
I-17 SYSTEM DESIGN / OPERATIONS STUDY

SUMMARY REPORT

FREEWAY MANAGEMENT SYSTEM

CONTRACT No. 87-02

PROJECT No. IR-17-1 (179) PE

IR-10-3 (255) PE



**ARIZONA
DEPARTMENT
OF
TRANSPORTATION**



JACK E. LEISCH TRANSPORTATION GROUP
A DIVISION OF CH2M HILL

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INTRODUCTION

The purpose of this design study was to develop conceptual level long-range improvement and implementation plans for the rehabilitation of 22 miles of Interstate 17 from the Maricopa Freeway Interchange northward to Deer Valley Road. The study area is outlined in Figure 1. The study has been amended to include the development of the interim plans that will add capacity, safety, and operational improvements between Thomas Road and Thunderbird Road. The results of the study, documented in this report and the final engineering report, provide guidelines for programming and budgeting incremental improvements for the reconstruction of the I-17 corridor.

The study was divided into two phases. The first phase included an evaluation of existing conditions and the development of a design framework for future improvements. The second phase included the development and evaluation of long-range alternative concepts and the preparation of preliminary interim improvement plans. A discussion of the project background and results of the work completed in the first phase of the study were documented in Report 1: "Existing Freeway Evaluation and Concept Development" (April 1989). A summary of this material has been included in this report.

The basic premise of this study is that funding is not currently available to accomplish the total improvement program. Therefore, an incremental improvement program was developed that can be implemented to match available funding.

PROJECT BACKGROUND

Interstate 17 was designed in the late 1950s and constructed in the early 1960s. Over the years, I-17 has formed the backbone of the Phoenix metropolitan transportation system, with development expanding northward along the corridor. Recently, development adjacent to the corridor has intensified with office buildings and hotels replacing residential homes and small businesses. I-17 is also the central link in the proposed regional freeway network and is expected to continue to serve an increasing interstate, regional, and local travel demand.

I-17 is an aging facility and major capital improvements will be required to maintain and expand the facility to accommodate the increasing traffic demand. To facilitate the development and prioritization of improvements, a comprehensive evaluation of the existing facility was performed. A brief summary of this evaluation follows.

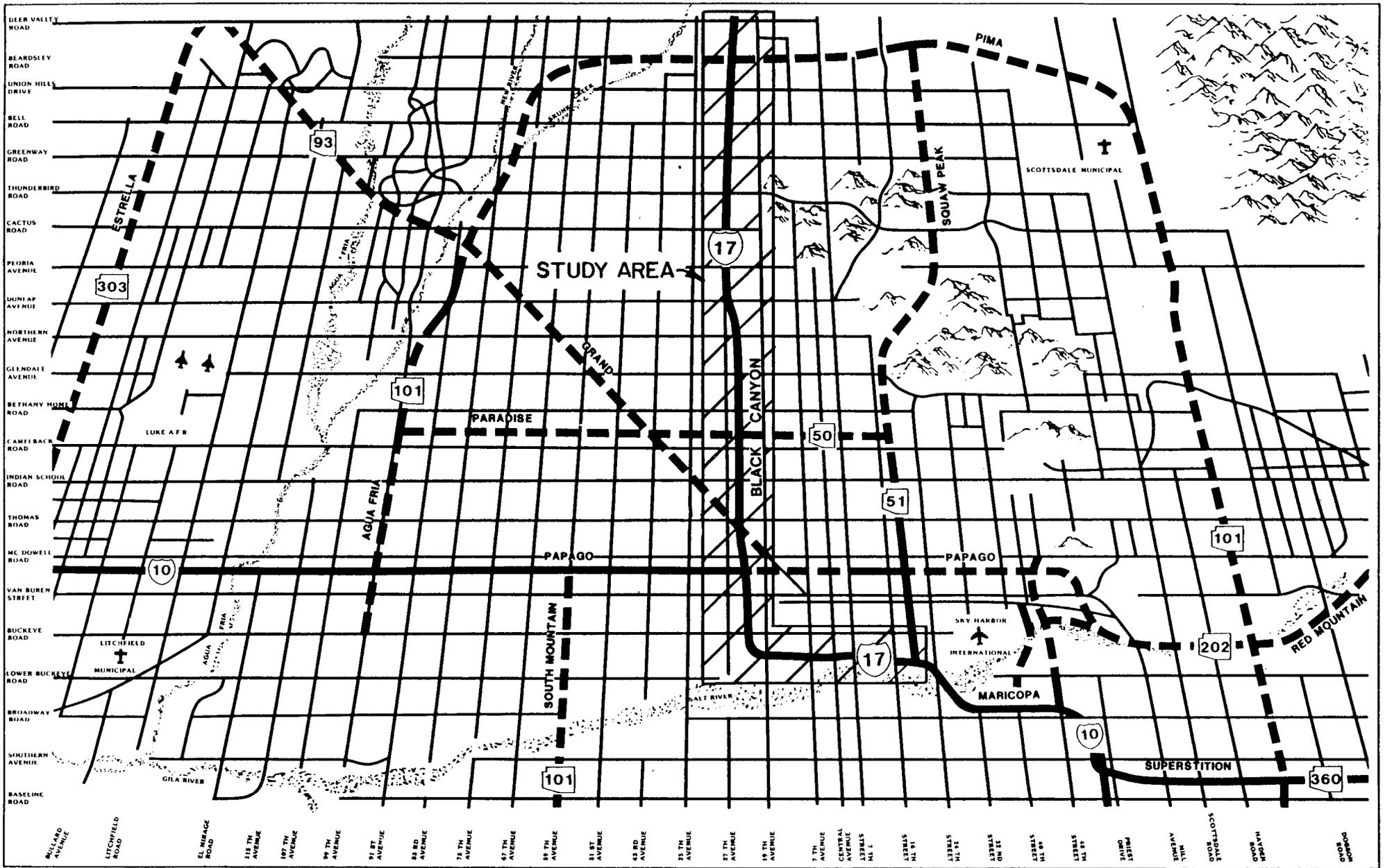


FIGURE I
VICINITY MAP

EVALUATION OF THE EXISTING FACILITY

The first element of the corridor to be analyzed was the existing right-of-way widths. Existing right-of-way widths vary between 200 and 300 feet at the mid-mile and 400 and 500 feet at the cross streets. The segment with the narrowest right-of-way extends from Thomas Road to Dunlap Avenue. Improvements in this segment will require extensive right-of-way acquisition.

Geometrically, the freeway reflects both urban and rural design characteristics of the late 1950s. The segment between the Maricopa T.I. and Dunlap Avenue (urban design) exhibits inadequate ramp terminal design related to current criteria. In some cases, there are insufficient taper lengths to safely complete merge and diverge maneuvers. A majority of the horizontal curves within these sections have insufficient superelevation. In the depressed segment (Thomas Road to Dunlap Avenue), where the mainline undulates to pass under the cross streets, many of the cross-sectional elements do not meet current design criteria.

North of Dunlap Avenue, the freeway profile is uniformly at or slightly above grade, while the cross streets pass under I-17. In this section, there are several full or partial cloverleaf interchanges that are operationally incompatible with the recent evolution to a suburban environment. The cloverleaf ramps and the sequencing of the exit and entrance ramps between Dunlap Avenue and Peoria Avenue are the only design elements which do not meet current design criteria.

Two analyses were conducted to measure the operational performance of the corridor. A level of service analysis revealed that current traffic demands equalled or exceeded the capacity of the existing facility. In both directions during the a.m. and p.m. peak periods, most segments operate at either Level of Service E or F. Many of the segments are congested for 12 continuous hours.

An analysis of the accident experience within the corridor revealed that the accident rate for the entire facility was 30 percent higher than the statewide urban interstate average. In some segments, the rate was double the statewide average. The highest accident rates are found between Van Buren Street and Thunderbird Road; over half of the accidents are rear-end collisions. The higher accident rates can be generally attributed to the congestion in this segment.

FUTURE DESIGN FRAMEWORK

Before developing improvement concepts, a long-range planning framework was established. The primary purpose of the framework was to establish future design traffic volumes and other requirements that assisted in focusing on the viable alternatives.

Year 2010 peak hour and 24-hour traffic volumes were developed based on the MAGTPO 2010-34 Transportation Network Model. This network includes the proposed Paradise and Outer Loop Freeways. Existing and year 2010 peak-hour link volumes (two directions) are displayed in Figure 2. The existing peak-hour link volumes range from 2,910 vehicles per hour (vph) (Union Hills-Deer Valley) to 12,650 vph (Glendale-Northern). The central segment (Thomas-Thunderbird) carries an average 11,800 vph during the peak hour.

The year 2010 peak-hour link volumes range from 6,540 vph (Outer Loop Freeway-Deer Valley) to 22,180 vph (Bethany Home-Glendale). In the segment between Bell Road and Union Hills Drive, the projected volume increases from the present 5,160 to 13,750 vph; a growth of 167 percent. This projected increase can be attributed to the completion of the Outer Loop Freeway continuing development along and adjacent to the I-17 corridor and general traffic growth. The central segment (Thomas-Thunderbird) is projected to carry an average 19,200 vph during the peak hour; an average increase of 63 percent. The southern segment (Maricopa T.I. -Papago T.I.) growth is projected at less than 20 percent, which can be attributed to the completion of the Papago Freeway.

As part of the development of the future design framework, other transportation improvements which could influence the future volume and pattern of traffic on I-17 were identified. These included the completion of the Papago Freeway, the construction of the Outer Loop Freeway, and ultimately the development of the Paradise Freeway.

LONG-RANGE IMPROVEMENTS

Based on the future traffic requirements and physical constraints within the corridor, eight long-range improvement concepts were developed. The concepts ranged from a collector-distributor (C-D) road freeway system to an improved freeway, flanked by high-type frontage roads. Other concepts which were developed included elevated and/or double-deck roadways and elevated express roadways.

After an initial evaluation and discussions with the Arizona Department of Transportation and Federal Highway Administration staffs, four concepts were considered viable alternatives and the other four were eliminated from further consideration. The four viable concepts are described below.

- **Scheme E--Express Roadway Alternative.** With this alternative, the freeway mainline is flanked on either side by an elevated express roadway. The express facilities would be constructed in the central section, between the Paradise Freeway and Thunderbird Road, where the

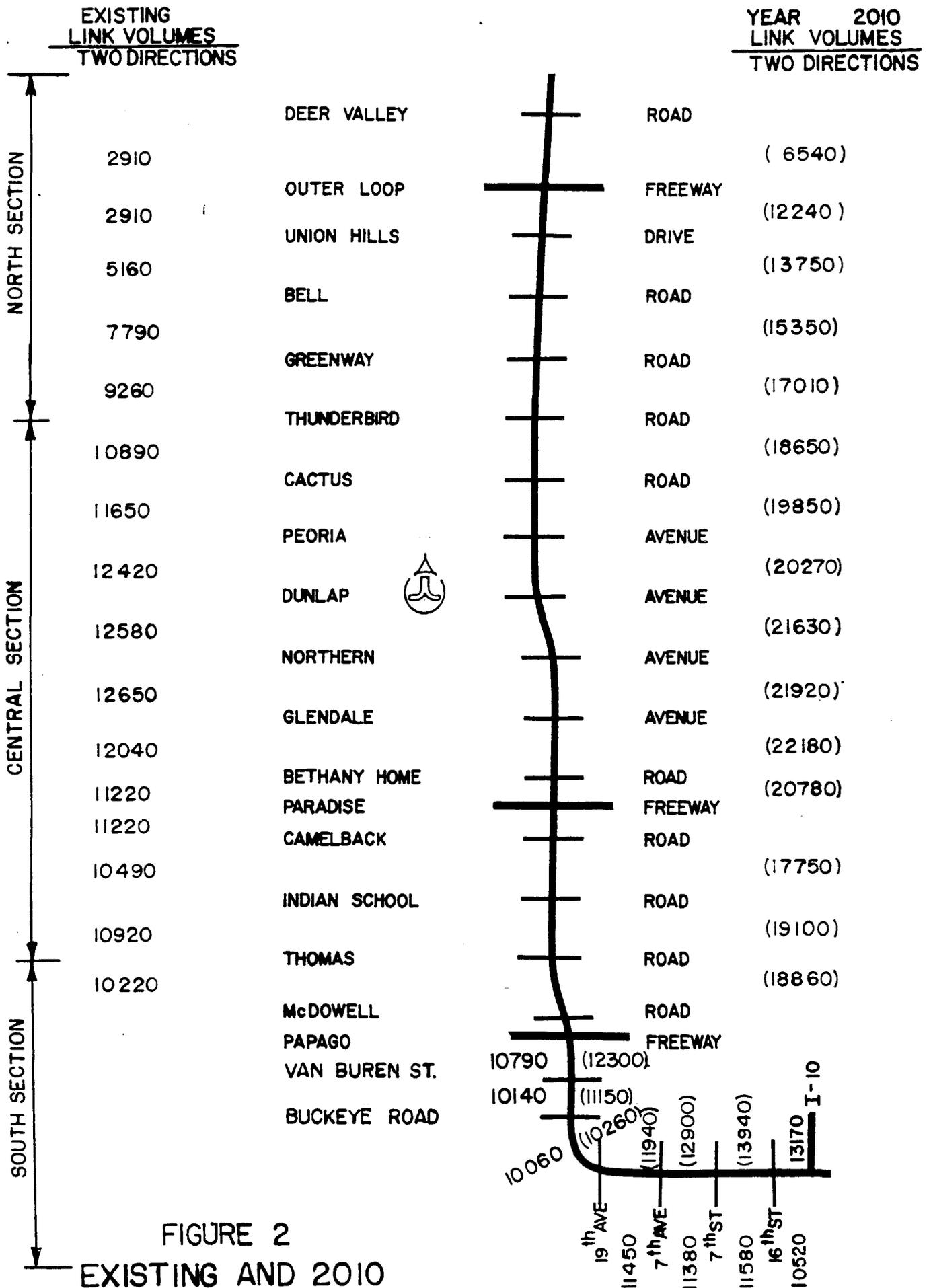


FIGURE 2
EXISTING AND 2010
PEAK HOUR VOLUMES

traffic volumes are the highest. The ramps between the mainline and the frontage roads would be spaced two miles apart and grade separated from the express roadways.

- **Scheme F--C-D/Frontage Road Alternative.** This alternative is a combination C-D road and frontage road design. Approaching the cross streets, the frontage road would split--one roadway would access the cross street and the other roadway would continue through, passing over/under the cross street. With this design, ramps providing access between the mainline and the frontage road would be spaced at three-mile intervals. Scheme F improvements would be implemented between the Papago T.I. and Thunderbird Road.
- **Scheme G--Frontage Road Alternative.** This alternative represents the reconstruction and expansion of the existing facility. With this design, the mainline would be widened and reconstructed and the frontage road would also be widened. The one-mile interchange spacing would be retained. These improvements would be implemented over the entire corridor.
- **Scheme H--Double-Deck Alternative.** With this concept, the northbound and southbound mainline are double-decked. As with Scheme F, these improvements would be implemented between Thomas Road and Thunderbird Road. Access between the mainline and the frontage road would be spaced at two-mile intervals.

After additional review and evaluation, Scheme H was eliminated from further consideration due to the high construction cost and the inability to phase improvements. A preliminary phasing plan for the remaining three alternatives was developed for the implementation of the long-range improvements. Initially, Scheme G would be implemented, reconstructing the entire corridor. If additional capacity and operational improvements were needed, Scheme E or Scheme F could be implemented. The advantages of phasing the long-range improvements are two-fold. First, initial construction costs are considerably lower. Second, additional studies and analyses could be conducted as traffic develops and the metropolitan freeway system evolves to determine whether Scheme E or Scheme F best meets the needs of the corridor.

IMPLEMENTATION OF PROPOSED IMPROVEMENTS

The evaluation of the existing corridor revealed that extensive improvements are required to improve the operations and safety of the facility and accommodate increasing traffic demand. These improvements would be implemented over the next 30 years. To facilitate the implementation process, the improvements have been divided into three construction phases. The first construction phase is an interim

improvement plan to alleviate the existing operational and capacity problems in the most critical segment of I-17 (Thomas Road to Thunderbird Road). The second phase is major reconstruction of the entire facility. The final phase enhances the capacity and operation of the Phase II rehabilitation plan. The construction phases are graphically shown in Figure 3.

INTERIM IMPROVEMENTS--PHASE I

Interim improvements - Phase I are needed to relieve the congestion within the central section of the corridor between Thomas Road and Thunderbird Road prior to the reconstruction of the facility.

Phase I has been divided into two subphases. Phase IA would increase the capacity and improve the operation of the mainline by adding a fourth basic lane and implementing a Freeway Management System (FMS). This system would include incident detection, ramp metering, and variable message signing. These improvements can be constructed within the existing right-of-way by reducing lane and shoulder widths. The second subphase, Phase IB would widen the mainline to provide an auxiliary lane between interchanges, and widen the frontage roads to provide additional corridor capacity.

