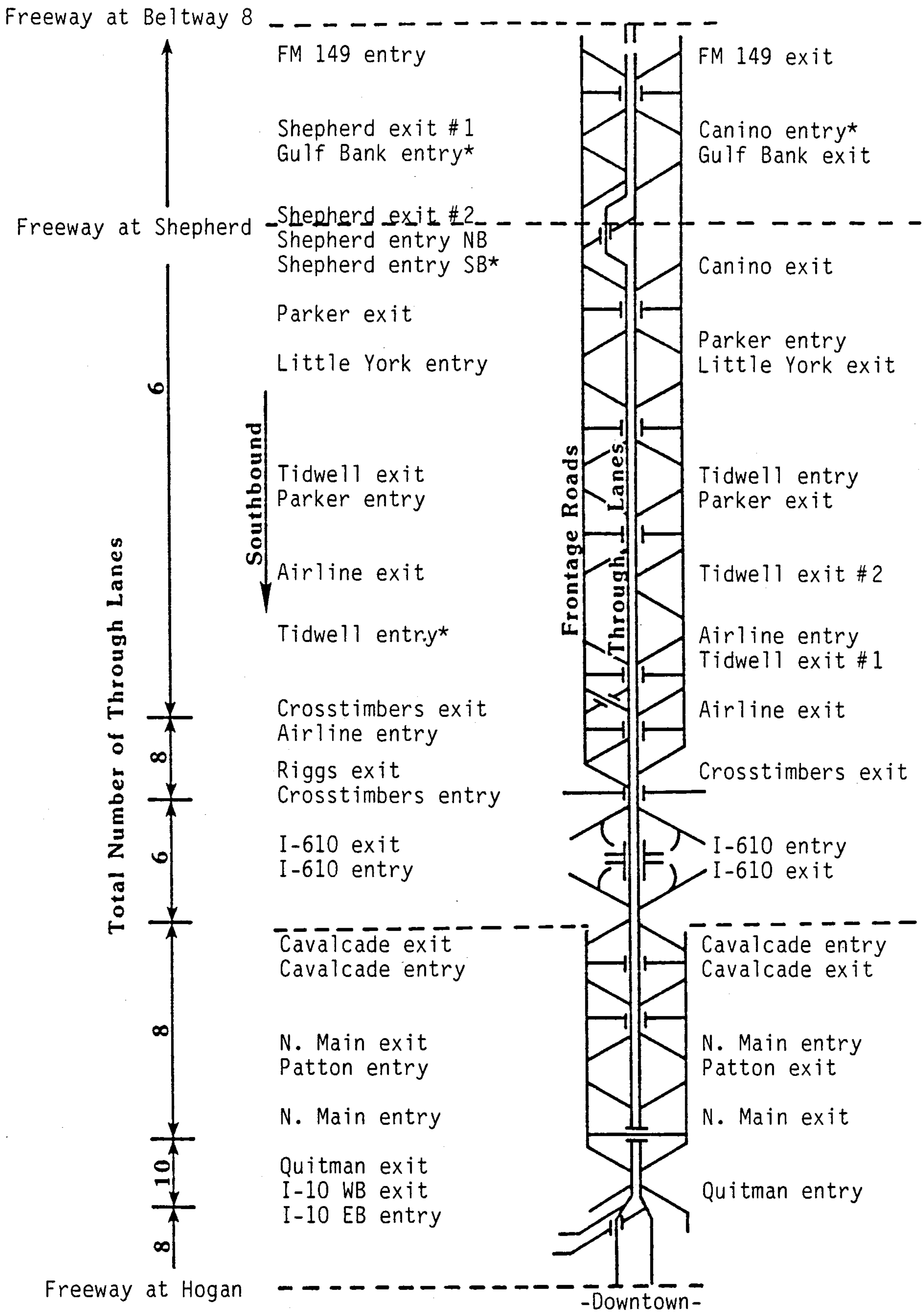
Figure 11. Contraflow Fixed Message Signs

Figure 12. Contraflow Changeable Message Signs

In conjunction with the implementation of the contraflow project, two issues had to be addressed: 1) the maintenance of an acceptable level of service in the off-peak direction during contraflow operation, and 2) the generation of sufficient transit demand in a corridor which had previously not received much transit service. The first issue was partially addressed through the use of selected temporary ramp closures and through the introduction of entry ramp controls with localized mainlane density detectors (Figure 13). These ramp controls were designed to be activated when off-peak direction density detectors indicated that diversion onto or along the frontage road or onto other parallel arterials was desirable to reduce traffic congestion on the freeway mainlanes. The second issue was addressed by the provision of park-and-ride facilities within the corridor. The initial facilities were: 1) the North Shepherd lot, located at the northern terminus of the CFL, 2) the Kuykendahl lot, located approximately 6.5 miles north of the northern terminus, 3) the Greenspoint lot, located about 5 miles north of the CFL at Greenspoint Mall, and 4) the Champions lot, located approximately 14 miles north of the CFL at a local church parking lot within the Champions subdivision (Figure 14).

The North Shepherd lot was built by SDHPT with Federal Aid Urban System funding and opened with a capacity of 750 spaces in May 1980. The Kuykendahl lot was constructed by METRO with local funding and opened in January 1980 with a capacity of 1300 spaces. The Greenspoint and the Champions park-and-ride lots were both temporary facilities which were established in order to allow the CFL to begin operating as soon as it was completed. The North Shepherd and the Kuykendahl lots were not going to be ready until after the CFL opening date. The Greenspoint lot operated from August 1979 to December 1979, at which time Christmas shopping activity at the mall forced the lot to be relocated to the Aldine High School Stadium parking lot. This Aldine operation was subsequently terminated when the Kuykendahl facility was completed in January 1980. The Champions lot had a capacity of 350 spaces and continued to operate from August 1979 until October 1982 when a 1280-space facility was completed in the Spring area (3).

In addition to the four park-and-ride facilities originally planned to serve the CFL, a 1286-space facility in the Seton Lake area several miles



*Locations of Temporary Ramp Closures

Figure 13. Contraflow-Related Ramp Closures and Metering

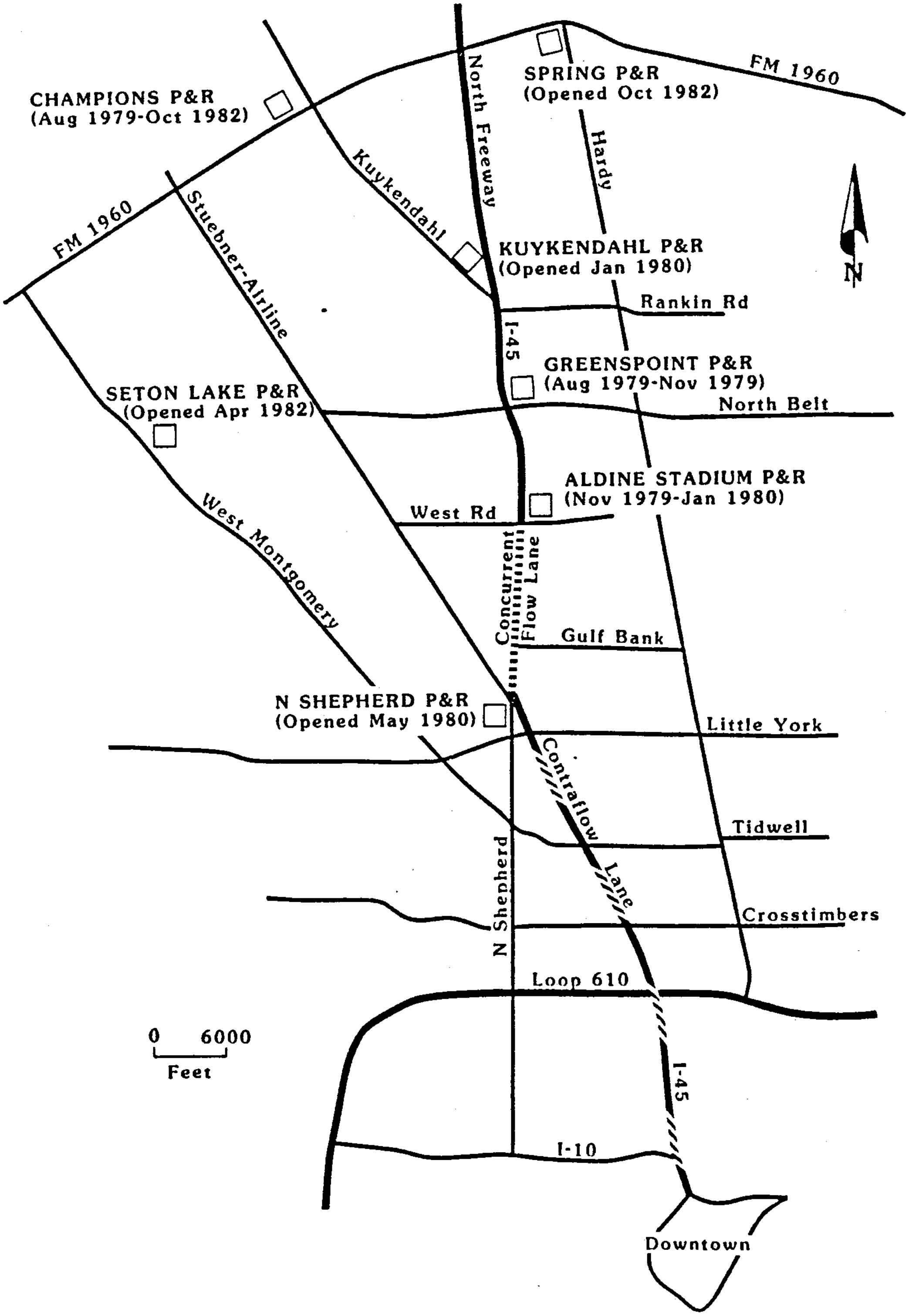


Figure 14. Contraflow Park-and-Ride Lots

west of the freeway was completed in April 1983. The Kuykendahl and the North Shepherd lots were also expanded in 1983 to 2246 and 1605 spaces respectively. These expansions brought the total corridor park-and-ride parking capacity to more than 6400 spaces available to North Freeway corridor residents. All four permanent facilities, Kuykendahl, North Shepherd, Spring, and Seton Lake, have 'kiss-and-ride' drop off areas, handicapped spaces, covered bus boarding areas, security lighting and fences, and other amenities generally provided to park-and-ride patrons (3).

The I-45 Contraflow Lane provided daily travel time savings of more than 15-minutes to CFL users. These travel time savings helped to fuel the rapid increase in CFL patronage. Utilization grew from an initial volume of 1450 person-trips per peak period to 4600 person-trips per peak period in its first year of operation (Figure 15). These high passenger volumes were accomplished through the authorization of both registered buses and 8+ vanpools. The I-45 Contraflow Lane was the first freeway HOV project to permit vanpools to use the facility. The decision to allow 8+ vanpools into the CFL was precipitated by several factors. Foremost among these considerations was the awareness that bus volumes alone would not be sufficient to ensure the visibility of the contraflow operation to oncoming traffic (and thus the safety of the contraflow lane). Consequently, vanpools were identified as an additional group of high occupancy vehicles which could contribute substantially to CFL volumes without presenting unreasonable traffic management and enforcement problems.

Initially, vanpool vehicle volumes exceeded bus volumes by a ratio of 3:1, although vanpool passenger volumes were only slightly greater than bus passenger volumes (Figure 16). However, within a year, although bus vehicle volumes rose only slightly while vanpool volumes continued to grow at a high rate, buses began carrying more passenger-trips than vanpools. Subsequently, bus patronage along the I-45 corridor continued to grow rapidly such that, by the time the contraflow project was finally terminated and the facility converted to a completely barrier-separated median HOV lane, bus passenger volumes exceeded vanpool passenger volumes by more than 2:1 though vanpool vehicle volumes still exceeded bus vehicle volumes by nearly 2:1.

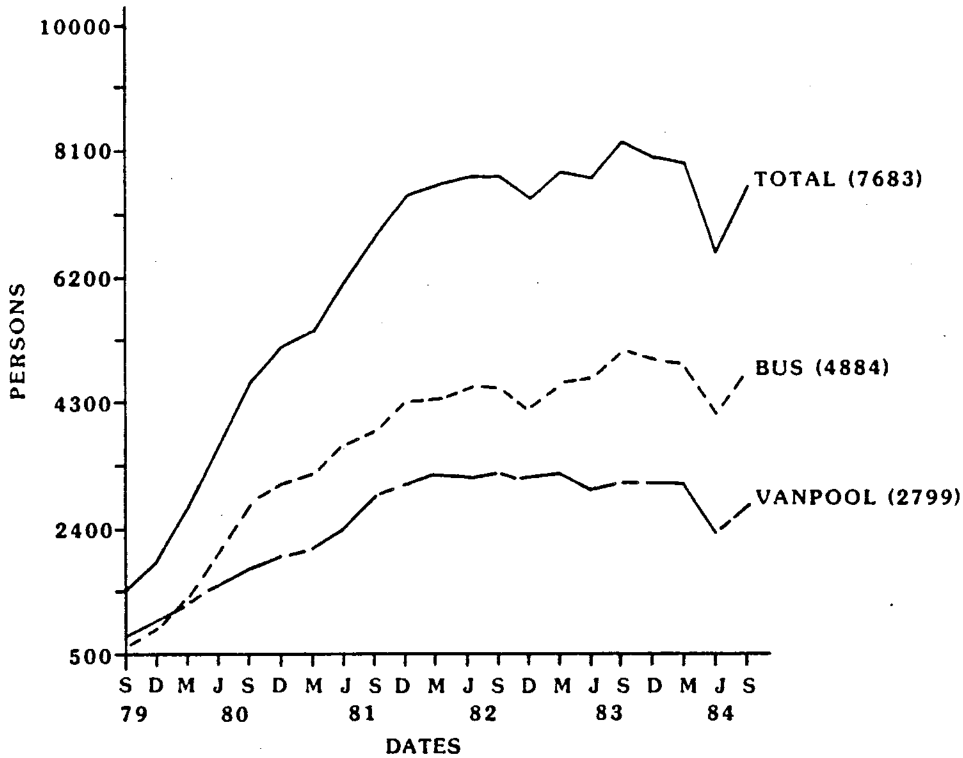


Figure 15. Contraflow Peak Period Passenger Volumes, 1979-1984

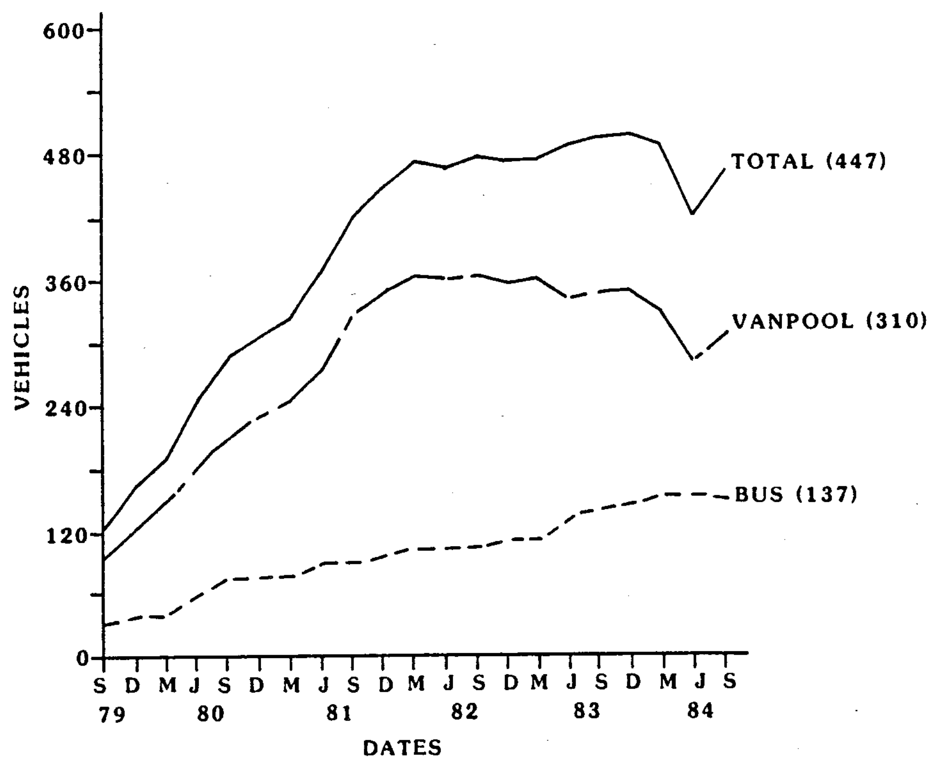


Figure 16. Contraflow Peak Period Vehicle Volumes, 1979-1984

As ridership increased on the CFL, so too did the morning inbound traffic volumes upstream of the CFL. Congestion, extending several miles north of the CFL's northern terminus near North Shepherd Drive, was causing CFL vehicles to experience delays between 5 and 15 minutes in accessing the facility each morning. In response to this problem, the SDHPT and METRO implemented a 3.3 mile concurrent flow lane in the inbound median shoulder of the North Freeway from the northern terminus of the CFL to North Belt (Figures 17 and 18). This concurrent-flow extension of the contraflow project helped CFL users to save an additional 5 minutes and more per trip each morning (3). This was a morning improvement only since a left travel freeway ramp precluded a similar operation in the afternoon.

Before the concurrent flow lane was available, approximately 78% of all vanpools entered the CFL from the I-45 mainlanes as opposed to the North Shepherd access ramp. Within one month after the concurrent flow lane was opened to CFL users (in the last week of March 1981), 95% of the vanpools were entering the facility from the concurrent flow lane. By the time the contraflow lane was finally replaced by the first phase of the North Freeway Transitway, about 90% of the vanpools and 85% of the buses were using the concurrent flow lane to gain access to the contraflow lane in the morning (4).

After more than 4 years of contraflow operation, only 15 serious accidents involving vehicles within the contraflow lane were observed. Three fatalities and several serious injuries resulted. A vast majority (80%) of these accidents involved non-priority vehicles swerving into the contraflow lane and colliding with contraflow vehicles. The first contraflow lane related fatalities occurred in April 1980 when an auto driver skidded out of control in rainy weather, entered the contraflow lane and was killed instantly. The second and third contraflow related fatalities occurred in September 1980 and in June 1982. Each incident involved a contraflow bus striking a pedestrian attempting to cross the freeway.

Contraflow was never intended as a long-term improvement to the corridor. At the outset of the contraflow project, it was recognized that at some time in the future, off-peak direction traffic would increase

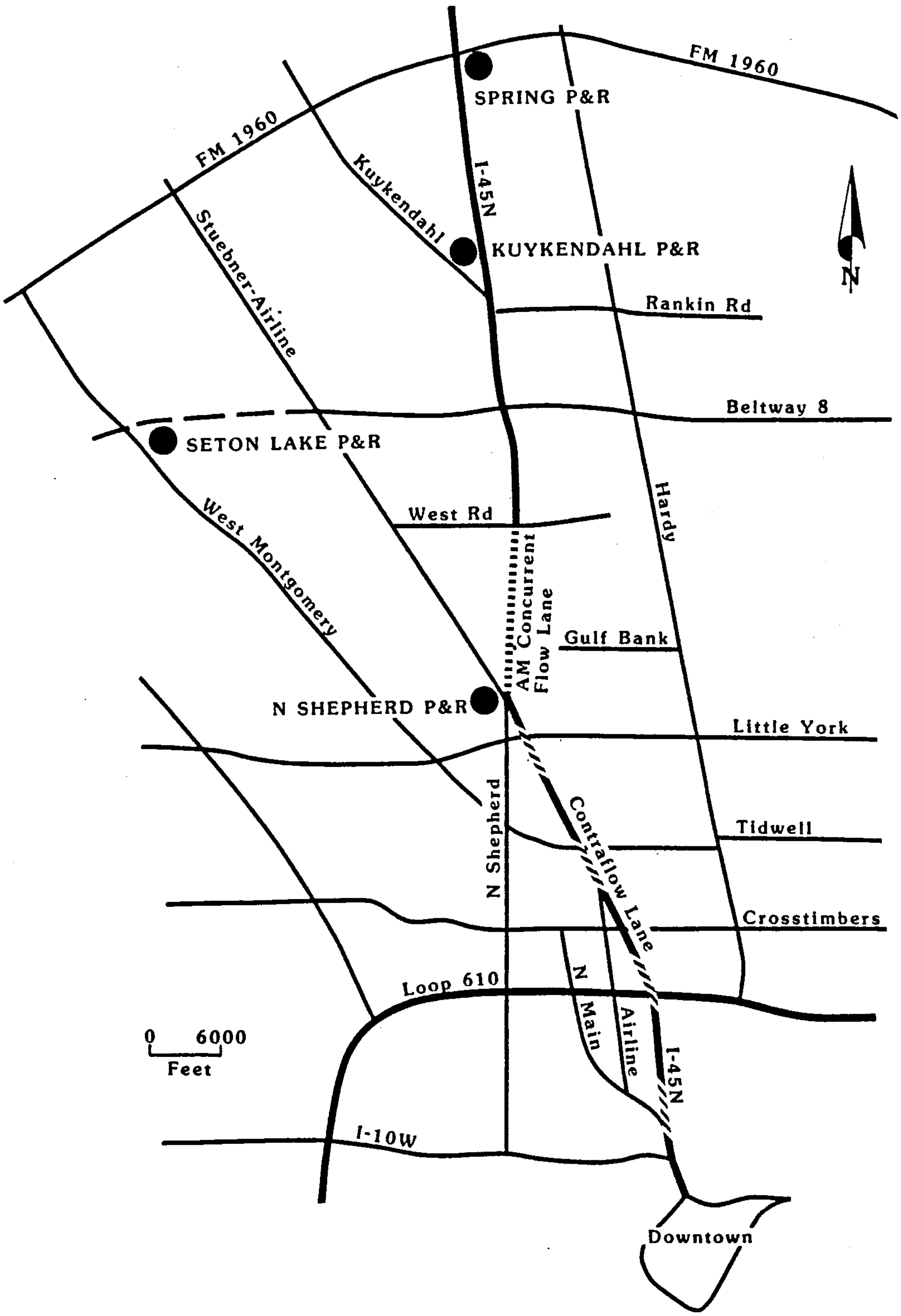


Figure 17. North Freeway Concurrent Flow Project Limits

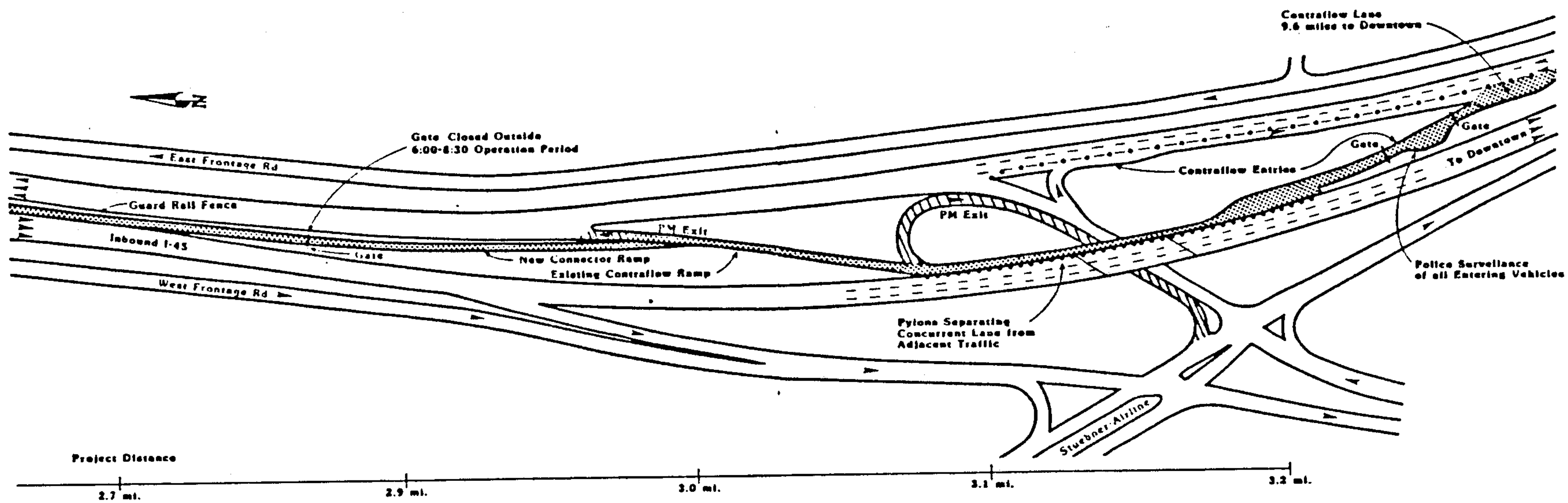


Figure 18. Concurrent Flow Access to Contraflow at North Shepherd

sufficiently to make continued contraflow operation undesirable. Consequently, studies were undertaken to assess the desirable operational life and to investigate the alternative actions possible once the contraflow project had reached the end of its desirable operating life. These studies indicated that, by 1985 if not sooner, off-peak direction traffic demand would have increased sufficiently to warrant the discontinuation of the I-45 Contraflow Lane. These studies also evaluated three alternative actions once the end of the CFL's desirable operational life had been reached: 1) continue CFL indefinitely, 2) eliminate CFL without replacement, and 3) replace CFL with a median Authorized Vehicle Lane (Transitway). Benefit/cost analyses for each of these alternatives supported the third alternative, the replacement of the CFL with a barrier-separated median HOV facility. The studies further recommended that the CFL should be replaced as early as 1983, and that this replacement would yield a benefit/cost ratio of almost 8:1 (5).

Recognizing the need to preserve the express transit benefits provided by the contraflow lane despite the apparently conflicting need to discontinue the contraflow project (due to increasing off-peak direction traffic volumes), the SDHPT and METRO agreed to pursue the development of a barrier-separated median transitway to replace the contraflow lane. This transitway development project was coordinated with a larger freeway improvement project in the corridor in order to minimize overall combined traffic disruption and project costs. It was also agreed that priority transit operation would be retained during construction of the permanent transitway.

