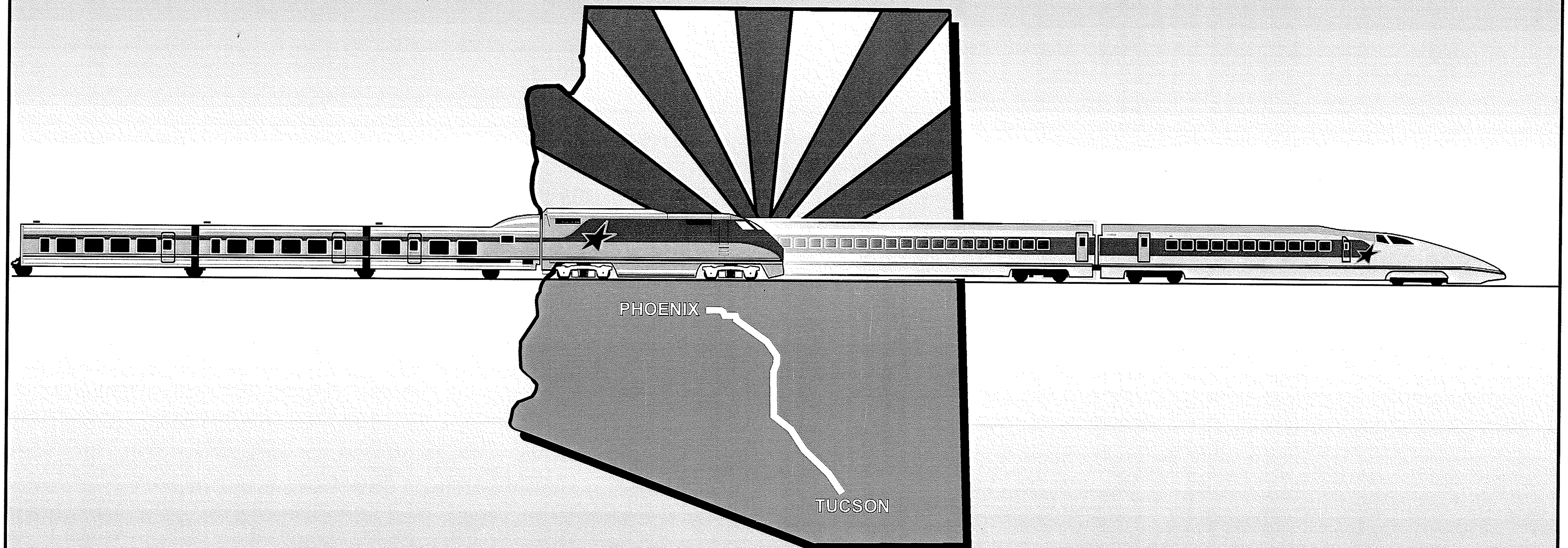
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY



FINAL REPORT

APRIL 1998

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and Associates, Inc.

Preface

The consultant team wishes to express its sincere appreciation for the significant contributions made to this study by the Arizona Department of Transportation and the Steering Committee and Task Force members listed below:

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Frequently Used Acronyms

ADOT	Arizona Department of Transportation
BNSF	Burlington Northern and Santa Fe
CAP	Central Arizona Project
CEI	Cost-effectiveness Index
CTC	Central Traffic Control
FMS	Freeway Management System
HOV	High-Occupancy Vehicle
HSGT	High Speed Ground Transportation
HSR	High Speed Rail
HURF	Highway User Revenue Fund
ICB	Intercity Bus
IMS	Intermodal Management System
ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation System
LTAF	Lottery Transportation Assistance Fund
LOS	Level of Service
LRTP	Long Range Transportation Plan
MAG	Maricopa Association of Governments
MIS	Major Investment Study
MMP	Mobility Management Plan
MTP	Metropolitan Transportation Plan
O&M	Operational and Maintenance (costs)
PAG	Pima Association of Governments
RASP	Regional Aviation System Plan
ROW	Right-Of-Way
SRTP	Short Range Transit Plan
STP	Surface Transportation Program
TDM	Transportation Demand Management
TMA	Transportation Management Associations
TSM	Transportation System Management
UPRR	Union Pacific Railroad
VPD	Vehicles Per Day
VMT	Vehicles Miles Traveled

1 Project Initiation

1.1 Introduction

In May 1997, at a keynote speech during the 70th Arizona Town Hall meeting in Prescott, Arizona, former Arizona Governor Fife Symington presented his vision for creating a multi-modal transportation system for the State in the 21st century. One of the cornerstones of his vision was the establishment of a high-speed passenger rail service between the Phoenix and Tucson metropolitan areas to augment existing automobile, bus, and airline travel between the two regions. Former Governor Symington also outlined his belief that institutional changes would be needed to result in the successful implementation of such a system, including major public/private partnerships and Federal funding.

Arizona has been examining passenger rail transportation as a realistic alternative to the automobile for several years. The earlier studies came to mixed conclusions about the feasibility of passenger rail service in the State. However, a number of factors made passenger rail service more attractive in the early 1990s. Urban mobility, congestion, air quality, and economic development concerns became more prominent in recent years. The Federal government, through its Intermodal Surface Transportation Efficiency Act (ISTEA) legislation, made a major commitment to rebuilding the country's transportation infrastructure as a means of stimulating the economy and improving the environment and quality of life in our cities, suburbs, and rural areas.

Consequently, in June 1992, the Arizona Legislature created a 21-member Joint Legislative Study Committee to examine the feasibility of establishing a passenger rail network in the State. A feasibility study, commissioned in response to the legislative action, and completed in November 1993, came to the conclusion that, in a limited number of locations in the State, new passenger rail service would be feasible. Four projects were recommended for implementation, including an intercity commuter line between Phoenix and Tucson, which was ranked highest of all 39 options examined during the study.

In 1992, The Phoenix-Tucson segment was recommended for implementation for several reasons:

- It is positioned near the center of the State and serves the two largest population centers in Arizona.
- It has the highest ridership potential of all intercity segments studied, at more than 1.5 million annual passengers or a daily average ridership of 4,200.
- It is among the most cost-effective segments of all those studied in terms or ridership related to capital costs.

The capital cost of the 121-mile Phoenix-Tucson segment was estimated at $259.4 million, comprised of $113.4 million for track and roadbed; $12.7 million for seven passenger stations and maintenance facilities; $27.6 million for rolling stock; and $105.7 million for other costs (such as right-of-way). The study estimated a two-hour one-way travel time between the two cities. Service frequency was projected at an optimum of five trains per day in each direction, with four passenger cars per train. Annual operating costs for the segment were estimated at $13.9 million.

The study also examined technology options for intercity corridors. Among the technologies studied were versions of European and Japanese high-speed trains. The study noted that "A diesel-powered version of this train represents the upper limit of technology that might be applied on study corridors in Arizona."

After a review of the 1993 study, the Joint Legislative Committee recommended that additional planning work should be conducted to more fully understand the physical and operating characteristics, benefits, and costs of the recommended projects. The Committee also recommended combining the Phoenix-Tucson project with an extension to Nogales. A follow-up Project Planning study was completed in June 1994; it provided more refined cost and ridership estimates for the Phoenix-Tucson-Nogales passenger rail system and provided an extensive inventory of existing track conditions along the entire corridor. However, no further action was taken on the project until the proposal by former Governor Symington for a high-speed rail study.

1.2 Key Study Issues

A number of key issues are addressed in this study that have major impacts on the costs and operating characteristics of the proposed high-speed rail system.

Alignment Issues

The 1993 and 1994 passenger rail studies proposed using existing railroad rights-of-way for the passenger rail network. However, it is unclear if those rights-of-way are appropriate for use for a high-speed system. The following questions must be addressed:

- Do they pass through too many populated areas, posing neighborhood safety concerns?
- Do they cross too many busy highways?
- Should alternative corridors be explored, such as highway medians or other highway rights-of-way?
- If railroad rights-of-way are used, are the roadbeds sufficient to support high-speed rail service, or will they need to be rebuilt at major expense?
- Can existing structures (such as bridges and culverts) be used, or do they need rehabilitation?
- Will a high-speed rail system interfere with existing freight train operations?
- Can the right-of-way accommodate both freight and high-speed trains?

- If highway rights-of-way are used, how much construction (and related expense) will be required to support a high-speed rail roadbed?
- Can passenger stations be built effectively in or near highway rights-of-way?
- Are there major environmental and safety issues that must be addressed?
- Are there any existing environmental hazards, or areas to be protected, in or near potential corridors that would interfere with the construction or operations of a high-speed rail system?
- Which alignments are more efficient from a passenger access point of view?
- Should existing passenger stations be used, or do they need to be rebuilt to handle high-speed rail?
- Should new stations be added to the network of existing sites?
- What type of passenger access should be provided by potential station sites?
- What improvements to the existing transit network will be needed to provide intermodal connections?
- Should the high-speed rail system provide interface with existing airports?

Vehicle Options

- Should proven off-the-shelf technologies, already in revenue service in other countries, be used in Arizona?
- Can those technologies meet U.S. safety standards?
- Should experimental technologies (such as maglev) be examined for use in the State?
- What types of passenger loading capacities would be required?
- What types of passenger amenities would be desired on passenger cars?
- Are there any non-standard features and/or amenities that should be added to vehicles to meet Arizona's specific climatic needs?

1.3 Major Investment Study Guidelines

While a number of innovative financing techniques exist that can be used to construct and operate a high-speed rail system, including public/private partnerships and joint development programs, Federal funding should still be considered if at all possible. The processes used in this and future studies should not preclude the use of Federal funds if desired by the State.

According to the metropolitan planning rules promulgated under ISTEA, a Major Investment Study (MIS) is required whenever Federal funds are being contemplated for a major transportation improvement. While this study is not yet a MIS, it was conducted to meet the minimum criteria of a federally sponsored MIS.

Typically, an MIS should include:

1. A cooperative and collaborative process comprised of major participants in the regional planning process, with the aim of coming to a regional consensus on the range of alternatives studied and the factors used to evaluate them;

2. An evaluation of the effectiveness and cost-effectiveness of alternatives in attaining regional transportation goals and policies;

3. A consideration of the capital and operating costs of alternatives studied, along with a variety of other key factors such as mobility benefits, community and environmental impacts, safety, and land use and economic development;

4. A mechanism through which highway, transit, and multi-modal alternatives can be developed and evaluated through a single integrated process; and

5. A proactive public involvement process that provides a variety of opportunities for the public and various interest groups in the study area to participate in the deliberative process.

The results and recommendations of an MIS are to be incorporated into fiscally constrained regional transportation planning documents.

These and other factors related to Federal funding were kept in mind as the study progressed.

