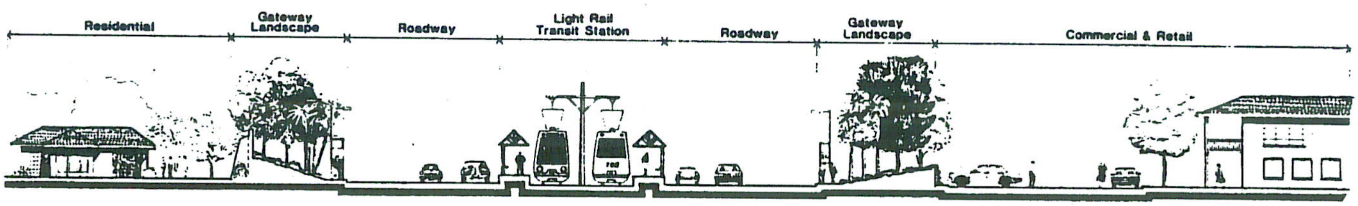
BROADWAY CORRIDOR STUDY

Phase II
Final Report



The City of Tucson
Department of Transportation

May 1990

prepared by

Parsons Brinckerhoff 100 YEARS

Comsis Corporation
Rillito Consulting Group

BROADWAY CORRIDOR STUDY

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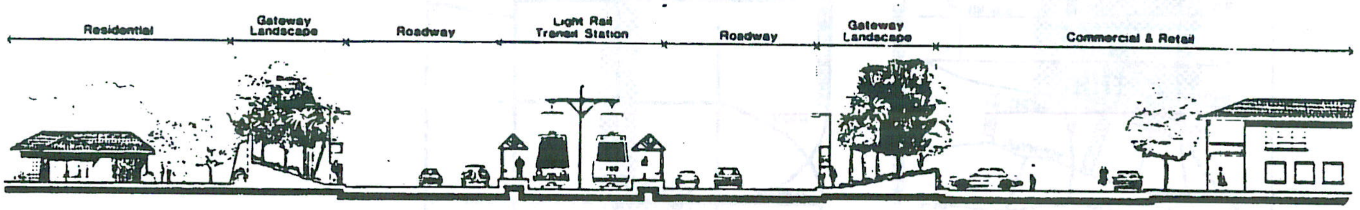
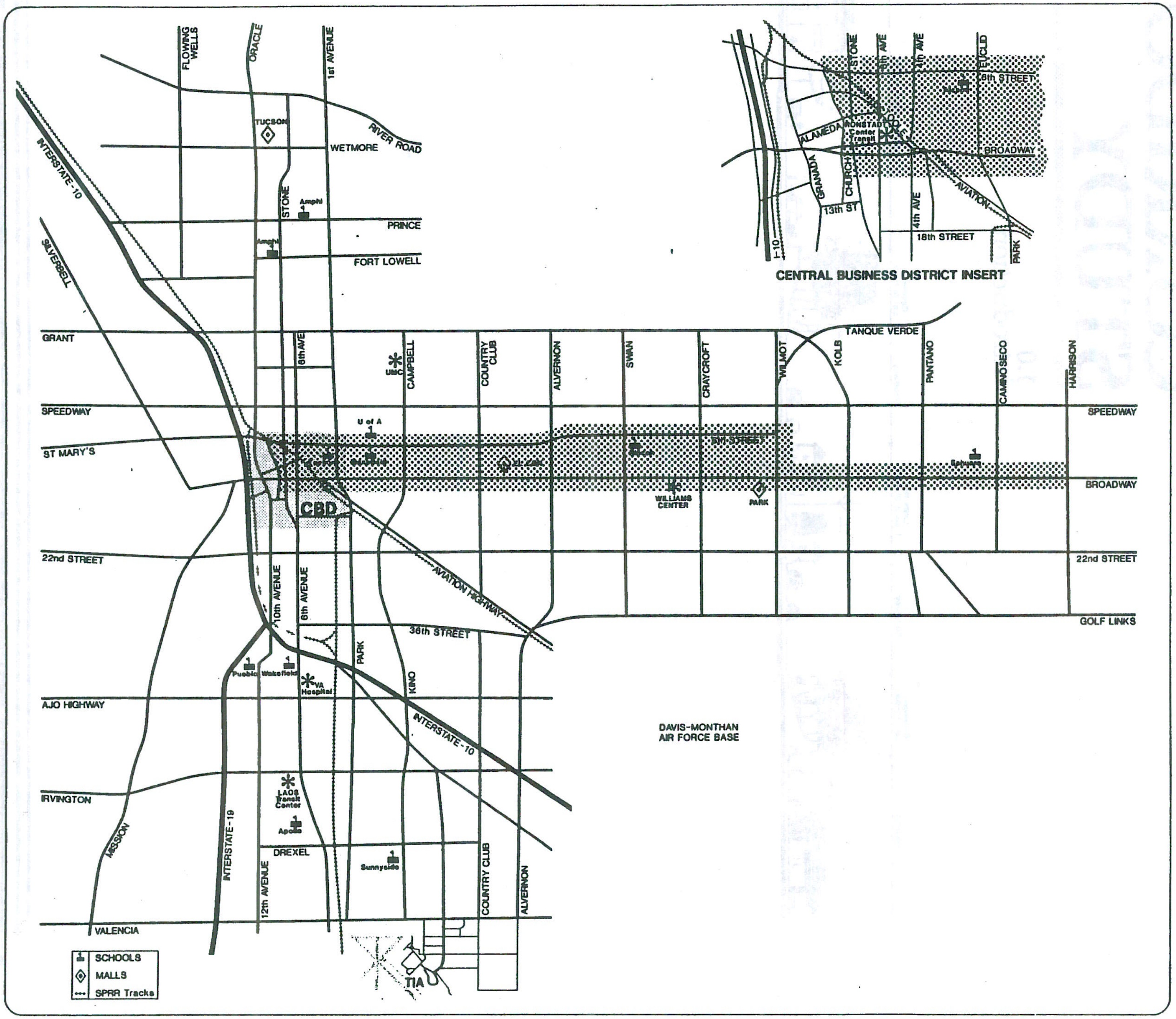
1.0 Introduction





BROADWAY CORRIDOR STUDY AREA

BROADWAY CORRIDOR STUDY

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1.1

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1.0 INTRODUCTION

This section provides an overview of the Broadway Corridor transportation studies, the relationship to the federal process for major capital investments in transit, and the relationship of this Transitional Corridor Analysis Study to the on-going Baja project.

1.1 Project History

The Broadway Corridor (Figure 1.1) extends from I-10 on the west to Houghton Road on the east, a distance of twelve miles. It is one mile wide and includes the area one-half of a mile either side of Broadway Boulevard. The only east-west arterials in the corridor are Broadway Boulevard, which extends the length of the corridor, and 5th/6th Street, which is one-half mile north of Broadway Boulevard and extends from I-10 to Wilmot Avenue, a distance of seven miles.

In 1987 a jointly sponsored (by the City of Tucson and the Urban Mass Transportation Administration) study of the Broadway Corridor, called the Phase I analysis, was conducted and a Corridor Concept Plan was adopted by the Mayor and City Council. The actions listed below were adopted by the City of Tucson:

1. Approve the Corridor Concept Plan and Draft Final Report of the Broadway Corridor Transportation Study Phase I as valid, appropriate, and proper.

2. Approve the key items of the Corridor Concept Plan which are:

   - Minimum 150 feet of right-of-way between Euclid and Camino Seco; and a minimum 120 feet of right-of-way between Camino Seco and Houghton Road.

   - Buffering of adjacent residential areas as outlined in the **Broadway Corridor Transportation Study Draft Final Report.**

   - Landscaping and urban design concepts as identified in the **Broadway Corridor Transportation Study Draft Final Report.**

   - Grade separations at warranted locations as defined in Phase I of the project (cross streets will be depressed).

   - Reaffirm Broadway Boulevard as a priority transit corridor for study of transit options.

3. Approve the recommendation that a major transit capital investment project be pursued in conjunction with the Federal Urban Mass Transportation Administration (UMTA).

4. Develop a Phase II Work Program requesting UMTA's participation and consent in the next phase of the major

transit capital investment process, Alternatives Analysis and Draft Environmental Impact Statement (AA/DEIS).

5. Develop an advanced right-of-way acquisition plan for the Broadway Corridor.

Based on the above recommendations and Phase I technical analyses, an application for more detailed study of the Broadway Corridor transit alternatives was made to the UMTA. This application was submitted consistent with UMTA's guidelines and policies on Major Urban Mass Transportation Capital Investments.

1.2 Background of the Transitional Corridor Analysis

During the discussions with UMTA officials, it was decided that more technical analyses and technical tools were needed before UMTA would consider a full application for an AA/DEIS. UMTA considers the entry into the AA/DEIS as a critical decision by UMTA related to their major transit capital investment policy. UMTA stated that they would participate financially in the development of a better travel demand forecasting tool (transit ridership forecasts), a new transit user survey to support the travel forecasting tool development, a refined definition of alternatives based on the Phase I study, and an initial assessment of other possible transit corridors (Figure 1.2).

A revised scope of work (Figure 1.3) was presented to UMTA that would meet the needs of UMTA in assessing their decision related to participating in future capital investment alternatives analysis. It was agreed that the tools developed in the Transitional Corridor Analysis would meet the requirements of the AA/DEIS guidelines and thus would not need additional development if UMTA approved further studies. In addition, because of the concern by UMTA and the City of Tucson, a review and concurrence by UMTA of the transit conceptual alternatives and travel demand forecasting procedures was part of the study process.

1.3 Relationship to the Baja Project

The Broadway Corridor Study is providing input and coordination with the on-going Baja Project being conducted by the Pima Association of Governments (PAG). This long-range planning study for eastern Pima County was authorized by the PAG Regional Council and is being directed by the Citizens' Air Quality Committee (CAQC). This study is evaluating future regional transportation alternatives taking into account air quality, land use/urban form, urban design, environmental, and legal/financial strategies. The product will be a Regional Air Quality/Transportation Plan and its associated air quality improvement and financial strategies. As the UMTA analysis requires a consistent set of future demographics and urban form definitions along with a specific cost-effectiveness analysis process, the Baja Project, on a regional level, is looking at substantial policy changes which could affect the future direction of transportation and land development in eastern Pima

UMTA PLANNING PROCESS

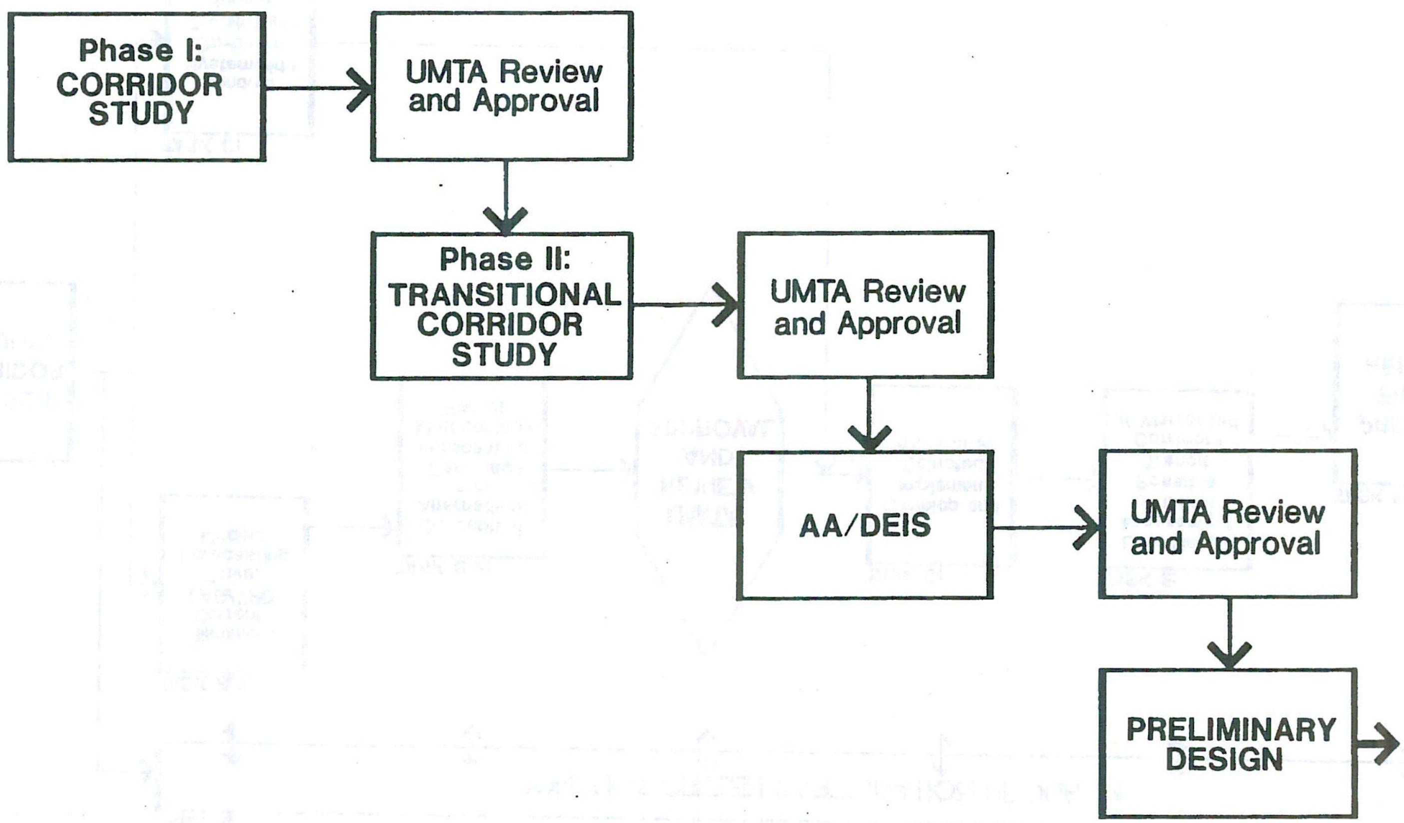

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figure 1.2

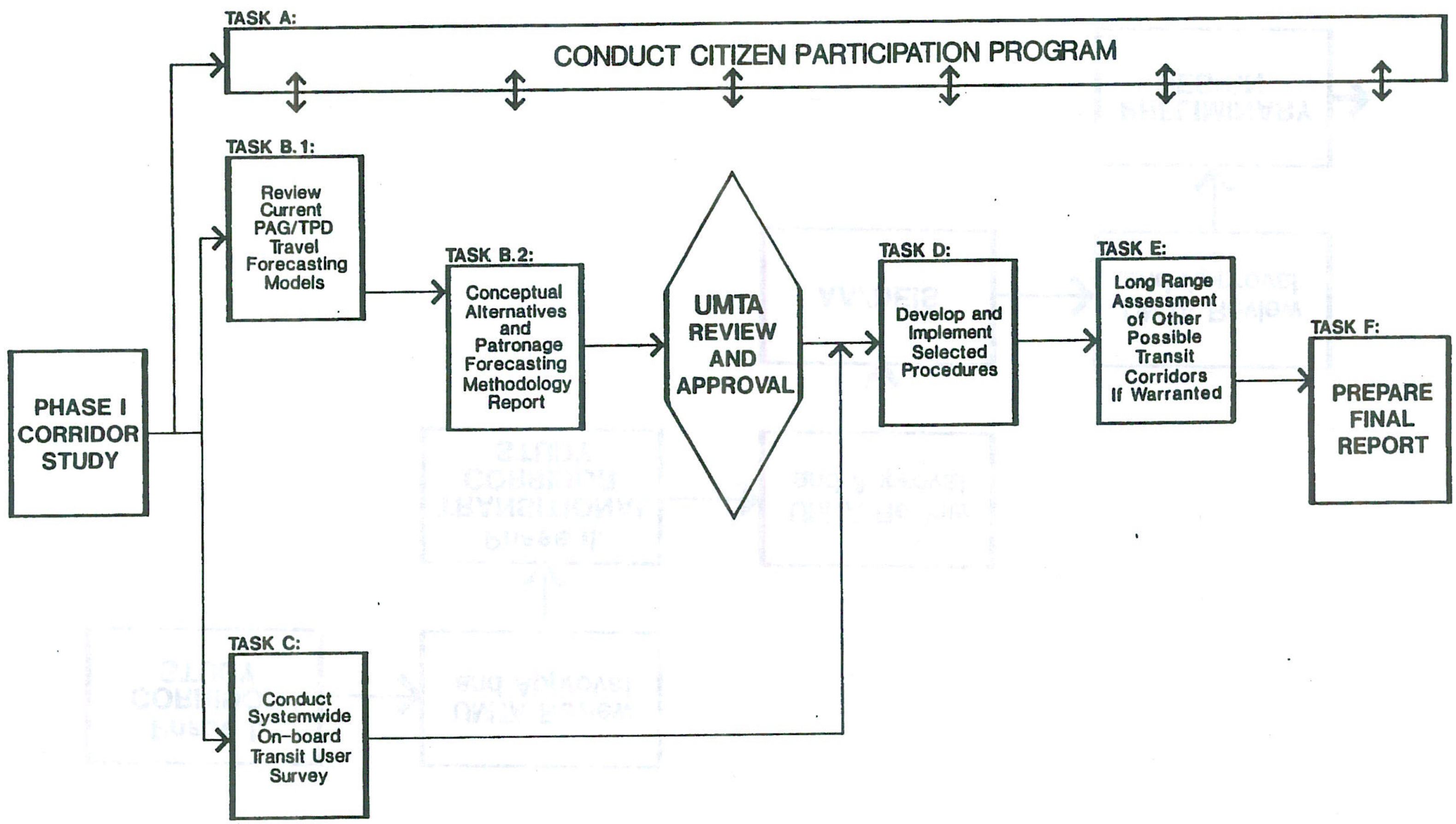

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figure 1.3

County. The new travel demand forecasting tool developed for the Broadway Corridor is being used as the forecasting model for the Baja Project, even though basic inputs are being modified for the development of alternatives.

During the summer of 1990 the Baja Project plan will be presented to the public, the Air Quality Executive Committee, PAG Environmental Planning Advisory Committee, Citizens' Air Quality Committee, PAG Transportation Planning Committee, PAG Management Committee, PAG Regional Council, and PAG member jurisdictions, for review, comment and acceptance.

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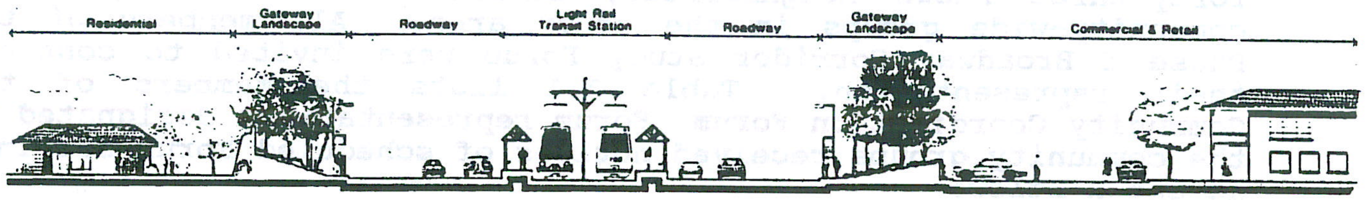
2.0 Community Participation



2.0 COMMUNITY PARTICIPATION

The citizen participation program for the Transitional Corridor Analysis of the Broadway Corridor was established to ensure close coordination with known interested and affected community interests. The program was built on the efforts of the Phase I study rather than developing a completely new and different program. The program components included a Community Coordination Forum (described below), public meetings, and presentations on study progress in response to requests from community organizations. The role of community participation in the study process was to provide opportunities for citizen review and comment on findings of the Transitional Corridor Analysis.

2.1 Community Coordination Forum

A community advisory panel was organized in October 1988 following mailed invitations to seventy individuals representing forty-three known neighborhood, business and commercial, and community-wide groups in the study area. All members of the Phase I Broadway Corridor Study Forum were invited to continue their representation. Table 2.1 lists the members of the Community Coordination Forum. Forum representatives designated by the community groups received notices of scheduled Forum meetings as shown below:

Date	Topic
November 17, 1988	Orientation to Transitional Corridor Analysis; Role of the Forum; Preliminary Alternatives
December 20, 1988	Discussion and comment on alternatives
January 17, 1989	Final alternatives and discussion of the "Best Bus" network
March 14, 1989	Presentation and discussion of the Travel Demand Forecasting Model
July 25, 1989	Development and equilibration of the "Best Bus" network; presentation about related City of Tucson studies (Downtown Land Use/Circulation; Oracle/South Sixth Corridor Study)
September 13, 1989	Preliminary transit ridership and mode split projections for selected alternatives
February 6, 1990	Review and comment on findings of the Transitional Corridor Analysis Draft Final Report

Minutes of the Forum meetings and full results of the comment forms are on file at the City of Tucson's Department of Transportation (TDOT) offices.

BROADWAY CORRIDOR STUDY

Table 2.1

COMMUNITY COORDINATION FORUM MEMBERS

American Institute of Architects (AIA)
American Society of Civil Engineers (ASCE)
Barrio San Antonio Neighborhood Association
Citizens Transportation Advisory Committee
Colonia Solana Neighborhood Association
Commercial Realtors
El Encanto Neighborhood Association
El Montevideo Neighborhood Association
Highland Vista Neighborhood Association
Houghton Neighborhood Association
Iron Horse Neighborhood Association
Loma Verde Neighborhood Association
Miles Neighborhood Association
Pantano East Area Plan
Park Mall Shopping Center
Pie Allen Neighborhood Association
Rincon Heights Neighborhood Association
Rogers Neighborhood Association
Sam Hughes Neighborhood Association
San Clemente Neighborhood Association
Sierra Estates Neighborhood Association
Southern Arizona Homebuilders Association (SAHBA)
Tucson Unified School District (TUSD)
University of Arizona
Vista del Sahuaro Coalition
Williams Centre
Willshire Heights Neighborhood Association

2.2 Public Meeting

General public involvement was solicited for a major presentation and open house from 4:30 - 9:00 p.m. on October 25, 1989. The meeting was sponsored by the City of Tucson Department of Transportation, the UMTA, and Parsons Brinckerhoff. The purpose of the open house was to present the preliminary findings of the Broadway Corridor Study and discussion of alignment options for a separate City study of light rail and busway options in the Oracle/South Sixth Avenue corridors.

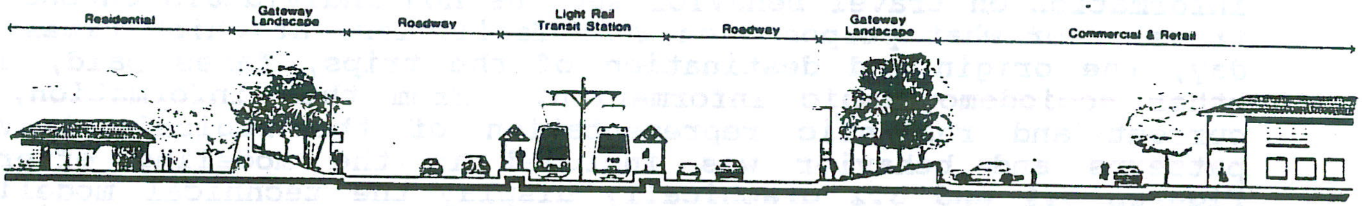
Extensive promotion included newspaper ads, radio and television features, posters on SunTran buses and in libraries, and postcard meeting notices mailed to over 2,000 people in the community. One hundred fifty (150) people attended one of two presentations scheduled during the open house. Meeting attendees received a public information packet summarizing the study findings, an agenda, and a comment form. Highlights of the comment form results showed a majority (66%) of respondents being in favor of the City conducting further studies of light rail transit, busways, and other mass transit alternatives. An additional 20% indicated they were somewhat in favor of further studies. By a margin of 2:1 comments specific to Broadway Corridor results were positive. Comments characterized as negative were skeptical about implementation or had questions about impacts, cost, and funding.

2.3 Other Presentations

During this phase, presentations about the purpose and progress of the Broadway Corridor Study were made to community groups or associations. Examples include the San Clemente Neighborhood Association in the Broadway/Alvernon area; the San Hughes Neighborhood Association, encompassing the area north of Broadway between Country Club and Campbell; and the Downtown Business Association. In addition to these activities, the project team responded to individuals with inquiries or requests for information by phone and in informal meetings throughout the study.

BROADWAY CORRIDOR STUDY

3.0
Travel Demand Forecasting Procedures and Assumptions



3.0 TRAVEL DEMAND FORECASTING PROCEDURES AND ASSUMPTIONS

This section briefly describes the methods and models used to estimate future travel in the Tucson area, and the key assumptions which shape the results of these forecasts. A series of documents has previously been prepared which details the travel forecasting procedures and models used in this analysis. These reports are on file at the City of Tucson Department of Transportation offices.

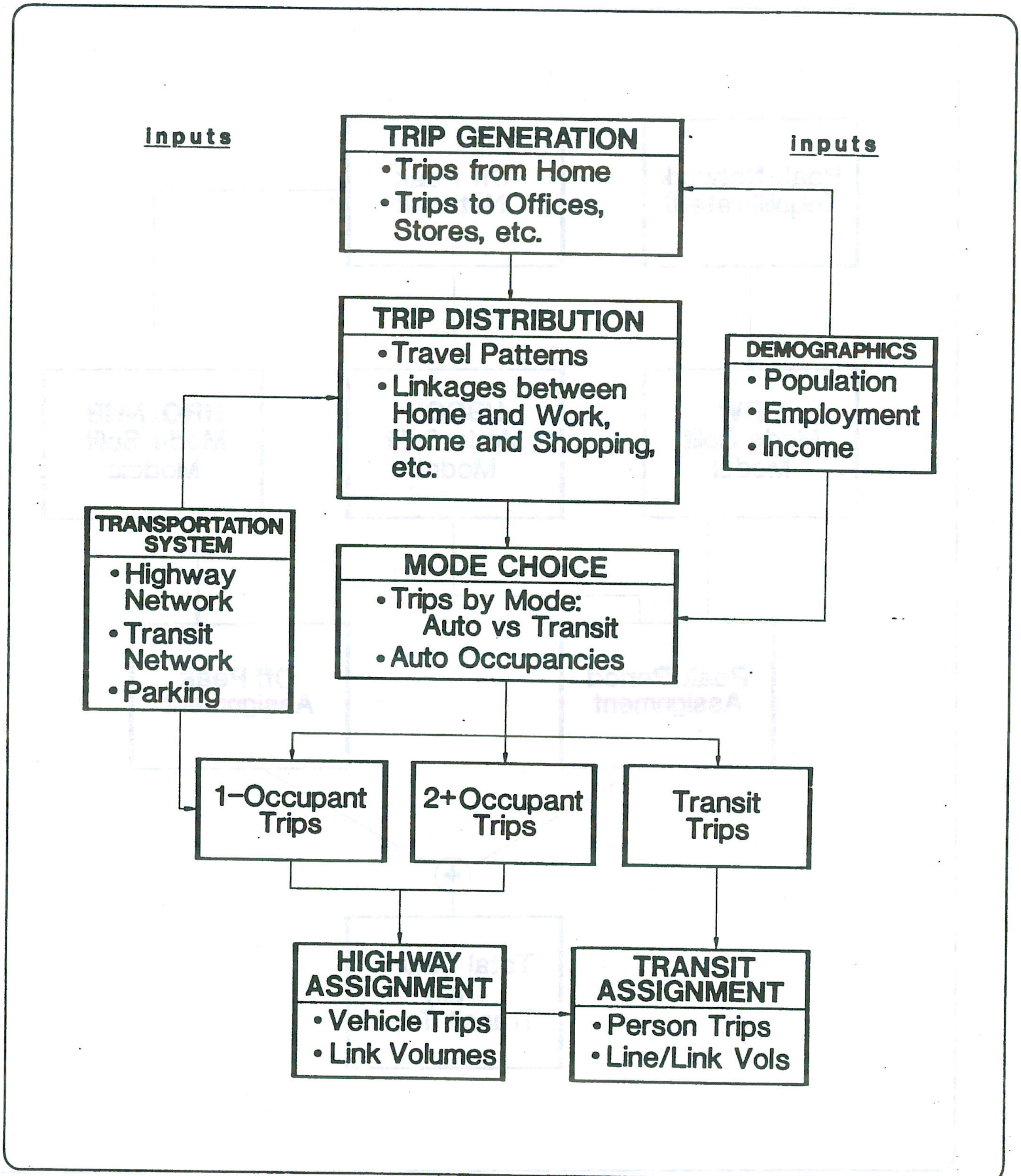
The travel forecasts were used to predict the impact of the various transportation alternatives serving the future demand of this major east/west corridor. The future regional travel demand was estimated using a series of mathematical models developed specifically for Tucson. The models were tailored to the Tucson area by using the Pima Association of Governments (PAG) data base and the information collected during the On-Board Survey conducted for SunTran in 1988. These two sources include information on travel behavior such as how individuals choose to travel, for what purpose, on what facilities, at which times of day, the origin and destination of the trips, fares paid, and other sociodemographic information. From this information, a current and realistic representation of the region's travel patterns and behavior was included in the modeling effort. Figures 3.1 and 3.2 graphically display the technical modeling process.

The travel data were carefully collected so they could be statistically used to forecast future travel demand based upon a set of easily forecasted demographic information. These include estimates of future population and employment and descriptions of the future transportation system. With this information the models can forecast the amount and location of person travel in the Tucson area. The models were developed to simulate travel for the 1987 base year. When the model was validated as accurately simulating 1987 travel, and confidence established among the reviewing agencies, then the exercise of applying the model to the year 2010 was undertaken.

The model estimates travel in four basic steps:

- trip generation,
- trip distribution,
- mode choice, and
- facility assignment.

The initial step, trip generation, geographically determines the amount of travel activity that the land use will generate, e.g. employment centers versus residential neighborhoods. The second step, trip distribution, links and disperses the generated travel by identifying origin and destination pairs. Mode choice then evaluates the various transportation options available and disaggregates the total demand by travel mode. The final step, facility assignment, is where the demand is placed on the various facilities. Each of these steps is briefly discussed below.