Phase IA

Due to existing design and right-of-way variations within this section, the Phase IA improvements have been divided into two distinct design sections: the depressed section and the at-grade section. The design details for the Phase IA improvements for each design section are described below.

The depressed section (Thomas Road to Dunlap Avenue) is constrained by the cross street overpass structures and a tight 200-foot right-of-way width. To provide the fourth basic lane and pass through the existing cross street structures, a reduction in lane and shoulder widths is required. The existing freeway cross section consists of three 12-foot wide lanes, a 7-foot left shoulder and a 10-foot right shoulder. The proposed cross section would provide four 11-foot lanes, a 3-foot left shoulder to a median barrier, and a right shoulder with a minimum width of 8 feet. Beneath the cross street structures, the left shoulder would narrow to 2 feet and the right shoulder would narrow to 6 feet. Existing and proposed cross sections are shown in Figures 4 and 5.

Several mainline safety improvements have been incorporated into the Phase IA Plan. The existing 16-foot median has an excessive .08 ft/ft cross slope and a substandard median barrier. The median would be reconstructed to a .01 ft/ft cross slope, matching existing pavement, with a new barrier. A modern lighting system would be installed in the median, and the existing light poles adjacent to the right shoulder removed. A

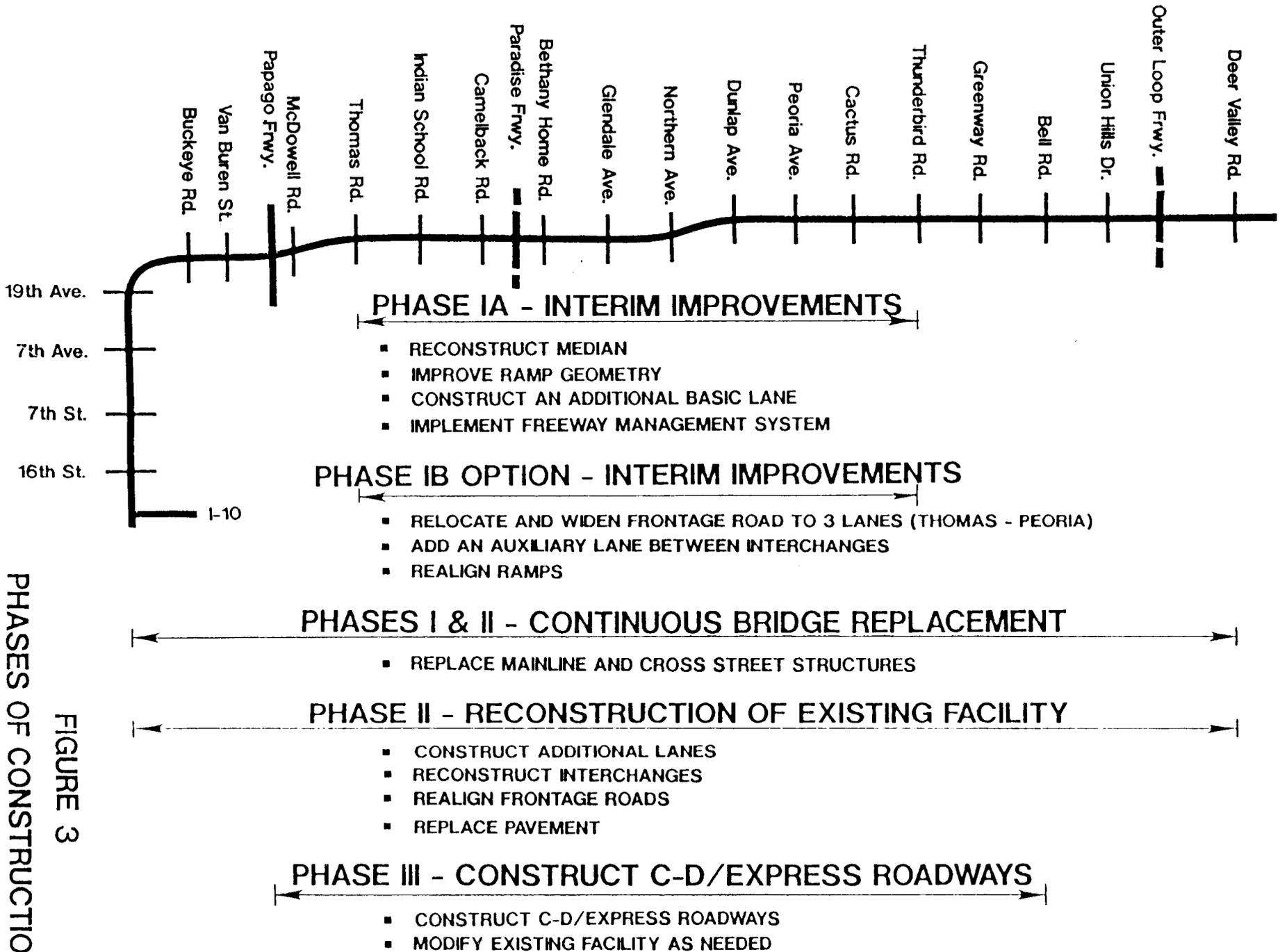
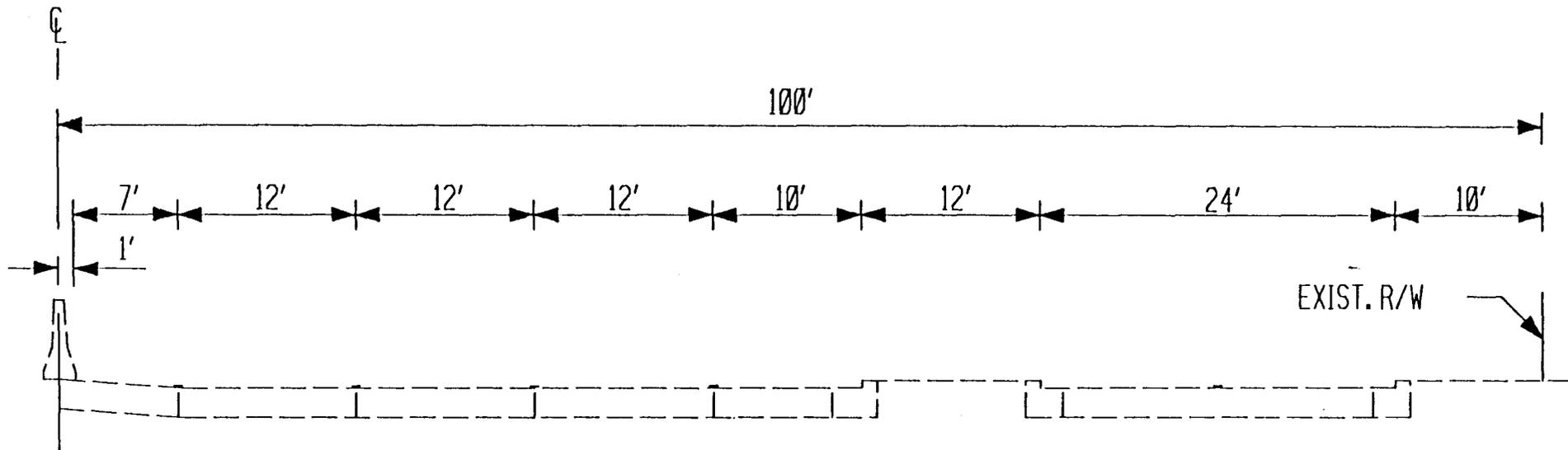
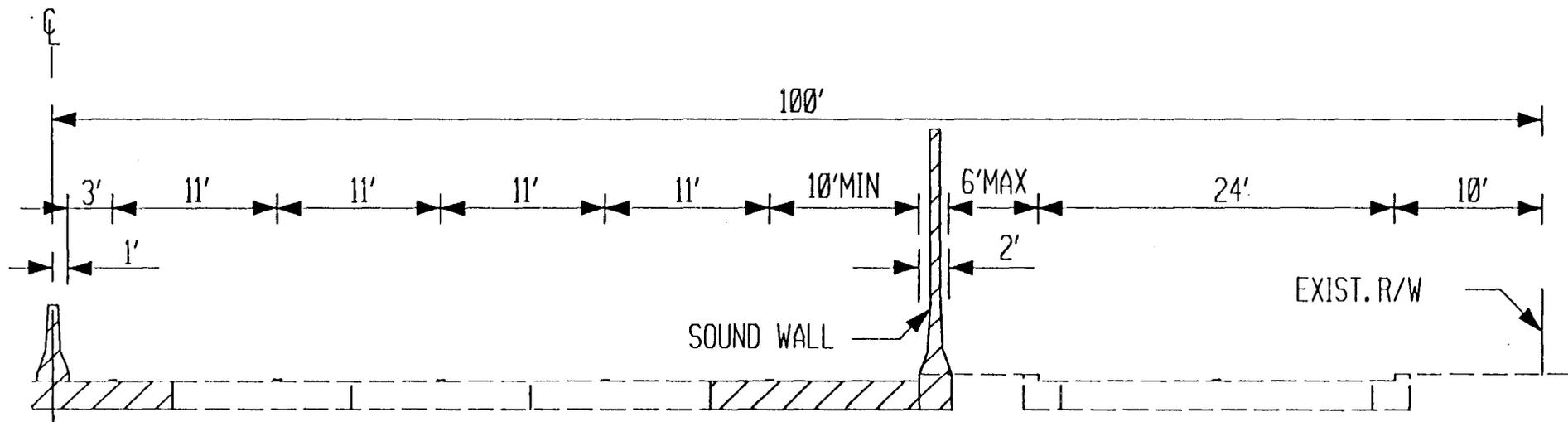


FIGURE 3
PHASES OF CONSTRUCTION

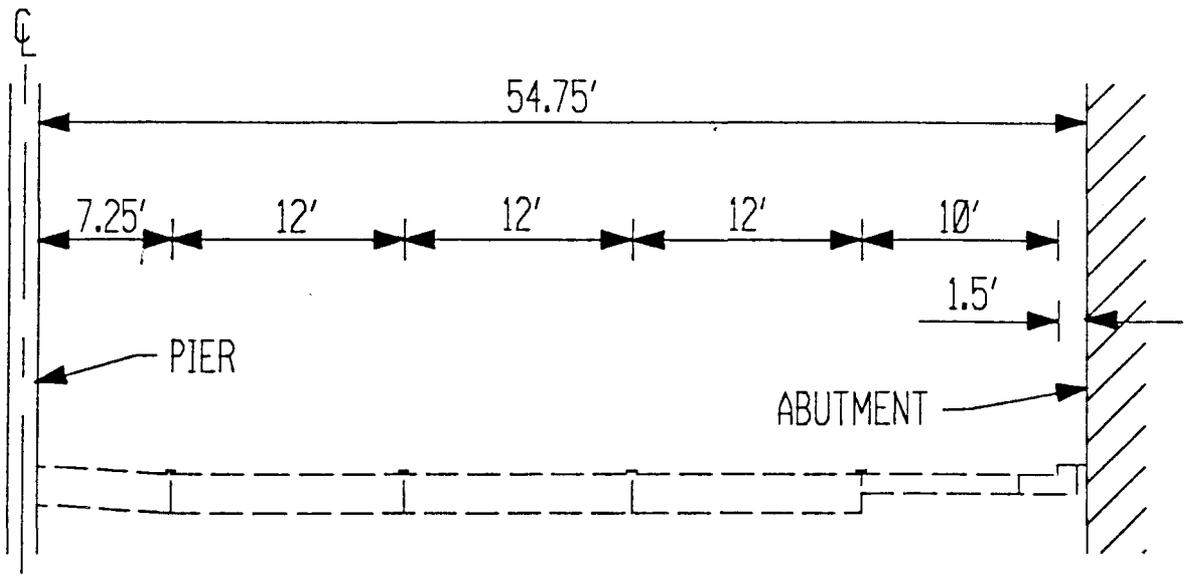


EXISTING

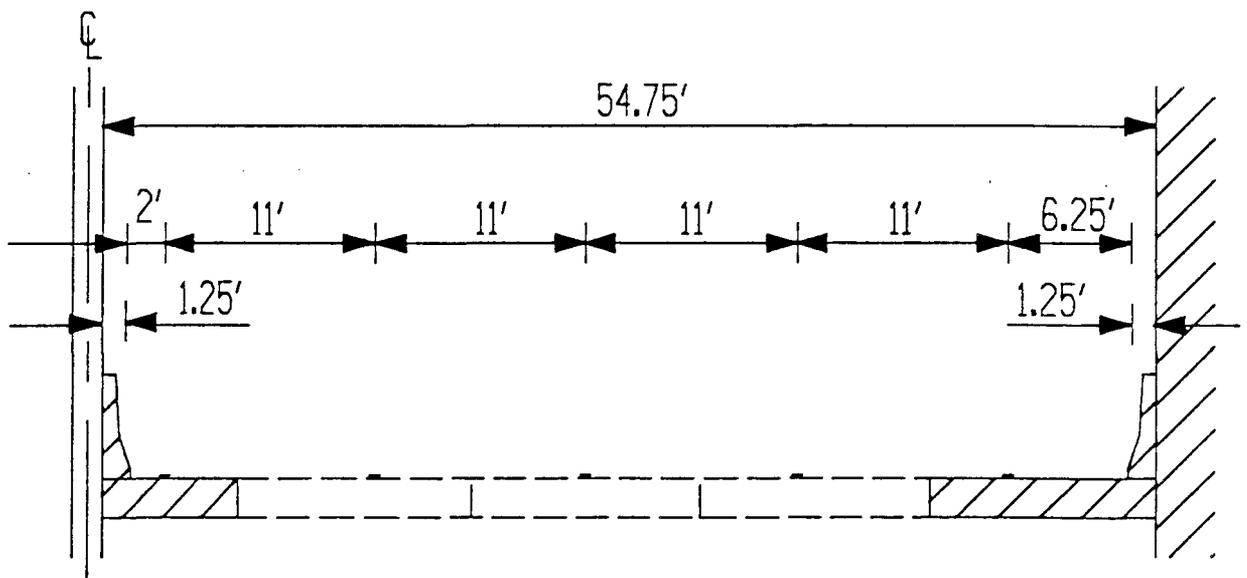


PROPOSED

FIGURE 4
 MID-MILE CROSS SECTION
 PHASE IA - DEPRESSED SECTION



EXISTING



PROPOSED

FIGURE 5
 UNDERPASS CROSS SECTION
 PHASE IA - DEPRESSED SECTION

concrete barrier would be constructed adjacent to the right shoulder to protect vehicles from the gunite side slope. Ramps with substandard merge and diverge tapers would be reconstructed.

The expanded travel way would encroach on the exit and entrance ramp tapers, and would consequently require reconstruction of the ramps. The frontage roads would be realigned for short distances in conjunction with the ramp reconstruction. The ramp reconstruction and frontage road realignment could be accomplished within the existing right-of-way.

The at-grade section of Phase IA, Dunlap Avenue to Thunderbird Road, does not contain the same restrictions as the south section. The minimum right-of-way width is 280 feet and the freeway passes over the cross streets. The existing median is 44-foot wide, allowing the fourth lane to be added in the median with no lane or shoulder width reductions. The mainline structures crossing over the cross streets would be widened to accept the fourth lane. The existing cross section consists of three 12-foot lanes, a 4-foot left shoulder, and a 10-foot right shoulder. The proposed cross section would provide four 12-foot lanes, a 9-foot left shoulder, and a 10-foot right shoulder. The proposed 9-foot left shoulder may require a design exception. The existing and proposed cross sections are shown in Figures 6 and 7.

The construction activities in this section are limited to the open median and the structures passing over the cross streets. Closing the 44-foot open median involves placement of new concrete pavement and barrier, installation of median lighting, and widening of six mainline structures, two at each cross road. In addition to median widening of the structures, the outside parapets would be replaced to conform to current standards. Since all mainline widening occurs in the median, no adjustment of the ramp or frontage road alignment would be required.

Phase IA improvements could be constructed in three separate stages. The first stage would involve reconstruction of the median in the south section on a mile-by-mile basis. This construction shifts mainline traffic to the right, requiring the closure of the ramps within the construction zone. The second stage of construction would be the median construction in the north section. Ramp closures are not required during this stage of construction. The third stage would involve the reconstruction of the ramps and realignment of the frontage roads in the south section. As with the median reconstruction, this construction stage would be completed on a mile-by-mile basis because the ramps within the construction zone would be closed during construction.

