Technical Report Documentation Page

1. Report No. TX-96/2903-4F	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle U.S. 83 MAIN LANE, RAMP, AND CROSS-STREET INTERCHANGE OPERATIONAL ANALYSIS MCALLEN, TEXAS		5. Report Date October 1995 6. Performing Organization Code
7. Author(s) Kelley S. Klaver, Kirk E. Barnes, and Russell H. Henk		8. Performing Organization Report No. Research Report 2903-4F
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		10. Work Unit No. (TRAIS) 11. Contract or Grant No. Study No. 7-2903
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Final: September 1993 - August 1995 14. Sponsoring Agency Code

15. Supplementary Notes
Research performed in cooperation with the Texas Department of Transportation.
Research Study Title: Planning, Design and Operation of Transportation Facilities in the Pharr District

16. Abstract

This report documents the procedures and results associated with the assessment of U.S. 83 Expressway and cross-street interchange operations between Conway Avenue and Sugar Road in Mission, McAllen, and Pharr, Texas. This area is faced with increasing congestion and is characterized by a mixture of freeway ramp and cross-street interchange designs.

The results of this analysis support the need for widening U.S. 83 from four lanes to six lanes and indicate that converting to uniform "x-ramp" configurations will produce improved long-term freeway mainlane operations. Construction of a new interchange at McColl Road and U.S. 83, as well as improvements to several additional cross-street interchanges, are also recommended.

17. Key Words Interchange, Signal Operations, Freeway Operations		18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161	
19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 90	22. Price

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

U.S. 83 MAIN LANE, RAMP, AND CROSS-STREET INTERCHANGE OPERATIONAL ANALYSIS McAllen, Texas

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Research Report 2903-4F
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Sponsored by the
Texas Department of Transportation

October 1995

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IMPLEMENTATION STATEMENT

This research report documents the existing and estimated future operations of U.S. 83 main lanes and ramps (through Mission, McAllen, and Pharr, Texas) and the cross-street interchanges from Conway Avenue to Sugar Road. This report further documents the evaluation of ramp, signal timing, and geometric improvements. With plans to widen the U.S. 83 Expressway (from four to six lanes) in this area, the opportunity exists to make operational and safety improvements at a lower cost without an additional disturbance to traffic. The results from this study can be used in the development of design drawings for ramp improvements along U.S. 83 and for signal timing and geometric improvements at the cross-street interchanges. The results can also be used in the development of either a new interchange at McColl Road or an improved interchange at Jackson Avenue.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. This report was prepared by Russell H. Henk (Texas certification number 74460).

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SUMMARY

This study addressed the issues involved with assessing the operations of the U.S. 83 Expressway and the cross-street interchanges from Conway Avenue to Sugar Road in Mission, McAllen, and Pharr, Texas. Although current operations along the freeway and at most of the cross-street interchanges are acceptable, rapid growth in this area is expected to significantly decrease the quality of traffic operations in the near future.

Effects of ramp reversals and re-locations on the operations of U.S. 83 and the cross-street interchanges were assessed. The results of these improvements will not only be an increased level-of-service along the freeway and at the cross-street interchanges, but they will provide improved system continuity and increased safety at merge and diverge points along U.S. 83. These improvements, along with signal optimization and short/long-term geometric improvements at the cross-street interchanges, will significantly decrease the delay at the interchanges. While the existing ramps in this area are a mixture of "diamond" and "x" configurations, this analysis supports the transition to uniform "x"-ramp configurations.

A more detailed analysis of the Jackson Avenue Interchange resulted from this study, as this interchange is currently operating at a poor level-of-service and is expected to get worse due to the rapidly growing retail business and medical center activities in this area. This detailed analysis resulted in the recommendation of implementing minor geometric improvements to the Jackson Avenue Interchange along with the construction of a new interchange at McColl Road. A new interchange at McColl Road will provide relief to the congestion at the Jackson Avenue Interchange by providing more capacity and an additional route to the mall and medical center area. Further, a McColl Road Interchange will provide better long-term circulation and system continuity.

I. INTRODUCTION

The Pharr District of the Texas Department of Transportation (TxDOT) will soon begin the development of detailed plans for widening a significant section of the U.S. 83 Expressway in Mission, McAllen, and Pharr from four lanes to six lanes. Prior to the development of these plans, the Pharr District requested that the Texas Transportation Institute (TTI) examine potential improvements which could be implemented in conjunction with the widening project within the section of U.S. 83 between Conway Avenue and Sugar Road.

STUDY OBJECTIVE

Researchers envisioned that many opportunities for additional improvements could be interwoven with the widening project in order to maximize the benefits from construction dollars being spent and to ensure safe and efficient long-term traffic operations along U.S. 83. The objective of this study is to develop and evaluate the effects of ramp reversals and/or relocations and cross-street interchange improvements. This report documents the major procedures and findings associated with the analysis of the U.S. 83 Expressway mainlane and ramp operations and the cross-street interchange operations.

BACKGROUND

Traffic operations along U.S. 83 in Hidalgo County have been a concern for TxDOT for many years. This issue was recently (1988) the focus of a study conducted by TTI in which general access along the U.S. 83 Expressway and operations at several interchanges were assessed.

Since that time, considerable additional retail development has taken place adjacent to U.S. 83. Much of this development has begun to create new operational problems on entrance and exit ramps, frontage roads, and thoroughfares within U.S. 83 interchanges.

Recent growth in traffic volumes has also been significant--averaging 5.5 percent annually over the past five years. In addition, new legislation in the form of the North American Free Trade Agreement (NAFTA) and apparent future changes in land use should ensure at least moderate growth in traffic volumes on U.S. 83 and surrounding roadways in the foreseeable future. All of these factors are combining to create a situation which, if not properly addressed, could lead to the significant degradation of mobility in the McAllen-Pharr urban area.

II. FREEWAY OPERATIONAL ASSESSMENT

Researchers analyzed freeway operations along U.S. 83 between Conway Avenue and Sugar Road using the CORFLO--model, a macroscopic freeway simulation model. Twenty-four hour machine traffic counts on mainlanes and ramps provided hourly volumes as input to the model. Traffic operations were evaluated for existing conditions and for the ten- and twenty-year horizons for the freeway segment. Historical traffic data were used as a basis for future traffic projections. An automatic traffic recorder (ATR) is located on U.S. 83, 0.322 kilometers (0.2 miles) west of Business 83 in Mission, Texas. Table 1 includes the annual average daily traffic (AADT) at this location and respective growth rate since 1988. The average annual traffic growth from this ATR station from 1988 to 1993 has been approximately 5.6 percent. A previous TTI report projected traffic growth in the Pharr District area to increase 117 percent between 1985 and 2005 (1)

TABLE 1. AADT Variation by Year, U.S. 83 Mission, Texas

Year	AADT	Annual Growth (%)
1988	15,019	--
1989	15,604	+3.9
1990	16,495	+5.7
1991	17,187	+4.2
1992	18,744	+9.1
1993	19,744	+5.3

ANALYSIS PROCEDURE FOR U.S. 83 EXPRESSWAY

The U.S. 83 Expressway was evaluated from Conway Avenue in Mission to Sugar Road in Pharr. The analysis procedure used for this analysis is described below.

1. Simulate existing freeway with existing and projected volumes;
2. Simulate proposed ramp improvements with existing and projected volumes;

3. Simulate proposed six-lane freeway, in twenty years, with proposed ramp improvements.

EXISTING AND PROJECTED OPERATIONS OF U.S. 83

Figure 1 indicates peak-hour volumes and 24-hour volumes on the U.S. 83 ramps and mainlanes in the study segment. Because peak-hour conditions occurred at different times on various weekdays, a 12-hour simulation (7:00 a.m. to 7:00 p.m.) was performed. For the analysis, a mainlane capacity of 2,000 vehicles per hour per lane was used in the model. The revised *Highway Capacity Manual* (HCM) (2) suggests a capacity of 2,300 passenger cars per hour per lane for multi-lane highways; however, the McAllen area is a host for many recreational vehicles and tractor-trailer trucks. Thus, a lower capacity was assumed for this section of freeway. The growth rate used for ten-year (2004) traffic projections was 5.5 percent per year. The twenty-year traffic projections were based on a growth rate of 5.5 percent for the first ten years and 3 percent for years eleven through twenty (i.e., 2005-2014).

Current traffic volumes (1994), ten-year projected traffic volumes (2004), and twenty-year projected traffic volumes (2014) were used as input for the CORFLO model, and traffic operations were analyzed. The measure-of-effectiveness (MOE) used from the simulation model was the expressway density for each segment, which can be directly related to a level-of-service (LOS) using the HCM guidelines (2) (Table 2). Figure 2 illustrates the existing ten-year and twenty-year peak-hour LOS for the single hour that produced the highest density (i.e., the worst LOS).

Simulations of existing conditions indicated that the expressway operates at an acceptable LOS (A-C range) throughout the entire study section. However, when ramp and mainlane volumes were increased for future projections, operations dropped to LOS F in many areas.

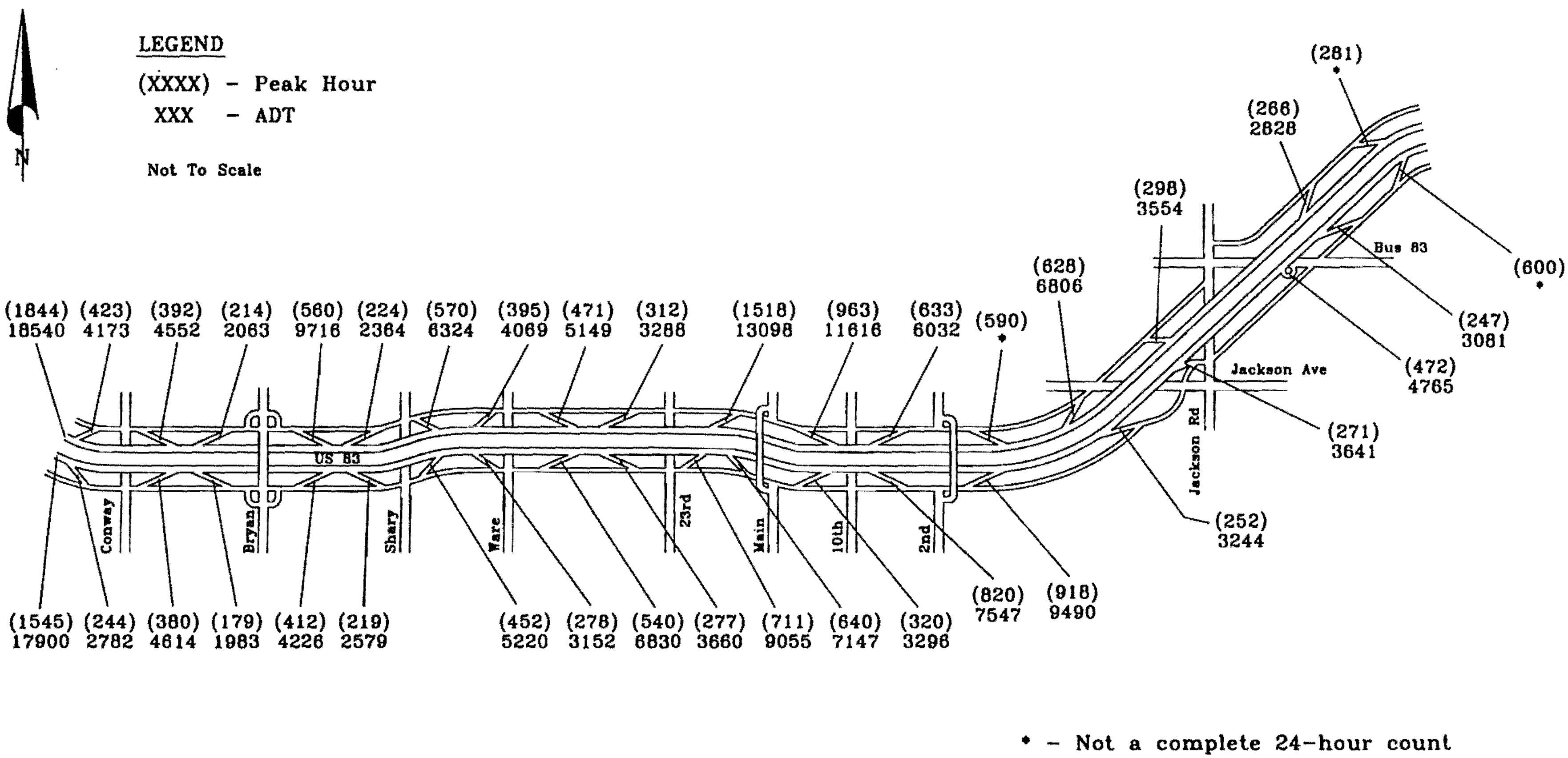

FIGURE 1. Existing Peak-Hour and Daily Volumes--U.S. 83 Ramps and Mainlanes

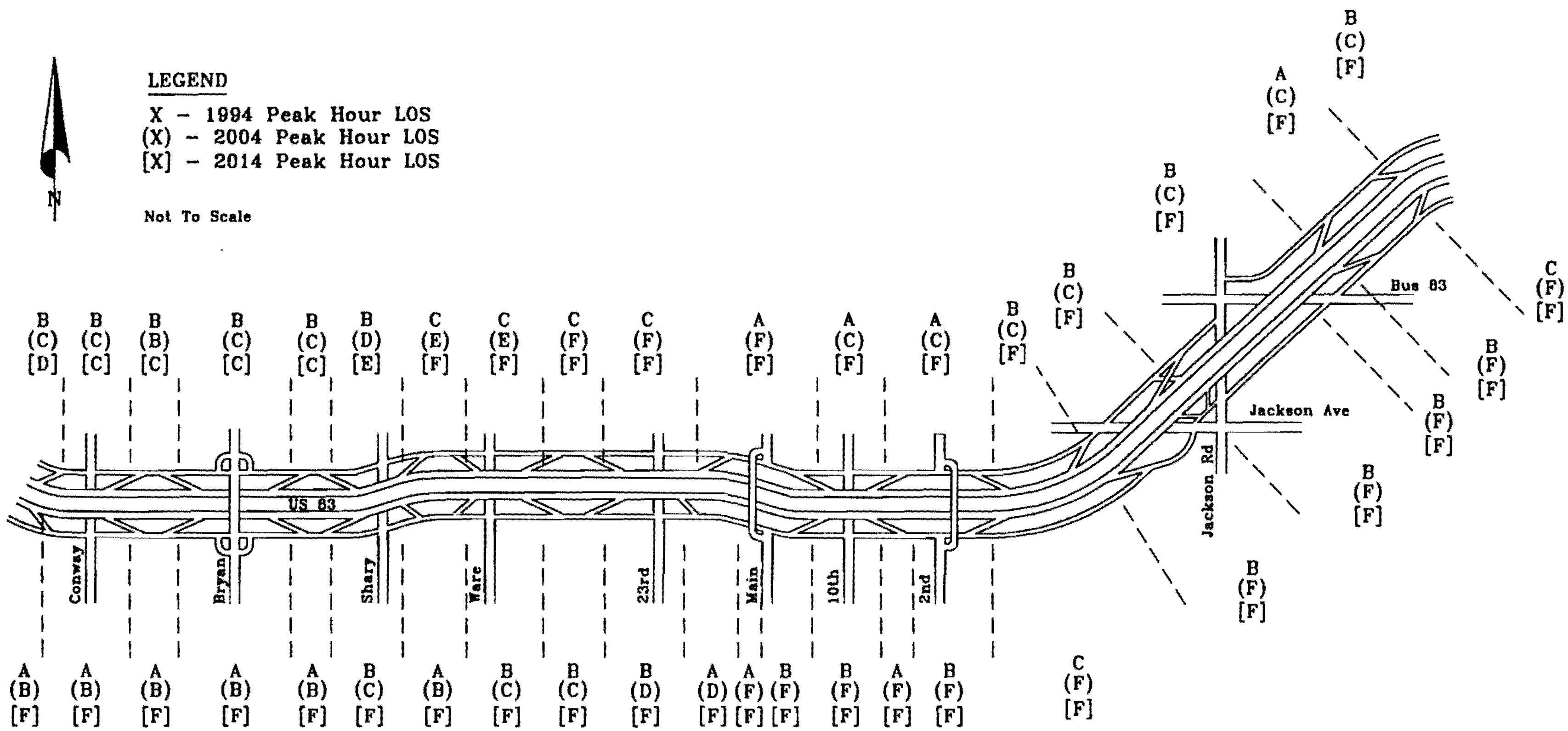

FIGURE 2. Peak-Hour Levels-of-Service for U.S. 83 Mainlanes--Existing Ramp Configuration and Number of Mainlanes

TABLE 2. Level-of-Service Criteria for Multi-lane Highways

Level-of-Service	Density (passenger cars/mile/lane)
A	12
B	20
C	30
D	42
E	67
F	>67

Source: Highway Capacity Manual (2).

POTENTIAL RAMP IMPROVEMENTS

U.S. 83 Expressway is a four-lane freeway (with the exception of short segments with auxiliary lanes) with continuous one-way frontage roads through Mission, McAllen, and Pharr. The predominant interchange design along the study section is the "diamond" configuration (Figure 3). Specific ramps have, however, recently been relocated and/or reversed near the more congested interchanges. The 10th Street Interchange now exhibits an "X" interchange configuration (Figure 4), and the 23rd Street Interchange has had the westbound diamond exit reconstructed as an entrance (as in an "X" ramping scheme). Local officials suggested that the existing ramping scheme from Conway Avenue to 23rd Street should be examined in order to assess the potential for providing congestion relief at the cross-street interchanges and improved operations on the expressway mainlanes.

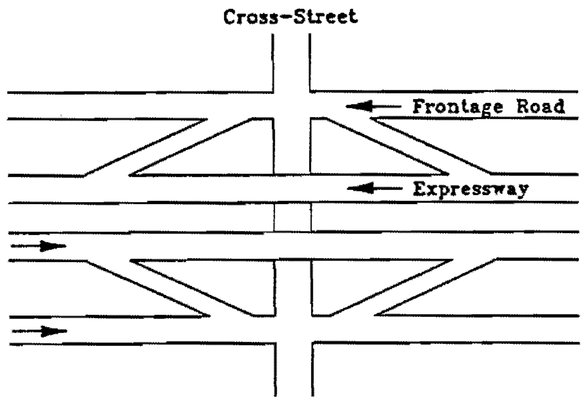

FIGURE 3. Example of a "Diamond" Configuration Interchange

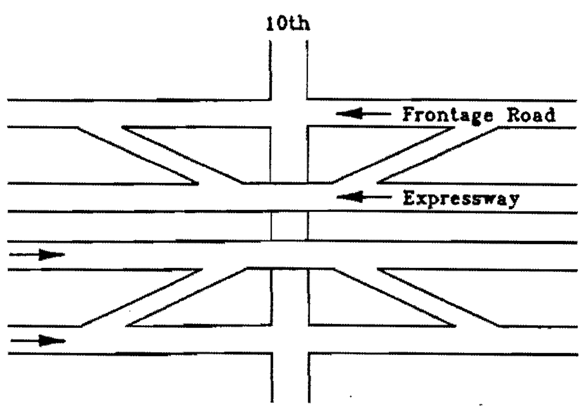

FIGURE 4. Example of an "X" Configuration Interchange

An advantage of the "X" interchange configuration is the benefit of providing increased expressway access to frontage road development. Expressway traffic can potentially exit, access the frontage development, and re-enter the expressway without ever having to negotiate a cross-street signalized intersection. The expressway weaving area resulting from an entrance ramp followed by an exit ramp will change location along the expressway with ramp reversals, which, if implemented correctly, should have a positive effect on the operations.

Development and traffic patterns have changed dramatically since the 1988 U.S. 83 Expressway Study (3). Areas that were (until recently) agricultural are now occupied by expanding commercial and retail businesses. The land development, changing traffic patterns, and reconfigured ramping scheme created the need for this new U.S. 83 Expressway analysis.

Several aspects of expressway ramp location must be considered when alternative geometrics are proposed.

- The *Texas Operations and Procedures Manual* indicates that a minimum distance of 509.4 meters (1,670 feet) should be maintained between an entrance and an exit ramp without an auxiliary lane. However, recently-completed research has shown that a minimum distance of 610 meters (2,000 feet) should be used between entrance and exit ramps (4).
- Location of the frontage road access points in relation to the ramp terminus should be restricted. Driveway access should not be allowed from the intersection of the exit ramp and frontage road travelways to a point 76.3 meters (250 feet) downstream of the painted gore. The *Texas Operations and Procedures Manual* recommends this distance as a *minimum*, and states that longer distances are desirable for higher volume exit ramps to frontage roads. This distance is provided to minimize the effect of extreme

deceleration of exit ramp vehicles which are attempting to access frontage road driveways in close proximity to the exit ramp terminus. In addition, driveway access should not be allowed from the intersection of the entrance ramp and frontage road travelways to a point 30.5 meters (100 feet) (minimum) upstream of the painted gore. The primary reason for this design guideline is to maintain an adequate speed for entrance ramp vehicles. The American Association of State Highway and Transportation Officials (AASHTO) indicated that it requires 183 meters (600 feet) for a vehicle to accelerate to 72 kph (45 mph) from a stop on level ground (5).

- Desirable separation distances should be maintained between the exit ramp terminus and the cross-street. The *Texas Operations and Procedures Manual* presents the minimum and desirable exit to cross-street distance for a range of ramp and frontage road volumes (4).