TRAVEL FORECASTING PROCESS

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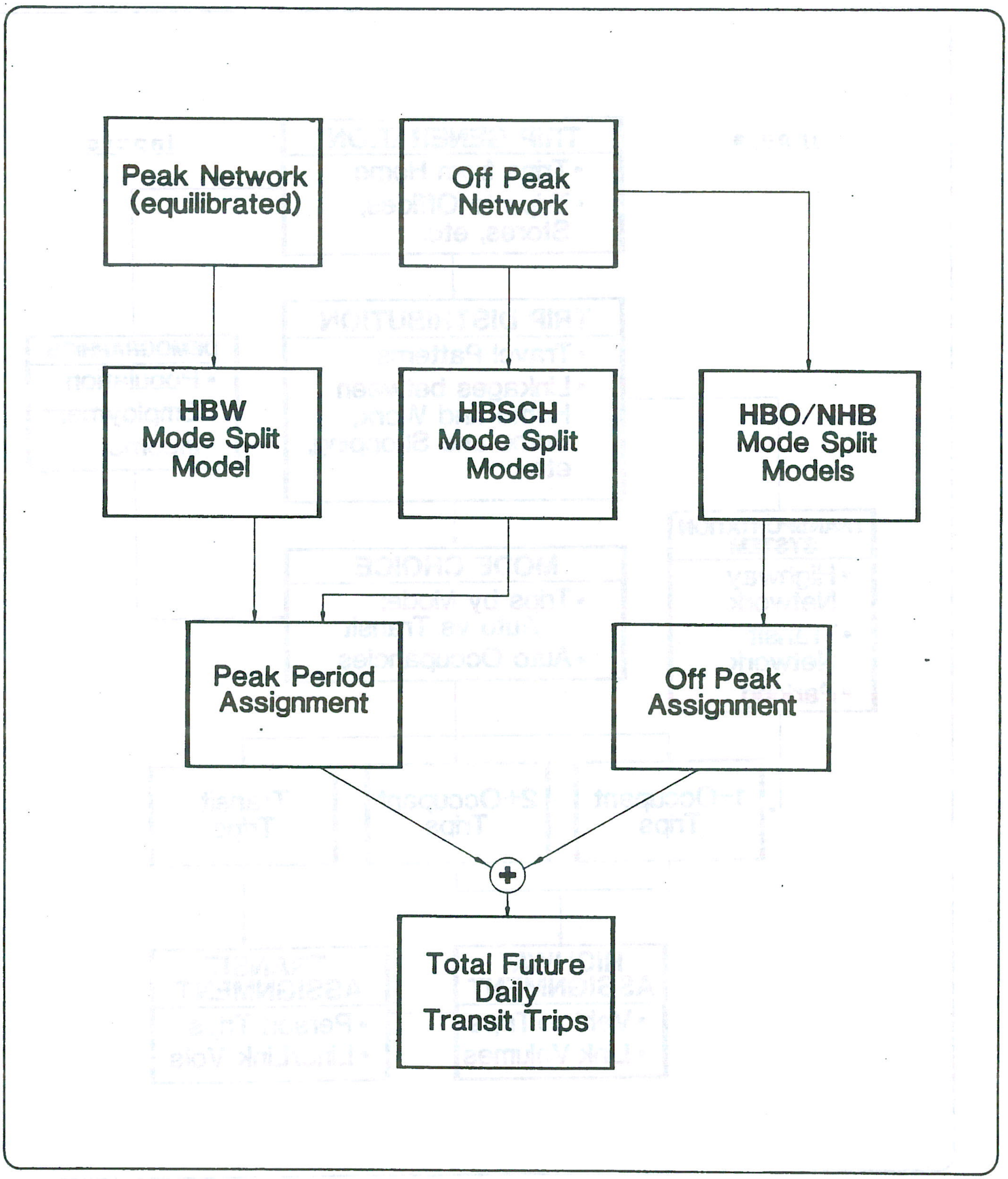
3.1 figure



TRANSIT FORECASTING PROCEDURE

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3.2 figure

The **trip generation** step estimates the number of person trips made on an average weekday by residents of the region. This is based upon characteristics of the household producing the trip (family size and income level) and the activities attracting the trips (jobs, shopping, medical offices, etc.). These "productions" and "attractions" are tabulated by geographic areas called traffic analysis zones (TAZs). The Tucson region is divided into 501 TAZs. The key inputs to the trip generation model are forecasts of the number and location of future households and employment by type. The land use forecasts used are the PAG regionally adopted forecasts. The forecasts of the geographic location and intensity of future population and employment shape the estimates of future travel demand more than any other inputs to the travel forecasting process.

Trip distribution is the process of estimating the trip linkages between the trip productions and trip attractions created during the trip generation step. This model estimates these trip interchanges based upon the number of trip productions and attractions in each TAZ and the amount of time estimated to travel between each pair of zones. The time required to travel between zones is estimated based upon the definition of the transportation system assumed to be in place in the future. The transportation system for each alternative is made up of two networks, one highway and one transit, which describe the system in terms of location, capacity, and travel speed of the roadway and transit components. All of the alternatives contain a common highway network which assumes additional committed improvements and enhancements over the current network in the Tucson region. The committed improvements and enhancements to the highway network will provide increased mobility to many areas in the year 2010, and hence, will have a significant influence on the distribution of trips.

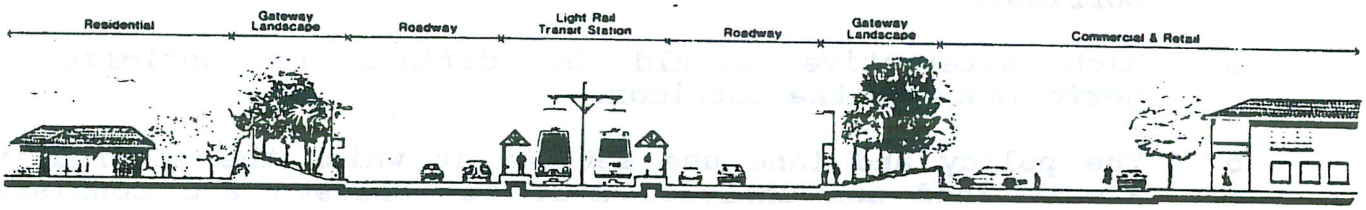
Once the regional travel has been distributed and the zone pairs linked, **mode choice** is the step that determines which mode of travel - driving alone, carpooling, or transit - a person will choose for a given trip. Numerous studies have shown that people choose a trip mode based upon the relative levels of services - travel time and cost - offered by the competing modes for that trip. Furthermore, these studies show that travelers value components of travel time differently. For instance, time spent waiting for a transit transfer or transit ride is considered more onerous than the time spent riding in the transit vehicle. Travel times and costs for each zone-to-zone trip are estimated separately from the highway and transit networks and input to the mode choice model along with characteristics of the trip makers (income and proximity to transit) and characteristics of the trip destination (parking times and costs). The output of the model is forecasts of the number of people for each zone-to-zone movement who are likely to choose driving alone, carpooling, and transit. The mode choice model was developed and calibrated from data collected during the On-Board survey and, therefore, reflects the local attitudes and travel behavior characteristic of the Tucson area.

The final step in the travel forecasting process is the **assignment of trips** to the specific facilities in both the highway and transit networks. The trips, by mode, from the mode choice model are assigned to the respective highway and transit networks. Person trips are converted to vehicle trips for highway assignment, and the zone-to-zone vehicle trips are assigned to the specific roadways based on the premise that people will choose the fastest path between the origin and destination zone. Highway assignment accounts for congestion by slowing down the speed of a facility as the number of vehicles assigned approaches the capacity of the facility. The result is a tabulation of the average weekday traffic volume on each facility in the highway network.

Transit assignment works in a similar manner. Transit person trips from the mode choice model are assigned to the network representing transit services as defined by the respective alternative. Again, each group of zone-to-zone trips are assigned to the fastest path, including time required to wait for or transfer among transit vehicles. The result is a tabulation of the number of persons forecasted to ride each transit line in the alternative's transit system.

BROADWAY CORRIDOR STUDY

4.0 Summary of the Transit Alternatives



4.0 SUMMARY OF THE TRANSIT ALTERNATIVES

4.1 Development of Alternatives Process

The public transit alternatives presented in this section of the report have been carried through the full analysis process. These represent the final definition of alternatives which provided the basis for developing the capital costs, operating and maintenance costs, and transit ridership estimates.

The process for developing these final alternatives has been evolutionary and has followed UMTA's guidelines while considering local desires. UMTA uses the following considerations in evaluating the adequacy of the transit alternatives proposed for analysis:

- The alternatives must, within the limits of the technology, respond to the transportation needs identified in the study corridor.
- Each alternative should be defined to optimize its performance in the corridor.
- The policy and land use setting in which the alternatives are defined and analyzed must be unbiased and consistent across the alternatives.
- The alternatives must be defined in all dimensions, including their operating plans, fare policies, etc.
- To the extent possible, the alternatives should be designed initially with environmental considerations in mind.
- The mode and alignment alternatives must be significantly different, or they are simply design variations that can be resolved in later engineering work.

Four conceptual alternatives were developed during Phase I of the Broadway Corridor Study. These four alternatives were further refined in terms of possible alignments, operating characteristics, and other considerations which resulted in 13 preliminary alternatives described in the December 1988 report, Preliminary Definition of Alternatives. Based on UMTA guidelines and policies, City of Tucson Department of Transportation staff review, input from the Technical Advisory Committee, and the review by the Broadway Corridor Community Coordination Forum, 11 alternatives were developed for further definition and analysis.

The 11 alternatives, described in the September 12, 1989 report, Detailed Definition of Alternatives, included the Short Range Transit Plan (SRTP), a large all-bus alternative, two busway alternatives, several light rail transit alternatives, and alternatives using electric buses in a busway. The operating plan for each alternative has undergone an incremental analysis and review as described in the following sections to balance the supply and demand (called equilibration) of transit services.

This process maximizes the economic efficiency of the transit system alternatives.

4.2 Summary Description of the Alternatives

A summary description of the 11 alternatives analyzed are given below. Even though this study is directed toward the transit or fixed guideway options, a companion highway network, consistent for all 11 alternatives except as modified by the transit elements, is assumed for each alternative in our forecast year of 2010. More detailed descriptions of the number of buses, rail vehicles, costs, etc., are given in later sections of this report.

Alternative 1 - Short Range Transit Plan (Do Nothing)

The "Do Nothing" alternative is mandated as a necessary alternative for analysis by UMTA. For study purposes, this alternative assumed implementation of the Short Range Transit Plan (SRTP) for the transit component and implementation of the "existing + committed + reasonable" highway elements of the adopted Regional Transportation Plan (RTP) as shown in Figure 4.1.

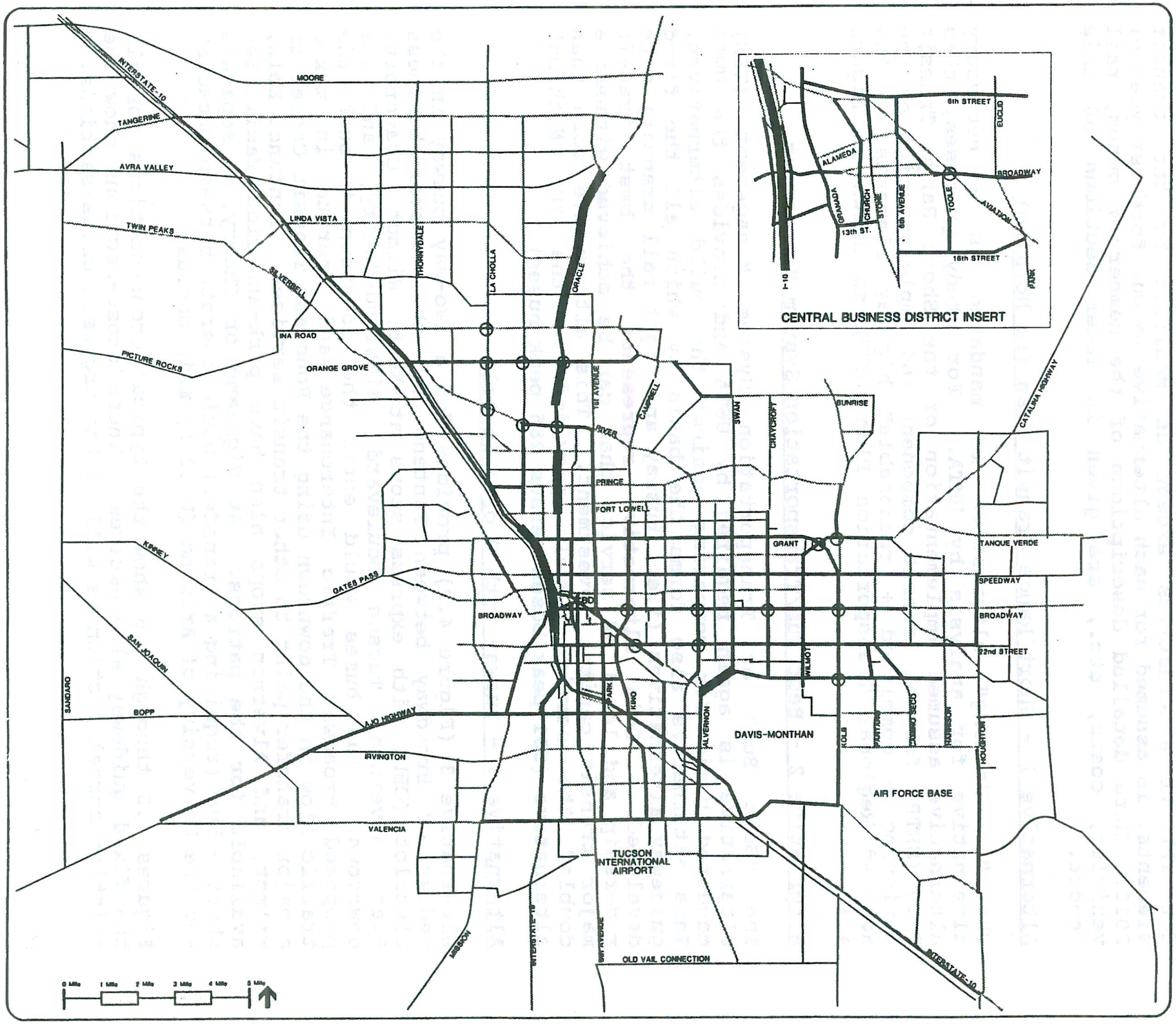
Alternative 2 - Best Bus/Transportation System Management

The "Best Bus" or Transportation System Management (TSM) alternative is again required by UMTA and provides the UMTA mandated basis for comparing against the build alternatives. This alternative also forms the basis by which all the fixed guideway alternatives (i.e., busway and light rail transit) were developed. This alternative represents the best transit ridership and level of service that can be achieved without a major transit capital investment. This alternative more than doubled the service levels provided in the "Do Nothing" alternative (581 peak buses versus 285 peak buses).

Alternative 3 - Busway with U of A Shuttle

Alternative 3 (Figure 4.2) provides for a two-way busway in the median of Broadway between Pantano and the central business district (CBD) with express stops at Kolb, Wilmot, Craycroft, Swan, Alvernon, Tucson Boulevard, Highland-Cherry, and the downtown. The buses would enter the downtown through the proposed Broadway Traffic Interchange and operate in mixed traffic flow in the downtown using the Ronstadt Transit Center as a major transfer point to other transit services. Pantano, Kolb, Wilmot, and Alvernon stops also have park-and-ride facilities available for the patrons. At Highland or Cherry, a separate shuttle bus (requiring a transfer) would operate between Broadway and the University of Arizona (U of A) main campus.

Figures 4.3 through 4.6 show the typical cross-sections for all the fixed guideway alternatives. These cross-sections show the existing street section as well as the proposed cross-sections.



YEAR 2010 BASE HIGHWAY NETWORK

- 2 Lane
- 4 Lane
- 6 Lane
- 8 Lane
- Grade Separated Intersection

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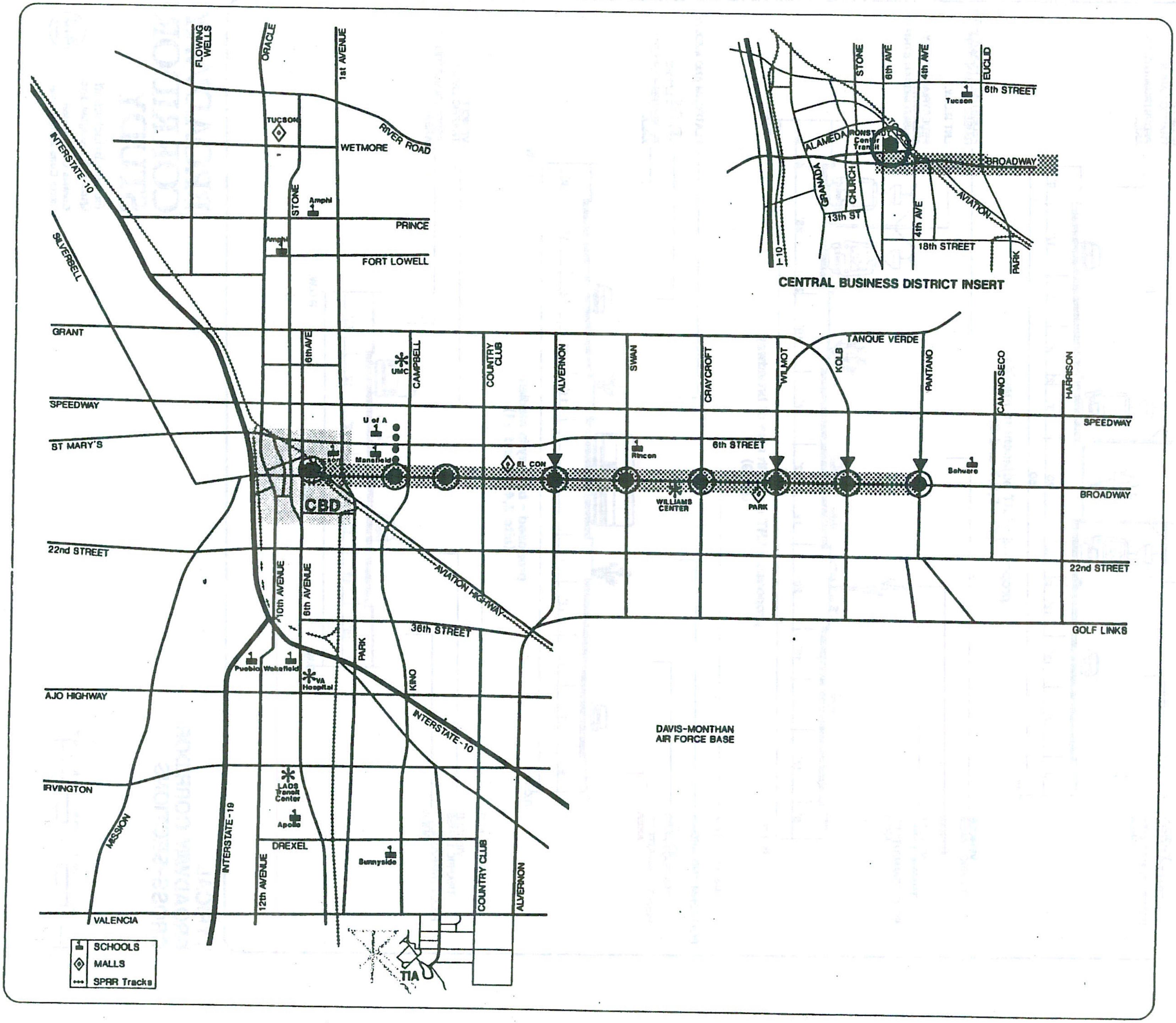
4.1 figure



ALTERNATIVE 3: BUSWAY WITH SHUTTLE TO UA

- Busway
- UA Shuttle
- Park and Ride Lots
- Stations
- Best Bus Network

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4.2 figure

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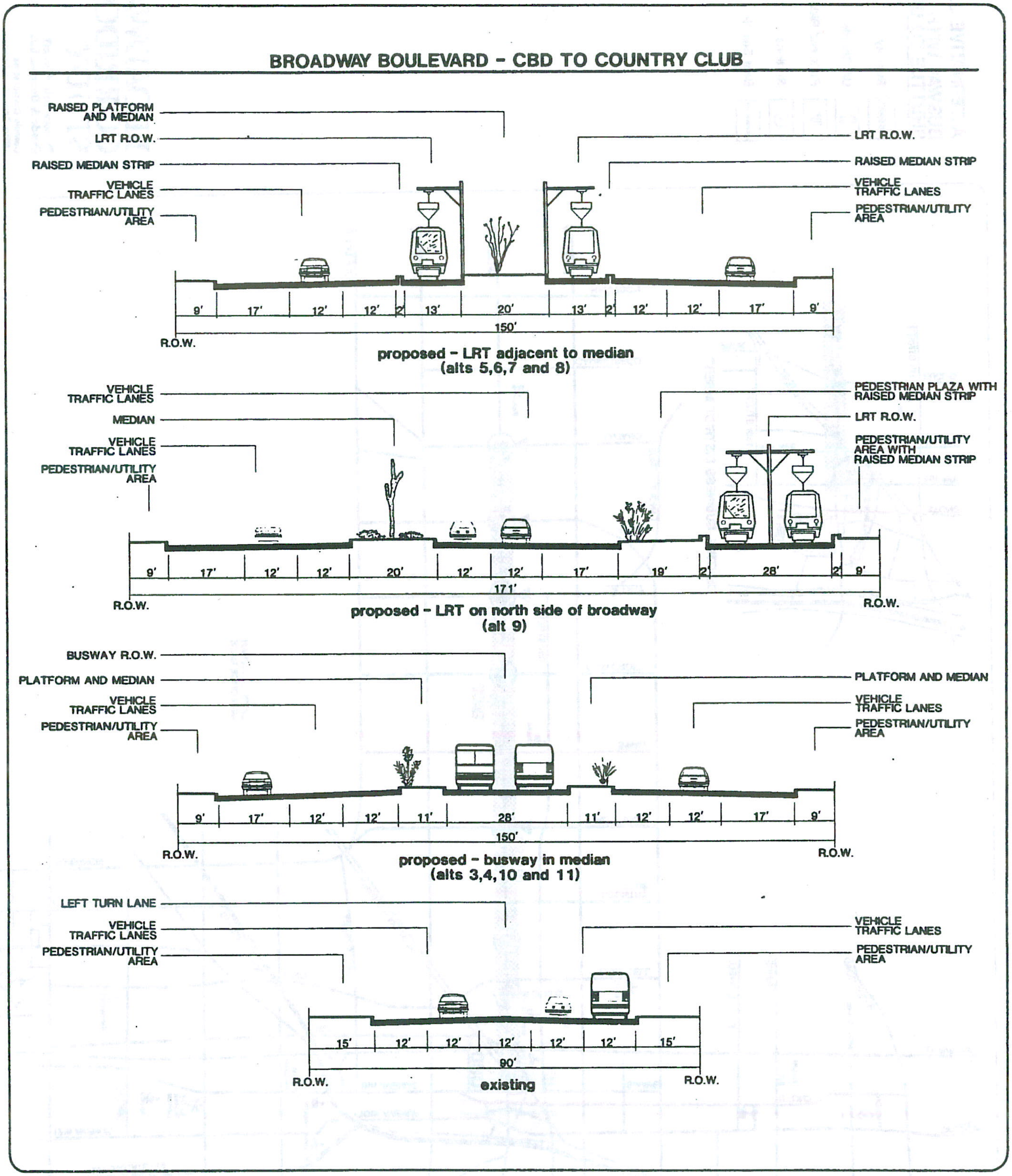
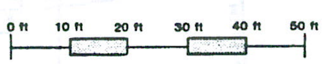


TYPICAL BROADWAY CORRIDOR CROSS-SECTIONS



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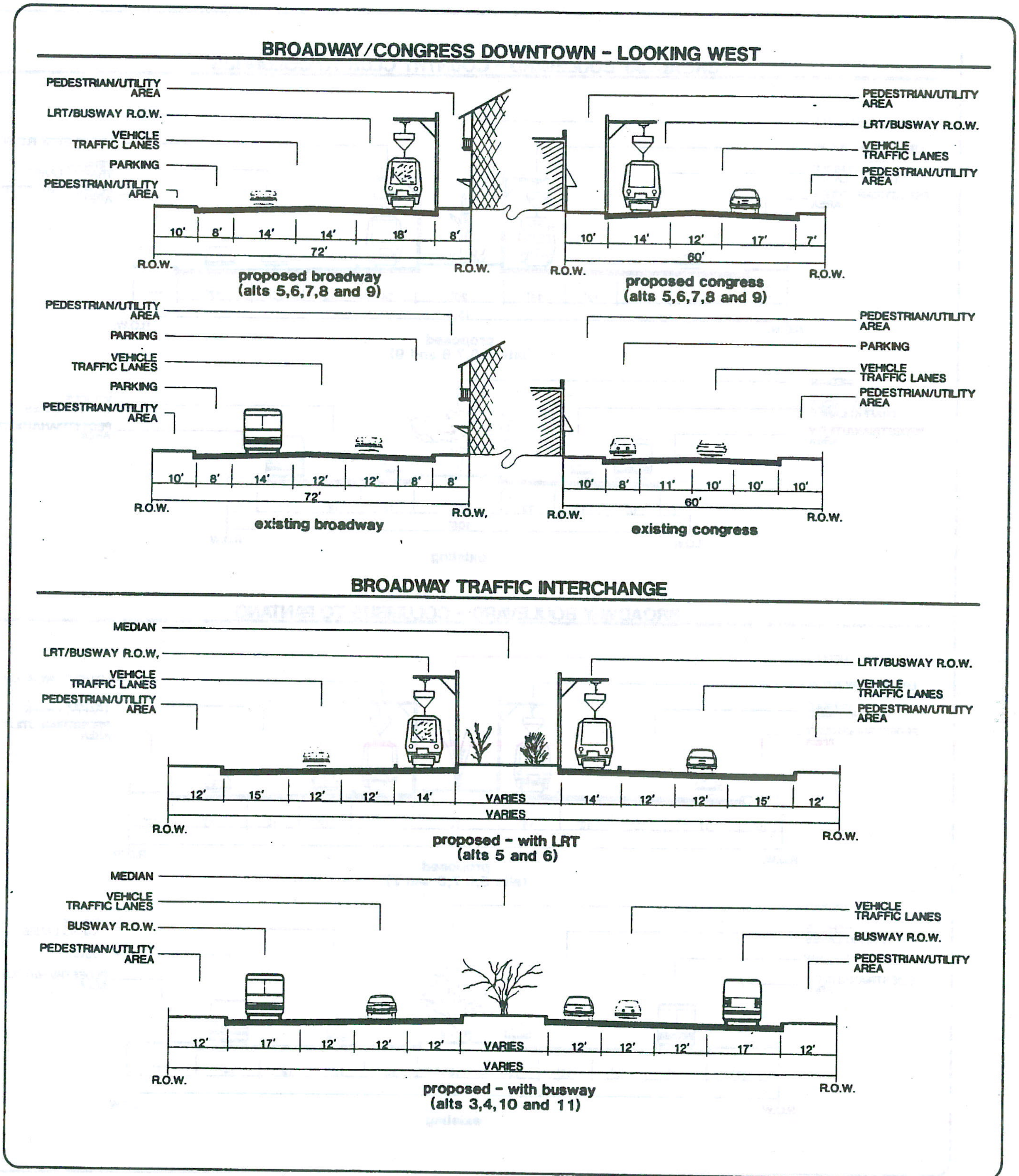
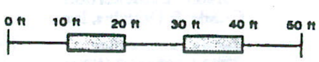
4.3 figure



TYPICAL BROADWAY CORRIDOR CROSS-SECTIONS



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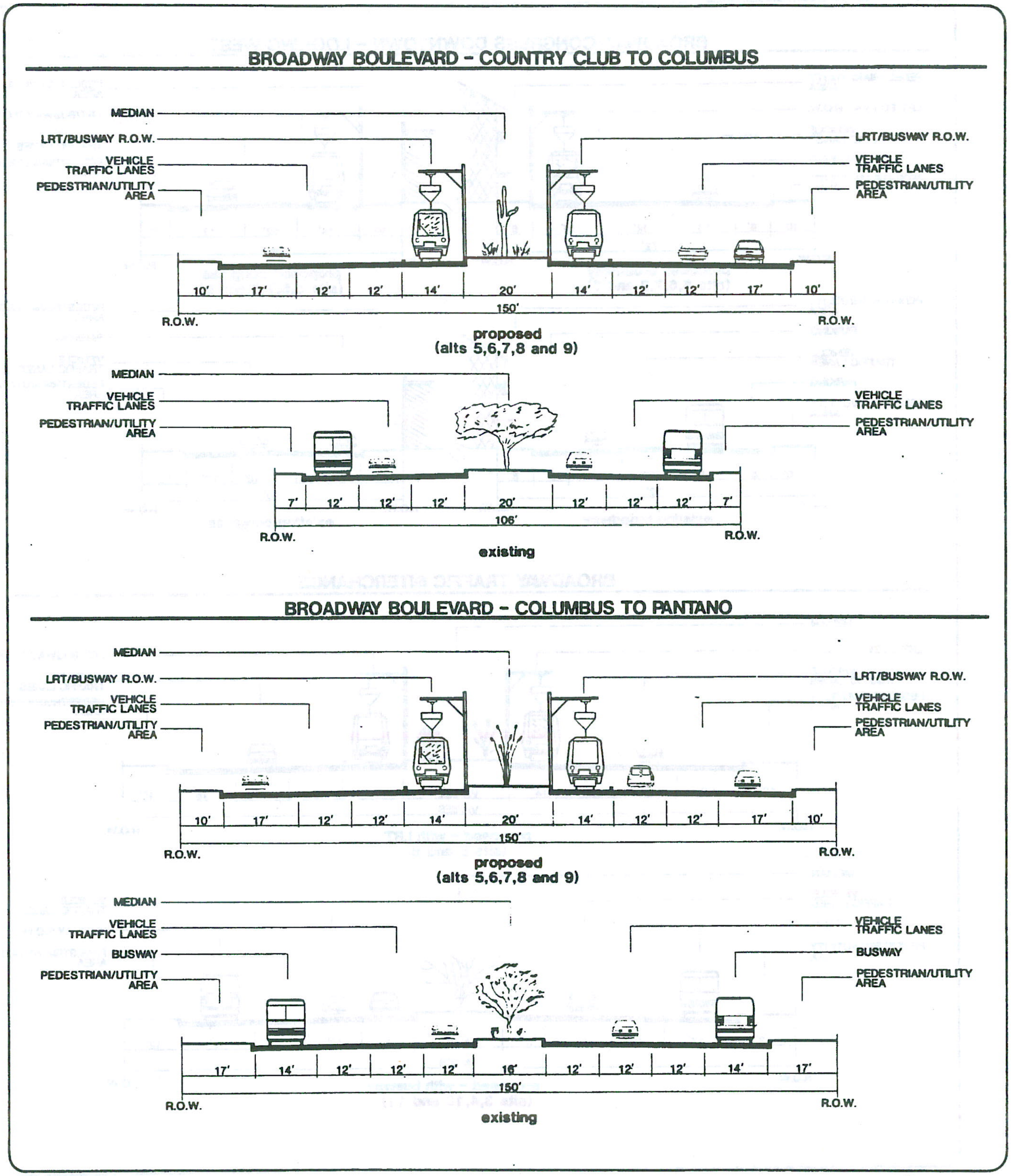
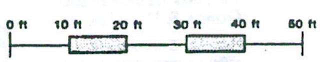
4.4 figure