NORTH FREEWAY TRANSITWAY DEVELOPMENT AND CONSTRUCTION

Project Description

The North Freeway Transitway and Freeway Improvement Project is being implemented in four phases (Figure 19). Phase 1 construction extended from downtown Houston to North Shepherd Drive, essentially replacing the contra-flow lane with a narrow (16-foot) barrier-separated reversible median HOV lane. This first phase was operational by the end of November 1984. Phase 2 also extends from downtown Houston to North Shepherd Drive but covers the general freeway improvements including the widening of the freeway to provide additional freeway lanes and to allow the median transitway to be expanded to its final width of approximately 20 feet. Phase 3 will extend the transitway 4.5 miles from North Shepherd Drive to the North Belt (Beltway 8). This phase effectively replaces the concurrent-flow lane (which currently operates in the morning north of North Shepherd) and extends its limits approximately 1 mile further north. Phase 3 is scheduled for completion in 1988. Finally, Phase 4 still under discussion, will take the transitway another 5.6 miles to FM 1960 bringing the transitway to its final length of 19.7 miles from downtown Houston to FM 1960.

This report focuses on the first year of operation behind barriers for the first phase of the North Freeway Transitway. This first year of operation has been at a narrow (14-16 feet) width, several feet narrower than the ultimate width of approximately 20 feet.

Funding

In order to expedite the construction of the project's first two phases, METRO agreed to pay the transitway-and freeway-related costs for phases 1 and 2, and SDHPT agreed to fund and to construct the third phase of the project from North Shepherd to the North Belt. Phase 4 is proposed to be jointly funded with SDHPT supervising the construction. Overall, METRO will have contributed close to $74 million towards the transitway and freeway

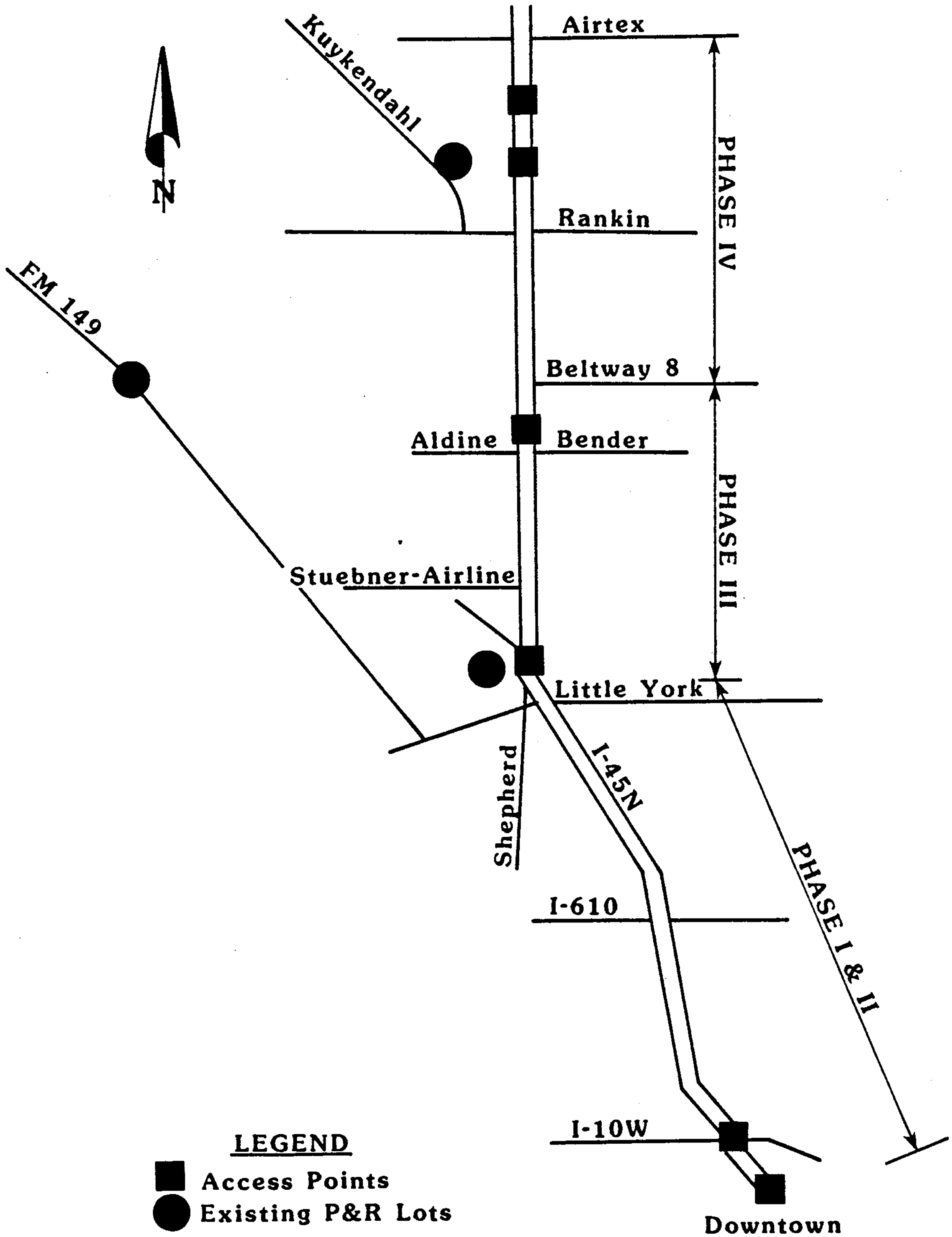


Figure 19. North Freeway Transitway Construction Phases

improvement project (with 80% or approximately $59 million coming from the Urban Mass Transportation Administration). SDHPT will have contributed almost $90 million, almost $81 million, or 90%, of which it will obtain from the Federal Highway Administration. Table 1 lists the expected total contributions for each agency for the entire combined transitway and freeway improvement project. Table 4 details the total expected contributions by each agency for each transitway phase.

Table 1. Estimated Total Agency Participation (Phases 1-3)

Agency	Transitway Improvements	Freeway Improvements
METRO	$14.8 million	
UMTA	59.1 million	
SDHPT		$ 8.9 million
FHWA		80.6 million
Total	$73.9 million	$89.5 million

Source: (1)

Transition from CFL to Transitway Operation (6)

Phase 1A of the North Freeway construction project involved the relocation of signing and lighting to clear out the median area. These construction activities had the most impact on frontage road operation in the form of lane closures. The contract was awarded on April 18, 1983, and work continued until October 5, 1984.

Phase 1B covered the actual reconstruction of the North Freeway median. This contract was awarded on December 20, 1983 and resulted in construction mobilization by January 16, 1984. The ultimate objective of Phase 1 was to place the CFL within the freeway median so that it could be protected by concrete median barriers. A constraint on this objective was that some form of priority HOV treatment had to continue while this construction was taking place. The solution came in the form of a shared, protected work zone. An envelope that encapsulated the inside lane of the freeway was provided by restriping the freeway over to the outer shoulders (and onto the shoulders in many places) and then placing barriers around the median plus 10 or 12 feet on either side of the median (Figure 20).

Table 2. Agency Participation by Construction Elements

Cost Breakdown by Agency Interests

Project Phases	METRO & UMTA	SDHPT & FHWA	TOTAL	Agency
Phase 1 (Transitway):				
Signing and Lighting	$ 2.9 M	---	$ 2.9 M	
Design and Constr.	10.1 M	---	10.1 M	
Phase 1 Total:	$13.0 M	---	$13.0 M*	METRO
Phase 2 (Freeway):				
Design and Constr.	$18.5 M	$25.3 M	$43.8 M	
Incentive	1.0 M	---	1.0 M	
Phase 2 Total:	$19.5 M	$25.3 M	$44.8 M**	
Phase 3 (N. Shepherd to N. Belt):				
Design and Constr.				
Transitway at-grade	$13.6 M	---	$13.6 M	
Aldine-Bender Transitway Interchange	6.3 M	---	6.3 M	
Freeway Improvements	---	$47.9 M	47.9 M	
Total Design & Constr.	19.9 M	47.9 M	67.8 M**	SDHPT
SC&C (Downtown to N. Belt)	2.5 M	1.6 M	4.1 M***	Joint
Phase 3 Total:	$22.4 M	$49.5 M	$71.9 M	
Phase 4 (N. Belt to FM 1960):				
Total Design & Constr.	$17.9 M	$14.0 M	$31.9 M***	Joint
SC&C	1.1 M	0.7 M	1.8 M***	Joint
Phase 4 Total:	$19.0 M	$14.7 M	$33.7 M	

*Actual Costs

**Engineer's Estimate

***Projection based upon plan development (January 1985)

Source: (1)

The initial plans called for the placement of concrete barriers on both sides of the median for a distance of some 9 miles on the freeway. However, until Phase 2 construction was completed (which included the widening of the freeway cross section), this design would result in a very narrow transitway. With this narrow configuration, the potential impact of an incident within the facility could be severe. Concrete barriers only 14 to 16 feet apart for

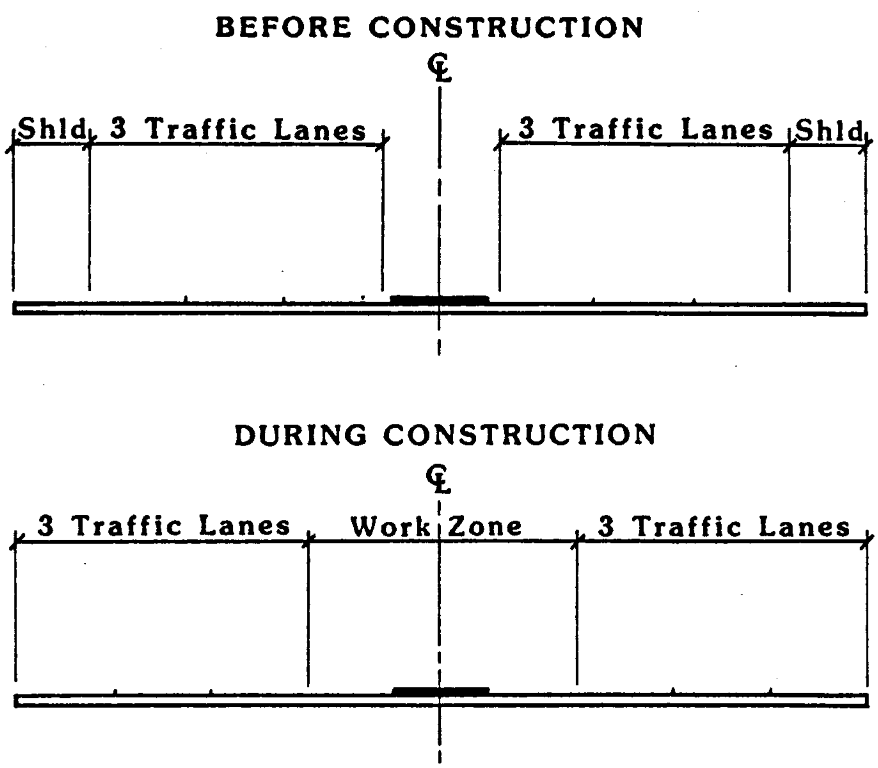


Figure 20. Typical Freeway Phase 1 Construction Cross Section

a distance of 9 miles restricted access to, and passage around, the incident. In response to this problem, "bubble points" were added south of Airline Road. These "bubble points" were locations where the transitway was widened to allow the METRO wrecker enough room to turn around. Since an incident within the narrow facility would completely block passage through the facility, the METRO wrecker had to access the incident from the opposite direction, driving in the wrong direction until it reached the bubble point closest to the incident location. The wrecker then turned around and backed up to the incident location to tow the immobilized vehicle out of the facility in the correct flow direction. North of Airline Road, there were no structures wide enough to accommodate any "bubble points." Consequently, the decision was made to eliminate the concrete barrier on one side and to replace it with permanent pylons which would be continually checked before operation. Although this modification presented a higher potential for violations to occur in the afternoon period, it also provides a means to clear up an incident quickly, or at least, to bypass the incident on one side.

If the transitway was not going to be encapsulated on both sides, there was no need to cast the concrete barriers for both sides. Consequently, the contractor chose not to cover both sides of the work zone with concrete barriers. Instead, north of Airline, the contractor used the concrete barriers on the side of the work zone which was "pushing" the alignment over to cover the inside freeway lane, and, on the other side, he simply used ordinary traffic barrels (Figure 21). Fortunately, although neither AVL lane operation nor the contractor were fully physically protected in that northern segment of the work zone, there were no incidents that occurred during the period when the median was being rehabilitated.

The envelope was expanded at night. Precast barriers were taken out of the staging yard, transported to the freeway and set up at night. At the same time, the freeway mainlanes were restriped to direct traffic around the median work area. On the inbound side of the freeway, a permanent taper was developed at the northern end of the project. Each night, as the work zone was extended to the south, the new detour alignment was simply extended from the point where the old alignment left off. The outbound side was chosen to be the compromise direction since only traffic barrels were used on that side of the work zone; and the creation of a new taper each night required relatively less effort with traffic barrels than if the same new taper would have had to have been created by using concrete barriers on the inbound side.

Once the barriers were placed, contraflow operation was replaced by reversible flow operation within that segment. One of the encapsulated inner lanes was essentially converted to a reversible flow lane (RFL) operating within the work area (Figure 22). For safety reasons, median reconstruction

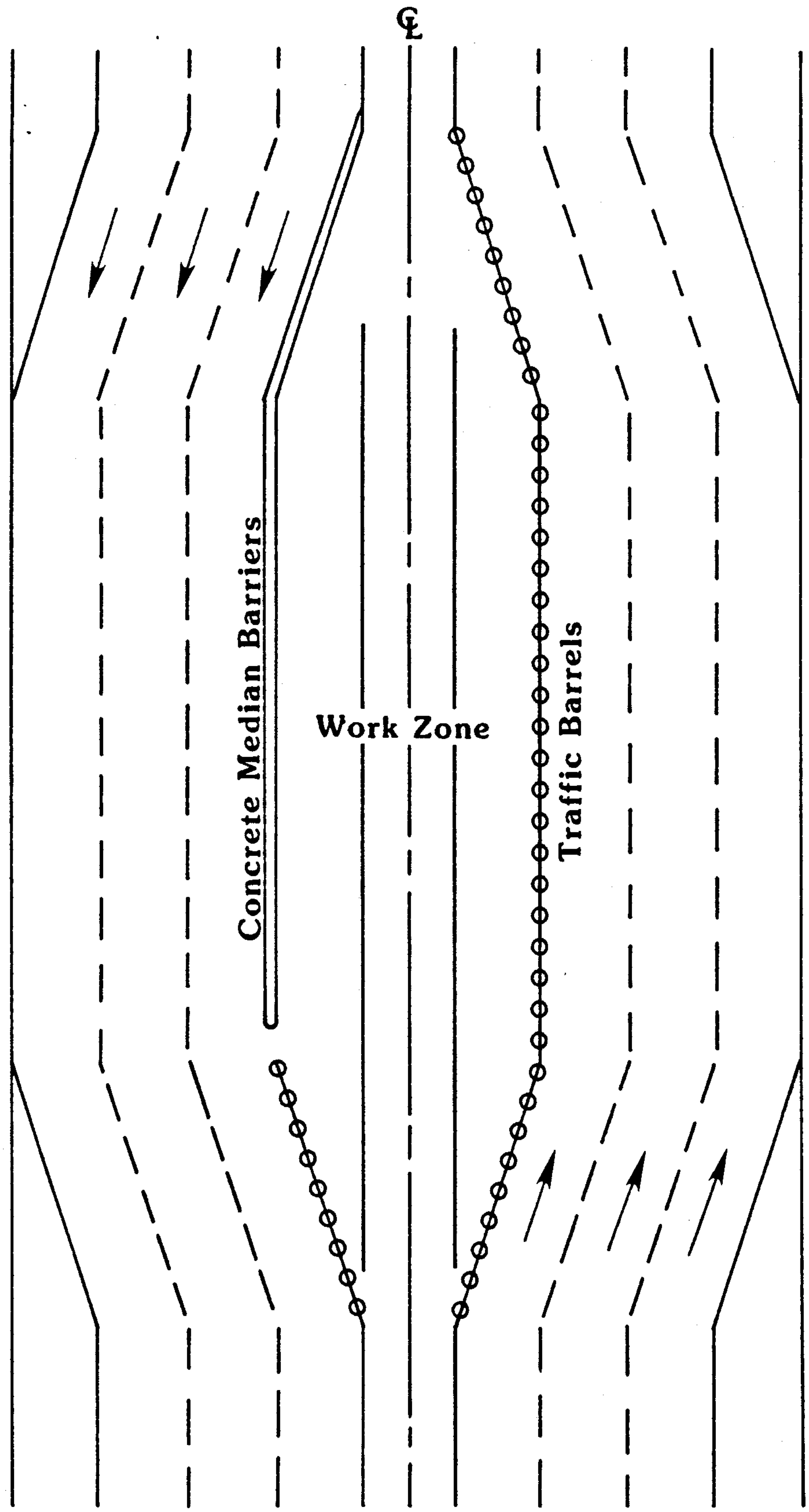


Figure 21. Establishment of Construction Zones

could not occur at the same time that CFL vehicles were operating on the adjacent lane within the work zone. Consequently, an issue of construction versus RFL operating times arose. Because they were no longer impacting regular freeway traffic, the RFL users felt justified in asking for longer operating periods. Specifically, an additional 30 minutes preceding the afternoon operation and following the morning operation were requested. In order to accommodate these requests while fulfilling contractual agreements with the contractor, the afternoon period was extended by 15 minutes, starting at 3:45 pm as opposed to 4:00 pm, but the tail end of the morning period was cut by 15 minutes. In order to allow the work zone to clear out by 8:30 am, no vehicles were allowed to enter the facility after 8:15 am. This compromise gave users a little more time in the afternoon (accommodating those motorists who get off work at 3:30) while leaving the contractor with the same total amount of time to work on a 24-hour basis as was available to him at the time the contract was signed.

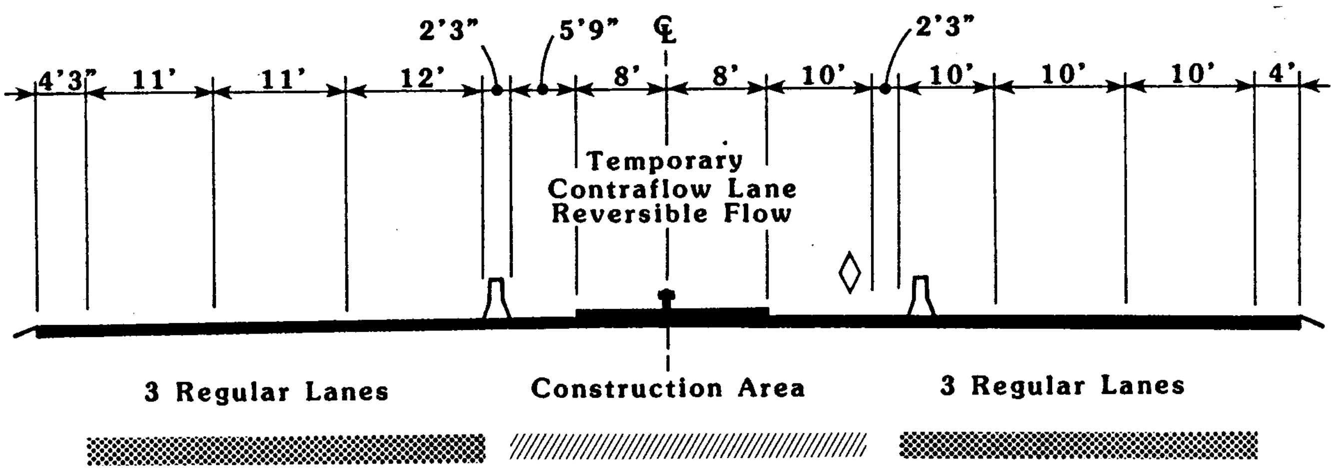


Figure 22. Provision of Reversible Flow Lane Within Work Zones

It was important to maintain the same number of contractor working hours because the Phase 1B construction contract included both incentive and liquidated damages clauses which were designed to encourage the contractor to complete construction as quickly as possible. A thorough assessment of the use of incentive/disincentive contracting provisions for early project completion is presented in a separate report (7). A consequence of the incentive contract combined with continued CFL operation during construction was that a great deal of the construction was undertaken at night. Because there was not enough time between the morning and the afternoon peak periods to do a substantial amount of pavement pouring without having conflicts with the afternoon period, most of the concrete work was pushed to the nighttime between the hours of 8:00 pm and 6:00 am. In some cases, construction continued almost up to the time when the RFL would open for morning operation.

Within the encapsulated work area, the portion of the work area which was not being reconstructed was used by CFL vehicles operating in reversible flow -- inbound in the morning and outbound in the afternoon (Figure 23). Changeable sign trailers alternately stationed at the Hogan Street or the North Shepherd access locations were used to communicate information to the users on a daily basis (since diversions of traffic from one side of the median to the other were being implemented daily). The signs might display messages such as "Caution at Airline Today -- New Detour" (Figure 24). Traffic control devices such as construction barrels and concrete barriers with yellow reflector stripes were used to direct both mainlane traffic and CFL/RFL traffic within the work zones.

The first taper was formed near North Shepherd in the southbound direction. In order to accommodate the continuation of HOV operation, morning concurrent flow traffic was diverted to the afternoon exit ramp. Once on the exit ramp and operating in the reverse direction, concurrent-flow vehicles accessed the morning configuration using the same morning entrance ramp that had always existed. During construction, this morning ramp wrapped traffic around the North Shepherd intersection and brought it into the work zone inside the concrete barriers.

Within the wider sections of the work zone, CFL/RFL vehicles were permitted to utilize the encapsulated lane closest to the outbound freeway lanes while the median was carved out and rehabilitated. Within the narrower freeway and work zone sections, because CFL/RFL operations had to be accommodated and because of the difficulty of getting equipment in and out, the

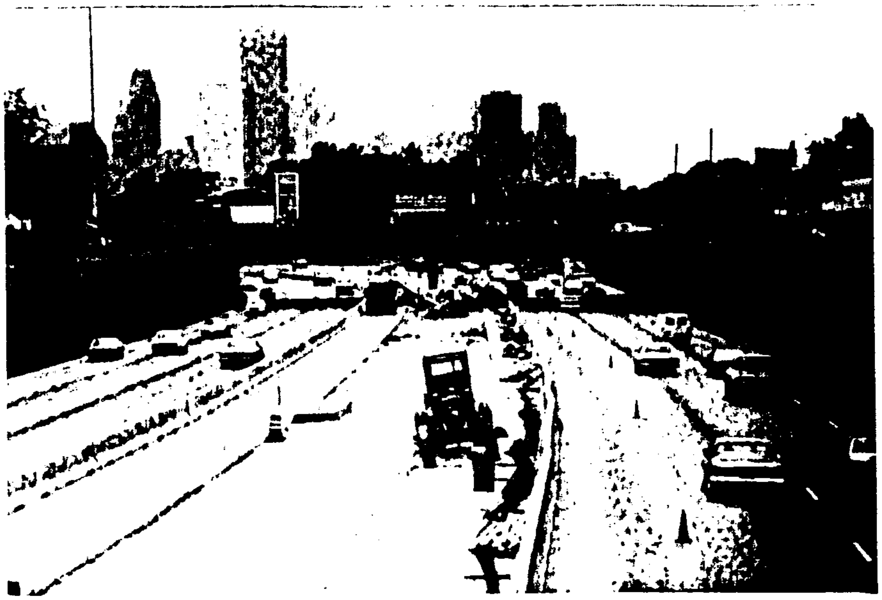


Figure 23. Reversible Flow Operation Within Work Zones

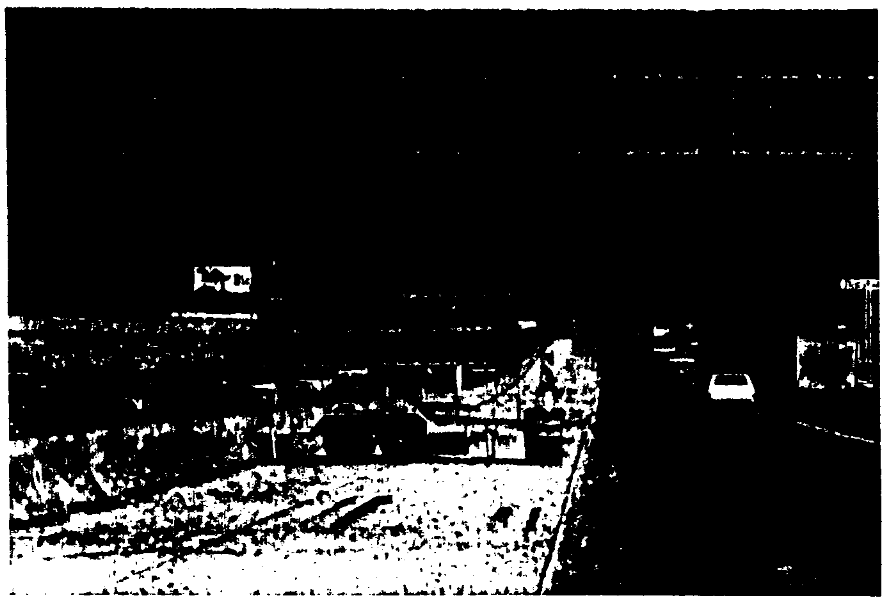


Figure 24. Advisory Construction Signing

panel closest to the CFL/RFL could not be worked on. Consequently, the median was rehabilitated in halves. In essence, as CFL/RFL operated on one side of the encapsulated area, the median construction proceeded on the other. Then the CFL/RFL was shifted to the completed side so that the other half of the median could be carved out and rehabilitated.