The reconstruction of the median from Thomas Road to Dunlap Avenue (Stage 1) is estimated at \$15 million. The cost of constructing the median lanes from Dunlap Avenue to Thunderbird Avenue and widening the six mainline structures (Stage 2) is estimated at \$10 million. The reconstruction of the right shoulder and ramps and the realignment of the frontage roads in the vicinity of the ramp merges and diverges

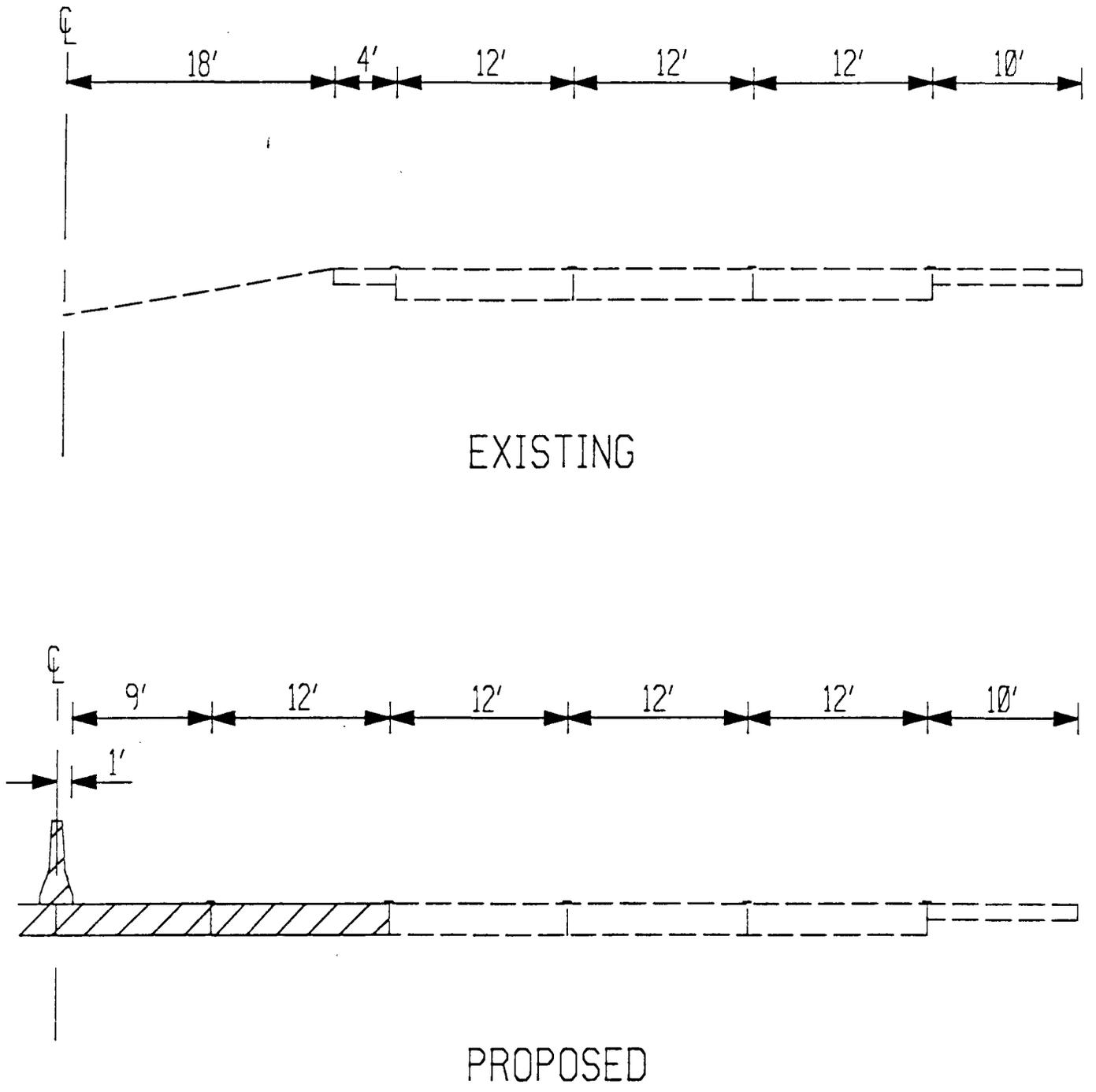
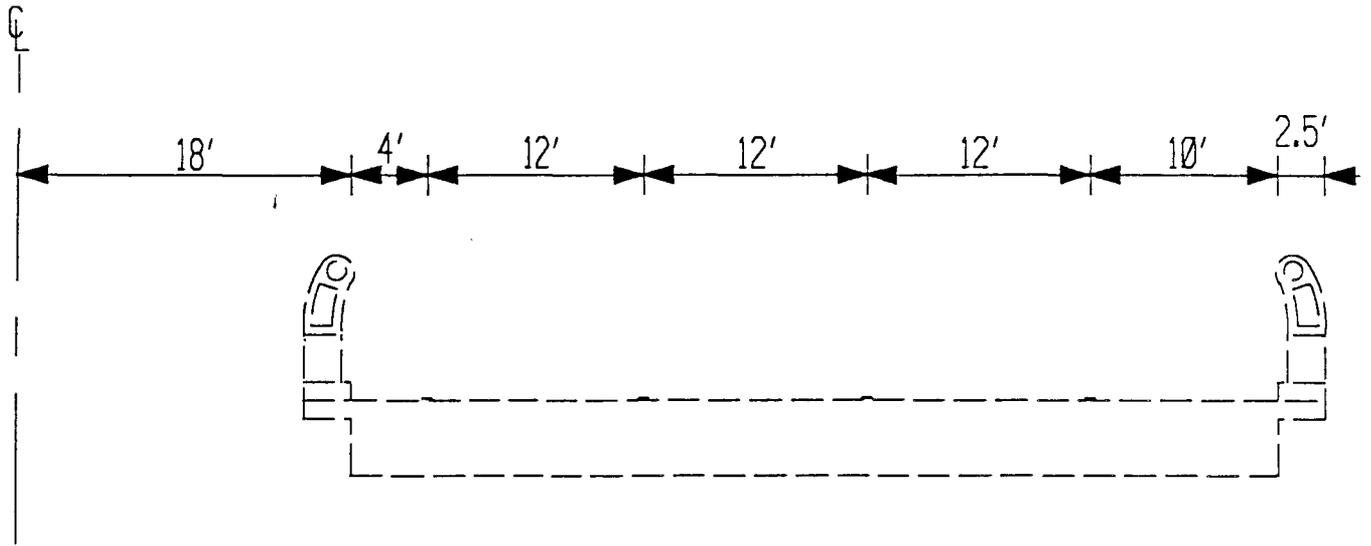
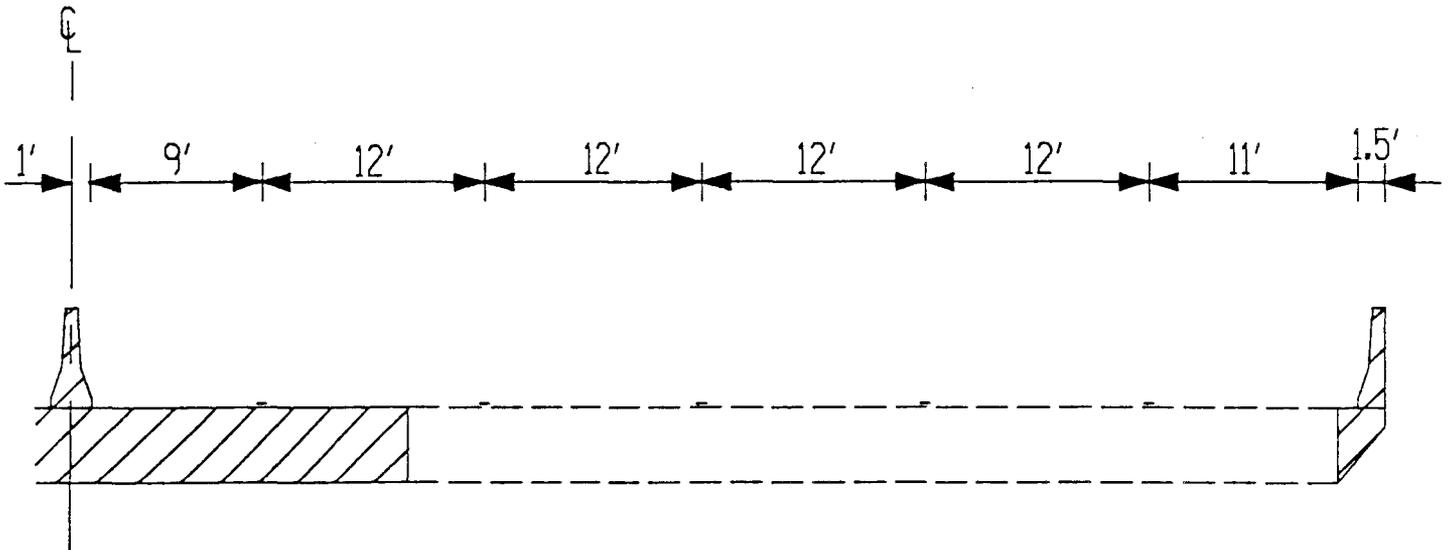


FIGURE 6
 MID-MILE CROSS SECTION
 PHASE IA - AT GRADE SECTION



EXISTING



PROPOSED

FIGURE 7
 OVERPASS CROSS SECTION
 PHASE IA - AT GRADE SECTION

(Stage 3) is estimated at \$20 million. The total estimated cost for implementing Phase IA improvements is \$45 million. Construction of the Phase IA improvements has been included in the fourth and fifth years (1994 and 1995) of the current five-year plan (1991-1995).

Demonstration Project

A demonstration project in the depressed section was undertaken to ensure the feasibility of constructing the Phase IA improvements within the existing right-of-way. The demonstration project involved 1.2 miles of I-17 including the Bethany Home Road interchange. The limits of the project extended 0.4 miles south and 0.8 miles north of Bethany Home Road. This section was chosen because it was judged to contain the greatest number of constraints.

The final product of the demonstration project was a 30 percent submittal of final construction plan documents. The submittal included final horizontal and vertical geometric alignments, and representative cross sections. Also included were preliminary plans for drainage, lighting, maintenance and protection of traffic, paving, signing, and striping.

The project verified Phase IA improvements could be implemented within the existing right-of-way and developed guidelines for the design of the ramps and frontage roads. A 20-foot minimum width was established for the ramps. In the vicinity of the ramp merges and diverges, the frontage road narrows to one lane with a minimum width of 16 feet.

Freeway Management System

A key element in the Arizona Department of Transportation's program of freeway improvements is the implementation of a Freeway Management System (FMS). This system is being designed to utilize state-of-the-art technology and sound traffic management procedures to optimize freeway operations.

Once the FMS is in operation, vehicle detectors will monitor traffic flow patterns on the freeway and facilitate the identification of congestion or other disruptions to traffic flow; remote television cameras will allow visual confirmation of problems on the freeway; ramp meter controllers will regulate access to the freeway; and variable message signs will inform motorists of freeway conditions--all under the control of the central computer system. Lane control signals have been recommended as a demonstration element of the system for a section of I-17 from Thomas Road to Thunderbird Road.

It is recommended that implementation of the FMS immediately follow the construction of the Phase IA interim improvements. The conduit system would be

located in such a way as to eliminate the need for its relocation at the time the Phase IB improvements are constructed. While implementation of Phase IB improvements would require relocating the FMS field equipment, the benefits derived in the interim would justify the expense.

Phase IB

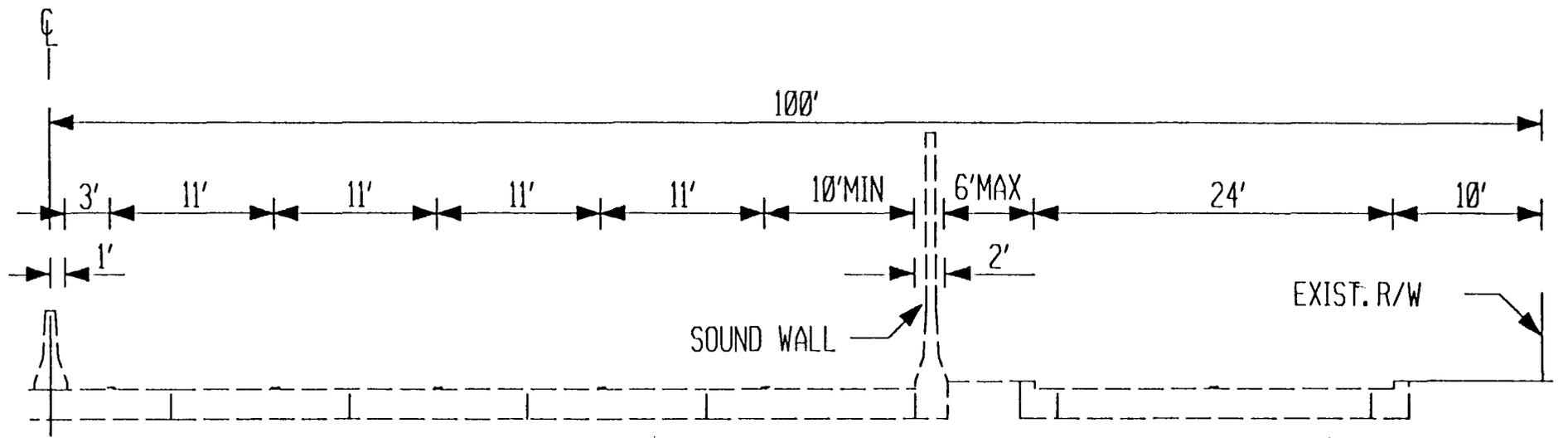
The Phase IA improvements would provide additional corridor capacity to accommodate the existing traffic demand between Thomas Road and Thunderbird Road. With the implementation of the FMS, I-17 should operate more efficiently with more uniform operating speed. The traffic demand through this section, however, is predicted to exceed the capacity provided by the Phase IA improvements and the FMS. Due to budgetary and scheduling constraints, total reconstruction of the facility (Phase II) will still be several years in the future when demand exceeds capacity of the Phase IA improvements. Therefore an additional interim improvement would most likely become necessary before Phase II is implemented. The additional interim improvements have been incorporated into Phase IB.

As traffic volumes increase, the intensity of the weaving traffic between interchanges will most likely increase. To reduce weaving conflicts, entering traffic would be metered more hours during the day, and the cycle length of the meter would lengthen. The queues behind the meter would most likely become longer, and more traffic would probably divert to the frontage roads to bypass the queues. Additional improvements will be needed to reduce the mainline weaving conflicts and increase the capacity of the frontage roads.

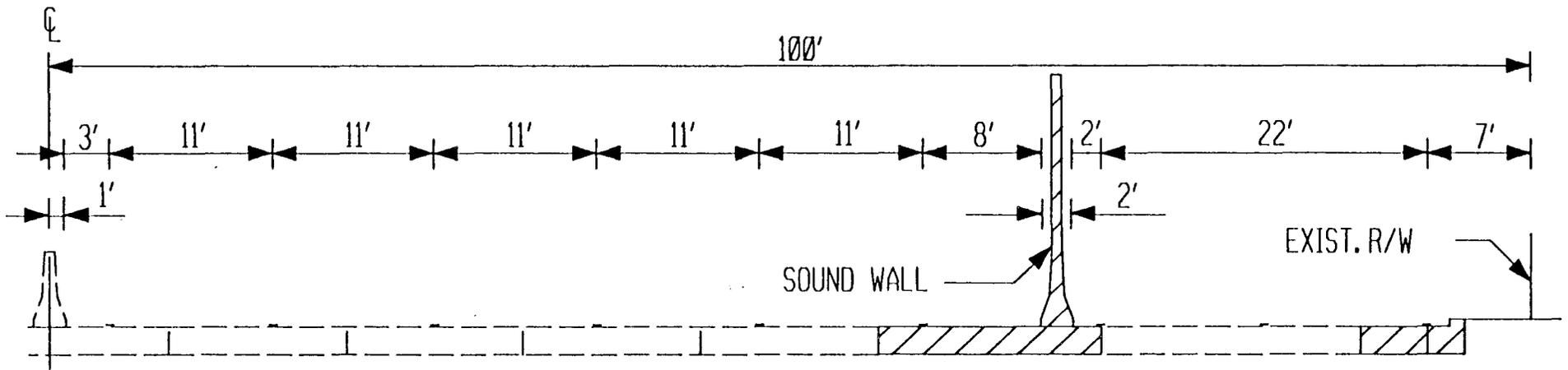
As previously described, Phase IB would add an auxiliary lane between interchanges, relocate and widen the ramps, and realign and widen the frontage roads, while maintaining the existing cross street structures. Two plans were developed for this subphase: the IB Plan and the IB Option Plan.

IB Plan. The IB Plan was developed as a minimal improvement plan from Thomas Road to Thunderbird Road. The mainline pavement would be widened to accommodate an 11-foot wide auxiliary lane and an 8-foot shoulder. The proposed widening would reduce the separation between the mainline and the frontage road, and widen the frontage road 3 feet toward the right-of-way line. A mid-mile typical section of the IB Plan is illustrated in Figure 8.

As part of the IB Plan improvements, the exit and entrance ramps would be reconstructed. The auxiliary lane would be added with the entrance ramp and dropped at the succeeding exit with a two-lane ramp. This would allow the mainline underpasses to remain as constructed during Phase IA. Entrance ramp operation and ramp metering efficiency will be improved by relocating the entrance ramp and frontage road diverge 800 feet from the cross street and increasing the ramp length to 600 feet. The



EXISTING - PHASE IA



PROPOSED

FIGURE 8

MID-MILE CROSS SECTION
IB PLAN - DEPRESSED SECTION

exit ramp merge with the frontage road would be relocated 1,000 feet in advance of the cross street to reduce the weaving conflicts and improve the operation of the frontage road. A schematic of a typical one-mile segment is diagrammed in Figure 9.