2 *Public Involvement Plan*

2.1 Introduction

Citizen support for a project of this magnitude is critical to its success. The consensus building process is intended to produce a better result through community participation. This assumes that the combined efforts of technical experts, government policy makers, and knowledgeable local community members will yield a higher quality result. In large part, a meaningful public process requires a shift of attitudes. The government and its consultants must be committed to empowering the community and letting them influence the project's outcome. Conversely, the community must act responsibly and go far beyond merely protesting what should *not* be done; instead, they must demonstrate "buy-in" and should be included in major decisions and support their actions to make the right things happen.

Too often, public meetings are called to give information about plans. Conversely, public meetings could be opportunities for the Project Team to gather information before any plans are made so that the public's views are reflected in the development of alternatives. In any plan, the ideas raised by the citizenry need to be reviewed from a technical standpoint for feasibility. This fulfills two functions. First, it is a good reality check; and secondly, it keeps those likely to be in charge of implementation informed as to the views of the public.

Citizen involvement in public projects is an increasingly critical part of project success. Making the citizen process a *positive* influence on design and implementation often leads to a better end product. If citizens feel they have not had the opportunity to be involved, that they have not been heard, or that their ideas have not been adequately considered, the entire project can be in jeopardy. The combination of technical expertise from the Project Team and local knowledge from the community will ensure a higher-quality result. Citizens must have a *meaningful* role in the decision-making process; otherwise, their frustrations can lead to significant project delay and "lack of ownership" by the public of the project's recommendations.

Making the public process work requires a well thought-out process. The following activities should result in an efficient and effective public process because it interweaves the views of the public with the ongoing technical tasks. The process is flexible so that it can respond to situations that may arise and that cannot now be anticipated.

2.2 Community Involvement Principles

The joint FTA/FHWA Final Rule on Metropolitan Planning (23 CFR Sec 450.316) defines several principles of public involvement. Although this study was not a Major Investment Study, the principles were useful for guiding the public involvement process. According to these principles, the public involvement process for a major transportation project must be:

- **Proactive**, in that the agencies involved in the project must make a concerted outreach effort to ensure that the community is aware of and involved in the process;
- **Early and continuing**, with involvement of the community at key project review and decision points;
- **Complete**, so that the public is provided with up-to-date and accurate information on the alternatives being considered;
- **Timely**, with meeting notices sent out well in advance of meeting dates to provide as much advance notice as possible;
- **Broad** in their outreach to ensure the widest possible range of individuals and groups are aware of and involved in the process; and
- **Responsive**, with a process for ensuring that public comments will be taken into account during the decision-making process.

2.3 Consensus Building Objectives

The objectives for the public involvement program for the Arizona High Speed Rail Feasibility Study were to:

- Improve the planning process by ensuring that the key issues and concerns of the public were aired and discussed early and throughout the study process;
- Facilitate decision-making by allowing public agencies to be comfortable that the public has had legitimate input into the process;
- Enhance credibility and legitimacy by providing a level of trust in the community and assurance that the public's views are genuinely taken into account; and
- Increase the prospects for implementation of any recommended projects by addressing any public concerns early in the process before they become irresolvable issues.

2.4 Consensus Building Techniques

In addition to the ongoing regular meetings of the consultant team and ADOT project team, a number of public involvement techniques were identified to help achieve the objectives of this study.

2.4.1 Step 1: Establish Study Task Force

The Task Force, appointed by former Governor Fife Symington, is a broad group comprised of elected and appointed officials, policy-makers, and representatives of key interest groups (such as educators, transportation advocates, business leaders, public interest groups, and others) from throughout the study corridor. The Task Force met monthly throughout the project to provide overall guidance and policy direction in addition to reviewing study conclusions and recommendations. Those meetings were open to the public.

2.4.2 Step 2: Establish Steering Committee

The project's Steering Committee consisted of a number of technical staff members from ADOT and the Task Force that provided most of the day-to-day guidance for the project. The Committee met every two weeks throughout the course of the study. Those meetings were open to the public.

2.4.3 Step 3: Develop Project Mailing List

To ensure successful implementation of the study's recommendations, public support must complement sound technical analysis. Elected officials and agency officials are key members of the public whose support is integral to implementation. Some of these officials were represented on the Task Force. The objective was to encourage the elected and agency officials to complement public support for implementation of the study recommendations.

Because of the number of names on the list, one-on-one contact with each, beyond the resources of the project, were sometimes more involved than many of these officials desired. Yet, these individuals needed sufficient information on a regular basis to avoid unpleasant surprises during the process, in order to be able to answer constituent's questions satisfactorily.

The technical information directed to these officials did not need to be as extensive and detailed as the information given to the Steering Committee and Task Force. Beyond the newsletters, the Key Elected and Agency Officials received the Technical Report Executive Summaries. For those officials who wanted additional information, the complete Technical Reports were available.

This project mailing list was a "living document," with additions made throughout the course of the project as more and more individuals throughout the region became involved and interested. The consultant developed the mailing list based on input from ADOT and added to it throughout the project.

2.4.4 Step 4: Integration into Regional Planning Processes

Because of the timing and schedule of the project, the regional transportation planning processes of the two major Metropolitan Planning Organizations (MPOs) involved in the study overlapped somewhat with the High Speed Rail Feasibility Study's public involvement process. Therefore, it was recommended that briefings on the High Speed Rail Study be incorporated into the regional plan's public meeting agendas. The Maricopa Association of Government (MAG) planned four open houses throughout the MAG region in October 1997 on the regional planning process. Information on the High Speed Rail Study, and mechanisms for public comment on the study, was available at those meetings. Similar activities also occurred during the public meetings planned by the Pima Association of Governments (PAG).

2.4.5 Step 5: Develop General Public Information Mechanisms

Newsletters

A newsletter transmitted significant amounts of project information to the public through a variety of distribution mechanisms. The newsletters anticipated public questions, provided answers, and raised the public's comfort level with the study.

The consultant team prepared the newsletters to accompany meeting notices, providing information on key project milestones and schedules. ADOT was responsible for distributing and mailing newsletters to the public.

Public Comment Forms

The consultant team also worked with ADOT in developing standardized public comment forms that were used at the public meetings and other forums throughout the course of the project. These forms, when widely distributed at meetings, with newsletters, and at key locations throughout the corridor, provided valuable public feedback on the results of the study.

Media Relations

Media relations were handled by ADOT staff, with guidance and assistance from the consultant team as needed and requested. ADOT was the prime focus of contact for all media activities. The consultant team assisted in the preparation of news releases and other briefing materials that were distributed to the media to keep them informed on the status of the project and its recommendations.

2.4.6 Step 6: Hold Initial Round of Public Meetings

Meeting Series I: Alternatives Definition, held in December 1997 in Phoenix and Tucson, was an opportunity to:

- Inform the public of the feasibility study and its objectives;
- Discuss the community's desires, fears, and suggestions for major transportation improvements in the corridor,
- Review the initial "long list" of alternative alignments and technologies;
- Provide the public with an overview of the technical information gathered to date and the types of information to come as the study continued; and
- Explain initial passenger rail feasibility data, including potential ridership, revenue, capital expense and operating budget figures.

ADOT was responsible for establishing the public meeting dates, making the necessary meeting place and equipment arrangements, notifying the public, and related administrative tasks. The consultant team was responsible for preparing the meeting presentation materials and participating in the meeting presentations and public discussions. Approximately 150 people attended the meeting in Tucson and approximately 25 people attended the meeting in Phoenix.

2.4.7 Step 7: Hold Group and Individual Meetings

In addition to the formal public meetings, the consultant team assisted ADOT with other smaller meetings with governmental entities, community groups, business groups, and others on as-needed basis. These types of meetings were often extremely valuable in pinpointing important local issues of concern that may not have been readily apparent in a large corridor-wide study such as this one. A reasonable number of these additional meetings were provided for in the study budget, and they were scheduled by ADOT as requests came in and resources allowed.

There were groups and individuals that had a special interest in this project and needed contact throughout the planning phases. These groups included neighborhood organizations, business interests, and property owners. ADOT worked with the consultant team to identify key groups and scheduled meetings with those groups as budget resources allowed.

2.4.8 Step 8: Hold Second Round of Public Meetings

Meeting Series II: Evaluation, held in February 1998 in Phoenix and Tucson and included:

- Presentations on the remaining packages of alternatives and their evaluations;
- An analysis, at a conceptual level, of the environmental factors and costs;
- A review of the necessary steps to realize implementation of the study recommendations;
- The consideration of any additional issues contained in the study draft report.

As with the first round of meetings, ADOT was responsible for establishing the public meeting dates, making the necessary meeting place and equipment arrangements, notifying the public, and related administrative tasks. The consultant team was responsible for preparing the meeting presentation materials and participating in the meeting presentations and public discussions. Approximately 60 people attended the meeting in Tucson and approximately 30 people attended the meeting in Phoenix.

2.4.9 Step 9: Develop Materials for Presentation of Recommendations

The study's recommendations and findings were presented to the Task Force and, ultimately, to the State Legislature, in a user-friendly format. The consultant team worked with ADOT to develop appropriate presentation materials on the study's recommendations. These materials included summaries of technical reports, audio-visual materials (such as slides), and other similar materials.

2.4.10 Create Public Involvement Record

The consultant team worked with ADOT to compile a comprehensive public involvement record for the project that documented all meetings, briefings, and public comments generated by the study. (Appendix A is available as a separate document). This documentation will be a necessary element in any future Major Investment Study activities should ADOT choose to pursue a MIS for the corridor.

3 Data Collection/Purpose and Need

3.1 Introduction

The State of Arizona and the Arizona Department of Transportation (ADOT) have long recognized the need for a multimodal/intermodal approach to the movement of persons and goods throughout the State. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provides the impetus for greater emphasis on considering the role of transit services in the State. In the major metropolitan areas of the State, the Maricopa Association of Governments (MAG) and the Pima Association of Governments (PAG) have been engaged in multi-modal transportation planning activities since the 1970s for the Phoenix and Tucson metropolitan areas, respectively.

Transportation in the corridor between Phoenix and Tucson is of vital interest to the State's economy. Convenient and fast travel of persons and the free flow of goods movement are essential for the State's commerce, tourism, employment, industry and overall growth and development. Interstate 10 is the primary transportation route for truck traffic between the two metropolitan regions. Intercity bus and airline services are available in the corridor. The Union Pacific Railroad Mainline tracks are also in the corridor, and carry freight traffic in the corridor. Cargo tonnage is low in the portion of the route north of Picacho Junction, but very heavy south (east) of Picacho Junction.

Since Amtrak discontinued passenger rail service through Phoenix in May of 1996, there has been no passenger rail service between Phoenix and Tucson. While Phoenix is not served by Amtrak directly, Tucson still has service as part of the route between California and points east via the Union Pacific (formerly Southern Pacific) rail route through Yuma and Benson. A connection by bus is provided by Amtrak between Phoenix and the Amtrak depot stop in Tucson, to enable Phoenix passengers to use Amtrak.