In a few locations (primarily the bridge structures at Airline and south), less than 10 feet of space was available between the barrier and the point at which it was necessary to start cutting out the median. At these locations, there were no outside shoulders available for freeway traffic to be moved onto, and, thus, it was necessary to place the barriers no more than 4 to 5 feet away from the freeway inside median. (The 4 to 5 feet could be obtained by reducing freeway lane widths from 12 feet down to 10 feet per lane.) In order to accommodate the CFL/RFL even within these constricted sections, it was necessary to leave the median fencing in place, at least initially, and to carve out the median panel on just one side of the fence. On the other side of the median fencing, asphalt was laid between the median's roll back curve and the concrete barrier in order to obtain a flush surface. This surface was used by the CFL/RFL vehicles until the other side had been completed. RFL operation was shifted to that side so that construction could proceed on the unfinished side.

This latter solution created a few difficulties. First, RFL traffic traveling through the work zones of various widths was forced to endure transitions which literally required the vehicles to climb onto the built up surface in order to proceed through the narrowest sections and then to climb back down to travel on the enclosed freeway lane again. And second, because the construction was done in halves at night, the panels would often not align correctly. In particular, the original structures at these narrow overpasses were laid on steel girders with an expansion joint in the middle of the cross-section. The two sides of the freeway operated independently of one another. Constructing the new median with each side of the median tied to its respective freeway deck presented no problems, but difficulties arose when the two halves of the median had to be tied together. The two halves were often not constructed at the same height (Figure 25). At locations where the differential between the two decks was excessive, the lips had to be removed so that: 1) the existing steel girders could be bridged, 2) a new beam could be placed from above, and 3) a new deck could be cast across the new beam. More typically, the two median panels were cast separately and the two were forced to align by grinding them to the same height.

About halfway through the project, a major problem arose. Almost immediately after buses and vans began running over rehabilitated sections of the median, surface irregularities began to appear. These irregularities were appearing after the first day of operation at locations with two to three percent grades. By the end of the first week of operation, the pavement heaving and rutting was so severe that surface patching became necessary (Figure 26). By the end of the first month of operation, even the surface patches began to fail. Consequently, full depth patches which required the median base to be dug out were applied (Figure 27). Upon proceeding to dig out the "base," the source of the problem became clear. A great deal of clay, some small amounts of gravel, and an underlay of clay was discovered underneath the newly laid asphalt. It became clear that a base had never been laid underneath the median. Subsequent efforts to build a freeway had only served to create a water trap. Initially, the freeway had had only a turf median. As the freeway was improved, the median was simply filled in with asphalt which covered the V-shaped layers of clay. The result was that these layers of clay held water. There was practically no place for the water to drain because the clay was blocked on either side by cement-stabilized limestone that had been laid as a base for the freeway lanes. Once heavy buses and vanpools began driving over the median, base failure occurred. The problem was most severe near the bottom of the sloped sections because water was running off the slopes and pooling at those locations first. However, the problem continued to worsen to the extent that the at-grade sections eventually experienced the same deformations. Typically, the deflection pattern was a reflection of the weighting on the pavement. Some of these troughs extended over 100 feet in length and from 6 to 8 inches in depth. The deformations were significant enough to throw a vehicle out of control.

Figure 25. Typical Height Differential Between Two Halves of Rehabilitated Median Surfaces

Figure 26. Median Paving Failure

Full-depth patching was continued for another month at a cost of approximately $76,000 in charges in that first month, and continuation beyond this first month was projected to accumulate expenses at a rate of $70,000 per each additional month. At this point, two alternative actions could be pursued to remedy the base-failure problem. The short-term solution was to continue patching indefinitely over ever increasing areas, and the long-term solution was to discontinue RFL and temporarily revert back to CFL operation in order to remove the old "base" and replace it with a more suitable material.

By default, the short-term solution (i.e., indefinite patching) was already being pursued. It was costing approximately $70,000 per month with no definite termination date. Furthermore, there was no assurance that the full-depth patches would hold, and, despite the cost, the patching was disrupting operations without yielding a smooth surface. The quality of the driving surface deteriorated during the period when full-depth patching was being implemented. After the base was dug out, usually in 50 to 60 feet lengths, and replaced with cement stabilized limestone, at least a day or two was required for the poured material to cure sufficiently before asphalt could be laid (Figure 28). Consequently the CFL/RFL vehicles had to drive over the unfinished surface which was so rough that buses could not negotiate those segments at speeds any greater than 5 to 10 miles per hour. The potential impact on the public's acceptance of the entire project as well as on CFL/transitway utilization could be devastating.

On the other hand, the long-term solution required the immediate payment of a large sum of money which was reduced somewhat only by the consideration that, if the freeway was to receive a concrete overlay in the next phase of construction anyway, either a more economical grade of asphalt or an unreinforced (and thus less expensive) concrete could be used to replace the median base. The advantages that the long-term solution possessed over the short-term solution were its certainty and its immediacy. The cost of the long-term remedy could be ascertained with reasonable certainty beforehand. Replacing the median was estimated to cost approximately $1 million as compared with continued patching which was costing about $70,000 per month

Figure 27. Full-Depth Patching In-Progress

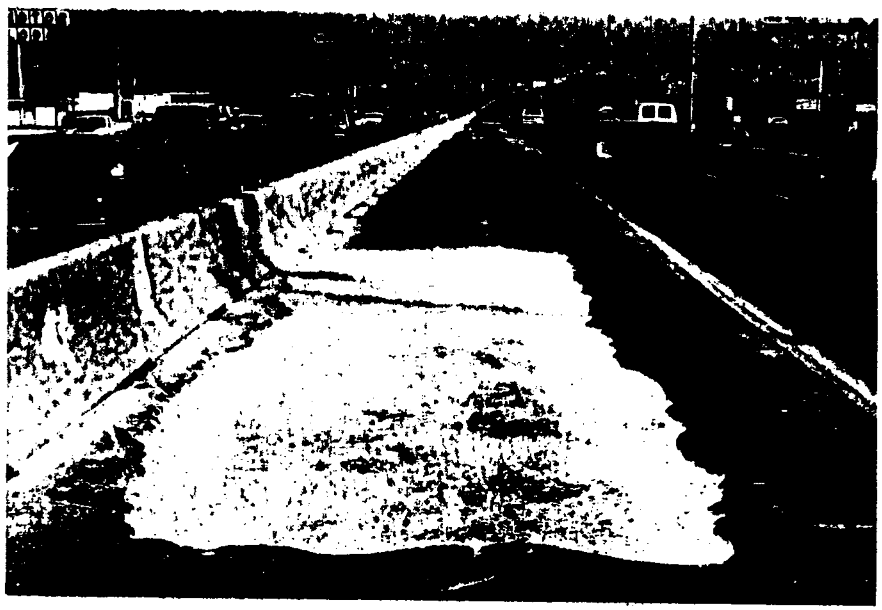


Figure 28. Unfinished Full-Depth Patch

for as long as 18 months for a possible total cost of more than $1.2 million. Furthermore, construction to completely replace the median could be completed within a relatively short period of time, especially compared to continued patching which could continued to inconvenience CFL/RFL patrons indefinitely. Consequently, the decision was made to pursue the long-term solution, to completely replace the median base either with a concrete or an asphaltic material. Subsequently, the decision was made to use concrete. First, the concrete could act as both a base and a travel surface. Second, there was only a 15% cost differential between concrete and asphalt. Third, asphalt couldn't be laid at night because the quantity required was too small to make it worthwhile for any local manufacturer to set up a plant to produce the asphalt at night. Fourth, and finally, the source which was already supplying the concrete being used throughout the rest of the project could also be used to satisfy the additional concrete needs.

A question regarding the use of unreinforced concrete arose during analysis of the long-term solution. There was some concern that the concrete would crack, and that it would crack on an uneven basis. The concern is standard for a project designed to last at least 20 years, however, since the results of Phase 1 construction were needed for a period of only 2 to 4 years, it was more cost effective to use the unreinforced concrete rather than to use steel reinforced concrete which would have added additional cost to the field change. By replacing the median base with a concrete material, albeit unreinforced, the median was receiving a better base than that which lay underneath the freeway lanes to either side of it (cement-stabilized limestone overlaid with numerous layers of asphalt -- no concrete). As part of Phase 2 construction, a new continuously reinforced concrete pavement (CRCP) would be placed on top of the entire freeway cross section. The new pavement will literally "float" on top of the existing pavement (Figure 29). A bond-breaker, consisting of a "gluey" tar similar to asphalt, will be laid between the two pavements to prevent them from bonding and to prevent any irregularities in the old pavement from propagating through the new pavement.

By the middle of the summer of 1984, approximately 3 months after the base failure was first detected, replacement of the median with a concrete base was finally undertaken. From Airline to North Shepherd (about 4 miles in length), the interim transitway returned to CFL operation outside of the median work envelope. This mode of operation continued from July to November of 1984. Originally, the base replacement was projected to take up to 9 months, however, the contractor was able to complete the project in less than 6 months. Contraflow operation on the North Freeway effectively came to an end the day before Thanksgiving, on November 21, 1984.

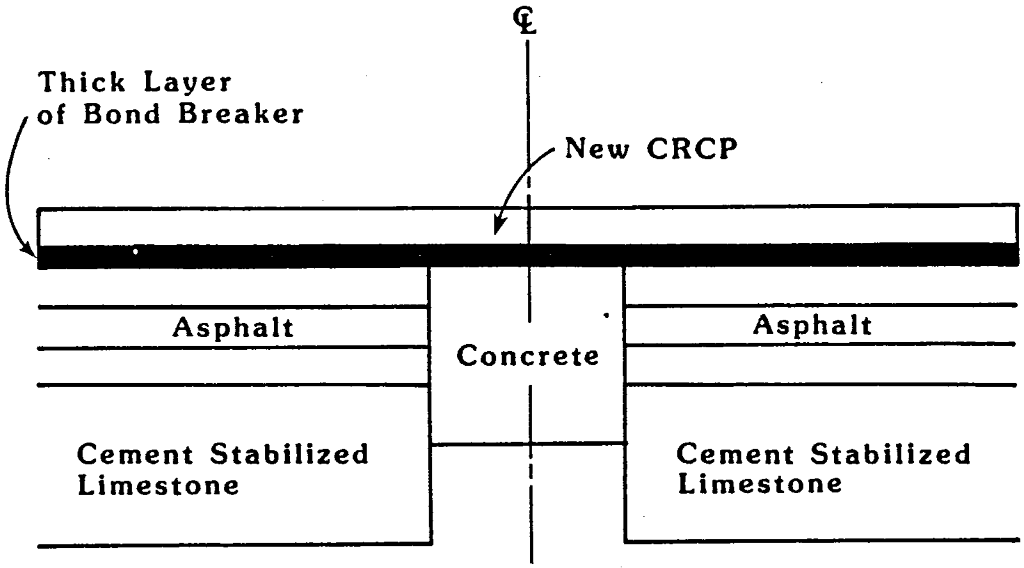
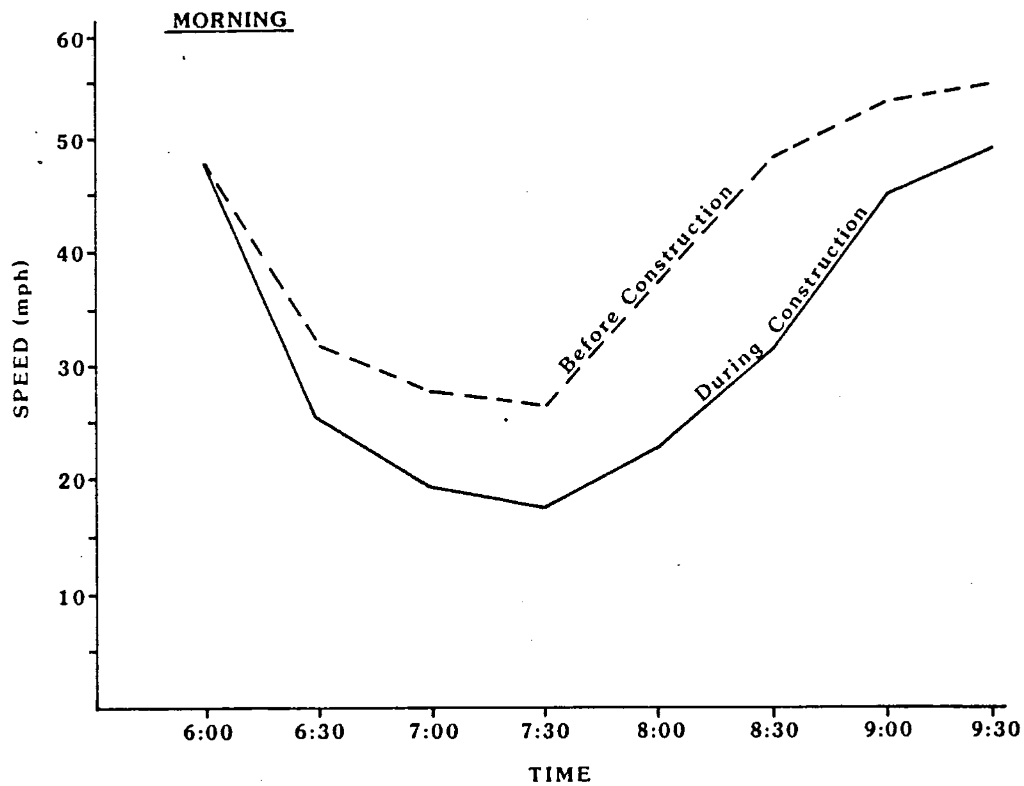


Figure 29. Ultimate Freeway Structure (After Phase 2)

Construction Impacts on Mainlane Traffic

During the eleven months that transitway construction progressed on the North Freeway median, a few impacts to mainlane operation were observed. As illustrated in Figure 30, mainlane speeds dropped by as much as 16 mph during the morning peak period. On average, during a typical 3-hour morning peak-period from 6:00 to 9:00 am speeds dropped from 37 mph to 28 mph during the construction period. Speeds in the afternoon however appear to have improved by as much as 9 mph while construction was going on. Average afternoon peak-period from 4:00 to 7:00 pm speeds actually rose from 30 mph to 36 mph during the construction period.

Mainlane vehicle flow rates dropped noticeably during the construction period by as much as 210 vehicles (21%) in a single 15-minute period at a three lane section of the morning inbound lanes. A smaller decrease of



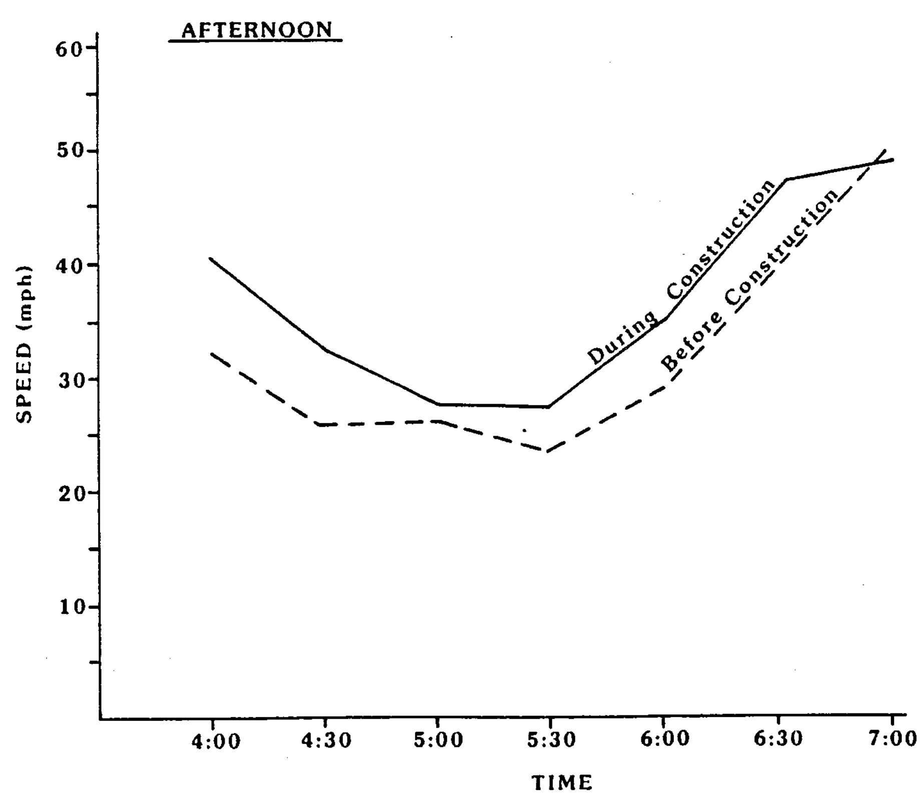


Figure 30. Average Mainlane Speeds (Before vs. During Construction)

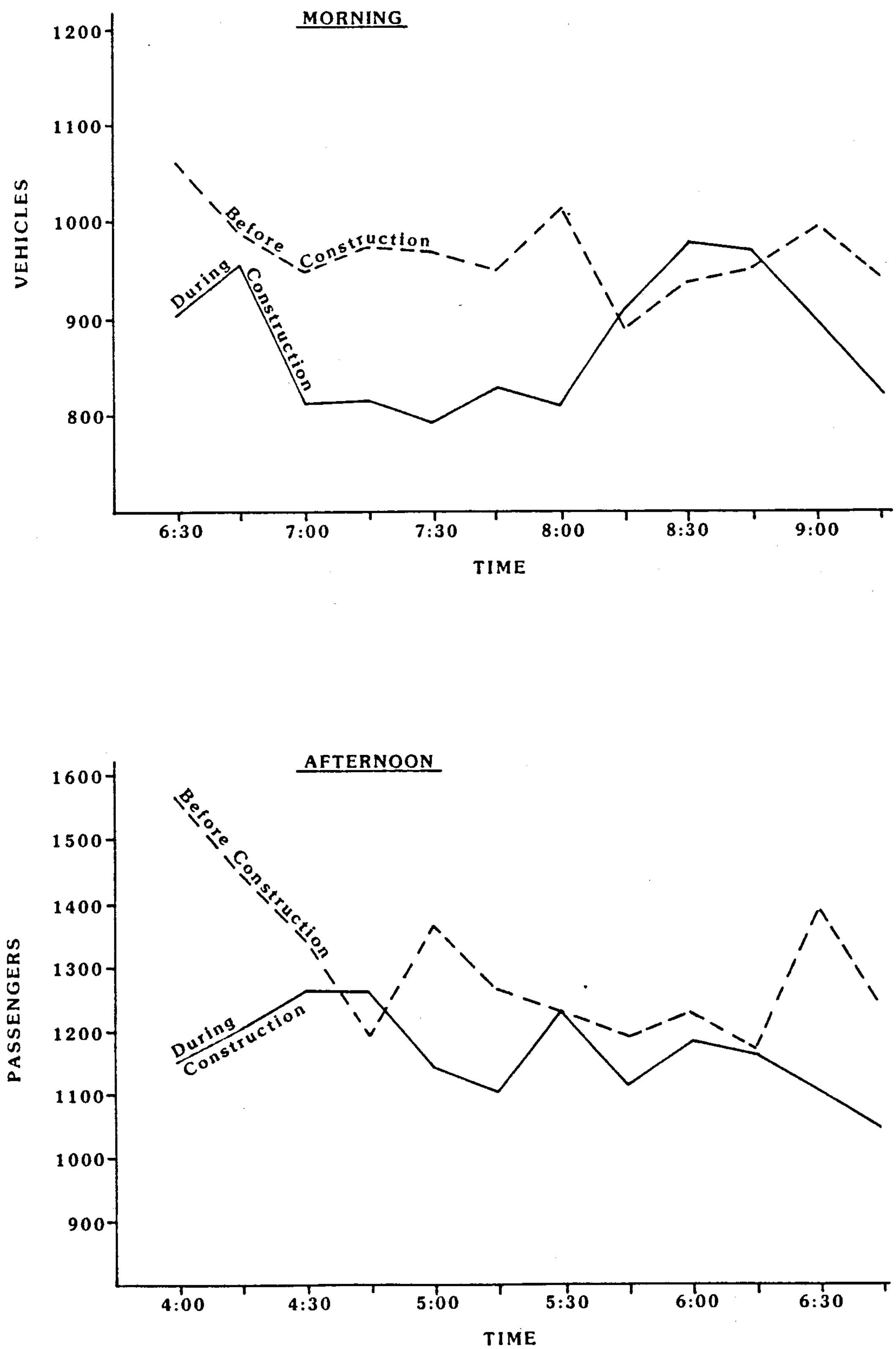
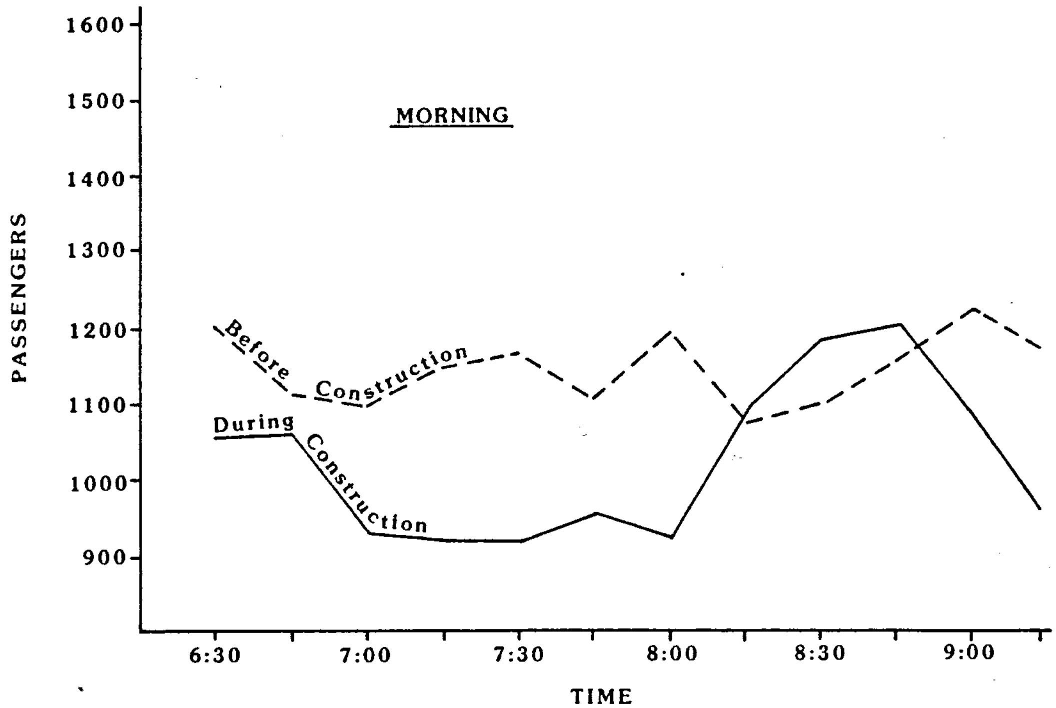


Figure 31. Average Mainlane Vehicle Volumes (Before vs. During Construction)

approximately 18% was also observed during the afternoon peak-period. A great deal of the mainlane decrease in both the morning and the afternoon peak periods has been absorbed by the parallel freeway frontage roads. Peak-period frontage road volumes increased an average of 11% in the morning and 7% in the afternoon. In addition to experiencing a higher absolute decline in 15-minute flow rates, the morning decline in vehicle flow rates was also consistently lower than preconstruction levels over an entire peak-hour of operation, from 7:30 am to 8:30 am (Figure 31). Both morning and afternoon peak-hour flow rates declined by less than 5% during construction. Morning peak-hour flow rates declined from a preconstruction average of 1330 vehicles per hour per lane to a during construction average of 1260 vehicles per hour per lane. In the afternoon, average peak-hour flow rates dropped from 1400 vehicles per hour per lane to 1350 vehicles per hour per lane. Overall, peak-period vehicle volumes dropped from an average of 1300 vehicles per hour per lane to 1170 vehicles per hour per lane in the morning and from 1330 vehicles per hour per lane to 1270 vehicles per hour per lane in the afternoon. Passenger flow rates as illustrated in Figure 32, reflected the same trends associated with vehicle flow rates.

As the quality of the priority driving surface deteriorated during construction, a few vanpools voluntarily chose not to utilize the median lane and returned to the mixed-flow lanes. The addition of these HOV vehicles to the mainlane volumes, however, did not substantially impact mainlane occupancy rates during construction. While morning occupancy levels remained close to 1.2 passengers per vehicle, afternoon levels dropped from 1.3 to a little higher than 1.2 passengers per vehicle.