TYPICAL BROADWAY CORRIDOR CROSS-SECTIONS



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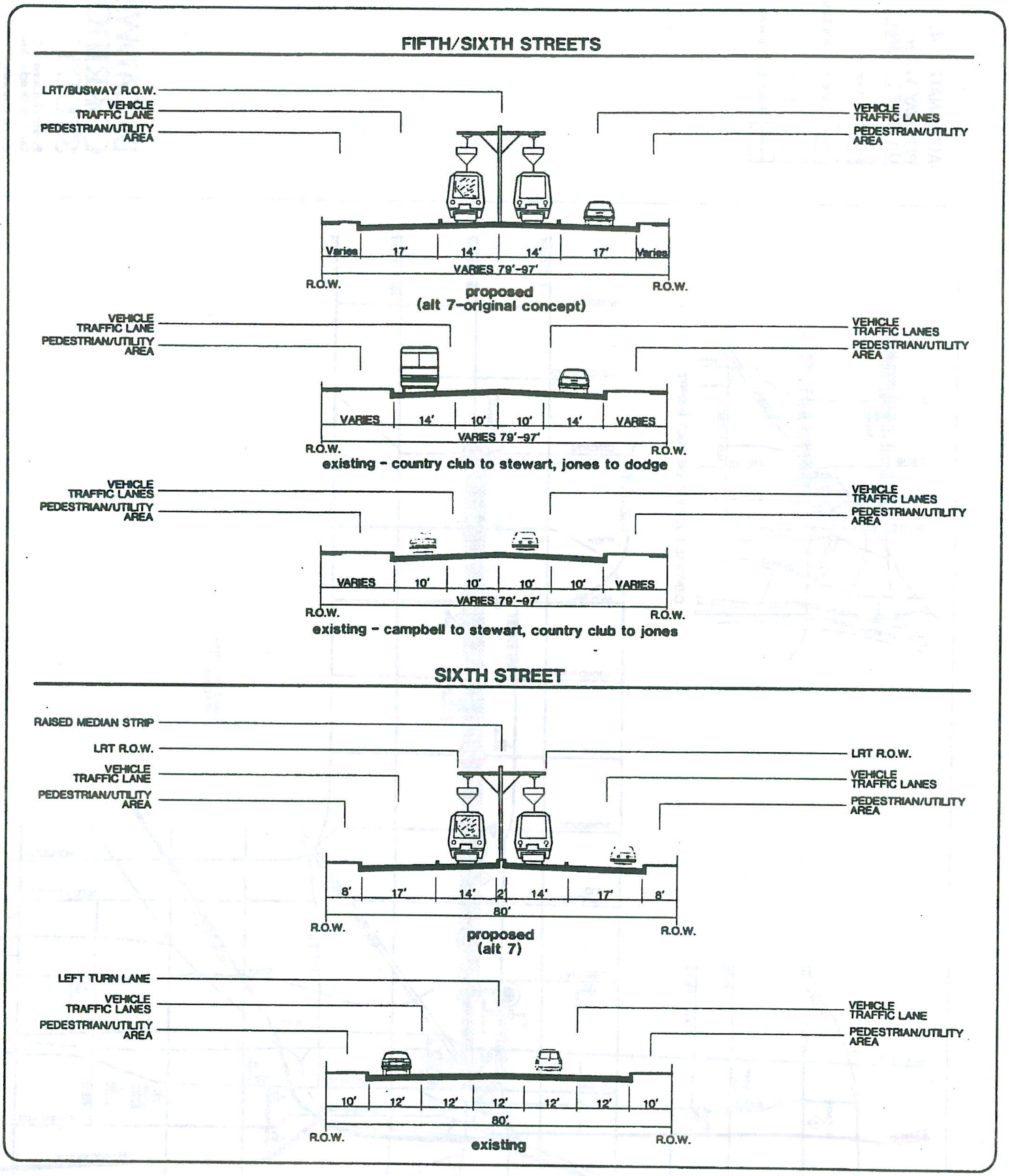
4.5 figure



TYPICAL BROADWAY CORRIDOR CROSS-SECTIONS

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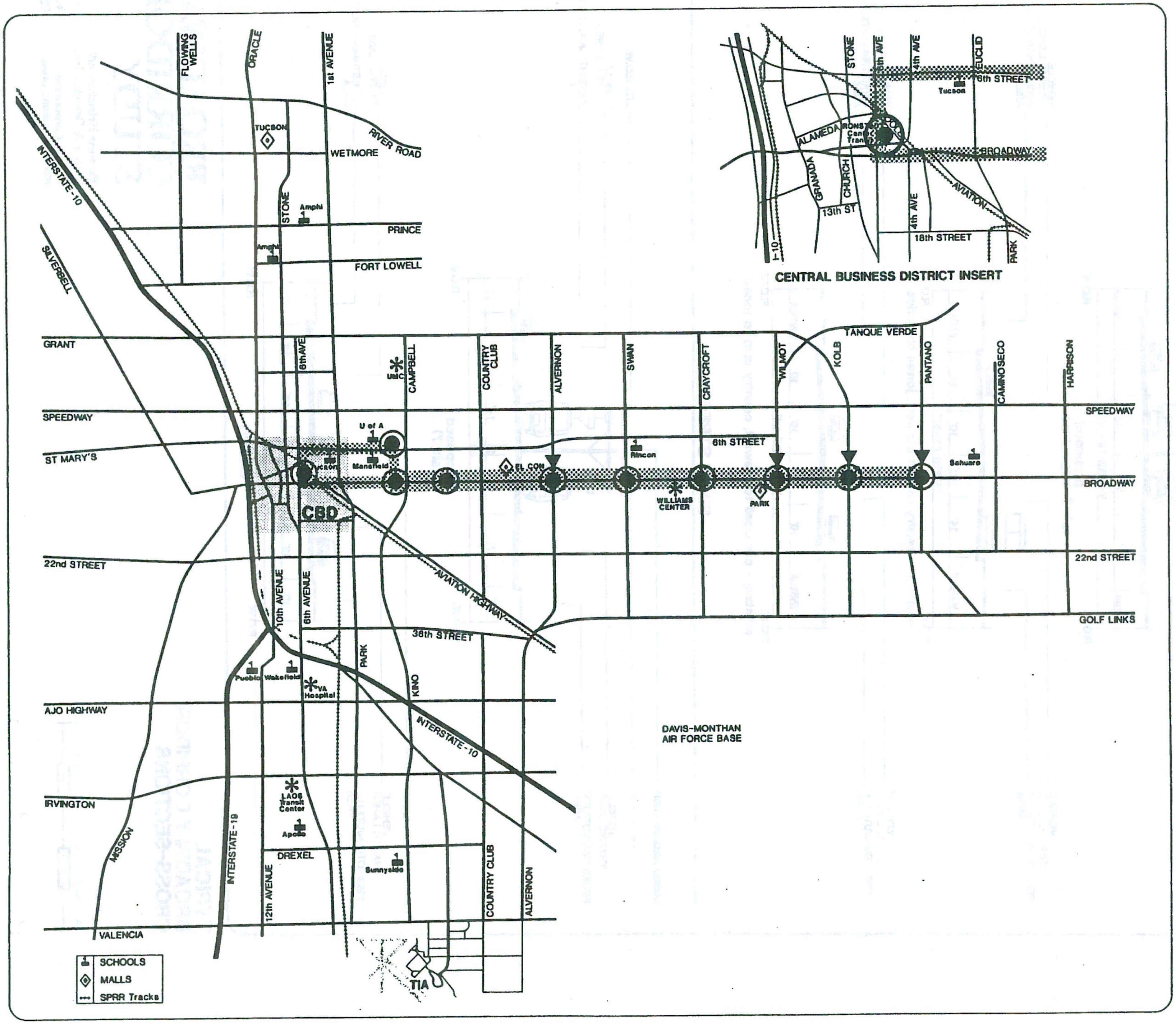
4.6 figure



ALTERNATIVE 4:
BUSWAY WITH UA DIRECT LINK

- Busway
- Park and Ride Lots
- Stations
- Best Bus Network

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For example, Figure 4.3 shows the typical cross-sections for Broadway Boulevard from the CBD to Country Club. Existing Broadway Boulevard right-of-way width varies from 90 feet (CBD to Country Club) to 106 feet (Country Club to Columbus - Figure 4.5) to 150 feet (Columbus to Pantano). The busway cross-section shown in Figure 4.3 would extend from the CBD to Pantano. Figure 4.4 shows the busway cross-section as it would enter and leave the CBD through the proposed Broadway Traffic Interchange.

<u>Alternative 4 - Busway with U of A Direct Link</u>

Alternative 4 (Figure 4.7) provides for a two-way busway in the median of Broadway with a similar design and express stop concept as developed in Alternative 3. Operationally, the major express bus routes would be split thereby providing direct service to the University of Arizona campus (rather than a shuttle service from Broadway which requires a transfer) and to the CBD. The U of A connection would route the Broadway buses via Campbell, Sixth Street, and Stone to the downtown in regular mixed traffic flow operations.

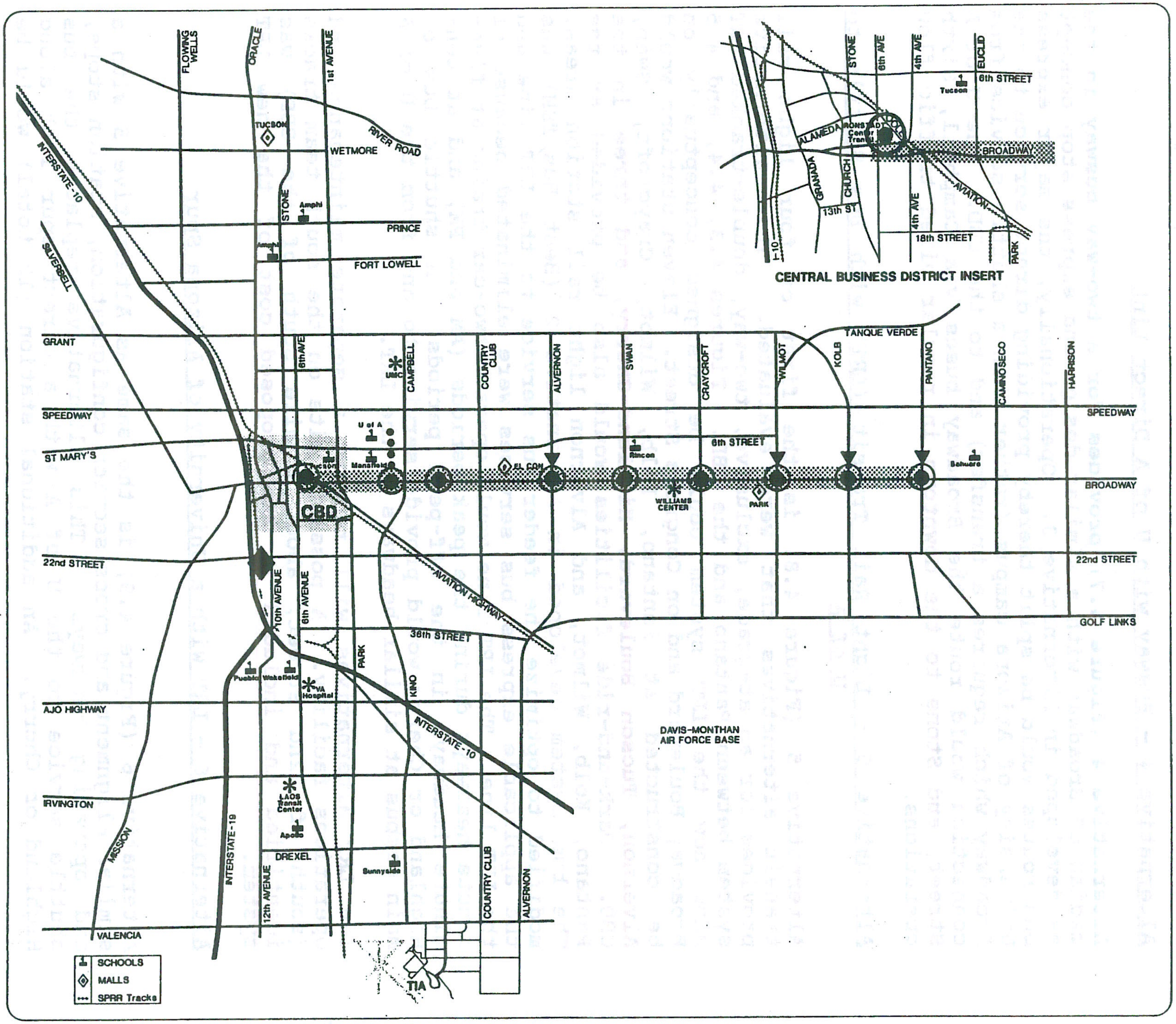
<u>Alternative 5 - Light Rail Transit (LRT) with Bus Shuttle to U of A</u>

Alternative 5 (Figure 4.8) is the first of four light rail transit alternatives that were evaluated. This alternative provides for an at-grade, exclusive, two-way, double-tracked LRT system between Pantano and the CBD. Figures 4.3, 4.4, and 4.5 show how the LRT system could be designed conceptually on Broadway Boulevard and on Congress Street. Eleven stations would be constructed at Pantano, Kolb, Wilmot, Craycroft, Swan, Alvernon, Tucson Boulevard, Highland-Cherry, and three in the CBD. Park-and-ride facilities would also be provided at the Pantano, Kolb, Wilmot, and Alvernon light rail station areas. The bus system developed in Alternative 2 (Best Bus/TSM) was modified to optimize the feeder bus service to the LRT line and the applicable express bus services were eliminated because of the LRT line. The LRT line would operate two-car trains at five-minute headways during the peak periods (AM and PM) and at ten-minute headways in the off-peak periods. A shuttle bus on Highland or Cherry would provide service to and from the U of A main campus at similar headways as the LRT.

The LRT alternatives will require a separate maintenance and operations facility. A possible site on the south team tracks (south of 22nd Street; about 1 mile south of the CBD) was identified and included in the proposed cost of the new LRT system.

<u>Alternative 6 - LRT with a University of Arizona Spur</u>

Alternative 6 (Figure 4.9) is the same as Alternative 5 with a similar alignment and cross-section configuration, station stops, and operating headways. This alternative replaces the bus shuttle service to the U of A with a direct spur link along Highland or Cherry. An additional station (12 total) would be



ALTERNATIVE 5: LIGHT RAIL TRANSIT WITH SHUTTLE TO UA

- Light Rail Transit
- UA Shuttle
- Park and Ride Lots
- Stations
- Best Bus Network

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4.8 figure

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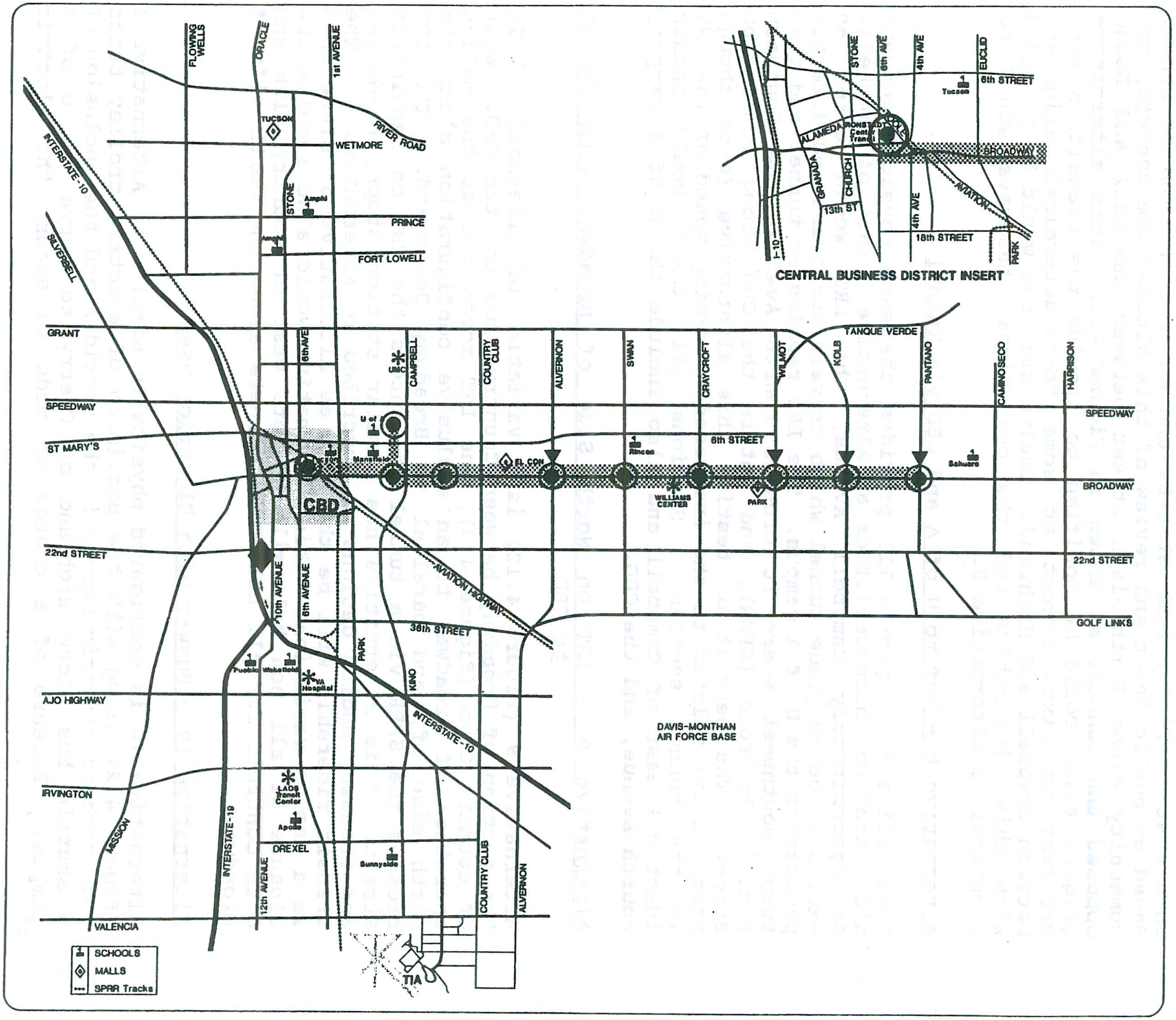

ALTERNATIVE 6: LIGHT RAIL TRANSIT WITH UA SPUR

- Light Rail Transit
- Possible LRT Maintenance and Operation Facility
- Park and Ride Lots
- Stations
- Best Bus Network

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4.9 Figure

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needed at the U of A. From an operations concept, every other train would serve the U of A campus with the terminus at Highland or Cherry and Sixth Street.

Alternative 7 - LRT to CBD via Sixth Street

This alternative as originally defined was similar to Alternative 5 east of Alvernon. The LRT line then headed north on Dodge and then west on Fifth/Sixth Streets and entered the CBD on Stone. Based on public input and review of this alternative concept, the community along Fifth/Sixth Street between Campbell and Dodge opposed the concept as shown in Figure 4.6. This alternative (Figure 4.10) could be modified to provide the transition from Broadway to Sixth Street at some to-be-determined alignment between Campbell and Highland. Twelve stations would be provided with this alternative and the operational headways would be identical to Alternative 5.

Alternative 8 - LRT to U of A and CBD via Tunnel

Alternative 8 (Figure 4.11) provides the same physical concept and operating characteristics as Alternative 5 east of Campbell. At approximately Campbell Avenue, the LRT would enter an exclusive below-grade tunnel which travels northwest and directly penetrates the U of A campus. The LRT remains in tunnel and then turns southwest where it crosses Fourth Avenue, the Southern Pacific Railroad (SPRR), and enters the CBD along Pennington Street. The benefit of testing this alternative (even though more costly) related to the increased operating speed of the LRT in the tunnel section. Stations (11 total) would remain identical east of Campbell and also include the U of A campus, Fourth Avenue, and the CBD.

Alternative 9 - LRT on North Side of Broadway with Tunnel to CBD

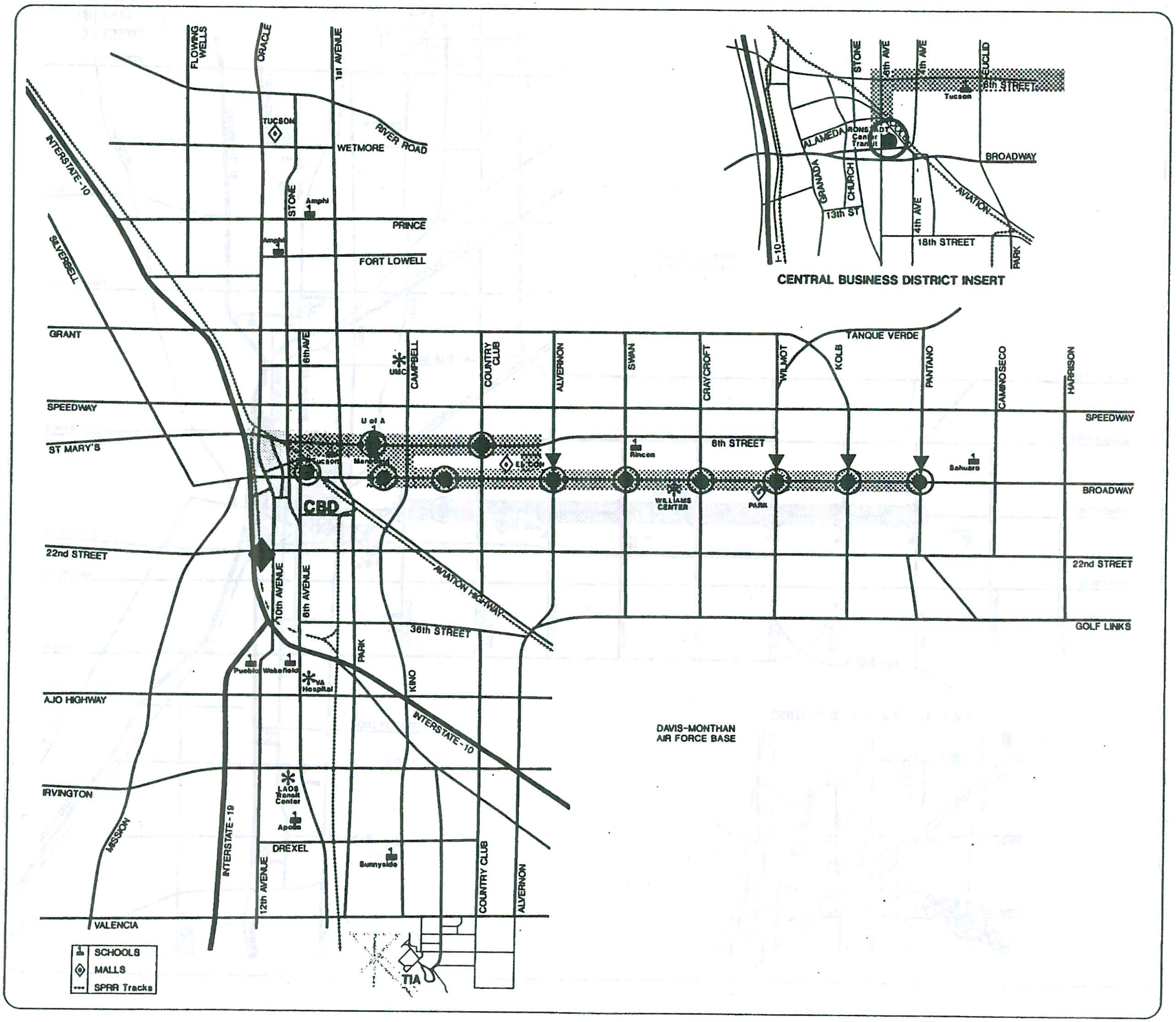
Alternative 9 (Figure 4.12) is a variation of Alternative 5 in the section of Broadway between Country Club and the CBD. West of Country Club (Figure 4.3), the LRT moves out of the median operation of Broadway to an exclusive configuration along the north side of, and parallel to Broadway Boulevard. The LRT crosses the SPRR via a tunnel and enters the CBD on Pennington Street. This alternative has similar station stops, headways, and Broadway median designs as described in Alternative 5. The transit ridership will be the same as Alternative 5, since this is a design variation. This alternative would also require the closure of all non half-mile streets west of Country Club and gate controls for all half-mile streets along the north side of Broadway.

Alternative 10 - Busway with Electric Buses

Alternative 10 is configured physically similar to Alternative 3 (Figure 4.2) along with the provision of electric trolley buses and overhead electric supply in the corridor and the inclusion of a shuttle bus along Highland or Cherry to serve the U of A campus. Because of a change of mode to access the electric

ALTERNATIVE 7:
LIGHT RAIL TRANSIT VIA SIXTH STREET

- Light Rail Transit via 6th Street
- Possible LRT Maintenance and Operation Facility
- Park and Ride Lots
- Stations
- Best Bus Network



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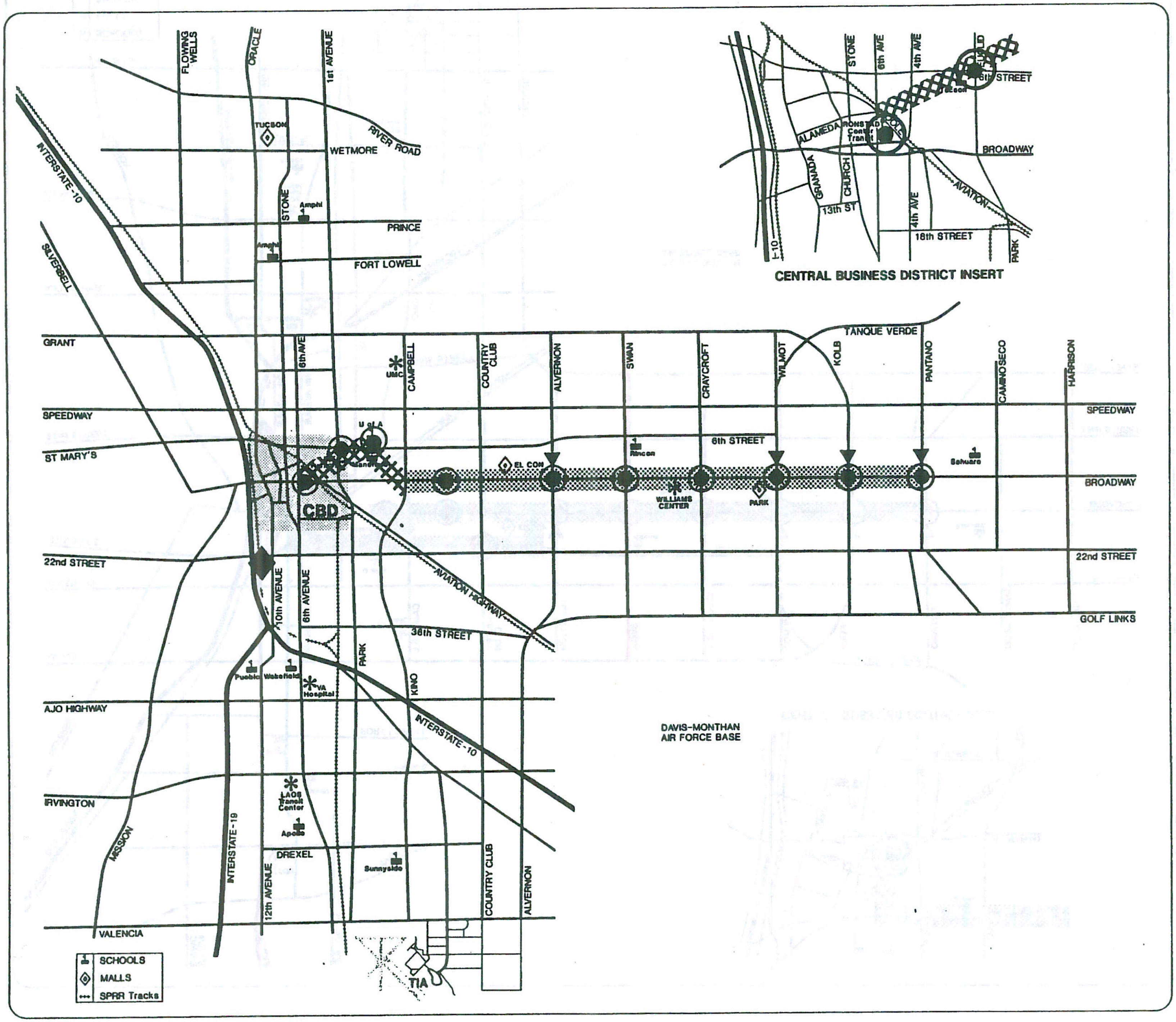
ALTERNATIVE 8:
LIGHT RAIL TRANSIT TO UA AND TO DOWNTOWN VIA TUNNEL

- Light Rail Transit
- LRT via Tunnel
- Possible LRT Maintenance and Operation Facility
- Park and Ride Lots
- Stations
- Best Bus Network



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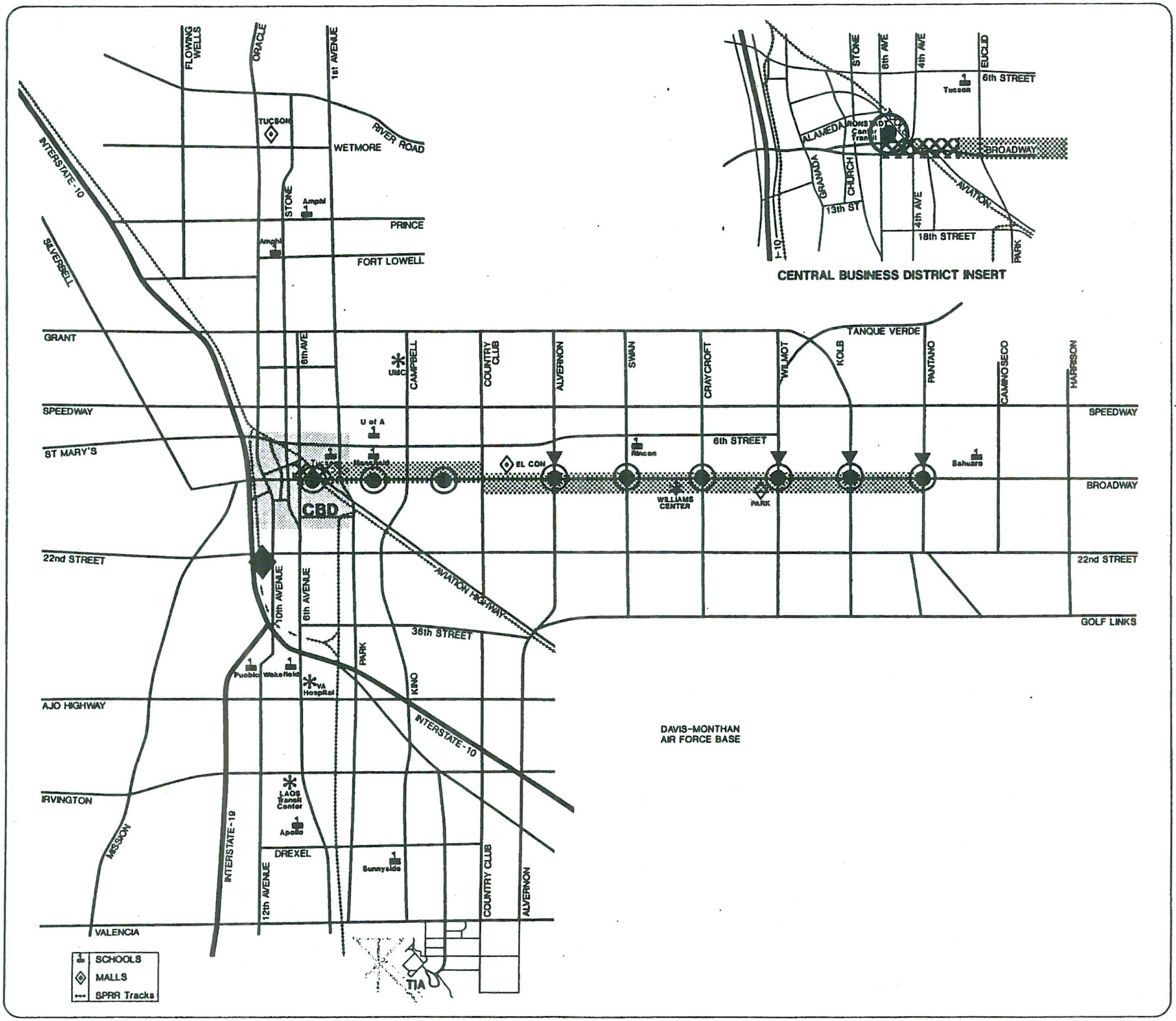
ALTERNATIVE 9:

LIGHT RAIL TRANSIT ON NORTH SIDE OF BROADWAY WITH TUNNEL TO CBD

- Light Rail Transit
- LRT via Tunnel
- Possible LRT Maintenance and Operation Facility
- Park and Ride Lots
- Stations
- Best Bus Network



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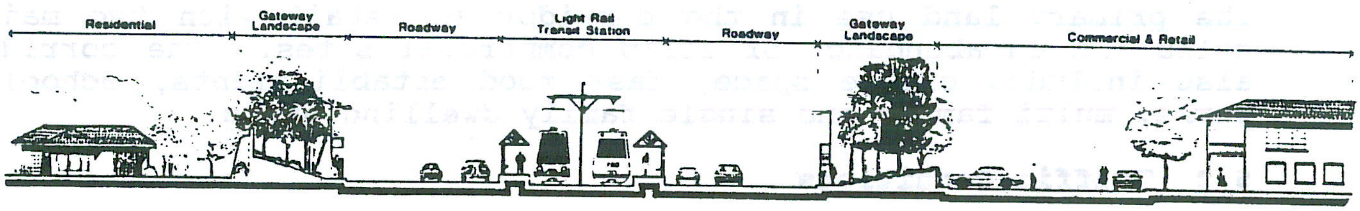
BROADWAY CORRIDOR STUDY

5.0 Current Conditions



5.0 CURRENT CONDITIONS

This section includes an overview of the sociodemographic characteristics, current traffic conditions, and transit service provided within the Broadway Corridor.