All of the ramps from Conway Avenue to Sugar Road (both eastbound and westbound) were reviewed for their location with respect to frontage road access, weaving distances, and consistency to determine if geometric changes would be beneficial. The guidelines cited previously were all used to ensure ideal future locations and/or configurations for these ramps. After numerous iterations, researchers determined that the U.S. 83 Expressway ramping changes indicated in Tables 3 and 4 provided the most effective operational long-term improvements.

Reversal of the ramps from Conway Avenue to 23rd Street was proposed in an attempt to alleviate some of the congestion at the cross-street interchanges and to mitigate some of the undesirable effects of the existing frontage road access points.

Table 3. Summary of Proposed Changes in Ramp Configurations-- Conway Avenue to Sugar Road, Eastbound

Limits	Change From Existing Configuration[1]				
	Eastbound				
				Critical Access Point[3]	
	Existing	Proposed	Reason[2]	Guideline, meters (ft)[4]	Proposed, meters (ft)[5]
Conway to Bryan	Entrance from Conway Exit to Bryan	Exit to Bryan Entrance from Conway	Continuity Proximity to Bryan Intersection	92 (300) 46 (150)	153 (500) 610 (2,000)
Bryan to Shary	Entrance from Bryan Exit to Shary	Exit to Shary Entrance to Bryan	Continuity Proximity to Shary Intersection	92 (300) 46 (150)	207 (680) 107 (350)
Shary to Ware	Entrance from Shary Exit to Ware	Exit to Ware Entrance from Shary	Continuity Proximity to Ware Intersection	92 (300) 46 (150)	702 (2,300) 259 (850)
Ware to 23rd	Entrance from Ware Exit to 23rd	Exit to 23rd Entrance from Ware	Continuity Proximity to 23rd Intersection	92 (300) 46 (150)	107 (350) 275 (900)
23rd to 10th	Entrance from 23rd Exit to 10th	Exit to Main/10th Remove	Continuity/Access to Bicentennial Ramp spacing	92 (300) N/A	336 (1,100) N/A
Jackson Avenue to Jackson Road	Exit to Jackson Road N/A	Relocate exit to the West Entrance from Jackson Avenue	To provide space for entrance Continuity/Congestion relief	92 (300) 46 (150)	595 (1,950) 412 (1,350)
Jackson to Business 83	Entrance from Business 83	Remove	Ramp spacing/continuity	N/A	N/A

1 Only changes from existing configurations are noted.
2 The primary reason for the change in ramp configuration.
3 The distance(s) from the proposed ramp relocation to the nearest point of access from adjacent frontage road land use.
4 The design guideline (as dictated by the Texas Highway Design Division Operations and Procedures Manual) for the distance between the ramp-frontage road access point and the nearest point of access from adjacent frontage road land use.
5 The proposed distance between the ramp-frontage road access point and the nearest point of access from adjacent frontage road land use.

Table 4. Summary of Proposed Changes in Ramp Configurations-- Conway Avenue to Sugar Road, Westbound

Limits	Change From Existing Configuration[1]				
	Westbound				
				Critical Access Point[3]	
	Existing	Proposed	Reason[2]	Guideline, meters (ft)[4]	Proposed, meters (ft)[5]
Business 83 to Jackson Avenue	Exit to Jackson Avenue	Braided Entrance from Business 83 with exit to Jackson Avenue	Congestion Relief	46 (150)	46 (150)
23rd to Ware	Entrance from 23rd Exit to Ware	Exit to Ware Entrance from 23rd	Continuity Proximity to Ware Intersection	92 (300) 46 (150)	320 (1,050) 458 (1,500)
Ware to Shary	Entrance from Ware Exit to Shary	Exit to Shary Entrance from Ware	Continuity Proximity to Shary Intersection	92 (300) 46 (150)	153 (500) 122 (400)
Shary to Bryan	Entrance from Shary Exit to Bryan	Exit to Bryan Entrance from Shary	Continuity Driveway access Problem	92 (300) 46 (150)	220 (720) 92 (300)
Bryan to Conway	Entrance from Bryan Exit to Conway	Exit to Conway Entrance from Bryan	Continuity Driveway Access Problem	92 (300) 46 (150)	198 (650) 61 (200)

1 Only changes from existing configurations are noted.
2 The primary reason for the change in ramp configuration.
3 The distance(s) from the proposed ramp relocation to the nearest point of access from adjacent frontage road land use.
4 The design guideline (as dictated by the Texas Highway Design Division Operations and Procedures Manual) for the distance between the ramp-frontage road point and the nearest point of access from adjacent frontage road lane use.
5 The proposed distance between the ramp-frontage road access point and the nearest point of access from adjacent frontage road land use.

access to the proposed southern extension of Bicentennial Boulevard (discussed in detail in Research Report 2903-1 (6)). In order to maintain an adequate deceleration and lane change maneuver distance for eastbound U.S. 83 to southbound Bicentennial Boulevard, the exit ramp must begin just east of the 23rd Street bridge structure.

Removal of the eastbound exit to Main Street was proposed to maintain desirable ramp spacing between 23rd and 10th Streets. Traffic currently using the eastbound exit to Main Street would use the new eastbound exit just west of 23rd Street.

Relocation of the eastbound exit to Jackson Road is proposed so the eastbound Jackson Avenue entrance can be added. The eastbound exit to Jackson Road should begin at the Jackson Avenue bridge structure. The eastbound Jackson Avenue entrance can be constructed before Jackson Road, but will require using minimum design standards. It is felt, however, that this improvement is a vital part of improving traffic circulation in this area. The distance between the eastbound Jackson Road exit and the new eastbound Jackson Avenue entrance along the frontage road would be approximately 305 meters (1,000 feet). An auxiliary lane (on the frontage road) between the exit and the entrance is recommended.

The addition of a westbound "braided" entrance ramp from Jackson Road will allow traffic from the Jackson Road/Business 83 area to access the expressway without having to travel through the already congested Jackson Avenue Interchange. Reduction of westbound through traffic at the Jackson Avenue Interchange will not only reduce the delay at that interchange, but will also reduce weaving maneuvers that occur between the westbound Jackson Avenue entrance and the 2nd/10th Street exit.

Removal of the eastbound Business 83 entrance ramp is proposed due to the short distance between the entrance ramp and the subsequent exit ramp. Traffic using the existing cloverleaf entrance ramp would be forced to use the eastbound entrance ramp from U.S. 83 just east of Business 83. Analysis of the intersections of Business 83 and the frontage road indicated that the additional volume resulting from the ramp closure would have only a minimal impact on the level-of-service.

OPERATIONS OF EXISTING U.S. 83 WITH PROPOSED RAMP IMPROVEMENTS

The reversal, relocation, and/or removal of ramps listed previously (Table 3 and 4) were considered to improve expressway and interchange operations and to provide better access for frontage road development. Entrance and exit ramps were reversed (both eastbound and westbound) from the existing "diamond" configuration (from Conway Avenue to 23rd Street) to an "X" configuration and again analyzed using the CORFLO simulation model. Simulation results (Figure 5) indicated that the conversion of "diamond" interchanges to "X" interchanges at Conway Avenue, Bryan Road, Shary Road, and Ware Road produced a notable improvement in expressway operations. Improvement in operational LOS can primarily be attributed to the selection of ramp placement in order to maintain expressway weaving distances of at least 610 meters (2,000 feet).

Major benefits associated with the ramp reversals and/or relocations will appear in the operations of the cross-street interchanges, discussed in Chapter III. Simulations further indicated that additional mainlane capacity will be necessary to accommodate projected traffic volumes.

OPERATIONS OF SIX-LANE U.S. 83 WITH PROPOSED RAMP IMPROVEMENTS

Simulations indicated that three expressway lanes in each direction would be necessary to provide acceptable operations with twenty-year projected traffic volumes. Figure 6 illustrates the anticipated LOS U.S. 83 Expressway with the "X" ramp configuration and three mainlanes in each direction.

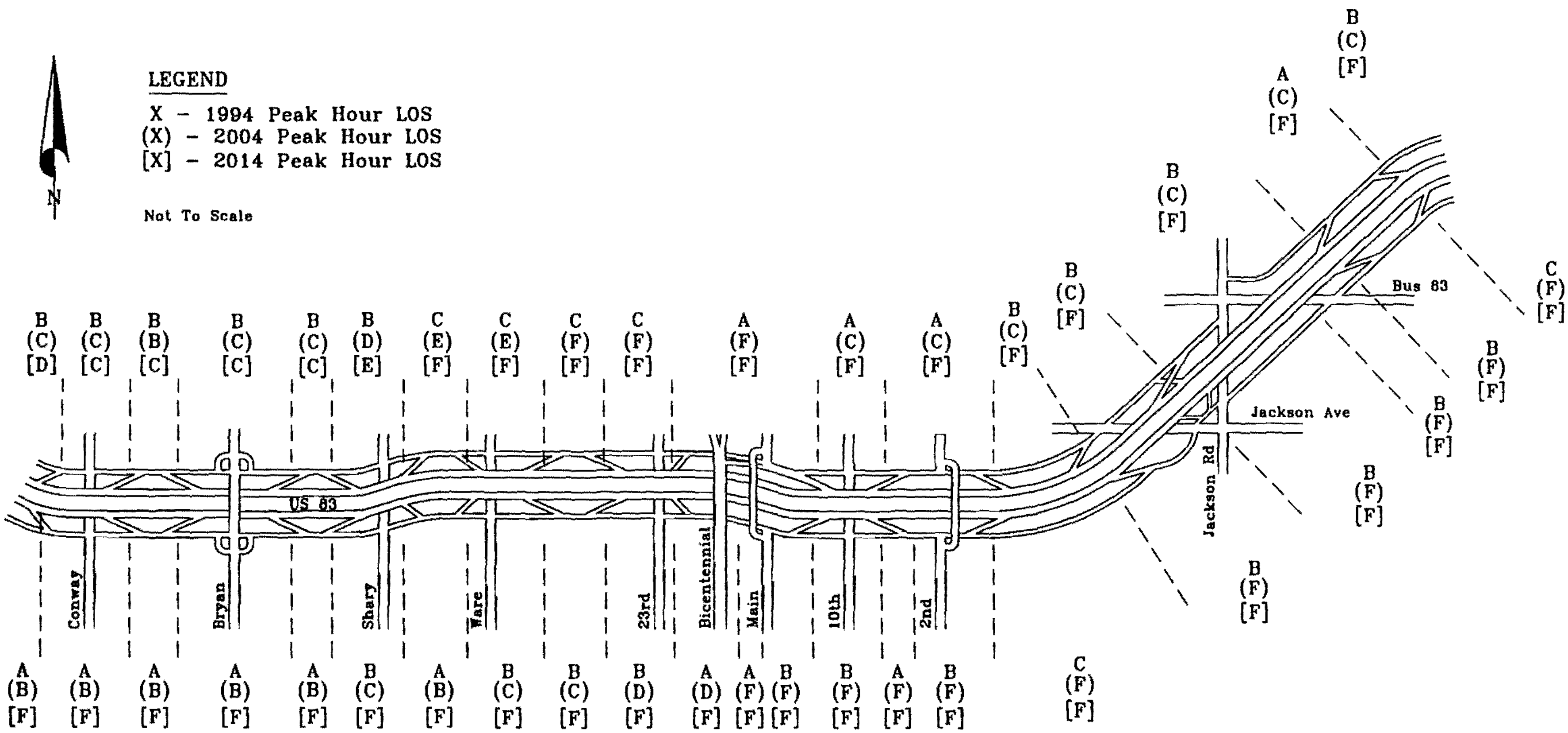

FIGURE 5. Peak-Hour Levels-of-Service for U.S. 83 Mainlanes--Proposed Ramp Configuration and Existing Number of Mainlanes

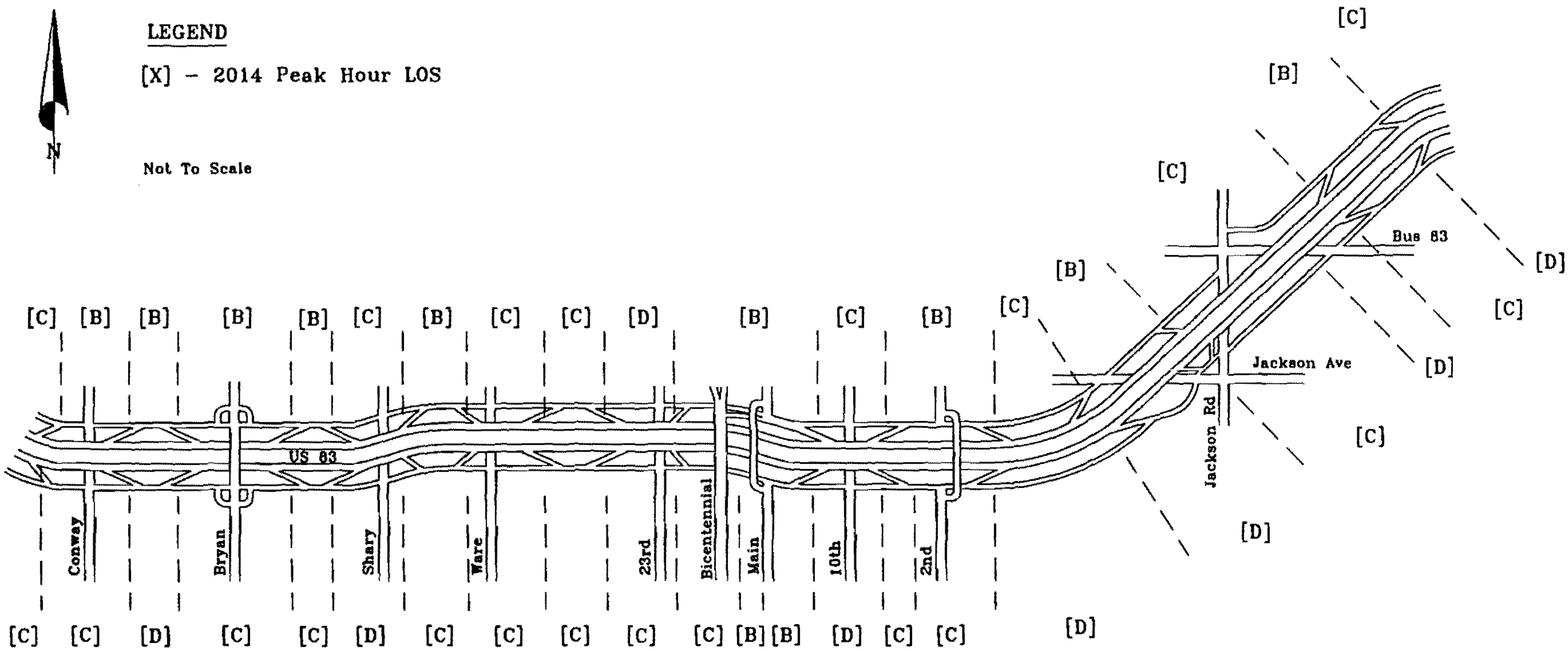

FIGURE 6. Peak-Hour Levels-of-Service for U.S. 83 Mainlanes--Proposed Ramp Configuration and Three Mainlanes in Each Direction

III. U.S. 83 CROSS-STREET INTERCHANGE OPERATIONAL ASSESSMENT

Existing and future operations at seven interchanges with U.S. 83 in Mission, McAllen, and Pharr were evaluated. The seven interchanges included those at Conway Avenue, Bryan Road, Shary Road, Ware Road, 23rd Street, 10th Street, and Jackson Avenue. Data were collected during the morning peak period (7:00 a.m. to 9:00 a.m.) and the evening peak period (4:00 p.m. to 6:00 p.m.). Traffic operations were evaluated with existing volumes and for the ten- and twenty-year horizons for each of the seven interchanges. As with the freeway analysis, a growth rate of 5.5 percent per year was used to project the ten-year volumes, while a growth rate of 5.5 percent for the first 10 years and 3 percent for the following ten years was used to project the twenty-year volumes. Short-term, relatively inexpensive geometric improvements were evaluated for the interchanges along with long-term geometric improvements that should be considered in conjunction with the widening of U.S. 83 to six lanes.

ANALYSIS PROCEDURE FOR SIGNALIZED INTERCHANGES

Five of the seven interchanges evaluated were signalized--Conway Avenue, Shary Road, 23rd Street, 10th Street, and Jackson Avenue. The procedure used to analyze the traffic operations at these interchanges is indicated below:

1. Simulate existing conditions;
2. Optimize signal timing with existing volumes;
3. Evaluate optimized signal timing with ten- and twenty-year projected volumes;
4. Propose short-term geometric improvements and evaluate with existing volumes, ten-year projected volumes, and twenty-year projected volumes; and

5. Propose long-term geometric improvements, and evaluate with ten- and twenty-year projected volumes.

PASSER III-90 was used for the simulation and optimization of traffic operations at the signalized interchanges. Appendix A presents detailed results of the interchange operational analyses; existing and projected volumes at each interchange are shown in Appendix B.

Conway Avenue Interchange

The Conway Avenue Interchange (Figure 7) is currently operating with a 130-second cycle length and a four-phase, TTI-lead phasing plan (the south-side intersection has leading left-turns). Current traffic operations can be improved by one level-of-service (LOS) during both the morning and evening peak hours by simply optimizing the signal timing; however, ten-year projected operations during the evening peak hour and twenty-year projected operations during the morning and evening peak hours were LOS F with the existing geometric configuration of the Conway Avenue Interchange. Thus, short-term geometric improvements were examined for this interchange. These improvements are described below.

Short-Term Improvements

Make use of the shoulders to provide right-turn lanes on both frontage road approaches, and provide a right-turn lane on the southbound Conway Avenue approach (Figure 8).

The short-term improvements boosted the ten-year projected traffic operations to LOS C during the morning peak hour and LOS E during the evening peak hour. The short-term improvements did not, however, provide traffic operations above LOS F for the twenty-year horizon. Thus, long-term improvements were examined for the Conway Avenue Interchange. These improvements are described below.

Long-Term Improvements

Add a lane to the northbound and southbound Conway Avenue approaches, and provide three continuous lanes through the interchange. Provide four-lane approaches and U-turn lanes on both frontage roads (Figure 9). (Note: These long-term improvements to the Conway Avenue Interchange would require relocation U.S. 83 overpass columns and reconstruction of the bridge. These improvements would, most likely, not be cost effective unless completed as part of the U.S. 83 expansion to six lanes.)