Finally as similarly experienced during construction of the Katy Freeway Transitway, overall accident rates did rise during the North Freeway Transitway construction period. In the year preceding construction, with the CFL in operation during peak periods, an accident rate of 2.1 accidents per million vehicle-miles was experienced. This rate increased to 2.4 accidents per million vehicle-miles during the eleven month construction period. Although overall accident rates did increase during both construction projects, it is well to realize that after an adjustment period of a few weeks following each change in freeway alignment, drivers on the Katy Freeway were able to cope



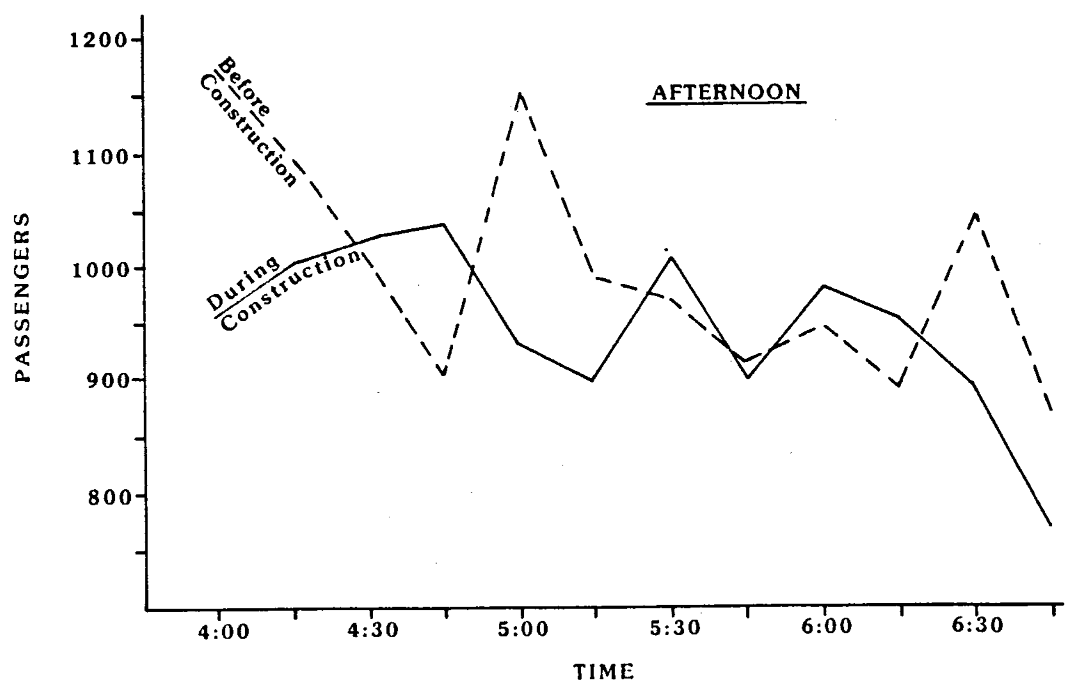


Figure 32. Average Mainlane Passenger Volumes (Before vs. During Construction)

with the adverse operating conditions to the extent that accident rates during construction but after the adjustment period were not significantly different from those rates experienced prior to the beginning of the transitway construction project (8).

FIRST YEAR OF TRANSITWAY OPERATION

Design Implementation

The North Freeway Contraflow Lane was officially converted into the North Freeway Transitway on November 29, 1984. Although the transitway was substantially completed as early as September 12, 1984, the facility did not officially begin transitway mode operation until November because of pavement problems that subsequently arose between Airline and North Shepherd. The conversion was implemented with little fanfare although extensive efforts were made to inform all CFL users of the operational change. CFL users continue to access and exit the facility in essentially the same manner under either configuration (CFL vs. transitway). The only major differences are that the facility is now protected by concrete median barriers on both sides throughout most of its length, and that the facility no longer usurps a travel lane from the off-peak direction traffic (Figure 33). Concrete barrier protection is provided on both sides from downtown Houston to a distance more than 5 miles north near Airline Drive. From Airline to North Shepherd, the transitway is protected by semi-permanent traffic pylons spaced at 60 foot intervals on the outbound side of the facility. This section will alternately be protected by concrete barriers or by traffic pylons during Phase 2 construction depending upon the available freeway width at the various construction locations. The inbound side is protected by concrete barriers throughout the entire length of the facility.

As under contraflow operation, morning access can be accomplished by two different methods at North Shepherd. As illustrated in Figure 34, transitway vehicles can access the facility either from the North Shepherd transitway ramp or from the median concurrent flow lane which operates immediately upstream of the transitway. Afternoon exit from the transitway may also be accomplished through two different means. Transitway vehicles may either merge into mixed-flow outbound traffic from a special transitway freeway ramp connection, or they may exit onto North Shepherd Drive by turning onto a button hook ramp which directs vehicles off of the facility and onto a

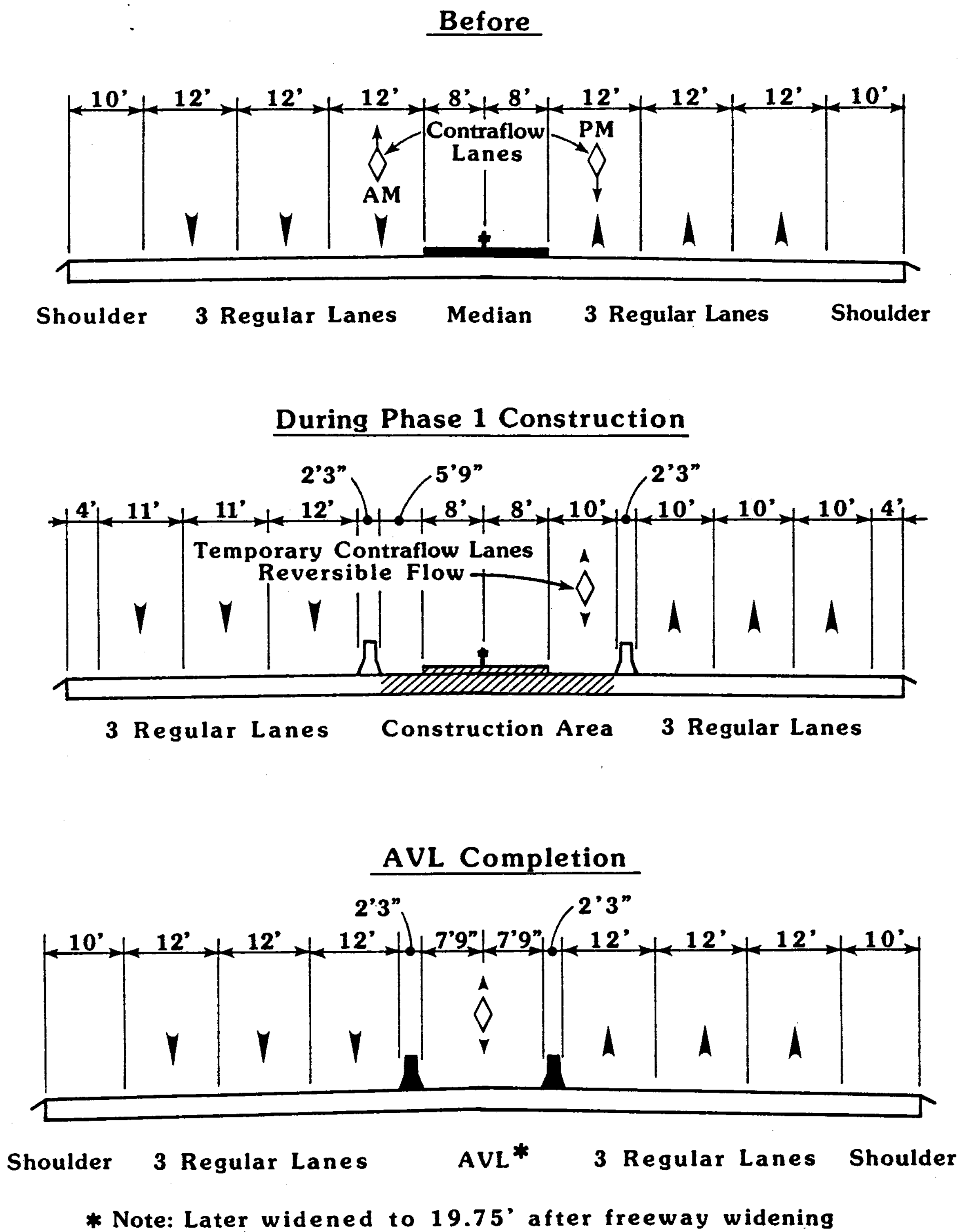


Figure 33. North Freeway Typical At-Grade Cross Section North of I-610

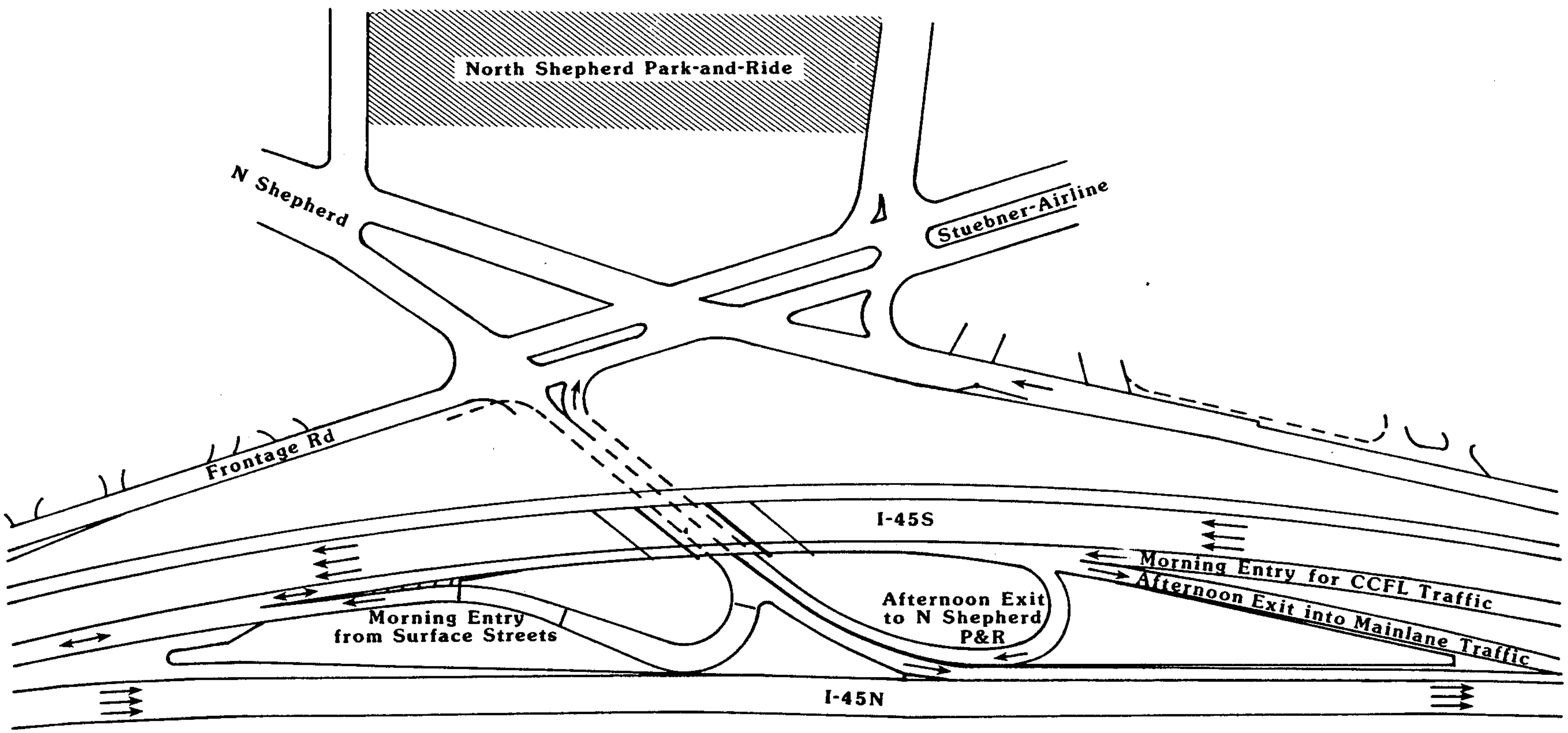


Figure 34. Transitway Access at North Shepherd

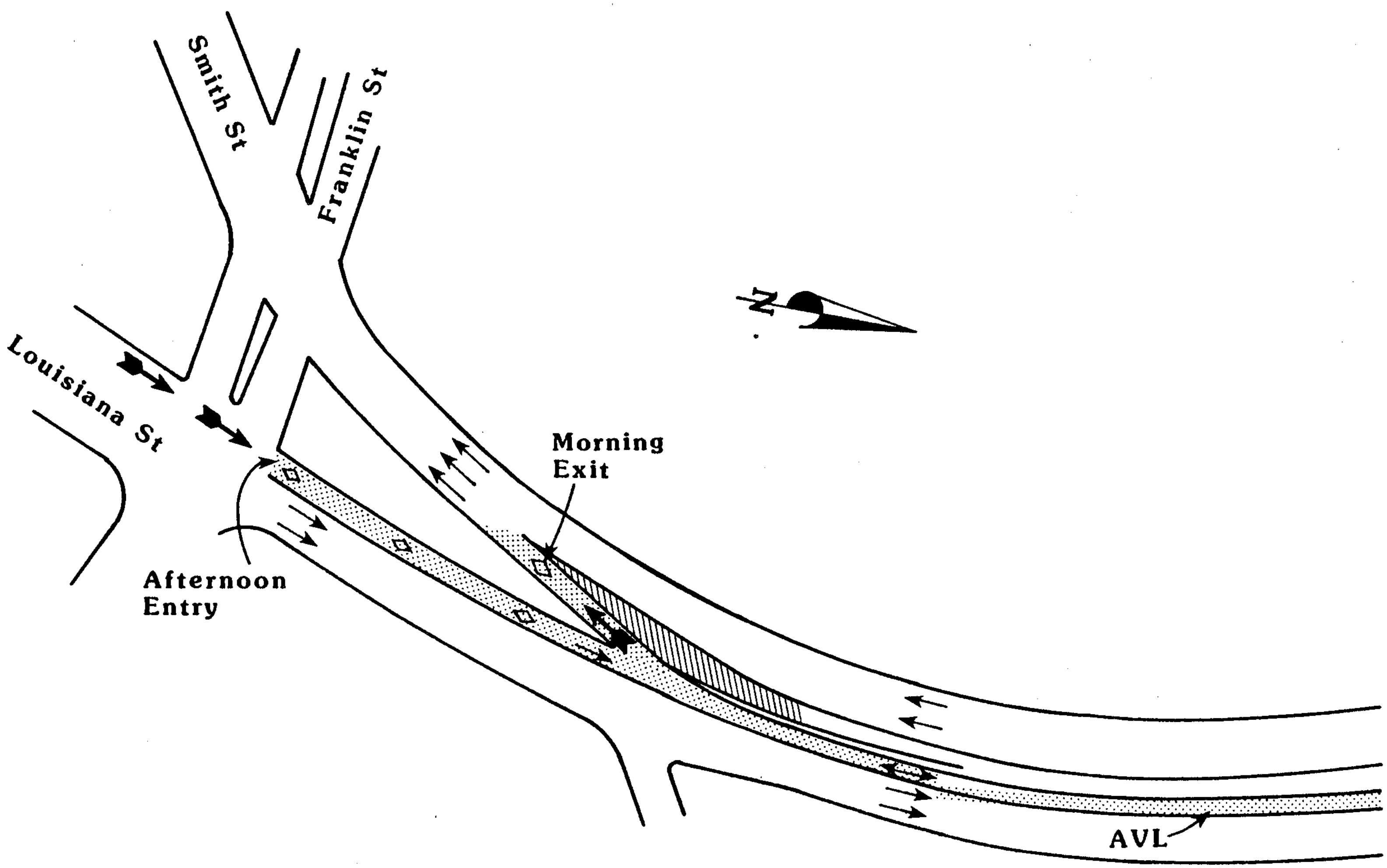


Figure 35. Transitway Terminus at Smith and Louisiana

surface street intersection (North Shepherd Drive and Stuebner-Airline Road) where transitway buses may access the North Shepherd park-and-ride Lot.

At the facility's southern terminus, access from Louisiana and egress to Smith Streets are essentially the same as under CFL operation (Figure 35). Additionally, a new egress location has also been made available to transitway vehicles desiring to exit the facility onto Milam Street in the morning. The transitway's southern access and egress treatments are illustrated in Figure 36).

Demand Volumes

Tables 3 and 4 present monthly North Transitway vehicle and passenger volumes from the facility's opening through November 1985. The cumulative increases are also presented. Average peak period are depicted graphically in Figures 37 and 38. In the last month of CFL operation, the facility was

Table 3. Daily Transitway Vehicle Demand

Date	Daily Vehicles			Percent Change	
	Buses	Vanpools	Total	Per Month	Cumulative
November '84 (pre-transitway)	272	489	761	---	---
December '84	277	488	765	1%	1%
January '85	285	499	784	2%	3%
February '85	292	534	826	5%	9%
March '85	299	556	855	4%	12%
April '85	302	562	864	1%	14%
May '85	299	561	860	0%	13%
June '85	292	528	820	-5%	8%
July '85	295	556	851	4%	12%
August '85	293	528	821	-4%	8%
September '85	290	537	827	1%	9%
October '85	300	515	815	-1%	7%
November '85	291	499	790	-3%	4%
12-Month Avg.	293	530	823	---	--

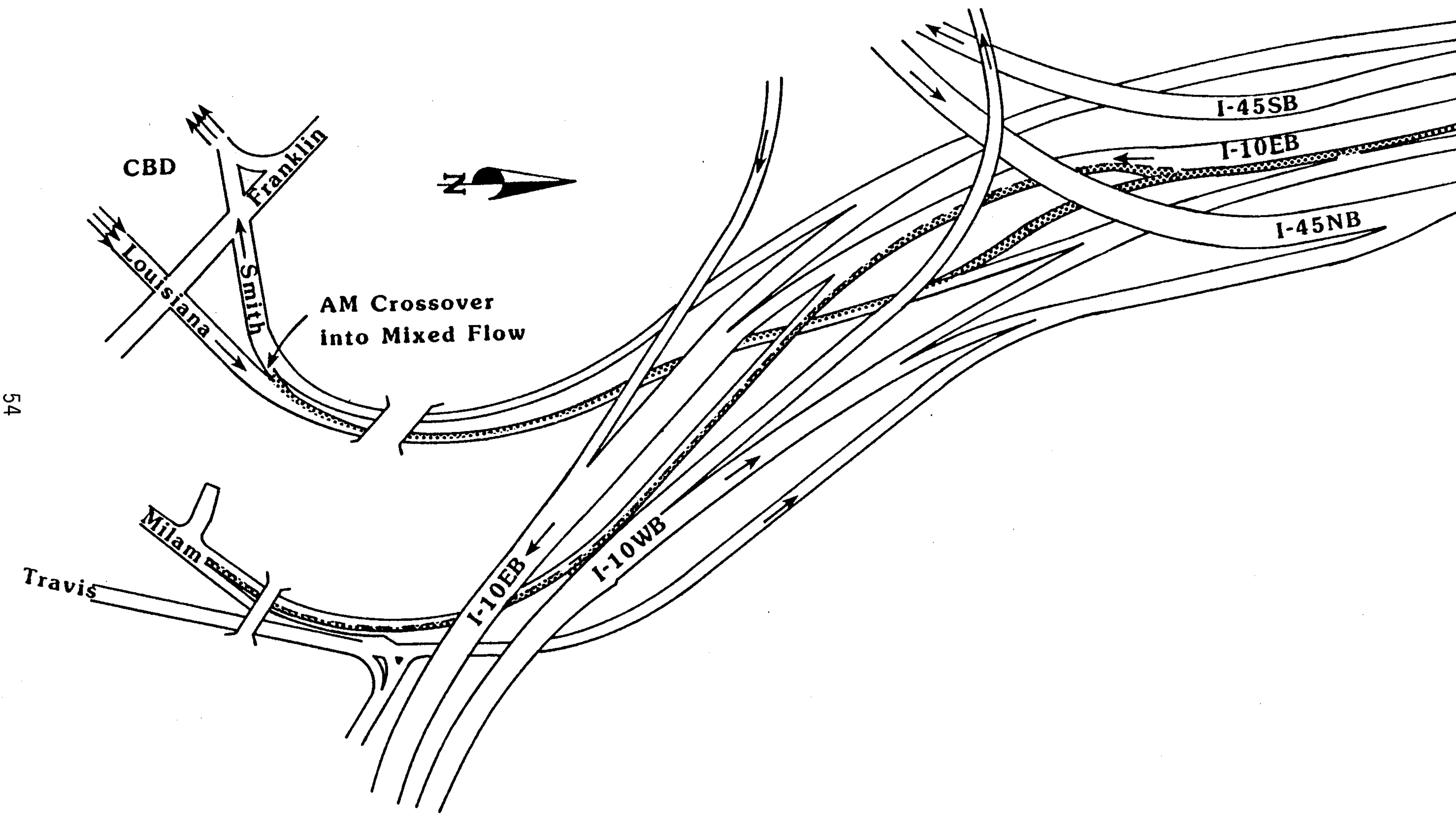


Figure 36. Transitway Terminus Downtown

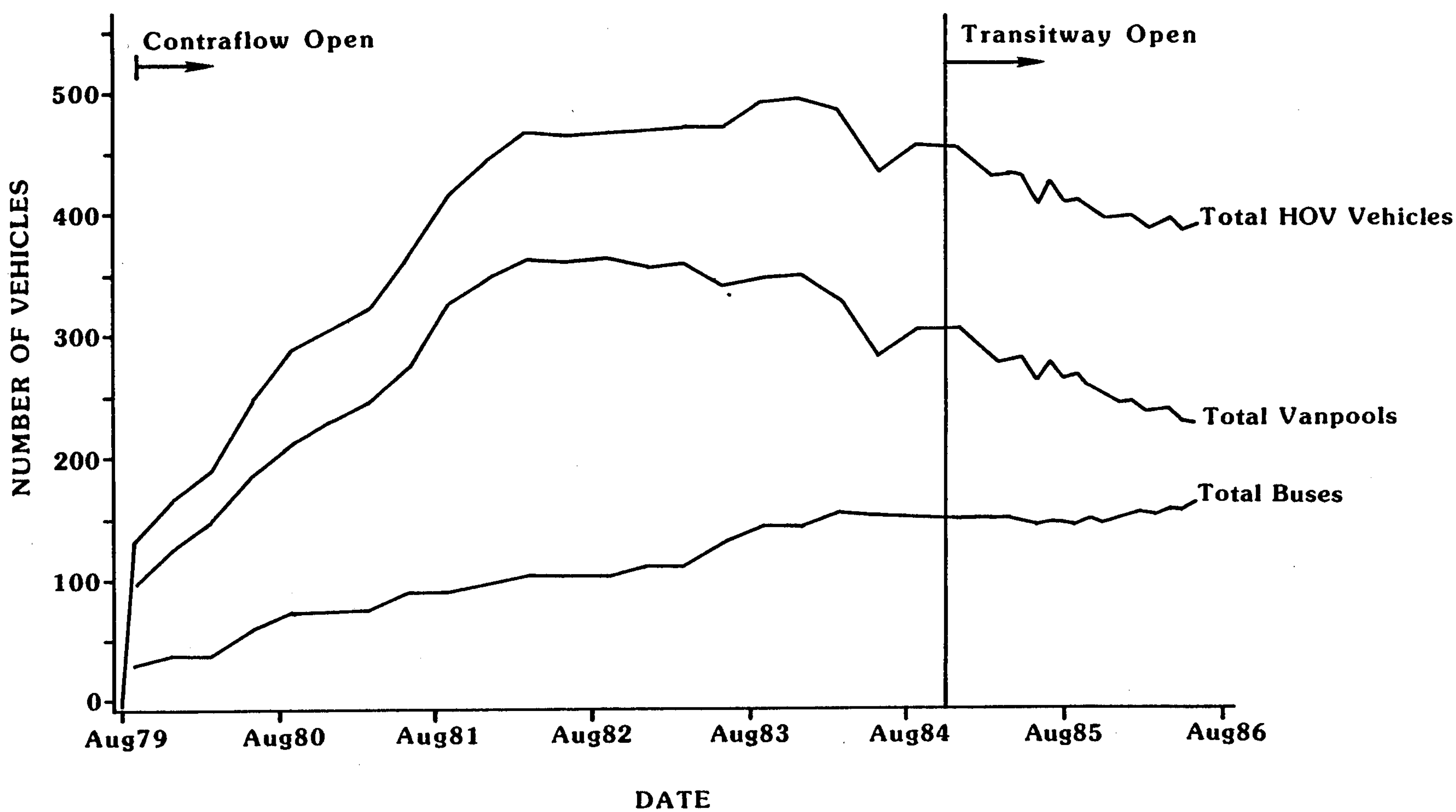


Figure 37. Transitway Average Peak Period Vehicle Volumes

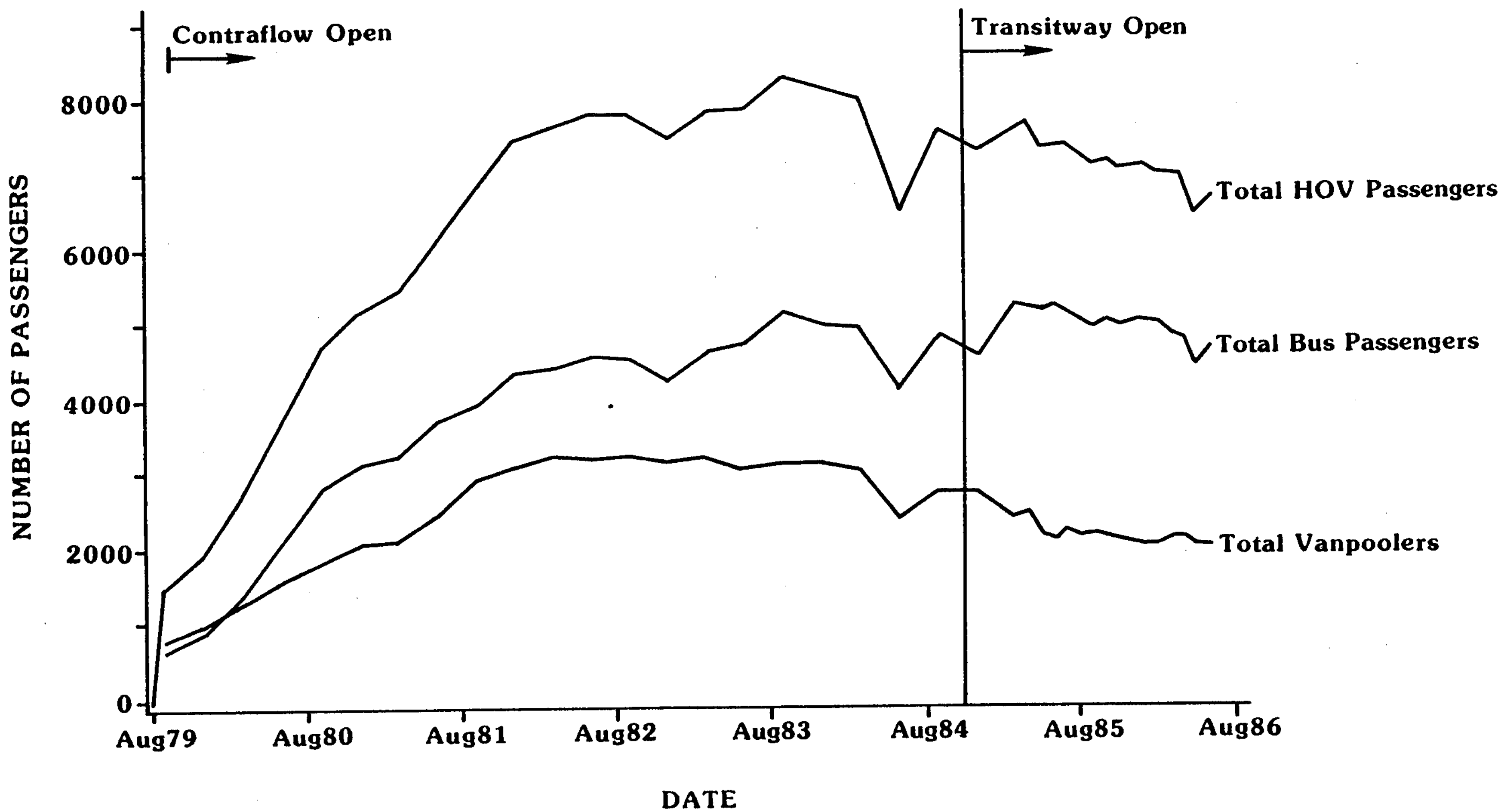


Figure 38. Transitway Average Peak Period Passenger Volumes

serving 272 buses and 489 vanpools carrying 9,390 and 4,526 passengers, respectively. Volumes increased until, in April 1985 about 5 months after the beginning of transitway operation, vehicle volumes reached 864 vehicles

Table 4. Daily Transitway Passenger Demand

Date	Daily Passengers			Percent Change	
	Buses	Vanpools	Total	Per Month	Cumulative
November '84 (pretransitway)	9,390	4,526	13,916	---	---
December '84	8,970	4,890	13,860	-0%	-0%
January '85	9,190	4,784	13,974	1%	0%
February '85	10,210	4,818	15,028	8%	8%
March '85	10,430	4,830	15,260	2%	10%
April '85	10,420	4,927	15,347	1%	10%
May '85	10,310	4,355	14,665	-4%	5%
June '85	10,460	4,206	14,666	0%	5%
July '85	10,260	4,467	14,727	0%	6%
August '85	10,100	4,297	14,397	-2%	3%
September '85	9,870	4,344	14,214	-1%	2%
October '85	10,060	4,225	14,285	1%	3%
November '85	9,910	4,174	14,084	-1%	1%
12-Month Average	10,016	4526	14,542		

per day, and passenger volumes reached 15,347 passenger-trips per day. These volumes represented increases of 14% in vehicle volumes and 10% in passenger volumes over volumes observed in the last month of CFL operation. However, after April 1985, the volumes began to decline with each month to the point that, by the end of the North Transitway's first year of operation, vehicle and passenger volumes were only 4% and 1%, respectively, higher than they had been one year earlier. Although utilization of the facility has not grown substantially from pre-transitway configuration levels, during a typical peak hour of operation the facility still serves more passenger trips than two adjacent freeway lanes while carrying less than 15% of the vehicle volume that may be served on a single adjacent freeway lane. Furthermore, it is well to recall that the controlling reasons for converting the CFL operation to transitway operation were, first, to return a badly needed lane back to off-peak direction traffic, and second, to improve the operating safety of the freeway. The North Freeway CFL was already an established project in terms of ridership, and thus, the transitway improvement was not expected to result in any substantial increases in utilization over CFL levels. Additionally, the downturn in the Houston economy has not been conclusive to growth in transitway utilization levels.