The IB Plan would widen and realign the frontage roads to provide two continuous lanes, improving operations and capacity. The intersection approaches would be widened to five lanes for better progression along the frontage roads. The frontage road improvements would require the acquisition of right-of-way.

In the at-grade section, from Dunlap Avenue to Thunderbird Road, the improvements would minimize the realignment of the frontage roads to stay within the existing right-of-way. Two continuous lanes would be maintained along the frontage roads, and the existing intersection approaches would be maintained. A mid-mile typical cross section of the IB Plan for the at-grade section is shown in Figure 10.

The level of effort to complete these improvements is much greater than the improvements included in Phase IA. The IB Plan would require modifications to the existing drainage system and some relocation of utilities along the frontage roads. The IB Plan would also require partial right-of-way takes along a majority of the southern section (Thomas-Dunlap).

When Phase II is implemented there are few of the IB Plan improvements that could be utilized. The modifications to the drainage system would be replaced with the Phase II drainage system. The utilities would have to be relocated again because the Phase II corridor width requirements are much greater than the IB Plan. The properties affected by the acquisition of right-of-way for the IB Plan would be affected a second time when Phase II right-of-way is acquired.

Cost estimates were developed for the construction of the IB Plan. The cost of constructing the IB Plan is estimated at \$40 million. The estimated cost of right-of-way is \$27 million.

The IB Plan is a minimal plan to increase the capacity of the corridor to accommodate the increase in traffic volumes until Phase II can be implemented. The IB Plan is not desirable because few of the costly improvements can be salvaged when Phase II is implemented. A more desirable interim plan would implement portions of the Phase II improvements to provide the necessary increase in capacity with little, if any, waste in implementation costs. It is recommended that the IB Plan be dropped from further consideration.

IB Option Plan. The IB Option Plan was specifically developed to minimize reconstruction and traffic maintenance problems when Phase II is implemented. The IB Option Plan has also been designed as a staged development of the Phase II plan within the depressed section, between Thomas Road and Peoria Avenue. North of

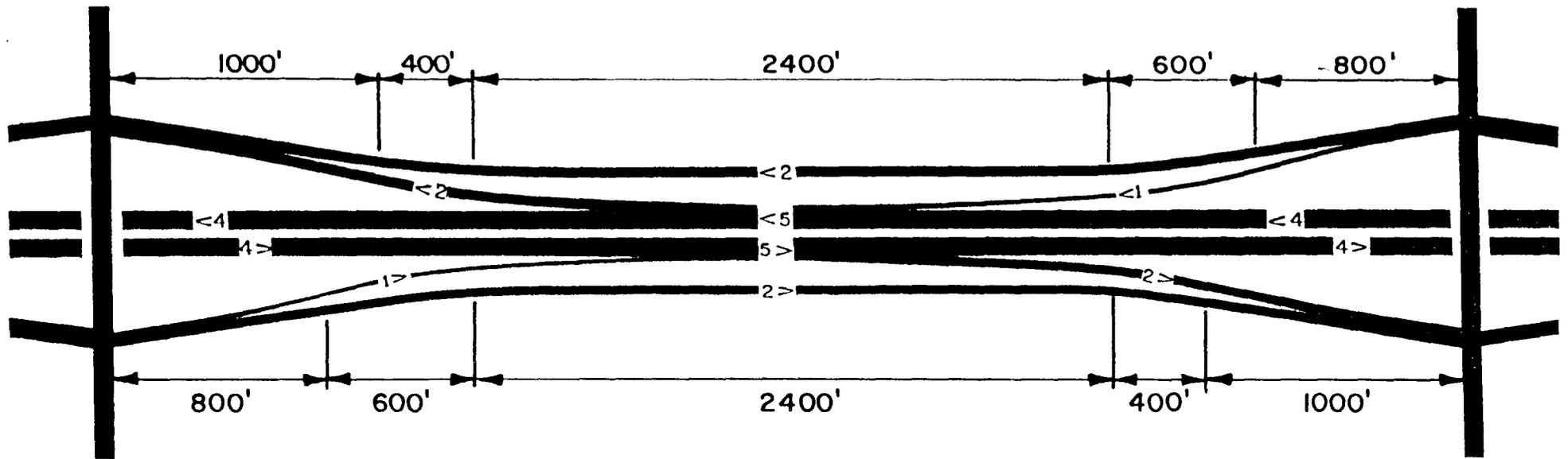


FIGURE 9
 PHASE IB
 TYPICAL ONE MILE SEGMENT

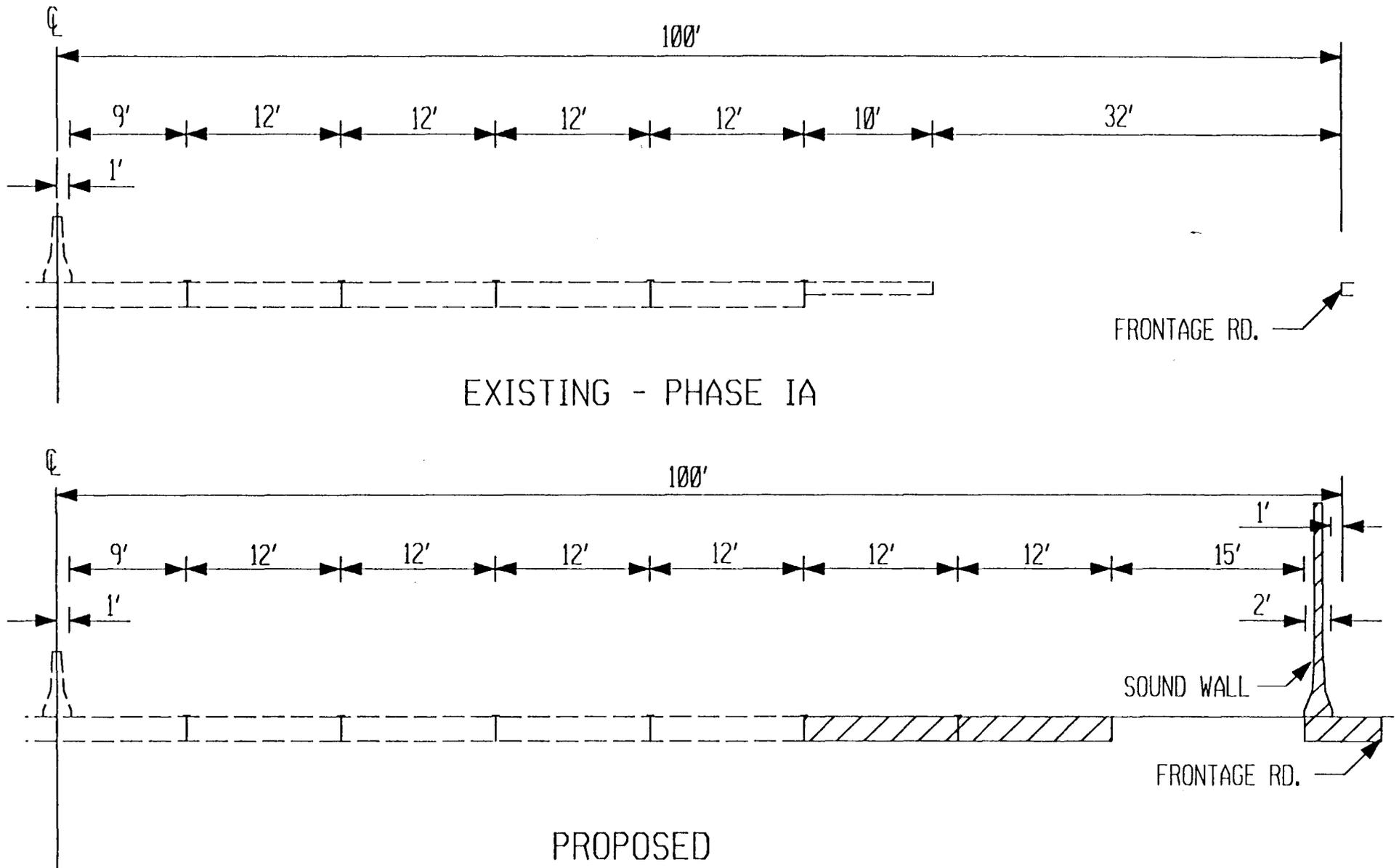


FIGURE 10
 MID-MILE CROSS SECTION
 PHASE IB - AT GRADE SECTION

Peoria Avenue, the proposed IB Option Plan improvements would be identical to the IB Plan.

Similar to the IB Plan, the mainline would be widened by constructing an 11-foot wide auxiliary lane between interchanges. A minimum 8-foot right shoulder would be maintained except beneath the cross streets. The location of the ramp merges and diverges in relation to the frontage roads and the mainline would be similar to the design developed for the IB Plan, diagrammed in Figure 9. As with the IB Plan, the entrances would be one-lane ramps and the exits would be two-lane ramps.

In the depressed section, the frontage roads would be widened to three continuous lanes in each direction, and relocated to the Phase II alignment. A proposed mid-mile cross section is shown in Figure 11. Relocating the frontage roads to the Phase II alignment would require extensive right-of-way acquisition. Between Thomas Road and Peoria Avenue, right-of-way requirements would include many complete parcel takes ranging from single-family homes to business complexes. North of Peoria Avenue, the right-of-way impacts are not as severe and would include mostly partial takes. The right-of-way acquisition proposed for the IB Option Plans would be sufficient to implement the Phase II Plan.

The relocation of the frontage roads and the extensive right-of-way acquisition would create an opportunity to consolidate the access along the frontage roads. Concentration of access points would improve the operations along the frontage roads by limiting the locations where turning conflicts can occur. The exact locations and amount of access provided would need to be determined during right-of-way acquisition and design stages of the project.

Relocation of the frontage roads would create many utility conflicts. The utilities presently located along the frontage roads would have to be relocated to outside the new, proposed frontage road alignment. However, this would relocate the utilities to their Phase II location.

The expansion of the corridor and increased width of the frontage roads would require construction of the Phase II drainage system between Thomas Road and Peoria Avenue. The new system would be located beneath the realigned frontage road, and would include construction of new pump stations to replace the existing under-sized stations. It is anticipated that with the expansion of the drainage systems, a new outfall to the Salt River would be required.

Construction of the IB Option improvements would have a minimal affect on existing traffic operation. The new frontage roads could be built on the Phase II alignment without disturbing the traffic on the existing frontage roads. As an additional benefit, the IB Option Plan would simplify the maintenance of traffic during Phase II construction. The three continuous lanes on the frontage roads would provide

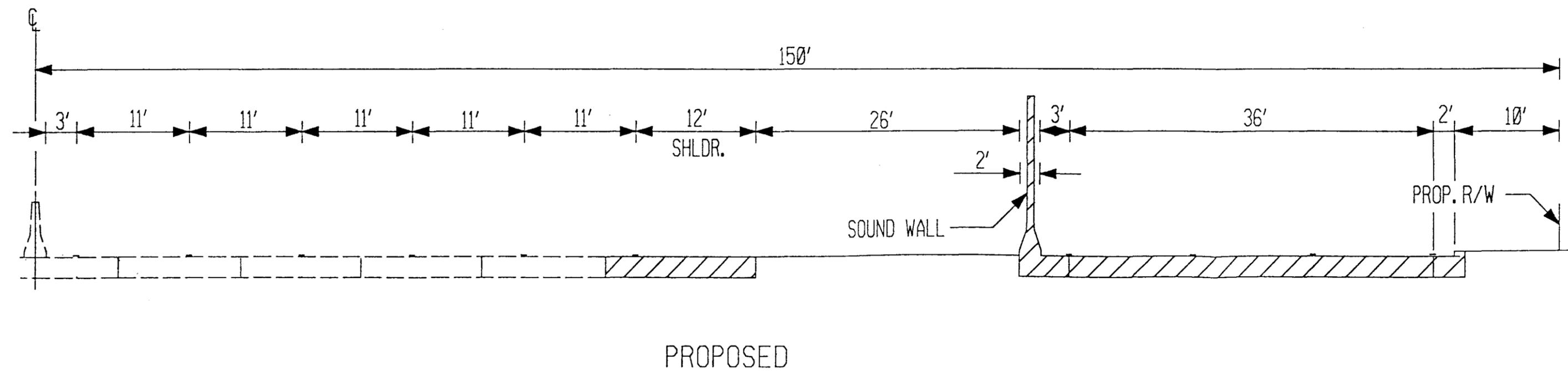
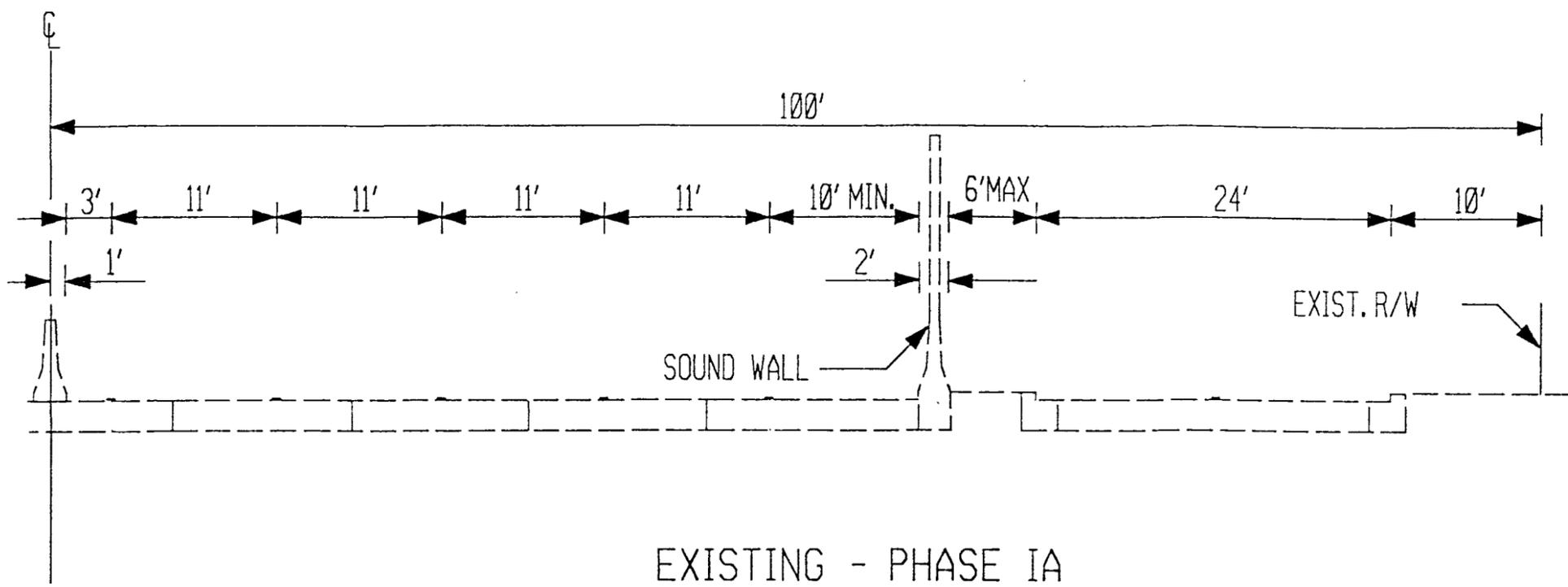


FIGURE 11
 MID-MILE CROSS SECTION
 IB-OPTION
 DEPRESSED SECTION

additional capacity during the reconstruction of the mainline pavement.

While the cost of the IB Option Plan is much greater than the IB Plan, the advantage of the IB Option Plan is that only a small portion of the improvements are "throw-away" items when Phase II improvements are constructed. An estimate of the cost of constructing the IB Option Plan is \$90 million. The estimated right-of-way cost is \$95 million.

In conclusion, the IB Option Plan should be constructed when the Phase IB improvements are implemented. Hereafter the Phase IB improvements will be referred to as the Phase IB Option Improvements.

CORRIDOR RECONSTRUCTION - PHASE II

Phase II is a long-range improvement program, with the objective of increasing the capacity and operational flexibility of the corridor. Phase II would significantly upgrade the facility by reconstructing and widening the mainline, rebuilding cross street structures, modifying interchange configurations, realigning and widening the frontage roads, and widening intersection approaches.

Implementation of Phase II would be completed over a 30-year period. The first task would be to widen the corridor to the required width. Widening the corridor includes relocation of the frontage roads, replacement of the existing drainage system, and utility relocation. (Note: Between Thomas Road and Thunderbird Road, these elements are included in the Phase IB Option improvements.) The second task of Phase II is the reconstruction of the I-17 mainline. This construction would follow the replacement of the cross street structures. Replacement of the cross street structures would be an ongoing process implemented during Phases I and II as needed and as funds become available.