5.1 Travel Markets

As mentioned in Chapter 3, the location and intensity of population and employment shape travel demand more than any other factors. Table 5.1 displays the 1987 population and employment for the region and a breakdown by major area. The population in the Broadway Corridor is 73,900, which accounts for 18 percent of the City's population and 12 percent of the County's population. The Broadway Corridor also houses a major portion of the regional employment, accounting for 19 percent or 52,600 of the 278,330 jobs within Pima County. This is over three times the employment in the CBD or at the U of A.

The primary land use in the corridor is retail with two major malls and an abundance of strip commercial sites. The corridor also includes office space, fast food establishments, schools, parks, multi-family and single family dwelling units.

5.2 Traffic Conditions

The roadway system serving the Tucson area consists mainly of major arterials. The east/west movement is primarily served by four major roadways, Grant Road, Speedway Boulevard, Broadway Boulevard, and 22nd Street. The major north/south movement is served by Interstate I-10, Oracle Road, and the Campbell/Kino thoroughfare. Other facilities such as Wilmot Road and Golf Links also carry a large volume of traffic. Figure 5.1 displays the existing roadway network with the 1987 average daily traffic.

Peak hour turning movement counts were taken at thirteen intersections along Broadway Boulevard and Sixth Street in order to have a base for assessing the localized impacts of the respective alternatives. The existing intersection operations were computed based on 1989 p.m. peak hour traffic counts and utilizing a computerized version of the methodologies defined in the 1985 Highway Capacity Manual. Table 5.2 summarizes the intersection operations in terms of level of service (LOS), weighted average delay seconds and (DELAY) by which LOS is defined, and the volume to capacity (V/C) ratio. The intersection with the worst level of service is Kolb Road. Six other intersections on Broadway also have a LOS of D or worse, as shown in Table 5.2. This can be equated to an average wait of 30 or more seconds.

5.3 Current Transit Conditions

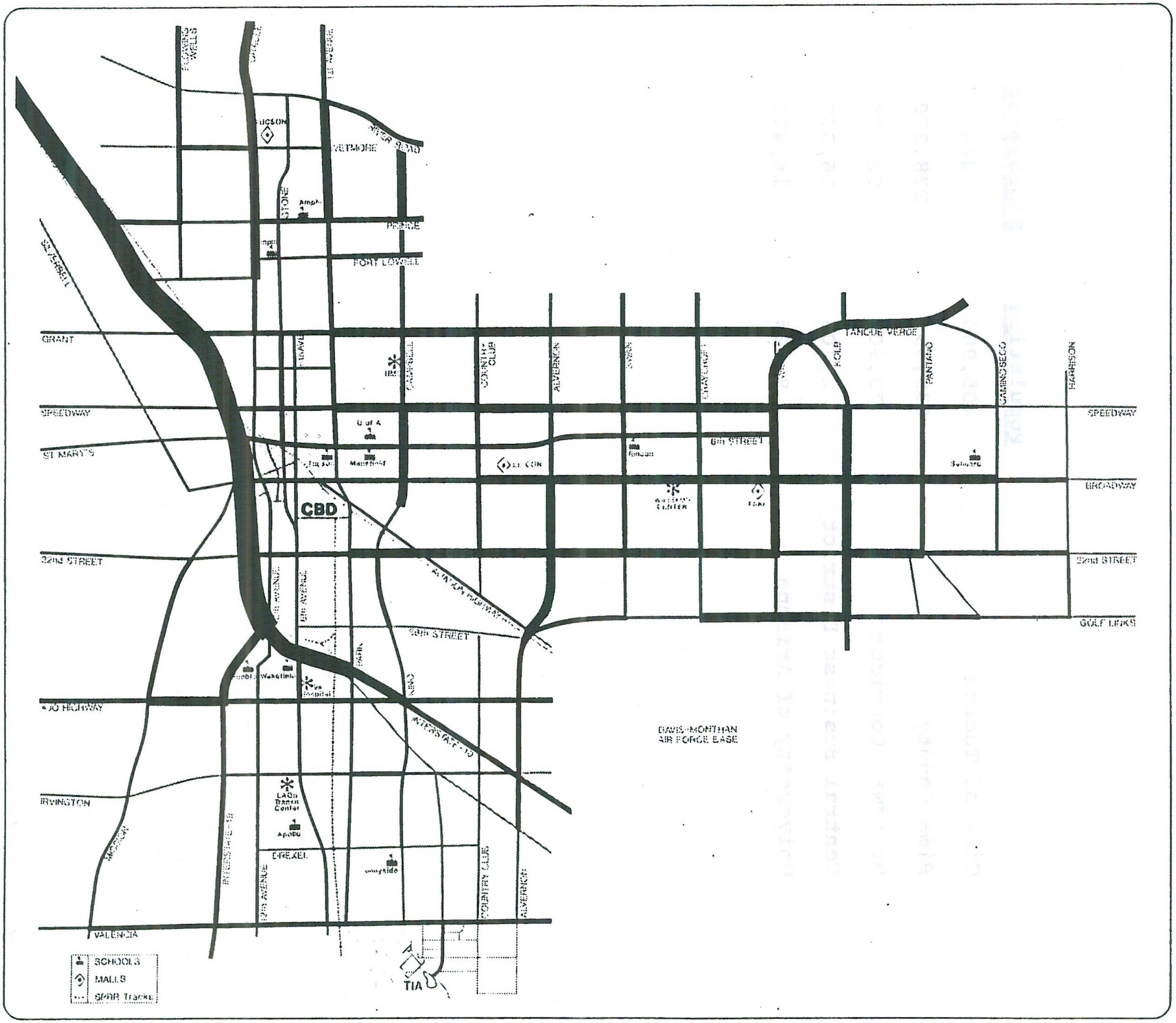
SunTran currently operates 142 buses in the a.m. peak, 87 in the mid-day and 140 in the p.m. peak. Service consists of 117 buses serving approximately 30 local routes, and 25 buses serving five express routes and several "trippers". The peak headways range

BROADWAY CORRIDOR STUDY

Table 5.1

1987 POPULATION AND EMPLOYMENT

	Population	Employment
City of Tucson	405,900	N/A
Pima County	639,990	278,330
Broadway Corridor	73,900	52,600
Central Business District	2,700	16,300
University of Arizona	9,425	16,420



1987/1988 AVERAGE WEEKDAY TRAFFIC FLOWS

- Under 10,000
- 10,001 to 20,000
- 20,001 to 35,000
- 35,001 to 50,000
- 50,001 to 70,000
- 70,001 and Above

Source:
PIMA ASSOCIATION OF GOVERNMENTS

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BROADWAY CORRIDOR STUDY

Table 5.2

EXISTING INTERSECTION ANALYSIS

Corridor Street: Broadway Boulevard

Location	LOS[1]	Delay[2] (Seconds)	V/C[3]
Euclid	B	11.0	0.63
Campbell	D	28.5	0.85
Country Club	E	40.1	0.93
Dodge	B	7.2	0.60
Alvernon	E	41.1	0.87
Swan	D	36.0	0.89
Craycroft	C	19.9	0.74
Wilmot	D	34.6	0.87
Kolb	F	60.1	0.89
Pantano	D	31.5	0.78

Corridor Street: Fifth/Sixth Street

Location	LOS	Delay (Seconds)	V/C
Stone	B	9.3	0.50
Country Club	B	9.5	0.53
Dodge	B	7.1	0.58

[1] LOS - level of service

[2] Delay - weighted average delay in seconds

[3] V/C - volume to capacity ratio

from 15 to 60 minutes for local routes and 60 to 90 minutes for the express routes. During the off peak, headways are generally less frequent for local service, and no express service is operated.

SunTran also maintains 15 shared-use park-n-ride lots, three publicly-owned lots throughout the service area, and the Laos Transit Center on the south side of Tucson.

Transit fares based on the 1988 On-Board Survey showed the following average fare by trip purpose:

Work Trips:	$.60
School Trips:	$.40 regional; $.10 U of A
Home Based Other Trips:	$.55
Non-Home Based Trips:	$.60

Based on the 1988 On-Board Survey the average daily boardings were approximately 42,000 system-wide and 9,200 on Route 8, which runs along Broadway Boulevard, and South Sixth Avenue.

5.4 Work Trip Mode Share

Table 5.3 presents the various travel modes workers use to get to work, as developed by PAG for the Tucson urbanized area. This data indicates that the transit modal share is approximately three percent for workers in both 1980 and 1988, while 80 to 81 percent of the trips are made by drivers traveling alone. The data also show that between 1980 and 1988 an additional one percent drove alone rather than taking an "other" mode of transportation. Twelve percent carpool to work.

BROADWAY CORRIDOR STUDY

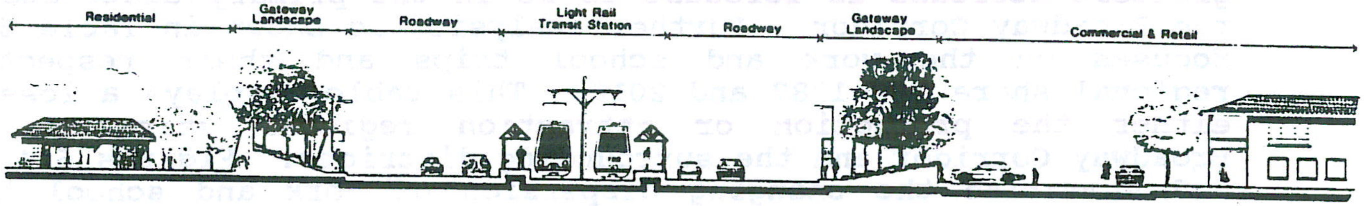
Table 5.3

WORK TRIP MODAL SHARES

Mode/Configuration	1980		1988	
	Total	Percent	Total	Percent
Drive Alone	292,112	80%	387,993	81%
Carpool	43,649	12%	57,976	12%
Transit	10,949	3%	14,386	3%
Other	17,793	5%	32,977	4%
Total	**364,503**	**100%**	**484,332**	**100%**

BROADWAY CORRIDOR STUDY

6.0
Regional Growth



6.0 REGIONAL GROWTH

The 2010 forecast growth will have a significant affect on the future travel demands, both transit and highway, particularly the dispersion of the growth throughout the region. The Tucson area has been divided into 16 districts in order to analyze the geographic distribution of travel demand and the associated impacts and changes. The districts, shown in Figure 6.1, are aggregations of TAZs and represent logical community or geographic areas.

Figures 6.2 and 6.3 show the change in attractions to the CBD and U of A from 1987 to 2010. Every district has an increase in attractions to the CBD; however, the northwest and northside districts have the greatest increase while the U of A and Broadway Central have the least increase as displayed in Figure 6.2. In looking at the change in attractions to the U of A, five of the 16 districts have a decrease from 1987 to 2010. The greatest decrease is forecast to be in the primary districts in the Broadway Corridor. Further analysis, as shown in Table 6.1, focuses on the work and school trips and their respective regional share for 1987 and 2010. This table displays a loss in either the production or attraction regional share in the Broadway Corridor and the surrounding districts. Figures 6.4 and 6.5 summarize the changing dispersion of work and school trip productions and attractions by highlighting those districts which are forecasted to increase or decrease in regional share. These figures graphically show how the regional growth trends are forecasted to shift to the suburban areas, and not focus as heavily on the Broadway Corridor.

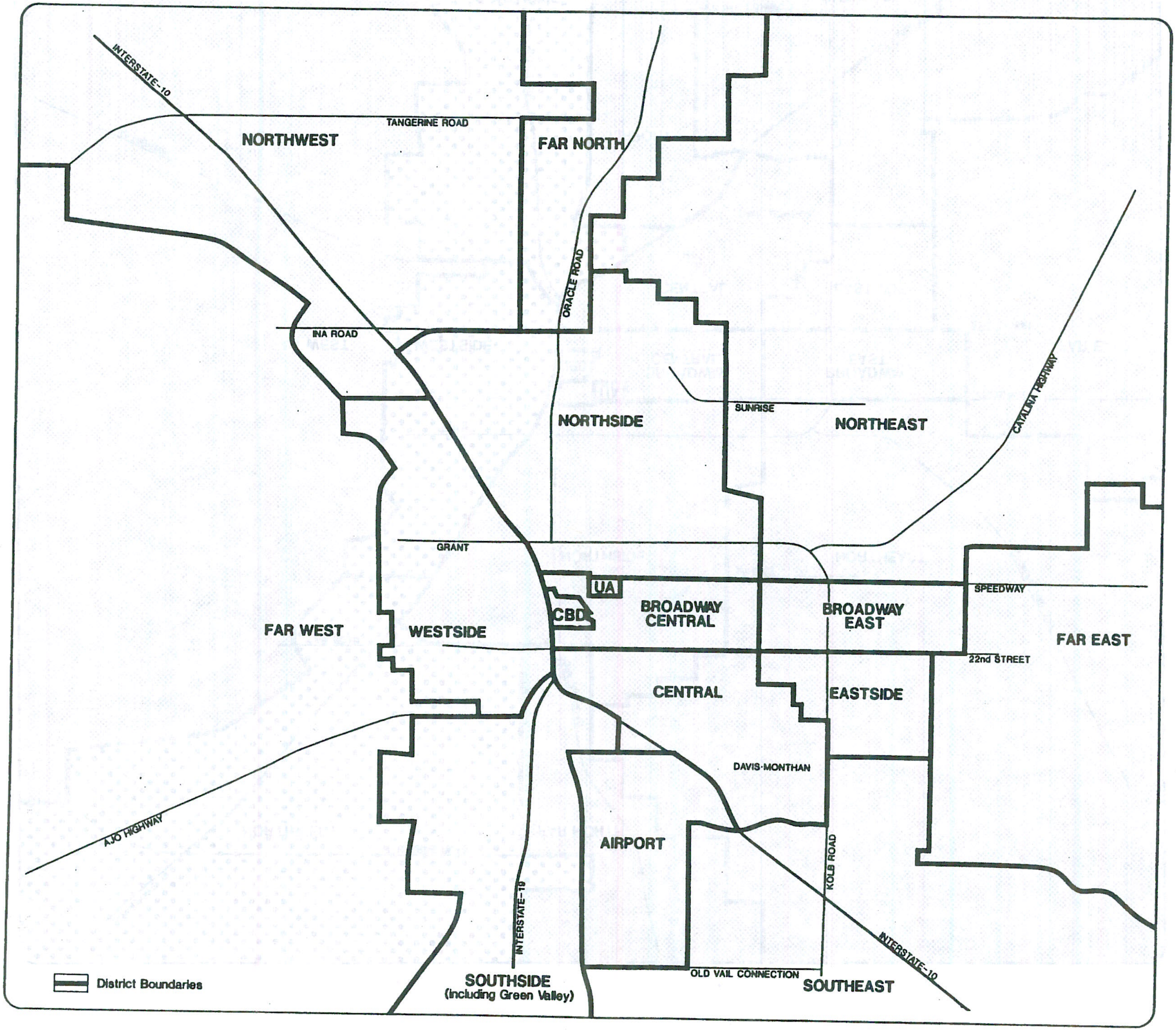
In addition, the committed expansions to the highway system were based on the adopted Regional Transportation Plan (RTP), the forecasted revenue streams, and political realities for new construction. As a result, the roadway system utilized, as displayed in Figure 4.1, assumed the following factors:

- those elements of the adopted RTP excluding the "Beyond 20 Years" time frame elements (i.e., Sandario Loop); and
- deletion of selected roadway elements politically infeasible to construct including the La Cholla/Greasewood Connection, Kolb Road Extension, and the downtown portion of Aviation Parkway.

Other roadway elements included are selected roadway widenings, Prince Road extension, River Road, Tangerine Road, and Sahuarita Road improvements. The adopted RTP can be reviewed for more detailed information on these highway improvements.

Future population and employment are also projected to increase by the year 2010. PAG, in conjunction with the Population Technical Advisory Committee, is responsible for the development of long-range forecasts and spatial distribution of population and employment in the Tucson metropolitan region. Table 6.2 displays the 1987 and 2010 population, employment, and the percent change for major areas within the region. Between 1987

STUDY DISTRICTS



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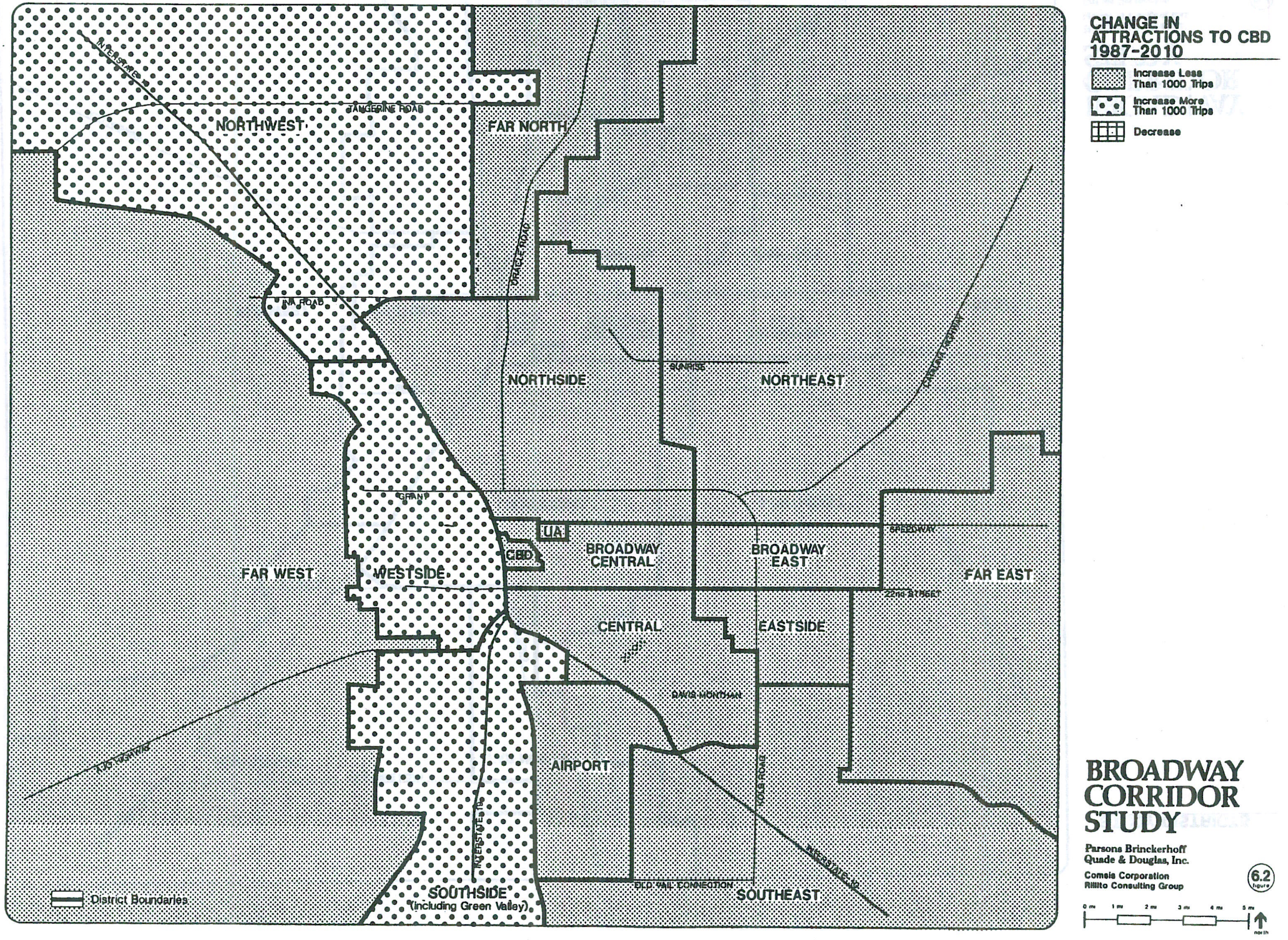
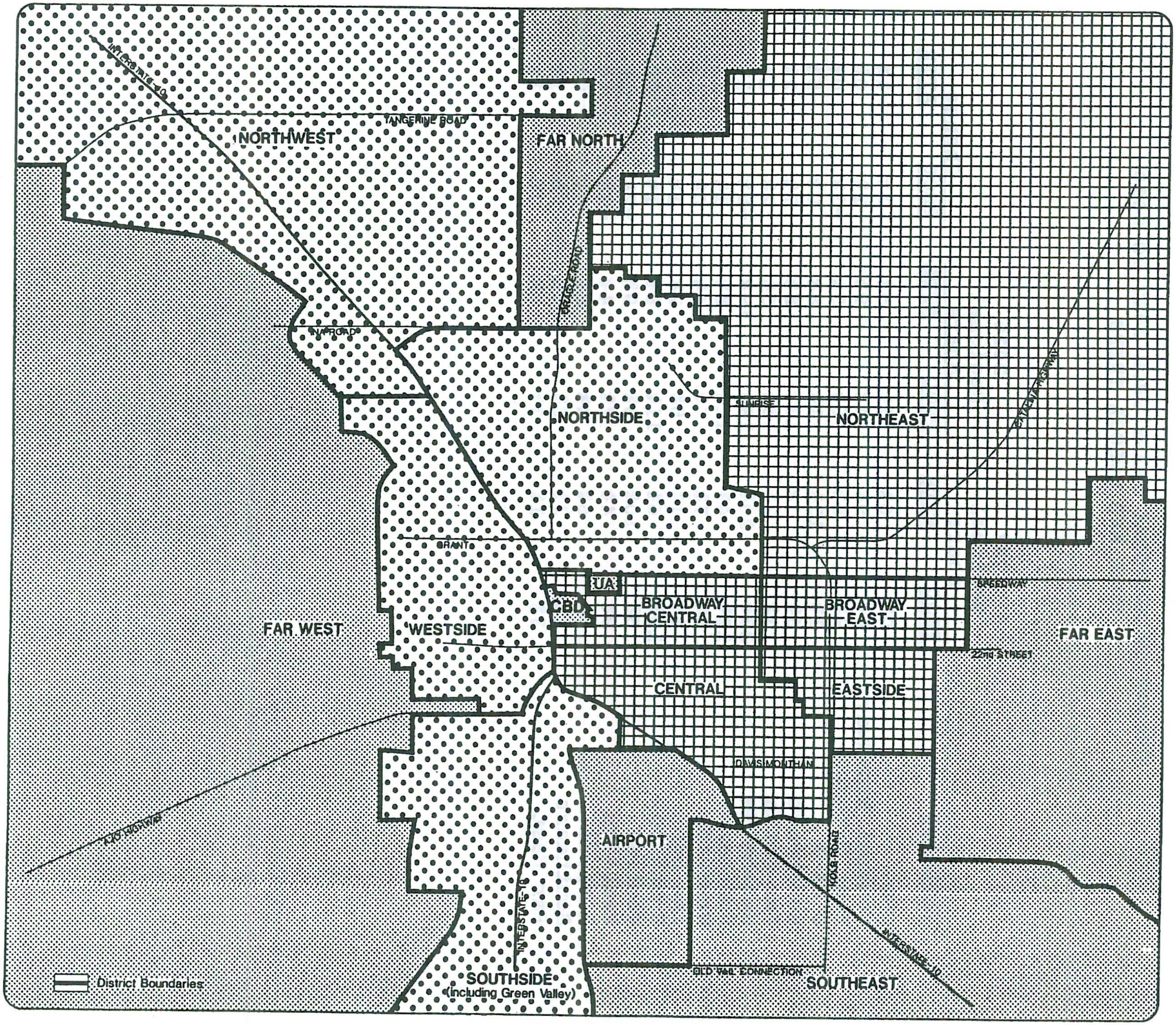

CHANGE IN ATTRACTIONS TO CBD 1987-2010
Increase Less Than 1000 Trips
Increase More Than 1000 Trips
Decrease
NORTHWEST
TANGERINE ROAD
FAR NORTH
ORACLE ROAD
INA ROAD
NORTHSIDE
SUNRISE
NORTHEAST
GRANT
UA
SPEEDWAY
CBD
BROADWAY CENTRAL
BROADWAY EAST
FAR WEST
WESTSIDE
FAR EAST
22nd STREET
CENTRAL
EASTSIDE
DAVIS MONTHAN
AIRPORT
KOLB ROAD
OLD VAIL CONNECTION
SOUTHSIDE (Including Green Valley)
SOUTHEAST
INTERSTATE 19
INTERSTATE 10
District Boundaries
BROADWAY CORRIDOR STUDY
Parsons Brinckerhoff Quade & Douglas, Inc.
Comsis Corporation
Rillito Consulting Group
6.2 figure
north



CHANGE IN ATTRACTIONS TO UA 1987-2010

- Increase Less Than 1000 Trips
- Increase More Than 1000 Trips
- Decrease

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6.3 figure

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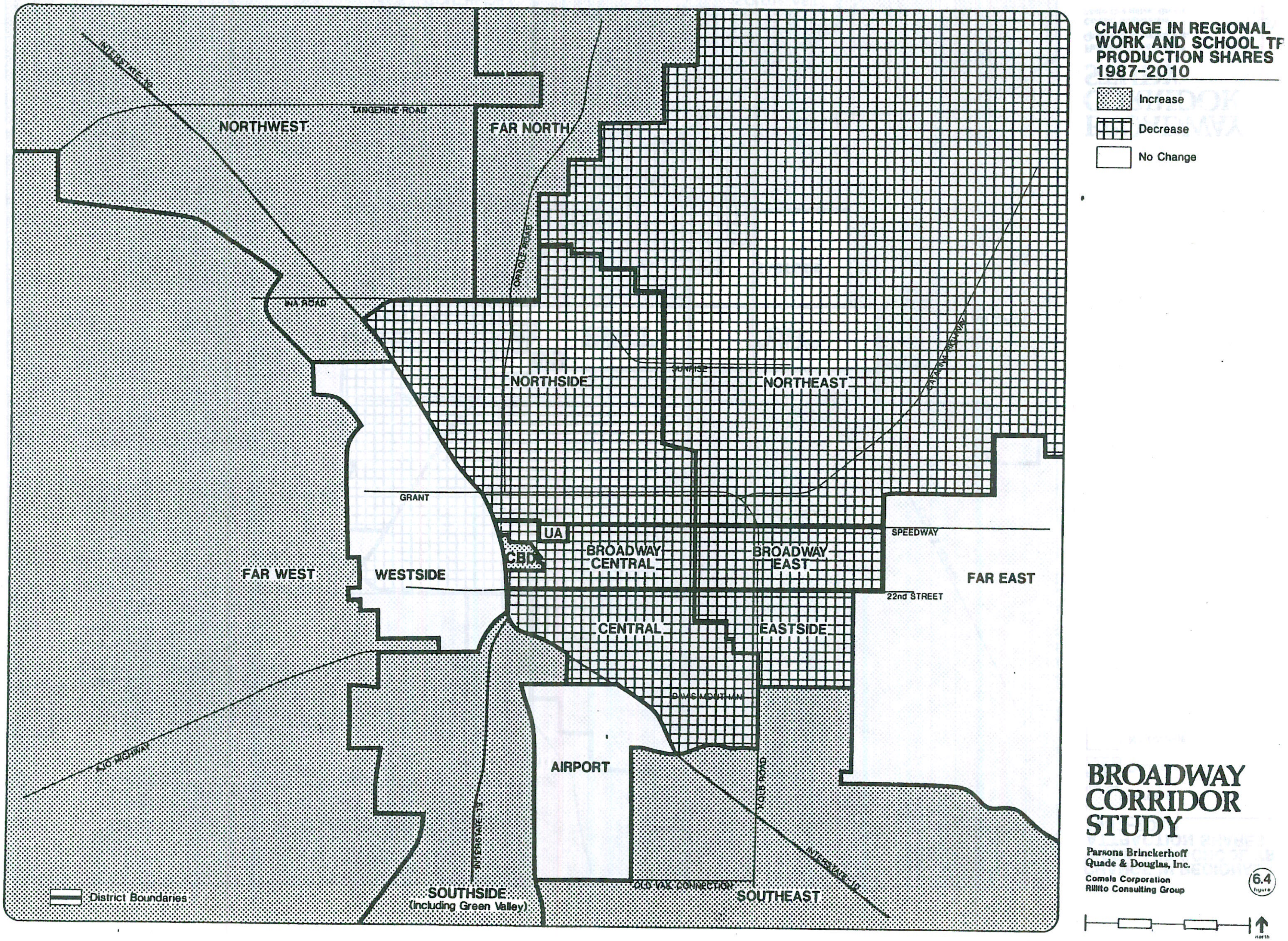
north