The purpose of this chapter is to document the work effort in Task 3 (Data Collection/Purpose and Need) and to provide a general background for the High Speed Rail Feasibility Study. This chapter addresses: previous transportation studies, existing and projected demographic and transportation features in the study area, general goals and objectives of the project, and existing high speed rail systems worldwide (Appendix B is available as a separate document).

3.2 Previous Studies

This section is a review of the relevant background studies and reports completed by ADOT, MAG, and PAG applicable to Maricopa, Pima and Pinal counties in recent years. Some of these studies have direct applicability to the High Speed Rail Feasibility Study while others merely provide background information and help to explain the setting for this project. A brief discussion of the relevance of each study is also provided, where appropriate.
The previous studies are grouped into studies by ADOT (State-level applicability), by MAG (applicable to Phoenix metropolitan area matters), and by PAG (applicable to Tucson metropolitan area matters). Studies in Pinal County are also included to the extent that they have a bearing on the rail corridor between Phoenix and Tucson.

3.2.1 ADOT Studies

ADOT studies pertaining to the Arizona High Speed Rail Feasibility Study are discussed in the following paragraphs.

3.2.1.1 Arizona State Transportation Plan

This State Transportation Plan, published in 1994, was the State's first multimodal plan. It addressed all surface modes of transportation: highways, railroads, public transit, bicycles and pedestrians. The plan reflected the expected increases in the State population from 4.13 million in 1995 to 6.21 million in the year 2015. Statewide employment is expected to increase from 1.66 million to 2.41 million in the same period. The report forecasted that only 50 percent of the needed $1 billion per year will be available for highway, transit and rail improvements to meet increases in population and employment.

The State Transportation Plan includes goals and objectives in six major categories:

Goal 1 - Transportation System: To develop and maintain an integrated, balanced and multimodal State Transportation System that meets the needs of the State of Arizona.

Goal 2 - Economic Development: To promote a transportation system that promotes Arizona's economic development, accommodates the State's population growth and serves permanent and part-time residents and tourists.

Goal 3 - Land Use: To develop a transportation system that is compatible with existing and planned land uses.

Goal 4 - Environmental Considerations: To develop a transportation system that preserves and enhances Arizona's environmental conditions and values.

Goal 5 - Implementation and Financing: To develop an effective system for implementing the elements of the planned transportation system on a stable and equitable funding basis.

Goal 6 - Coordination: To establish a coordinated transportation system that is compatible among all transportation modes and all governmental jurisdictions.

Within each of the major goals, a number of more specific goals are stated. The Plan identifies "Transportation Corridors of Statewide Significance" and presents recommendations pertaining to Funding, Coordination, Corridors, and the State Transportation Plan. This report is important to the High Speed Rail Study for three reasons:

1. The Plan recognizes the need for multimodal transportation system improvements and intermodal linkages/facilities. The High Speed Rail Study is in keeping with the Plan's heavy emphasis on the need to include non-highway modes in corridor plans.

2. The Plan recognizes that traditional funding sources will not be sufficient to make all the necessary transportation system improvements and that the participation of non-traditional transportation interests must be sought. In implementing a high speed rail system, it is therefore very likely that non-traditional funding sources and alliances will be essential.

3. Criteria for evaluating transportation system needs and alternatives should include economic, environmental, and land use considerations in addition to those pertaining to transportation service. Hence, in the High Speed Rail Study, all applicable criteria will need to be considered so that the evaluation of alternatives is truly reflective of the policies and the spirit of the State Transportation Plan.

3.2.1.2 State Rail Plan Update FY 1994

This report was sponsored by ADOT in 1994. The incentive for this plan update was the passage of the ISTEA, which mandated that the State of Arizona prepare a Statewide transportation plan by January 1995. The first State Rail Plan was prepared late in the 1970s. Although some portions of the State Rail Plan were updated in the 1980s, the 1994 update was the first to analyze the entire rail network since the preparation of the original plan. The report provides a detailed analysis including needs and the conditions on each railroad.

The report identifies the locations of both passenger and freight intermodal facilities and presents estimates of freight movement on various segments along the railroads. The segment of the Union Pacific Railroad between Picacho Junction and Tucson is a busy freight route, which in 1995 carried approximately 53 million gross tons. By way of comparison, the UP rail line between Welton and Phoenix carried approximately 4.3 million tons of cargo that year. Freight and passenger intermodal facilities in the corridor between Phoenix and Tucson are:

Freight:	Passenger:
Phoenix	Phoenix (no longer in service)
Casa Grande	Tempe (no longer in service)
Tucson	Coolidge (no longer in service)
	Tucson

A more detailed discussion of the intermodal passenger facilities in the corridor are presented in Working Paper No. 2 of the State Rail Plan Update, discussed next.

3.2.1.3 Working Paper No. 2, Arizona State Rail Plan Update: Intermodal Passenger Facilities

This 1994 report was sponsored by ADOT to provide an inventory of intermodal passenger rail facilities in the State. Below is a summary of the primary findings for Amtrak stations in the High Speed Rail Study area.

Phoenix - This is an historic station building which has a ticket office, waiting room and rest rooms. The station complies with ADA requirements. In 1995, approximately 21,500 passengers used the Phoenix Amtrak station.

Tempe - This stop does not have a station building or ticketing office. The platform is not in compliance with ADA requirements. In 1995, approximately 3,200 passengers used the Tempe Amtrak station.

Coolidge - This station consists of one small shelter with no station building or ticketing office. The station does not comply with ADA requirements. In 1995, approximately 700 passengers used the Coolidge Amtrak station.

Tucson - This station consists of a station building; however, there are no ticketing offices, and the station is not in compliance with ADA requirements. In 1995, approximately 16,000 passengers used the Tucson Amtrak station.

If passenger rail service between Phoenix and Tucson were to be implemented, the station building in Phoenix could be used to provide the necessary facilities. While upgrades may be needed, fundamentally the building would be suitable. Other station locations in the vicinity of Central Avenue should also be considered. The Tucson station would need substantial upgrade, including compliance with ADA requirements. The Tempe and Coolidge stations, if they were to be used as stops along the high speed rail route, would need substantial upgrades, including the construction of a station building and ensuring ADA compliance at each station.

3.2.1.4 Intercity Bus Analysis

This study, conducted under the auspices of ADOT, published in June 1995, presents an inventory of Intercity Bus (ICB) Operators in Arizona, describes the corridors and city pairs served, presents demographic data about riders to the extent available, and presents a discussion of ICB needs. As might be expected, the corridor between Phoenix and Tucson is identified as the corridor with the highest level of service (the most bus trips between city pairs).

While not stated, the report implies that the State has an interest in preserving, or perhaps enhancing, the levels of ICB service in the State so that mobility throughout the State is maintained. The report raises objections to State financial support (subsidy) for rail passenger service, since such subsidized service would compete with unsubsidized private ICBs. This raises a policy issue that the State must address as part of the discussion of the "feasibility" of a high speed rail service.

3.2.1.5 Arizona Rail Passenger Feasibility Study

This study, performed in 1993 by Kimley-Horn and Associates for ADOT, was conducted to determine the feasibility of low-cost passenger rail service throughout the State.

In addition to 39 Statewide intercity corridors studied 16 Phoenix-area commuter rail alternatives and seven Tucson area commuter rail alternatives were identified. Evaluation of this "long list" of alternative projects centered on estimated ridership levels, capital costs, and operating and maintenance costs. The purpose of this study was to test the initial viability of passenger rail service in these locations to determine if further planning and engineering of one or more specific projects is warranted. This study evaluated the conditions and problems that exist on railroad segments that were deemed likely possibilities for passenger rail service.

The study concluded that there are a limited number of locations in the State where new passenger service is feasible. Based on the results of this study, service plans were set for four integrated projects which had the most promise in meeting the goals and objectives. Included in the recommended plan for passenger service in Arizona were two rail lines including:

1. *Phoenix-Tucson Intercity Rail Line*
   Connecting Phoenix and Tucson with intercity service ranked the highest among all of the 39 options studied in overall ridership. However, it is the most costly of the 10 intercity segments studied. Phoenix-Tucson is the only segment studied that will require the construction of significant new trackage due to several conflicts with existing and planned freight railroad operations, namely the Southern Pacific route (now Union Pacific), a heavily used freight operation between Los Angeles and New Orleans. This 121-mile segment has a capital cost of $260 million and an annual operating cost of $14 million, and would carry an estimated 4,200 passengers per day.

2. *Glendale-Mesa Commuter Rail Line*
   The most cost-effective commuter rail option connects Glendale and Mesa through downtown Phoenix Union Station. This project differs substantially from the intercity recommendations in that it is a major "urban" transportation solution, with benefits that relate to congestion relief, air quality and other large-city problems. Although less cost-effective than the intercity project, this option becomes more cost-effective if the Phoenix-Tucson intercity project is also implemented, since 19 miles of the 29-mile Glendale-Mesa commuter rail line overlap, east of Phoenix Union Station.

3.2.1.6 Arizona Rail Passenger Feasibility Continuation Study: Project Planning

Kimley-Horn was contracted by ADOT in June of 1994 to develop a detailed project plan of the major recommendations resulting from the Arizona Rail Passenger Feasibility Study. In November 1993, the Joint Legislative Study Committee on Rail Passenger Transportation, created by the Arizona Legislature to examine rail passenger service in the State, recommended that two projects be subject to more detailed planning activities including:
1. Phoenix-area Commuter Rail Project; and
2. Phoenix-Tucson-Nogales Intercity Rail Project.

Phoenix-Area Commuter Rail Project
The study cites the following benefits of implementing this project including:
- Increased mobility for commuters in a very congested urban corridor;
- Improvements to air quality within the corridor; and
- Economic stimulation through the creation of new jobs and potential new development or redevelopment adjacent to the proposed commuter rail passenger stations.

Phoenix-Tucson-Nogales Intercity Rail Project
The study states the following benefits of a Phoenix-Tucson-Nogales intercity project:
- Increased mobility and access for travelers within the corridor; and
- Increased economic development through the promotion of trade between Arizona and Mexico.

Ridership estimates for intercity service shown in the 1993 Feasibility Study are recommended as reliable and conservative estimates for continued utilization in the project planning phase. Ridership forecasts estimate that 4,700 people will board on weekdays in the year 2000, and 6,400 in 2015.

Estimated capital costs for the 187-mile segment are $298 million, with annual operating costs of $20 million. The study uses an example average fare of $8 for the segment between Phoenix and Tucson and $5 for the Tucson-Nogales segment to estimate an annual revenue of

$11.7 million in 2000 and $16.1 million in 2015. These fares are calculated using the base figure of 10 to 15 cents per passenger mile. By way of comparison, Amtrak's standard round-trip fare between Phoenix and Tucson was $41, or 17 cents per mile (Amtrak discontinued service to Phoenix in 1996).

3.2.1.7 Intermodal Management System for the State of Arizona

This report was an effort by ADOT in 1995 to develop an Intermodal Management System (IMS) in response to Federal mandates embodied in the Intermodal Surface Transportation Efficiency Act. This report was developed in concert with the IMSs being developed by MAG and PAG.