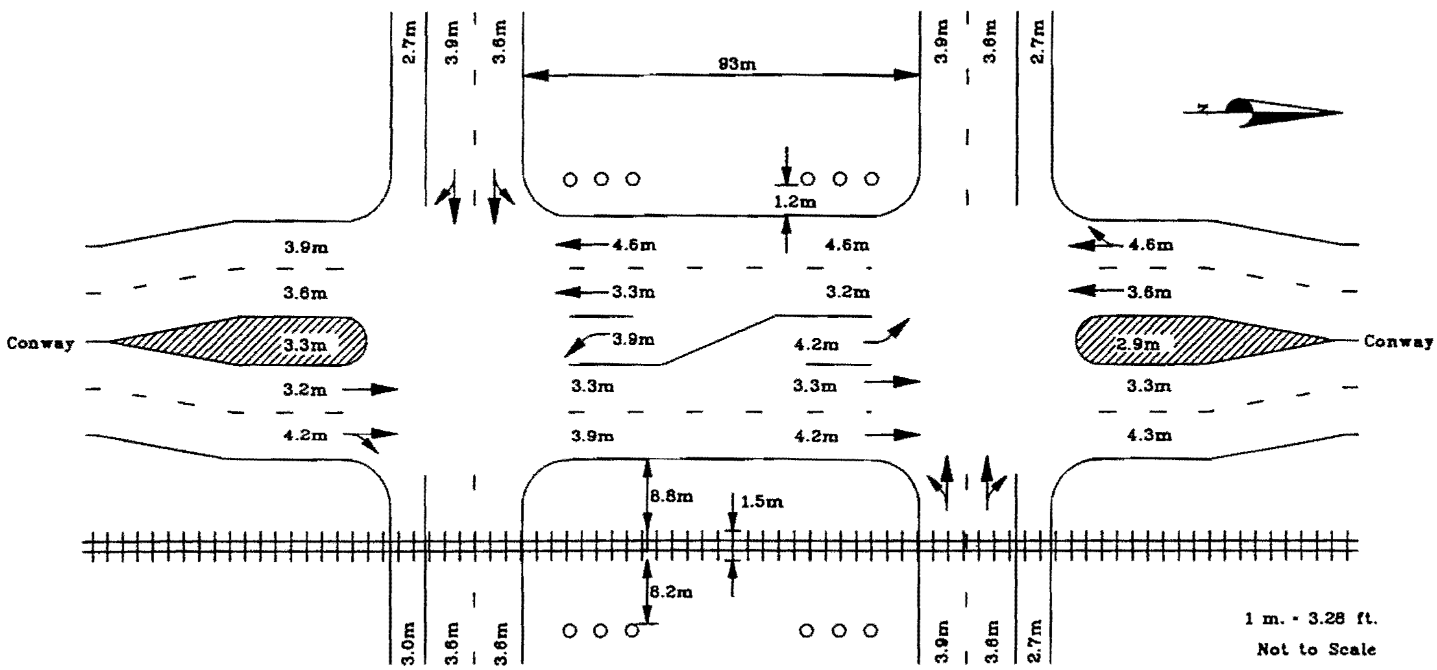

FIGURE 7. Existing Geometric Configuration of the Conway Avenue Interchange

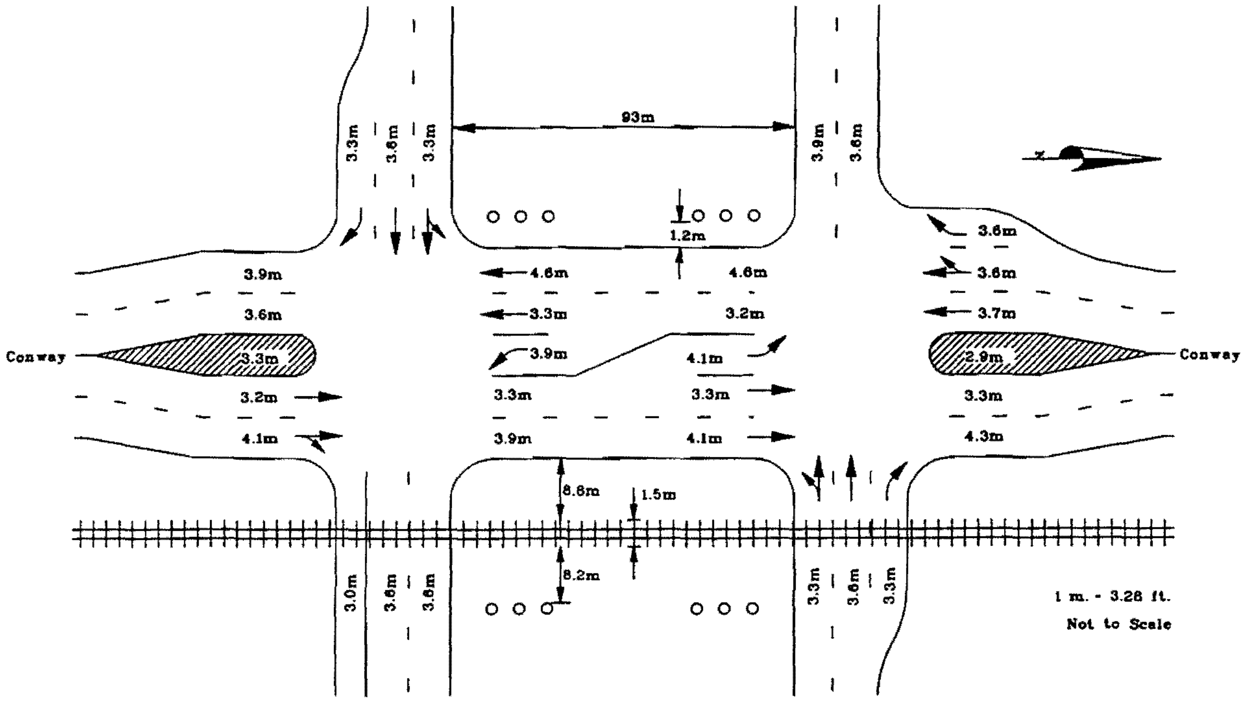

FIGURE 8. Proposed Short-Term Improvements to the Conway Avenue Interchange

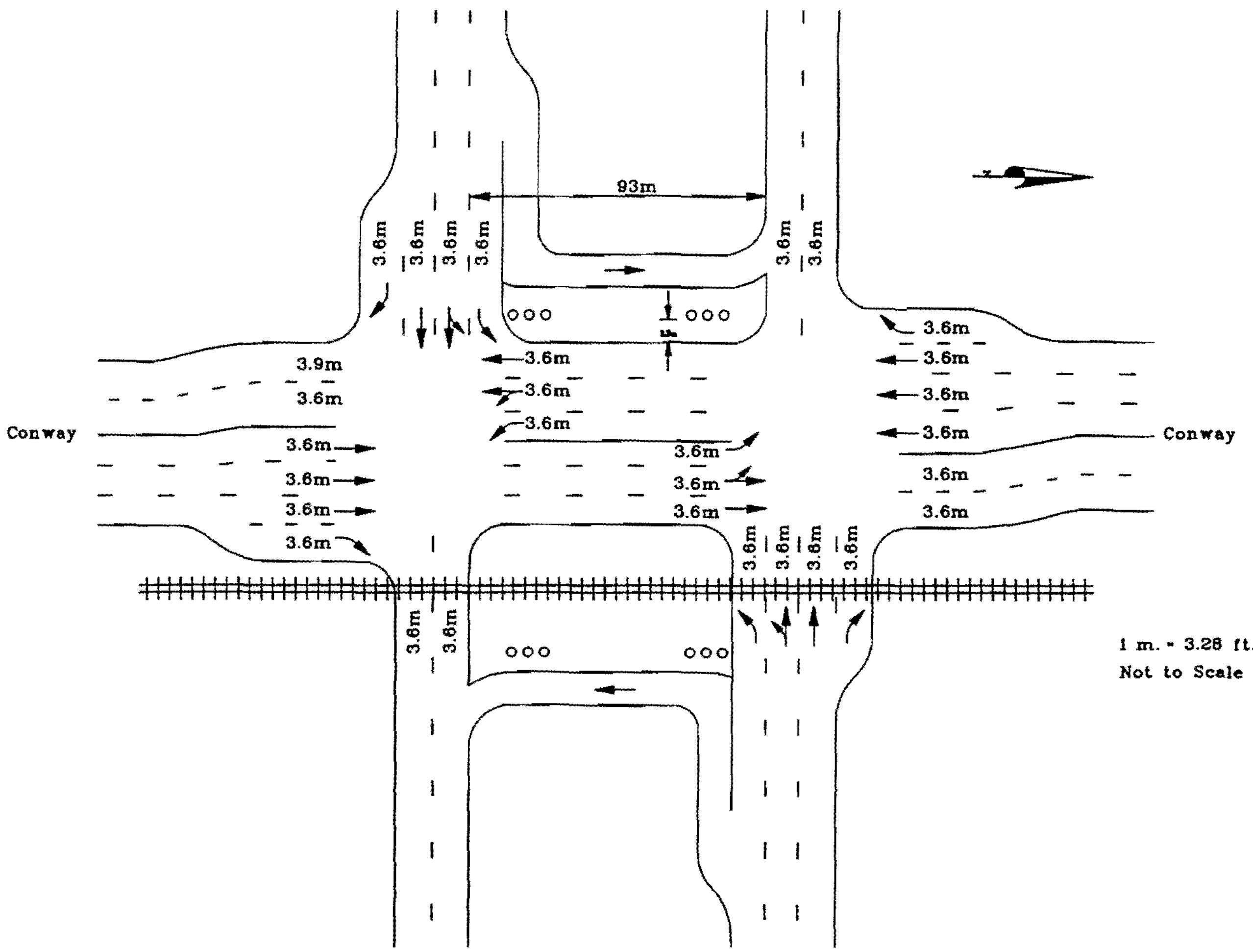

FIGURE 9. Proposed Long-Term Improvements to the Conway Avenue Interchange

Long-term improvements and the assumed 50 percent removal of frontage road thru traffic (result of reversing ramps adjacent to the Conway Avenue Interchange) reduced the average stopped delay at the Conway Avenue Interchange to provide LOS B and LOS E during the morning and evening peak hours, respectively. Tables A-1 and A-2 present a more detailed explanation of the results associated with the Conway Avenue Interchange analyses. Volumes are shown in Figures B-1 and B-2.

Shary Road Interchange

The Shary Road Interchange (Figure 10) is currently operating with a 165-second cycle length and a four-phase, TTI-lead phasing plan. Analysis of this interchange indicated LOS F existing operations during both the morning and evening peak hours. With optimization of the signal timing, however, traffic operations were improved to LOS C during the morning peak hour and LOS D during the evening peak hour.

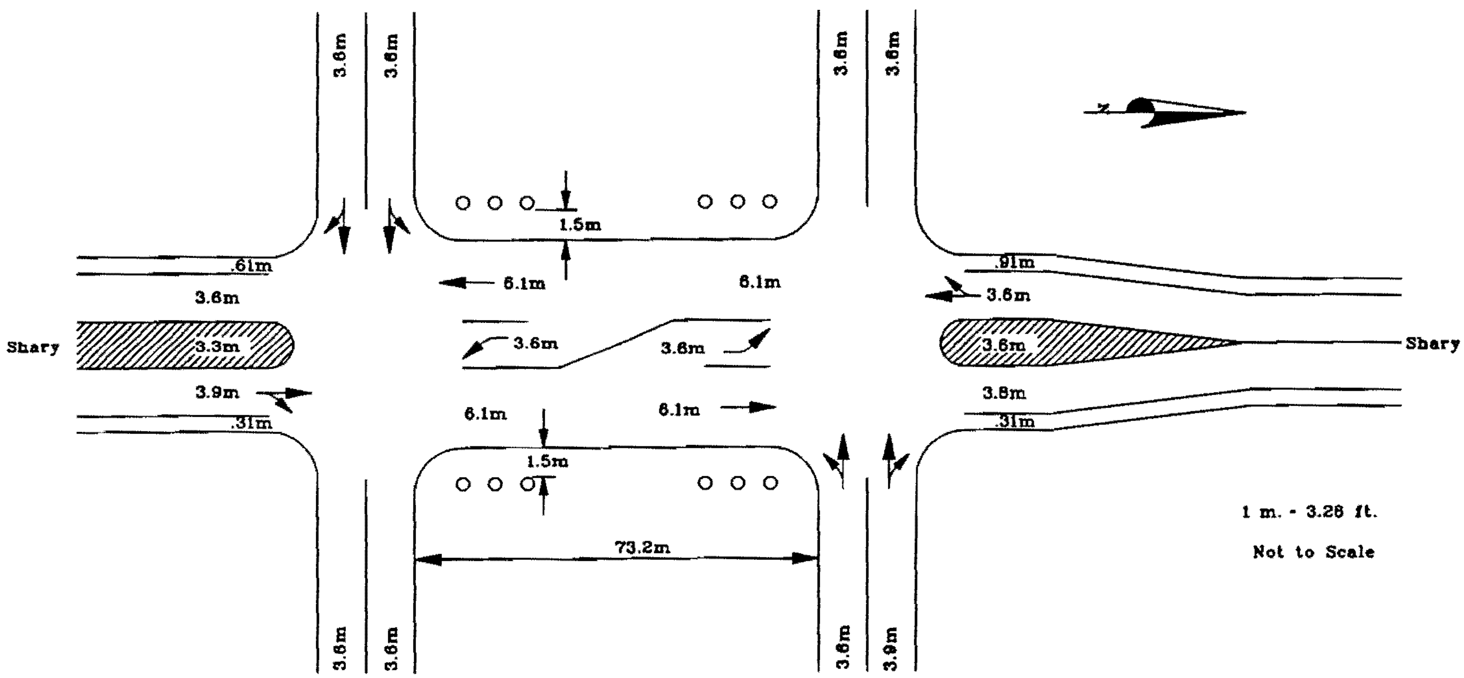

FIGURE 10. Existing Geometric Configuration of the Shary Road Interchange

Although current operations were improved by optimizing the signal timing, ten- and twenty-year projected operations were LOS F with the existing geometric configuration of the Shary Road Interchange. Thus, short-term geometric improvements were examined for this interchange. These improvements are described below.

Short-Term Improvements

Widen Shary Road north and south of the bridge structure to provide two lanes on each approach. Remove the left-turn bays under the bridge structure, and restripe as two continuous lanes in each direction. Provide right-turn lanes on both frontage road approaches (Figure 11).

The proposed short-term improvements boosted the morning peak-hour operations to LOS D; however, evening peak hour operations were not improved above LOS F. Thus, long-term improvements were examined for the Shary Road Interchange. These improvements are described on the next page.

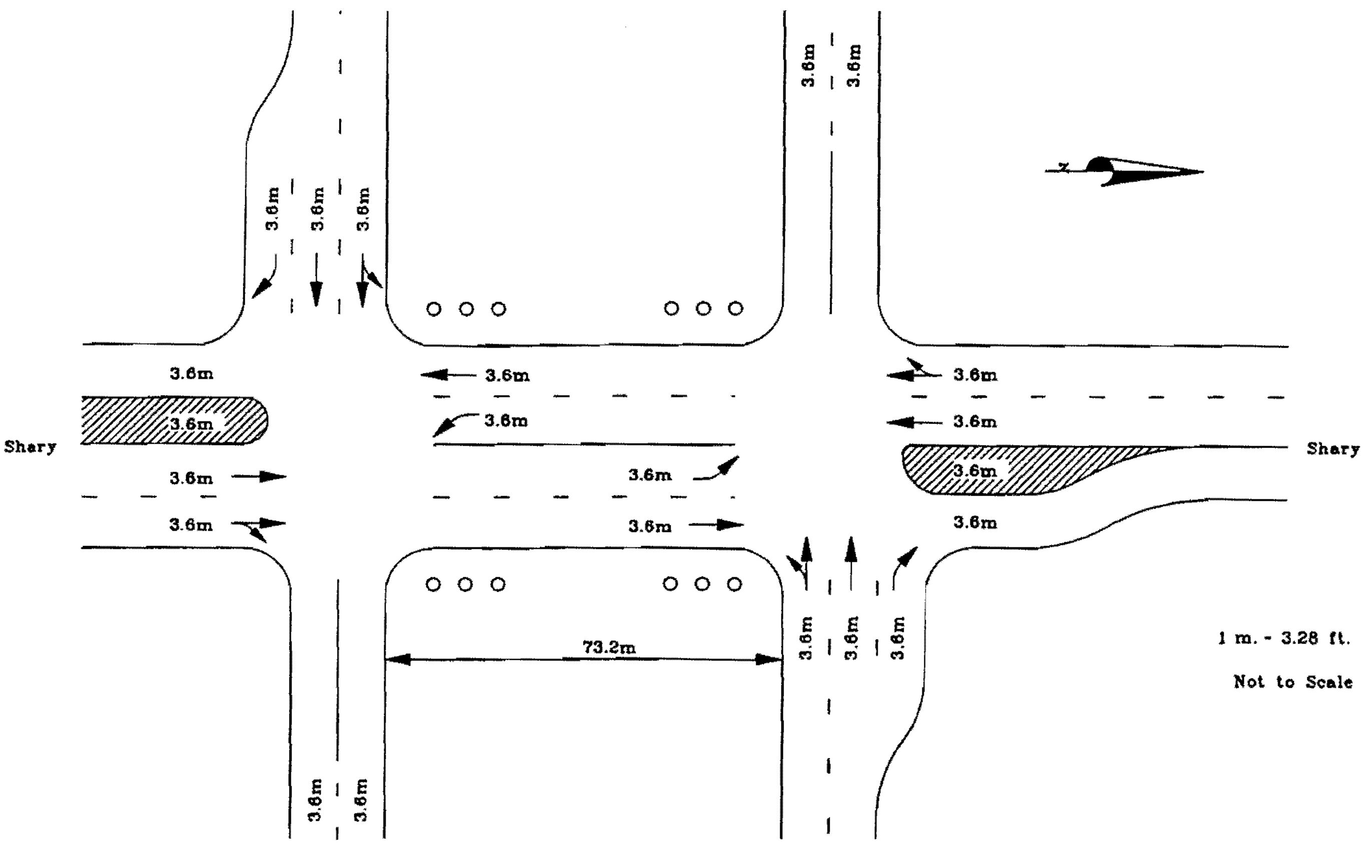

FIGURE 11. Proposed Short-Term Improvements to the Shary Road Interchange

Long Term Improvements

Add a lane to both Shary Road approaches, and provide three continuous lanes northbound and southbound through the interchange. Provide four-lane approaches and U-turn lanes on both frontage roads (Figure 12). (Note: These long-term improvements to the Shary Road Interchange would require relocation of U.S. 83 overpass columns and reconstruction of the bridge. These improvements would, most likely, not be cost effective unless completed as part of the U.S. 83 expansion to six lanes.)

The proposed long-term improvements and the 50 percent assumed removal of frontage road thru traffic (result of reversing ramps adjacent to the Shary Road Interchange) reduced the average stopped delay during the morning and evening peak hours to provide LOS C at the twenty-year horizon. Tables A-3 and A-4 present a more detailed explanation of the results associated with the Shary Road Interchange analyses. Volumes are shown in Figures B-3 and B-4.

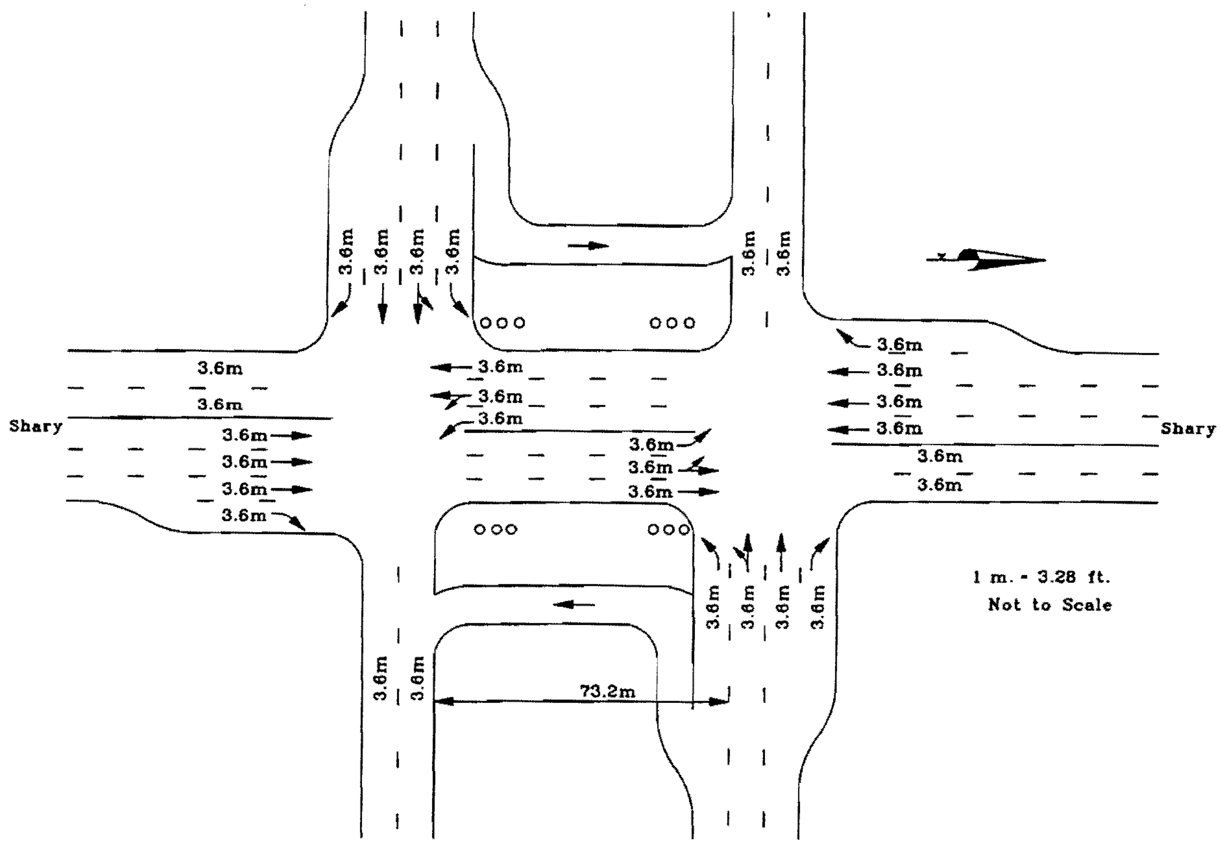

FIGURE 12. Proposed Long-Term Improvements to the Shary Road Interchange

23rd Street Interchange

The 23rd Street Interchange (Figure 13) is currently operating with an 85-second cycle length and a four-phase, TTI-lead phasing plan. Analysis of this interchange indicated LOS C and LOS D existing operations during the morning and evening peak hours, respectively. With optimization of the signal timing, however, delay was reduced during the morning peak hour, and traffic operations were improved to LOS C during the evening peak hour.

Although current traffic operations were improved by optimizing the signal timing, ten-year projected operations during the evening peak hour and twenty-year projected conditions during the morning and evening peak hours were LOS F with the existing geometric configuration of the 23rd Street Interchange. Thus, short-term geometric improvements were examined for this interchange. These improvements are described on the next page.