BROADWAY CORRIDOR STUDY

Table 6.1

CHANGE IN REGIONAL SHARE FROM 1987 TO 2010
WORK AND SCHOOL TRIPS

District	1987 Regional Share		2010 Regional Share		Change	
	PROD	ATTR	PROD	ATTR	PROD	ATTR
CBD	0%	6%	1%	5%	1%	-1%
Central Broadway	6%	9%	4%	9%	-2%	0%
East Broadway	9%	5%	6%	5%	-3%	0%
U of A	1%	13%	1%	8%	0%	-5%
Northwest	6%	3%	13%	5%	7%	2%
Far North	3%	2%	5%	3%	2%	1%
Northside	23%	20%	19%	19%	-5%	-1%
Northeast	12%	4%	11%	5%	-1%	1%
Westside	5%	7%	5%	6%	0%	1%
Far West	4%	1%	5%	2%	1%	1%
Southside	10%	6%	11%	8%	1%	2%
Central	5%	10%	3%	9%	-2%	-1%
Eastside	9%	4%	7%	4%	-2%	0%
Airport	3%	6%	4%	6%	0%	0%
Southeast	1%	3%	3%	4%	2%	1%
Far East	3%	1%	3%	2%	0%	1%



CHANGE IN REGIONAL WORK AND SCHOOL TF PRODUCTION SHARES 1987-2010
Increase
Decrease
No Change
NORTHWEST
TANGERINE ROAD
FAR NORTH
INTERSTATE 10
INA ROAD
ORACLE ROAD
NORTHSIDE
SUNRISE
NORTHEAST
GRANT
UA
CBD
BROADWAY CENTRAL
BROADWAY EAST
SPEEDWAY
22nd STREET
FAR EAST
FAR WEST
WESTSIDE
CENTRAL
EASTSIDE
AIRPORT
KOLB ROAD
AJO HIGHWAY
INTERSTATE 19
OLD VAIL CONNECTION
SOUTHSIDE (Including Green Valley)
SOUTHEAST
District Boundaries
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6.4 figure
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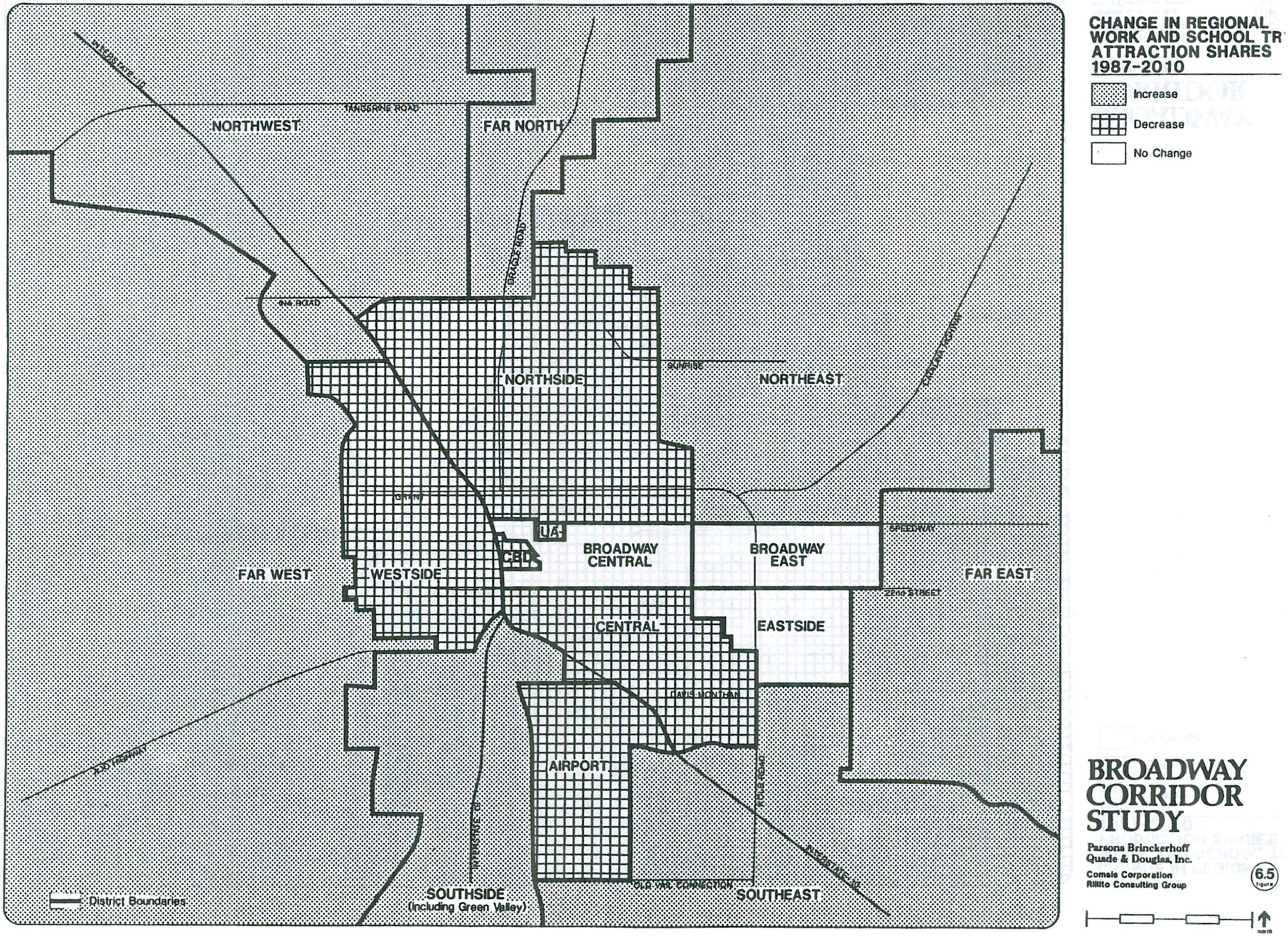

CHANGE IN REGIONAL WORK AND SCHOOL TR ATTRACTION SHARES 1987-2010
Increase
Decrease
No Change
NORTHWEST
TANGERINE ROAD
FAR NORTH
INA ROAD
NORTHSIDE
SUNRISE
NORTHEAST
GRANT
UA
BROADWAY CENTRAL
BROADWAY EAST
SPEEDWAY
FAR WEST
WESTSIDE
CBD
FAR EAST
22nd STREET
CENTRAL
EASTSIDE
DAVIS-MONTHAN
AIRPORT
KOLB ROAD
SOUTHSIDE
(Including Green Valley)
OLD VAIL CONNECTION
SOUTHEAST
District Boundaries
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BROADWAY CORRIDOR STUDY

Table 6.2

REGIONAL POPULATION/EMPLOYMENT GROWTH

Population

	1987	2010	% Change
City of Tucson	405,900	558,600	38%
Pima County	639,990	1,218,900	90%
Broadway Corridor	73,900	97,100	31%
Central Business District	2,700	3,600	33%
University of Arizona	9,425	11,025	17%

Employment

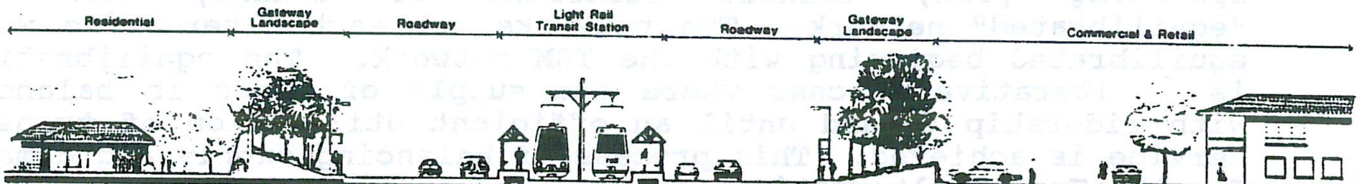
	1987	2010	% Change
City of Tucson	NA	NA	NA
Pima County	278,330	574,825	107%
Broadway Corridor	52,600	99,900	90%
Central Business District	16,300	28,300	75%
University of Arizona	16,420	21,380	30%

and 2010 the overall population within the County is forecast almost to double with projections for the Broadway Corridor forecasting an increase by one-third. The general area with the largest population increase for 1987 to 2010 is north of Ina Road. Employment is also projected to double in the County and increase by ninety percent in the study corridor. Although the employment growth is more dispersed than the population, the strongest growth areas for employment tend to lie closer to the city's core. The 1988 adopted regional socioeconomic forecast assumed a population of over 1.2 million and employment over 600,000 for the year 2010.

Thus, the region is expected to experience a significant increase of trip making from today. Although no major new special generators are forecasted for the Broadway Corridor, the U of A, Park Mall and El Con Mall will remain major generators for the region.

BROADWAY CORRIDOR STUDY

7.0
Transit System Forecast



7.0 TRANSIT SYSTEM FORECAST

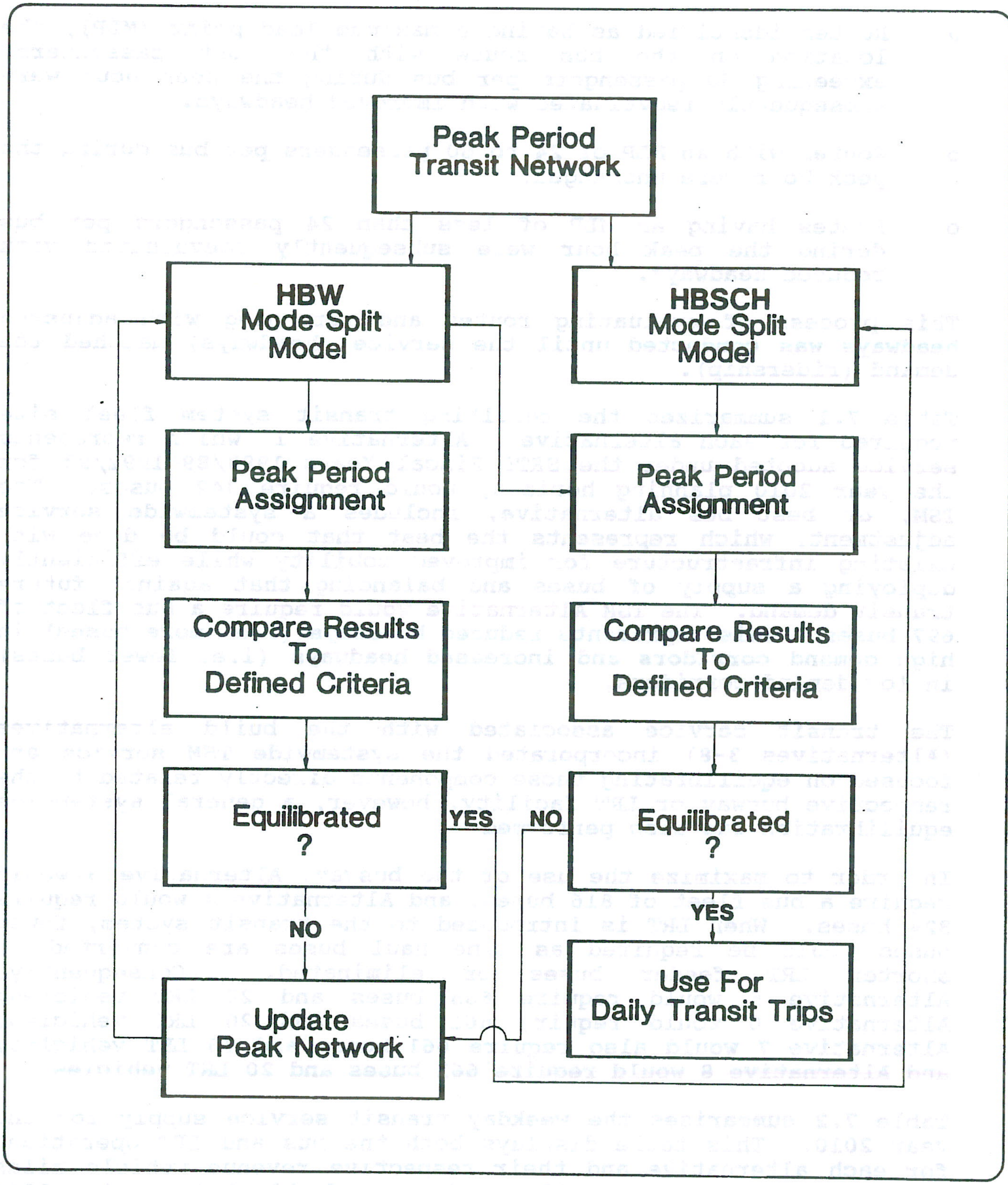
The key factors which affect a person's choice between using one mode of travel over another are future roadway systems, their socioeconomic characteristics, future highway and transit speeds, future transit fares, parking costs and transit service levels. In comparing the transit alternatives, all these factors except the transit service levels are held constant throughout each of the alternatives. Consequently, changes in transit ridership forecasts reflect only changes in transit service levels. This chapter discusses the future transit characteristics, service levels, and the equilibration process.

7.1 Transit Service Supply

The service level forecast with each transit alternative has a direct effect on the system ridership. The resulting vehicle fleet associated with each alternative is based on the transit operating plan, transit ridership or demand, and the "equilibrated" network. The networks for each alternative were equilibrated beginning with the TSM network. The equilibration is an iterative process where the supply of buses is balanced with ridership demand until an efficient utilization of transit service is achieved. This process of balancing supply and demand for the Tucson alternatives is depicted in Figure 7.1.

The equilibration process involved two major steps. First, the unproductive routes were determined and second, the route headways were determined. The criterion used to determine productivity was passengers per revenue mile. An example of passengers per revenue mile is two fare-paying riders on the bus traveling 10 miles equals 20 revenue miles or two revenue passengers per revenue mile. If a route had less than 25 percent of the systemwide average then the route was dropped. This is a conservative approach because SunTran classifies a route "unproductive" in the SRTP when the route is less than 75 percent of the system average threshold. Based on the transit trip assignment, a systemwide average of passengers per revenue mile was calculated, and each individual transit line was compared to this criterion. Those lines identified as less than 25 percent of the system average were reviewed to determine if unproductive line segments could be deleted, allowing the remainder of the line to achieve the productivity threshold. The only exception was the policy decision made by the Technical Advisory Committee to maintain one-mile transit routings in the far northwest area.

The criterion used to determine route headways was based on projected transit loadings or the number of passengers on the bus. Where projected loadings exceeded the criteria, headways were improved; where loadings were less than the criteria, headways were reduced. Peak loadings were identified from the model output and by assigning a peak hour factor to the three-hour peak period loadings. The peak hour factor utilized was 45 percent. Therefore, 45 percent of the three-hour peak loadings were assigned to the peak hour to determine transit headway requirements based on route capacity. Based on SunTran route



EQUILIBRATION PROCESS

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7.1 figure

performance standards, the following criteria were developed for determining the efficiency of each route headway:

- Routes identified as having a maximum load point (MLP), the location on the bus route with the most passengers, exceeding 60 passengers per bus during the peak hour were subsequently reevaluated with improved headways.

- Routes with an MLP of 24 to 60 passengers per bus during the peak hour were unchanged.

- Routes having an MLP of less than 24 passengers per bus during the peak hour were subsequently reevaluated with reduced headways.

This process of evaluating routes and rerunning with adjusted headways was conducted until the service (headways) matched the demand (ridership).

Table 7.1 summarizes the resulting transit system fleet size required for each alternative. Alternative 1, which represents service adopted under the SRTP Fiscal Years 1988/89-1992/93 for the year 2010 planning horizon, would require 342 buses. The TSM, or best bus alternative, includes a systemwide service adjustment, which represents the best that could be done with existing infrastructure for improved mobility while efficiently deploying a supply of buses and balancing that against future transit demand. The TSM Alternative would require a bus fleet of 697 buses. This represents reduced headways (i.e. more buses) in high demand corridors and increased headways (i.e. fewer buses) in low demand corridors.

The transit service associated with the build alternatives (Alternatives 3-8) incorporated the systemwide TSM service and focused on equilibrating those components directly related to the respective busway or LRT facility, however, a general systemwide equilibration was also performed.

In order to maximize the use of the busway, Alternative 3 would require a bus fleet of 816 buses, and Alternative 4 would require 824 buses. When LRT is introduced to the transit system, fewer buses would be required as line haul buses are converted to shorter LRT feeder buses or eliminated. Consequently, Alternative 5 would require 665 buses and 20 LRT vehicles; Alternative 6 would require 661 buses and 20 LRT vehicles; Alternative 7 would also require 661 buses and 26 LRT vehicles; and Alternative 8 would require 661 buses and 20 LRT vehicles.

Table 7.2 summarizes the weekday transit service supply for the year 2010. This table displays both the bus and LRT operations for each alternative and their respective revenue vehicle miles and hours. The revenue miles and hours double between the 1988 service levels and the forecasts for the SRTP and they double (or more) again between the SRTP and Alternatives 2-11. This represents a substantial increase in service supply over today.

BROADWAY CORRIDOR STUDY

Table 7.1

2010 TRANSIT FLEET
(VEHICLES)

Alternative	Bus	LRT	Electric Bus
1 SRTP	342	---	---
2 Best Bus/TSM	697	---	---
3 Busway, U of A Shuttle	816	---	---
4 Busway, U of A Direct	824	---	---
5 LRT, U of A Shuttle	665	20	---
6 LRT, U of A Spur	661	20	---
7 LRT via Sixth Street	661	26	---
8 LRT, U of A Tunnel	661	20	---
9 LRT, Northside	665	20	---
10 Busway, Electric Trolley Buses; U of A Shuttle	736	---	80
11 Busway, Electric Trolley Buses, U of A Direct	734	---	90

BROADWAY CORRIDOR STUDY

Table 7.2

WEEKDAY TRANSIT SERVICE SUPPLY
(Year 2010)

		Bus Operations		Light Rail Transit Operations	
Alternative		Revenue Vehicle Miles	Revenue Vehicle Hours	Revenue Vehicle Miles	Revenue Vehicle Hours
Existing (1988)		18,404	1,290	--	--
1	SRTP	40,058	3,077	--	--
2	Best Bus/TSM	92,736	6,637	--	--
3	Busway, U of A Shuttle	117,952	6,784	--	--
4	Busway, U of A Direct	118,308	6,849	--	--
5	LRT, U of A Shuttle	96,131	5,618	4,416	84
6	LRT, U of A Spur	93,719	5,488	4,068	77
7	LRT via Sixth Street	93,719	5,488	5,040	112
8	LRT, U of A Tunnel	93,719	5,488	5,136	84
9	LRT, Northside	96,131	5,618	5,136	84
10	Busway, Electric Trolley Buses; U of A Shuttle	117,952	6,784	--	--
11	Busway, Electric Trolley Buses; U of A Direct	118,308	6,849	--	--

7.2 System Characteristics

Not only is the supply of transit service critical to attracting new ridership, but several other characteristics also play an important role. The characteristics discussed in this section are headways, network speeds, and fares.

Headways for the background bus system are similar for each alternative; they range from 5 minutes to 60 minutes for both local and express service. In the busway alternatives the main emphasis was the frequency within the busway. Six routes run inbound and outbound in the busway with headways ranging from 5 to 15 minutes in the peak and 15 and 30 minutes in the off peak. Therefore, the bus service frequency by direction in the busway is less than one and a half minutes in the peak and approximately three minutes in the off peak. In the LRT alternatives, the rail frequency is 5 minutes during the peak and 10 minutes in the off peak.

The existing transit speeds were developed as part of the mode split model calibration and validation process based on existing transit schedules. Discussions with SunTran and TDOT staff concluded that future year transit speeds are anticipated to drop 12 percent below existing speeds. This is expected to result from increased dwell times resulting from increased ridership and decreased operating speeds resulting from increased congestion as the region grows. The future highway speeds were assumed to drop by approximately 30 percent below existing speeds. For example, the average forecast speed for buses on Broadway is 15 mph, and the auto speed is 28 mph.

The LRT and busway speed characteristics were developed using industry standard rates for acceleration, deceleration, radius of curve, and dwell time. The maximum speed attainable was assumed to be the posted highway speed, when the systems are in the median adjacent to vehicular traffic and 55 mph in the tunnel. The average busway and LRT speeds are as follows:

Busway:	Alternative 3	21 mph
	Alternative 4	19 mph
LRT:	Alternative 5	29 mph
	Alternative 6	29 mph
	Alternative 7	24 mph
	Alternative 8	34 mph
	Alternative 9	29 mph
Electric Bus:	Alternative 10	29 mph
	Alternative 11	29 mph

Another related system characteristic is the fare structure. The fare structure assumed to be in place in 2010 (in 1987 dollars) is the same structure that exists today and is described in Chapter 5. The proposed method of fare collection for the LRT is the self-serve or "honor" system. To the extent possible, stations will be designed for unmanned operations utilizing automatic ticket dispensing and validating equipment.

7.3 Transit Patronage Forecasts

Table 7.3 summarizes, for each alternative, the systemwide transit ridership forecasts for both work and school trips and other trips. Work and school trips constitute over two-thirds of the daily ridership for each alternative. The 1988 On-Board Survey results showed 62 percent of the daily ridership was home-based work and school trips.

The SRTP alternative, with improved coverage to serve 2010 sociodemographic characteristics, shows a significant increase in ridership over the existing system. A comparison of Tables 7.1 and 7.3 clearly shows that increased service levels would induce higher transit ridership. The systemwide equilibration of the TSM bus system in combination with the TSM capital improvements results in the most dramatic increase in transit ridership. Total daily work and school transit trips increase by approximately 66 percent from the SRTP Alternative.

The capital improvements associated with Alternatives 3-8 would improve service in the Broadway Corridor only, and thus will have an increase in ridership over the TSM Alternative relative to that market share. Daily system ridership for the busway Alternatives 3 and 4 would increase between four and six percent over the TSM and the best LRT alternative, Alternative 8, by slightly over three percent. Alternative 5 has increased ridership of almost one percent over the TSM and Alternatives 6 and 7 have slightly less ridership.

The 2010 forecast ridership for the guideway facilities is presented in Table 7.4. Each of the guideway facilities would attract a substantial percentage of the ridership for the respective alternatives. The transit demand in the Broadway Corridor is significant and the guideway ridership forecasts support that finding. Alternatives 3 and 4 include a busway along Broadway and consequently will attract 23 and 30 percent, respectively, of the system ridership. Alternative 8, the LRT along Broadway to the University and a tunnel into the CBD, has over 38 percent guideway ridership; the other three LRT alternatives have slightly less than 30 percent of their ridership on the guideway. The remainder would be carried by bus.

The AM peak station activity along several of the alternatives is presented in Figures 7.2 - 7.6. Stations at both ends of the corridor have the most activity, however, locations which access a transfer point to the U of A also have substantial activity in the build alternatives. In general, there is activity at all stations, with the biggest difference being the comparison between the TSM and build alternatives.

Table 7.5 presents a comparison of linked transit trips and unlinked transit trips or boardings. Linked trips represent fare paying trips with each origin to destination representing one trip, regardless of the number of transfers. Unlinked trips represent transit boardings and includes transfers. Thus, a trip

BROADWAY CORRIDOR STUDY

Table 7.3

2010 SYSTEMWIDE DAILY RIDERSHIP

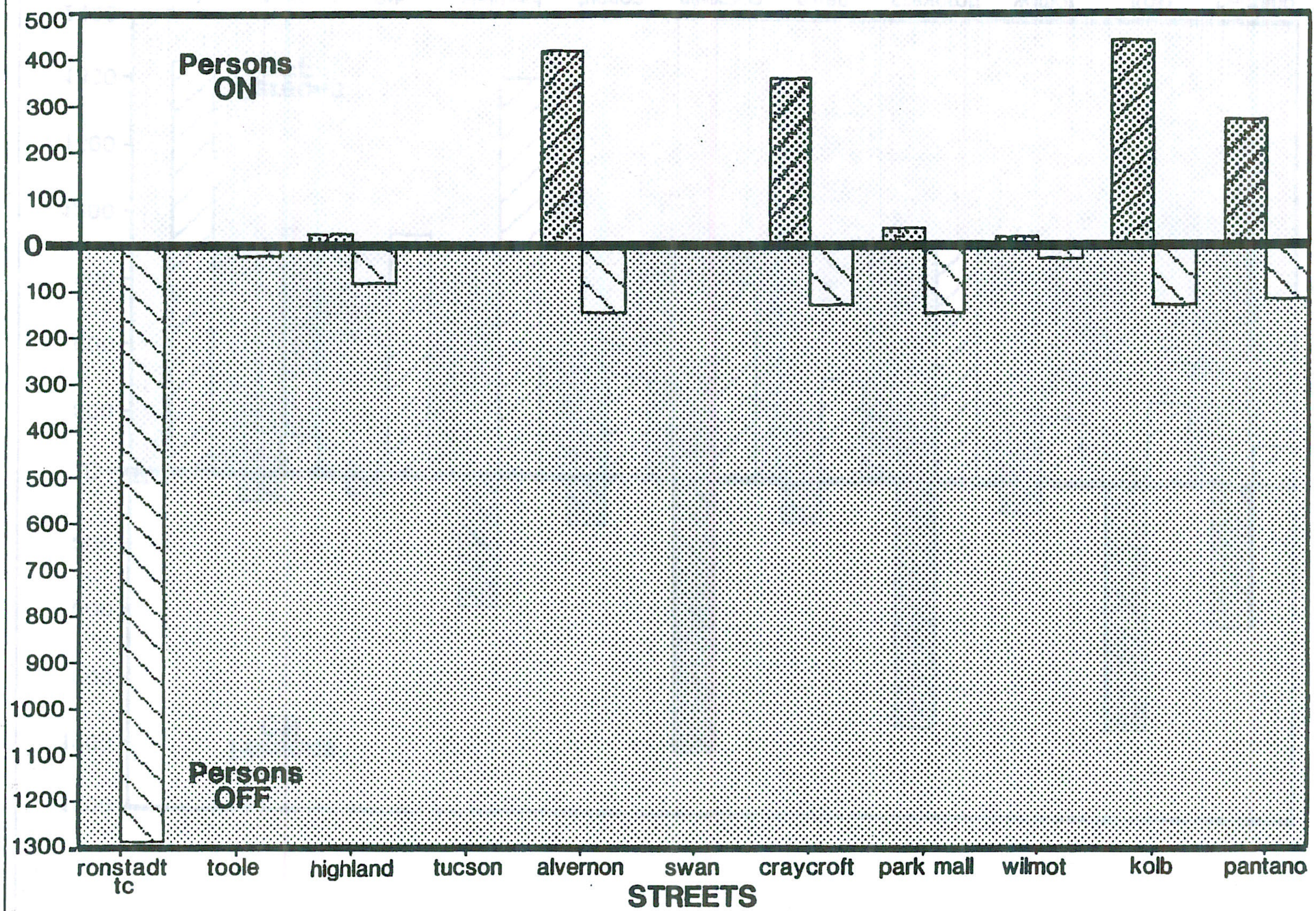
Alternative		HBW	HBSCHOOL	HBO	NHB	Total
1	SRTP	21,569	17,277	13,852	7,894	60,592
2	Best Bus/ TSM	44,056	19,674	16,319	12,059	92,116
3	Busway, U of A Shuttle	43,047	24,494	15,696	13,612	96,849
4	Busway, U of A Direct	42,929	24,600	15,684	12,388	95,601
5	LRT, U of A Shuttle	42,503	23,165	15,517	11,537	92,722
6	LRT, U of A Spur	41,507	23,198	15,437	10,901	91,043
7	LRT via Sixth St.	44,094	19,560	16,243	11,949	91,846
8	LRT U of A Tunnel	43,953	23,440	15,543	11,870	94,806
9	LRT, Northside	45,702	19,634	16,225	11,813	92,826
10	Busway, Electric Trolley Buses; U of A Shuttle	45,702	19,634	16,225	11,813	92,826
11	Busway, Electric Trolley Buses; U of A Direct	44,018	19,702	16,172	11,162	91,054

BROADWAY CORRIDOR STUDY

Table 7.4

2010 DAILY GUIDEWAY RIDERSHIP

Alternative	Busway	LRT	Electric Bus	Percent of System Ridership
3 Busway, U of A Shuttle	22,100	--		22.8%
4 Busway, U of A Direct	27,900	--		29.2%
5 LRT, U of A Shuttle	--	26,600		28.7%
6 LRT-U of A Spur	--	23,400		25.7%
7 LRT via Sixth Street	--	26,900		29.3%
8 LRT U of A Tunnel	--	36,200		38.2%
9 LRT, Northside		26,600		28.7%
10 Busway, Electric Trolley Buses; U of A Shuttle			26,600	28.7%
11 Busway, Electric Trolley Buses; U of A Direct			23,400	25.7%