Intermodal facilities in Maricopa and Pima counties were not analyzed in this study; however they were catalogued in separate IMS studies conducted by MAG and PAG. The study did however inventory intermodal facilities in Pinal County. The Coolidge Amtrak station was the only one with relevance to the High Speed Rail Study, which was noted as being deficient in ADA compliance, passenger amenities and ticket facilities.

3.2.1.8 Alternative Transportation System Task Force

In May of 1996, former Governor Fife Symington established the Alternative Transportation Task force to provide guidance on the development of alternative transportation measures. This task force was created in response to increasing traffic volumes and air quality problems in the Phoenix Metropolitan Area. The task force sought to develop an alternative transportation strategy that would reduce air pollution in a cost-effective manner and that would have a positive impact on regional economic development, and the comfort and welfare of Valley citizens. The task force developed short term (one to five years) and long term (three to seven years) recommendations that include such items as telecommuting, alternative work schedules, HOV lane pricing, carpooling, conversion of government fleets to alternative fuels, vanpooling, bus transit, and rail transit.

Because of its focus on travel within the metropolitan area, this study has no direct bearing on the High Speed Rail Study except for its recognition, as background information, that reductions in travel in single occupant vehicles would have air quality and congestion reduction benefits.

Table 3-1 Cost Effectiveness of Short Term Options

Short Term Option	Estimated Total Pollution Reduction (Tons/year)	Estimated Annual Public Cost (000's of 1996$)	Measure of Cost-Effectiveness (Cost/Ton) of Pollution Reduced
Telecommuting - High	2,797	$700	$250
Alternate Work Schedules - High	2,034	$600	$295
Carpooling - High	1,017	$3,500	$3,441
Alternate Fuels Conversion (Government Fleets)	399	$150	$375

3.2.1.9 Arizona Transit Plan

The Arizona Transit Plan was published in July of 1997 by ADOT. The plan identifies a Priority Transit System, outlining the financing, planning activities, and important issues that must be addressed in order to develop an effective transit network. The plan describes existing transportation services, facilities and the needs of public transit users. The I-10 corridor between Phoenix and Tucson is listed as one of the fourteen top priority corridors in the State of Arizona for multimodal "Corridor Profile" studies. In addition, studies were conducted to identify public and private sector service needs leading to the following conclusions:

- Many communities do not have public transit services to meet the needs of the communities.
- Terminals and stations are generally perceived to be run-down, unclean and unsafe.
- Three sites holding the most potential for intermodal transport, in order of priority, are Phoenix, Tucson and Flagstaff.
- Pinal County was identified as a top priority for developing regional services.
- Transit services are limited in the Phoenix metro area, funded at $25 per capita while peer communities average $58 per capita.
- City of Tucson has significant funding shortfalls in its transit system.

The estimated cost to implement the Priority Transit System is an additional $93 million in expansion funding, along with $108 million in facilities (or approximately double the current public investment in transit services). These investments would be focused on meeting needs within the major metropolitan areas and in rural areas. No funding is indicated for intercity passenger rail service or intercity bus service. About $3,190,000 is included for intercity bus system studies and for Statewide transit signage.

3.2.2 MAG Studies

Following is a brief presentation and discussion of selected MAG studies considered applicable to the Arizona High Speed Rail Feasibility Study.

3.2.2.1 MAG Long Range Transportation Plan

The Long Range Transportation Plan (LRTP) of MAG is a document that is usually updated annually and addresses all applicable transportation modes within a 20-year or longer time frame. The most recent update of the MAG LRTP is a Draft prepared in September 1997 that addresses the planning horizon year 2017. Population in Maricopa County is expected to increase 70 percent and regional travel is expected to increase almost 80 percent. The LRTP includes new freeway construction, addition of HOV lanes to existing freeways, doubling of bus transit service, tripling of dial-a-ride service, a fixed guideway starter corridor, major street improvements, bicycle facilities, guidelines for pedestrian facilities, and the Regional Airport System Plan (RASP). The LRTP also includes Transportation System Management (TSM), Transportation Demand Management (TDM) and Intelligent Transportation System (ITS) improvements and measures.

The MAG LRTP indicates that the I-10 freeway at the southern boundary of the MAG planning area would have a daily traffic volume of 65,000 vehicles in 2017. The portion of I-10 south of the South Mountain Freeway would be in the "congested" category. This portion of I-10, because of its location near the MAG boundary, carries primarily external traffic (traffic to/from or through the MAG area). This traffic volume projection and expectation of congestion on I-10 have implications for the high speed rail system and will be considered in the evaluation of alternatives in a subsequent task.

The LRTP provision for doubling transit service is also important because of its implications of connector service at high speed rail stations. The allocation of resources for such a major upgrading of the transit service would allow for flexibility in designing feeder routes to transport passengers to/from the stations. Likewise, connectivity with the fixed guideway system would be a system planning consideration.

3.2.2.2 MAG Intermodal Management System

The purpose of the MAG Intermodal Management System Study, conducted in 1995 by the Maricopa Association of Governments, was to survey and analyze the intermodal facilities in the Phoenix region. The goal of the study was to identify, evaluate, and rank projects to enhance mobility and accessibility to and from inter-regional and inter-modal facilities. The focus of this report was on freight terminals and passenger intermodal facilities providing a connection between Phoenix and other cities, states or nations. This study is relevant to the High Speed Rail Study because it identifies passenger mobility and accessibility problems in the Phoenix region.

The intermodal facilities inventoried in this report include:
- Phoenix Sky Harbor Airport;
- Greyhound bus terminals located in Phoenix, Glendale, Mesa, Tempe, Buckeye, Tolleson;
- rail freight terminals- Southern Pacific and Sante Fe;
- rail passenger terminal - Amtrak;
- pipeline terminals; and
- truck terminals.

As a result of the survey, the following relevant concerns were identified:
- Traffic congestion in 43 locations, several along I-10.
- Locations with inadequate signage, pavement, clearance, traffic signals, and merging lanes.
- Phoenix Amtrak Station has no direction signs, and access on South 4th can be blocked by commercial vehicles.
- Sky Harbor Airport is affected by congestion.
- Greyhound Stations at Phoenix, Chandler, Mesa, Tempe have no information booths or racks, no courtesy phones, and the station is affected by congestion.
- The Regional Public Transit Authority (RPTA) does not operate fixed-route, fixed-schedule bus service on Sundays.
- The RPTA's bus routes are generally out of service by 8 PM.

The following goals were recommended for the IMS:
- Increase the opportunities available to have transportation users select from more than one mode.
- Define actions that can be implemented by public agencies or private companies to support a variety of modes.
- Provide convenient, rapid, efficient and safe transfers between modes.
- Involve representatives of both the public and private sectors in the planning process.

3.2.3 PAG Studies

Following is a brief presentation and discussion of selected PAG studies considered applicable to the Arizona High Speed Feasibility Study.

3.2.3.1 Pima Association of Governments Metropolitan Transportation Plan

The Metropolitan Transportation Plan (MTP) was adopted by PAG on September 28,1994. PAG is currently engaged in a major update of the MTP, expected to be completed in June, 1998. The plan provides a 20-year vision for the eastern Pima County transportation system which includes unincorporated Pima County, the City of Tucson, the City of South Tucson, the Town of Marana, the Town of Oro Valley, the San Xavier District of the Tohono O'Odham Nation, the Town of Sahuarita, and the Pascua Yaqui Tribe. This plan is an update of the Regional Long Range Transportation and Air Quality Plan, last updated in the fall of 1993.

The report found that with the expected growth in the region there will be increased trip lengths, longer trip times, and more vehicle miles of travel within the urban area of the county. Since 1960, growth in Pima County has averaged between 2.0 and 2.3 percent annually. During that same period the County has also experienced a strong employment growth rate of 4.1 percent. However, while population and employment have increased, the percentage of the population using alternate modes of transportation has decreased creating an increase in single occupant vehicle travel demand. Thus, a more efficient utilization of the transportation facilities will be required to meet the increase in demand.

Transit improvements recommended by the report include the following:
- Doubling of the existing bus fleet.
- Reducing headways to 5 to 15 minutes in the central district and 20 to 30 minutes in the peripheral zone.
- Park and Ride lots to accommodate 2,000 autos.
- Transit center expansions to include commuter services.
- Conversion of the bus fleet to alternative fuels.
- Development of a Light Rail Transit System.

The plan recommends that priorities shift to travel demand reduction and growth management to minimize the need for new facilities; utilizing new technologies to make the best use of existing facilities; and expanding revenue sources to meet future needs.

3.2.3.2 PAG 1992 Mobility Management Plan

This document was developed by PAG in accordance with the ISTEA. The purpose of this study, published in December 1993, was to develop the components of a congestion management system which would emphasize air quality and mobility enhancement aspects. The study contains recommended actions to alleviate congestion and enhance mobility within the metropolitan area at both a system-wide and corridor sub-area level. The Mobility Management Plan (MMP) sets forth performance criteria for the roadway network and the transit system. The MMP does not address intercity travel matters, so it has no direct applicability to the Arizona High Speed Rail Feasibility Study; intercity passenger rail service would support this plan.

3.2.3.3 Pima Association of Governments Travel Demand Study

This study was conducted under a consultant contract for PAG in late 1993. Telephone interviews were conducted with area residents to better understand the travel patterns in the county.

The survey revealed an average of 8.03 person trips per household, of which approximately 73 percent were to and from home (home based) and 27 percent were non-home based. Of the home based trips, approximately 25 percent were to and/or from work, 15 percent were for school, 15 percent were for shopping, 20 percent were for social/recreational purposes, and the remaining 25 percent were for other miscellaneous purposes.
The PAG Travel Demand Study provides the basis for the PAG Travel Demand Models. The raw data, not included in the published report, also provides an indication of the magnitude of the daily trip-making by residents of the Tucson metropolitan area to the Phoenix metropolitan area.

3.2.3.4 Metropolitan Tucson Short Range Transit Plan

This document was prepared by the Tucson Department of Transportation, in cooperation with Sun Tran, the City of South Tucson and the Pima County Department of Transportation for the period of fiscal years 1993/94 through 1997/98. The Short Range Transit Plan (SRTP) is a plan for future transit service delivery. The study reports that the percent of the public that are riders increased from 17 percent in 1983, to 24 percent in 1992. Furthermore, the percent of the public identified as potential riders rose from 31 percent in 1983, to 50 percent in 1992. The report states that with anticipated cutbacks of Federal transit operating assistance programs, any service expansion will be dependent on increased support by local elected officials and or the public.

3.2.3.5 PAG Intermodal Management System

The purpose of the PAG Intermodal Management System Study, conducted in 1995 by a consultant for PAG, was to identify and inventory the type of services provided by each transportation mode and the characteristics of the facilities in Pima County. The goal of the study was to recommend project improvements to create a transportation system that fosters a more efficient transfer of passengers and goods between modes. This study is relevant to the High Speed Rail Study because it identifies existing mobility and accessibility deficiencies in Pima County.