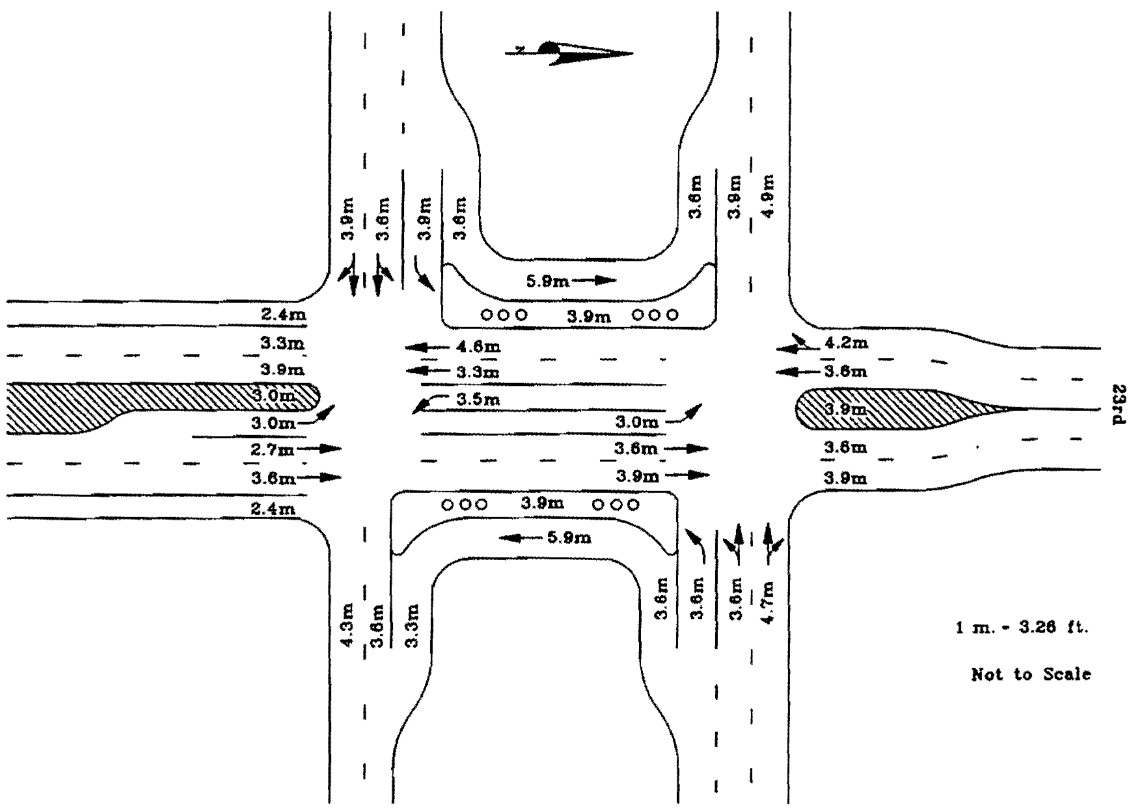

FIGURE 13. Existing Geometric Configuration of the 23rd Street Interchange

Short-Term Improvements

Add right-turn bays on both frontage road approaches. Use the center median on the southbound exterior approach of 23rd Street to provide a continuous left-turn lane through the interchange (Figure 14).

Proposed short-term improvements reduced the morning peak-hour delay, improving operations to LOS C; however, evening peak hour operations were not improved above LOS F. Due to the development adjacent to the 23rd Street Interchange and the existing U.S. 83 bridge structure, there was no room for additional geometric improvements.

A long-term improvement recommended in the vicinity of the 23rd Street Interchange is the construction of a new overpass at Bicentennial Boulevard (6). An overpass at Bicentennial Boulevard would cause a shift in trip patterns to and from the mall and airport, although it is difficult to estimate the exact percentage of traffic that would divert from 23rd Street to Bicentennial Boulevard. After an overall assessment of land use and traffic patterns, it was estimated that approximately 30 percent of the applicable left-turn and thru movements on 23rd Street and the westbound frontage road left turns at the 23rd Street Interchange would divert to the new overpass at Bicentennial Boulevard. Thus, short-term improvements to the 23rd Street Interchange and traffic diversion from 23rd Street to the new overpass were considered to be long-term improvements for the operational analysis of the 23rd Street Interchange.

The short-term improvements, the construction of an overpass at Bicentennial Boulevard, and the 50 percent assumed removal of frontage road thru traffic (result of reversing ramps adjacent to the 23rd Street Interchange) reduced the average stopped delay to vehicles at the 23rd Street Interchange to LOS E during the morning peak hour at the twenty-year horizon. Evening peak hour operations were LOS F. Tables A-5 and

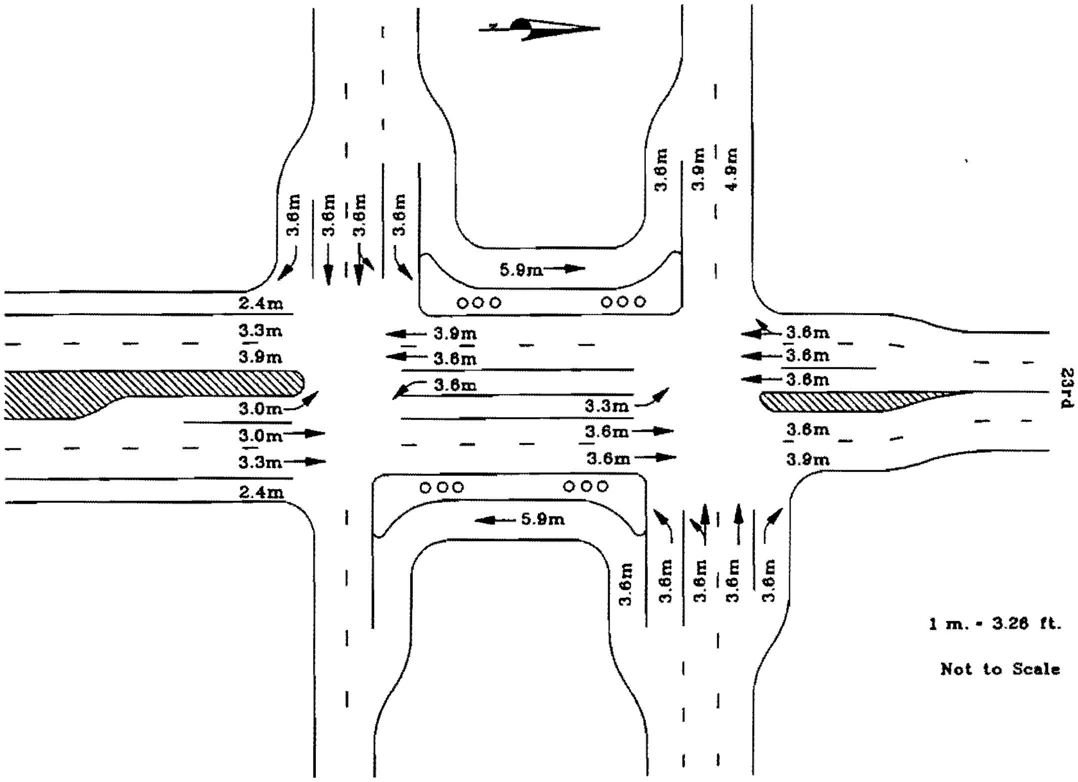

FIGURE 14. Proposed Short-Term Improvements to the 23rd Street Interchange

A-6 present a more detailed explanation of the results associated with the 23rd Street Interchange analyses. Volumes are shown in Figures B-5 and B-6. (Note: As already noted, the development which currently exists along 23rd Street, Main Street, 10th Street, and U.S. 83 limits additional growth in this area. Further, the growth rate used for the analysis of the twenty-year horizon was a liberal assumption; however, to be consistent with the growth rates used for the freeway and other interchanges, these rates were also applied to the volumes at the 23rd Street Interchange. Therefore, results of the twenty-year operational analysis of the 23rd Street Interchange indicated a lower LOS [i.e., higher delays] than what is reasonable for the interchange.)

10th Street Interchange

The 10th Street Interchange (Figure 15) is currently operating with an 80-second cycle length and a four-phase, TTI-lead phasing plan. Analysis of this interchange indicated LOS C and D operations during the morning and evening peak hours, respectively. With optimization of the signal timing, however, traffic operations were improved to LOS B during the morning peak hour, and delay was reduced during the evening peak hour.

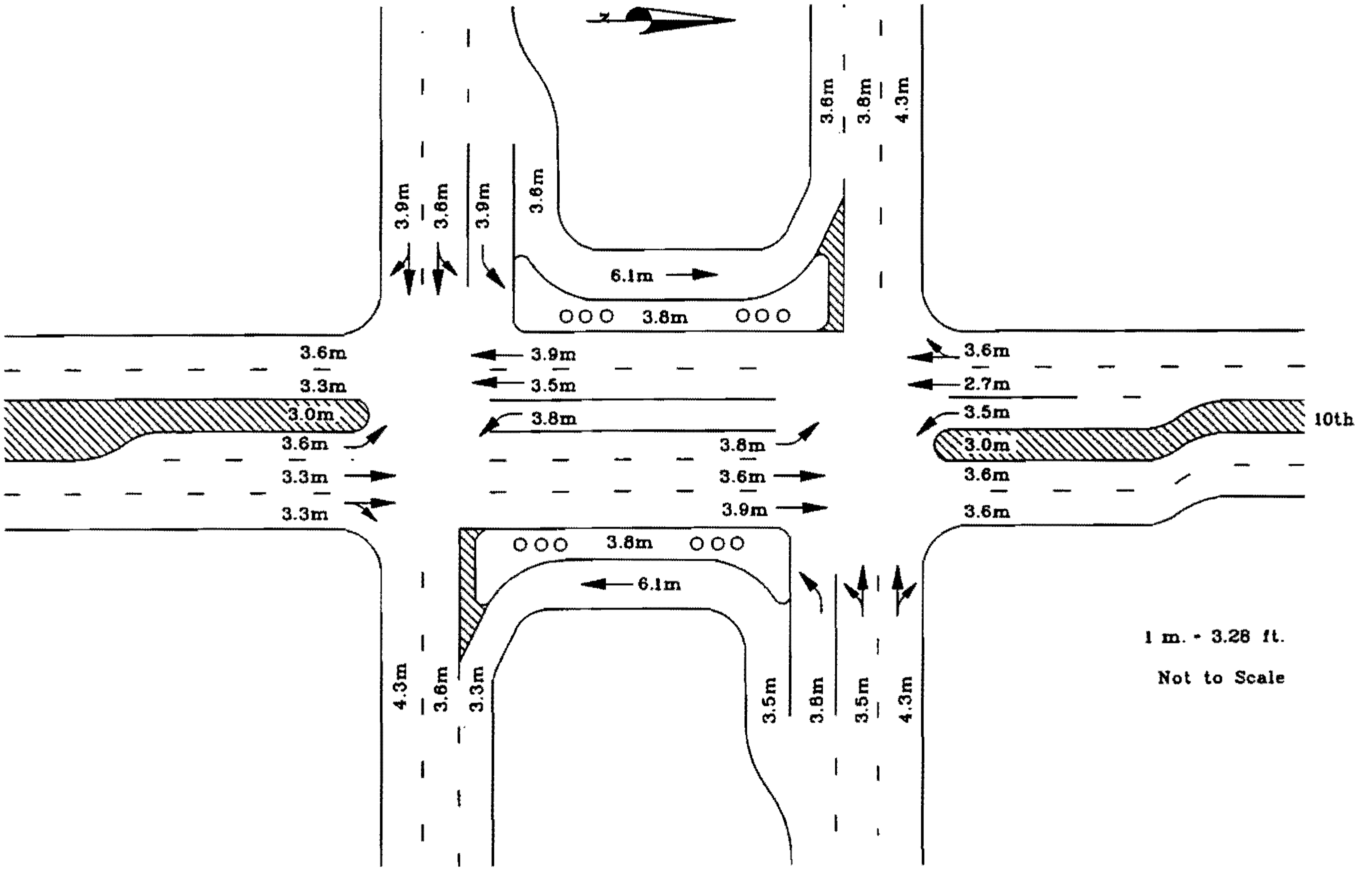

FIGURE 15. Existing Geometric Configuration of the 10th Street Interchange

Although current traffic operations were improved by optimizing signal timing, ten-year projected operations during the evening peak hour and twenty-year projected operations during the morning and evening peak hours were LOS F with the existing geometric configuration of the 10th Street Interchange. Thus, short-term geometric improvements were examined for this interchange. These improvements are described below.

Short-Term Improvements

Add a right-turn bay on the eastbound frontage road approach and the southbound 10th Street approach (Figure 16).

The proposed short-term improvements reduced the morning peak-hour delay, improving operations to LOS C; however, evening peak hour operations were not improved above LOS F. Due to the development adjacent to the 10th Street Interchange and the existing U.S. 83 bridge structure, there was no room for additional geometric improvements.

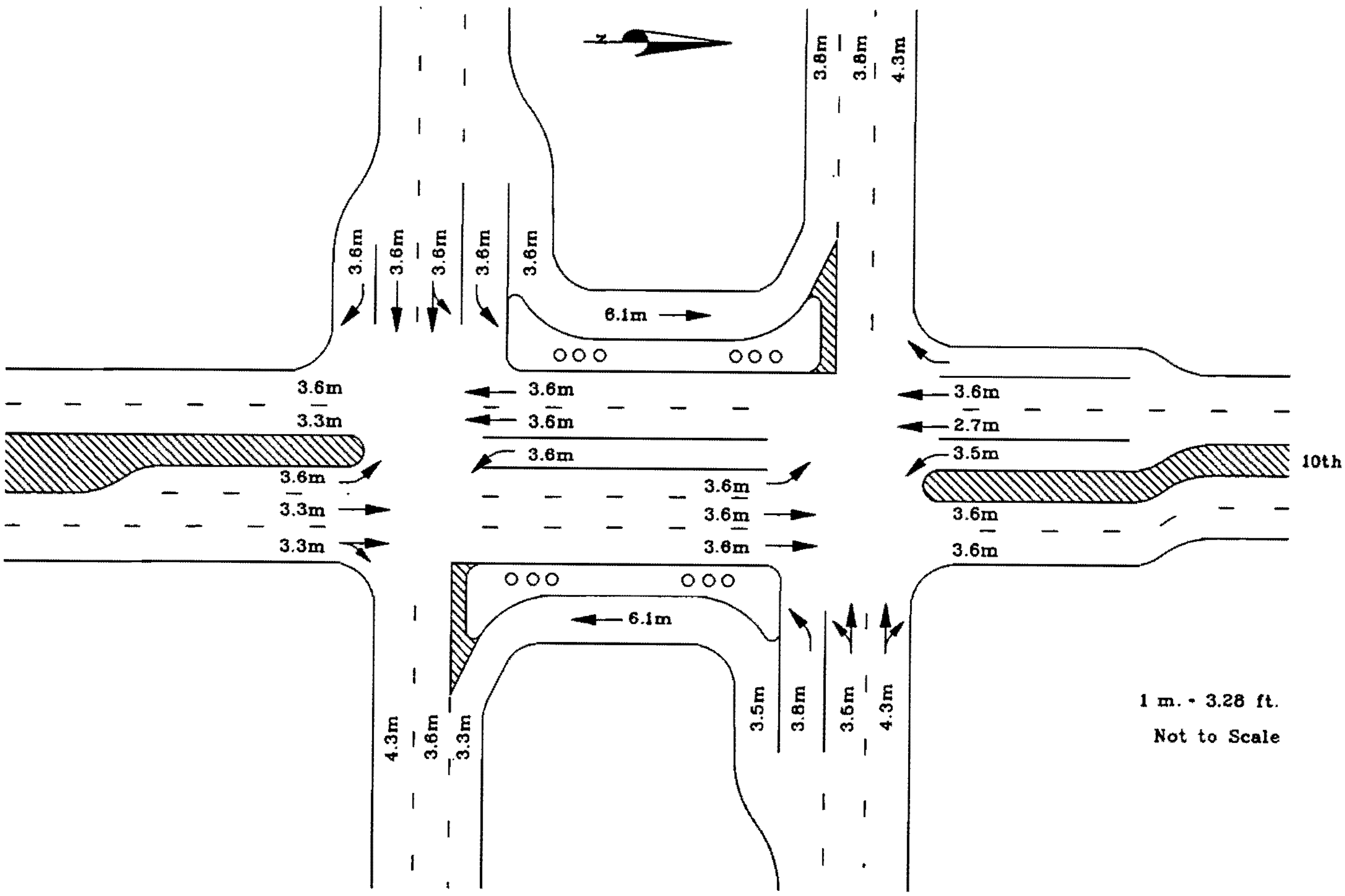

FIGURE 16. Proposed Short-Term Improvements to the 10th Street Interchange

A long-term improvement recommended in the vicinity of the 10th Street Interchange is the construction of a new overpass at Bicentennial Boulevard (previously mentioned in the 23rd Street Interchange analysis). As stated in the discussion of the 23rd Street Interchange, it is difficult to estimate the percentage of traffic that would divert from 10th and 23rd Streets to Bicentennial Boulevard; however, after an overall assessment of land use and traffic patterns, it was estimated that approximately 30 percent of the applicable left-turn and thru movements on 10th Street and the westbound frontage road left turns at the 10th Street Interchange would divert to the new overpass at Bicentennial Boulevard. Thus, short-term improvements to the 10th Street Interchange and the traffic diversion from 10th Street to the new overpass were considered to be long-term improvements for the operational analysis of the 10th Street Interchange.

Short-term improvements and the construction of an overpass at Bicentennial Boulevard reduced the average stopped delay to vehicles at the 10th Street Interchange to provide LOS D during the morning peak hour in twenty years. Evening peak-hour operations were LOS F. Tables A-7 and A-8 present a more detailed explanation of the results associated with the 10th Street Interchange analyses. Volumes are shown in Figures B-7 and B-8. (Note: As already noted, the development which currently exists along 10th Street, Main Street, 23rd Street, and U.S. 83 limits additional growth in this area. Further, the growth rate used for the analysis of the twenty-year operations was a liberal assumption; however, to be consistent with the growth rates used for the freeway and other interchanges, these rates were also applied to the volumes at the 10th Street Interchange. Therefore, results of the twenty-year operational analysis of the 10th Street Interchange indicated a lower LOS [i.e., higher delays] than what is reasonable for the interchange.)

Jackson Avenue Interchange

The Jackson Avenue Interchange (Figure 17) is currently operating with a 135-second cycle length and a four-phase, TTI-lead phasing plan. Analysis of this interchange indicated LOS D and LOS E existing operations during the morning and evening peak hours, respectively. With optimization of the signal timing, however, traffic operations were improved to LOS C during the morning peak hour and LOS D during the evening peak hour.

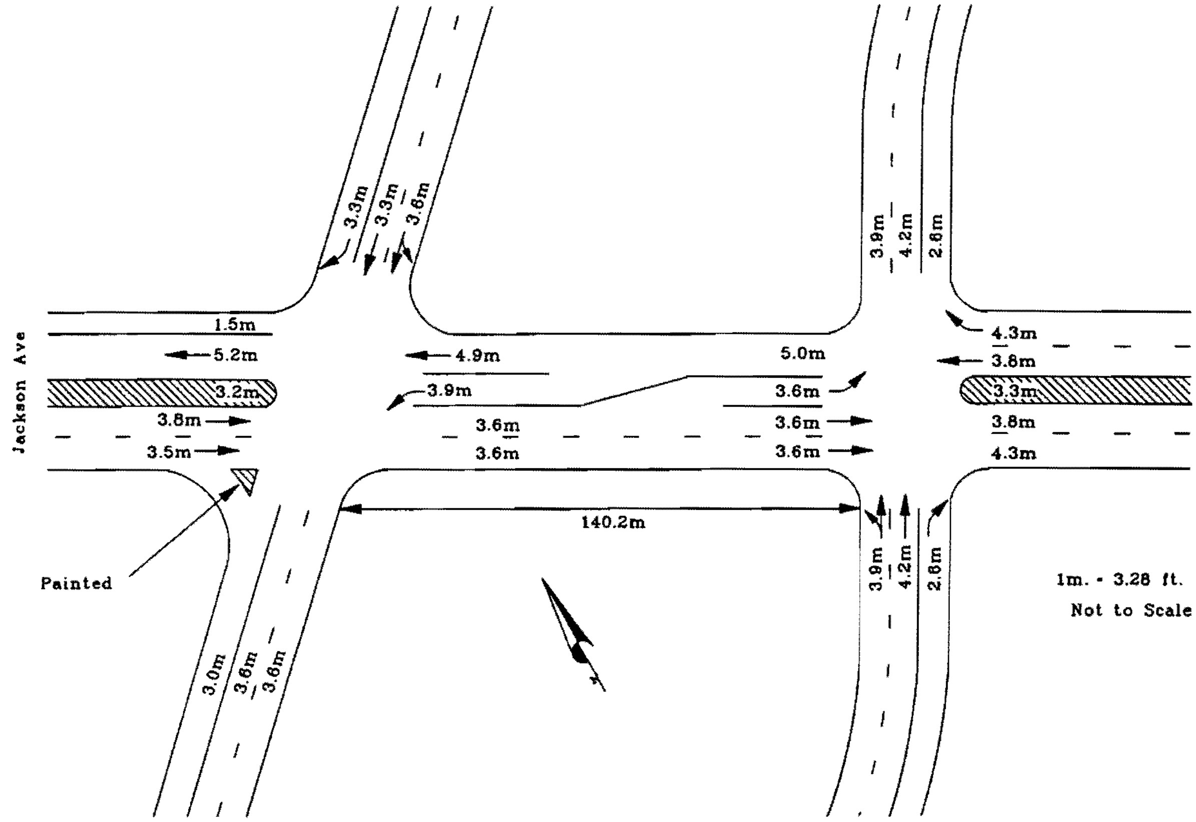

FIGURE 17. Existing Geometric Configuration of the Jackson Avenue Interchange

Although current traffic operations were improved by optimizing signal timing, ten-year projected operations during the evening peak hour and twenty-year projected operations during the morning and evening peak hours were LOS F with the existing geometric configuration of the Jackson Avenue Interchange. Thus, short-term geometric improvements were examined for this interchange. These improvements are described below.

Short-Term Improvements

Add an exclusive left-turn lane and a U-turn lane and bay to the eastbound frontage road approach. Provide a right-turn bay on the southbound Jackson Avenue approach. Restripe the lanes under the bridge to provide two thru lanes and a left-turn bay on northbound Jackson Avenue, and add an additional thru lane to the exterior approach on northbound Jackson Avenue (Figure 18).