ALTERNATIVE TWO

AM Peak On/Off Boardings on Broadway

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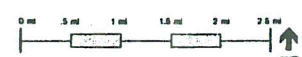
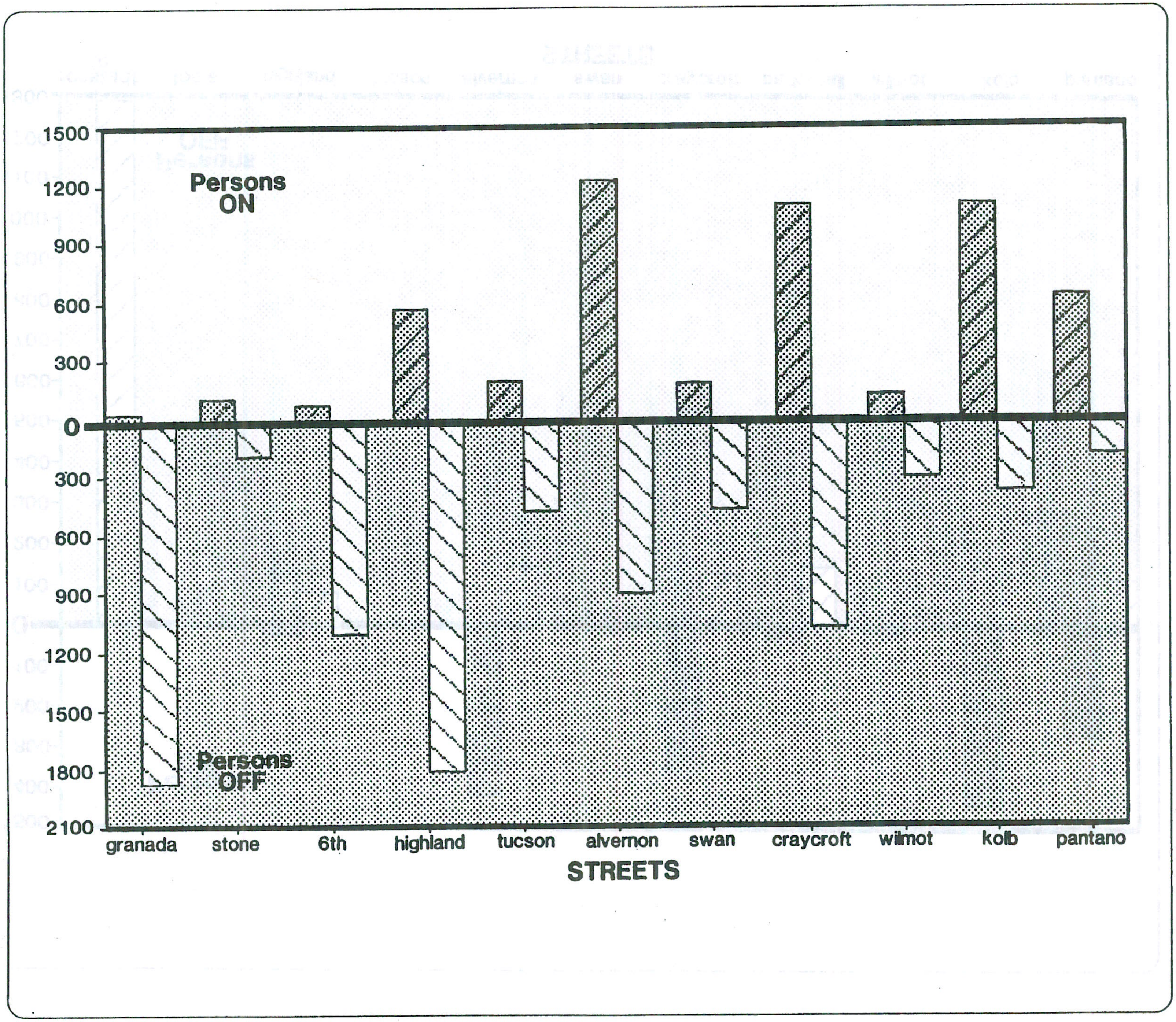
7.2 figure



ALTERNATIVE THREE

AM Peak On/Off Boardings on Broadway



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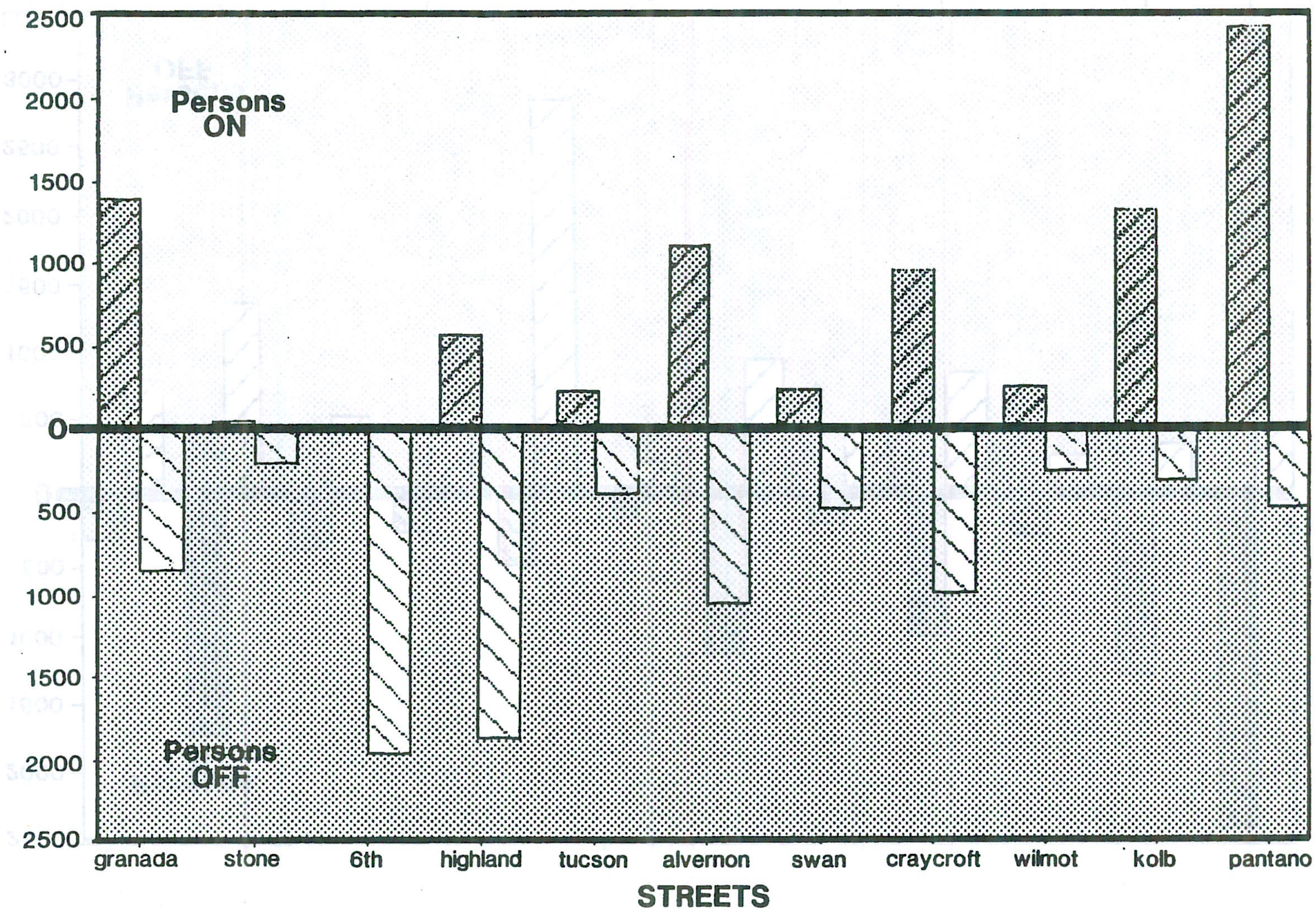
7.3 figure



ALTERNATIVE FIVE

AM Peak On/Off Boardings on Broadway

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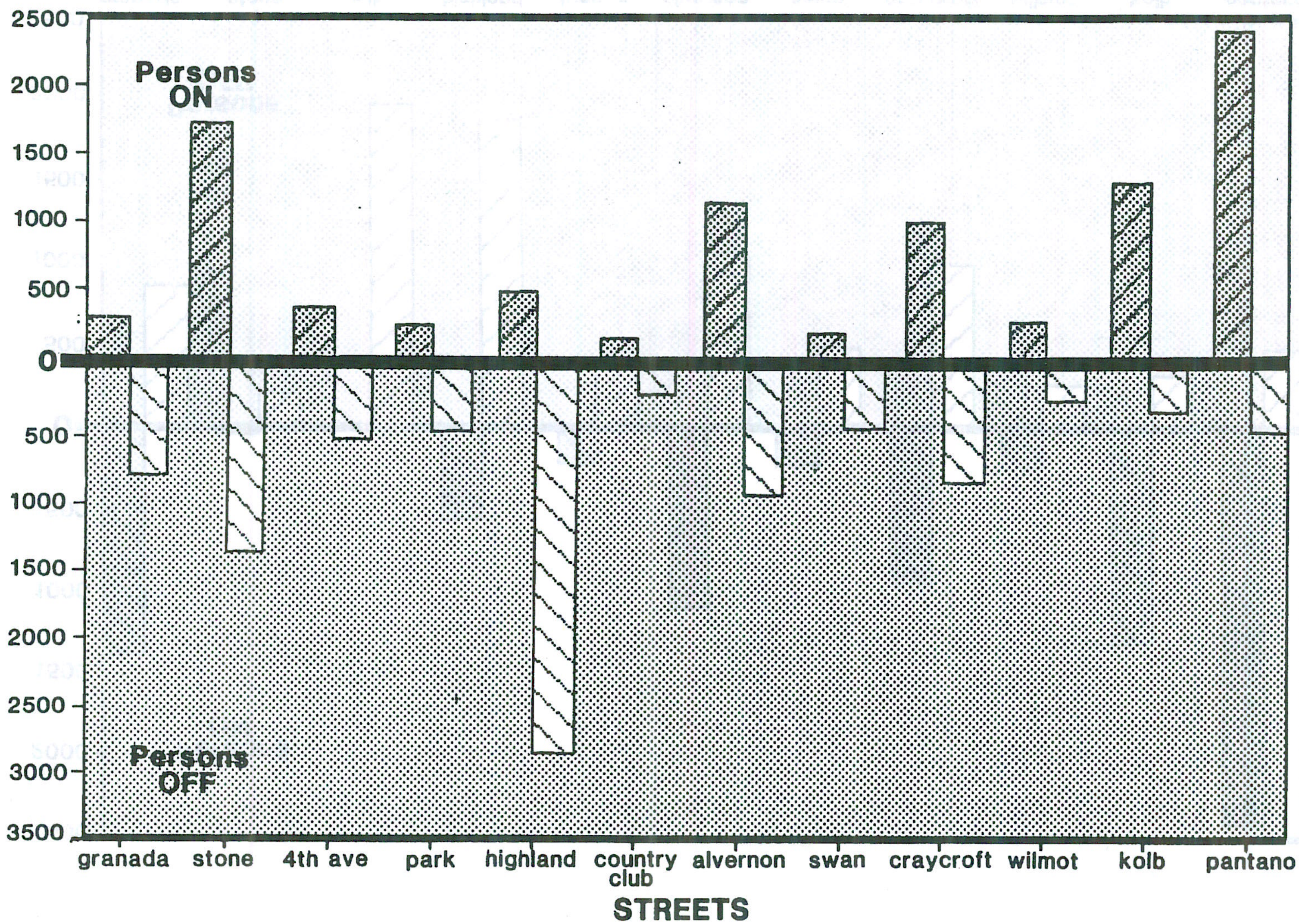
7.4



ALTERNATIVE SEVEN

AM Peak On/Off Boardings on Broadway

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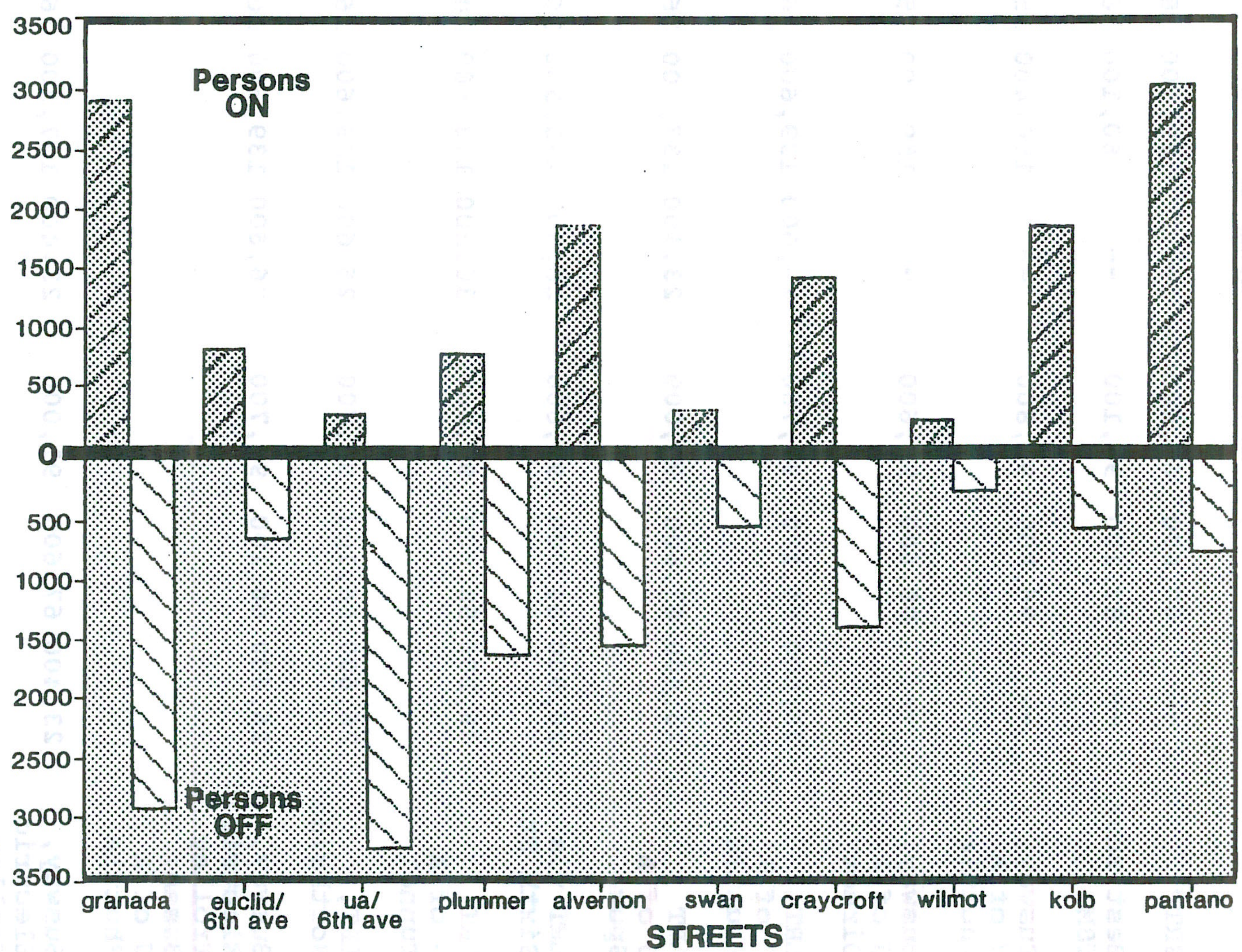
7.5



ALTERNATIVE EIGHT

AM Peak On/Off Boardings on Broadway

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7.6 figure

BROADWAY CORRIDOR STUDY

Table 7.5

DAILY SYSTEM RIDERSHIP (2010)

Alternative	Linked Trips			Boardings		
	Rail/ Trolley	Bus	Total	Rail/ Trolley	Bus	Total
1 SRTP	--	60,600	60,600	--	89,500	89,500
2 Best Bus/ TSM	--	92,100	92,100	--	160,100	160,100
3 Busway, U of A Shuttle	--	96,800	96,800	--	156,400	156,400
4 Busway, U of A Direct	--	95,600	95,600	--	159,600	159,600
5 LRT, U of A Shuttle	26,600	66,100	92,700	26,600	139,600	166,200
6 LRT U of A Spur	23,400	67,600	91,000	23,400	137,300	160,700
7 LRT via Sixth St.	26,900	64,900	91,800	26,900	133,300	160,200
8 LRT, U of A Tunnel	36,200	58,600	94,800	36,200	143,800	180,000
9 LRT, Northside	26,600	66,100	92,700	26,600	139,600	166,200
10 Busway, Electric Trolley Buses; U of A Shuttle	26,600	66,100	92,700	26,600	139,600	166,200
11 Busway, Electric Trolley Buses; U of A Direct	23,400	67,600	91,000	23,400	137,300	160,700

with two transfers would account for one linked transit trip and three unlinked transit trips or boardings. Table 7.5 shows that unlinked transit trips (boardings) are approximately 70 percent higher than linked trips indicating that, on average, one transfer is required in 7 out of 10 linked trips.

7.4 Expansion Factors

Expansion factors have been derived to convert average weekday estimates of ridership and ridership related statistics to annual estimates. The annual information is needed to calculate the UMTA required indices. Expansion factors are usually based on the transit system's current operating characteristics and ridership patterns. The following assumptions were made:

1. Current SunTran service supply characteristics remain the same.

2. Current distribution of trips will remain the same.
   A. 38% of the daily ridership is HBW
   B. 31% of the daily ridership is HBSchool
   C. 31% of the daily ridership is Other

3. F overall = Annual Boardings/Average Weekday Boardings = 295.

4. F work = 260 work days per year.

5. F school = 200 school days per year.

With these assumptions the UMTA methodology for calculating the needed expansion factors to determine the annual estimation of ridership can be utilized. The equation follows:

F overall = (% work*F work)+(% non-work*F non-work)

and is modified to utilize the local school characteristics:

295=(38%*260)+(31%*200)+(31%*F non-work)

therefore: F non-work = 433

Table 7.6 displays the annual ridership calculated using these expansion factors. Table 7.7 displays the annual transit service supply which is based on the current daily-to-annual ratios. The service supply expansion factors for each item is approximately 300 times the weekday estimates.

7.5 Mode Choice

The distribution of the travel market among the modes involved and the variation across the alternatives is a direct measure of the alternatives' impacts. The estimate of future automobile trips provides an indicator of traffic and its effects. The comparison of transit use across alternatives is a direct indication of the effectiveness of alternative transit improvements.

BROADWAY CORRIDOR STUDY

Table 7.6

ESTIMATE OF ANNUAL TRANSIT TRIPS FOR 2010

Alternative	DAILY Total	HBW	School	Non-Work	Annual
1 SRTP	60,600	21,600	17,300	21,700	18,479,400
2 Best Bus/TSM	92,100	44,100	19,700	28,400	27,677,000
3 Busway, U of A Shuttle	97,200	45,700	21,100	30,500	29,284,200
4 Busway, U of A Direct	95,900	45,500	21,200	29,200	28,703,800
5 LRT, U of A Shuttle	92,700	45,100	19,600	28,000	27,786,000
6 LRT, U of A Spur	91,100	44,000	19,700	27,300	27,220,700
7 LRT via Sixth Street	91,800	44,100	19,600	28,200	27,583,600
8 LRT, U of A Tunnel	95,000	46,600	20,000	28,500	28,437,500
9 LRT, Northside	92,700	45,100	19,600	28,000	27,786,000
10 Busway, Electric Trolley Buses; U of A Shuttle	92,700	45,100	19,600	28,000	27,786,000
11 Busway, Electric Trolley Buses; U of A Direct	91,100	44,000	19,700	27,300	27,220,700

BROADWAY CORRIDOR STUDY

Table 7.7

ANNUAL TRANSIT SERVICE SUPPLY

Alternative		Bus Operations Revenue Vehicle Miles	Bus Operations Revenue Vehicle Hours	Light Rail Transit Operations Revenue Vehicle Miles	Light Rail Transit Operations Revenue Vehicle Hours
1	SRTP	12,017,400	923,100	--	--
2	Best Bus/TSM	27,820,800	1,691,000	--	--
3	Busway, U of A Shuttle	35,385,600	2,035,200	--	--
4	Busway, U of A Direct	35,492,400	2,054,700	--	--
5	LRT, U of A Shuttle	28,839,300	1,685,400	1,324,800	25,200
6	LRT, U of A Spur	28,115,700	1,646,400	1,220,400	23,100
7	LRT via Sixth Street	28,115,700	1,646,400	1,512,000	33,600
8	LRT, U of A Tunnel	28,115,700	1,646,400	1,540,800	25,200
9	LRT, Northside	28,839,300	1,685,400	1,540,800	25,200
10	Busway, Electric Trolley Buses; U of A Shuttle	35,385,600	2,035,200	--	--
11	Busway, Electric Trolley Buses; U of A Direct	35,492,400	2,054,700	--	--

Expansion factors to estimate Annual Revenue Vehicle Miles and Hours were based on current daily-to-annual ratios. The expansion factor for each item is approximately 300 times the weekday estimates.

Table 7.8 shows the modal split of the daily work and school trips projected for the year 2010. An examination of the transit shares reveals that the work and school transit mode share is sensitive to the amount of service provided. The SRTP Alternative has the least transit supply and would attract the smallest transit share, 3.5 percent. The TSM Alternative would provide an improved, efficient bus system and thus would attract a larger mode share, 5.8 percent. The six build alternatives would provide better, faster service to the Broadway Corridor and consequently would draw from 5.8 to 6.0 percent of the total regional person trips.

Table 7.9 presents a more detailed breakdown of the work and school trip mode share by transit component. This table shows that all the build alternatives have very similar overall transit mode shares of between 5.8 and 6.0 percent; however, the composition between bus and rail differs by alternative.

Downtown Tucson would be well served by transit in each alternative. In order to evaluate the performance of the alternatives in serving the downtown core employment center, the CBD District (see Figure 6.1) was defined as the downtown core area. Table 7.10 presents a breakdown of the work and school transit mode shares to the downtown core area; this includes all routes accessing the downtown area. The findings highlight the significance of transit level of service in attracting downtown transit ridership. In comparing Tables 7.9 and 7.10, one sees that for each alternative, the overall transit mode share to the downtown core area is approximately triple that for the entire transit system.

As bus service is improved from the SRTP to the TSM Alternative, the systemwide transit mode share is increased by 2.3 percent (3.5 percent to 5.8 percent) while the transit mode share to downtown is increased by more than four percent (11.6 percent to 15.9 percent) (see Table 7.10). A similar comparison from the TSM to the build alternatives shows that the improved service yields an additional two percent in systemwide transit mode share to the downtown district.

Table 7.11 displays the 2010 automobile and transit person trips and their associated systemwide mode share. Of the 3,622,700 person trips, over 97 percent are made by auto and under three percent are made by transit. The percent mode share varies by two-tenths of a percent among alternatives. Table 7.12 shows a detailed breakdown of the auto trips by occupancy. In general, one person auto occupancy accounts for half of the automobile trips and two person and three or more persons account for 31 and 19 percent, respectively.

BROADWAY CORRIDOR STUDY

Table 7.8

2010 SYSTEM

DAILY WORK AND SCHOOL TRIPS

Alternative	Auto Person Trips	Auto Mode Share	Transit Person Trips	Transit Mode Share	Total Person Trips	Total Mode Share
1 SRTP	1,066,800	96.5%	38,900	3.5%	1,105,700	100%
2 Best Bus/ TSM	1,041,900	94.2%	63,800	5.8%	1,105,700	100%
3 Busway, U of A Shuttle	1,039,100	94.0%	66,600	6.0%	1,105,700	100%
4 Busway, U of A Direct	1,039,100	94.0%	66,600	6.0%	1,105,700	100%
5 LRT, U of A Shuttle	1,041,000	94.1%	64,700	5.9%	1,105,700	100%
6 LRT, U of A Spur	1,041,900	94.2%	63,800	5.8%	1,105,700	100%
7 LRT via Sixth St.	1,042,000	94.2%	63,700	5.8%	1,105,700	100%
8 LRT, U of A Tunnel	1,039,300	94.0%	66,400	6.0%	1,105,700	100%
9 LRT, Northside	1,041,000	94.1%	64,700	5.9%	1,105,700	100%
10 Busway, Electric Trolley Buses; U of A Shuttle	1,041,000	94.1%	64,700	5.9%	1,105,700	100%
11 Busway, Electric Trolley Buses; U of A Direct	1,041,000	94.2%	63,800	5.8%	1,105,700	100%

BROADWAY CORRIDOR STUDY

Table 7.9

DAILY WORK AND SCHOOL TRIPS AND ASSOCIATED MODE SPLIT

Alternative	Rail Trips	Rail Mode Share	Bus Trips	Bus Mode Share	Total Trips	Total Mode Share
1 SRTP			38,900	3.5%	38,900	3.5%
2 Best Bus/TSM			63,800	5.8%	63,800	5.8%
3 Busway, U of A Shuttle			66,600	6.0%	66,600	6.0%
4 Busway, U of A Direct			66,600	6.0%	66,600	6.0%
5 LRT, U of A Shuttle	18,400	1.7%	46,300	4.2%	64,700	5.9%
6 LRT, U of A Spur	16,200	1.5%	47,600	4.3%	63,800	5.8%
7 LRT via Sixth St.	18,600	1.7%	45,100	4.2%	63,700	5.8%
8 LRT, U of A Tunnel	25,000	2.3%	41,400	3.7%	66,400	6.0%
9 LRT, Northside	18,400	1.7%	46,300	4.2%	64,700	5.9%
10 Busway, Electric Trolley Buses; U of A Shuttle	18,400	1.7%	46,300	4.2%	64,700	5.9%
11 Busway Electric Trolley Buses; U of A Direct	16,200	1.5%	47,600	4.3%	63,800	5.8%

BROADWAY CORRIDOR STUDY

Table 7.10

MODE SPLIT TO DOWNTOWN CORE AREA (WORK TRIPS)

Alternative	Total Person Trips (Transit & Auto to CBD)	Transit Trips			Transit Mode Split		
		Rail	Bus	Total	Rail	Bus	Total
1 SRTP	46,530	NA	5,380	5,380	NA	11.6%	11.6%
2 Best Bus/ TSM	46,530	NA	7,390	7,390	NA	15.9%	15.9%
3 Busway, U of A Shuttle	46,530	NA	8,290	8,290	NA	17.8%	17.8%
4 Busway, U of A Direct	46,530	NA	8,200	8,200	NA	17.6%	17.6%
5 LRT, U of A Shuttle	46,530	5,390	3,100	8,490	11.6%	6.7%	18.3%
6 LRT, U of A Spur	46,530	4,550	3,580	8,130	9.8%	7.7%	17.5%
7 LRT via Sixth St.	46,530	4,900	3,330	8,230	10.5%	7.2%	17.7%
8 LRT, U of A Tunnel	46,530	5,440	3,060	8,500	11.7%	6.6%	18.3%
9 LRT, Northside	46,530	5,390	3,100	8,490	11.6%	6.7%	18.3%
10 Busway, Electric Trolley Buses; U of A Shuttle	46,530	5,390	3,100	8,490	11.6%	6.7%	18.3%
11 Busway, Electric Trolley Buses; U of A Direct	46,530	4,550	3,580	8,130	9.8%	7.7%	17.5%

BROADWAY CORRIDOR STUDY

Table 7.11

2010 SYSTEM SUMMARY

	Auto		Transit		Total	
Alternative	Person Trips	Mode Share	Person Trips	Mode Share	Person Trips	Mode Share
1 SRTP	3,562,100	98.3	60,600	1.7%	3,622,700	100%
2 Best Bus/ TSM	3,530,600	97.5%	92,100	2.5%	3,622,700	100%
3 Busway, U of A Shuttle	3,525,900	97.3%	96,800	2.7%	3,622,700	100%
4 Busway, U of A Direct	3,527,100	97.4%	95,600	2.6%	3,622,700	100%
5 LRT, U of A Shuttle	3,530,000	97.4%	92,700	2.6%	3,622,700	100%
6 LRT, U of A Spur	3,531,700	97.5%	91,000	2.5%	3,622,700	100%
7 LRT via Sixth St.	3,530,900	97.5%	91,800	2.5%	3,622,700	100%
8 LRT, U of A Tunnel	3,527,900	97.4%	94,800	2.6%	3,622,700	100%
9 LRT, Northside	3,530,000	97.4%	92,700	2.6%	3,622,700	100%
10 Busway, Electric Trolley Buses; U of A Shuttle	3,530,000	97.4%	92,700	2.6%	3,622,700	100%
11 Busway Electric Trolley Buses; U of A Direct	3,531,700	97.5%	91,000	2.5%	3,622,700	100%

BROADWAY CORRIDOR STUDY

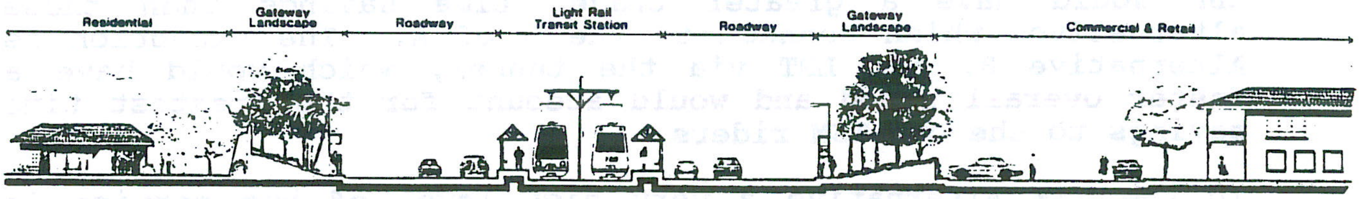
Table 7.12

2010 SYSTEM
DAILY AUTOMOBILE OCCUPANCY

Alternative	Persons Per Auto 1	Persons Per Auto 2	Persons Per Auto 3+	Person Trips Total
2 Best Bus/ TSM	1,774,500	1,074,400	681,700	3,530,600
3 Busway, U of A Shuttle	1,765,600	1,075,600	684,700	3,525,900
4 Busway, U of A Direct	1,766,300	1,067,000	684,800	3,527,100
5 LRT, U of A Shuttle	1,774,100	1,074,300	681,600	3,530,000
6 LRT, U of A Spur	1,768,900	1,077,300	685,500	3,531,700
7 LRT via Sixth St.	1,768,500	1,077,000	685,400	3,530,900
8 LRT, U of A Tunnel	1,766,500	1,076,400	685,000	3,527,900
9 LRT, Northside	1,774,100	1,074,300	681,600	3,530,000
10 Busway, Electric Trolley Buses; U of A Shuttle	1,774,100	1,074,300	681,600	3,530,000
11 Busway, Electric Trolley Buses; U of A Direct	1,768,900	1,077,300	685,500	3,531,700

BROADWAY CORRIDOR STUDY

8.0
Transportation Impacts



8.0 TRANSPORTATION IMPACTS

8.1 Travel Time Savings

Another measure of an alternative's effectiveness is the travel time savings resulting from the corresponding improved service. Using the TSM Alternative as a base, Table 8.1 shows the travel time savings that the TSM bus riders (92,100 daily) would experience with the build alternatives. This assumes an existing transit rider using the TSM alternative would elect to use the faster LRT, busway or trolley bus. This calculation of travel time savings to TSM riders is one of the direct inputs into the UMTA cost-effectiveness indices. The resulting calculations measure the benefits to "existing riders" (or TSM riders) as opposed to new riders.

The alternatives that would provide a more direct link to the CBD would have a greater travel time savings than those alternatives which connect to the U of A. The exception is Alternative 8, the LRT via the tunnel, which would have a faster overall speed and would account for the greatest time savings to the bus TSM riders.

In the TSM Alternative a very high level of bus service is provided throughout the region attracting high bus ridership. Because of this high level of service and consequently low travel time savings, the SRTP ridership was also analyzed as a comparison. Table 8.2 displays the travel time savings the SRTP riders (60,600 daily) would experience on some of the other networks. Again, the LRT with the direct link to the CBD Alternative 8, has the most travel time savings (Table 8.1). A more illuminating comparison is one between the SRTP and the TSM travel time savings. For example, the average time savings per TSM trip on the Alternative 5 network is less than two minutes and the average SRTP trip savings on the same network is 13 minutes. The primary reason for the larger savings for the SRTP trip is the substantial savings in out-of-vehicle time from the SRTP network to the LRT network. Because of the high level of service on the TSM network little time savings can be made on the built networks; however, significant improvements over the SRTP ridership travel times would be achieved.