The intermodal facilities inventoried in this report include:

- Nine airport facilities;
- Roadway networks;
- Rail line facilities;
- Ports of entry;
- Pipeline facilities;
- Truck terminals;
- Transit facilities;
- Intercity/interstate bus terminals;
- Bicycle facilities; and
- Pedestrian intermodal facilities.

The major existing deficiencies and findings applicable to the high speed rail project include:

- The results of the physical facility performance measure rating indicated that Amtrak's facility rated low, due to poor pedestrian access, non-conformance to ADA standards, as well as inefficiencies with its operations.
- Intercity vans (Arizona Shuttle Service, Fast Transportation) are affected by congestion on most arterials in the Tucson area.
- Greyhound Bus Lines are affected by congestion on Congress Street/Broadway Blvd., and access into the facility is not to ADA standards.

The study recommends the following relevant improvement projects:

- Geometric/signal improvements;
- Roadway drainage improvements;
- Pedestrian/ADA improvements (Greyhound and Amtrak terminals);
- Pavement/overlay; and
- Improved linkages between Amtrak Station, Sun Tran Transit Center and the Greyhound Station in downtown.

3.2.4 Pinal County Transportation Study

This study was performed for the Pinal County Highway Department and ADOT in January of 1994. The purpose of the study was to assess the long range (20 year) roadway system improvement needs for Pinal County. Two travel scenarios were evaluated, "no-build" and "build". "No-build" assumes that no roadway improvements are made to city streets, county roads, State highways or Interstate freeways. Under this scenario, all county roadways are forecast to operate at a level of service A or B. The "build" scenario incorporated a proposed access controlled beltway around Casa Grande. As expected, traffic volumes decreased under this scenario on I-10 from south of McCartney Road to I-8, and on I-8 from west of I-10 to Bianco Road.

3.2.5 Current On-Going Studies

Following is a brief presentation and discussion of current on-going studies considered applicable to the Arizona High Speed Feasibility Study.

3.2.5.1 Downtown Tempe/Rio Salado MIS

This study, currently in nearing completion, is looking at the various transportation options including a light rail system that would greatly improve circulation in Tempe. This has relevance to this study in that there is potential to connect to a high speed rail station in the study corridor and provide circulation.

3.2.5.2 Fixed Guideway System Study

This study which is currently in progress is sponsored by MAG. The purpose of this study is to identify potential corridors in the Phoenix Metro area for high capacity transit solutions.

3.3 Corridor Demographics

All other things being equal, travel in the corridor between Phoenix and Tucson will increase as the Phoenix and Tucson metropolitan areas continue to grow. Therefore, an understanding of the existing and future demographics in the corridor was one of the factors in estimating potential future travel in the corridor. In this section, population, employment and levels of socioeconomic characteristics are discussed.

3.3.1 Population

Current and future population figures for Maricopa, Pinal and Pima were compiled from a number of sources, including the US Census Bureau and the Arizona Department of Economic Security, and are presented in Table 3-2.

Table 3-2 County Populations for 1990 & 1997, with Forecasts for 2020

County	1990*	1997**	2020**	Change***
Maricopa	2,122,101	2,721,750	4,516,100	65.9%
Pima	666,880	799,834	1,206,244	50.8%
Pinal	116,379	148,648	231,228	55.5%
Total	2,905,360	3,670,232	5,953,572	62.2%

* US Census Bureau
** Arizona Department of Economic Security, Research Administration, Population and Statistics Unit
*** Change between 1997 and 2020.

This table shows that over the next two decades, population in the three county area is forecast to increase by more than 60 percent, with Maricopa County's population increasing to more than 4.5 million.

Table 3-3 presents existing and future population figures for individual cities in the three counties that are relevant to the corridor alignment.

Table 3-3 Study Area Populations for 1990 and 1997, with 2020 Forecasts

City	1990*	1997**	2020**	Change***
Phoenix **	1,000,145	1,205,285	1,795,539	48.9%
Tucson	405,390	455,085	589,899	29.6%
Mesa **	288,091	350,555	593,962	69.4%
Chandler **	90,524	151,370	258,915	88.8%
Gilbert **	29,188	79,310	244,842	208.7%
Tempe **	141,865	158,135	183,466	16.0%
Marana	2,187	7,578	76,553	910.2%
Oro Valley	N/A	23,120	59,338	156.7%
Casa Grande	19,082	21,660	48,275	122.8%
Queen Creek **	2,478	3,270	20,505	527.0%
Eloy	7,201	9,175	11,562	26.0%
Coolidge	6,927	7,173	7,784	8.5%
Gila River **	N/A	2,660	3,073	15.5%

* US Census Bureau
** Provided by Maricopa Association of Governments and Pima Association of Governments. Reflects the future corporate limits for the Municipal Planning Areas for MAG. It should be noted that Tempe cannot expand its corporate limits.
*** Change between 1997 and 2020.

The Town of Marana in Pima County and the City of Queen Creek in Maricopa County will experience the highest projected growth rates of any municipalities in the study area, followed by Gilbert, Oro Valley, and Casa Grande. It should be noted that the population projections include anticipated expanded boundaries, with the exception of Tucson. Of the larger cities, Phoenix, which already has a large population of 1,205,285, is still projected to grow by approximately 49 percent by the year 2020. Substantial growth is also expected in virtually every city, indicating that the growing metropolitan areas are not concentrated in any single geographic subarea. This pattern of expected growth was one of the considerations in establishing station locations in the planning process.

3.3.2 *Employment*

Current and future employment figures for Maricopa, Pima and Pinal Counties were compiled from MAG, PAG, and the Central Arizona Association of Governments, and are presented in Table 3-4 and 3-5.

Table 3-4 Study Area County Employment for 1990 and 1997, with forecasts for 2020

County	1990	1997	2020	Change *
Maricopa	975,037	1,352,073	2,212,900	63.6%
Pima	307,355	388,430	650,296	67.4%
Pinal	36,608	54,999	-	-
Total	1,319,000	1,795,502	-	-

Source: MAG, PAG, and Central Arizona Association of Governments.
* Change between 1997 and 2020.
- No data available.

This table shows that over the next two decades, employment is expected to increase approximately 63 percent in Maricopa County, and approximately 67 percent in Pima County. At this time, employment projections for Pinal County are not available.

Table 3-5 presents existing and future employment figures for individual cities in Maricopa and Pima Counties that are relevant to the corridor alignment.

Table 3-5 Study Area Employment for 1990 and 1995, with 2020 Forecasts

City	1990	1995	2020	Change***
Phoenix	556,777	666,878	873,975	31.0%
Tucson*	239,166	262,700	348,000	32.4%
Mesa	93,561	128,373	264,158	105.7%
Tempe	86,006	138,858	194,775	40.2%
Chandler	29,118	47,288	168,484	256.2%
Gilbert	6,060	16,838	63,748	278.5%
Gila River	1,330	3,939	19,007	382.5%
Marana*	500	1,215	17,525	1,342.3%
Oro Valley*	4,179	5,557	16,465	196.29%
Queen Creek	754	1,439	9,796	580.7%
Casa Grande**	7,122	10,496	-	-
Coolidge**	2,856	2,992	-	-
Eloy**	2,463	2,922	-	-

Source: MAG and PAG.
* Population figures for Pima County are maintained by Traffic Analysis Zone (TAZ) for current and future years. TAZ boundaries do not directly correlate with city boundaries; therefore, some TAZs assigned to a particular city may include persons living outside the actual city boundary, and vice versa.
** Provided by Central Arizona Association of Governments.
*** Change between 1995 and 2020.
- No data available.

The Town of Marana will experience the highest projected growth rate of any municipality in the study area, with an increase of approximately 1,300 percent, followed by the Cities of Queen Creek and Gila River in Maricopa County. At this time, 2020 employment projections for Casa Grande, Coolidge and Eloy in Pinal County are not available.

3.3.3 *Title VI Considerations*

According to Executive Order 12898, entitled "Federal Actions to Address Environmental Justice in Minority and Low Income Populations", an assessment must be made to determine if the proposed project will create disproportionately higher or adverse effects on minority and low income populations in the project area. As the High Speed Rail project moves through the planning process, the requirements of Title VI must be addressed fully. At this stage of the planning process, demographic information of the three counties was compiled at the county-wide level and is presented in Table 3-6. In subsequent stages, analyses at the census tract level would be appropriate to evaluate specific project impacts.

Table 3-6 Demographic Composition in Three-County Corridor

County	Total Pop.	Gender (No./%)		Age (No./%)		
		Male (No./%)	Female (No./%)	<21 yrs (No./%)	21-59 yrs (No./%)	60+ yrs (No./%)
Maricopa	2,122,101	1,044,235 *49%*	1,077,866 *51%*	651,795 *30%*	1,123,432 *53%*	346,874 *17%*
Pima	666,880	325,288 *48%*	341,592 *52%*	200,561 *30%*	346,051 *52%*	120,268 *18%*
Pinal	116,379	59,466 *51%*	56,891 *49%*	39,154 *34%*	55,722 *48%*	21,513 *18%*

County	Total Pop.	Population by Race					
		White Non-Hispanic	Hispanic	Black	American Indian	Asian	Other
Maricopa	2122101	1,459,303 *69%*	340,117 *16%*	74,257 *3%*	38,017 *2%*	36,294 *2%*	174,113 *8%*
Pima	666880	365,351 *55%*	161,053 *24%*	20,856 *3%*	20,034 *3%*	12,149 *2%*	87,437 *13%*
Pinal	116379	53,130 *46%*	34,062 *29%*	3,639 *3%*	11,150 *10%*	677 *0.5%*	13,721 *11.5%*

County	Total Pop.	Median Income			Population below Poverty Level	
		Household	Family	Per/Capita	No.	%
Maricopa	2,122,101	30,797	36,078	14,970	257,359	12.1%
Pima	666,880	25,401	30,985	13,349	111,880	16.7%
Pinal	116,379	21,301	23,993	9,228	26,155	22.4%

Source: 1990 U.S. Census Data

Based on the county-level demographic data, the percentage of persons over 60 years of age is approximately the same in each of the three counties (approximately 17-18 percent). In terms of race, the percentage of blacks in each community is approximately three percent; however, Pinal County has a higher percentage of Native Americans (approximately 10 percent) compared to Maricopa and Pima Counties (two-three percent). Median income is highest in Maricopa County, followed by Pima and Pinal Counties. Likewise, the percentage of the population below poverty level is lowest in Maricopa County, followed by Pima and Pinal Counties.
Based on the county-wide comparisons, Federal environmental justice issues might arise at the stage of project planning when environmental clearances are sought. At that time, a census tract-level analysis along the project corridor would need to be performed.