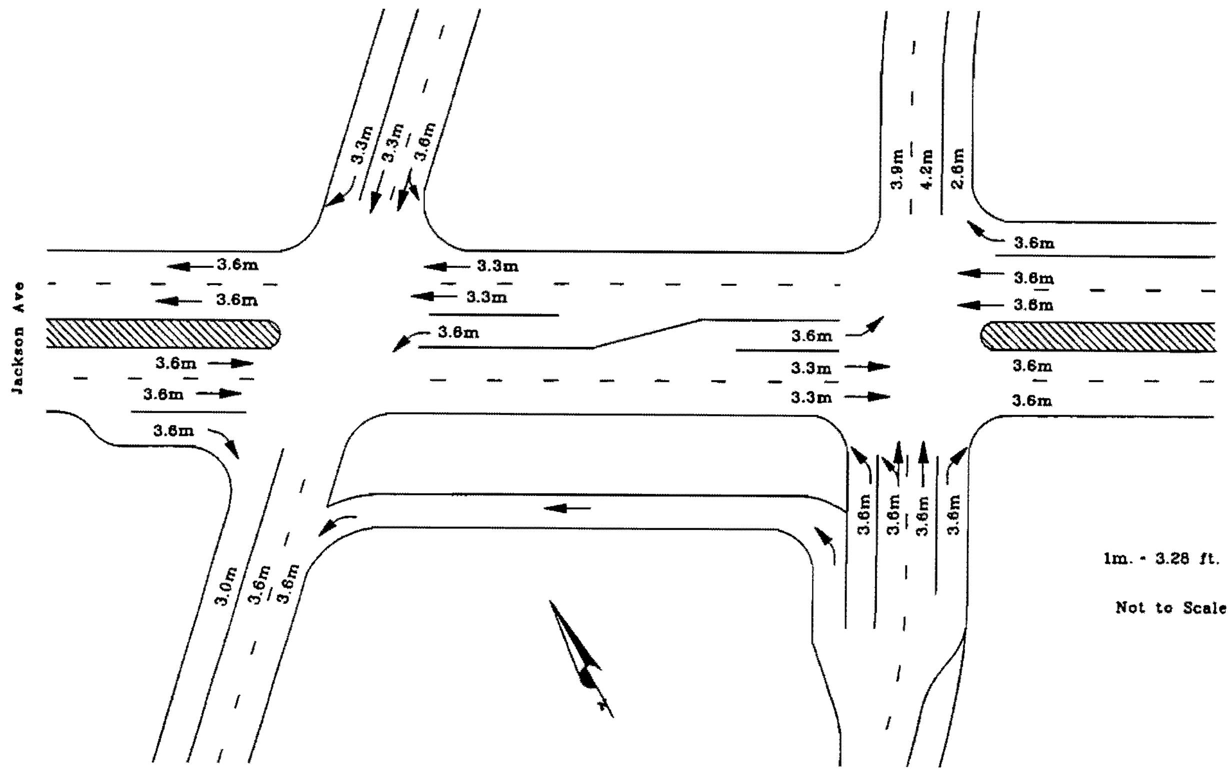

FIGURE 18. Proposed Short-Term Improvements and Long-Term Improvements, Option B, to the Jackson Avenue Interchange

The proposed short-term improvements reduced the morning peak-hour delay and improved operations to LOS E during the evening peak hour. The short-term improvements, however, did not provide an acceptable LOS in twenty years. Thus, two long-term improvement alternatives were examined for the Jackson Avenue Interchange. These improvements are described below.

Long Term Improvements, Option A

The first long-term option includes rebuilding the U.S. 83 overpass at Jackson Avenue, and constructing a new interchange at McColl Road providing four-lane approaches on both frontage roads, five-lanes on both Jackson Avenue approaches, and providing two exclusive left-turn lanes and two thru lanes on north- and southbound Jackson Avenue under the bridge structure (Figure 19).

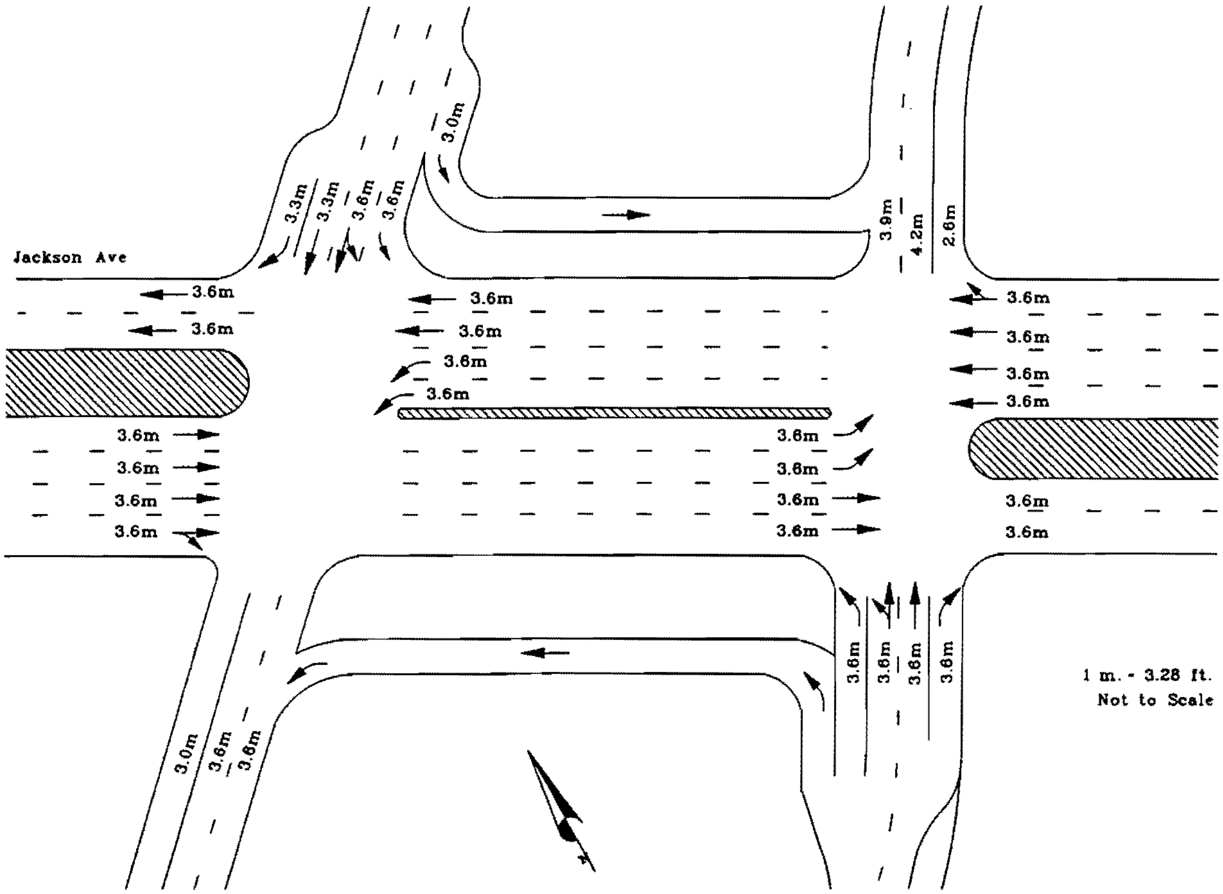

FIGURE 19. Proposed Long-Term Improvements, Option A, to the Jackson Avenue Interchange

Long Term Improvements, Option B

The second long-term improvement consists of the short-term improvements described previously (Figure 18) in conjunction with a new interchange at McColl Road (see Chapter IV, Major Interchange Analyses, for details).

The proposed long-term improvements (Options A and B), along with the provision of a westbound braided on-ramp or new at-grade on-ramp prior to the Jackson Avenue Interchange, improved operations to LOS B and LOS C during the morning and evening peak hours, respectively, in ten years. These improvements also provided LOS C and LOS E during the morning and evening peak hours, respectively, in twenty years. Although the operational LOS is nearly identical for the two long-term improvement alternatives, it is believed that the short-term improvements to the Jackson Avenue Interchange in conjunction with a new interchange at McColl Road is the better alternative because two interchanges will provide greater flexibility in this vicinity. For instance, traffic can "shift" between the two interchanges depending on daily fluctuations in traffic conditions which will provide better long-term circulation for the area. Further, two interchanges will provide more capacity for growth beyond the twenty-year horizon. Tables A-9 and A-10 present a more detailed explanation of the results associated with the Jackson Avenue Interchange analyses. Volumes are shown in Figures B-9 and B-10.

ANALYSIS PROCEDURE FOR UNSIGNALIZED INTERCHANGES

Two of the seven interchanges evaluated were unsignalized--Bryan Road and Ware Road. The procedure used to analyze the traffic operations at these interchanges is indicated below:

1. Simulate existing conditions;
2. Evaluate as signalized interchange with existing volumes;
3. Evaluate signalized interchange with ten- and twenty-year projected volumes;
4. Propose short-term geometric improvements, and evaluate signalized interchange with existing volumes and projected ten- and twenty-year volumes; and
5. Propose long-term geometric improvements, and evaluate with ten- and twenty-year projected volumes.

Appendix A presents the detailed results of the interchange operational analyses, and the existing and projected volumes at each interchange are shown in Appendix B.

Bryan Road Interchange

The Bryan Road Interchange (Figure 20) is currently unsignalized and is stop-controlled only on the frontage roads. TRANSYT-7F was used for the evaluation of this interchange because PASSER III-90 does not evaluate unsignalized interchanges.

The existing traffic operations at the Bryan Road Interchange were LOS A during both the morning and evening peak hours; however, the analysis of future conditions showed that morning and evening peak-hour operations reached LOS F within ten years.

Because of the geometric design constraints of the Bryan Road Interchange, no improvements have been proposed at this time. Improvements to the Bryan Road Interchange would require an extensive analysis. Tables A-11 and A-12 present a more detailed explanation of the results associated with the Bryan Road Interchange analyses. Volumes are shown in Figures B-11 and B-12.

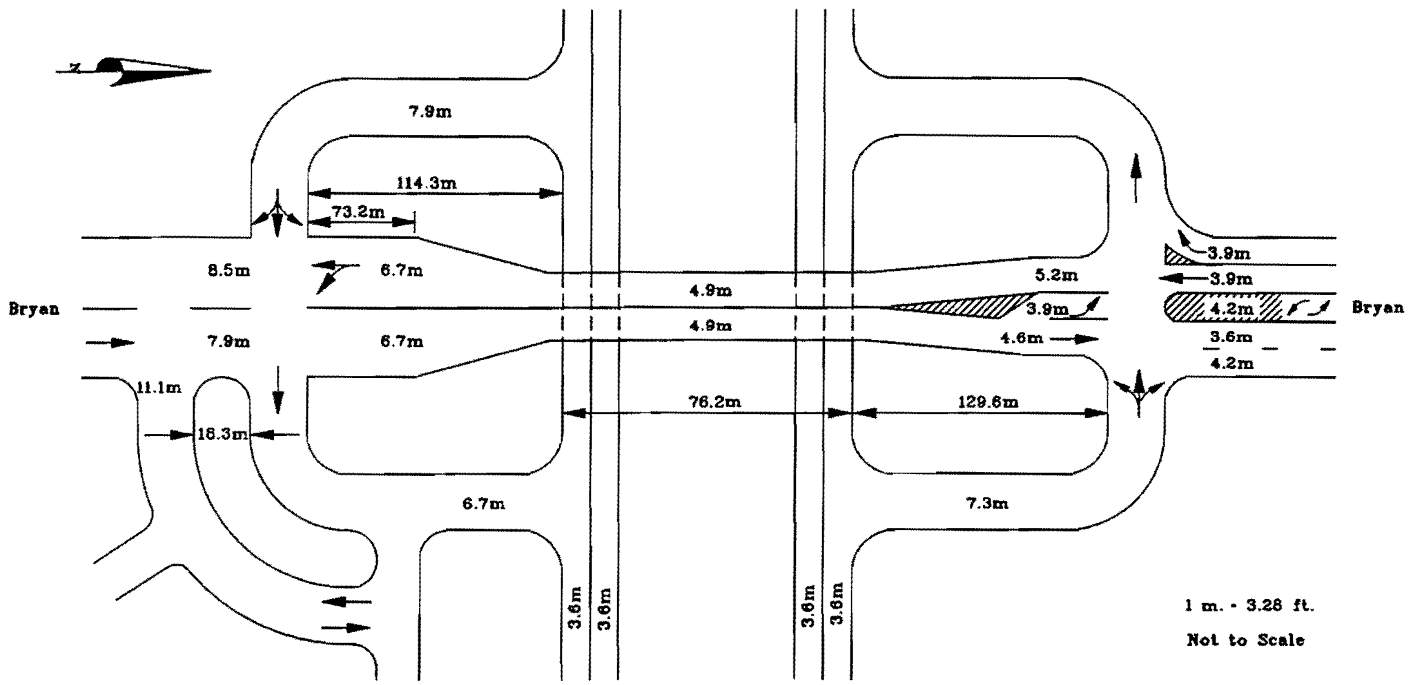

FIGURE 20. Existing Geometric Configuration of the Bryan Road Interchange

Ware Road Interchange

The Ware Road Interchange (Figure 21) is currently stop-controlled on all approaches. Since neither PASSER III-90 nor TRANSYT-7F can evaluate all-way stop-controlled (AWSC) interchanges or intersections, a method outlined in revised Chapter 10 of the HCM was used for the evaluation. The interchange was then analyzed as a signalized interchange using PASSER III-90.

The AWSC analysis of this interchange indicated LOS E operations during both the morning and evening peak hours. In ten years, however, projections indicated operations of LOS F during both the morning and evening peak hours. Thus, the Ware Road Interchange was evaluated as a signalized interchange with existing and projected volumes.

Signalizing the interchange improved operations to LOS C during the morning and evening peak hours. Signalization of the interchange did not, however, improve ten-year operations above LOS F. Thus, short-term improvements were evaluated for the Ware Road Interchange. These improvements are discussed below.

Short-Term Improvements

Widen Ware Road north and south of the bridge structure to provide two lanes on each approach, and remove the channelization island for the right-turn lane on the southbound approach. Restripe the lanes under the bridge structure as two lanes in each direction. Provide a right-turn bay on both frontage road approaches (Figure 22).

The short-term improvements provided LOS E during the morning and evening peak hours at the ten-year horizon. Since, however, the short-term improvements did not improve twenty-year projected traffic operations above LOS F, long-term improvements to the Ware Road Interchange were proposed. These improvements are described below.

Long-Term Improvements

Add a lane to both Ware Road approaches, and provide three continuous lanes (northbound and southbound) through the interchange (Figure 23). (Note: These long-term improvements to the Ware Road Interchange would require relocation of the U.S. 83 overpass columns and reconstruction of the bridge. These improvements would, most likely, not be cost effective unless completed as part of the U.S. 83 expansion to six lanes.)

The proposed long-term improvements to the frontage roads and the 75 percent assumed removal of frontage road thru traffic (result of reversing ramps adjacent to the Ware Road Interchange) provided LOS C and LOS E operations during the morning and evening peak hours, respectively, for the twenty-year horizon. Tables A-13 and A-14 present more detailed explanation of the results associated with the Ware Road Interchange analyses. Volumes are shown in Figures B-13 and B-14.