Transitway Occupancy Rates

Exhibiting a pattern similar to that observed in the transitway's vehicle and passenger volumes, occupancy rates have also risen and then fallen back down to initial rates. Buses started with occupancy rates of approximately 34 passengers per bus during the peak period and the peak hour. Peak period occupancies were more or less stable, varying only between 34 and 36 passengers per bus during the entire year (Figure 39). Peak hour occupancy rates, however, increased to as high as 39 passengers per bus in August 1985 before dropping back down again. Vanpool occupancy rates hovered between 8 and 9 passengers per van (including the driver) throughout most of the year (Figure 40).

Park-and-Ride Demand

The locations of the park-and-ride facilities serving the North Transitway are illustrated in Figure 41. Park-and-ride utilization has continued to increase in the corridor. Park-and-ride demand, as gauged by the number of vehicles parked at each facility, is provided in Table 5. As illustrated in Figure 42, park-and-ride utilization has increased by 14% in the year following the termination of CFL and the beginning of transitway operation. A great majority of this gain in utilization was observed at the Spring and the Kuykendahl Park-and-ride lots which grew 22% and 25%, respectively, in the first year of transitway operation.

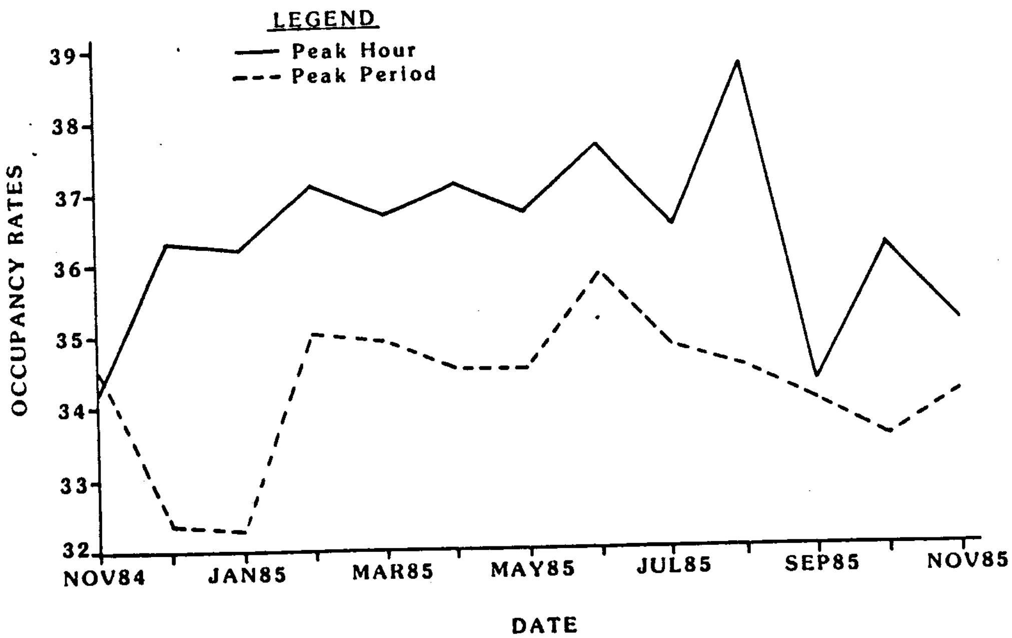


Figure 39. Transitway Bus Occupancy Rates

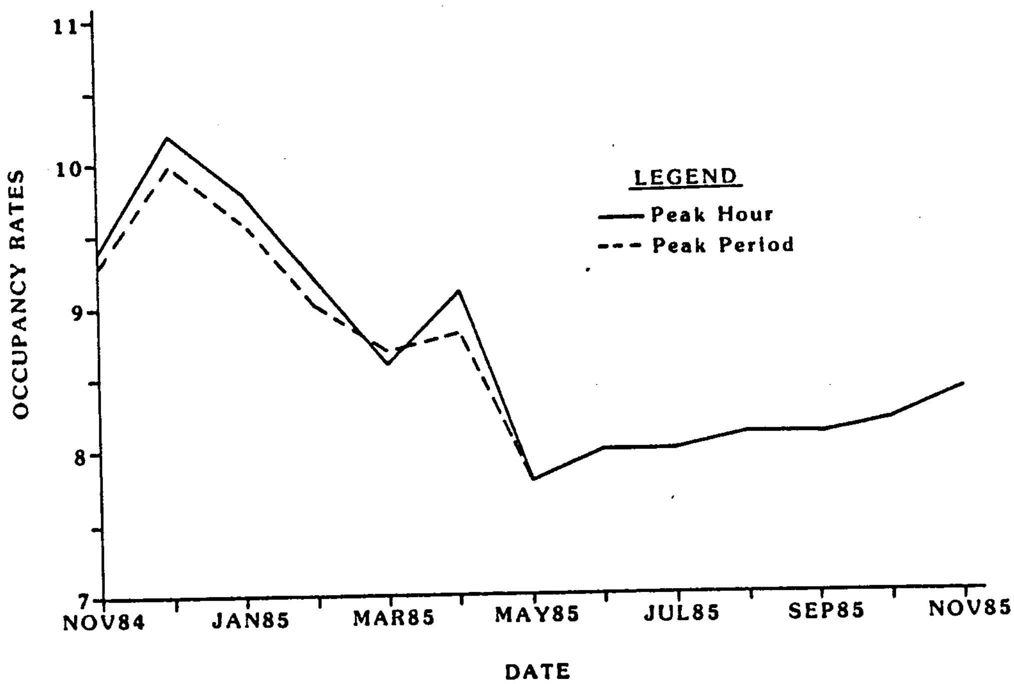


Figure 40. Transitway Vanpool Occupancy Rates

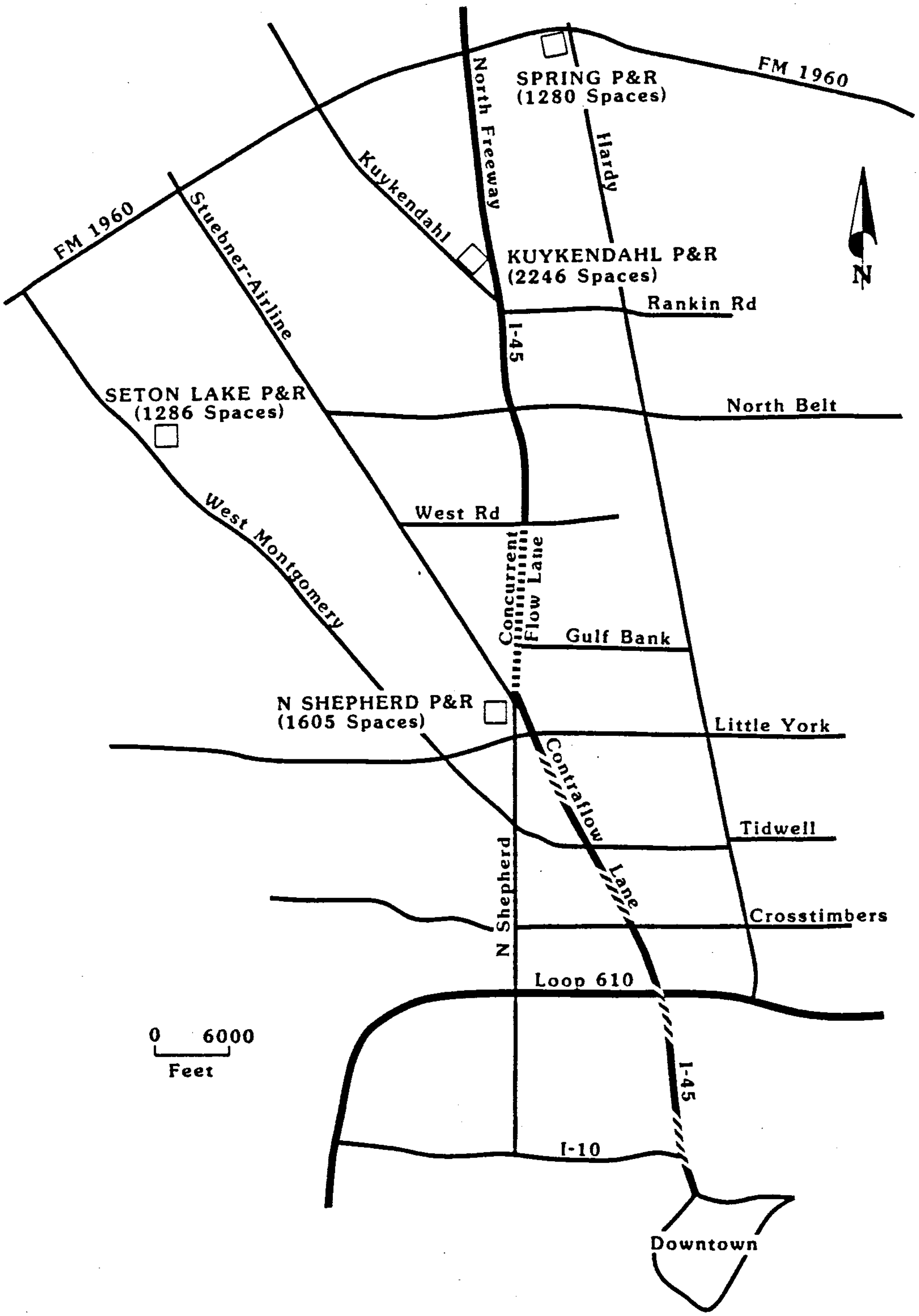


Figure 41. Transitway Park-and-Ride Lots

Table 5. North Freeway Park-and-Ride Demand

(# Parked Vehicles)

Month/Year	Seton Lake	Spring	Kuykendahl	N. Shepherd	Total	% Change
November '84	650*	848	1,470	736	3,704	---
December '84	650*	887	1,466	735	3,738	1%
January '85	652	888	1,519	763	3,822	3%
February '85	662	1,088	1,649	760	4,159	12%
March '85	681	1,073	1,670	689	4,113	11%
April '85	606	1,021	1,682	715	4,024	9%
May '85	641	980	1,783	748	4,152	12%
June '85	693	963	1,778	710	4,144	12%
July '85	648	902	1,820	675	4,045	9%
August '85	638	982	1,849	739	4,208	14%
September '85	651	1,023	1,831	754	4,259	15%
October '85	647	1,013	1,863	764	4,287	16%
November '85	654	1,036	1,842	692	4,234	14%

* estimated, no data available

As summarized in Table 6, transitway users share some personal characteristics with non-users but very dissimilar trip characteristics. On average, the typical transitway user is about 3 years older than non-users. Women comprise a larger proportion of the transitway population than they do of the non-transitway commuter population. The median education level is approximately the same (16 years) in both groups; and the distribution of occupations is similar across both groups although a smaller percentage of clerical and a higher percentage of sales occupations was found among the non-transitway users. The most salient difference between the two commuter groups lies in their ultimate trip destinations. While transitway users were overwhelmly destined for the downtown area (94% of the express transit trips and 61% of the vanpool trips), less than one-third of the non-transitway commuters (31%) were similarly destined for downtown Houston.

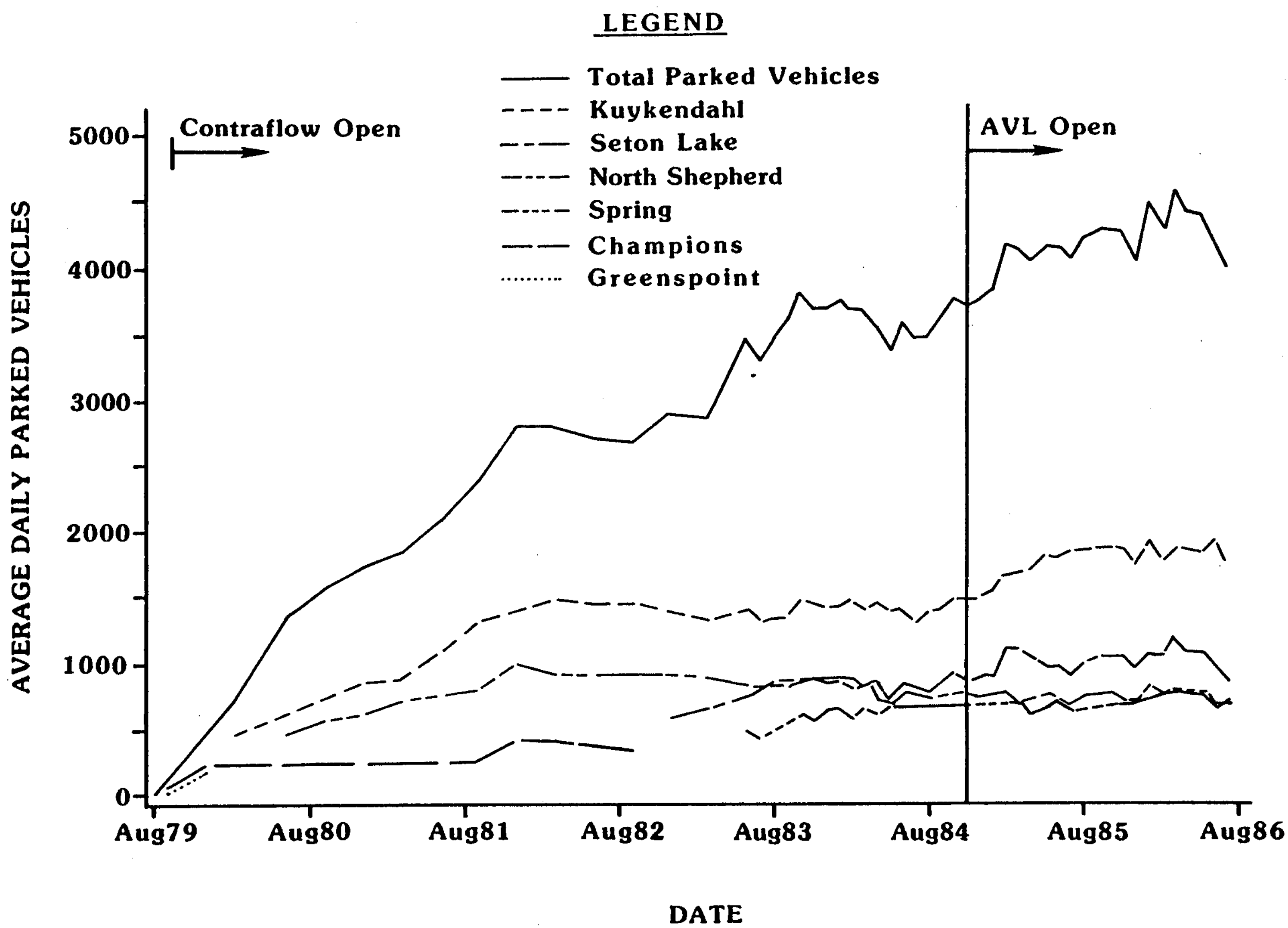


Figure 42. North Freeway Corridor, Park-and-Ride Utilization

Table 6. Personal and Trip Characteristics of Survey Respondents

Characteristic	Transitway Users		Non-Transitway Users
	Transit (P&R)	Vanpools	Motorists
Median Age (years)	39	39	36
Sex (% male)	44%	55%	62%
Median Education (years)	16	16	16
Occupation			
% Professional	38%	45%	38%
% Managerial	23%	24%	21%
% Clerical	30%	23%	15%
% Sales	3%	7%	13%
Trip Destination			
Downtown	94%	61%	31%
Greenway Plaza	2%	8%	5%
University of Houston	2%	1%	1%
Galleria/City Post Oak	1%	7%	7%
Texas Medical Center	1%	4%	4%

Source: TTI survey of North Freeway commuters, January 1986.

Transitway Peaking Characteristics

Transitway vehicle demand has exhibited relatively consistent peaking patterns throughout the first year of transitway operation. Bus volumes in particular changed very little from month to month. As illustrated in Figures 43 and 44, approximately 50% of total peak period bus volumes may be observed on the facility during a typical peak hour of operation and about 14% in the peak 15-minutes of operation. Vanpools, on the other hand, exhibited sharper peaking patterns. Between 20% to 30% of total peak period vanpools used the facility during a typical peak 15-minutes of operation. More than 65% used the facility during a typical peak hour of operation. Overall, about 60% of all peak-period transitway vehicles utilized the facility during the peak hour of operation.

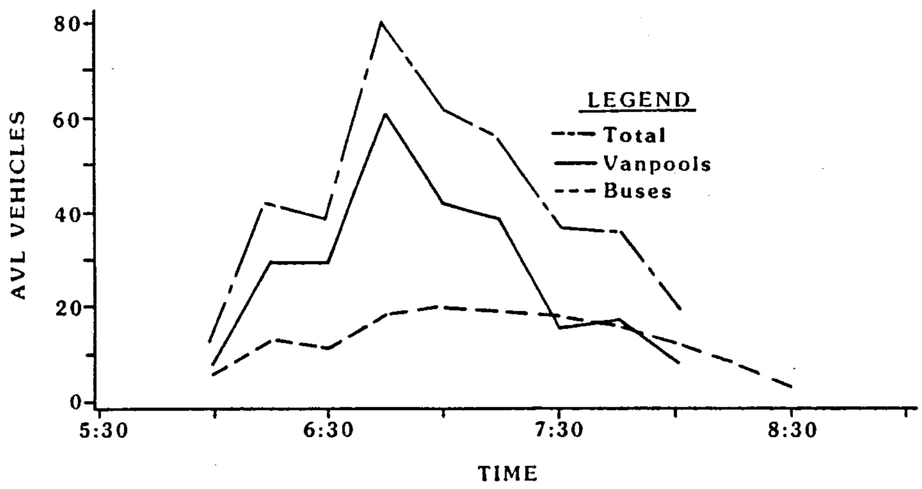


Figure 43. North Transitway Morning Distribution of Volume

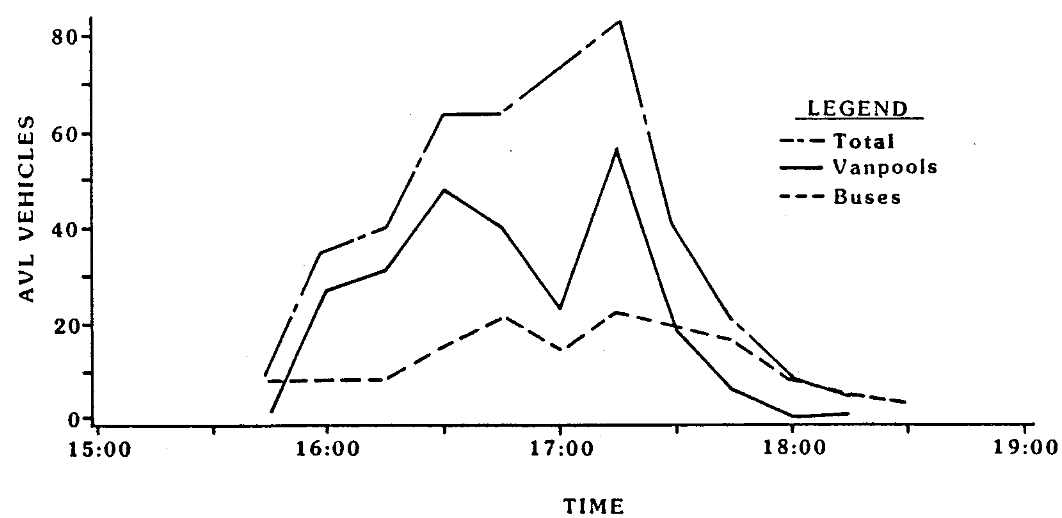


Figure 44. North Transitway Afternoon Distribution of Volume

Bus scheduling and schedule adherence was consistent between the morning and the afternoon periods. Vanpool volumes, on the other hand, showed markedly different patterns of peaking in the morning as opposed to the afternoon. Except for a few months in the spring, morning vanpool volumes consistently peaked at a single 15-minute time period, starting at approximately 6:45 am. In the afternoon, however, vanpool volumes consistently peaked at two different 15-minute time periods, starting at 4:30 pm and at 5:15 pm.

Transitway Travel Time Savings

In September 1985, travel time studies were conducted along the freeway mainlanes from North Shepherd to downtown Houston. Although Phase 2 construction had already commenced at that point, the construction work was confined primarily to the frontage roads and the I-45N freeway shoulders within the I-610 loop. Various ongoing operational studies indicated little to no impact on freeway operating speeds at this early stage of the construction sequences (9). Travel time runs were made at 30 minute intervals throughout the peak 3-hours of operation during the morning as well as the afternoon peak periods. As listed in Table 7 and illustrated in Figures 45 and 46, transitway users receive a distinct advantage over mainlane motorists. Transit users save an average of approximately 6.5 minutes per trip in the morning and 11.5 minutes per trip in the afternoon over mainlane trips made during a typical 3-hour peak period. These travel time savings increase to an average of 9.2 minutes per trip and 15.2 minutes per trip in the morning and in the afternoon, respectively, during the peak hours on the mainlanes.