3.3.4 *Passenger Rail Station Location Options*

One of the key components in the planning of an intercity passenger rail system is the number and location for stations. Ridership is very sensitive to the opposing forces of (a) market accessibility to the system achieved by the addition of stations and (b) travel-time reductions achieved by subtracting the number of stations. The challenge is to maximize ridership by finding the optimum balance (ie. maximum ridership) between these two opposing forces. Too many stations reduces travel time and too few stations reduces market penetration.

The Steering Committee discussed several potential station locations for a passenger rail system. There was consensus that the termini be in downtown Phoenix and Tucson; however, there are several options for additional stations between Phoenix and Tucson. Tentatively, potential station locations were identified at:

- Central Avenue (downtown Phoenix)
- Sky Harbor (Optional)
- Tempe Depot (Optional)
- Mesa/Gilbert
- Coolidge/Casa Grande (Optional)
- Orange Grove (north Tucson)
- Tucson Depot (downtown Tucson)

To help the Steering Committee select appropriate station locations for the alternatives being studied, population levels by Traffic Analysis Zones (TAZ) projected for the year 2020 for each station is provided in Table 3-7.

Table 3-7 2020 Population Projections with a Five Mile Radius

Candidate Station Area	2020 Population *
Central Avenue	797,026
Sky Harbor	825,917
Tempe	589,962
Mesa/Gilbert Station (Mainline RR Option)	372,850
Mesa/Gilbert Station (Chandler Branch RR Option)	380,256
Orange Grove	163,685
Tucson	321,855

* Population within a five mile radius of candidate stations, obtained by summing MAG and PAG TAZ level population projections.

Figure 3-1a and 3-1b shows the core service areas for the candidate station locations in the Phoenix and Tucson areas. Final decisions on the appropriate locations for stations will be made in Chapter 4, Definition of Alternatives, for each of the passenger rail options.

Each of the core service areas is assumed to consist of a circle with a five mile radius. In actuality, the terminal stations would likely serve a broader area, especially to the north and west in the Phoenix area and to the south and east in the Tucson area. For specific stations, the five mile radius will vary and the circular shape may change depending on topography, roadway access, and other factors. As illustrated in Figures 3-1a and 3-1b, the two terminal stations serve a large portion of their respective metropolitan areas. Also, there is some overlap in the potential service areas of the candidate stations.

Figure 3-1a Core Service Areas for Candidate Phoenix Metro Stations

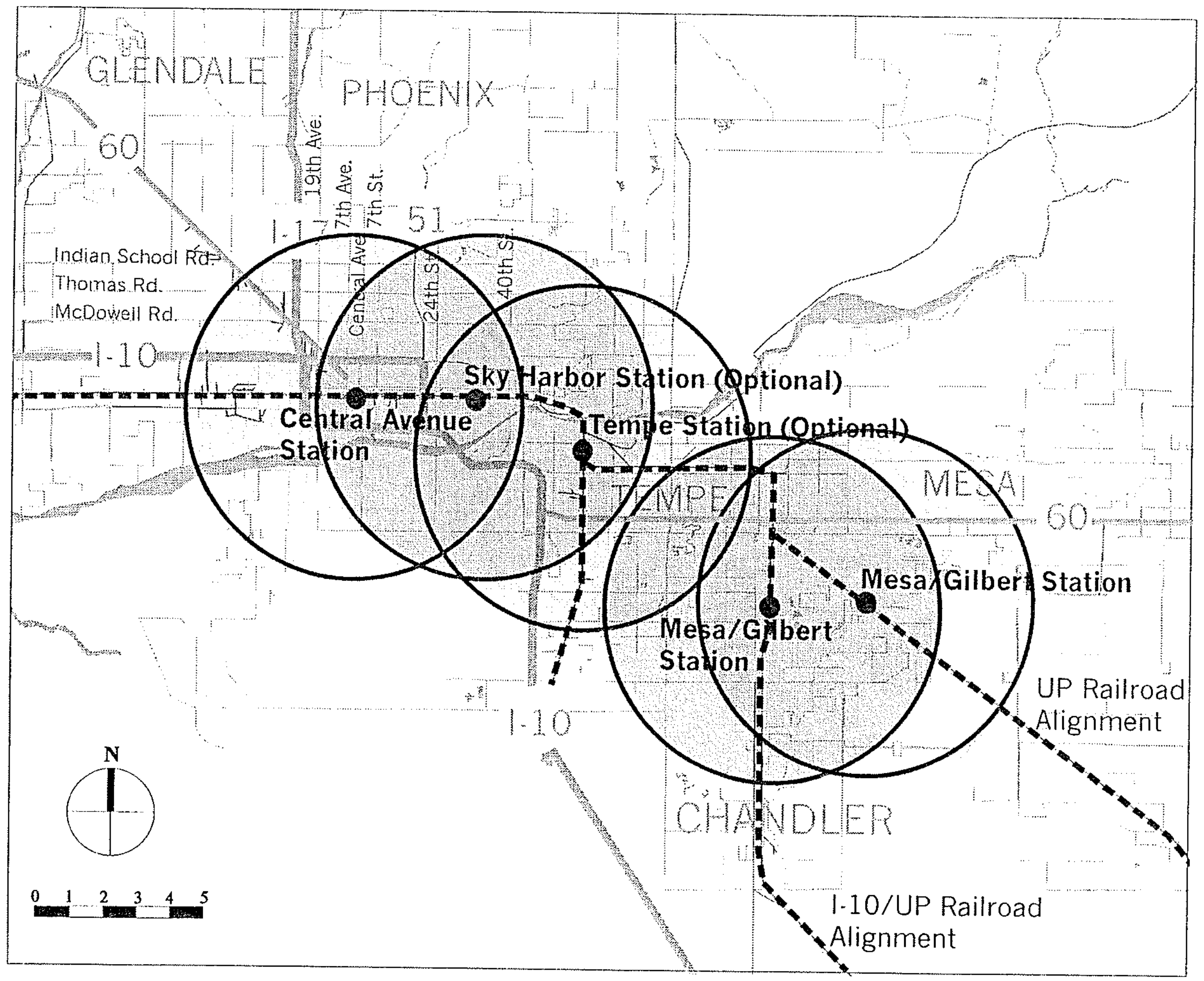
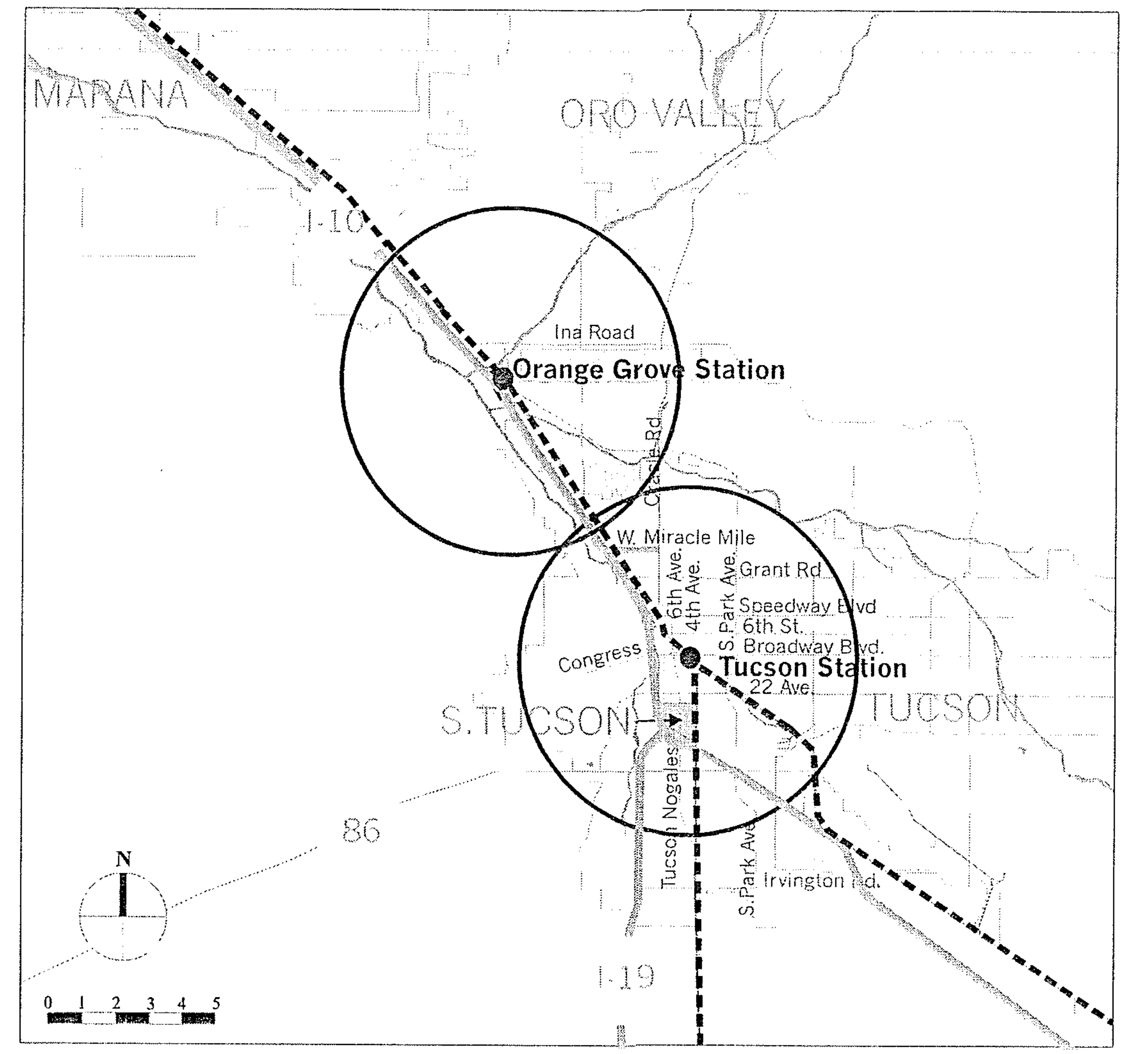