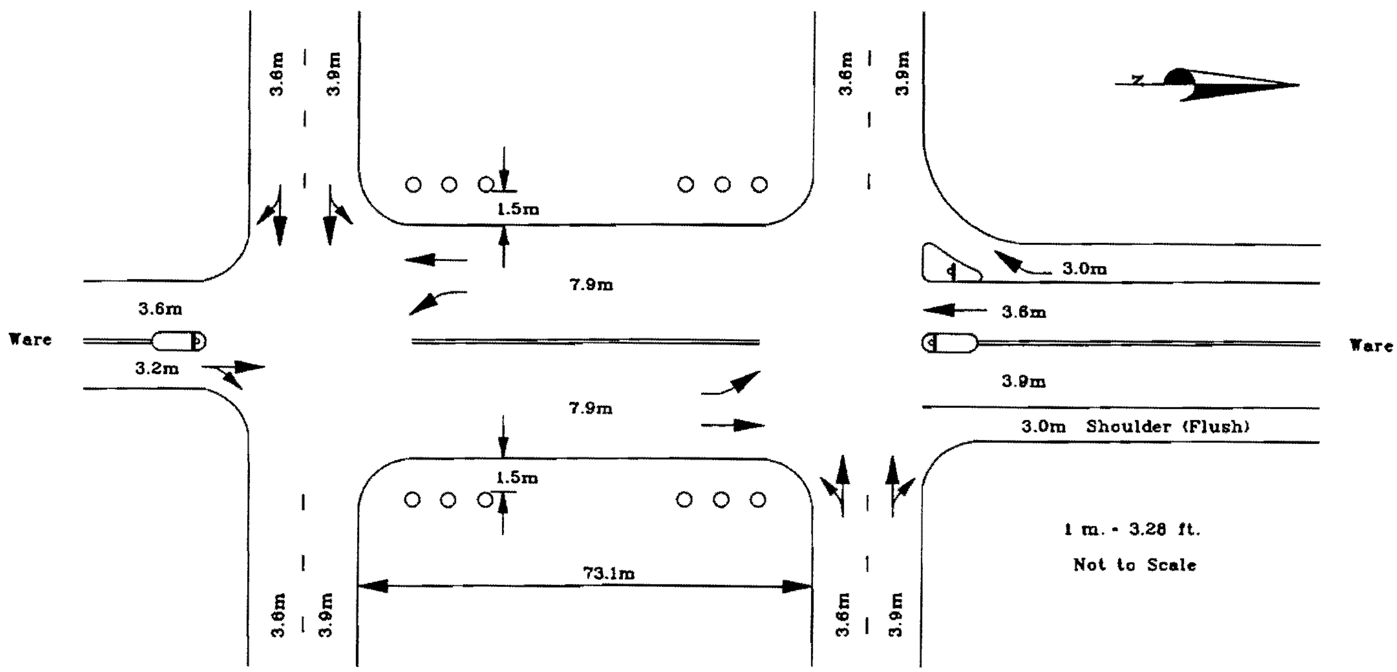

FIGURE 21. Existing Geometric Configuration of the Ware Road Interchange

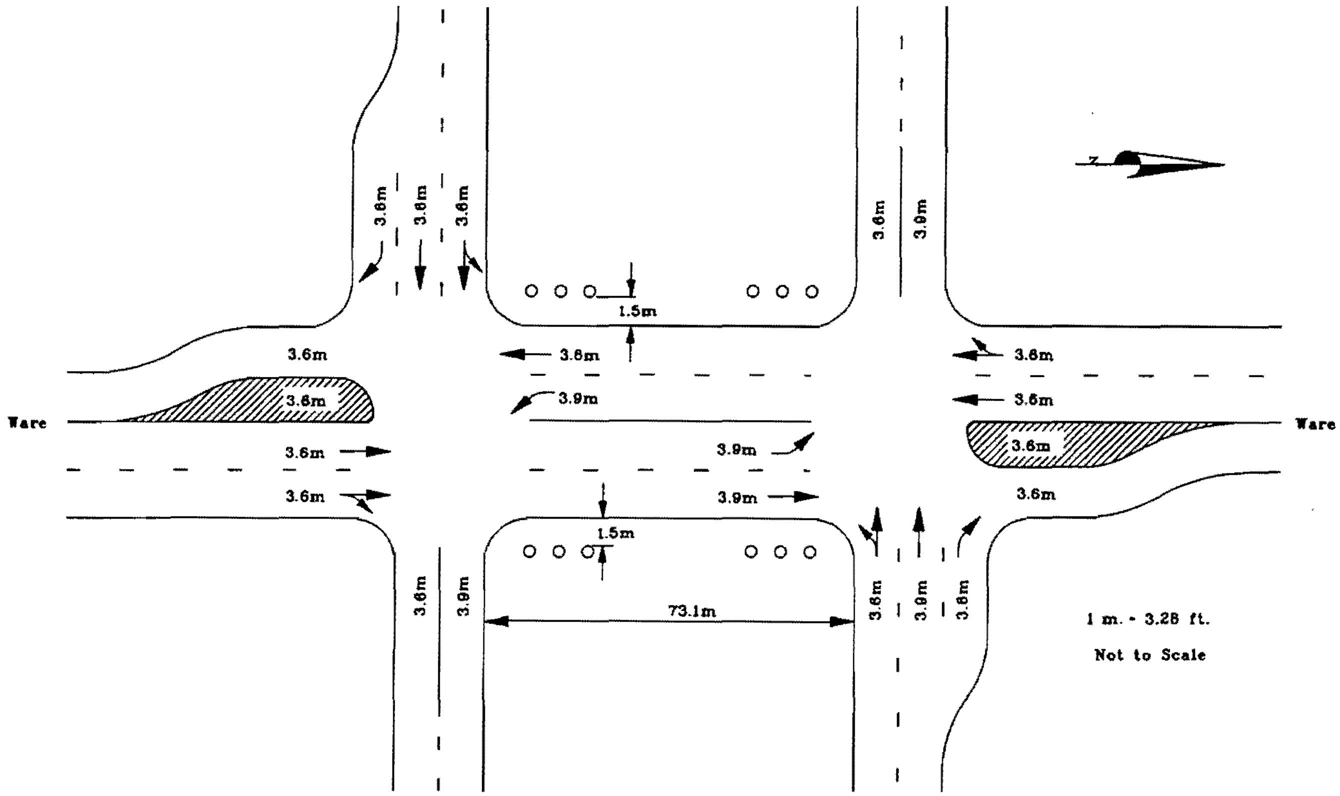

FIGURE 22. Proposed Short-Term Improvements to the Ware Road Interchange

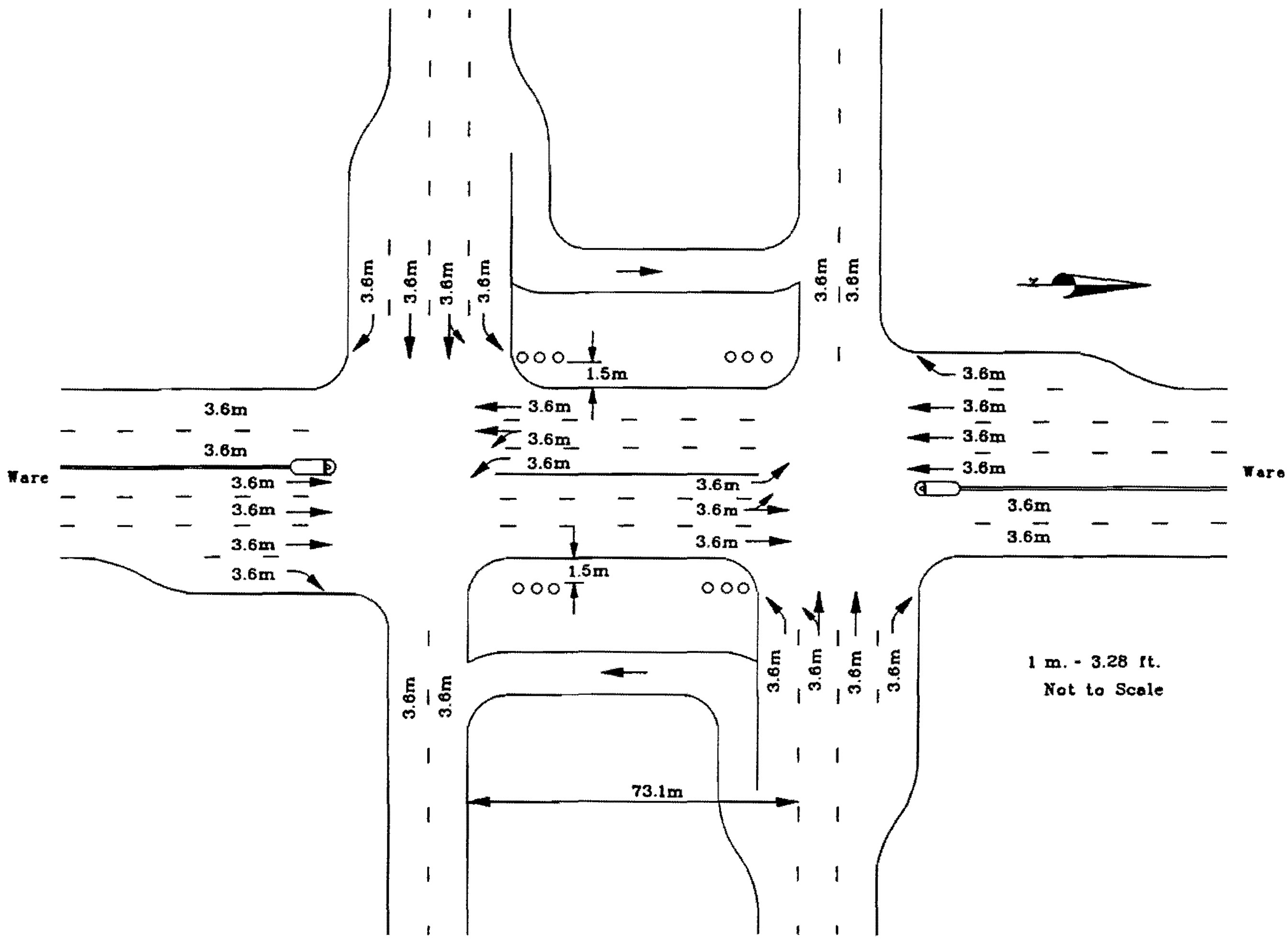

FIGURE 23. Proposed Long-Term Improvements to the Ware Road Interchange

IV. MAJOR INTERCHANGE ANALYSES

The analyses of the U.S. 83 mainlanes and cross-street interchanges in McAllen indicated that traffic operations were either at an acceptable LOS or that operations could be improved to an acceptable LOS through changes in signal timing, short-term geometric improvements, and/or relocating or reversing freeway ramps. Two locations along U.S. 83, however, have experienced recent major development; traffic circulation has deteriorated, and congestion has become a problem. Although signal timing or geometric changes improved current operations and possibly five- to ten-year operations, these improvements did not provide acceptable long-term operations. The two areas where traffic operations needed additional analysis were between 23rd Street and 10th Street and between McColl Road and Jackson Avenue.

BICENTENNIAL BOULEVARD INTERCHANGE

Because of the traffic problems in this area of McAllen, emphasis has been placed on the development of a new interchange at Bicentennial Boulevard. This enhancement would provide a more direct route to Miller International Airport and an alternate route to La Plaza Mall, thereby relieving traffic congestion at the adjacent interchanges. Bicentennial Boulevard is a north-south collector stretching through McAllen on the north side of U.S. 83 and ending at the westbound U.S. 83 frontage road. It is located between 23rd Street and Main Street. A new overpass, along with the extension of Bicentennial Boulevard south of U.S. 83, would serve as a main entrance to the airport and would provide an alternate route for mall traffic.

TTI Research Report 2903-1(6) contains detailed discussion of the development and analysis of a new Bicentennial Interchange.

MCCOLL ROAD AND JACKSON AVENUE

As discussed in the cross-street interchange operational assessments, the Jackson Avenue Interchange is currently operating at LOS D during the peak hour of the day, and operations are expected to drop to LOS F within ten years. Although short-term geometric improvements may provide some additional capacity at the interchange, the operational assessment indicated that these improvements would not provide adequate capacity past the ten-year horizon. Thus, the section of U.S. 83 between McColl Road and Jackson Avenue was examined in further detail.

The recent development of several large shopping establishments just southwest of the Jackson Avenue Interchange has contributed to the generation of more than 3,200 vehicles through the Jackson Avenue Interchange during the peak hour. Jackson Avenue currently provides the most direct access into and out of this shopping area. In order to access the shopping from eastbound U.S. 83 prior to Jackson Avenue, vehicles must exit the freeway immediately after 10th Street, nearly a mile before the first access driveway into the mall. Further, there is a hospital planned south of U.S. 83 along McColl Road which will generate more traffic in this area (Figure 24).

As a result of recent and planned development near the Jackson Avenue Interchange, two long-term improvement alternatives were examined for this section of U.S. 83. The first alternative examined was the construction of a new interchange at Jackson Avenue. The current interchange provides only two thru lanes southbound through the interchange and one thru lane northbound through the interchange, with left-turn bays in both directions. As stated previously, this interchange serves as the main access into and out of the shopping area from U.S. 83 and north McAllen. To provide adequate capacity at this interchange, the interchange would have to be reconstructed. The proposed geometric configuration for a new Jackson Avenue Interchange was shown in Figure 19.

The second long-term improvement alternative which was examined included making short-term, relatively inexpensive, geometric improvements to the Jackson Avenue Interchange (Figure 18) and constructing a new interchange at McColl Road (Figure 25; volumes on the McColl Road Interchange are shown in Figure B-15). McColl Road is a north-south collector stretching from north McAllen to the westbound U.S. 83 frontage road. Although McColl Road does not bisect the U.S. 83 mainlanes, it continues south of the expressway and serves the shopping area. An interchange at McColl Road would not only better serve the shopping area, but would help relieve congestion at the Jackson Avenue Interchange. The operational assessment of the two long-term design alternatives is presented in Tables 5 and 6.

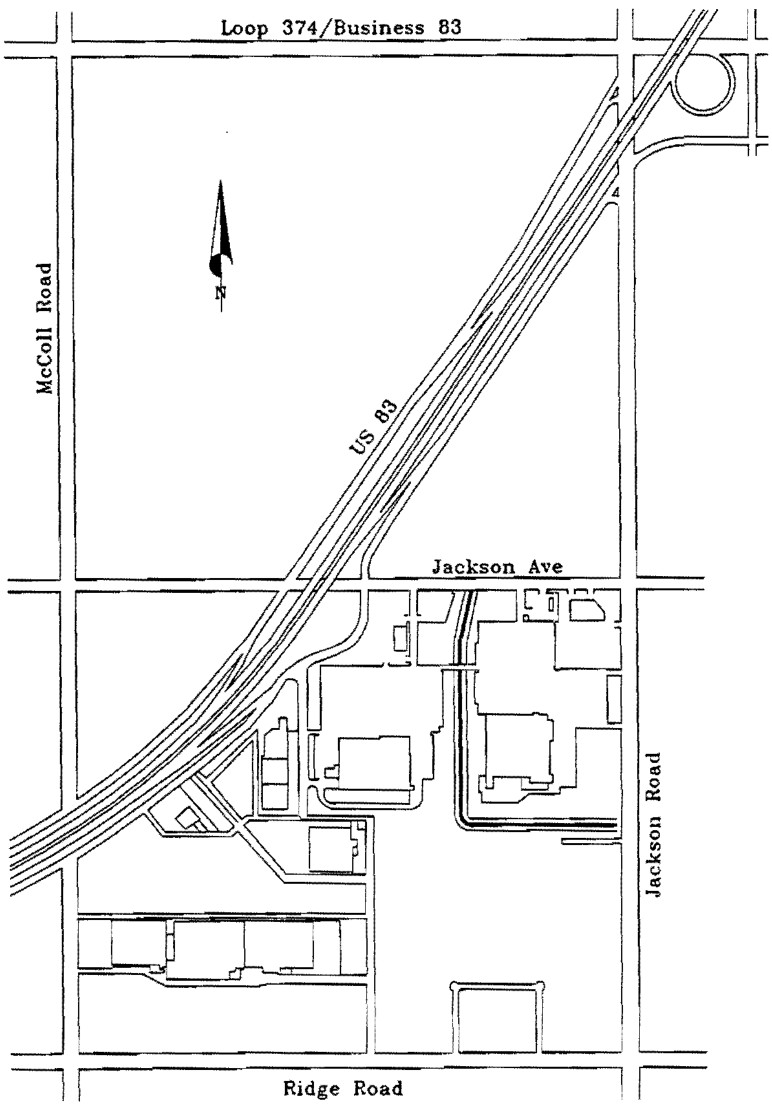

FIGURE 24. Jackson Avenue-McColl Road Vicinity Map

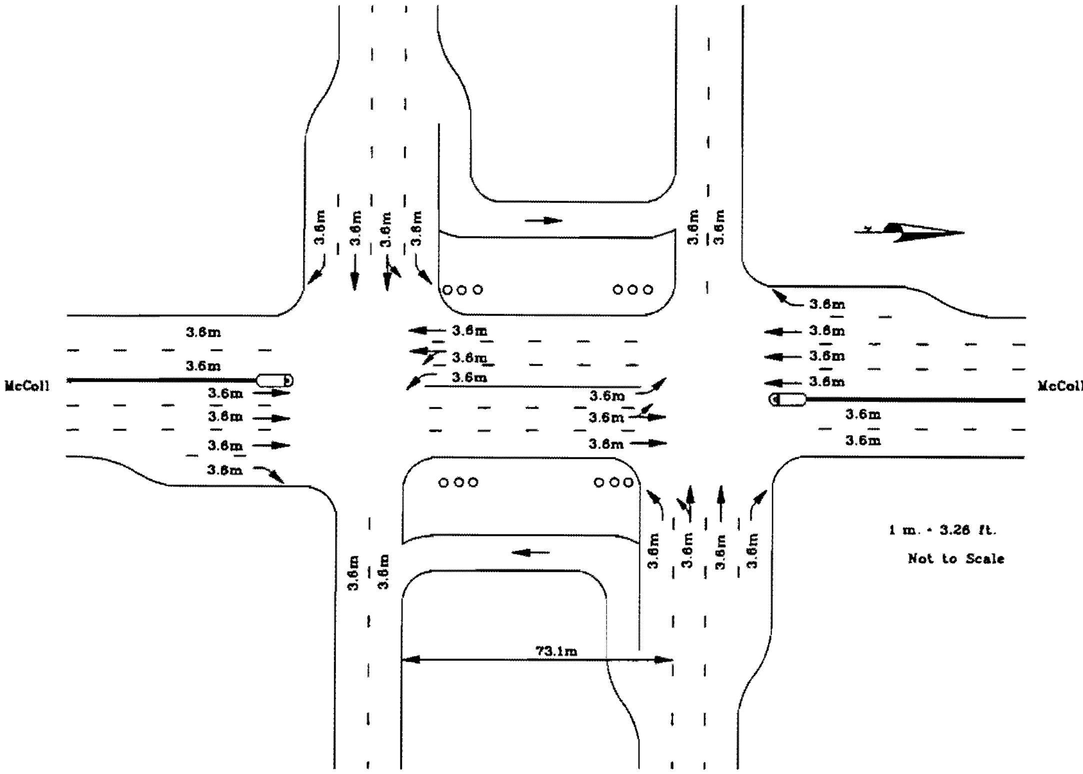

FIGURE 25. Proposed Geometric Configuration of a McColl Road Interchange

TABLE 5. Operational Assessment of Long-Term Design Alternatives--
Jackson Avenue Interchange

Conditions	Cycle Length (sec)	Total Stopped Delay (veh-hr/hr)	Average Stopped Delay (sec/veh)	LOS
Evening Peak Hour 10-Year Projected Volumes New Jackson Ave. Interchange Improved Ramp Configuration[1]	75-second Lag-Lag	28	21	C
Evening Peak Hour 10-Year Projected Volumes Improved Jackson Ave. Interchange New McColl Road Interchange Improved Ramp Configuration[1]	60-second Lag-Lag	22	21	C
Evening Peak Hour 20-Year Projected Volumes New Jackson Ave. Interchange Improved Ramp Configuration[1]	95-second Lag-Lag	84	48	E
Evening Peak Hour 20-Year Projected Volumes Improved Jackson Ave. Interchange New McColl Road Interchange Improved Ramp Configuration[1]	130-second Lag-Lag	73	53	E

[1]Refers to the provision of a braided on-ramp over the existing westbound exit ramp to Jackson Avenue or a new entrance ramp prior to the Jackson Avenue Interchange.

TABLE 6. Operational Assessment of Long-Term Design Alternatives--
McColl Road Interchange

Conditions	Cycle Length (sec)	Total Stopped Delay (veh-hr/hr)	Average Stopped Delay (sec-veh)	LOS
Evening Peak Hour 10-Year Projected Volumes Improve Jackson Ave. Interchange New McColl Road Interchange	60-second Lag-Lag	14	15	B
Evening Peak Hour 20-Year Projected Volumes Improve Jackson Ave. Interchange New McColl Road Interchange	65-second Lag-Lag	29	23	C

Although the two alternative designs provide nearly the same operational LOS at the Jackson Avenue Interchange for the ten- and twenty-year horizons, each alternative has advantages and disadvantages. Making geometric improvements to the Jackson Avenue Interchange and building a new interchange at McColl Road would be considerably more expensive than building a new interchange at Jackson Avenue. Two interchanges in proximity to the shopping area would, however, grant greater flexibility to drivers by providing an alternate route to and from the mall. Further, two interchanges would provide more capacity than one interchange at Jackson Avenue and would provide efficient operations beyond the twenty-year horizon. Table 7 summarizes the advantages and disadvantages of the two design alternatives.

TABLE 7. McColl vs. Jackson Avenue Improvements--Advantages and Disadvantages

Alternative	Advantages	Disadvantages
Major Improvements at Jackson Avenue	•Relatively inexpensive •Less difficult ROW acquisition	•Limits long-term circulation •Excessive delay during construction •Significant congestion soon after the twenty-year horizon
Minor Improvements at Jackson Avenue with McColl Road Interchange	•Better long-term circulation •Acceptable LOS at McColl and Jackson Avenue •Better system continuity •Less delay during construction	•Expensive •Potentially difficult ROW acquisition

Despite the advantages of a new interchange at Jackson Avenue, the recommended long-term design alternative is the combination of minor geometric improvements to the Jackson Avenue Interchange and a new interchange at McColl Road. These improvements will provide the best long-term solution to traffic problems in this area of McAllen.

V. SYSTEM-WIDE ASSESSMENT OF IMPROVEMENTS

An assessment of the total system-wide benefits associated with the proposed improvements was also conducted. This analysis quantified the difference between traffic operations during the morning and evening peak hours under existing conditions versus proposed conditions. Table 8 summarizes the results of this analysis.

Table 8. Net Benefits of Proposed Improvements

Corridor Component	Net Present Cost Due to Delay, $Millions[1]		Net Benefits $Millions
	Existing Geometrics	Proposed Improvements	
Freeway Mainlanes	38.8	1.3	37.5
Cross-Street Interchanges	142.3	25.9	116.4
Frontage Roads	0.2	4.1	-3.9
TOTAL	$181.3	$31.3	$150.0

[1]The net present cost of delay during the peak hours (a.m. plus p.m.) over 20 years, assuming a discount rate of 4%, 250 working days per year, and a value of time - $10.78/veh.-hr.

The primary benefits to be gained along this section of U.S. 77/83 are associated with signal-timing and minor geometric improvements at the cross-street interchanges. These improvements alone are estimated to generate benefits well over $100 million. The conversion of ramp designs to an "x"-ramp configuration will place a greater amount of traffic on the frontage roads, and, thus, result in minor decreases in frontage road travel speeds and levels-of-service. However, the proposed ramp configurations will significantly decrease the weaving conflicts which would otherwise exist on the freeway mainlanes. With regard to the mainlane and frontage road operations, the proposed design is estimated to result in a benefit of approximately $34 million -- producing an estimated system-wide benefit of approximately $150 million.

VI. CONCLUSIONS AND RECOMMENDATIONS

An analysis of the mainlanes and ramps along U.S. 83 indicated that reversing and removing some of the ramps from Conway Avenue to Sugar Road should improve expressway operations. Tables 3 and 4 summarize the recommended ramping changes. These changes should result in an improvement one or two levels-of-service in certain sections of the study segment. Several of the more congested areas, however, remained congested even after the ramp improvements. The U.S. 83 Expressway, therefore, will require an additional mainlane of capacity in each direction to provide acceptable long-term (twenty-year) operations.

Although operational benefits will be gained along the freeway after implementing the recommended ramp improvements, the major operational improvement that will result from the ramping changes is the significant reduction in delays associated with the cross-street interchanges. It is, therefore, recommended that these changes be made in conjunction with optimizing the signals at each interchange and providing short/long-term geometric improvements. The combination of these improvements will significantly decrease the existing delay experienced at the cross-street interchanges.

Finally, a detailed study of the U.S. 83 interchange at Jackson Avenue showed that geometric improvements are needed to improve the current operational LOS. After analyzing two long-term alternative improvement options (Options A and B), it is recommended that long-term Option B be constructed. This option provides minor (short-term) geometric improvements at the Jackson Avenue Interchange (which could be implemented immediately) along with a new interchange at McColl Road. This option not only provides more capacity and an acceptable LOS at both interchanges, but will ensure better traffic circulation now and into the future. The net benefit associated with all of the aforementioned proposed improvements (mainlane, ramp, and cross-street interchange improvements) is estimated to be $150 million.

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4. *Texas Highway Design Division Operations and Procedures Manual.* Texas Department of Transportation, Austin, Texas 1986.

5. *A Policy on Geometric Design of Highways and Streets.* American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 1990.

6. *Bicentennial Boulevard Interchange Analysis -- McAllen, Texas.* Research Report F2903-1, Texas Transportation Institute, College Station, Texas, 1995.