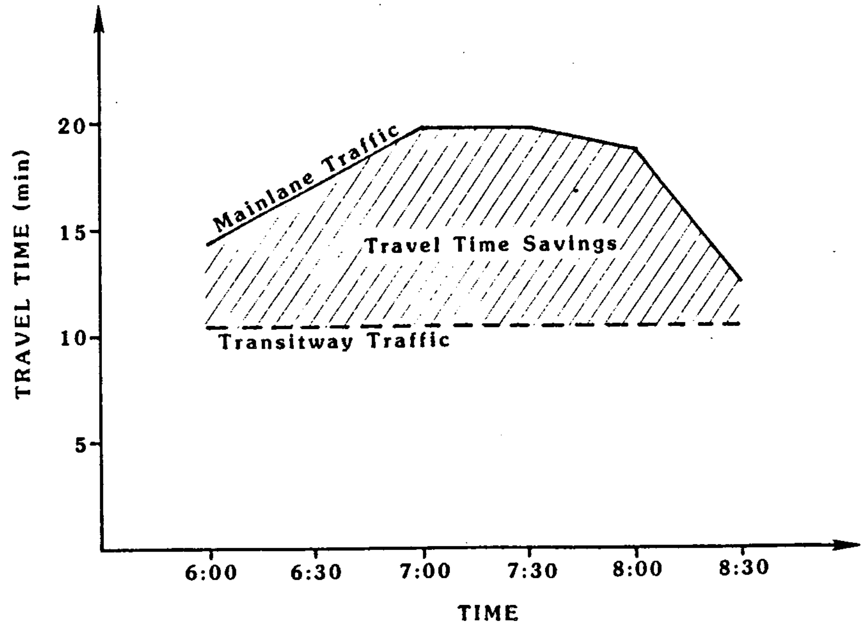


Figure 45. North Freeway Transitway and Mainlane Travel Times, Morning

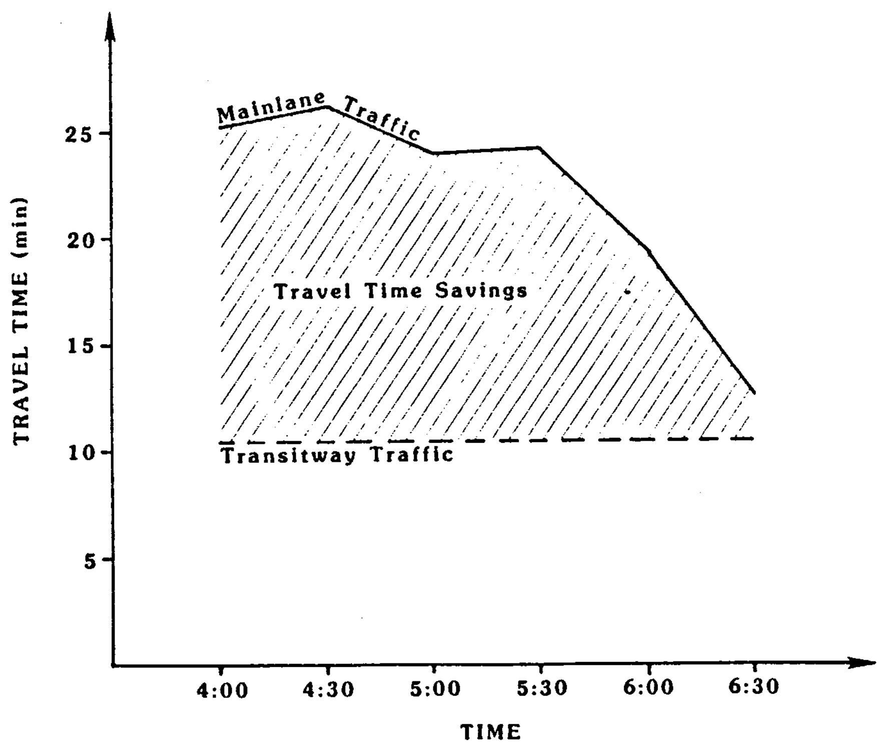


Figure 46. North Freeway Transitway and Mainlane Travel Times, Afternoon

Table 7. North Freeway Travel Times and Average Speeds - Mainlanes vs. Transitway (N. Shepherd to Downtown, 9.6 miles)

Starting Time	Average Travel Time Mainlanes	Average Travel Time Transitway	Average Speed Mainlanes	Average Speed Transitway
6:00 am	14.2 min.	10.5 min.	41 mph	55 mph
6:30	17.0		34	
7:00	19.7		29	
7:30	19.7		29	
8:00	18.7		31	
8:30	12.6		46	
Morning Average	17.0 min.	10.5 min.	35 mph	55 mph
4:00 pm	25.3 min	10.5 min	23 mph	55 mph
4:30	26.1		22	
5:00	24.0		24	
5:30	24.2		24	
6:00	19.3		30	
6:30	12.8		45	
Afternoon Average	22.0min.	10.5 min	28 mph	55 mph

Surveillance, Communication, and Control

The surveillance, communication, and control (SC&C) system is designed to provide traffic control, user communication, and incident management capabilities for the North Transitway. The system will be composed of the following elements:

1) Overhead Lane Control Signals (Figure 47),
2) Changeable Message Signs (Figure 48),
3) Pavement Vehicle Detection Loops,
4) Entry authorization gates and metering devices (Figure 49),
5) Closed Circuit Television Surveillance (Figure 50),
6) Fiber Optic Communications, and
7) Centralized Computer Controls (Figure 51).

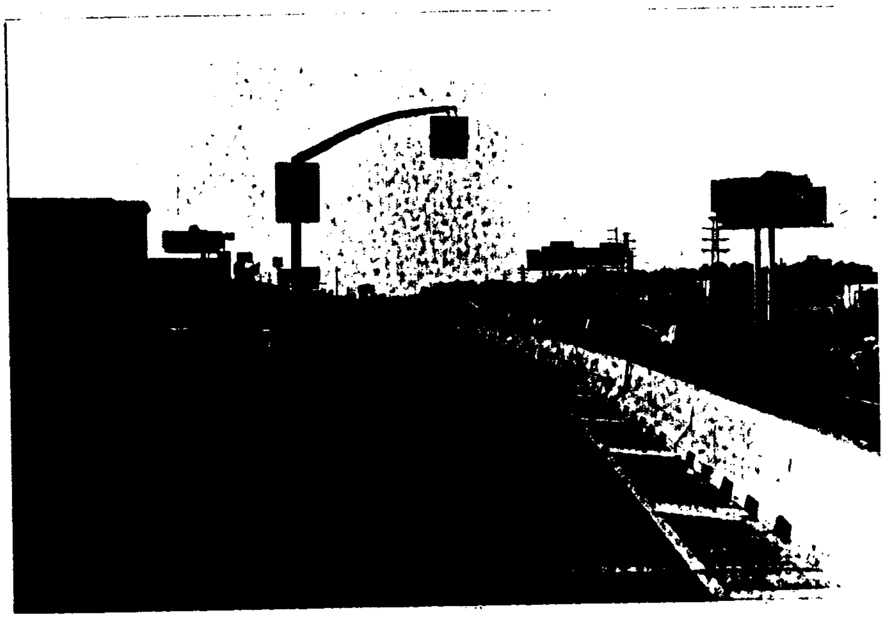


Figure 47. Transitway Overhead Lane Control Signals As Implemented on Katy Transitway

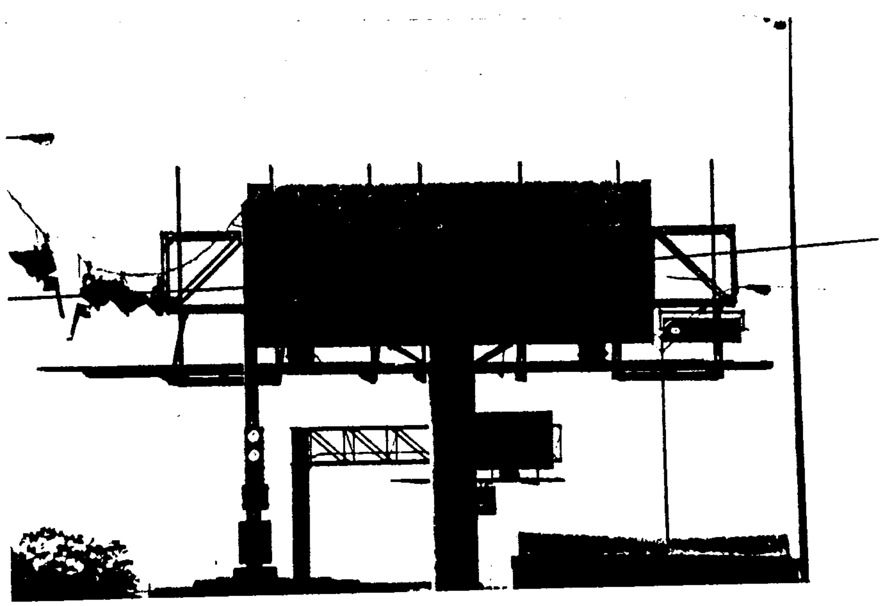


Figure 48. Transitway Changeable Message Signs As Implemented on Katy Transitway

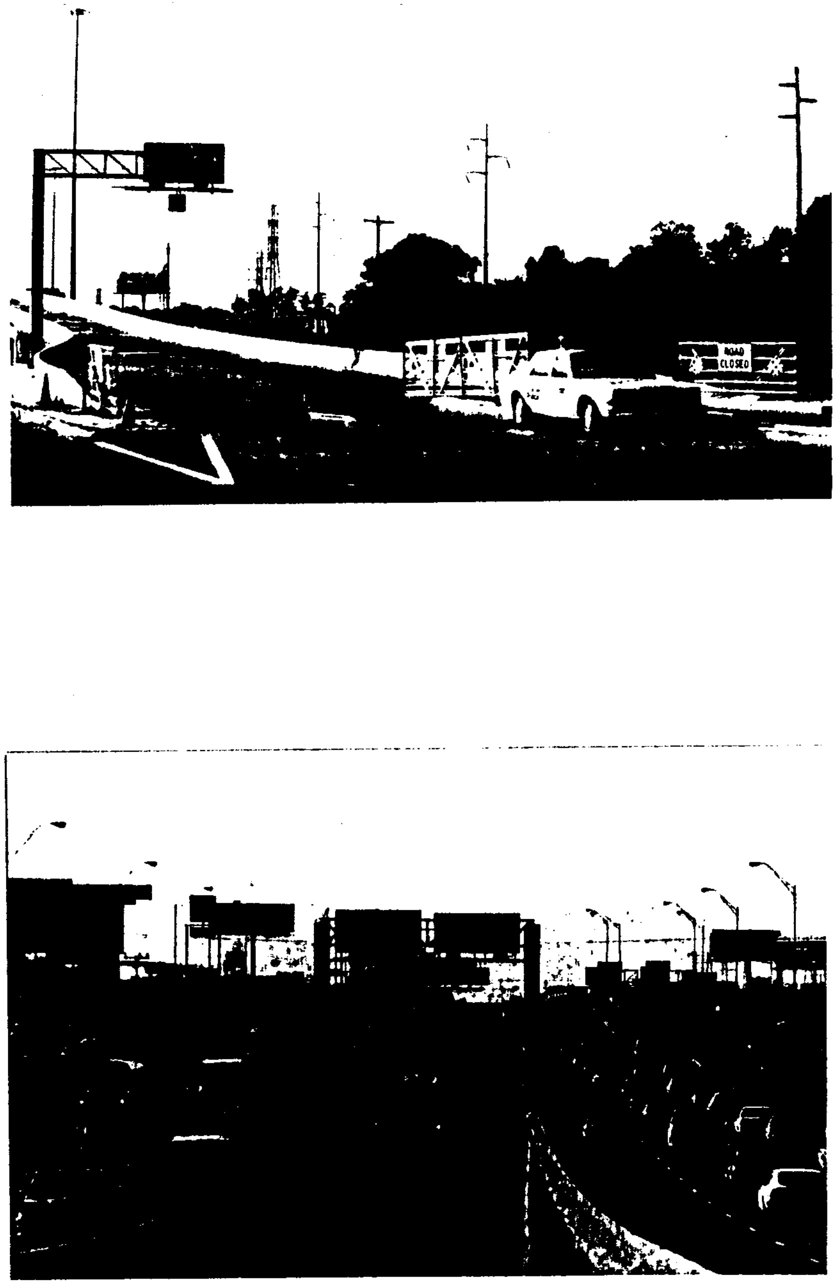


Figure 49. Transitway Entry Gates As Implemented On Katy Transitway

Figure 50. Transitway Closed Circuit Television Surveillance As Implemented For Katy Transitway

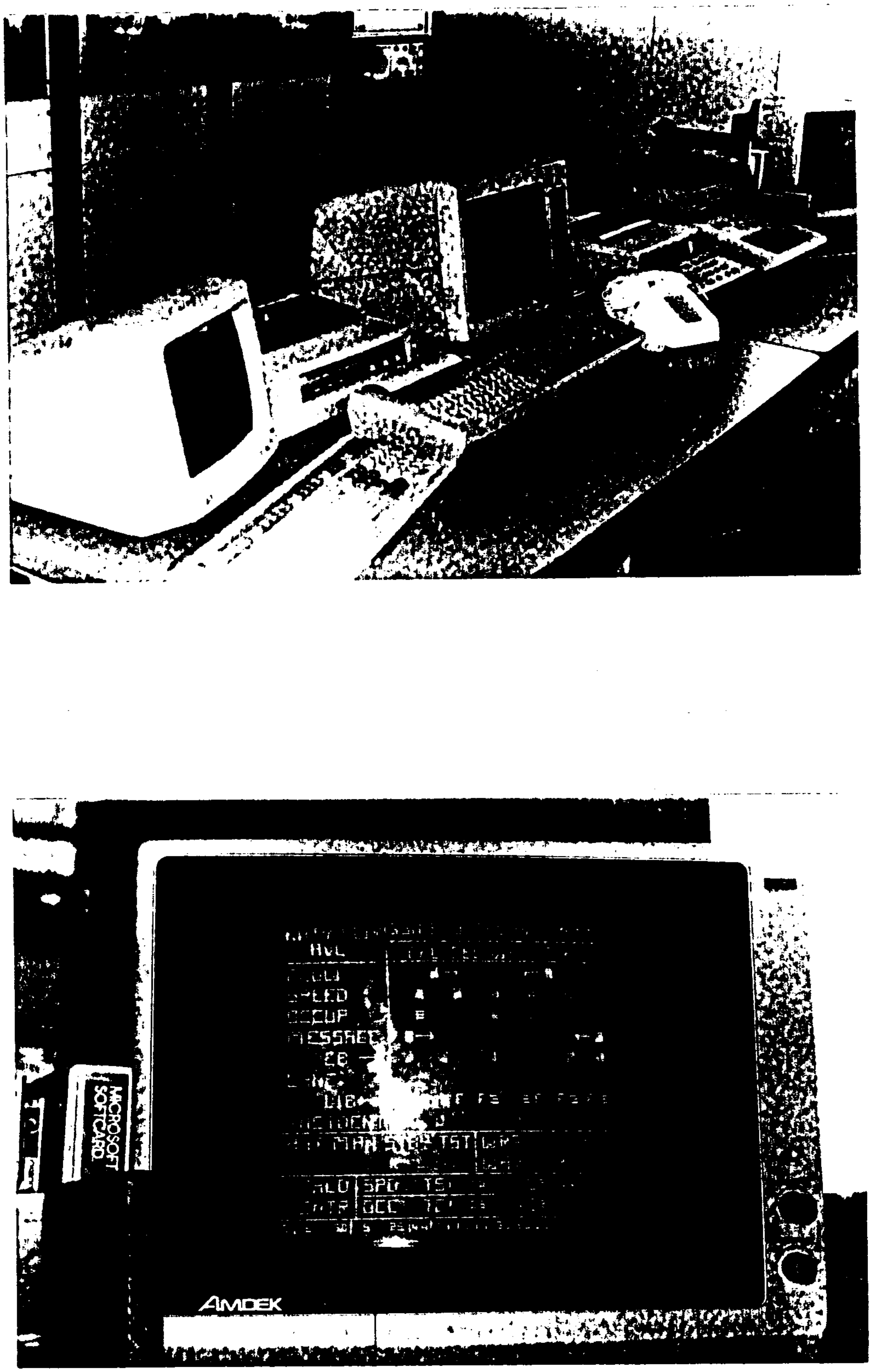


Figure 51. Transitway Computer Control as Implemented on Katy Transitway

The overhead lane control signals will provide directional information, and the changeable message signs will satisfy various other user and non-user information needs. The detection loops will provide operational data such as the volume, density, speed, and types of vehicles using the facility. Closed circuit television will provide a visual means to verify incidents that have been identified by the pavement detection loops. Finally, the entire network of overhead lane control signals, changeable message signs, vehicle detection loops, and closed circuit television will be integrated through a fiber-optic communications line and transmitted from an unmanned "satellite" control center. The unmanned control center will be located near the transitway underneath the I-45N/I-610 interchange, and the central control center is expected to be built within the existing Kashmere bus facility (Figure 52).

The Texas State Department of Highways and Public Transportation (SDHPT) has assumed most of the responsibilities for designing as well as funding a large portion of the North Freeway SC&C system. At the present time, it is understood that the SDHPT will commence implementation of the SC&C system during the Phase 3 construction project. Currently, the total cost of the system for Phases 1 through 3, approximately 12.7 miles of coverage from downtown Houston to the North Belt, is estimated to be approximately $4.0 million including all related transmission costs. The 5.6 mile extension of the system from the North Belt to as far north as FM 1960 is expected to cost approximately $1.8 million for a total system cost, from downtown Houston to FM 1960, of $5.8 million or $320,000 per mile.

Transitway Operations

Operation of the North Transitway, at this time, is still performed manually by an on-site METRO crew. Inbound operation begins at 6:00 am and is terminated by 8:30 am. Afternoon outbound operation commences at 3:45 pm and extends to 6:30 pm.

The transit police employ a roving vehicle with no permanent enforcement station to patrol the transitway. A specially designed METRO wrecker is situated at the southern terminus in the morning and at the northern terminus

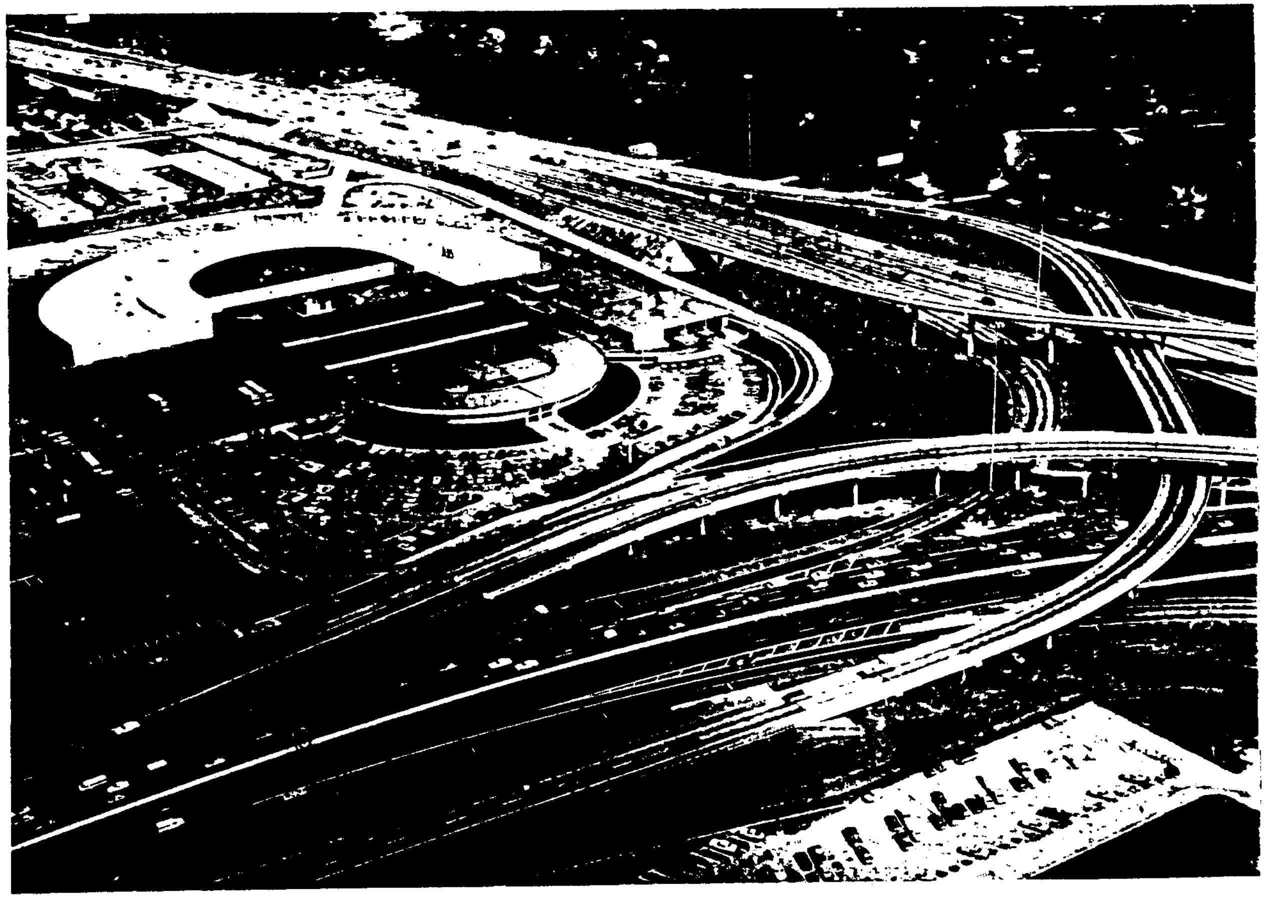


Figure 52. Central Control Center at Existing Kashmere Bus Facility

in the afternoon to respond to any incidents within the facility. The wrecker has been provided with an unusually short wheel base in order to provide it with the capability to turn around within the transitway (Figure 53).

Over the first year of transitway operation, an average of 9 vehicles became disabled within the facility each month (Table 8 and Figure 54).

Table 8. North Transitway Disabled and Towed Vehicles

	Buses		Vanpools		Others*		Total	
Month	Disabled	Towed	Disabled	Towed	Disabled	Towed	Disabled	Towed
Dec84	4	1	2	1	2	3	8	5
Jan85	1	0	1	1	3	2	5	3
Feb85	0	0	2	0	3	3	5	3
Mar85	4	3	2	0	5	5	11	8
Apr85	4	1	2	0	4	2	10	3
May85	4	0	3	0	2	1	9	1
Jun85	11	5	1	0	2	0	14	5
Jul85	4	2	4	1	1	1	9	4
Aug85	3	1	1	0	2	2	6	3
Sep85	2	1	1	0	6	4	9	5
Oct85	5	1	2	0	3	3	10	4
Nov85	6	1	3	1	3	2	12	4
12-Mo. Avg.	3.8	1.3	2.0	0.3	3.0	2.3	9.0	4.0

*Usually unauthorized vehicles

Source: (1)

Transitway buses comprised an ever increasing proportion of these disabled vehicles. Of these disabled vehicles, less than 50% required the services of the METRO wrecker to tow them out of the facility (Figure 55). The remaining disabled vehicles were able to exit the facility after being given short term remedies such as having their tires temporarily reinflated. Buses comprised roughly one-third of those vehicles that had to be towed out of the facility (Figure 56). These types of incidents are significant when they occur within the narrow transitway as it currently exists because such incidents tend to

Figure 53. METRO Transitway Wrecker

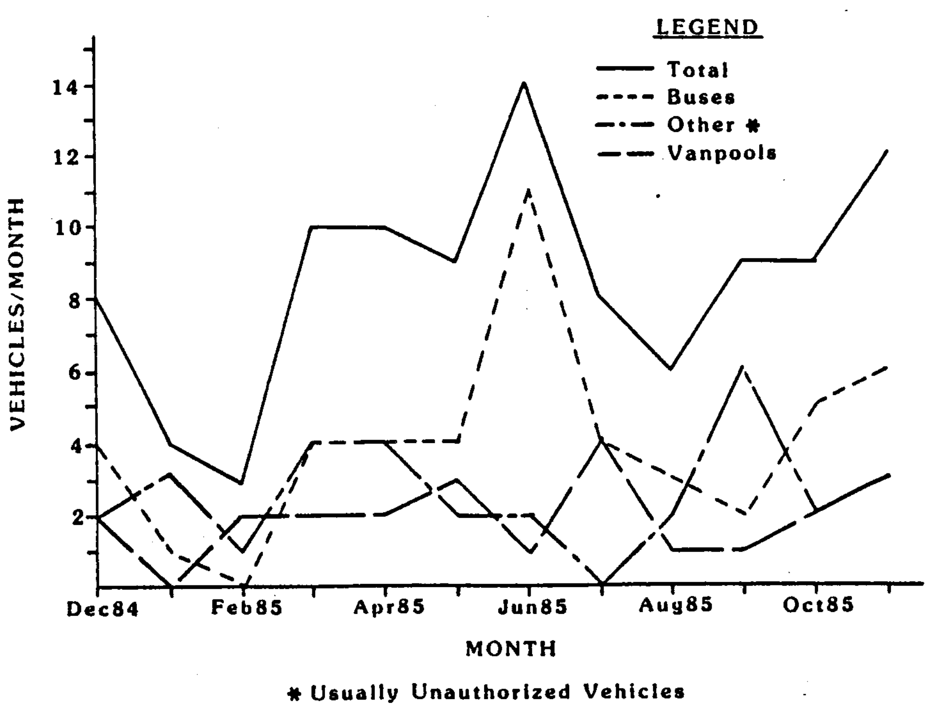


Figure 54. Total Transitway Disabled Vehicles

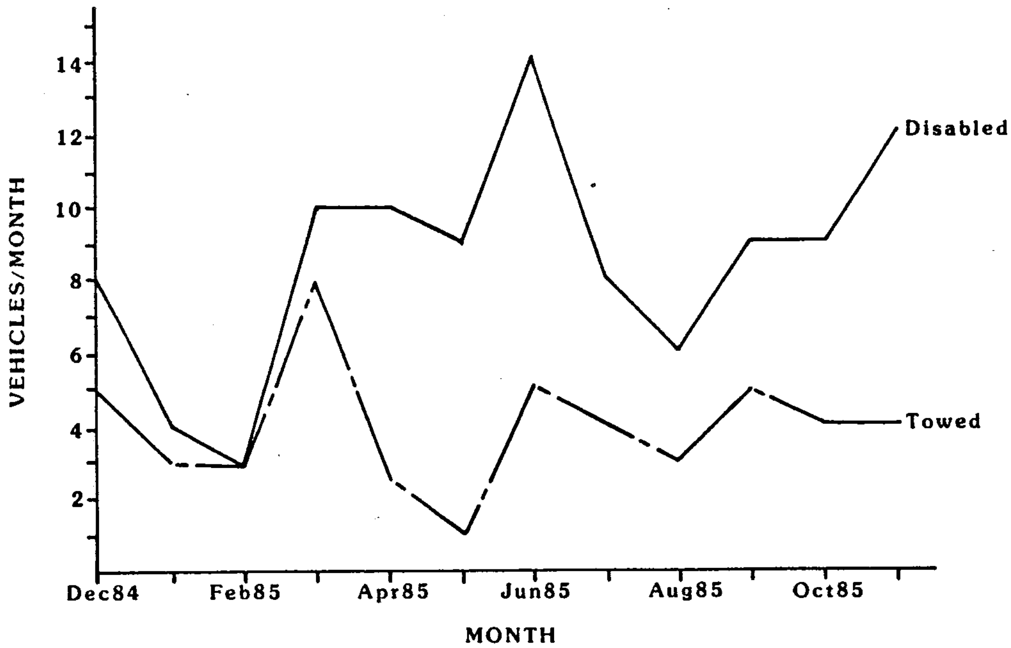


Figure 55. Transitway Disabled and Towed Vehicles

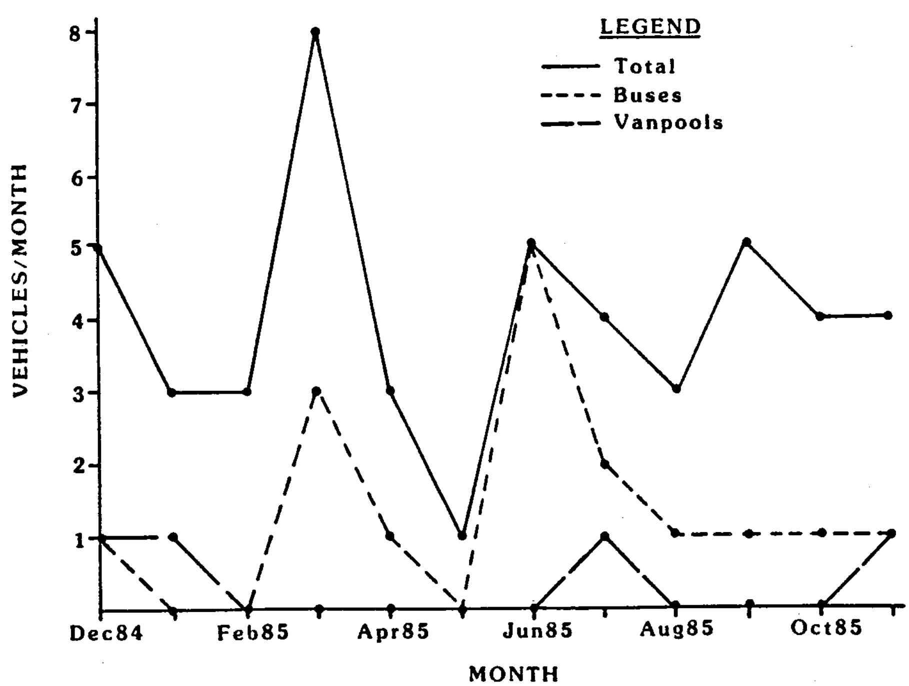


Figure 56. Transitway Towed Vehicle (bus & vanpool)

completely block the transitway until they are removed from the facility. In the future, after Phase 2 construction on the freeway is completed, the transitway will be expanded to its final, full width of almost 20 feet. Under this wider configuration, transitway operation will not have to be completely stopped if a vehicle should become disabled within the facility; the transitway will be wide enough to allow transitway vehicles to drive around the disabled vehicle. However, until the Phase 2 construction project is completed, the interim transitway must continue to operate at its current width of 14 to 16 feet. Under a worst case scenario, an incident could occur halfway between two of the transitway's "bubble" points (locations along the transitway wide enough for the METRO wrecker to turn around in). Such an incident could require up to 30 minutes to be cleared including the time needed to detect, respond, and remove the disabled vehicle. This transitway blocked time per incident would translate into an average delay of 15 minutes per vehicle for each vehicle which enters the queue upstream of the incident.