Phase II Plan

For purposes of this presentation, the Phase II Plan is divided into four geographic sections. Each section involves different engineering issues and decisions. The following is a description of the proposed Phase II improvements within each section.

Maricopa T.I. - Papago T.I. The Phase II Plan begins at the Maricopa T.I. where I-17 interchanges with Interstate 10 (I-10). A previous study¹ identified the need for a collector - distributor road system along I-10 beginning at the Maricopa T.I. and continuing eastward to Baseline Road. The Phase II Plan would tie into this proposed plan.

¹ DMJM/Jack E. Leisch and Associates, **Final Report, I-10 Corridor Refinement Study.**

Four basic lanes in each direction would be continuous on I-17 from the Maricopa T.I. to the Grant Street. Along this section, diamond interchanges are provided at one-mile intervals. There are three basic lanes in each direction from the Grant Street to the Papago T.I. Only three basic lanes can continue through this segment because of the configuration of the Papago T.I. Two-lane, one-way frontage roads parallel the mainline through this section. A single-line schematic of the proposed Phase II Plan between the Maricopa T.I. and the Papago T.I. is shown in Figures 12 and 13.

Modifications to the existing ramp sequence would eliminate direct access from the I-17 mainline to Buckeye Road, Jefferson Street, and Adams Street. These cross streets would be accessible from the continuous frontage roads.

Auxiliary lanes would be provided in both directions between many of the interchanges. The auxiliary lanes are added with an exclusive entrance ramp and dropped with a two-lane exit ramp.

The Phase II Plan addresses several major design issues within this section of the corridor. First, the recently completed Papago T.I., a four-level directional interchange, has been incorporated without modification into the Phase II Plan. Secondly, reconstruction of the Durango Curve and realignment of the southbound frontage road is proposed to correct the vertical difference between the mainlines and improve the operation and continuity of the frontage road. The final major issue in this section addresses the at-grade frontage road crossings of the Southern Pacific Railroad. The Phase II Plan proposes the reconstruction of the railroad bridge and the realignment of the frontage roads to pass under the railroad.

Papago T.I. - Paradise T.I. This section of the corridor is between two 4-level system interchanges. To accommodate the increased through traffic as well as weaving traffic, a fourth basic lane and an auxiliary lane in each direction would be added between the two system interchanges.

In addition to the forecasted weaving volumes between the two system interchanges, significant weaving between the Thomas Road and Indian School Road interchanges is also forecasted. To reduce the weaving conflicts, an auxiliary lane would be added between these interchanges. A single-line schematic of this segment is illustrated in Figure 14.

The addition of a third continuous lane on the frontage road would increase the capacity and operational flexibility of the corridor throughout this high-volume segment.

The proposed configuration of the Paradise T.I. has been incorporated into the Phase II design. Modification or elimination of the Paradise T.I. would require significant alteration of the proposed Phase II Plan.

MATCH LINE SEE FIGURE 13

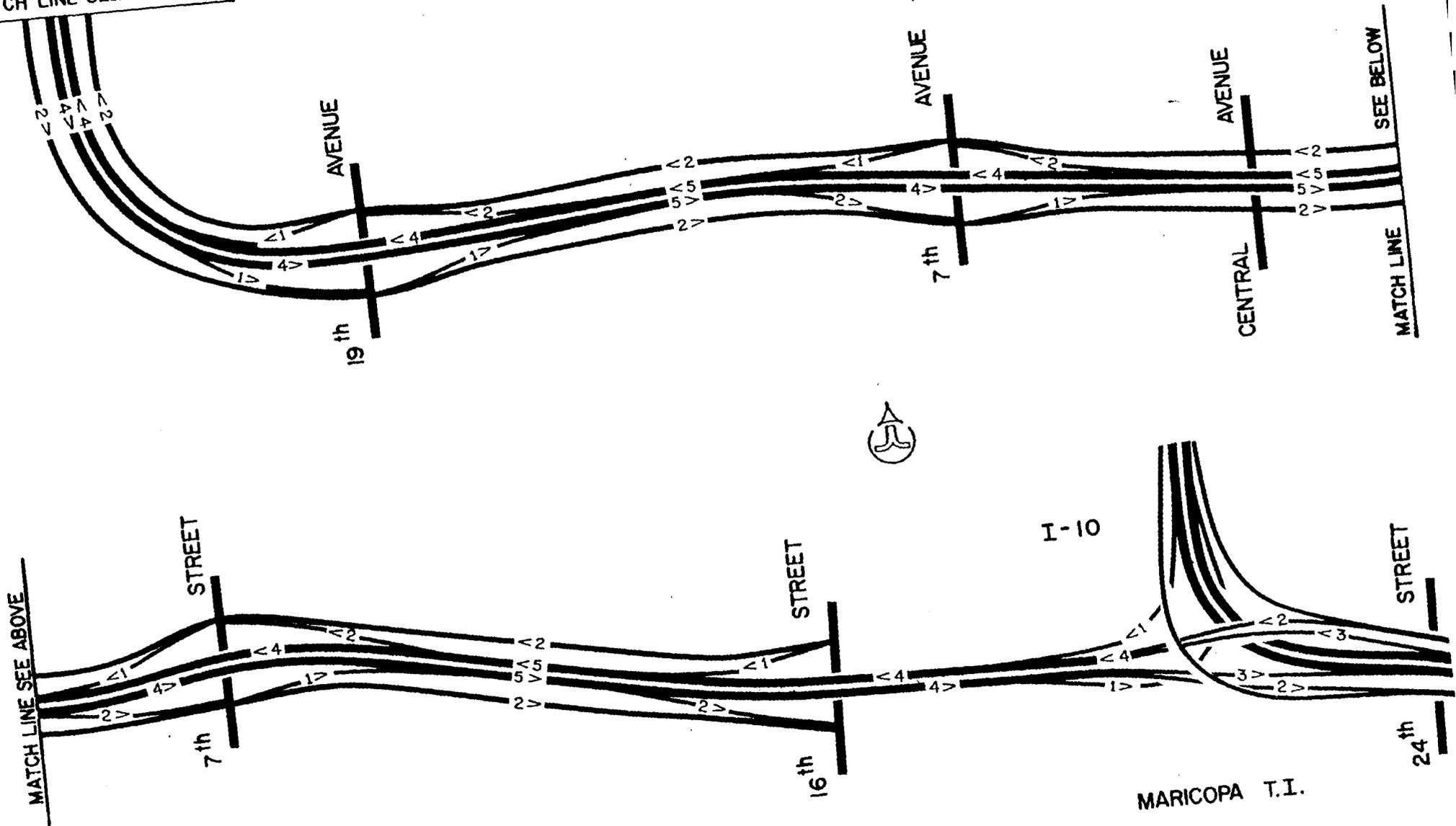


FIGURE 12
SINGLE LINE PLAN
PHASE II

MARICOPA T.I.

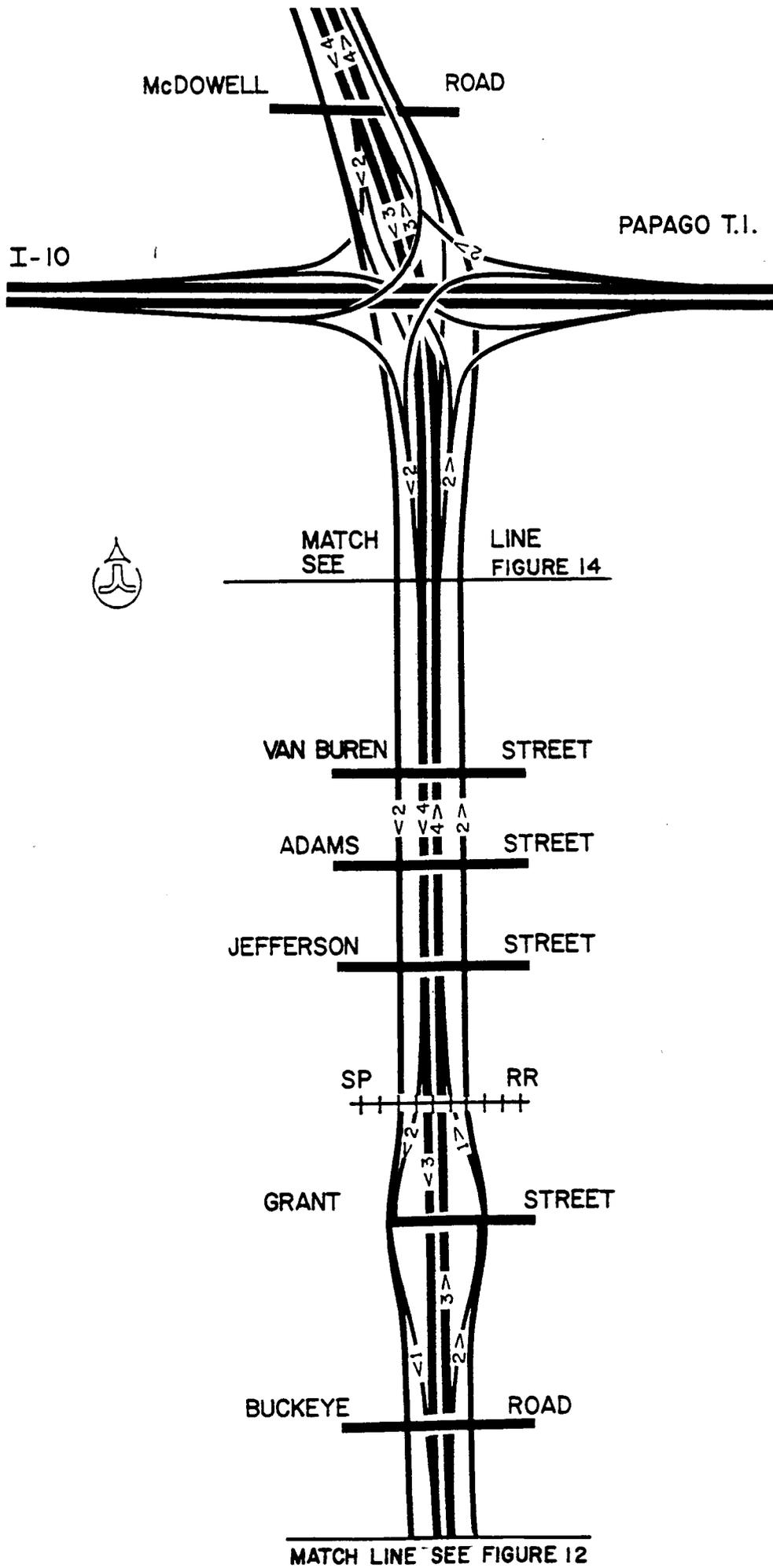


FIGURE 13
SINGLE LINE PLAN
PHASE II

Paradise T.I. - Greenway Road. One-mile spacing of the diamond interchanges in this segment creates weaving conflicts between each interchange pair. The weaving conflicts in combination with peak hour traffic projections exceeding 11,000 vehicles per hour in each direction in many of the mainline links requires a facility incorporating high capacity and operational flexibility.

Through this segment the mainline has been widened to five basic lanes and an auxiliary lane in each direction. This configuration maximizes the capacity of the mainline. The frontage roads have been widened to three lanes to provide additional capacity for short trips. A single-line drawing of the proposed plan in this segment is shown in Figures 15 and 16.

Greenway Road - Deer Valley Road. Traffic projections rapidly decrease north of Greenway Road. Consequently, throughout this segment the overall capacity of the corridor would gradually decrease as the number of basic lanes are reduced on the mainline and the frontage roads.

Five continuous basic lanes would be maintained from the Paradise T.I. until Bell Road, where one basic lane would be dropped. Another lane would be dropped at Rose Garden Lane, reducing the number of basic lanes in each direction to three. In addition to the basic lanes, auxiliary lanes are provided between most of the interchanges. A single-line schematic of the Phase II Plan, between Greenway Road and Deer Valley Road is shown in Figure 17.

To increase capacity and improve operations, most of the interchanges in this segment have been redesigned. The existing interchange at Bell Road is a full cloverleaf. The Phase II plan proposes the conversion of the interchange to a Parclo A configuration. A diamond interchange design would also accommodate the traffic volumes, and would reduce the right-of-way requirements.

The northern pair of ramps to Utopia Road would be removed to eliminate the short mainline weave with the Rose Garden Lane ramps. Access to the Utopia Road over crossing is only from the continuous frontage roads. The proposed configuration of the Outer Loop T.I. has been retained in the Phase II design. The ramps to and from the south at Deer Valley Road would be eliminated, with access provided at the half-diamond interchange at Rose Garden Lane.

Level of Service Analysis

Year 2010 traffic projections were assigned to the Phase II Plan and a level of service analysis using the **1985 Highway Capacity Manual** procedures was performed to determine the quality of traffic operation of each element of the corridor. An overall level of service was then determined for each one-mile segment of the facility. The level of service values are shown in Figure 18.