APPENDIX A

Existing and Future Level-of-Service Analyses for Cross-Street Interchanges

TABLE A-1. Conditions at Conway Avenue Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	130-second TTI-Lead	13	34	D
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lag	6	15	B
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	75-second Lead-Lag	21	31	D
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	60-second Lead-Lead	16	24	C
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	8	12	B
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	12	15	B

TABLE A-2. Conditions at Conway Avenue Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	130-second TTI-Lead	23	36	D
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lead	13	20	C
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	130-second Lead-Lead	78	72	F
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	95-second Lead-Lead	55	50	E
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	19	17	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	95-second Lead-Lead	60	43	E

TABLE A-3. Conditions at Shary Road Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	165-second TTI-Lead	29	62	F
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lead	11	23	C
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	135-second Lag-Lag	117	149	F
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	70-second Lead-Lead	27	32	D
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	12	15	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	20	18	C

TABLE A-4. Conditions at Shary Road Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	165-second TTI-Lead	51	87	F
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	85-second Lead-Lead	23	40	D
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	135-second Lead-Lead	331	331	F
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	115-second Lead-Lead	65	65	F
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	16	16	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	70-second Lead-Lead	29	24	C

TABLE A-5. Conditions at 23rd Street Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	85-second TTI-Lead	18	21	C
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lead	13	16	C
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	70-second Lead-Lead	49	33	D
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	60-second Lead-Lead	33	24	C
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	23	21	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	95-second Lead-Lead	70	47	E

TABLE A-6. Conditions at 23rd Street Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	85-second TTI-Lead	28	26	D
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lead	25	22	C
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	135-second Lead-Lead	280	150	F
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	115-second Lead-Lead	142	76	F
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	65-second Lead-Lead	34	25	D
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	135-second Lead-Lead	131	72	F

TABLE A-7. Conditions at 10th Street Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	80-second TTI-Lead	16	20	C
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lag-Lag	12	15	B
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	65-second Lag-Lag	38	28	D
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	60-second Lag-Lag	30	22	C
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	20	18	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	70-second Lead-Lead	44	29	D

TABLE A-8. Conditions at 10th Street Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	80-second TTI-Lead	33	27	D
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	65-second Lead-Lead	31	26	D
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	135-second Lead-Lead	456	220	F
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	135-second Lead-Lead	312	151	F
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	135-second Lag-Lead	108	63	F
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	135-second Lead-Lead	502	236	F

TABLE A-9. Conditions at Jackson Avenue Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	135-second TTI-Lead	15	30	D
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lag-Lag	8	17	C
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second TTI-Lead	18	21	C
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	60-second TTI-Lead	13	16	C
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Improved Ramp Configuration	60-second Lead-Lead	11	14	B
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[1] Improved Ramp Configuration[2]	60-second TTI-Lead	10	14	B
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[1] Improved Ramp Configuration[2]	60-second Lead-Lead	17	16	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[3] Improved Ramp Configuration[2]	60-second TTI-Lead	14	17	C

[1]Based on a new eight-lane interchange at Jackson Avenue and no overpass at McColl Road.
[2]Refers to the provision of a braided on-ramp over the existing westbound exit ramp to Jackson Avenue or a new entrance ramp prior to the Jackson Avenue Interchange.
[3]Based on improvements to the existing Jackson Avenue Interchange and a new overpass at McColl Road.

TABLE A-10. Conditions at Jackson Avenue Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Existing Signal Timing Existing Geometry Existing Ramp Configuration	135-second TTI-Lead	36	41	E
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lag-Lag	25	28	D
10-Year Projected Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	135-second Lag-Lead	358	235	F
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	110-second Lag-Lag	87	60	E
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[1] Improved Ramp Configuration[2]	75-second Lag-Lag	28	21	C
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[3] Improved Ramp Configuration[2]	60-second Lag-Lag	22	21	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[1] Improved Ramp Configuration[2]	95-second Lag-Lag	84	48	E
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry[3] Improved Ramp Configuration[2]	130-second Lag-Lag	73	53	E

[1]Based on a new eight-lane interchange at Jackson Avenue and no overpass at McColl Road.
[2]Refers to the provision of a braided on-ramp over the existing westbound exit ramp to Jackson Avenue or a new entrance ramp prior to the Jackson Avenue Interchange.
[3]Based on improvements to the existing Jackson Avenue Interchange and a new overpass at McColl Road.

TABLE A-11. Conditions at Bryan Road Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	1	2	A
10-Year Projected Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	65	124	F
20-Year Projected Volumes Unsignalized Long-Term Improved Geometry Existing Ramp Configuration	NA	185	264	F

NOTE: Recommended short-term and long-term improvements to the Bryan Road Interchange would require further evaluation. Improvements to the operational LOS of this interchange would require major geometric improvements.

TABLE A-12. Conditions at Bryan Road Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	1	2	A
10-Year Projected Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	71	107	F
20-Year Projected Volumes Unsignalized Long-Term Improved Geometry Existing Ramp Configuration	NA	298	336	F

NOTE: Recommended short-term and long-term improvements to the Bryan Road Interchange would require further evaluation. Improvements to the operational LOS of this interchange would require major geometric improvements.

TABLE A-13. Conditions at Ware Road Interchange--Morning Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	20	35	E
10-Year Projected Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	368	392	F
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lead	14	25	C
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	85-second Lead-Lead	39	40	E
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	16	17	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	29	23	C

TABLE A-14. Conditions at Ware Road Interchange--Evening Peak Hour

Condition	Phasing Plan	Total Stopped Delay, veh-hrs/hr	Average Stopped Delay, sec/veh	LOS
Existing Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	21	37	E
10-Year Projected Volumes Unsignalized Existing Geometry Existing Ramp Configuration	NA	31,513	25,066	F
Existing Volumes Optimized Signal Timing Existing Geometry Existing Ramp Configuration	60-second Lead-Lead	11	20	C
10-Year Projected Volumes Optimized Signal Timing Short-Term Improved Geometry Existing Ramp Configuration	90-second Lead-Lead	39	42	E
10-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	60-second Lead-Lead	18	19	C
20-Year Projected Volumes Optimized Signal Timing Long-Term Improved Geometry Reversed Ramp Configuration	85-second Lead-Lead	51	41	E