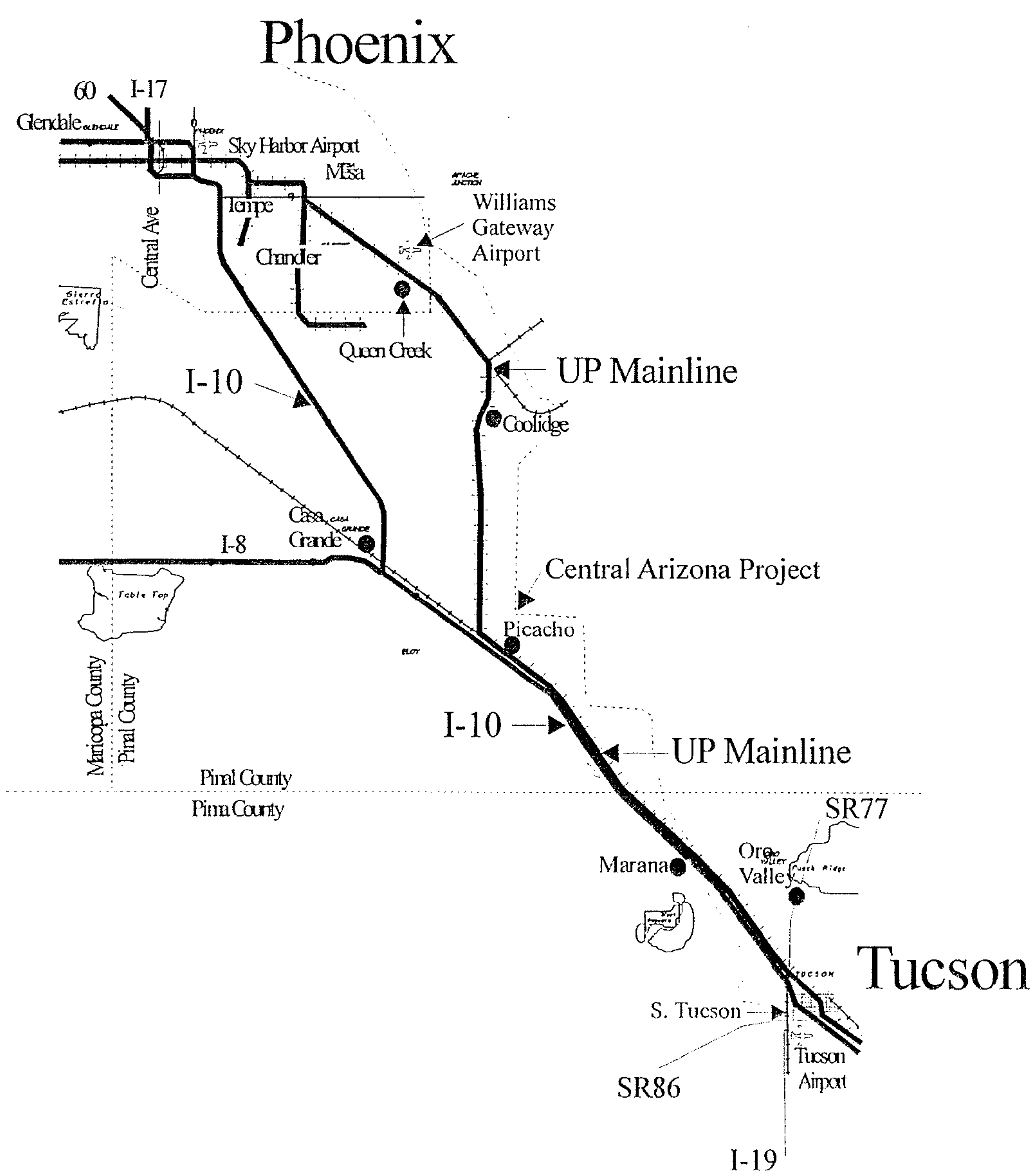
Figure 3-1b Core Service Areas for Candidate Tucson Metro Stations



3.4 Corridor Travel Characteristics

Interstate 10 and Union Pacific Railroad are the primary transportation facilities in the corridor between Phoenix and Tucson. The corridor lies in Maricopa, Pinal and Pima Counties and accommodates the largest intercity movement of persons in the State. The travel characteristics in the corridor are discussed in the following paragraphs. Figure 3-2 illustrates the urban areas and the key transportation features in the corridor.

Figure 3-2 Urban Areas and Key Transportation Features in Study Corridor



3.4.1 Vehicular Traffic

ADOT records indicate that traffic volume on I-10 just west, or north, of the junction of I-8 is between 30,000 and 35,000 vehicles per day (vpd). ADOT records indicate a count of 32,800 vpd for 1995 and just over 30,000 vpd for 1996. For the ensuing discussion, the 1995 traffic volume of 32,800 vpd is used. Of that total, approximately 25 percent consists of commercial vehicles.

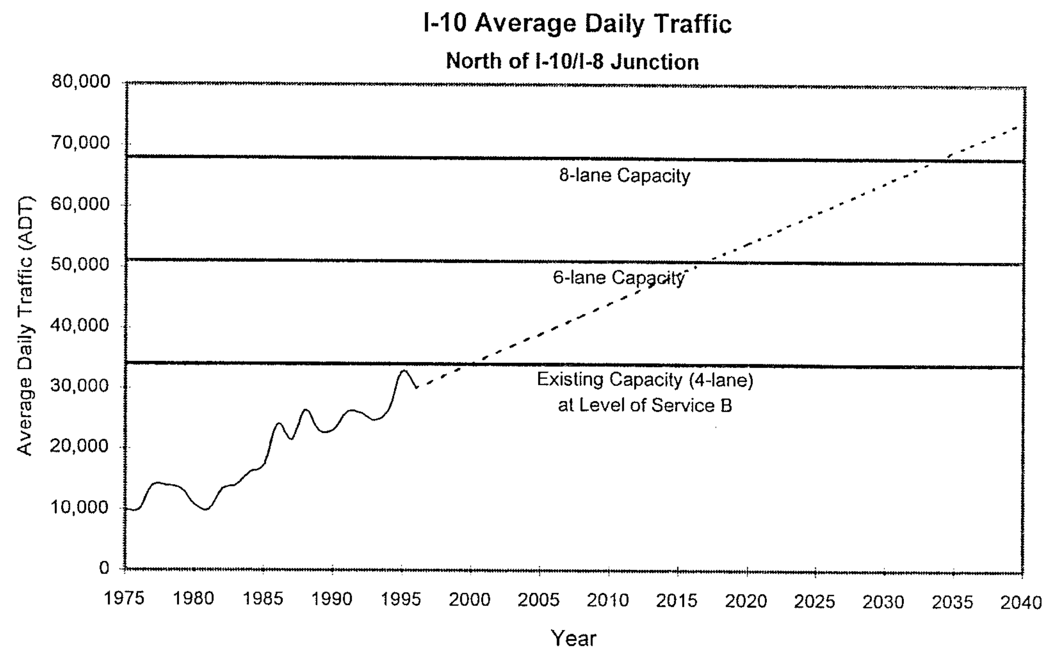
With information available at this time, it is not possible to identify the amount of traffic on I-10 that consists of travel specifically between Phoenix and Tucson. However, the specific location on I-10 discussed above (just west, or north, of the junction with I-8) is considered to be most representative of traffic having both an origin and a destination in Phoenix or Tucson metropolitan areas. It is true that traffic at this location on I-10 includes longer trips (for example, trips between California and New Mexico that go entirely through both the Phoenix and Tucson metropolitan areas), as well as traffic that has an origin or destination other than Phoenix or Tucson (examples would be a trip between Phoenix and points east of Tucson or between Tucson and points west of Phoenix). On the other hand, there are very few entry and exit points on I-10 between the junction of I-8 and the Tucson metropolitan area. Accordingly, it is a reasonable speculation that a very large percentage of the total vehicles on I-10 just west of the junction of I-8 consists of traffic between Phoenix and Tucson.

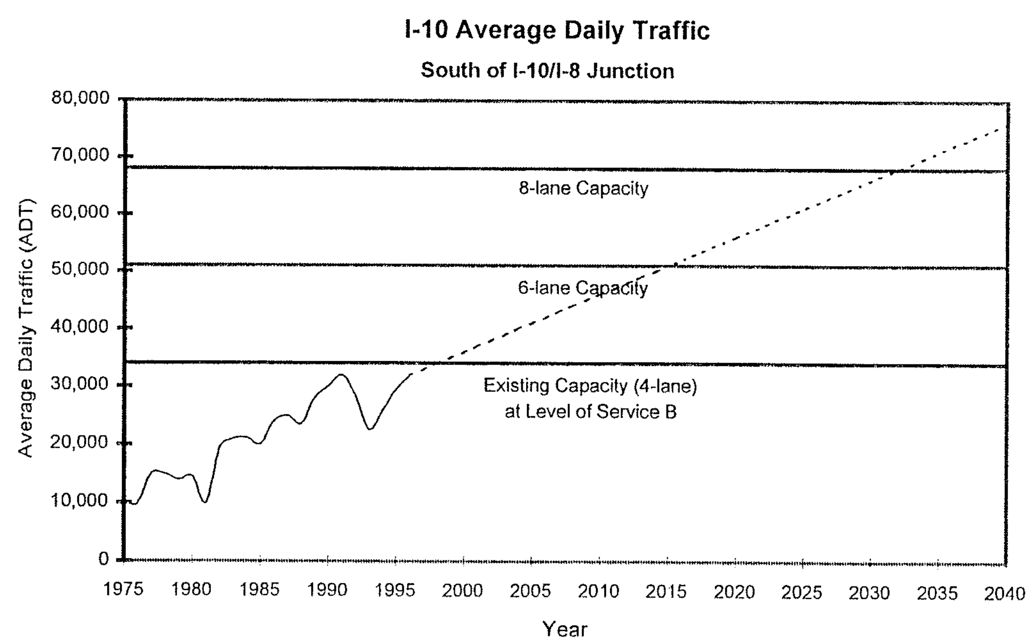
According to the PAG Travel Demand Study, 1993, (household trip diaries), Tucson metropolitan area residents make about 6,000 daily trips (one-way) to the Phoenix metropolitan area for a variety of trip purposes. Thus, approximately 12,000 daily trips in both directions combined on I-10 can be attributed to residents of the Tucson metropolitan area traveling to the Phoenix area.

At this time, no information is available on the number of residents in the Phoenix metropolitan area who travel to the Tucson metropolitan area. While the Phoenix area has approximately three times as many residents, Phoenix area residents have less reason to travel to the Tucson area. Specific reasons for Tucson area residents to travel to Phoenix include conducting State business, going to the Phoenix airport or ASU, attending sports events, general business, visiting friends and relatives, and others. Attractions that would draw Phoenix residents to Tucson include the University of Arizona and its medical facilities, general business reasons, visiting friends and relatives, and others. Pending additional investigation, it is assumed at this time that half as many Phoenix residents travel to Tucson as Tucson residents travel to Phoenix. Thus, it is estimated that approximately 18,000 vehicles per day of the total personal vehicular traffic on I-10 consists of travel exclusively between the two metropolitan areas.

Figure 3-3 shows current and projected average daily traffic counts on I-10 both north and south of the I-10/I-8 junction. Traffic level of Service B (near free-flow conditions) are deemed desirable by ADOT for non-urban freeways. The figure shows that I-10 will reach capacity (or will exceed LOS B) under its existing four-lane configuration by approximately the year 2000. Traffic trends show a need for two additional lanes (six lanes total) sometime before the year 2005, and another two additional lanes (eight lanes total) sometime before the year 2020.