In addition to the occurrence of disabled vehicles within the facility, the North Transitway has experienced a number of other types of incidents during its first year of transitway (as opposed to CFL) operation. On average, over the 12 month period, approximately 1.5 pedestrians had to be removed from the facility each month. Almost 3 vehicles were observed exceeding speed limits within the facility each month. More than 112 vehicles each month entered the facility without prior authorization (Figure 57). A great majority of these unauthorized entries occurred in the afternoons because of the location and the configuration of the southern access point and because of the use of pylons along the northern most segment on the outbound side of the transitway (Figure 58). Only 12% of the unauthorized vehicles were issued tickets carrying a maximum fine of $200 per violation, the remainder were given either verbal warnings or were simply not apprehended (Figure 58). Finally, accidents within the transitway (including near misses, and all other incidents involving any physical damage to vehicles or to facility equipment) occurred at a rate of about 1.6 accidents per month.

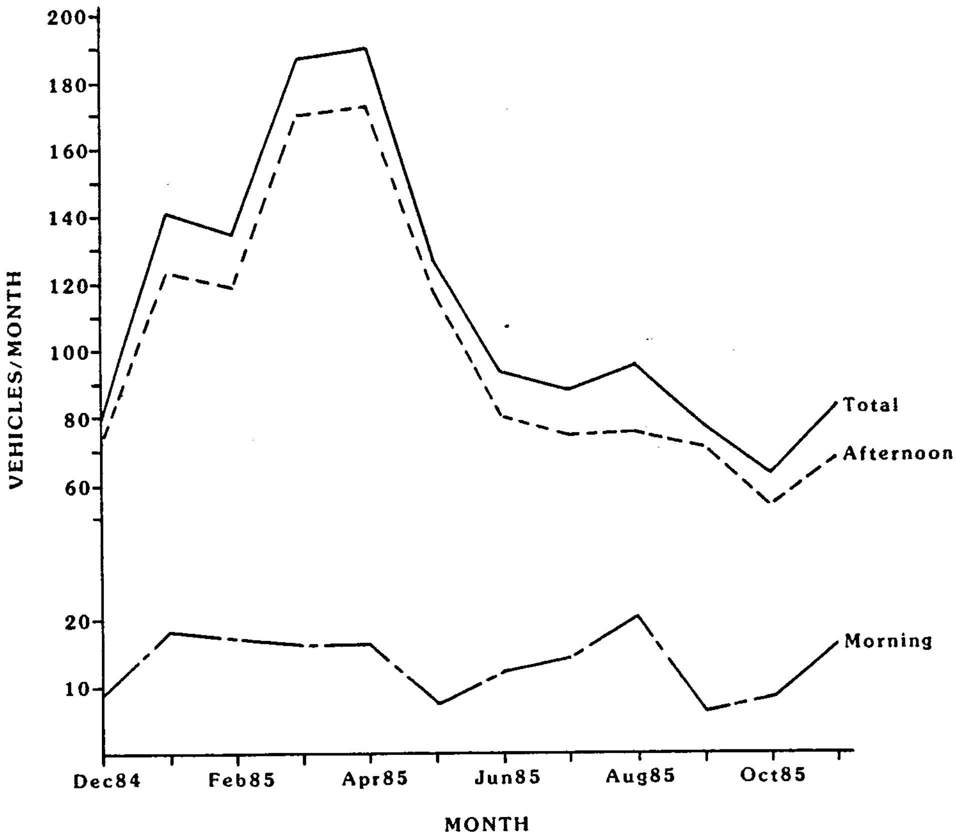


Figure 57. Total, Morning and Afternoon Unauthorized Vehicles

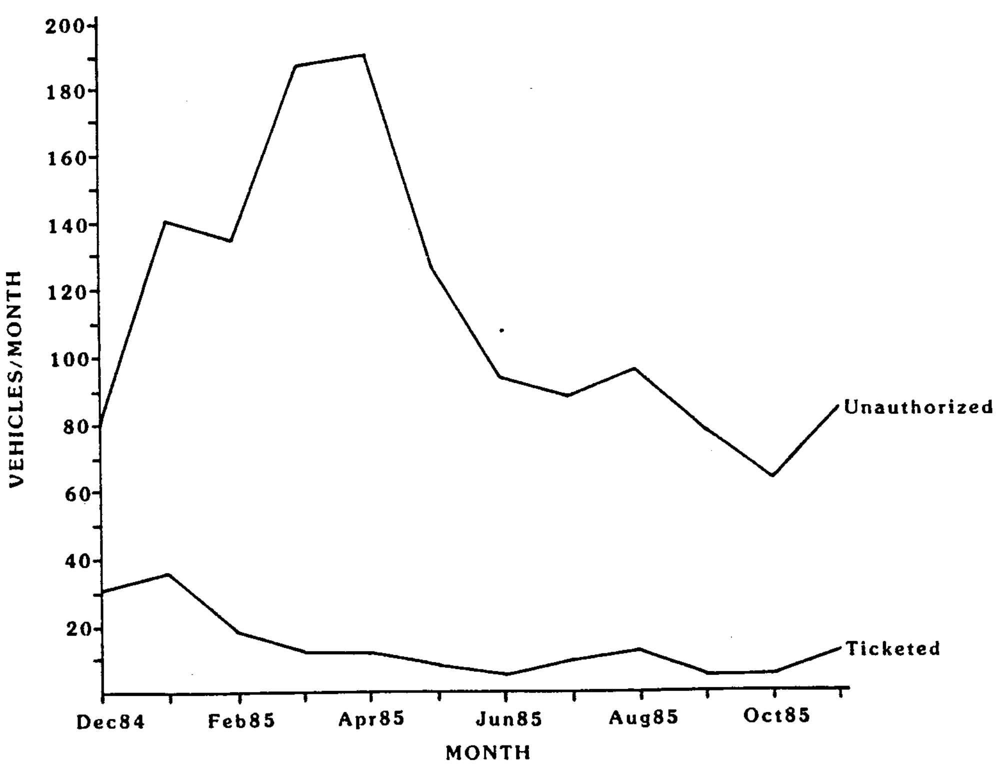


Figure 58. Unauthorized vs. Ticketed Vehicles

MAINLANE EFFECTS FROM TRANSITWAY IMPLEMENTATION

Since the completion of Phase 1 construction, the North Freeway mainlanes has returned to pre-transitway construction operating conditions in the peak directions. As illustrated in Figures 59 through 62, afternoon speeds are almost identical between the pre- and the post-transitway construction periods, although both are almost 6 mph slower than the speeds observed during construction of the transitway 30 mph before and after versus 36 mph during transitway construction. In the morning, peak-period speeds are still an average of 5 mph slower than before transitway construction (32 mph after versus 37 mph before transitway construction); however, average peak-period peak direction operating speeds have improved by 4 mph over the speeds observed during construction which averaged about 28 mph.

Some explanation for the slightly lower speeds in the morning may be derived from the higher volumes on the freeway in the morning. As shown in Figure 63, morning flow rates remain fairly constant across the 3-hour peak-period at a level slightly higher than pre-transitway construction levels (from an average of 1300 vehicles per hour per lane to 1340 vehicles per hour per lane during the entire peak period and from 1330 to 1350 vehicles per hour per lane during the peak hour). Afternoon flows, however, appear to have flattened out at a lower volume and no longer show the exaggerated peaks observed in the preconstruction data (Figure 64). The average afternoon peak period flow rate has decreased from 1330 to 1280 vehicles per hour per lane, and the afternoon peak-hour flow rate mimics the peak-period decline, dropping from 1400 vehicles per hour per lane to 1330 vehicles per hour per lane.

In the off-peak direction, a noticeable improvement has been observed in both peak-period and peak-hour operating conditions. As illustrated in Figures 65 and 66, both morning and afternoon average off-peak direction travel speeds have steadily improved, first from the suspension of contraflow operation (in its original form) during construction and then from the completion of the Phase 1 transitway construction project. In the morning, peak-hour speeds grew from a pre construction average of 43 mph to a during construction average of 54 mph. Since construction has ended, the morning

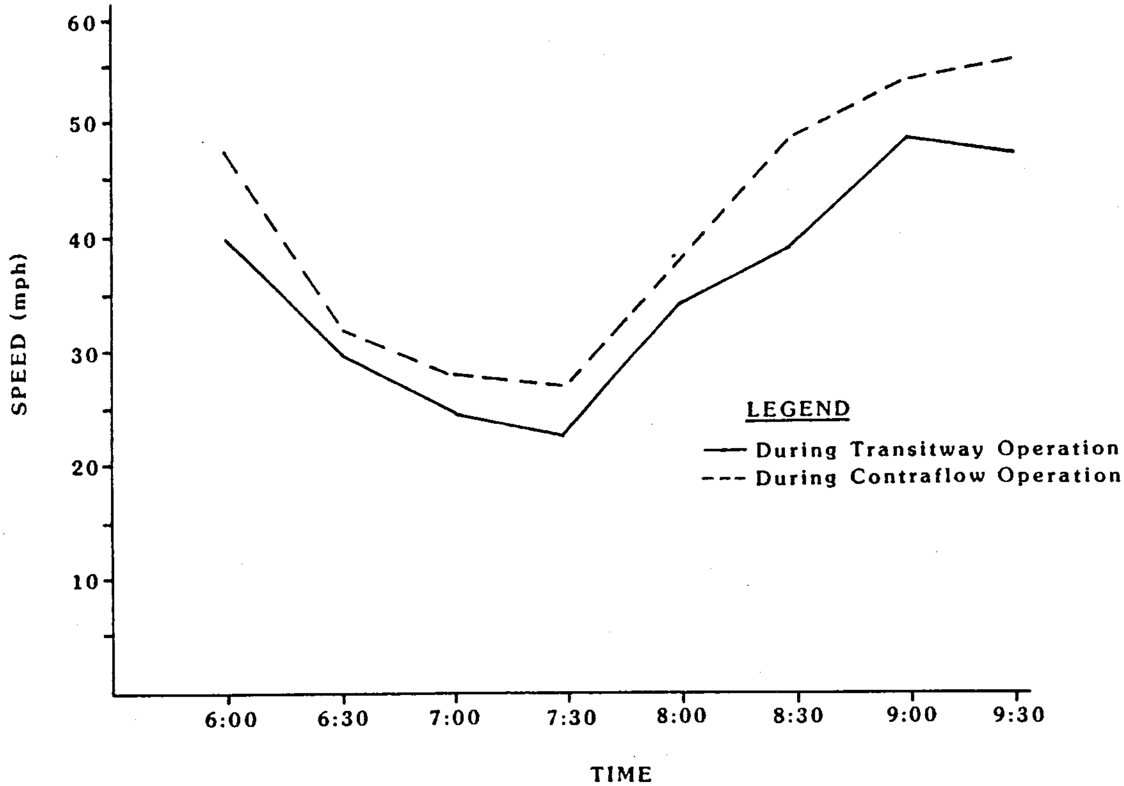


Figure 59. Average Morning Inbound Mainlane Speeds (Before vs. After Construction

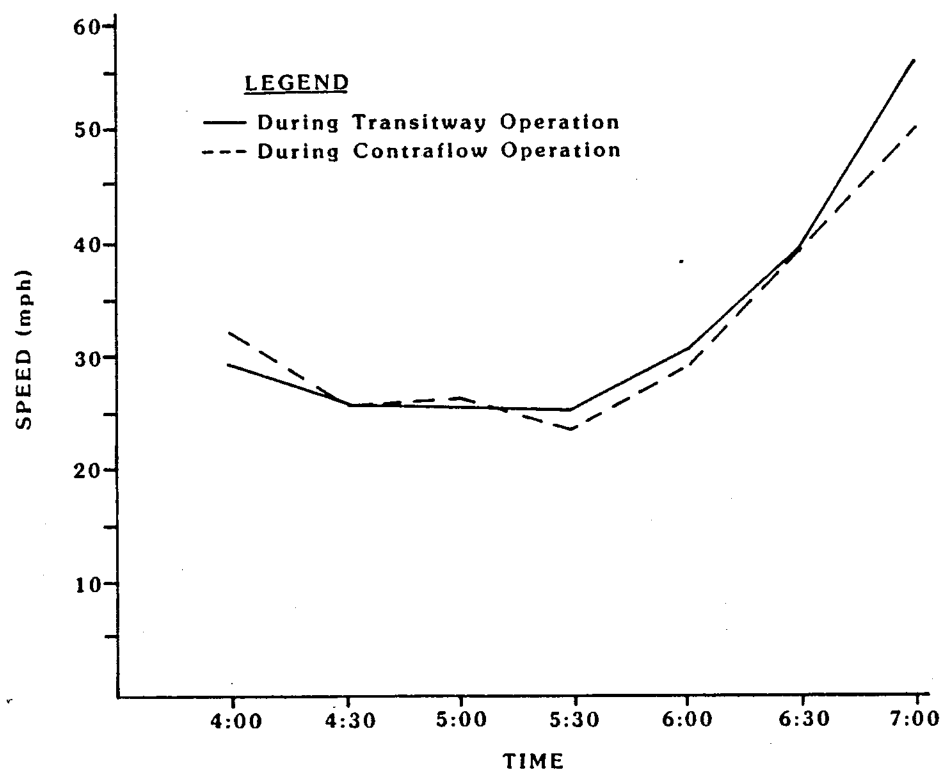


Figure 60. Average Afternoon Outbound Mainlane Speeds (Before vs. After Construction)

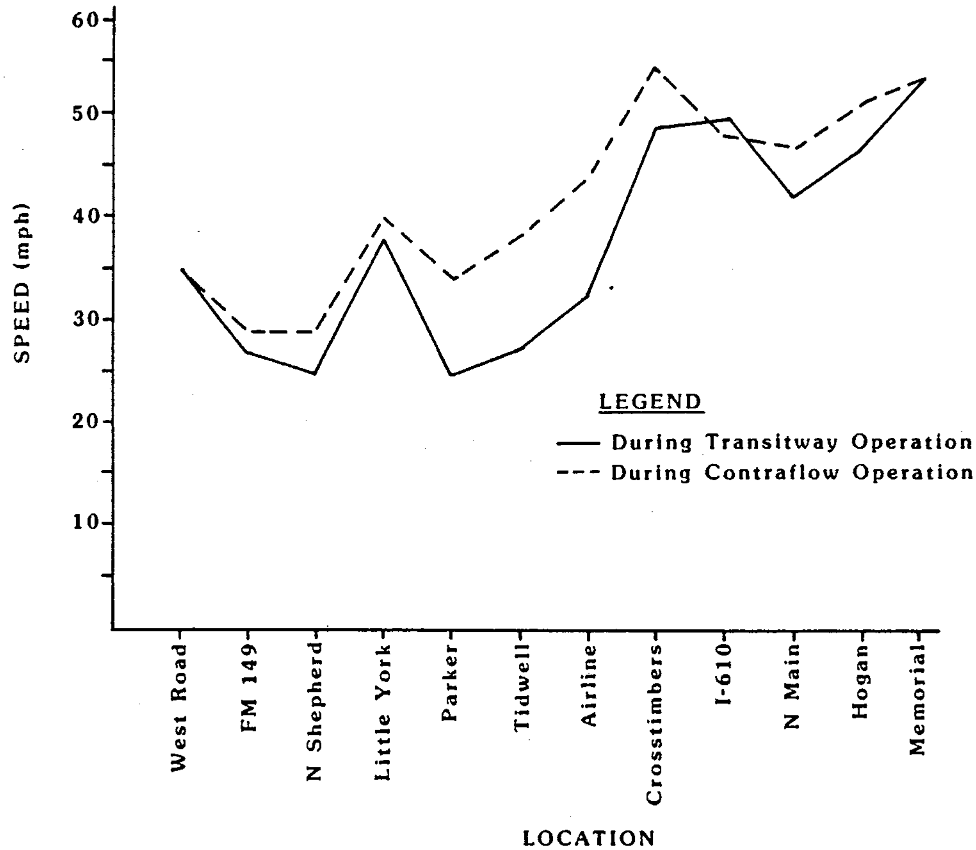


Figure 61. Average Morning Sectional Inbound Mainlane Speeds (Before vs. After Construction)

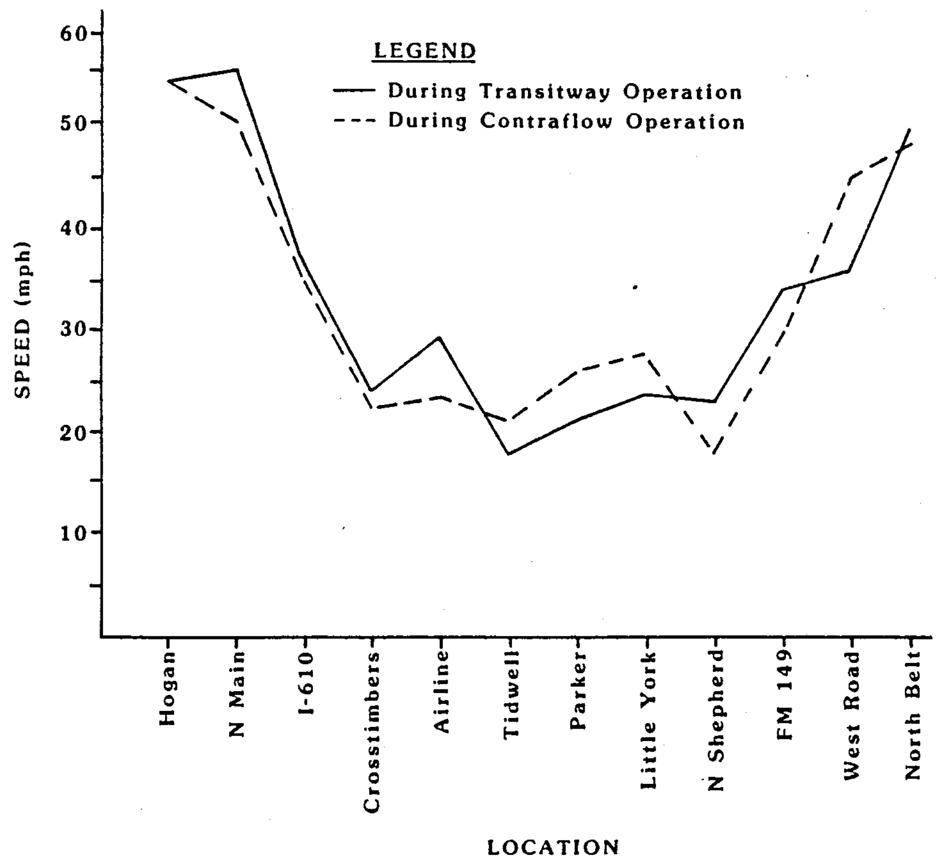


Figure 62. Average Afternoon Sectional Outbound Mainlane Speeds (Before vs. After Construction)

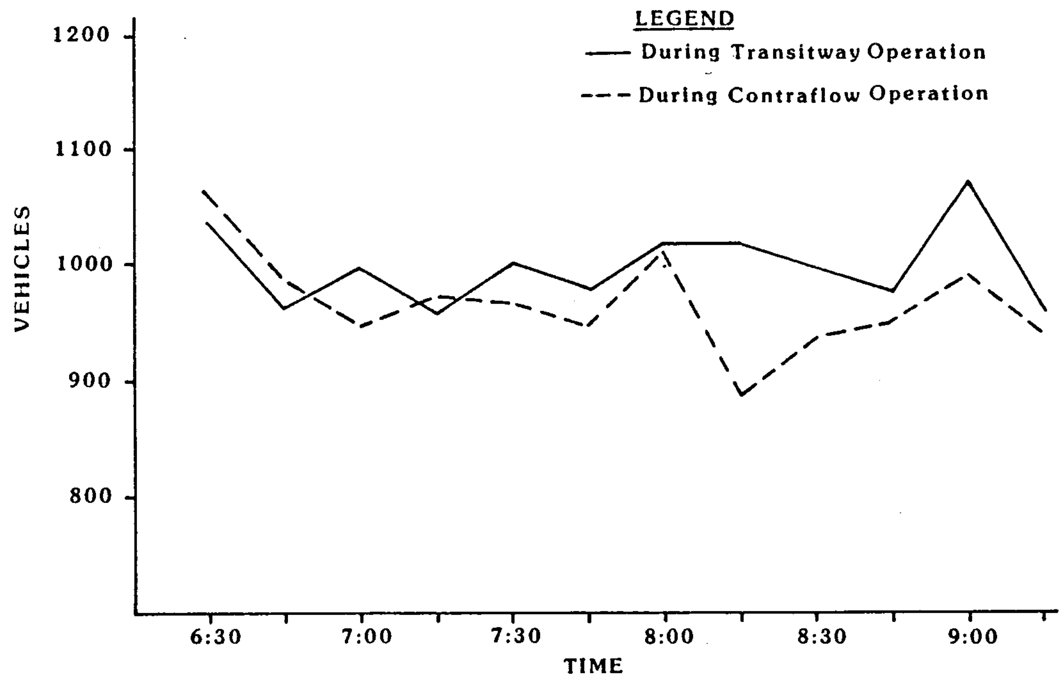


Figure 63. Average Morning Inbound Mainlane Volumes (Before vs. After Construction)

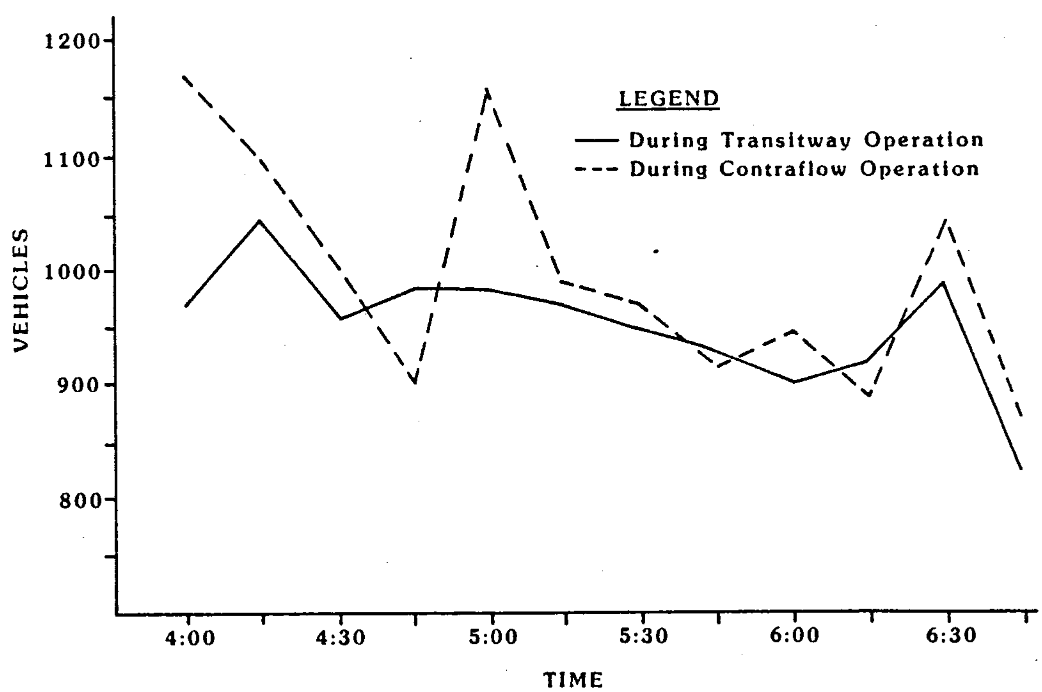


Figure 64. Average Afternoon Outbound Mainlane Vehicle Volumes (Before vs. After Construction)