APPENDIX B

Existing and Future Peak-Hour Volumes for Cross-Street Interchanges

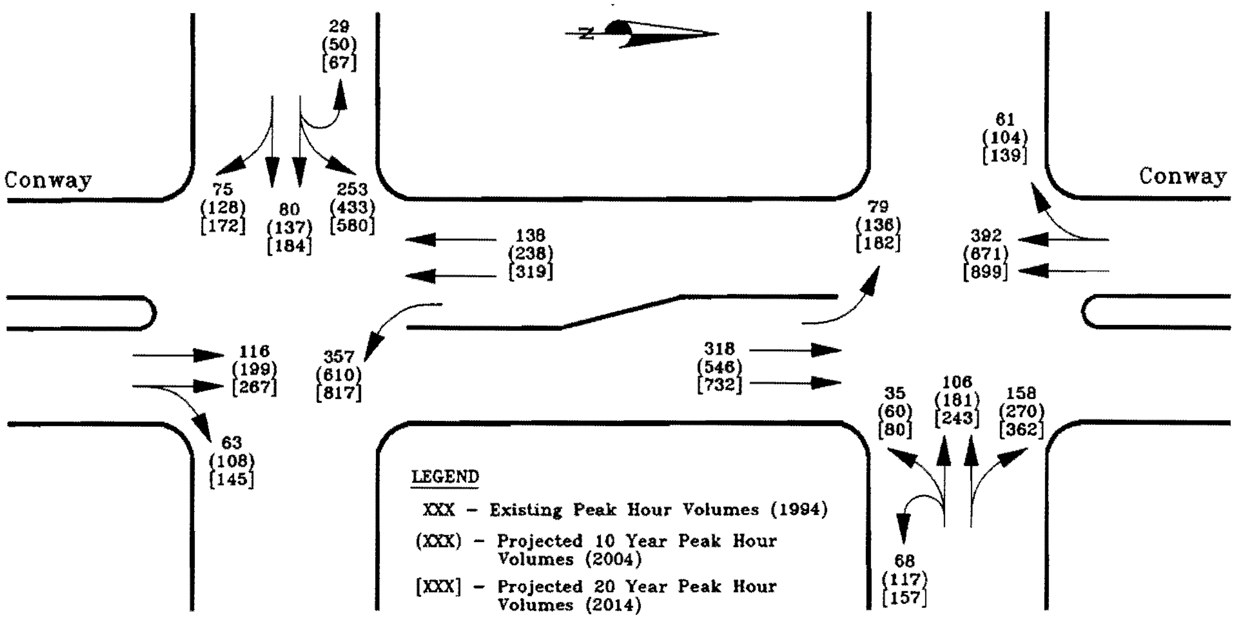

FIGURE B-1. Morning Peak-Hour Volumes for the Conway Avenue Interchange

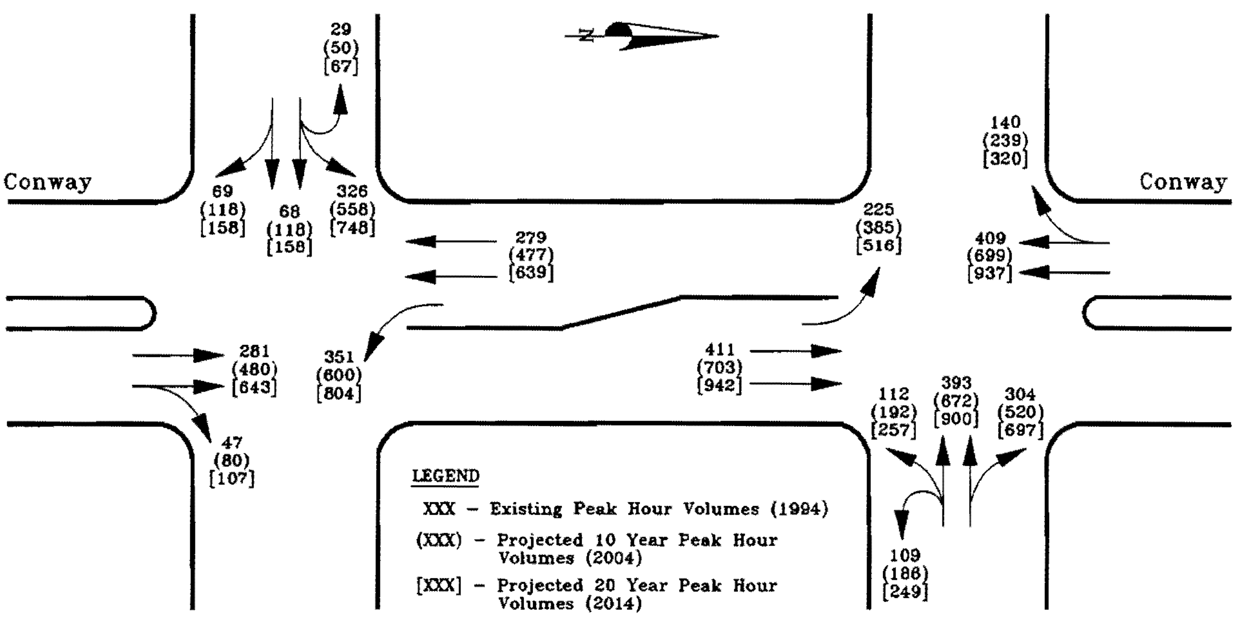

FIGURE B-2. Evening Peak-Hour Volumes for the Conway Avenue Interchange

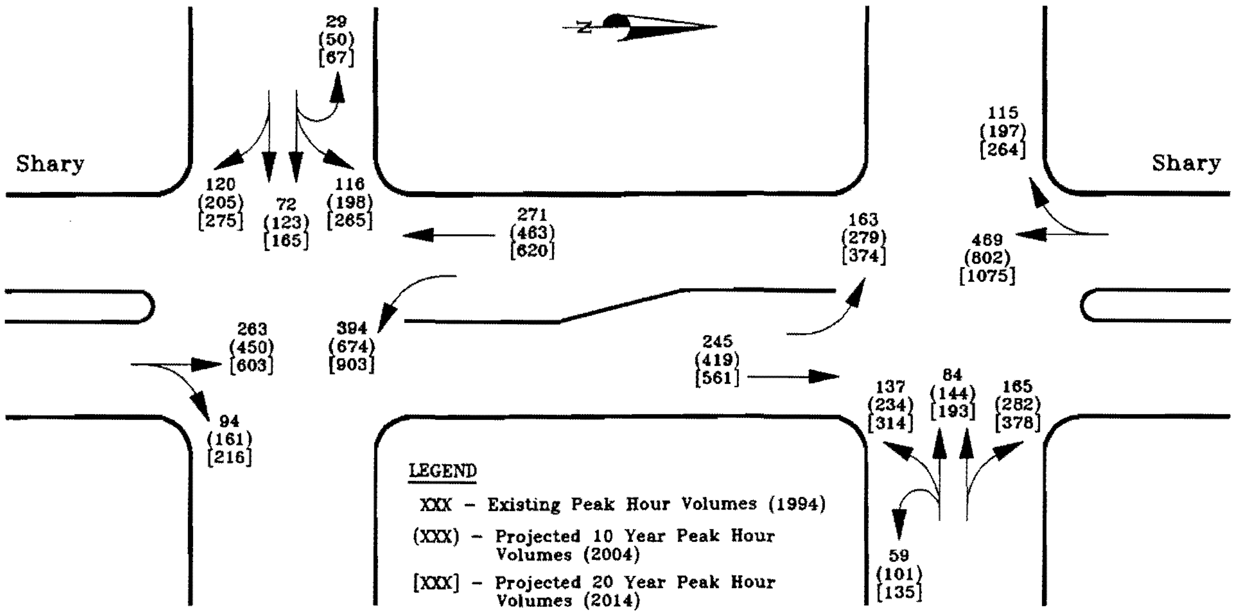

FIGURE B-3. Morning Peak-Hour Volumes for the Shary Road Interchange

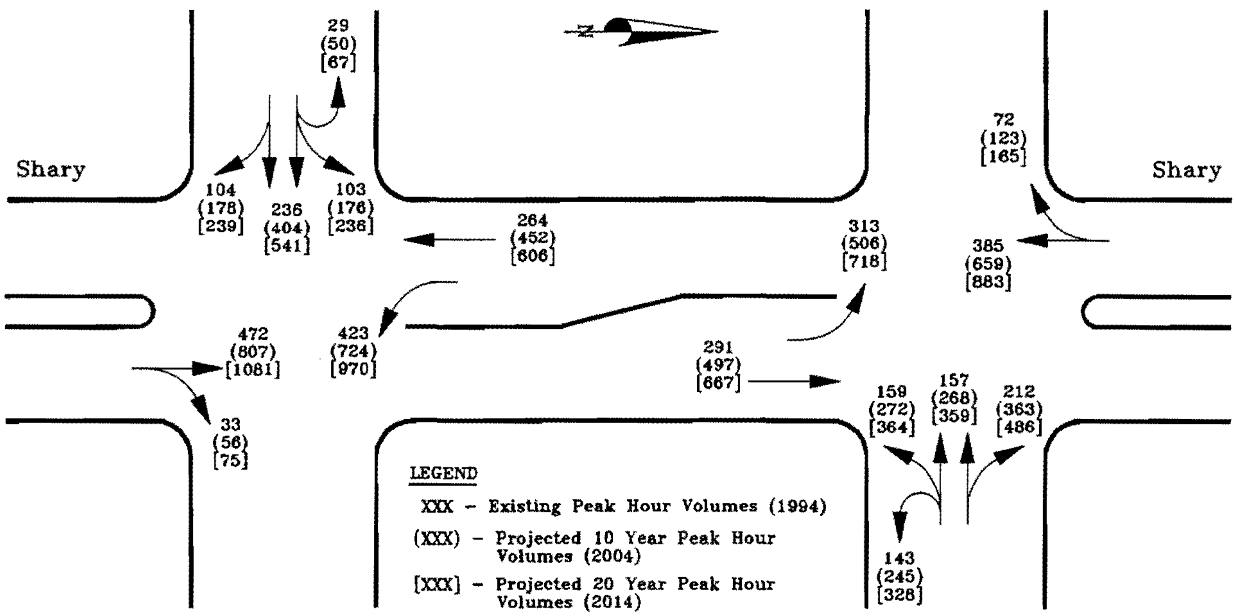

FIGURE B-4. Evening Peak-Hour Volumes for the Shary Road Interchange

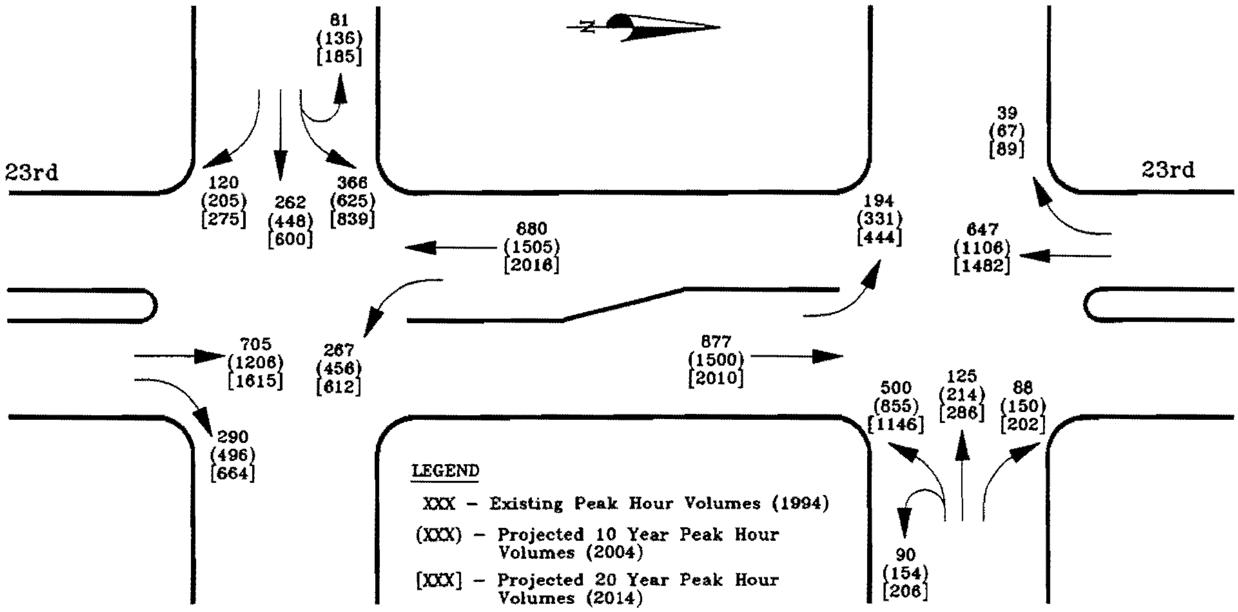

FIGURE B-5. Morning Peak-Hour Volumes for the 23rd Street Interchange

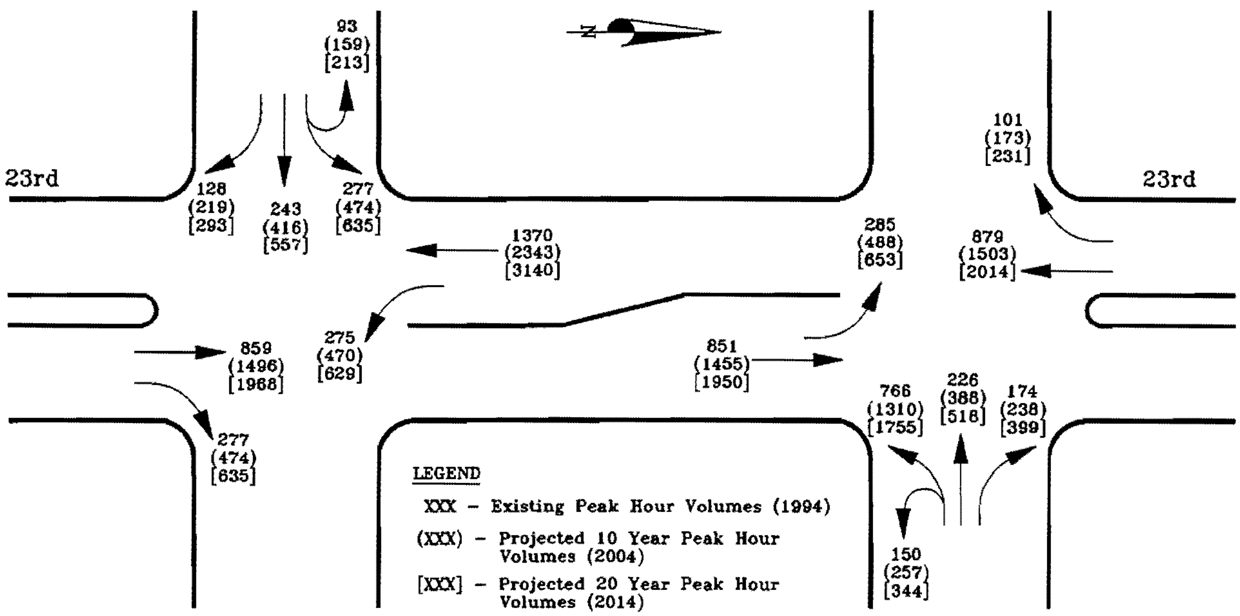

FIGURE B-6. Evening Peak-Hour Volumes for the 23rd Street Interchange

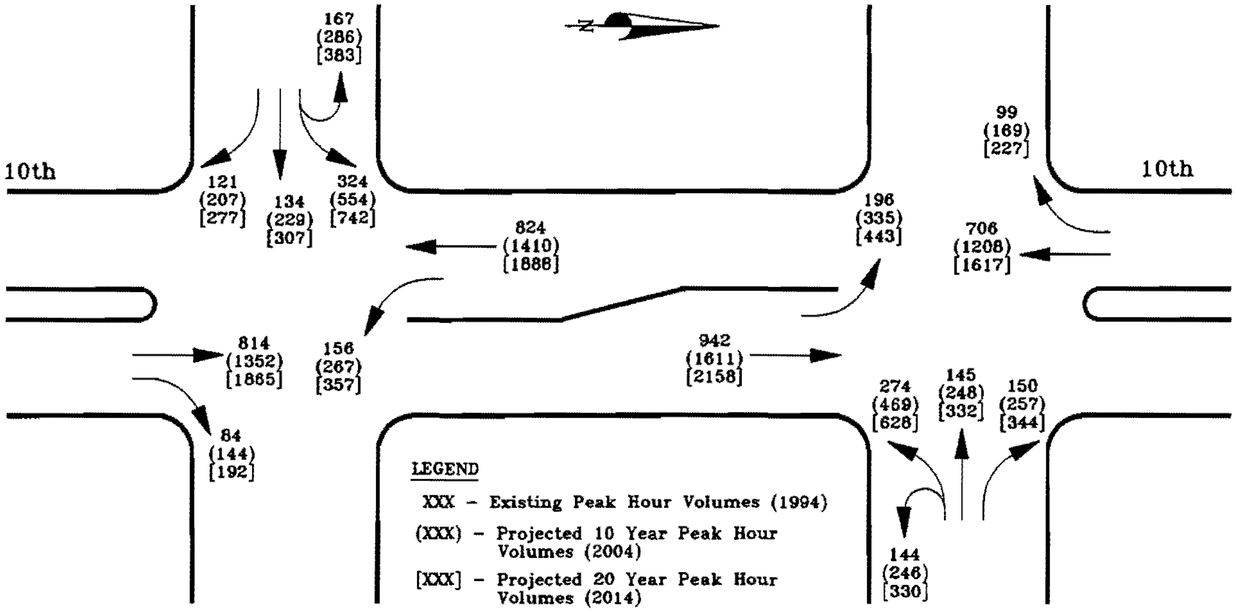

FIGURE B-7. Morning Peak-Hour Volumes for the 10th Street Interchange

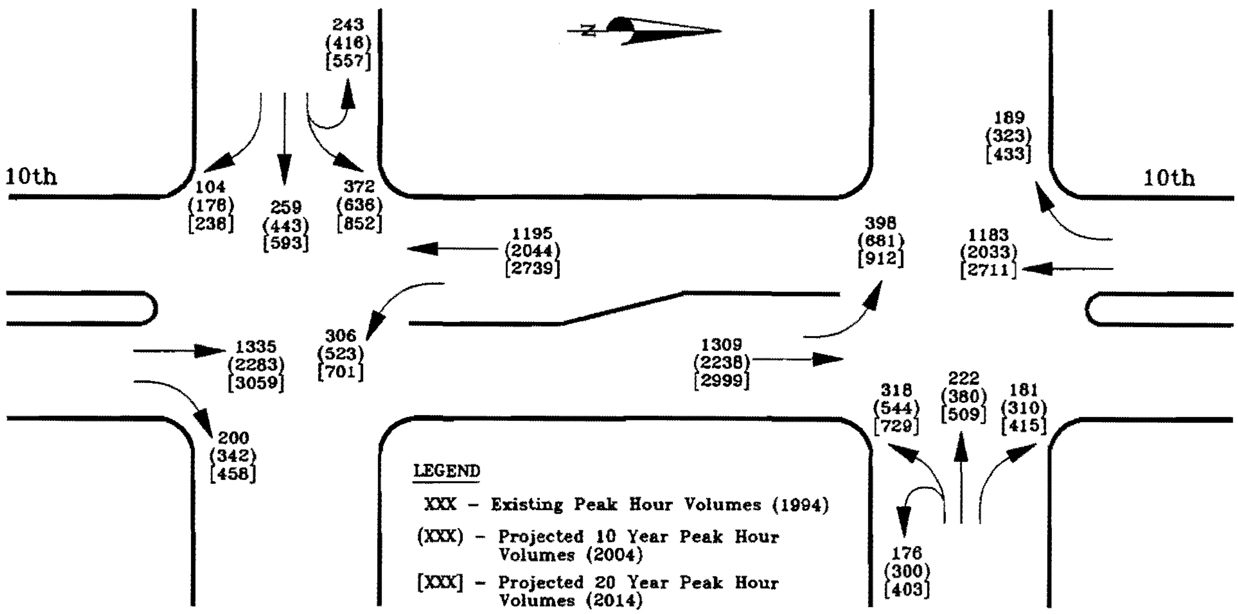

FIGURE B-8. Evening Peak-Hour Volumes for the 10th Street Interchange

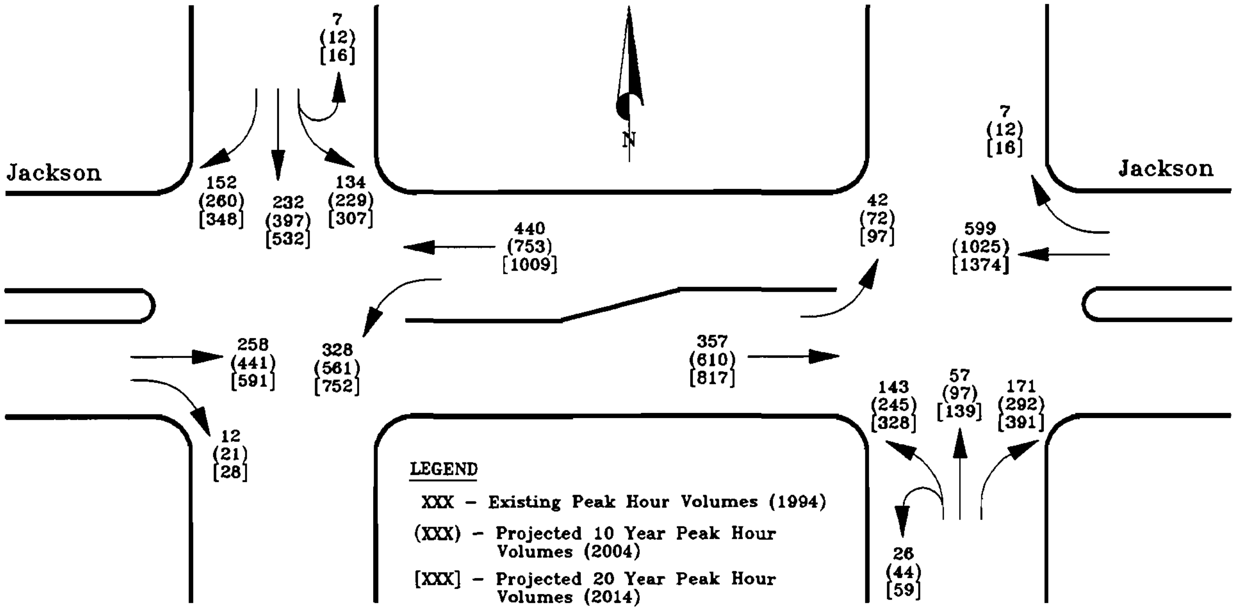

FIGURE B-9. Morning Peak-Hour Volumes for the Jackson Avenue Interchange

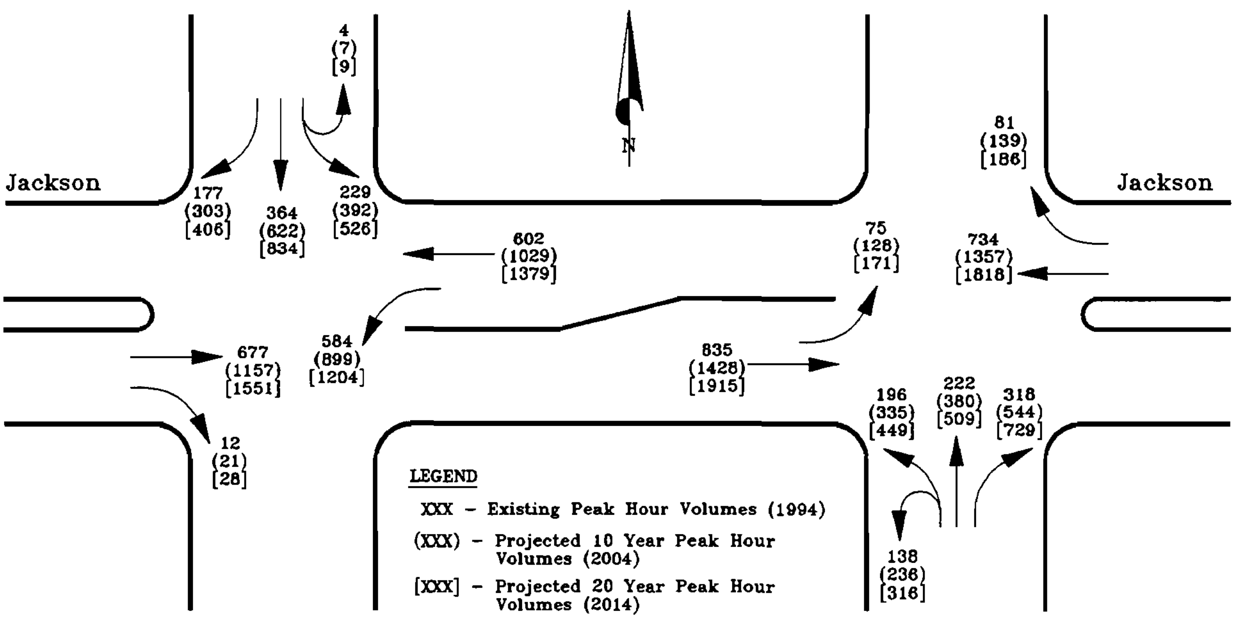

FIGURE B-10. Evening Peak-Hour Volumes for the Jackson Avenue Interchange

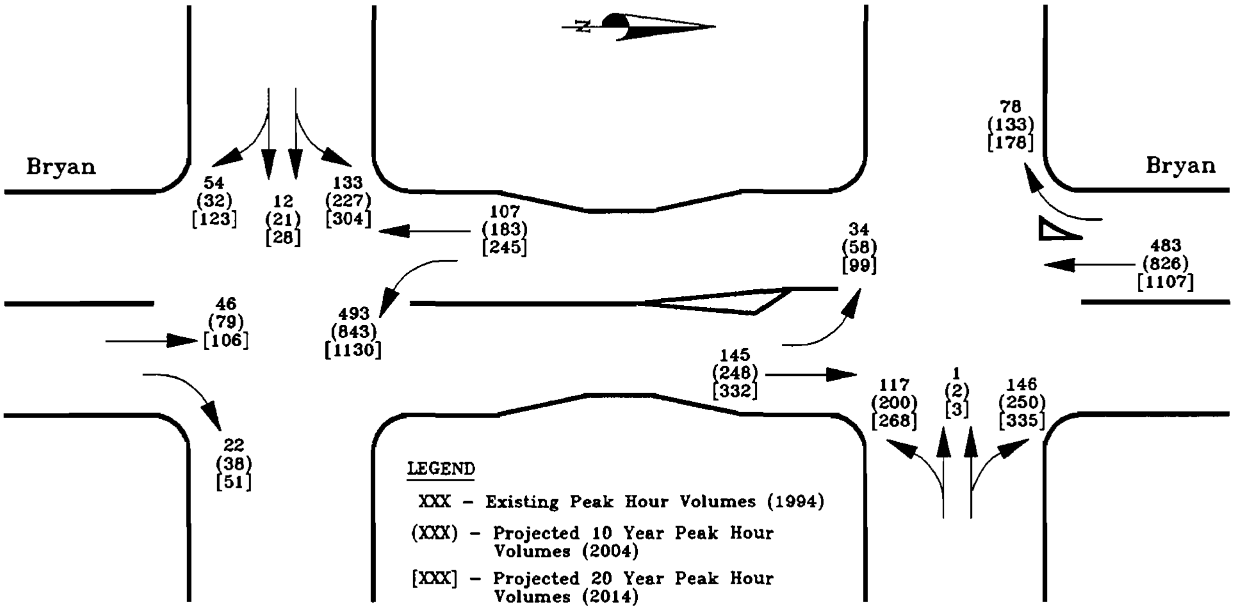

FIGURE B-11. Morning Peak-Hour Volumes for the Bryan Road Interchange

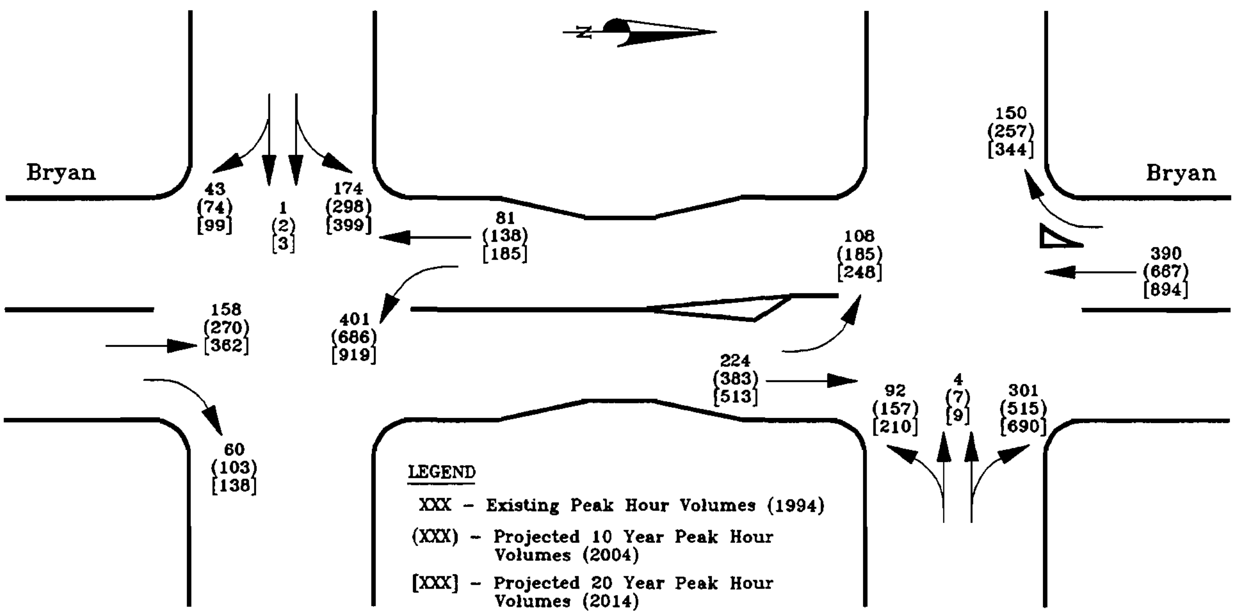

FIGURE B-12. Evening Peak-Hour Volumes for the Bryan Road Interchange

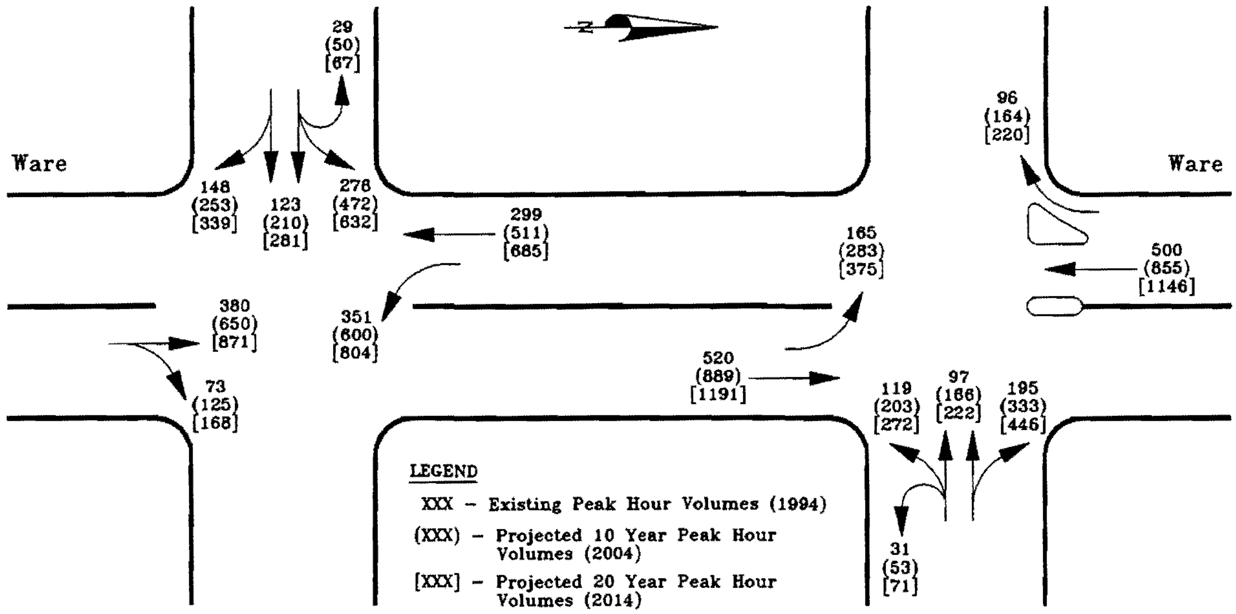

FIGURE B-13. Morning Peak-Hour Volumes for the Ware Road Interchange

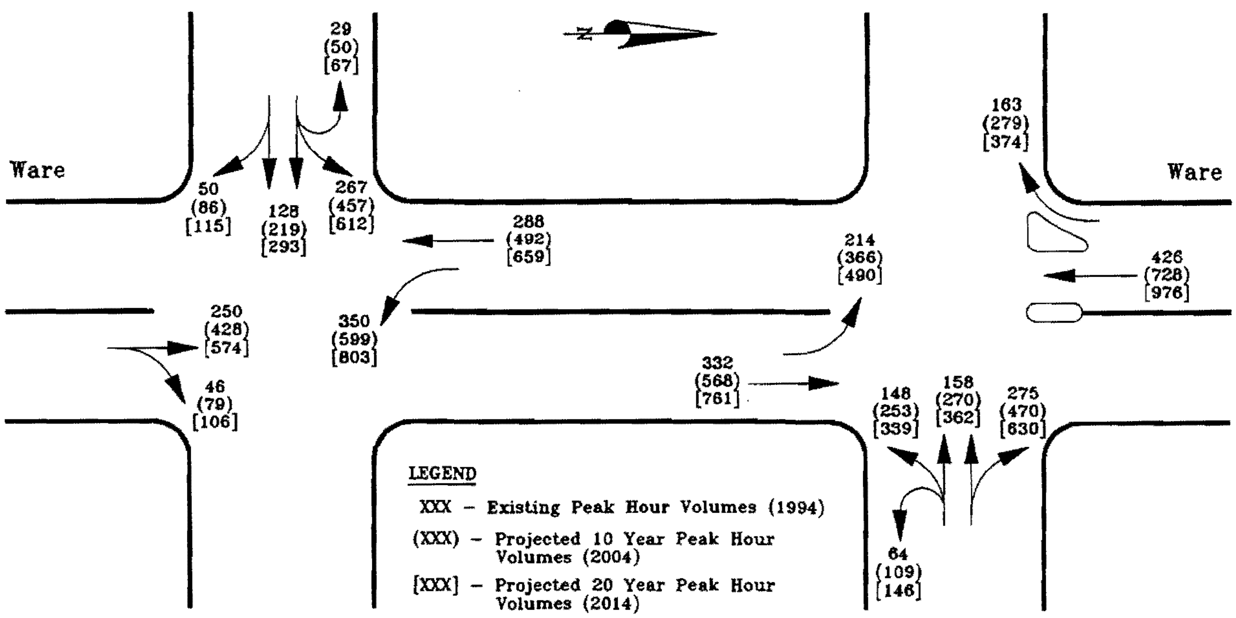

FIGURE B-14. Morning Peak-Hour Volumes for the Ware Road Interchange

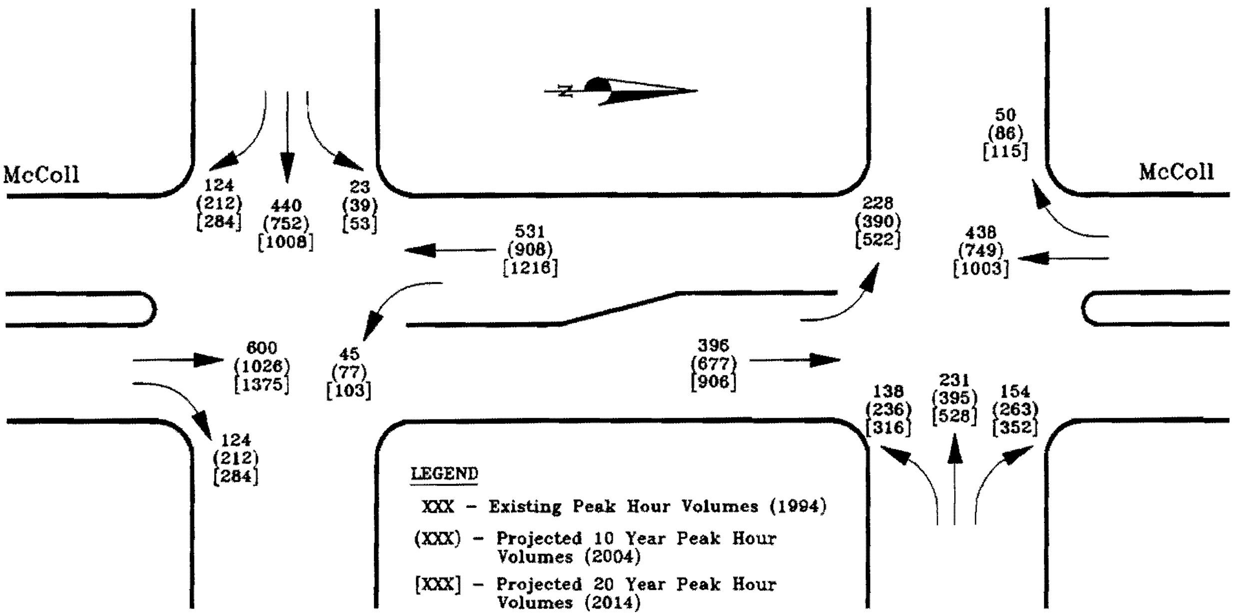

FIGURE B-15. Peak-Hour Volumes at the Proposed McColl Road Interchange