A second comparison of travel time savings is to identify the transit travel times associated with some alternatives for common origins and destinations throughout the study area. Table 8.3 summarizes these typical unweighted travel times from various locations throughout the Tucson area. The most dramatic difference in travel times is between the SRTP and the other alternatives. Over half the examples show a travel time savings from the TSM alternative to the build alternatives.

BROADWAY CORRIDOR STUDY

Table 8.1

TRAVEL TIME SAVINGS (TSM BUS RIDERS)

Alternative	Travel Time Savings Daily Hours
1 SRTP	N/A
2 Best Bus/TSM	0
3 Busway, U of A Shuttle	1760
4 Busway, U of A Direct	1740
5 LRT, U of A Shuttle	2009
6 LRT, U of A Spur	1381
7 LRT via Sixth Street	1317
8 LRT, U of A Tunnel	3039
9 LRT, Northside	2009
10 Busway, Electric Trolley Buses; U of A Shuttle	2009
11 Busway, Electric Trolley Buses; U of A Direct	1381

BROADWAY CORRIDOR STUDY

Table 8.2

TRAVEL TIME SAVINGS
(SRTP RIDERS)

Alternative		Travel Time Savings Daily Hours
1	SRTP	0
2	Best Bus/TSM	12,775
3	Busway, U of A Shuttle	13,393
5	LRT, U of A Shuttle	13,576
7	LRT via Sixth Street	13,278

BROADWAY CORRIDOR STUDY

Table 8.3

PEAK PERIOD
TYPICAL FORECAST TRANSIT UNWEIGHTED TRAVEL TIME
(Minute)

Alternative	Williams Center				Airport				Davis Monthan				Pima College			
	CBD	Tucson Mall	UofA	ElCon Mall	CBD	Tucson Mall	UofA	ElCon Mall	CBD	Tucson Mall	UofA	ElCon Mall	CBD	Tucson Mall	UofA	ElCon Mall
1 SRTP	42.3	69.6	43.5	26.0	70.0	98.7	85.6	89.3	86.0	95.3	80.4	68.8	25.8	47.4	40.3	44.3
2 Best Bus/ TSM	34.5	52.8	30.9	18.8	45.4	65.1	38.2	42.9	46.9	59.2	37.0	27.8	28.4	52.4	39.2	46.0
3 Busway, UofA Shuttle	27.0	54.9	28.9	23.8	43.3	65.1	38.2	42.0	33.1	61.0	35.0	27.4	23.4	47.4	36.4	38.0
5 LRT, UofA Shuttle	24.4	54.5	25.7	20.9	45.7	65.1	38.2	41.9	31.4	61.5	32.7	27.9	23.4	47.4	38.9	36.1
7 LRT Via Sixth St.	29.7	54.5	22.7	29.9	54.1	65.1	38.2	41.9	36.7	61.5	29.7	27.9	23.4	47.4	33.4	42.9

8.2 Transit Accessibility Index

Another measure of level of service analysis undertaken was the development of transit accessibility for each of the transit alternatives. Transit accessibility measures separately the accessibility to the CBD and the U of A as it is perceived by the transit user. The time spent getting to one's destination is the combination of two components. The first, in-vehicle time, is the time spent riding the bus or LRT and, if applicable, auto time while accessing transit. The second component is out-of-vehicle time or the time spent walking to a transit stop and waiting for transit, including transfer time. The transit accessibility is used in this analysis to compare the level of service throughout the region to the CBD and U of A.

Figures 8.1 through 8.4 display in map form the level of service comparisons for the alternatives providing access to the CBD, and Figures 8.5 through 8.8 to the U of A.

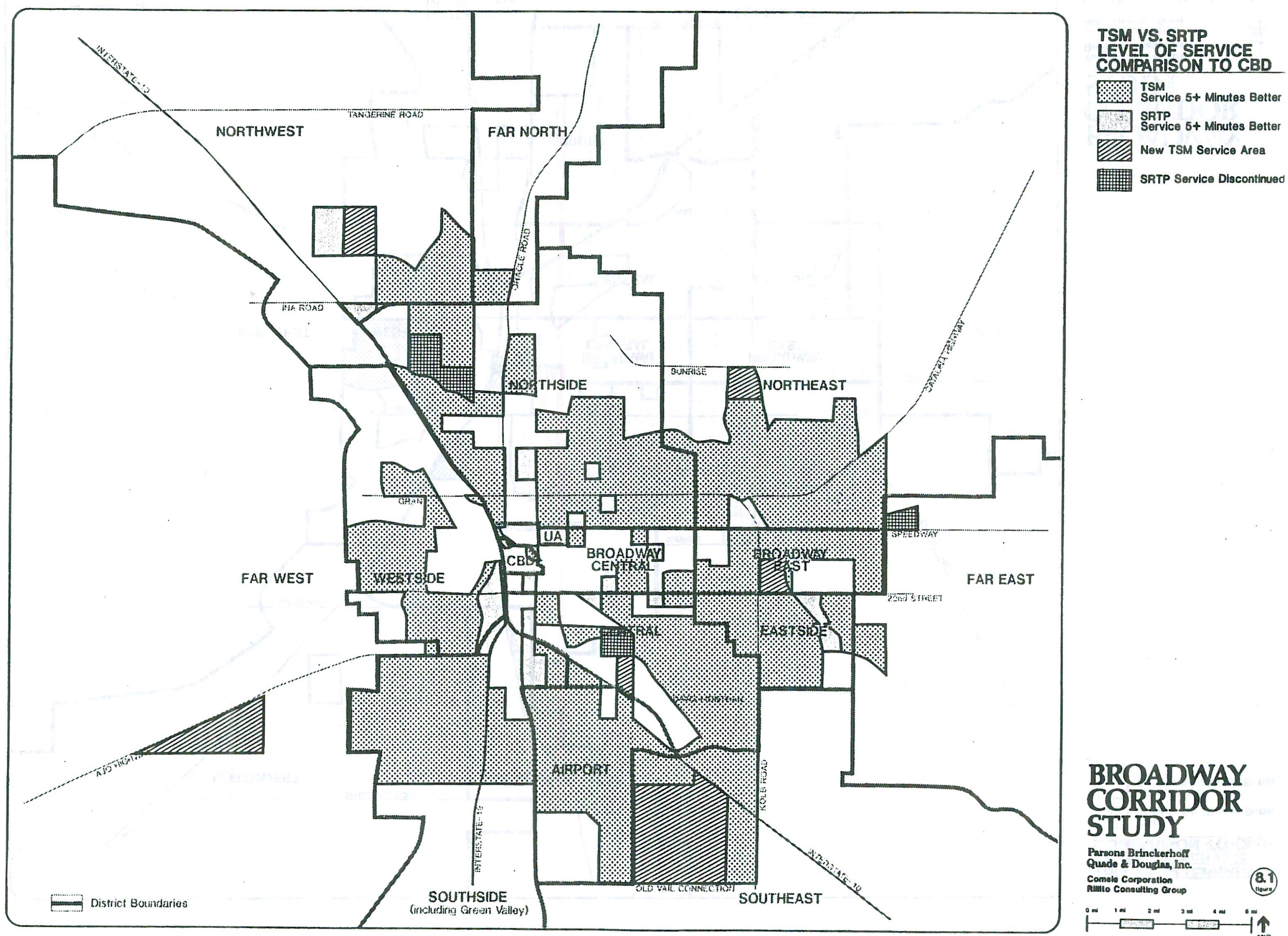
Figure 8.1 compares the level of service to reach the CBD in the TSM Alternative to the SRTP Alternative. The map highlights the areas around the region where the TSM Alternative provides better service by five minutes or more, where the SRTP Alternative provides five minutes or better service, and new service areas in the TSM Alternative. Figure 8.1 shows that the TSM Alternative consistently provides better service to the CBD than does the SRTP Alternative. This would be expected given the extensive TSM bus system and an increase in bus fleet from 342 buses to 697 buses. Those few areas where the SRTP provides better service is primarily due to not equilibrating the SRTP network.

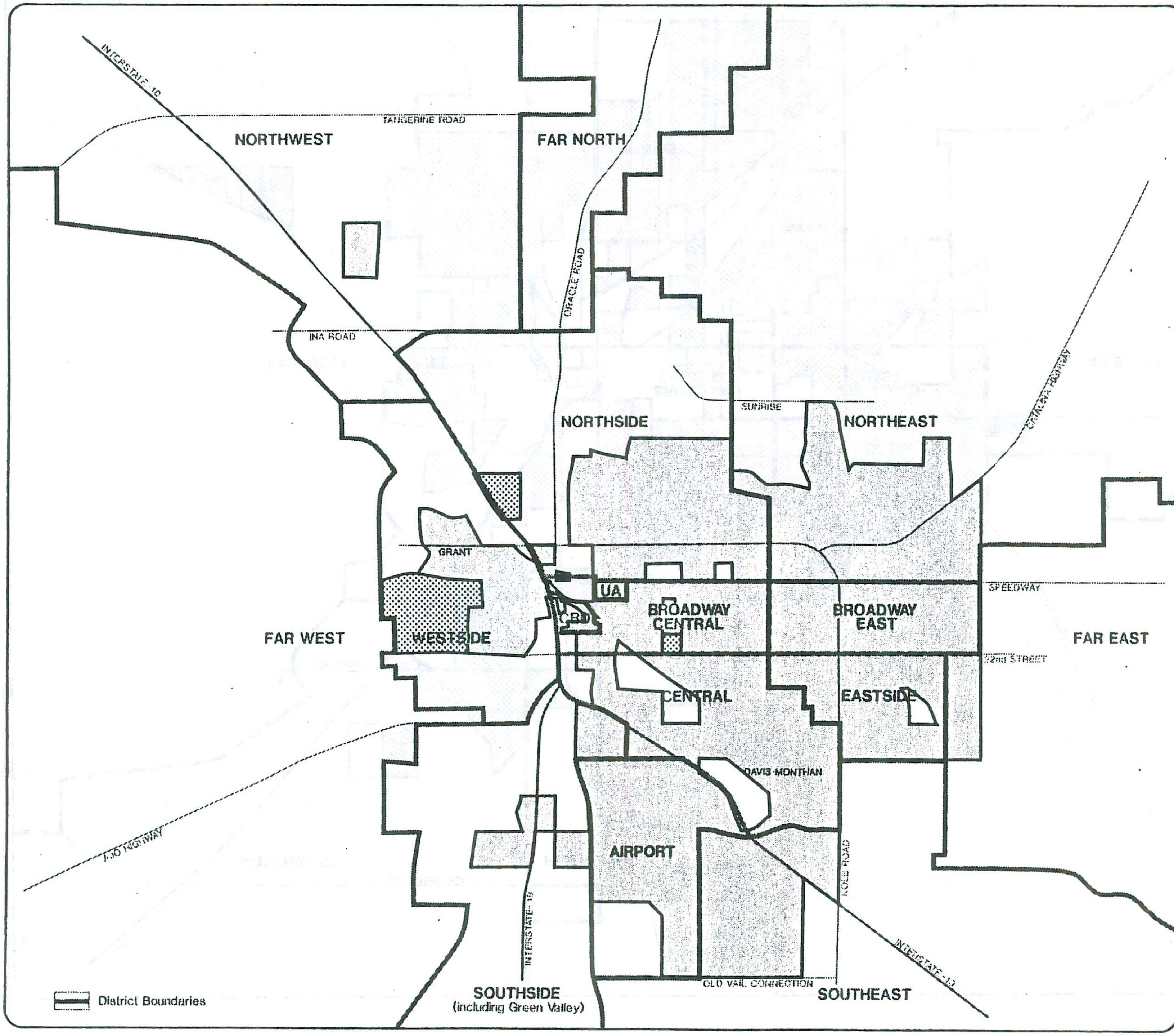
Figures 8.2 to 8.4 compare the build alternatives with the TSM for level of service to the CBD. All of the build alternatives, when compared to the TSM, provide better access to the CBD for most of the region. As the radius from the CBD gets longer the bus coverage in the TSM and the build alternatives is generally identical. In general, the LRT alternatives (see Figures 8.3 and 8.4) improve service in close proximity to the rail stations by using frequent feeder service.

Figures 8.5 through 8.8 present the level of service analysis to the U of A. The same conclusions can be drawn from the U of A analysis as in the CBD analysis, although for the build alternatives the variation in travel paths to reach U of A versus the CBD reflects less benefit.

8.3 Transit User Benefits

Benefits to transit users is a key consideration in the evaluation of alternatives. User benefits come in many forms, such as travel time savings, fare paid, transfers per trip,


TSM VS. SRTP
LEVEL OF SERVICE
COMPARISON TO CBD
TSM
Service 5+ Minutes Better
SRTP
Service 5+ Minutes Better
New TSM Service Area
SRTP Service Discontinued
NORTHWEST
FAR NORTH
NORTHSIDE
NORTHEAST
FAR WEST
WESTSIDE
CBD
UA
BROADWAY CENTRAL
BROADWAY EAST
EASTSIDE
FAR EAST
AIRPORT
SOUTHSIDE
(including Green Valley)
SOUTHEAST
INTERSTATE-10
INTERSTATE-19
TANGERINE ROAD
INA ROAD
ORACLE ROAD
SUNRISE
GRANT
SPEEDWAY
22ND STREET
KOLB ROAD
OLD VAIL CONNECTION
District Boundaries
BROADWAY
CORRIDOR
STUDY
Parsons Brinckerhoff
Quade & Douglas, Inc.
Comela Corporation
Rillito Consulting Group
8.1
figure
0 mi
1 mi
2 mi
3 mi
4 mi
5 mi
north



TSM VS. ALTERNATIVE 3 LEVEL OF SERVICE COMPARISON TO CBD

- TSM Service 5+ Minutes Better
- Alternative 3 Service 5+ Minutes Better

BROADWAY CORRIDOR STUDY

Parsons Brinckerhoff
Quade & Douglas, Inc.

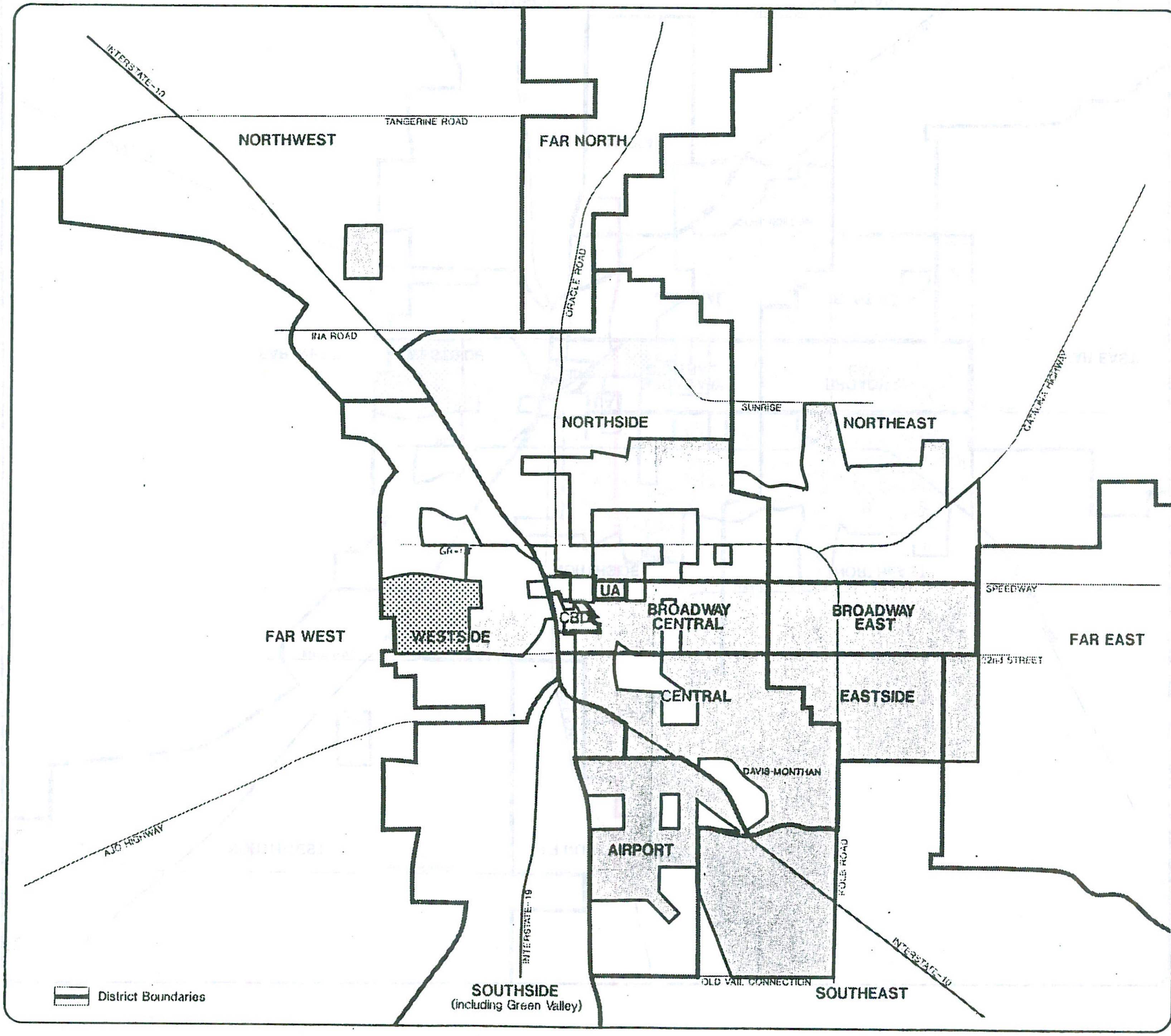
Comsis Corporation
Rillito Consulting Group

8.2 figure

0 mi 1 mi 2 mi 3 mi 4 mi 5 mi north

TSM VS. ALTERNATIVE 5 LEVEL OF SERVICE COMPARISON TO CBD

- TSM Service 5+ Minutes Better
- Alternative 5 Service 5+ Minutes Better



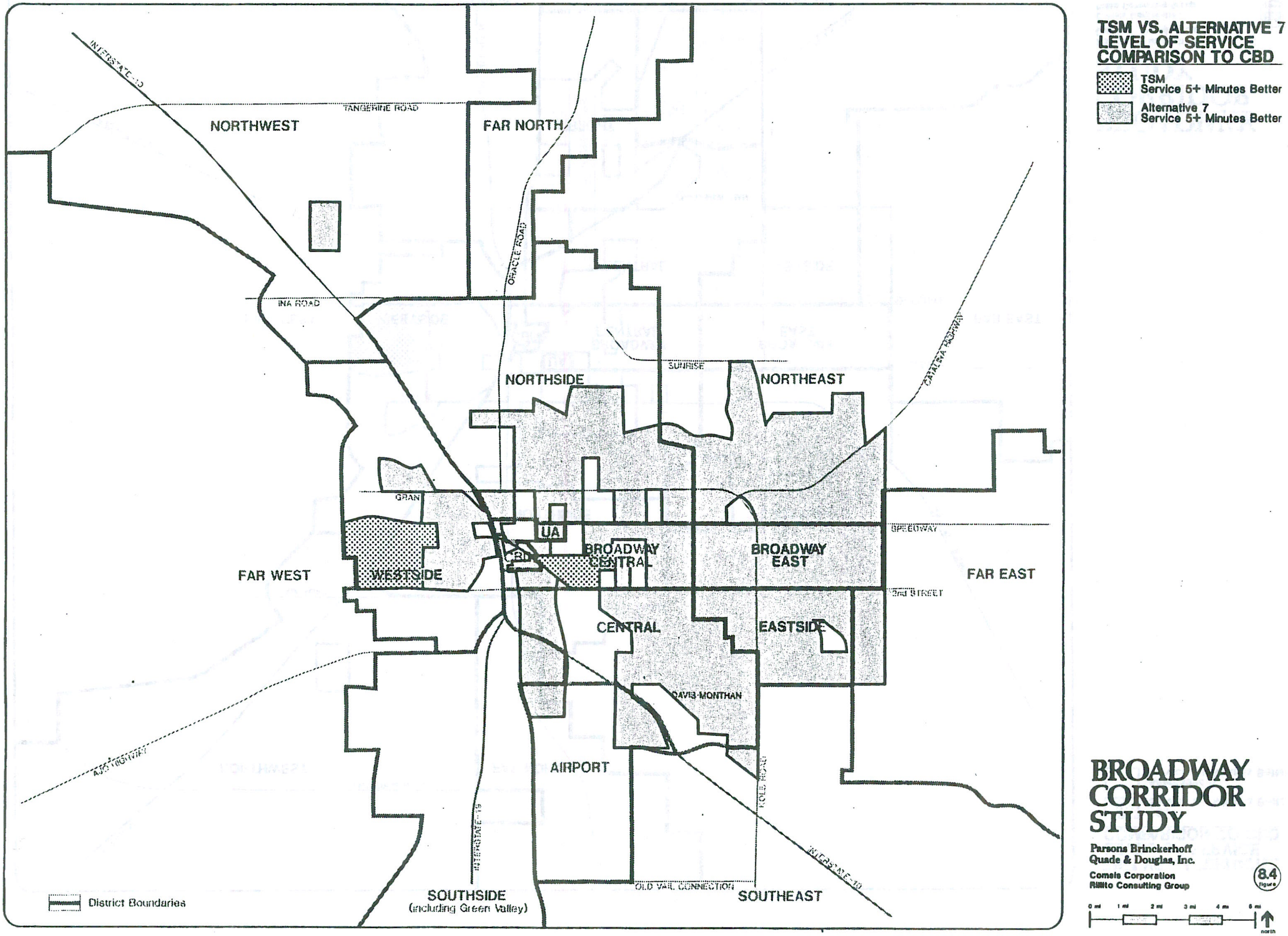
BROADWAY CORRIDOR STUDY

Parsons Brinckerhoff Quade & Douglas, Inc.
Comsis Corporation
Rillito Consulting Group

8.3 figure

0 mi 1 mi 2 mi 3 mi 4 mi 5 mi
north

TSM VS. ALTERNATIVE 7 LEVEL OF SERVICE COMPARISON TO CBD



BROADWAY CORRIDOR STUDY

Parsons Brinckerhoff
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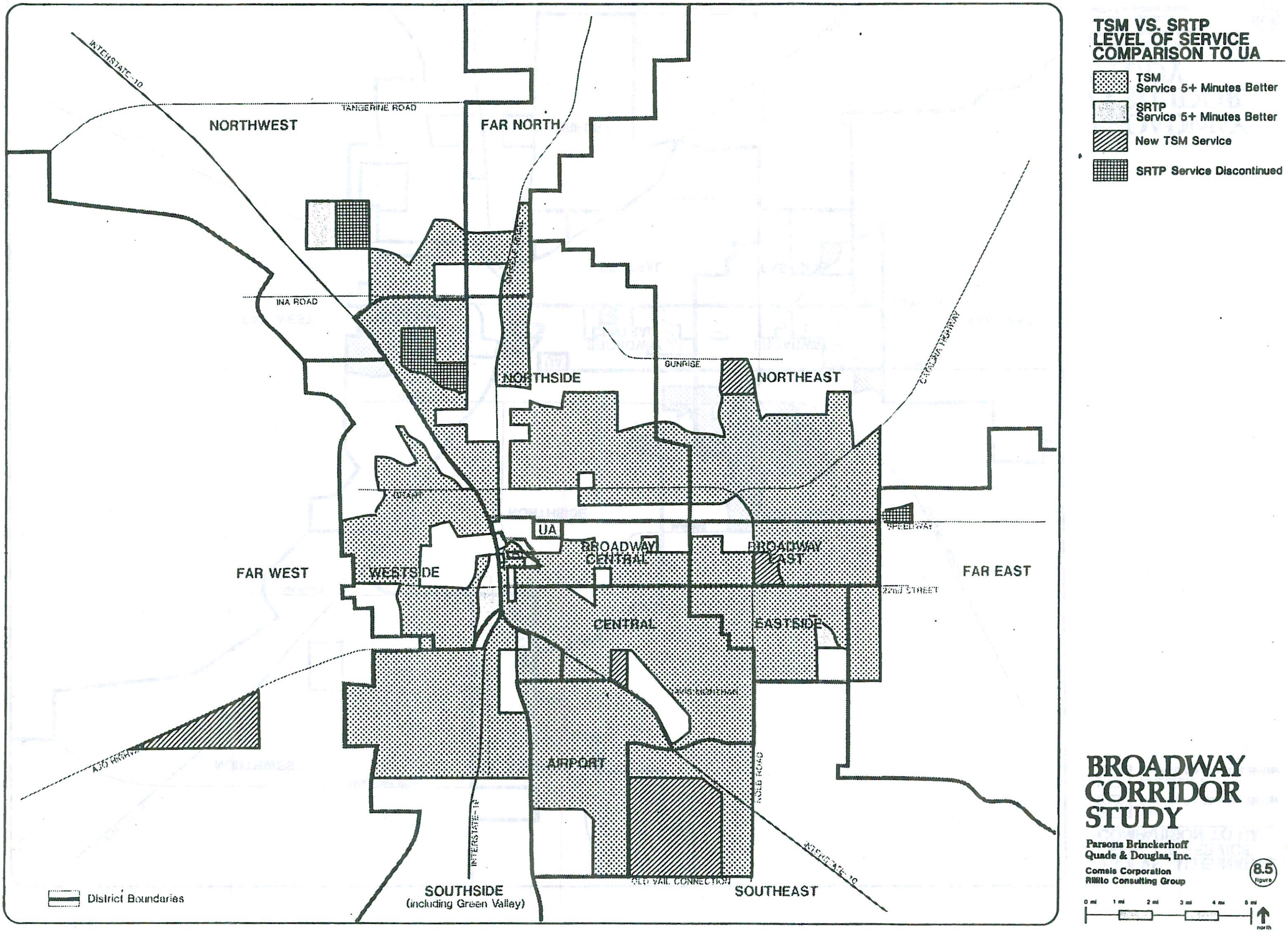
Rillito Consulting Group

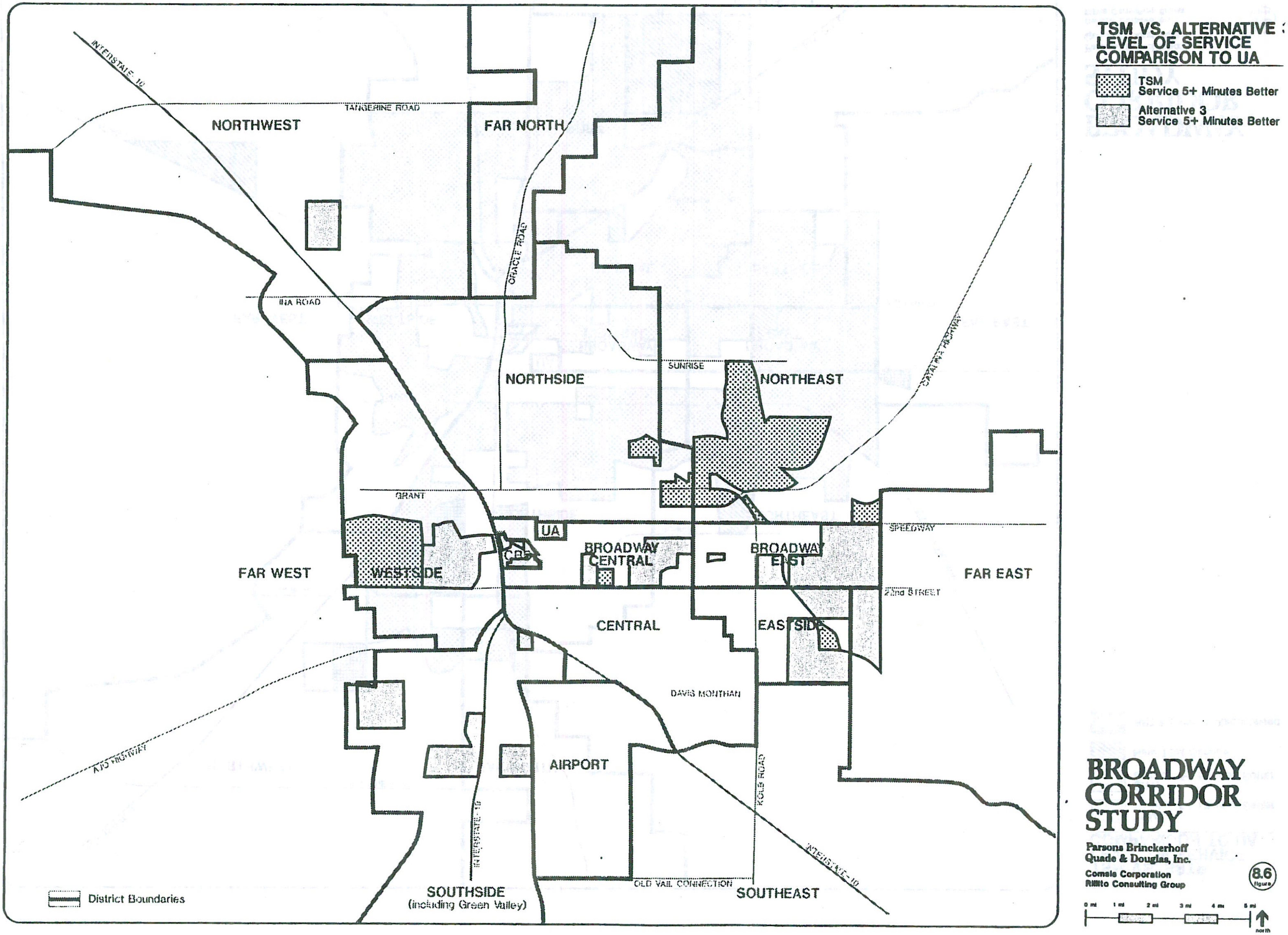
8.4 figure



BROADWAY CORRIDOR STUDY

Parsons Brinckerhoff Quade & Douglas, Inc.
Comsis Corporation
Rillito Consulting Group