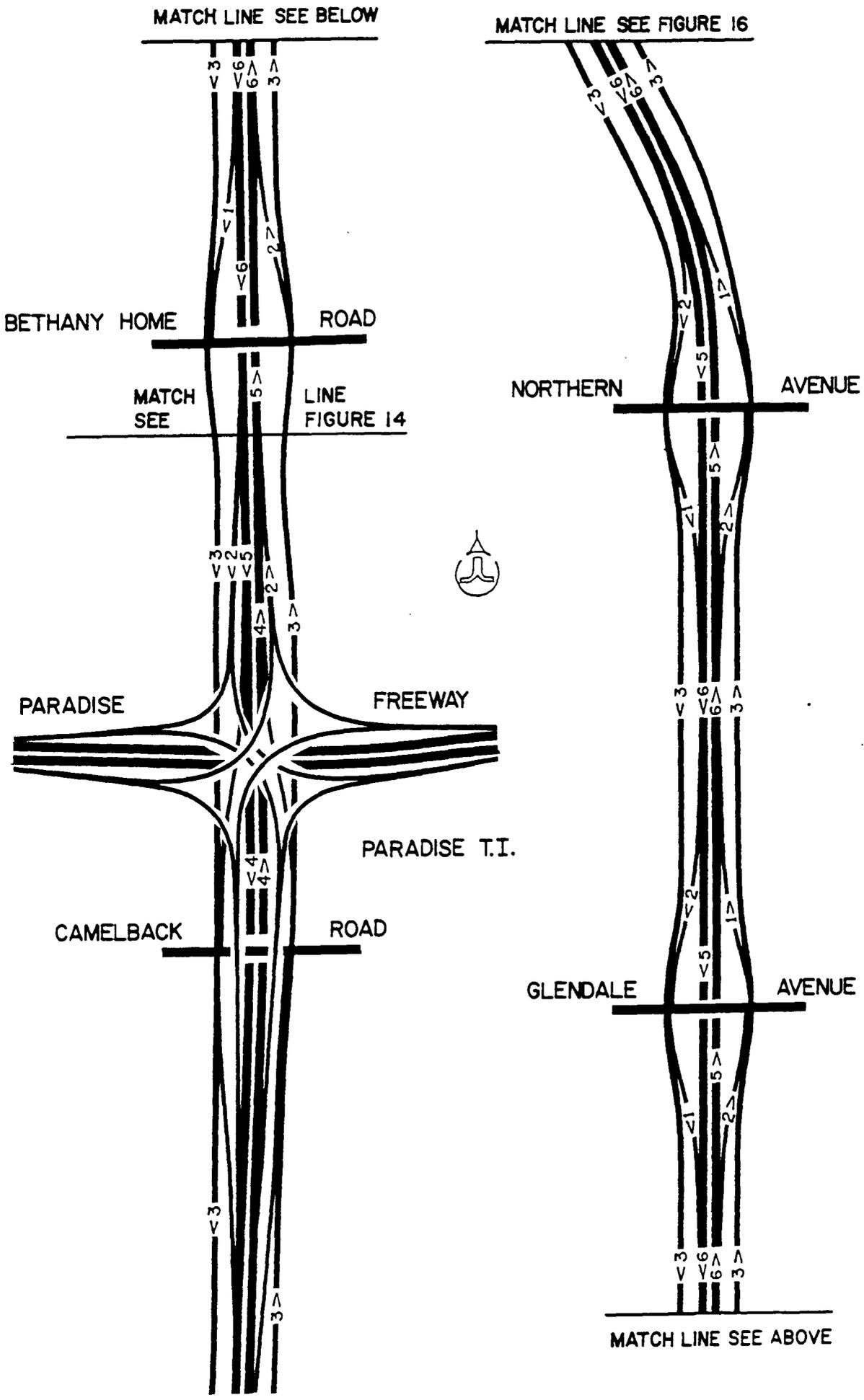


FIGURE 15
 SINGLE LINE PLAN
 PHASE II

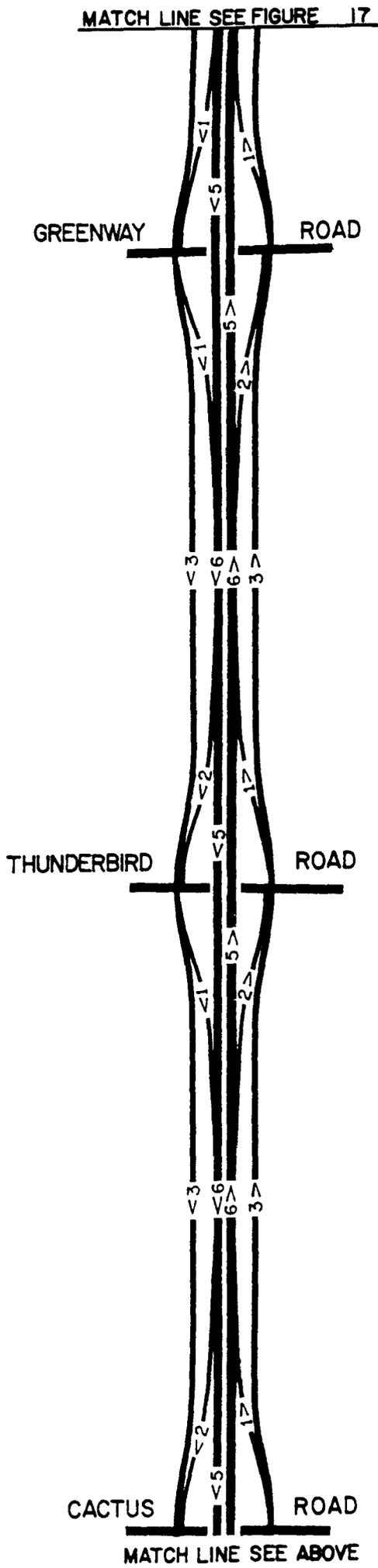
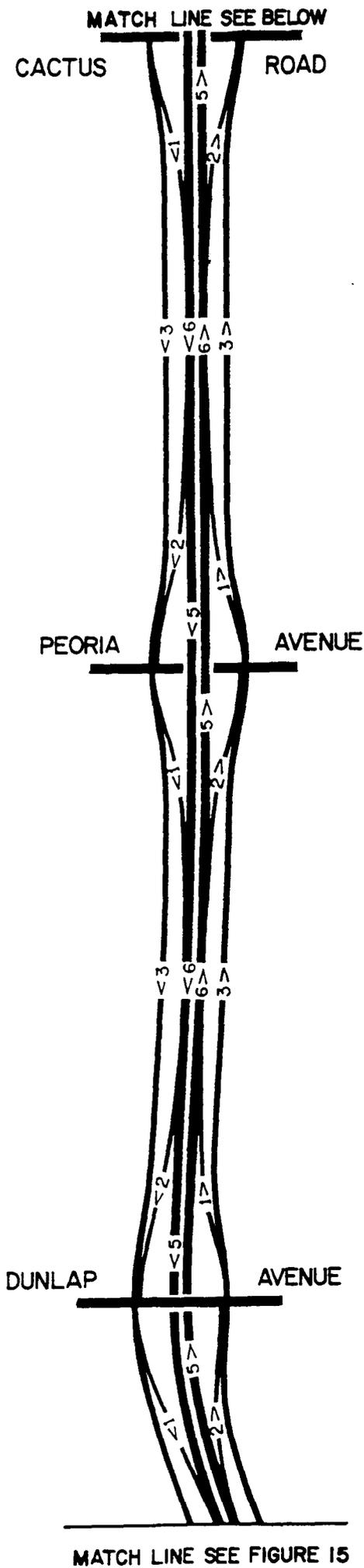


FIGURE 16
SINGLE LINE PLAN
PHASE II

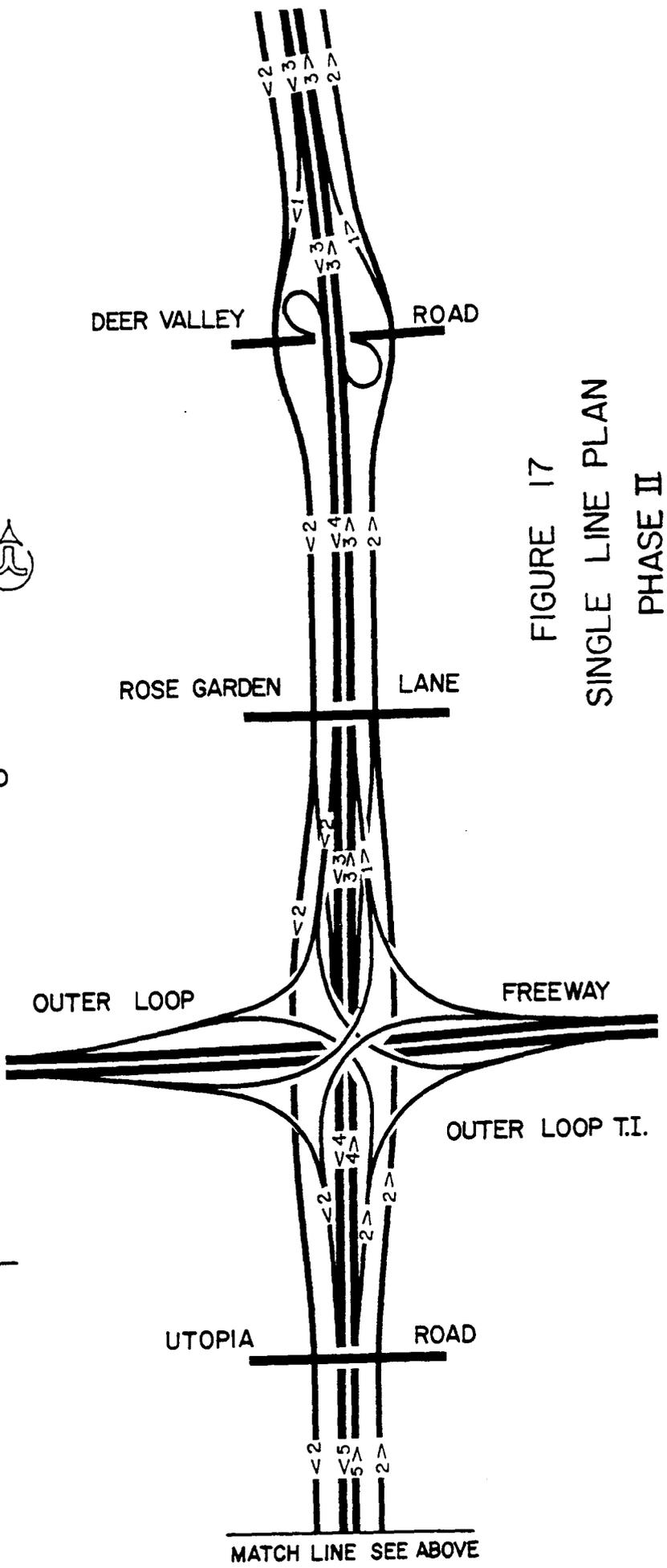
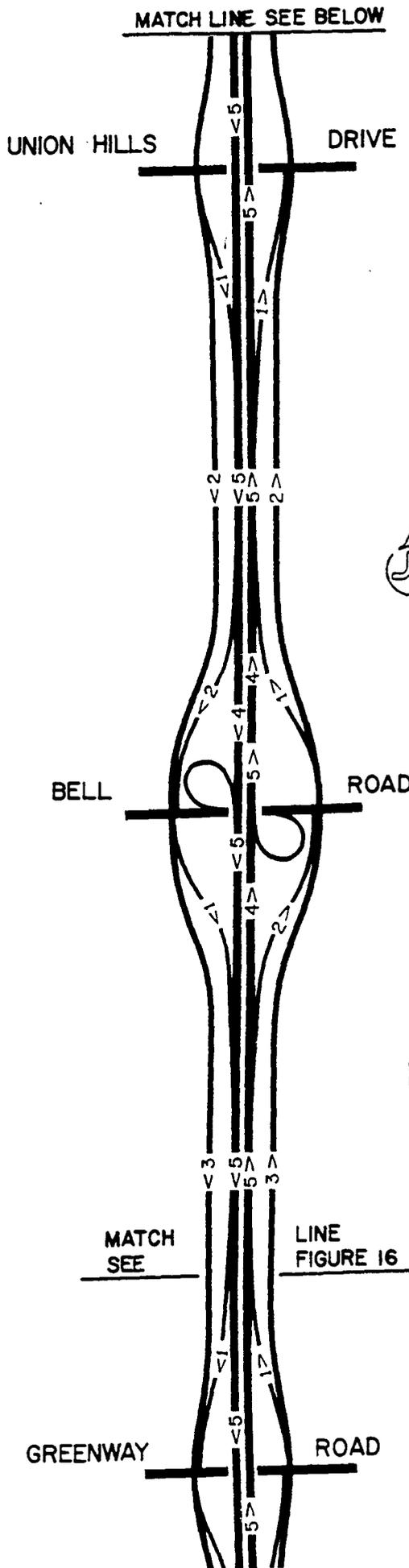
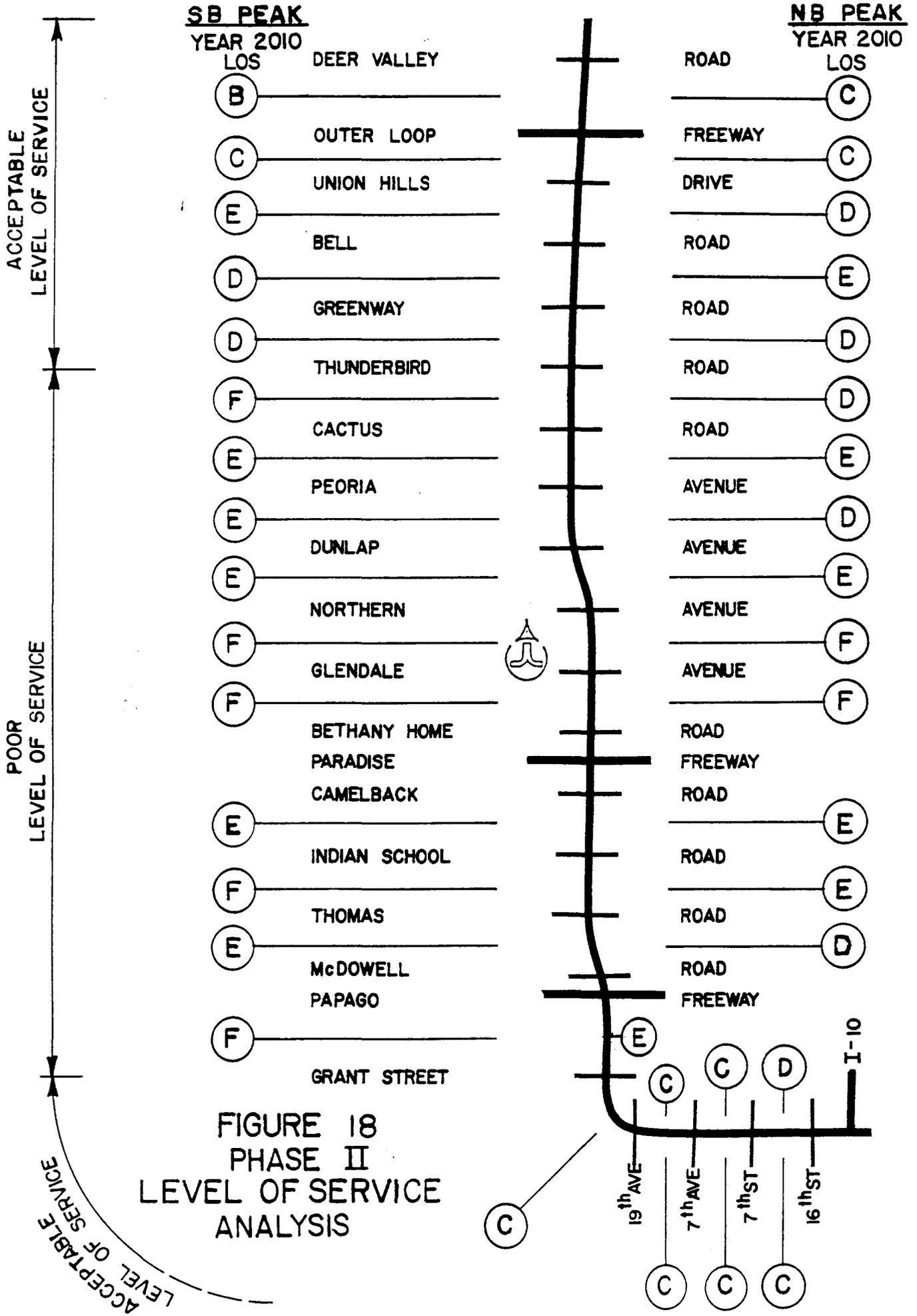


FIGURE 17
SINGLE LINE PLAN
PHASE II



The section of the corridor from the Maricopa T.I. to Grant Street exhibits acceptable levels of service throughout, with most segments projected to operate at a Level of Service C. North of Thunderbird Road, the Phase II Plan would provide Level of Service D or better over most segments. These sections of the corridor are forecasted to have moderate traffic volumes and minor weaving between the interchanges.

Poor levels of service are projected for the segment from the Grant Street interchange to Thunderbird Road. This central section of the corridor is plagued by extremely high link and weaving volumes. Most segments would operate at Level of Service E or lower.

The level of service analysis revealed the year 2010 traffic projections exceed the capacity of the Phase II Plan within the central segment of the corridor (Papago T.I. to Thunderbird Road). The Phase II Plan maximizes the capacity of the existing facility. If the year 2010 forecasted traffic volumes are realized, it is recommended that the Phase III improvements be implemented.

Right-of-Way

The total estimated right-of-way cost associated with Phase II improvements is \$115 million. This includes the right-of-way acquired for the Phase IB Option improvements, which was estimated at \$95 million. Therefore, after the implementation of Phase IB Option improvements, approximately \$20 million of additional right-of-way would need to be acquired to implement Phase II. This additional right-of-way would be acquired during the implementation of the Phase II Plan.

Improvements in the southern section of the corridor from the Maricopa T.I. to the Papago T.I. would generally remain within the existing right-of-way. Additional right-of-way is required only where the exit ramp merges with the frontage road. Right-of-way cost for this section is estimated at \$1.0 million.

North of the Papago T.I., there would be no significant right-of-way takes until Thomas Road. Between Thomas Road and Thunderbird Road, right-of-way for the Phase II improvements would be acquired during the construction of Phase IB Option improvements. Between Thomas Road and Dunlap Avenue, the Phase II right-of-way requirements are extensive. The right-of-way requirements between Dunlap Avenue and Thunderbird Road are not as extensive.

North of Thunderbird Road, additional right-of-way requirements would be minimal, but the affected properties have significant value. Several existing townhomes and apartment complexes would be affected by the proposed improvements. The estimated cost of right-of-way from Thunderbird Road to the study limits at Deer Valley Road is approximately \$19 million.

Phase II Implementation

The implementation of improvements in the corridor will be dictated by traffic growth and availability of funds. The central section will most likely experience the greatest increase in traffic volume. After the completion of the Papago Freeway, only a slight increase in traffic on I-17 south of the Papago Freeway may be experienced. North of Thunderbird Road, projected traffic volumes drop significantly. Based on these projections, Phase II improvements should be implemented first in the central section of the corridor.

The implementation of Phase II can be divided into eight individual projects; three projects in the central section, three projects in the south section, and two projects in the north section. The order of implementation and location of the projects reflect the predicted buildup of traffic volumes. Project limits of all eight projects are shown in Figure 19.

The first project, based on projected needs, is the implementation of the four-mile section from the Paradise T.I. to Dunlap Avenue. Since construction relating to the widening of the corridor would have been completed during the Phase IB Option, this project would involve only mainline widening and reconstruction. The second project extends from Dunlap Avenue to Thunderbird Road. The three-mile segment between the Papago T.I. and the Paradise T.I. (Project 3) would complete the widening and reconstruction of the central section. The timing and sequencing of the central section improvements are predicated on the timing of the completion of the Paradise Freeway.

Reconstruction of the first three miles of the north section from Thunderbird Road to Union Hills Drive (Project 4) would follow the reconstruction of the central section. With the completion of Project 4, attention would focus on the reconstruction of the south section of the corridor. Reconstruction of the south section would begin at the Maricopa T.I. and proceed northward. The limits of Project 5 extend from the Maricopa T.I. to Seventh Avenue. Project 6 involves the reconstruction of the Durango Curve. The mainline would be reconstructed to have a common centerline and profile. After completion of the Durango Curve, Project 7 would begin. Project 7 replaces the mainline pavement and rearranges the ramps between the Durango Curve and the Papago T.I.

Reconstruction of the remaining segment of the corridor, from Union Hills north to Deer Valley Road, (Project 8) would be implemented when traffic volumes warrant the improvements.