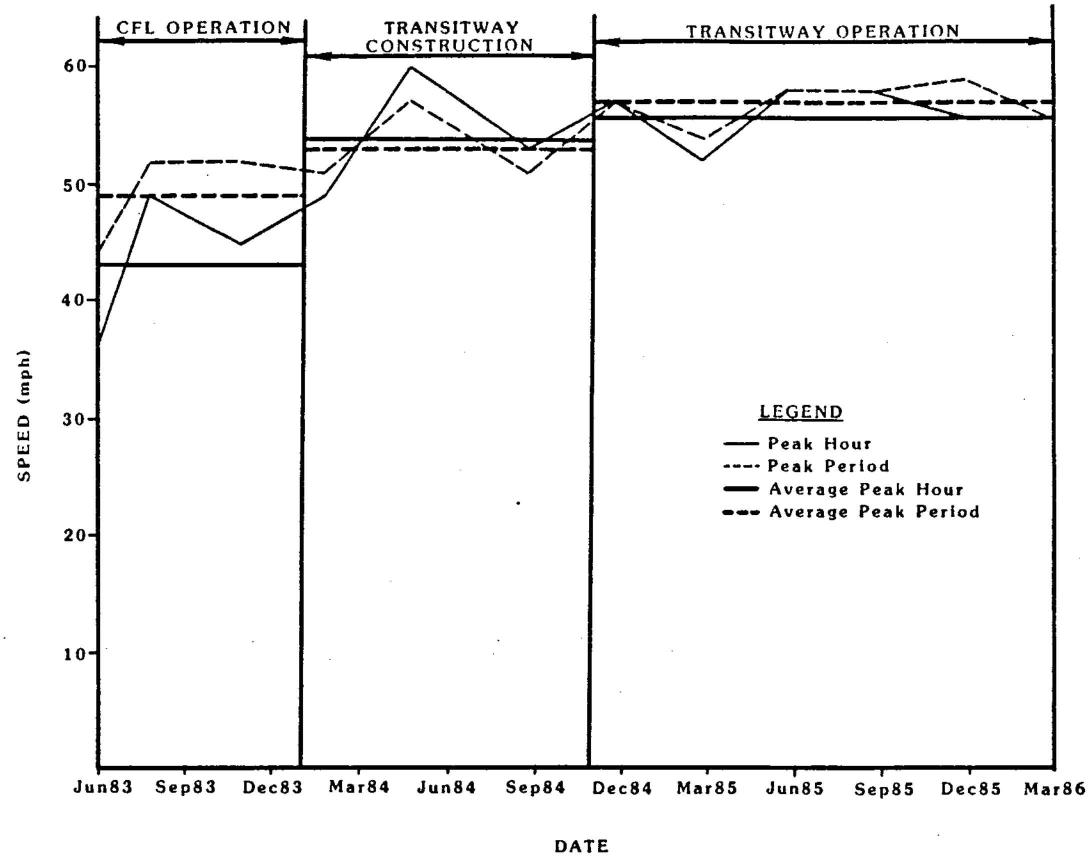


Figure 65. Average Morning Outbound Mainlane Speeds

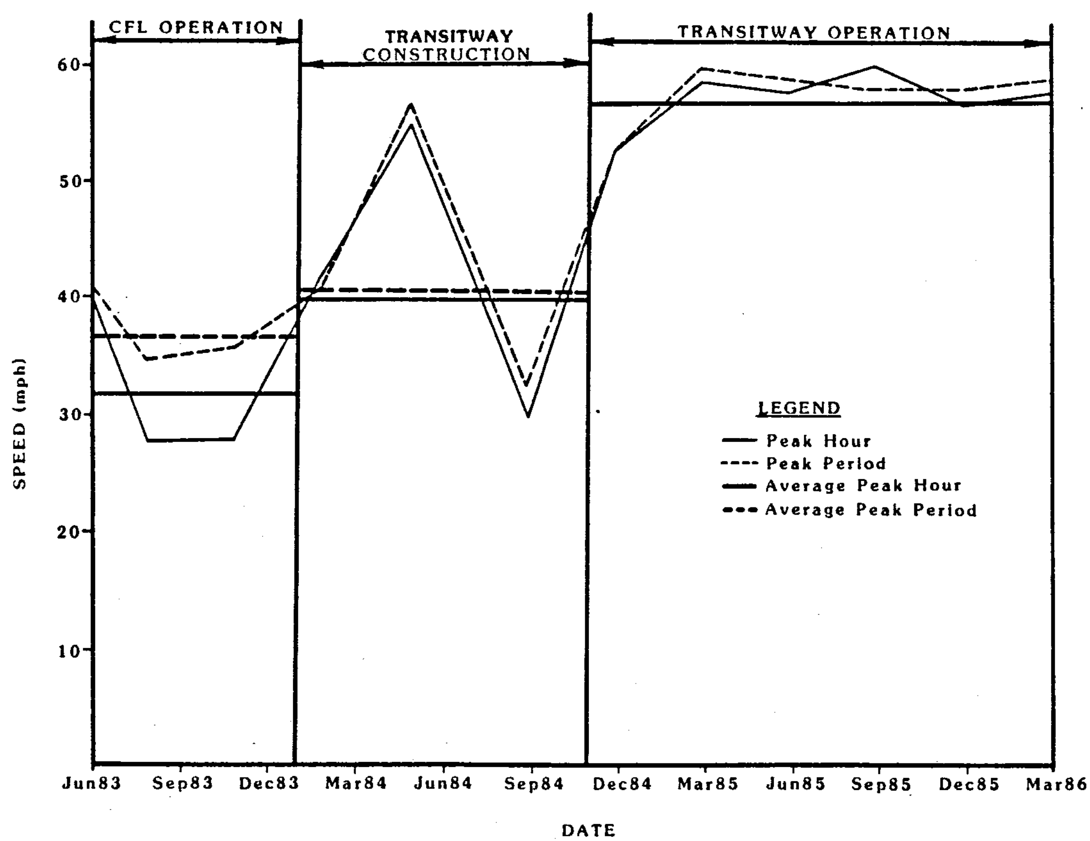


Figure 66. Average Afternoon Inbound Mainlane Speeds

speeds have continued to improve to the point of free-flow operation at an average speed of 56 mph. The improvement in afternoon operations is even more dramatic. Peak hour travel speeds climbed from 32 mph under contraflow operation to 40 mph during the construction period. After transitway construction was completed, the improvement in operating conditions accelerated, and average peak-hour speeds in the off-peak direction increased to 57 mph. Similar, though slightly less extreme, improvements in peak-period travel times and speeds have also been observed. In the morning, the average peak-period speed was from 49 mph to 53 mph and, finally, to 57 mph. Afternoon peak-period speeds once again experienced a greater improvement than the morning period since the afternoon period was initially more impacted by contraflow operation. Afternoon off-peak peak period speeds rose from 37 mph to 41 mph and, finally to 57 mph.

Mainlane accident rates before, during, and after median transitway construction are summarized in Table 9. As indicated, although mainlane accident rates did increase during transitway construction, they have since declined to 1.926 accidents per million vehicle miles traveled, a rate even lower than the preconstruction (CFL operation) rate of 2.105 accidents per million vehicle miles traveled.

Table 9. North Freeway Mainlane Accident Rates

(North Shepherd to Hogan, 8.0 miles)

Time Period	Total # Accidents	# Days	Avg. ADT	Accidents/MVM
CFL Operation (1/16/83-1/15/84)	929	365	151,138	2.105
During Construction (1/16/84-11/20/84)	958	310	158,807	2.432
Transitway Operation (11/21/84-11/20/85)	964	365	171,425	1.926

CORRIDOR IMPACTS OF TRANSITWAY IMPLEMENTATION

As summarized in Table 10, and illustrated in Figure 67, of the more than 11,300 vehicle-trips served by the corridor in a typical 3-hour peak period since transitway operation was implemented, less than 400 (3.3%) of these trips were made within the transitway. An examination of the passenger

Table 10. North Freeway Corridor, Average Peak Period Volumes

Month	Freeway Mainlanes		Transitway*		Corridor Total	
	Vehicles	Passengers	Vehicles	Passengers	Vehicles	Passengers
6/83	11,845	15,268	338	3,388	12,183	18,656
8/83	10,508	13,101	327	5,124	10,835	18,225
11/83**	13,286	15,272	254	4,137	13,540	18,847
Contraflow Avg.	11,880	14,547	306	7,216	12,186	18,576
2/84	12,193	14,710	379	6,189	12,572	20,899
5/84	10,533	13,011	383	6,381	10,916	19,392
9/84	10,285	12,096	335	5,746	10,620	17,842
Const. Avg.	11,004	13,272	366	6,105	11,369	19,378
12/84	11,850	13,341	360	6,557	12,210	19,898
3/85	9,845	11,651	406	6,932	10,251	18,583
6/85	10,086	12,258	370	6,788	10,456	19,046
9/85	12,103	14,108	369	6,511	12,472	20,619
Trans. Avg.	10,971	12,840	376	6,697	11,347	19,537

* Reflects only that fraction of total transitway volume that was observed in the transitway during the corridor's 3-hour peak periods, 6:30 - 9:30 am and 4:00 - 7:00 pm. Transitway hours are 6:00 - 8:30 am and 3:45 - 6:30 pm.

** Only morning peak period data available

volumes, however, reveals that almost 6,700 of the 19,500 peak period passenger-trips were served by the transitway; this represents more than 34% of the corridor's total passenger volume in a typical 3-hour peak period of operation (Figure 68). Throughout the observation period, the overall

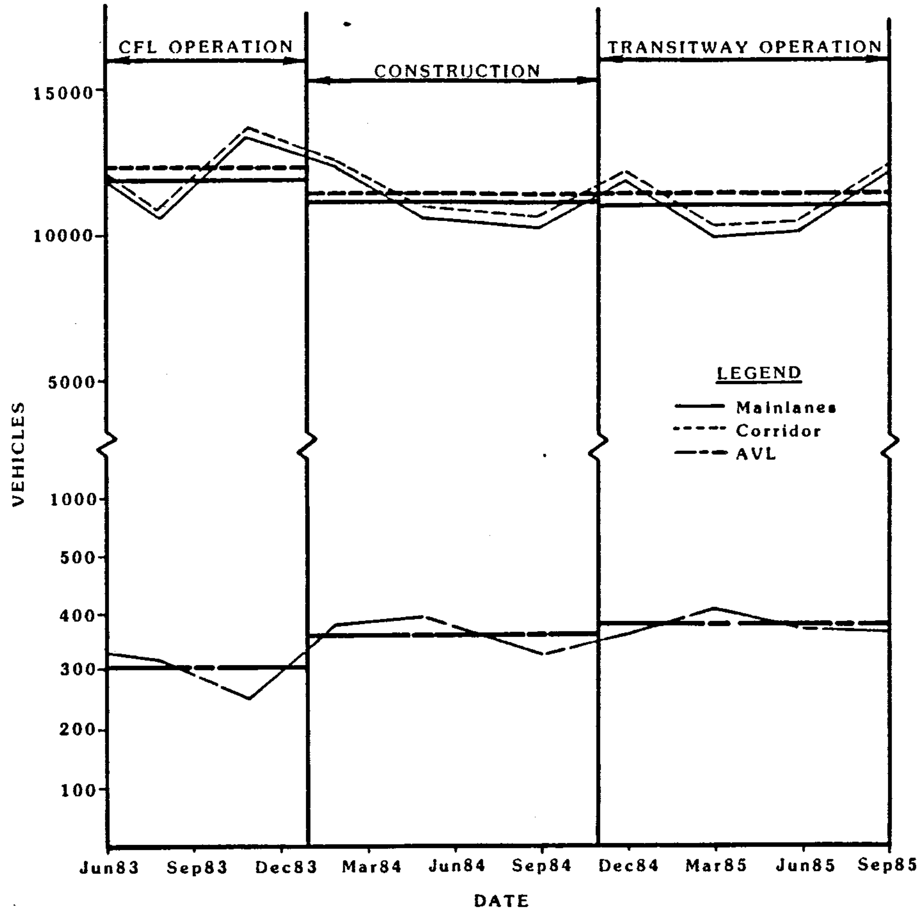


Figure 67. North Freeway Corridor Vehicle Volumes (Transitway vs. Mainlanes vs. Total)

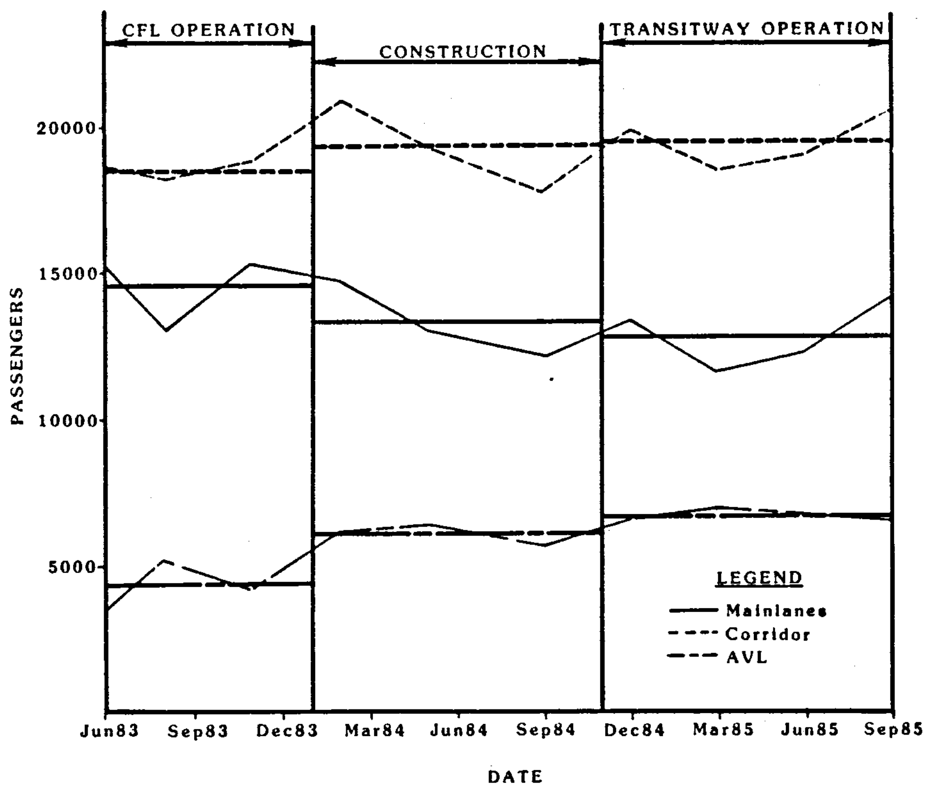


Figure 68. North Freeway Corridor Passenger Volumes (Transitway vs. Mainlanes vs. Total)

corridor occupancy rate has continued to rise from an average of approximately 1.52 passengers per vehicle during contraflow operation to about 1.72 passengers per vehicle in the year following the conversion from contraflow to transitway operation (Table 11 and Figure 69). This increase in occupancy rate is primarily attributable to gains observed on the CFL/Transitway. While mainlane occupancies dropped from a during-CFL average of approximately 1.22 passengers per vehicle to 1.17 passengers per vehicle since the beginning of transitway operation, authorized HOV occupancy rates rose from a CFL average of approximately 13.78 passengers per vehicle to almost 17.81 passengers per vehicle during transitway operation due at least in part to a decline in vanpooling volumes.

Table 11. North Freeway Corridor, Average Peak Period Occupancy Rates

Month	Mainlanes	Transitway	Corridor Total
6/83	1.29	10.02	1.53
8/83	1.25	15.67	1.68
11/83	1.15	16.29	1.39
CFL Avg.	1.22	13.78	1.52
2/84	1.21	16.33	1.66
5/84	1.24	16.66	1.78
9/84	1.18	17.15	1.68
Transitway Constr. Avg.	1.21	16.68	1.70
12/84	1.13	18.21	1.63
3/85	1.19	17.07	1.81
6/85	1.22	18.35	1.82
9/85	1.17	17.64	1.66
Post-Transitway Avg.	1.17	17.81	1.72

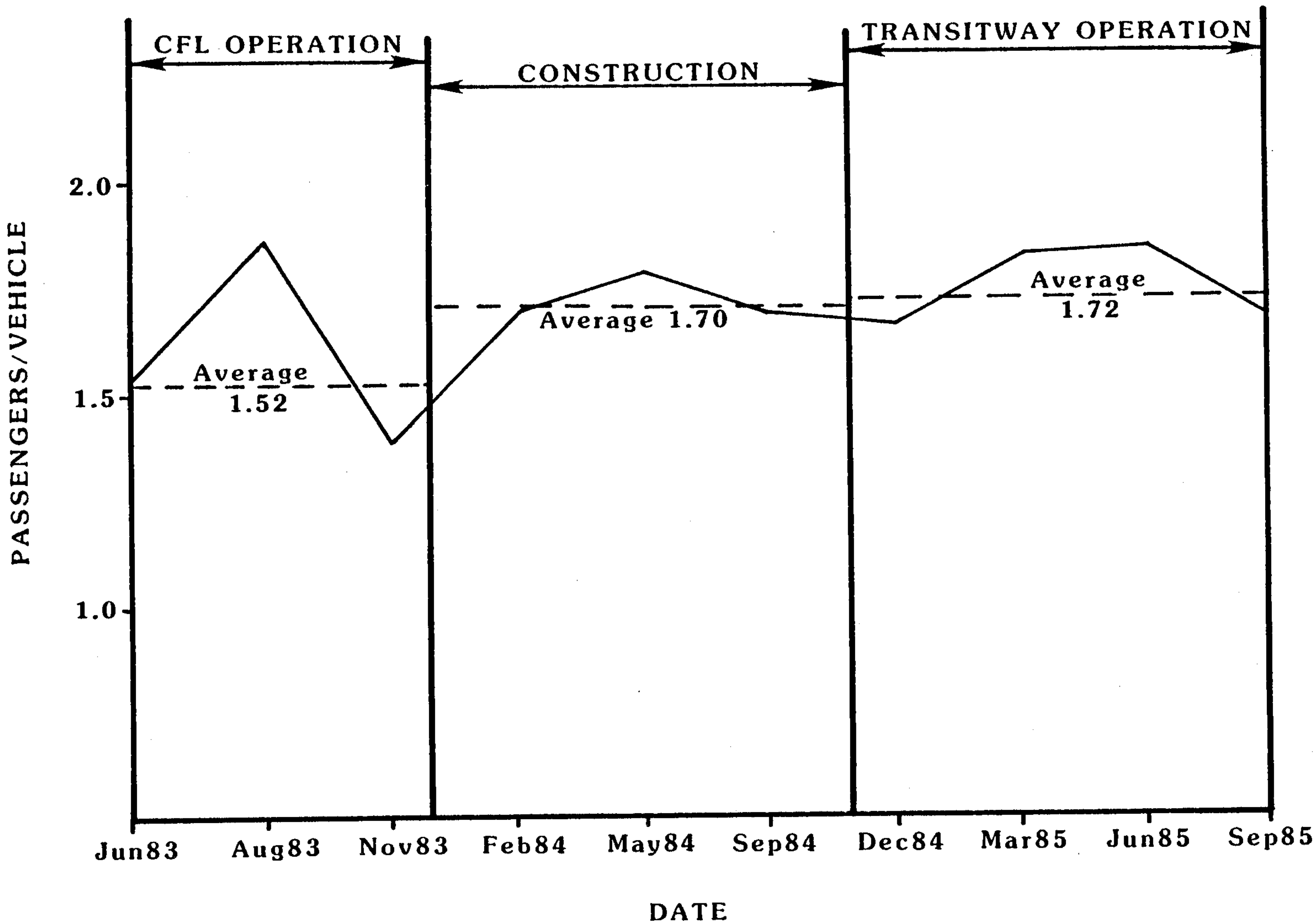


Figure 69. Total North Freeway Corridor Peak Period Occupancy Rates

BENEFIT/COST ANALYSIS

Based upon first year average transitway volumes, persons traveling by authorized bus or vanpools within the transitway realized a travel time savings over parallel freeway mainlane travelers of approximately 2,181 person-hours per day. This estimate is based upon an average travel time savings of 9 minutes per trip (the average of the morning and afternoon average peak period travel time savings) for each of the 14,542 person-trips which were typically made on the transitway each day during the first year of transitway operation. The 9 minute average is a very conservative estimate since most of the transitway trips are made during the peak-hour as opposed to being spread out uniformly across the entire peak period. Consequently, the weighted average travel-time savings per person would actually be greater than 9 minutes. Placing a value of $7.50 for each person-hour of delay saved and assuming that patronage remains unchanged, these travel time savings translate into an annual undiscounted benefit in excess of approximately $4.26 million each year (10).

An examination of the benefits and costs associated with the first phase of the North Transitway confirms the transitway's long-term cost-effectiveness. The analysis summarized in Table 12 is based upon the assumptions listed below.

1) All construction costs are stated at their nominal value (i.e., are assumed to have been expensed at the time the North Transitway became operational).

2) METRO's current level of operating expenses will remain constant over the 20-year analysis period at approximately $21,700 per month (1).

3) Transitway volumes will remain constant at their present levels for the length of the 20-year analysis period at approximately 14,500 person-trips per day.

4) Bus operating costs (valued at $60/bus-hour) can be reduced by the transitway assuming that the same headway between buses would need to be provided regardless of the availability of the transitway, and that without the transitway more buses would be needed to maintain that same headway (1).

5) Since ridership is assumed to remain constant, bus volumes are also assumed to remain constant at present levels (293 bus-trips per day).

6) A discount rate of 10% is assumed for the 20-year analysis period.

Table 12. Estimated Benefits and Costs, Phase 1 North Transitway

Benefit or Cost Component	Present Value (millions of '85 dollars)	
Benefits:		
Travel Time Savings	$ 36.3	
Reduced Bus Op. Costs	5.9	
Total Benefits		$ 42.2
Costs:		
Transitway Design & Constr.	$ 13.0*	
Transitway Operation	2.2	
Total Costs		$ 15.2
Benefit/Cost Ratio	2.77	

*Note: Phase 1 per mile cost is well below the projected per mile cost for the entire project, Phases 1 through 4.

As summarized in Table 12, even without considering the benefits to mainlane operations and safety, the first phase of the North Freeway transitway justifies itself with a benefit to cost ratio of almost 2.8. This ratio is extremely conservative due to the use of the 10% discount rate as well as to the assumption that utilization will not increase over the term of the analysis period.

CONCLUSIONS

Since 1979, the North Freeway Corridor has been able to improve its peak period, peak direction vehicle and passenger throughput by implementing a contraflow lane project along a 9.6 mile segment of the freeway from downtown Houston to North Shepherd Drive. However, because of increasing off-peak direction demand, the contraflow mode of operation could not be continued beyond the mid-1980's. The Texas State Department of Highways and Public Transportation and the Metropolitan Transit Authority of Harris County responded to this situation by proceeding to replace the contraflow project with a barrier-separated transitway located within the median of the North Freeway.

Transitway construction proceeded over an eleven month period and was completed by the last week of November 1984. Transitway operation officially commenced on November 21, 1984. Notable impacts both to peak direction mainlane and to contraflow operation were observed during the construction period, however, since the Phase 1 transitway construction has been completed, freeway and transitway operations have returned to pre-construction levels.

In the first year of barrier-protected operation, the North Transitway served an average of approximately 823 vehicles carrying approximately 14,542 people each operating day. Park-and-ride utilization, a key factor in the success of the contraflow project, continued to grow during transitway operation. After a year of transitway operation, park-and-ride utilization grew by 14% with most of the growth observed at the Spring and the Kuykendahl park-and-ride facilities. Travel time savings averaged about 6.5 minutes per trip in the morning peak period and 11.5 minutes per trip in the afternoon peak period with travel time savings as great as 15.6 minutes possible during the peak of the afternoon period.

On a corridor-wide basis, although the transitway accounts for less than 4% of the peak-period vehicle volume in the corridor, it serves more than 34% of the corridor's peak period passenger volume. Additionally, in the year since transitway operation has begun, mainlane accident rates in both the peak and the off-peak directions have dropped to 1.926 accidents per million vehicle miles. This represent an 8.5% decrease from the 2.105 rate which was experienced during the last year of contraflow operation. Off-peak direction speeds have also improved by as much as 25 mph during the afternoon peak hour. Finally, with a benefit to cost ratio of almost 3:1 (which does not include the mainlane peak and off-peak direction benefits), the first phase of the transitway from downtown Houston to North Shepherd Drive proves its cost-effectiveness.

Successive extensions of the transitway as far north as to FM 1960 are currently being pursued. With greater and greater time savings available as the transitway is extended to the north, it might be expected that additional mode shifts towards transitway-eligible modes will be induced. Such an occurrence would further increase the transitway's utility and allowthe transitway to continue to serve a higher proportion of the corridor's passenger-trip demand.

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