8.5
figure



BROADWAY CORRIDOR STUDY

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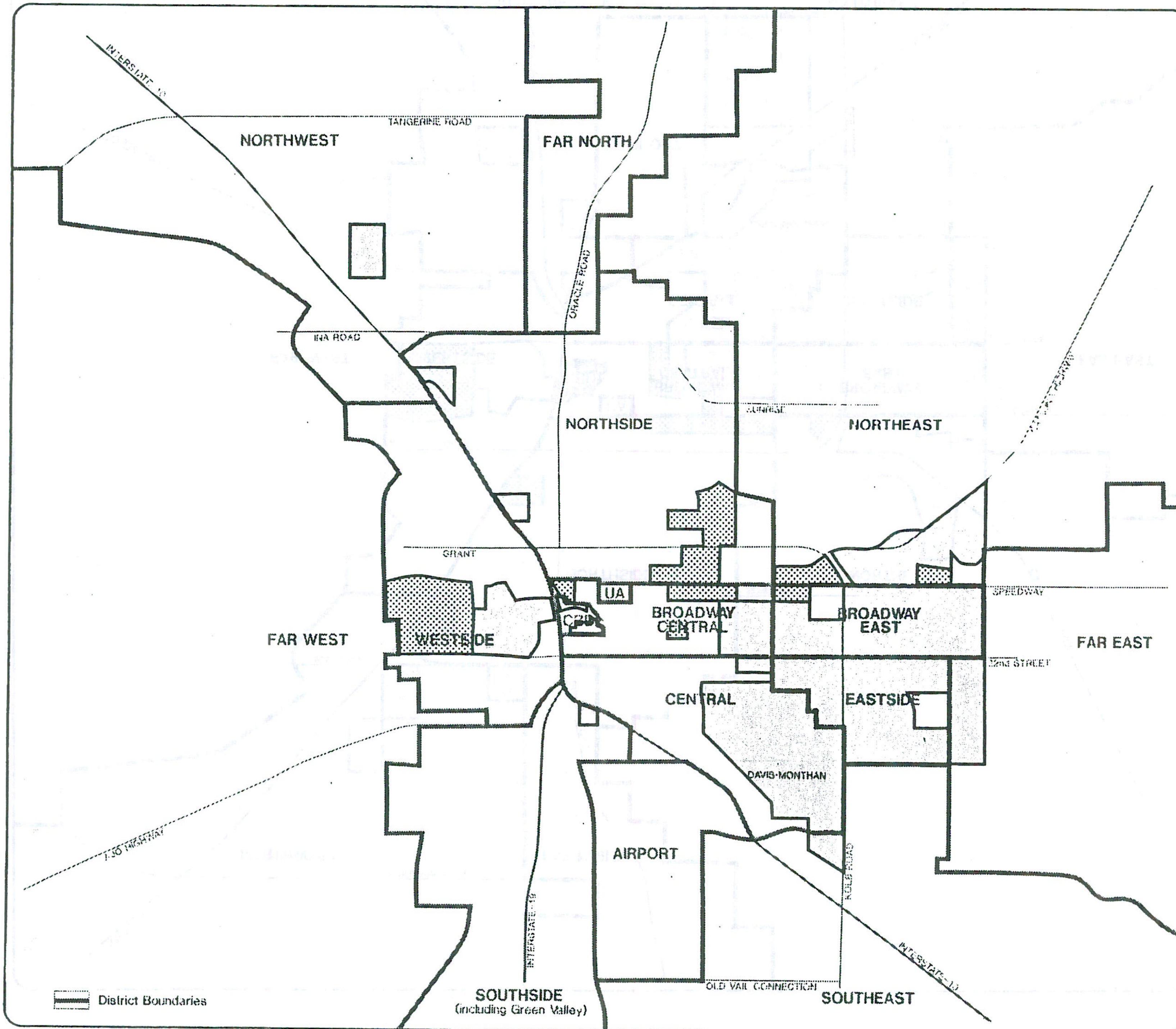
Comsis Corporation
Rillito Consulting Group

8.6
figure

0 mi 1 mi 2 mi 3 mi 4 mi 5 mi
north

TSM VS. ALTERNATIVE 5 LEVEL OF SERVICE COMPARISON TO UA



BROADWAY CORRIDOR STUDY

Parsons Brinckerhoff Quade & Douglas, Inc.
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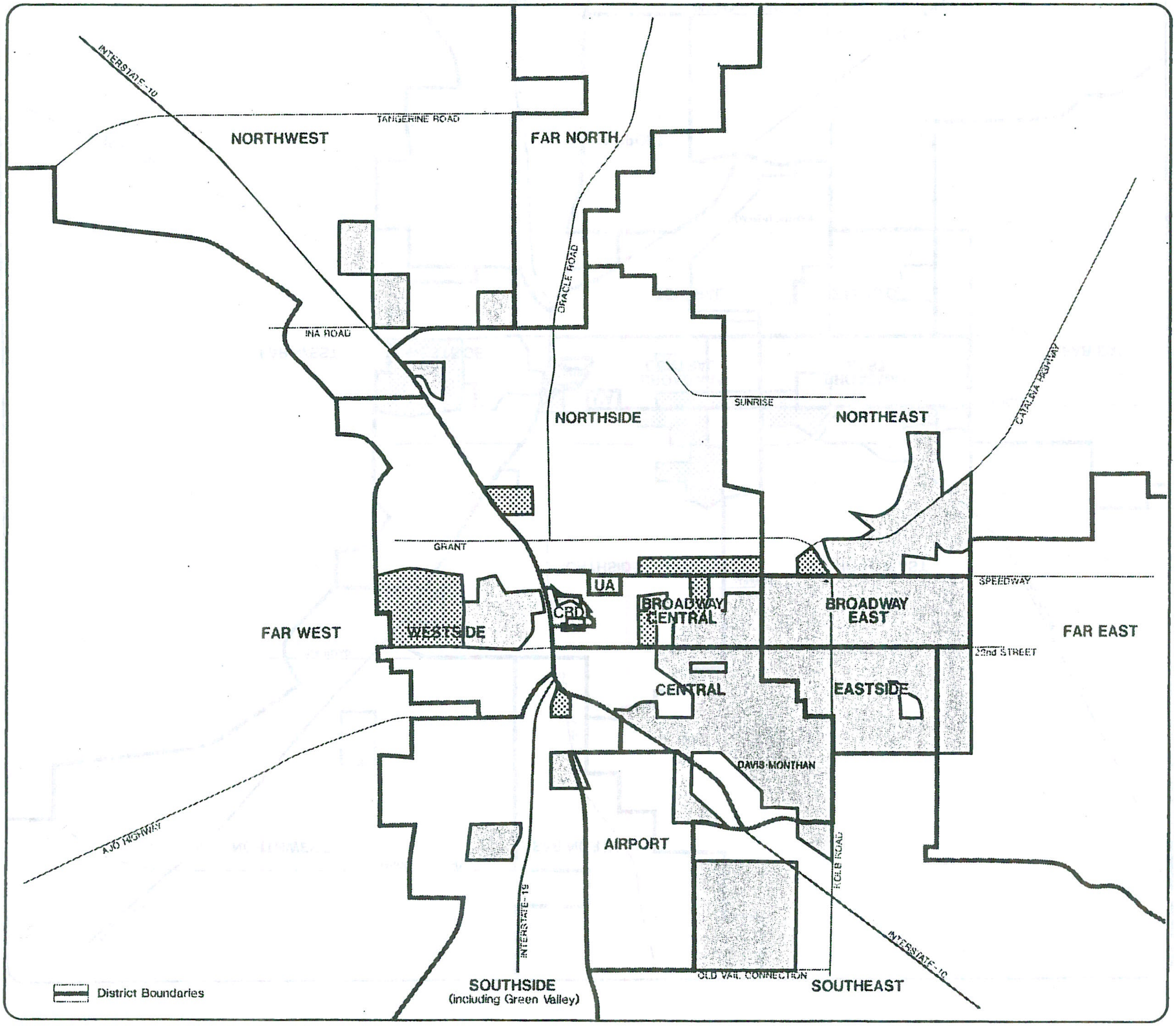
8.7 figure

TSM VS. ALTERNATIVE 7 LEVEL OF SERVICE COMPARISON TO UA

TSM Service 5+ Minutes Better

Alternative 7 Service 5+ Minutes Better



BROADWAY CORRIDOR STUDY

Parsons Brinckerhoff Quade & Douglas, Inc.
Comsis Corporation
Rillito Consulting Group

8.8 figure

0 mi 1 mi 2 mi 3 mi 4 mi 5 mi
north

and general level of service offered. It becomes difficult to compare alternatives in terms of user benefits when there are many types with different units. Thus, for the purposes of this study, the UMTA guidelines for measuring user benefits has been employed. These procedures attempt to consider all user benefits and combine them in one measure with common time units. Since the measure of user benefits is the combination of several factors, its absolute value is not very meaningful. However, comparing the composite measure among alternatives gives a good indication of the relative benefits that each alternative offers to users.

User benefits for each alternative are measured in the incremental benefit that is provided over the TSM Alternative. Thus, there are actually two user groups which receive benefit from a given alternative, "existing transit riders" (or TSM riders) and new transit riders attracted by the alternative. The new transit riders are those individuals who would elect to ride in an automobile in the TSM Alternative.

Research has shown that travelers dislike walking and waiting far more than in-vehicle time, and that out-of-vehicle time contributes twice as much to their perception of transit level of service. In addition, the out-of-pocket cost of transit, or fare, also contributes to the perception of transit level of service. The transit fare was converted to time units by dividing the transit fare by an hourly value of time. Consistent with the current UMTA guidelines, a value of $4.00 per hour for work trips and $2.00 per hour for non-work trips was used. The resulting index for work trips is:

Work Index = (In-Vehicle Time) + 2.0*(Out-of-Vehicle Time) + (Fare/$4.00 per hour)

The index for non-work trips is:

Non-work Index = (0.5 * In-Vehicle Time) + Out-of-Vehicle Time + (Fare/$2.00 per hour)

The benefit to existing or TSM riders capitalizes on the information presented in Section 8.2, Transit Accessibility. The transit accessibility quantifies the level of service from all origins around the region to the CBD and U of A. The user benefits analysis expands on these relationships to include transit accessibility from all origins to all destinations throughout the region and applies the principle that out-of-vehicle time contributes twice as much to their perception of transit level of service. The perceived time savings is then applied to the TSM bus riders and new riders yielding composite perceived travel time benefits (or user benefits) for each build alternative as compared to the TSM Alternative.

Table 8.4 presents the user benefits for each build alternative relative to the TSM Alternative. Alternative 8 has the greatest user benefit.

8.4 Traffic Forecasts

Traffic forecasts have been made for each alternative in order to assess the impacts on traffic operations. For the future year 2010 condition, an examination of the forecast traffic volumes was conducted at the intersection level.

The intersection level of service analysis was conducted for 13 intersections in the corridor. The traffic analysis shows that all of the alternatives have minimal impact on year 2010 traffic operations.

BROADWAY CORRIDOR STUDY

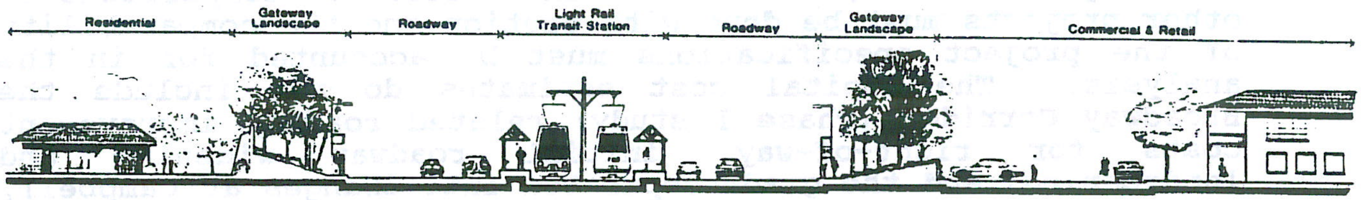
Table 8.4

DAILY USER BENEFITS

Alternative		Daily Hours
3	Busway, U of A Shuttle	1,039.8
4	Busway, U of A Direct	1,043.3
5	LRT, U of A Shuttle	412.3
6	LRT, U of A Spur	- 507.3
7	LRT via Sixth St.	2,198.3
8	LRT, U of A Tunnel	5,110.3
9	LRT, Northside	412.3
10	Busway, Electric Trolley Buses; U of A Shuttle	412.3
11	Busway, Electric Trolley Buses; U of A Direct	- 507.3

BROADWAY CORRIDOR STUDY

9.0 Costs



9.0 COSTS

This section presents the assumptions used for developing the estimated capital and operating and maintenance costs for each of the eleven alternatives. The costs have been developed in 1989 dollars for the purpose of analysis. The procedures have followed UMTA's guidelines and experience by the consultant on similar projects.

9.1 Capital Costs

The capital cost estimates were based on an analysis of the typical cross-sections presented in Chapter 2; the final operating and ridership parameters of the alternatives; previous work done on fixed guideway studies in Salt Lake City, Austin, Denver, and Dallas; and comparisons (adjusted to 1989 dollars) to actual built light rail transit projects in San Diego, San Jose, Sacramento, and Portland. Comparisons to other projects must be done with caution and the comparability of the project specifications must be accounted for in the analysis. The capital cost estimates do not include the Broadway Corridor (Phase I study) related roadway improvement costs for right-of-way; initial roadway widening and landscaping; and the grade-separated interchanges at Campbell, Alvernon, Craycroft, and Kolb. The total roadway costs are estimated to be $120 million.

The capital cost estimates for the alternatives in this Transitional Corridor Analysis were developed on a section-by-section basis depending on the typical cross-section identified for the component. An estimate of each cross-section (cost per linear foot) guideway cost was made which, depending on the alternative, included: (1) segment construction or mainline construction - site clearance, excavation, concrete and structural work, trackwork, paving, lighting, drainage, utilities, catenary pole foundations, etc.; (2) system elements - traction power, overhead catenary suspension, transit signals and control systems; (3) special trackwork - crossovers, etc.; and (4) add on costs related to insurance, design, construction management, agencies costs, and construction contingency.

In addition to the above mainline basic costs, additional capital costs for the items below are required:

- Special segment costs: grade-separated rail transit structure, tunnel sections, special non-revenue LRT tail track to proposed maintenance and operations facility (1.5 miles).
- Transit bus
- Electric trolley bus
- LRT vehicle
- Bus transit centers
- LRT stations (double, single, underground)

- o Busway stops
- o Busway and LRT park-and-ride lots (400 spaces)
- o Regular bus park-and-ride lots (100 spaces maximum)
- o Bus maintenance and operations facility (200 buses)
- o LRT maintenance and operations facility (20 vehicles)
- o Electric trolley bus additional maintenance and operations facility cost.

Table 9.1 summarizes the unit costs used in the final estimate of capital costs for each alternative. Table 9.2 presents the capital components for each alternative that were the basis for the estimate of capital costs. The capital costs for each alternative are summarized by capital component in Table 9.3. The total capital cost for Alternative 2 is approximately $184 million; the busway alternatives $240 million; the non-underground LRT alternatives $340 million; the underground LRT alternative $400 million; and electric trolley bus alternatives $310 million.

9.2 Operating and Maintenance Costs

One of the largest components of the costs of public transit is the on-going annual operating and maintenance costs of the system. In order to properly evaluate the overall cost-effectiveness of the alternatives being studied, a procedure for estimating the annual operating and maintenance costs of each alternative was developed.

UMTA specifies a cost allocation procedure to be followed based on the existing agency's current cost of bus operations and maintenance. The federally mandated Section 15 financial and system performance data are used as the basis for development of the formulas.

In areas such as Tucson where services such as light rail transit and electric trolley buses are not in use, productivity standards are taken from existing operations and the local agency (SunTran) labor rates and other applicable Tucson area costs are applied. For this study, light rail transit factors from existing operations in San Diego, Portland, Buffalo, and Sacramento were used. These new operations would most likely reflect the operation in Tucson, rather than older systems such as San Francisco, Philadelphia, Pittsburgh, and Boston. The estimate of the electric trolley bus costs are difficult because of the limited operations, but it was assumed that the major increase in cost of operations would be the maintenance of the electrical supply system.

Table 9.4 shows the basic formulas for estimating the operating and maintenance costs for each modal component of each alternative. Based on the expansion factors as discussed in Section 7.4, estimates were made of annual boardings (unlinked trips). Annual revenue vehicle miles and annual revenue vehicle hours were estimated based on existing service

Table 9.1

UNIT COSTS - CAPITAL COMPONENTS
(1989 Dollars)

Item	Unit Cost
> Mainline Construction	
- Busway (Regular Bus)	$460/linear foot (LF)
- Light Rail Transit	
o Double Track	$2,025-$2,400/LF
o Single Track	$ 1,010/LF
o Underground (double track)	$ 5,400/LF
- Busway (Electric Trolley Bus)	$ 1,375/LF
> Special LRT Tail Track to M & O Facility	$ 1,805/LF
> Standard Transit Bus	$ 209,000
> Electric Trolley Bus	$ 330,000
> LRT Vehicle	$ 1,500,000
> Bus Transit Center	$ 1,500,000
> LRT Station	
- Double	$ 400,000
- Single	$ 200,000
- Underground (double)	$ 3,000,000
> Busway Stop (station)	$ 100,000
> Busway/LRT Park-and-Ride Lot	$ 2,000,000
> Regular Bus Park-and-Ride Lot	$ 500,000
> Bus M & O Facility	$16,000,000
> LRT M & O Facility	$ 8,000,000
> Electric Trolley Bus M & O Facility Increment per Bus	$ 100,000
> Grade Separation-Railroad Structure (Alternative 7 only)	$ 800,000

BROADWAY CORRIDOR STUDY

Table 9.2

ALTERNATIVES CAPITAL COMPONENT CHARACTERISTICS

Alternative	Regular Buses	Electric Trolley Buses	LRT Vehicle	LRT Stations Busway Stops	Park-and-Ride Lots Regular Bus	Park-and-Ride Lots Busway/LRT	Bus Transit Center	Bus M & O Facility	LRT M & O Facility
Existing (1990)	167	0	0	0	3	0	2	1	0
1 SRTP	342	0	0	0	13	0	4	2	0
2 Best Bus/TSM	697	0	0	0	30	0	6	4	0
3 Busway, U of A Shuttle	816	0	0	8	30	4	6	4	0
4 Busway, U of A Direct	824	0	0	8	30	4	6	4	0
5 LRT, U of A Shuttle	665	0	20	11	20	4	4	3	1
6 LRT, U of A Spur	661	0	26	12	20	4	3	3	1
7 LRT via Sixth Street	661	0	20	12	20	4	3	3	1
8 LRT, U of A Tunnel	661	0	20	11	20	4	3	3	1
9 LRT, Northside	665	0	20	11	20	4	4	3	1
10 Busway, Electric Trolley Buses; U of A Shuttle	736	80	0	8	30	4	6	4	0
11 Busway, Electric Trolley Buses; U of A Direct	734	90	0	8	30	4	6	4	0

BROADWAY CORRIDOR STUDY

Table 9.3

CAPITAL COST SUMMARY (1989 Dollars)

	CAPITAL COST CATEGORY ($ MILLIONS)											
	Mainline Construction			New Vehicles								
	Busway (Regular Bus)	Busway (Elec. Bus)	LRT	Std. Bus	Electric Trolley Bus	LRT Cars	Stations	PNR Lots	Reg. Bus PNR & Transit Centers	Bus M & O Facilities	LRT M & O Facilities[(1)]	Total
1 SRTP				$ 42.4					$ 8.0	$16.0		$ 66.4
2 Best Bus/TSM				$116.6					$19.5	$48.0		$184.1
3 Busway, U of A Shuttle	$19.7			$141.5			$ 0.8	$8.0	$19.5	$49.1		$238.6
4 Busway, U of A Direct	$19.7			$143.2			$ 0.8	$8.0	$19.5	$49.7		$240.9
5 LRT, U of A Shuttle			$109.2	$109.9		$30.0	$ 4.4	$8.0	$11.5	$36.6	$22.3	$331.9
6 LRT, U of A Spur			$114.6	$109.1		$30.0	$ 4.8	$8.0	$10.0	$36.3	$22.3	$335.1
7 LRT via Sixth Street			$116.5	$109.1		$39.0	$ 4.8	$8.0	$10.0	$36.3	$24.7	$348.4
8 LRT, U of A Tunnel			$169.4	$109.1		$30.0	$12.2	$8.0	$10.0	$36.3	$22.3	$397.3
9 LRT, Northside			$121.4	$109.9		$30.0	$ 7.0	$8.0	$11.5	$36.6	$22.3	$346.7
10 Busway, Electric Trolley Buses; U of A Shuttle		$68.5		$124.8	$26.4		$ 0.8	$8.0	$19.5	$57.1		$305.1
11 Busway, Electric Trolley Buses; U of A Direct		$72.8		$124.4	$29.7		$ 0.8	$8.0	$19.5	$58.7		$313.9

(1) Includes 1.5 miles of tail track

Table 9.4

ANNUAL OPERATING AND MAINTENANCE COST FORMULAS
(1989 Dollars)

1. Regular Bus Transit Operations

Annual O & M Cost =	$ 0.958	x Annual Revenue Vehicle Miles
	+ $25.123	x Annual Revenue Vehicle Hours
	+ $3,142	x Number of Peak Vehicles
	+ $ 0.004	x Annual Passenger Boardings
	+ $254,197	x Number of M&O Facilities
	+ $300	x Number of Bus Shelters

2. Electric Trolley Buses

In addition to the regular costs in equation 1 above, there is an additional annual cost of $15,000 per one-way mile of trolley wire.

3. Light Rail Transit Operations

Annual O & M Cost =	$ 1.36	x Annual Revenue Vehicle Miles
	+ $31.59	x Annual Revenue Vehicle Hours
	+ $29,395	x Number of Peak Vehicles
	+ $27,107	x Directional (one-way) Track Miles
	+$150,064	x Number of M & O Facilities

durations and service supply as presented in Chapter 7. The expansion factor from daily estimates of miles and hours to annual estimates is approximately 300.

Table 9.5 summarizes the annual operating and maintenance cost by cost component and total for the eleven alternatives. The major expansion alternatives have an O & M cost range from $73 million to almost $90 million. To put these estimates in perspective, the current operating and maintenance cost for SunTran is approximately $16 million.

9.3 Annualized Capital Costs

In developing a summary of the capital and operating and maintenance costs for use in the UMTA evaluation process, the capital costs are translated in equivalent uniform annual capital costs. These annual capital costs reflect assumptions about the economic life of the capital components in each alternative and the cost of capital (i.e., the discount rate). Uniform annual capital costs are combined with annual operating and maintenance costs and then compared to the benefits of each alternative as discussed in Chapter 10.

Following the UMTA guidance on economic lives of the capital components and the Federal Office of Management and Budget required discount rate of ten (10) percent, Table 9.6 presents the annualization factor applied to the components of the capital costs.

Table 9.7 summarizes the annualized equivalent capital costs in 1989 dollars for each alternative.

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Table 9.5

ANNUAL OPERATING AND MAINTENANCE COSTS
(1989 Dollars)

		Cost Component ($ Millions)			
		Buses	Special Trolley Wire Maintenance	LRT	Total
1	SRTP	$36.4			$36.4
2	Best Bus/TSM	$73.4			$73.4
3	Busway, U of A Shuttle	$88.7			$88.7
4	Busway, U of A Direct	$89.4			$89.4
5	LRT, U of A Shuttle	$73.2		$3.7	$76.9
6	LRT, U of A Spur	$71.4		$3.5	$74.9
7	LRT via Sixth Street	$71.3		$4.5	$75.8
8	LRT, U of A Tunnel	$71.4		$4.1	$75.5
9	LRT, Northside	$73.2		$3.7	$76.9
10	Busway, Electric Trolley Buses; U of A Shuttle	$88.7	$0.3		$89.0
11	Busway, Electric Trolley Buses; U of A Direct	$89.4	$0.4		$89.8

Table 9.6

ANNUALIZED EQUIVALENT CAPITAL COST FACTORS
(Discount Rate = 10%)

Capital Item	Economic Life (Years)	Annualization Factor
Busway Mainline	20	0.117
LRT Mainline	30	0.106
Electric Trolley Mainline	30	0.106
Standard Buses	12	0.147
Electric Trolley Buses	20	0.117
LRT Vehicles	25	0.110
Stations, Centers	30	0.106
Maintenance and Operations Facilities	30	0.106

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Table 9.7

TOTAL EQUIVALENT ANNUAL CAPITAL COSTS
(1989 Dollars)

	Alternative	Total ($ Millions)
1	SRTP	$ 8.8
2	Best Bus/TSM	$24.3
3	Busway, U of A Shuttle	$31.3
4	Busway, U of A Direct	$31.6
5	LRT, U of A Shuttle	$39.8
6	LRT, U of A Spur	$40.1
7	LRT via Sixth St.	$41.6
8	LRT, U of A Tunnel	$46.7
9	LRT, Northside	$41.4
10	Busway, Electric Trolley Buses; U of A Shuttle	$38.0
11	Busway, Electric Trolley Buses; U of A Direct	$38.9

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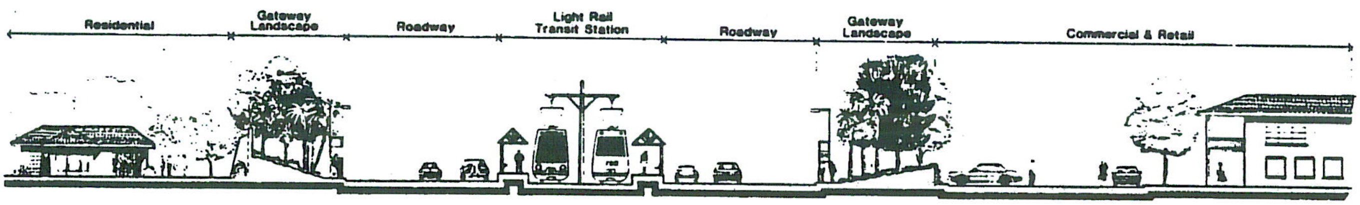
10.0
UMTA Cost-Effective Analysis



10.0 UMTA COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis provides a means for comparing the benefits of each alternative with its costs. The cost-effectiveness analysis also provides a measure for comparing alternatives to aid in the selection of a recommended alternative. The cost-effectiveness analysis has become an important part of the UMTA procedures for review of major transit projects. UMTA has established uniform procedures for calculation of a cost-effectiveness index for major projects. UMTA uses the index as an input to its rating system, which compares projects from throughout the nation and identifies those most worthy of Federal funding. UMTA also uses the index to measure projects against thresholds established as minimum criteria for advancing projects into the alternatives analysis, preliminary engineering, design, and construction phases.

The method for determining the cost-effectiveness measure is a formula described in "Procedures and Technical Methods for Transit Project Planning" published by UMTA, September 1986, and as updated by current UMTA practice. The formula is shown below:

$$\text{Total Cost-Effectiveness Index} = \frac{\Delta\$CAP + \Delta\$O\&M - \Delta\$TT}{\Delta RIDERS}$$

where the Δs' represent changes in costs and benefits compared to the Best Bus/TSM Alternative, and

- $\Delta\$CAP$ = change in equivalent annual capital costs (build vs. TSM)
- $\Delta\$O\&M$ = change in annual operating and maintenance costs (build vs. TSM)
- $\Delta\$TT$ = value of travel time savings for existing riders carried on the TSM Alternative; and
- $\Delta RIDERS$ = annual changes in transit ridership, measured in "linked" trips (build vs TSM)

The output of the formula is an alternative's cost per new passenger attracted relative to the TSM or Best Bus Alternative. The Best Bus/TSM Alternative is used as the baseline since it is designed to represent the most effective solution to transportation problems in the corridor, short of construction of major new facilities. Thus, the TSM Alternative provides a baseline against which it is possible to isolate the added costs and added benefits resulting from a proposed major investment.

Applying this index to the alternatives in this Transitional Corridor Analysis Study yields the results shown in Table 10.1. The current threshold by UMTA for entry into the alternatives analysis phase is $10 per new rider. This threshold is currently under review and may be changed in the future. Based on the study results, none of the build alternatives would pass the current threshold used by UMTA. Alternative 3, busway with the U of A shuttle, however, does have the highest ridership and has a $13 per new rider CEI.

Table 10.1

UMTA TOTAL COST-EFFECTIVENESS INDEX (CEI)
(Ridership Forecast Year - 2010)

Alternative	Annualized Capital Costs (1989 $, Millions)	Annual Operating & Maintenance Costs (1989 $ Millions)	Annual Travel Time Savings to the TSM Riders (1984 $ Millions)	2010 Annual Riders (Millions)	UMTA Total CEI[1] ($/New Rider)
1 SRTP	$ 8.8	$36.4	N.A.	18.5	N.A.
2 Best Bus/TSM	$24.3	$73.4	$0.0	27.7	Baseline
3 Busway, UofA Shuttle	$31.3	$88.7	$1.4	29.3	$ 13.06
4 Busway, UofA Direct	$31.6	$89.4	$1.3	28.7	$ 22.00
5 LRT, UofA Shuttle	$39.8	$76.9	$1.7	27.8	$173.00
6 LRT, UofA Spur	$40.1	$74.9	$1.1	27.2	Less Riders
7 LRT via Sixth Street	$41.6	$75.8	$0.9	27.6	Less Riders
8 LRT, UofA Tunnel	$46.7	$75.5	$2.4	28.4	$ 31.57
9 LRT, Northside	$41.4	$76.9	$1.7	27.8	$189.00
10 Busway, Electric Trolley Buses; UofA Shuttle	$38.0	$89.0	$1.7	27.8	$276.00
11 Busway, Electric Trolley Buses; UofA Direct	$38.9	$89.8	$1.1	27.2	Less Riders

(1) Compared to Alternative 2, Best Bus/TSM

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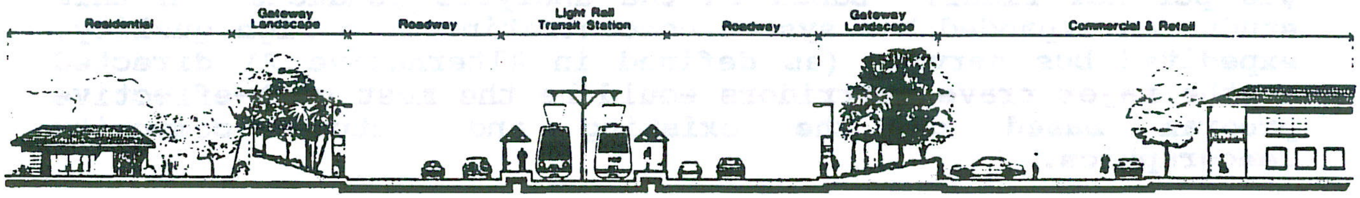
11.0 Conclusion



11.0 CONCLUSION

This phase of the Broadway Corridor Study (Transitional Corridor Analysis) was undertaken with the assistance of UMTA to more critically analyze the findings of the Phase I study related to the cost-effectiveness of implementing a major transit capital investment, as defined by UMTA, within the study area.

The study results revealed that in the Broadway Corridor, when the major build alternatives (3 to 11) are compared to the Best Bus/TSM alternative (2), none of them pass the UMTA thresholds of cost-effectiveness. In addition, Broadway has the highest transit patronage of other corridors in the City, therefore, UMTA does not foresee any federal investments in Tucson in the near future. The busway alternatives (3 and 4) perform the best but still do not pass the UMTA threshold of $10 per new rider. Based on the analyses conducted in this study, an expanded bus system concentrating on a high quality, expedited bus service (as defined in Alternative 2) directed at the major travel corridors would be the most cost-effective program based on the existing and future community demographics.