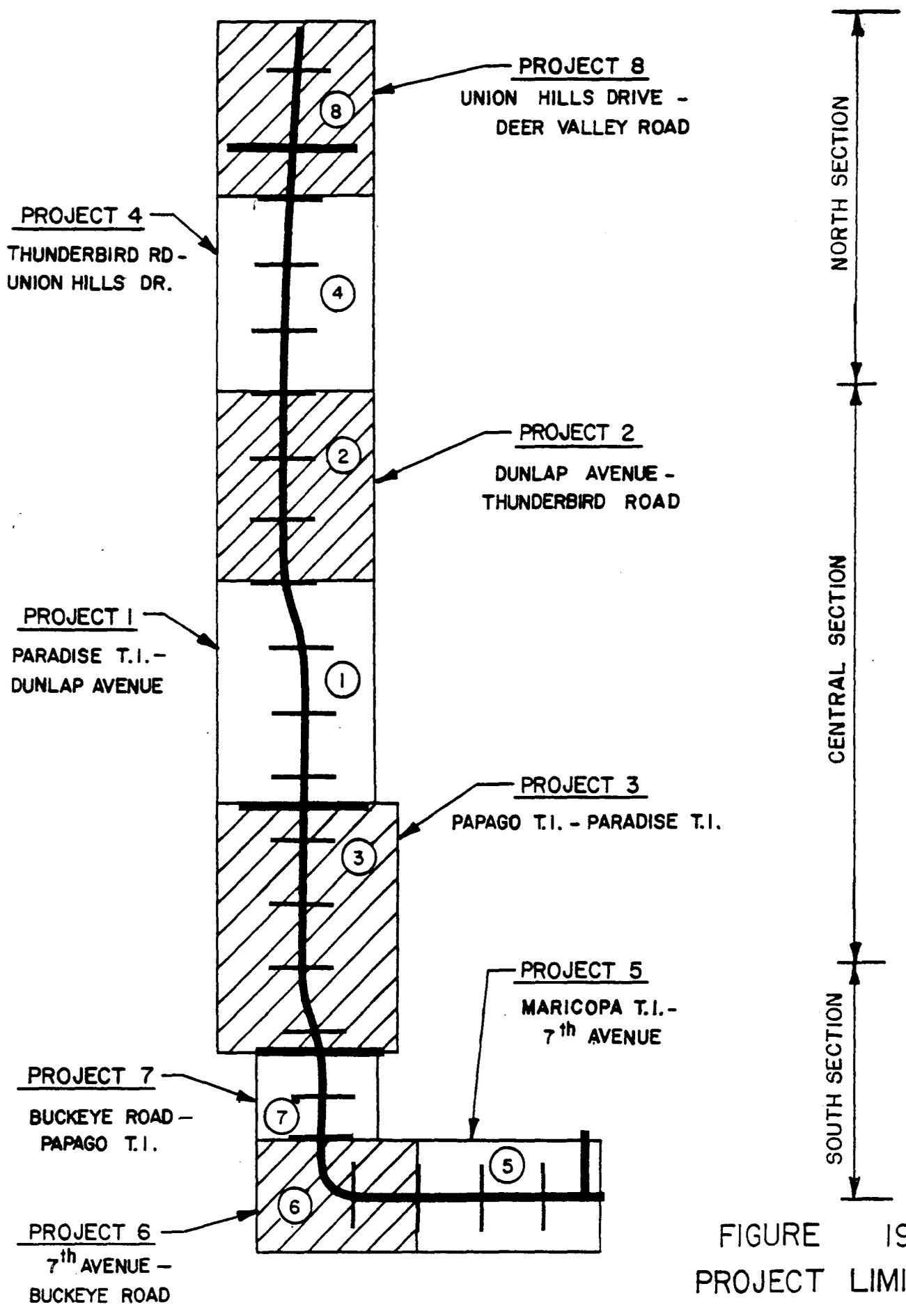


FIGURE 19
PROJECT LIMITS
PHASE II IMPROVEMENTS

Construction Costs

The cost of constructing Phase II improvements has been estimated at \$320 million. This cost does not include replacement of the freeway structures, which has been estimated at \$240 million. Also, the cost does not include the relocation of the frontage road and associated construction activities from Thomas Road to Peoria Avenue, which has been included in the Phase IB Option improvements. The estimated cost of constructing each project is listed in Table 1.

Table 1			
SUMMARY OF PHASE II CONSTRUCTION COSTS			
Project	Limits	Miles	Construction Cost
1	Paradise T.I. - Dunlap	4	\$ 80,000,000
2	Dunlap - Thunderbird	3	45,000,000
3	Papago T.I. - Paradise T.I.	3	30,000,000
4	Thunderbird - Union Hills	3	60,000,000
5	Maricopa T.I. - 7th Avenue	3	45,000,000
6	7th Avenue - Buckeye	2	30,000,000
7	Buckeye - Papago T.I.	2	20,000,000
8	Union Hills - Deer Valley	2	10,000,000
TOTAL	Maricopa - Deer Valley	22	\$320,000,000

CAPACITY ENHANCEMENTS--PHASE III

As previously indicated, when the year 2010 forecasted traffic volumes are realized, capacity and operational enhancements of the Phase II Plan would be needed in the central section of the corridor. The Phase III Plan would add additional roadways throughout this section to accommodate the heavy forecasted traffic demand.

The Phase III Plan improvements begin at the Papago T.I. and continue north to Thunderbird Road. The first three miles of the Phase III Plan, from the Papago T.I. to the Paradise T.I., consist of a C-D/frontage road system. A single line schematic of the Phase III Plan from the Papago T.I. to the Paradise T.I. is illustrated in Figure 20. The two significant features of this section are the C-D bypass at the cross streets and a pair of ramp braids. As the frontage road approaches the cross street, a C-D road splits off

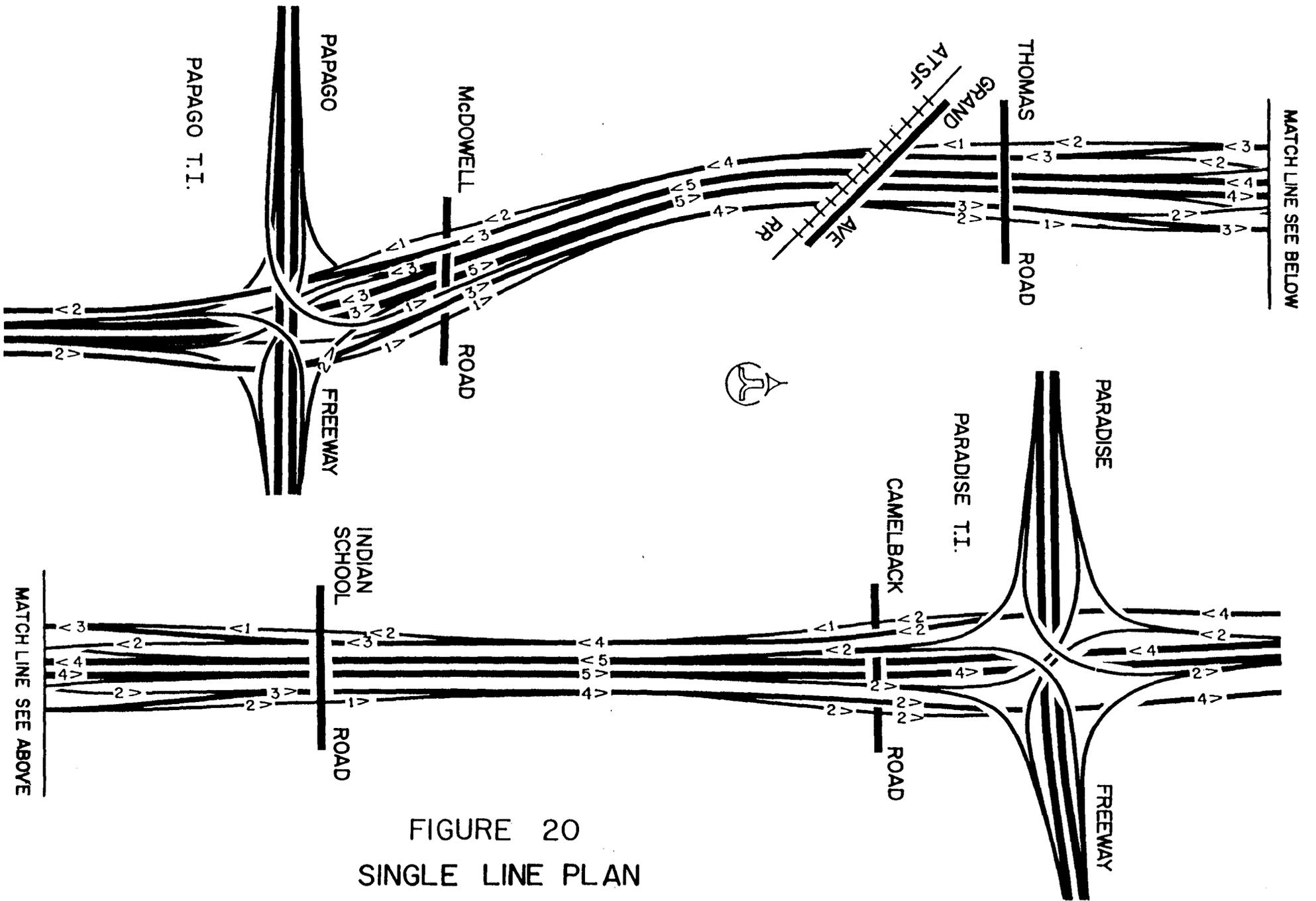


FIGURE 20
 SINGLE LINE PLAN
 PHASE III - PAPAGO T.I - PARADISE T.I

on the left. After the split, the frontage road continues, intersecting the cross street and the C-D road passes under the cross street, by-passing the at-grade intersection. The C-D road and frontage road then merge beyond the cross street. Between Thomas Road and Indian School Road, the mainline exit ramp and the frontage road entrance ramp are grade separated (braided). The ramps were braided in this location to reduce projected mainline weaving traffic conflicts. From the Paradise T.I. north to Thunderbird Road, two Phase III schemes were developed: an elevated express roadway (Scheme E) and a continuation of the C-D/frontage road system (Scheme F). The schemes are described in detail below.

Elevated Express Roadways--Scheme E

The proposed Phase III-Scheme E plan would include six miles of elevated express roadways in each direction, beginning within the Paradise T.I. and extending northward to Thunderbird Road. North of Thunderbird Road, the plan involves only minor modifications. Figure 21 shows a single-line schematic of the Phase III - Scheme E Plan.

The elevated express system would begin within the Paradise T.I. with express connections to the Paradise Freeway, to and from the east. The express roadways would continue northward to Thunderbird Road where they join the I-17 mainline. A set of transfer ramps between the mainline and the express roadways would be provided north of Peoria Avenue.

Implementation of the express roadways could be completed in two stages. The first stage would involve construction of the five-mile segment from the Paradise T.I. to the transfer ramps north of Peoria Avenue. The second stage would complete the roadways to Thunderbird Road. These stages would be implemented as traffic demands warrant the improvement and funds become available.

Through this seven-mile segment, the mainline would consist of five basic lanes and an auxiliary lane in the weaving sections. To reduce the number of ramp braids required between the access ramps and the elevated express roadways, interchange spacing would be increased to two miles. Each two-lane exit and one-lane entrance ramp would serve two cross streets with an average ramp volume of 1,600 vehicles.

A level of service analysis using the projected 2010 traffic volumes indicated the proposed Scheme E plan would operate at a relatively uniform Level of Service D.

Collector-Distributor/Frontage Road System--Scheme F

The Phase III--Scheme F Improvement would continue the C-D/frontage road system from the Paradise T.I. northward to Thunderbird Road. Figure 22 presents the Phase III--Scheme F Plan in single-line form. High speed slip ramps would provide

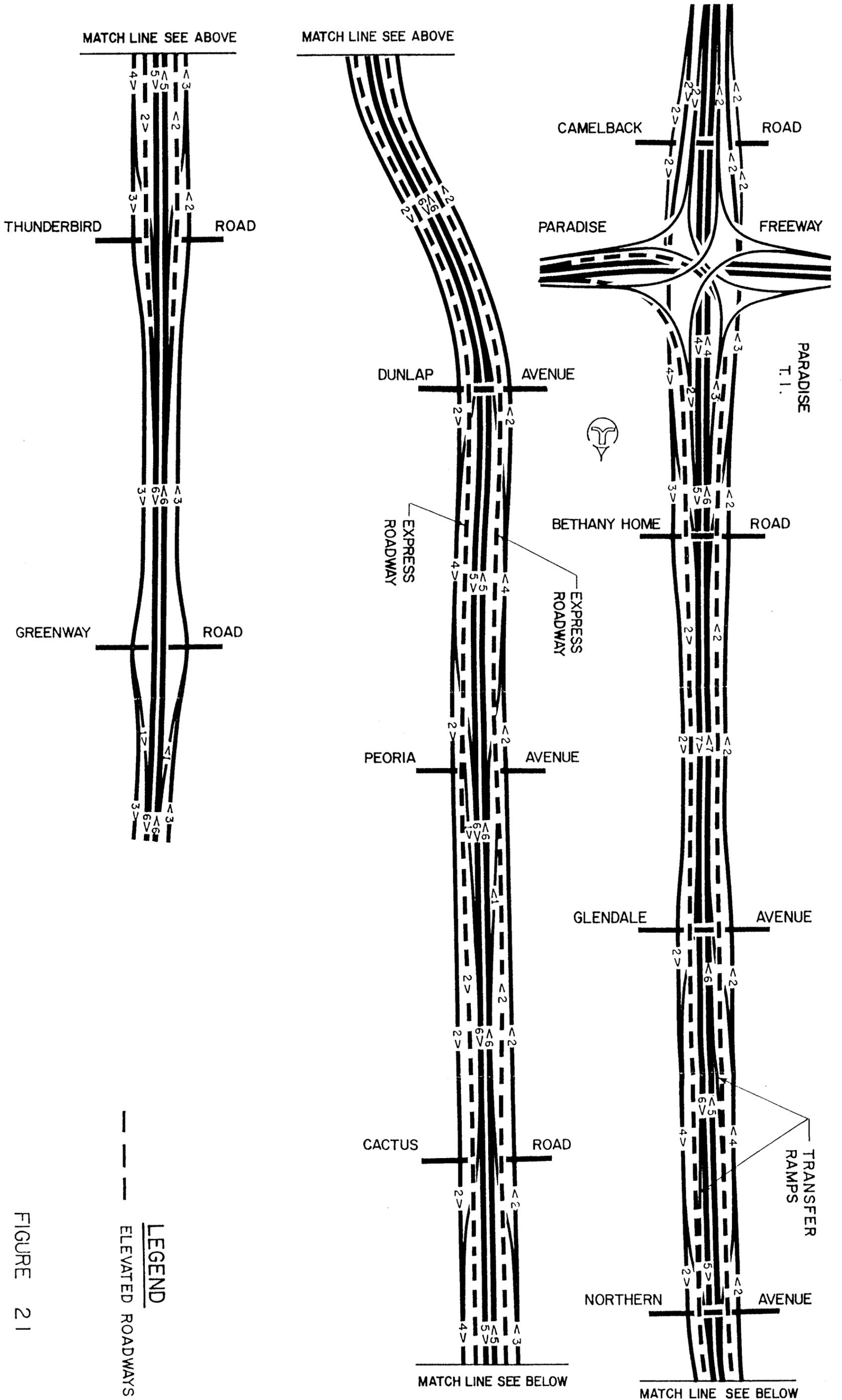


FIGURE 21
 SINGLE LINE PLAN
 PHASE III - SCHEME E

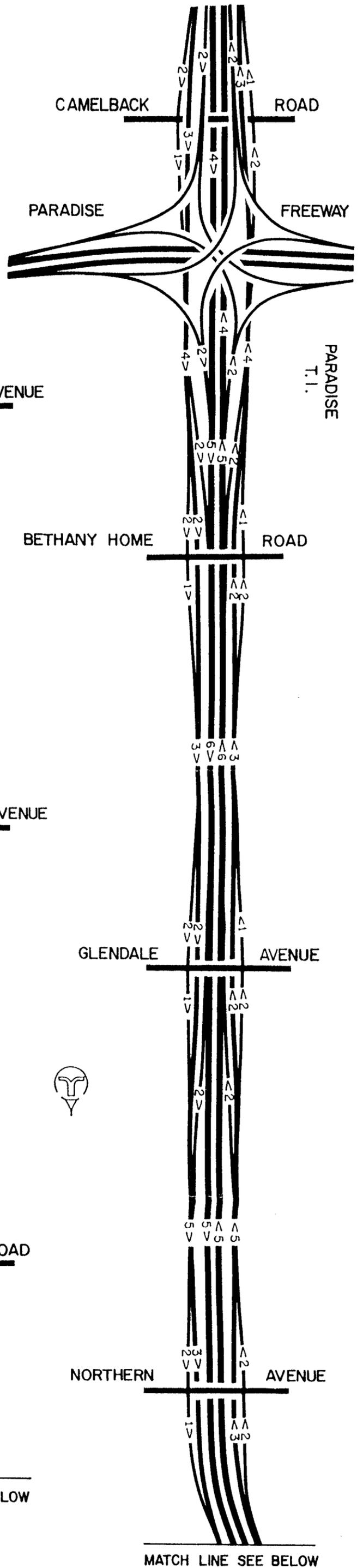
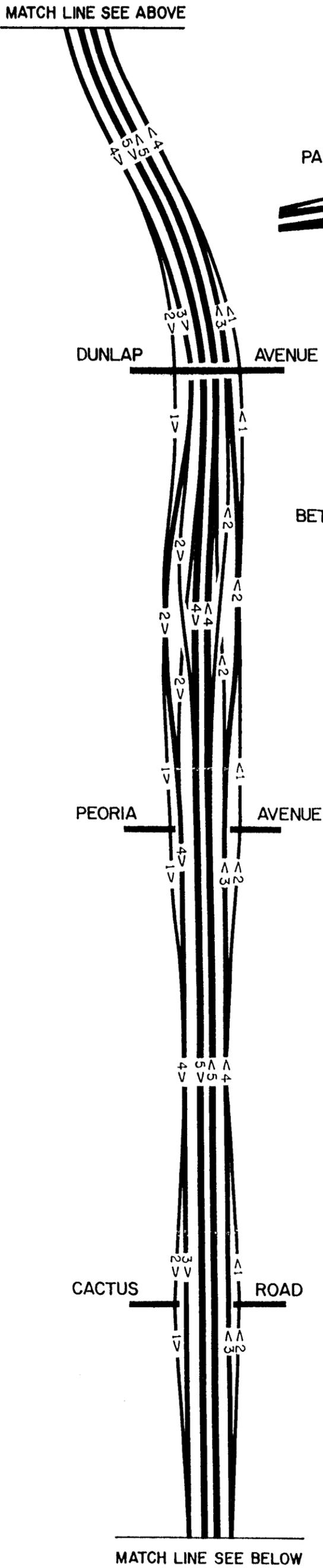
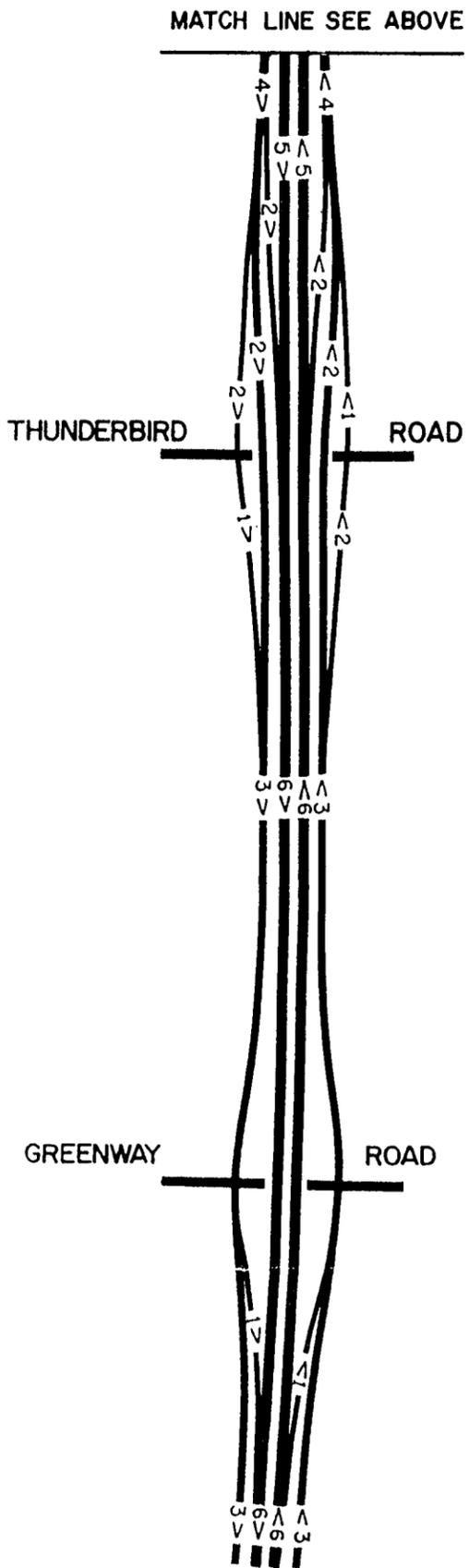


FIGURE 22
 SINGLE LINE PLAN
 PHASE III-SCHEME F

access to and from the mainline. The slip ramps would be spaced at three-mile intervals. Each exit ramp would be signed for the next three cross streets and would carry approximately 2,400 vehicles during the peak hour; access to each cross street would then be from the C-D/frontage road.

The Phase III–Scheme F Plan should be implemented in two 3-mile segments because of the proposed ramp spacing. The two segments would be implemented as traffic volumes warrant the proposed improvements.

A level of service analysis for Scheme F was performed using 2010 traffic volumes. The analysis shows the plan would operate at Level of Service D with the exception of a few links which would operate at Level of Service E.

SUMMARY

The need for the reconstruction of the I-17 corridor has been thoroughly documented. I-17 is an aging facility and many of the design elements do not meet current design guidelines. These include insufficient ramp tapers, unprotected sideslopes and obstructions, insufficient pavement cross slope and superelevation, an inadequate drainage system, insufficient lighting, barrier curb adjacent to the roadway, and insufficient vertical clearance.

In addition, the existing peak traffic demand exceeds the capacity of most segments of the facility, causing congestion, accidents, and delay. Many of the segments are congested for 12 continuous hours. The overall corridor accident rate is 30 percent higher than the statewide urban interstate rate, with some segments nearly double the statewide rate. A majority of the accidents are rear-end accidents which can be generally attributed to the congestion on the facility.

The year 2010 traffic forecast projects a 63 percent increase in traffic demand in the central section of the corridor. Traffic volumes in some of the northern segments could double. Less than a 20 percent increase, however, is projected for the south section (Maricopa T.I. to Papago T.I.). The low growth rate can be attributed to the completion of the Papago Freeway.

To correct the existing design deficiencies and accommodate the existing and future traffic demand, it is concluded that the entire corridor, from the Maricopa T.I. to Deer Valley Road, needs to be reconstructed. The reconstruction of the I-17 corridor is a massive undertaking, which could severely strain ADOT's physical and financial resources. To reduce these impacts and accommodate the continued growth of the corridor, the proposed improvements have been divided into several phases and projects. The implementation of the phased improvements would incrementally

increase capacity as traffic increases and reconstruct an aging facility that over time would require replacement.

To assist ADOT with programming and budgeting the proposed improvements, a preliminary implementation schedule and cost summary have been developed. The schedule is graphically portrayed in Figure 23 and the cost summary is listed in Table 2. The proposed schedule and cost summary are provided only as a guideline and should be continually evaluated and updated to ensure that the improvements are implemented as needed and funds are available. A brief description of the individual elements of the schedule follows.

PHASE IA IMPROVEMENTS

Phase IA involves widening the mainline from Thomas Road to Thunderbird Road to provide a fourth basic lane in each direction. This improvement would increase the capacity of the mainline to accommodate the existing and near-future traffic demand. The estimated cost to implement these improvements is \$45 million. The Phase IA improvements can be divided into two sections. The estimated cost for the depressed section (Thomas to Dunlap) is \$35 million. The construction cost for the at-grade section (Dunlap to Thunderbird) is estimated at \$10 million.

Allocation of funds for the implementation of Phase IA improvements has already been programmed by ADOT for the fourth and fifth years of the current five-year plan (1991-1995).

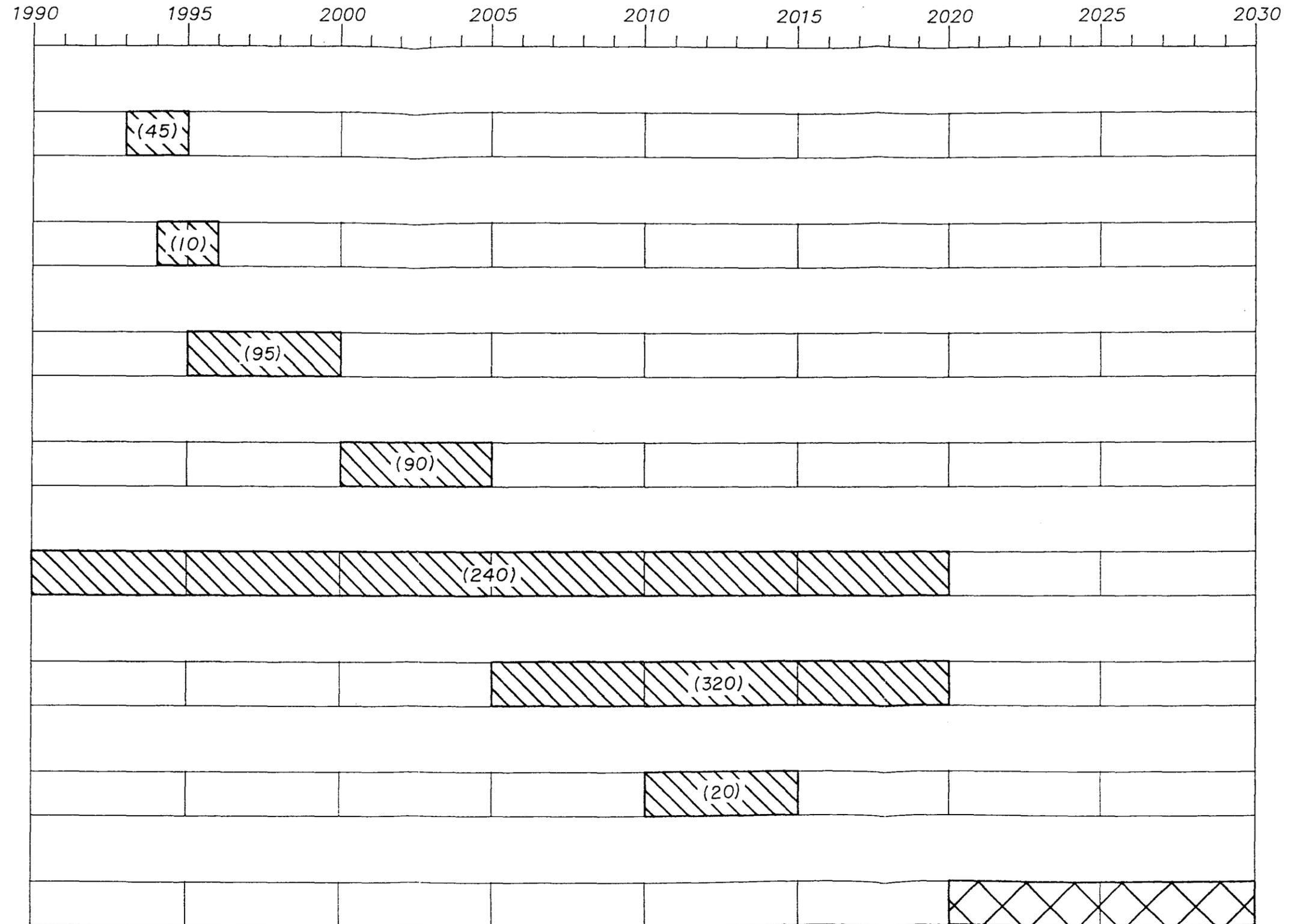
FREEWAY MANAGEMENT SYSTEM

Installation of an FMS has been recommended to improve the operation of the mainline. As part of the FMS, vehicle detectors and a ramp meter controller would be installed to identify congestion and regulate access to the mainline. Variable message signs would be installed to alert drivers to freeway conditions. Funds for the implementation of the FMS have been included in the 1991-1995 five-year plan. It is recommended that installation immediately follow the construction of the Phase IA improvements. The cost of implementing the FMS between Thomas Road and Beardsley Road is estimated at \$10 million.

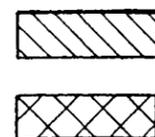
PHASE IB OPTION--RIGHT-OF-WAY

Prior to the construction of the Phase IB Option improvements, Phase II right-of-way should be acquired from Thomas Road to Thunderbird Road. As shown on the proposed implementation schedule, this activity has been scheduled for the years 1995 through 2000. The cost of acquiring the Phase II right-of-way for this section is estimated at \$95 million.

PROPOSED IMPLEMENTATION SCHEDULE



LEGEND



RECOMMENDED IMPROVEMENTS
OPTIONAL IMPROVEMENTS

(xx) ESTIMATED COST IN MILLIONS

FIGURE 23
PROPOSED IMPLEMENTATION
SCHEDULE

**Table 2
SUMMARY OF CONSTRUCTION COSTS**

Phase	Limits	Cost
IA - Stage 1	Thomas - Dunlap	\$15,000,000
IA - Stage 2	Dunlap - Thunderbird	10,000,000
IA - Stage 3	Thomas - Dunlap	20,000,000
PHASE IA IMPROVEMENTS	Thomas - Thunderbird	45,000,000
FREEWAY MANAGEMENT SYSTEM	Thomas - Beardsley	10,000,000
PHASE IB OPTION - RIGHT-OF-WAY	Thomas - Thunderbird	95,000,000
PHASE IB OPTION IMPROVEMENTS	Thomas - Thunderbird	90,000,000
PHASES I AND II BRIDGE REPLACEMENT	16th Street - Deer Valley	240,000,000
II - Project 1	Paradise T.I. - Dunlap	80,000,000
II - Project 2	Dunlap - Thunderbird	45,000,000
II - Project 3	Papago - Paradise	30,000,000
II - Project 4	Thunderbird - Union Hills	60,000,000
II - Project 5	Maricopa T.I. - 7th Avenue	45,000,000
II - Project 6	7th Avenue - Buckeye	30,000,000
II - Project 7	Buckeye - Papago	20,000,000
II - Project 8	Union Hills - Deer Valley	10,000,000
PHASE II IMPROVEMENTS	Maricopa T.I. - Deer Valley	320,000,000
PHASE II - RIGHT-OF-WAY	Maricopa T.I. - Van Buren Thunderbird - Deer Valley	20,000,000
TOTAL RECONSTRUCTION OF CORRIDOR	Maricopa T.I. - Deer Valley	\$820,000,000

The above cost estimates are intended to provide guidance in project evaluation and implementation. This estimate is derived from approximate 1990 costs. Actual right-of-way and construction costs will depend upon actual labor and materials costs, competitive market conditions, final project requirements, annual inflationary adjustments, and other variable factors.

PHASE IB OPTION IMPROVEMENTS

The Phase IB Option improvements would increase the capacity of the corridor and improve the operation of the mainline by widening the frontage roads and constructing a mainline auxiliary lane between interchanges. These improvements would be constructed between Thomas Road and Thunderbird Road to accommodate the increasing traffic demand within this section. These improvements can be constructed in one-mile intervals, allowing flexibility in the implementation and funding of these improvements. The proposed construction of the Phase IB Option improvements should be accomplished during the years 2000 through 2005. The estimated cost of implementing the Phase IB Option improvements is estimated at \$90 million.

PHASES I AND II--BRIDGE REPLACEMENT

Many of the structures within the corridor are approaching their design service life and constrain the width of the cross streets. It is recommended that an ongoing program be instituted to systematically replace these structures. Replacement of these structures would also allow the widening of cross streets, improving the capacity and operations of both the cross streets and frontage roads. This process has already begun--the Indian School Road structure is scheduled for replacement in 1990, at an estimated cost of \$10 million. Twenty-four structures in the I-17 Corridor have been identified for replacement during the first two phases of construction. The total cost of replacing these structures is estimated at \$240 million.

PHASE II--IMPROVEMENTS

Phase II reconstructs the entire corridor from the Maricopa T.I. to Deer Valley Road. Phase II improvements have been divided into eight projects; three projects in the central section, three projects in the south section, and two projects in the north section. Construction of the eight projects has been prioritized based on the projected traffic growth within the corridor.

A 15-year interval, starting in the year 2005, has been proposed for the implementation of Phase II improvements. The total construction cost for Phase II improvements is estimated at \$320 million.

PHASE II--RIGHT-OF-WAY

The remainder of the Phase II right-of-way requirements should be acquired concurrently with the construction of the Phase II improvements. Between the Maricopa T.I. and Thomas Road, an estimated \$1.0 million worth of right-of-way would need to be purchased for Phase II. In the north section (Thunderbird Road to Deer Valley), approximately \$19 million in additional right-of-way would need to be acquired.

PHASE III - IMPROVEMENTS

If needed, Phase III capacity enhancements which involve construction of a C-D/frontage road plan or express roadways could be implemented in the central section, to increase the capacity and improve the operation of the Phase II improvements. An implementation date for Phase III has not been included because it is dependent upon the growth of traffic and the availability of funds over the next 30 to 40 years. The possibility exists that through the development of the transportation network, both highway and transit, and possible changes in travel patterns, the Phase III improvements may never be needed. The Phase III plan, however, has been developed as a guide for the preparation of future improvements should the need arise.

CONCLUSION

This study has documented the need for and the feasibility of reconstructing the I-17 corridor. The proposed improvements have been divided into several phases and projects to permit incremental reconstruction of the facility over a 30-year period. The proposed improvements would require an average annual budget of \$30 million (in 1990 dollars). The implementation schedule should assist ADOT in programming and budgeting the proposed improvements.