Figure 3-3 Average Daily Traffic North and South of I-10/I-8 Junction





3.4.2 Commercial Vehicles

ADOT vehicle classification counts indicate that commercial vehicles are an extremely important consideration in intercity travel in the I-10 corridor, comprising approximately 25 percent of all traffic. As population and economic activity throughout the State increase, commercial vehicle traffic on I-10 would be expected to grow commensurately. In the preparation of vehicular and person travel estimates for the evaluation of alternatives, commercial vehicle traffic was addressed as appropriate. It is important to note that within the two metropolitan areas, I-10 is consistently at capacity during most peak commute times.

3.4.3 Person Trips in the Corridor

The following section describes the person travel volumes and characteristics in the corridor by mode.

3.4.3.1 Persons in Passenger Cars

As stated previously, the traffic volume on I-10 just west of the junction of I-8 is 32,800 vpd, of which approximately 25 percent is comprised of commercial vehicles. Thus, approximately 24,000 vpd consist of passenger cars. Based on vehicle occupancy counts in the corridor, the average occupancy of the passenger vehicles is 1.2. Accordingly, a total of approximately 28,800 persons traveled in the corridor (24,000 vehicle drivers plus 4,800 passengers) in passenger cars.

3.4.3.2 Intercity Bus Service

Intercity bus service is generally the lowest cost form of transportation in the State. In 1985, the State ceased regulating the number of ground transportation carriers, leaving market forces to determine the level of service and location of service by providers. Two carriers currently serve as transportation resources between the Phoenix and Tucson metropolitan areas: Arizona Shuttle Service and Greyhound. Table 3-8 gives a brief description of the service, the number of available seats for each vehicle type operated, and the average number of one-way trips per day.

Table 3-8 Transit Carriers Operating Between Phoenix and Tucson

Carrier	Description	Number of One-Way Vehicle Trips Per Day	Available Seats	One-Way Fare	One-Way Travel Time (Minutes)
Arizona Shuttle Service	Company primarily serves airline passengers but also carries passengers travelling for other purposes (ie. University of Tucson). Package delivery service provided.	36 (18 from Phoenix to Tucson; 18 from Tucson to Phoenix)	Van - 13 Bus - 25/29 (depending on the bus)	$19.00	120
Greyhound Lines, Inc.	Greyhound Lines, Inc. has been in business nearly 80 years. It is currently the only nationwide bus route service. Freight service is provided. Limited chartered service is operated in select urban areas.	36 (18 from Phoenix to Tucson; 18 from Tucson to Phoenix)	Bus - 47	$12.00	120 – 180 (depending on the number of stops)

*Source: Arizona Shuttle Service and Greyhound Lines, Inc.

Below is a listing of the intercity bus operators serving the study corridor:

- Arizona Shuttle Service
  This company (which recently purchased Arizona Flying Coach) primarily serves airline passengers but also carries passengers traveling for other purposes such as the University of Arizona. The company also provides package delivery service. The company makes 18 round trips daily between Tucson and Phoenix (Sky Harbor Airport) in a fleet of 15 standard vans. In 1997, a standard one-way ticket between Phoenix and Tucson cost $19.00. The Arizona Shuttle Service Tucson terminal does not connect with any other intercity bus line.

- Greyhound Lines, Inc
  Greyhound is the largest bus operator in the State. In addition to service between Phoenix and Tucson, Greyhound offers service between Phoenix and Flagstaff; Phoenix and Blythe; Phoenix and Yuma; and Phoenix and Las Vegas. There are 18 one-way trips made daily between Phoenix and Tucson and 18 one-way trips made from Tucson to Phoenix. In 1997, a standard one-way ticket between Phoenix and Tucson cost $12.00. The main Greyhound Terminal in Phoenix is located near Sky Harbor International Airport and is served also by K-T Services which offers bus service to Las Vegas via Kingman or via Lake Havasu City. Greyhound also operates satellite facilities in Tempe, Glendale, Chandler, Mesa and Tolleson. The Tempe facility is approximately eight blocks from the rail station near the University. Actual data on the number of passengers carried by Arizona Shuttle Service and by Greyhound between Phoenix and Tucson areas is not available. Assuming that the occupancy of transit vehicles range between 75 percent and 100 percent, the number of passengers would be between 1,620 and 2,736 persons per day on a weekday (number of one way trips multiplied by the number of available seats). Weekend travel and trips made by Amtrak shuttle buses are not included in these estimates.

3.4.3.3 Passenger Rail Service and Facilities

Amtrak (National Rail Passenger Corporation) operates two routes within Arizona. The Southwestern Chief (cross-country service from California to Chicago) utilizes the tracks of the Burlington Northern and Santa Fe with stops in Kingman, Flagstaff and Winslow; and the Sunset Limited runs between Los Angeles and Miami with stops in California, Arizona, New Mexico, Texas, Louisiana, Mississippi, Alabama, and Florida. The Sunset Limited runs on the Union Pacific Transportation Co. track with stops in Yuma, Tucson and Benson. No Amtrak service is operated between Phoenix and Tucson.

In addition to Amtrak, there are three private tourist railroads: 1) the Grand Canyon Railroad which offers an historic train service from Williams to the Grand Canyon, carrying approximately 125,000 passengers annually; 2) the Arizona Central Railroad Co. which operates a scenic train service from Clarksdale to Perkinsville, carrying approximately 70,000 passengers annually; and 3) the San Pedro and Southwestern Railroad which operates weekend scenic train service between Benson and Fairbank, carrying approximately 16,000 passengers in.

3.4.3.4 Air Travel in the Corridor

The State has at least 59 primary commercial, other commercial, reliever and public use airports in addition to numerous private airfields. In 1993, those airports provided more than 13 million enplanements. According to the 1994 Arizona State Transportation Plan, air travel in Arizona is expected to double by 2015. This is 40 percent higher than the forecast increase in population.

America West Airlines, Delta Airlines and United Airlines operate service between Phoenix and Tucson. All 737/757 flights are on-route to other destinations. Table 3-9 presents the number of flights daily between Phoenix and Tucson.

The City of Phoenix Aviation Department, the operator of Sky Harbor Airport, conducted a survey of the origins and destinations of passengers at Sky Harbor Airport. Tucson ranked 70th on the Top 100 Domestic Markets "True Origin and Destination" Passengers list (people who boarded the plane in Phoenix and got off in Tucson or vice versa), with just over 35,000 passengers for the year of 1996, or approximately 100 per day. Passengers travelling from Tucson to Phoenix or vice versa on-route to other destinations are not included in this number. However, according to the 1997 Phoenix Sky Harbor Master Plan, when including passengers travelling beyond either city, in 1994 a total of 367,404 passengers boarded Sky Harbor flights to Tucson. Assuming the reverse to be true, approximately 735,000 two-way passengers traveled between Phoenix and Tucson annually, or approximately 2,000 daily.

Table 3-9 Air Traffic Data

Carrier	Number of Daily Flights Phoenix-Tucson	Number of Daily Flights Tucson-Phoenix	Aircraft Capacity	One-Way Fare Range
America West	11	11	Boeing 737 (140 seats)	$88.00-$179.00
Delta	1	2	Boeing 757 (180 seats)	$88.00-$179.00
United	1	1	Boeing 757 (180 seats)	$88.00-$178.00

3.4.4 Rail Freight Traffic

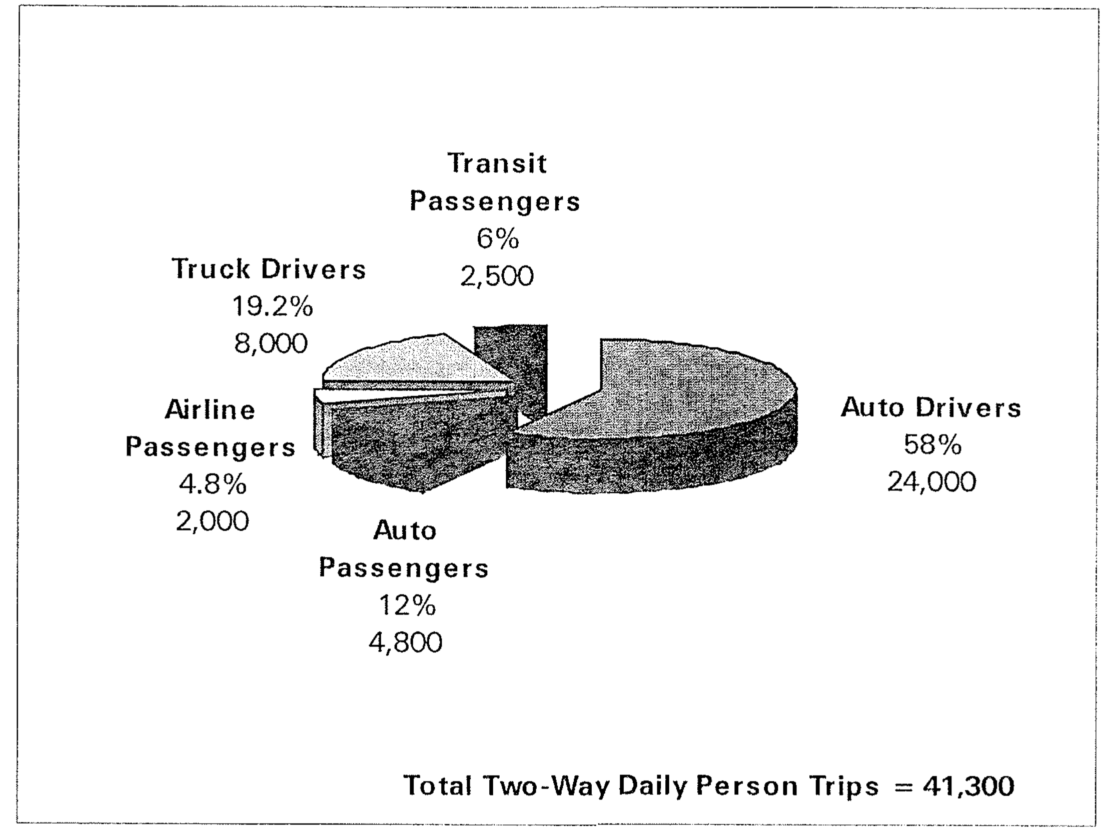
Railroads are classified as either Class 1, 2 or 3. Class 1 Railroads have an annual gross operating revenues of $250 million or more from railroad operations. Class 2 railroads have gross operating revenues between $20 million and $250 million, and Class 3 railroads have operating revenues less than $20 million annually from railroad operations. There are thirteen freight railroad companies in Arizona. Two are Class 1 carriers and eleven are Class 2 or 3 railroads.

The Union Pacific Railroad (UPRR) operates lines within the study area. According to 1995 information, the UPRR carries nearly 6 million annual gross tons of freight between Phoenix and Picacho Junction and approximately 53 million annual gross tons between Picacho Junction and Tucson.

3.4.5 Summary of I-10 Corridor mode Split

Figure 3-4 shows 1996 estimated 1-10 corridor Mode Split between Phoenix and Tucson using the most recent data from ADOT and other sources.

Figure 3-4 1996 I-10 Corridor Mode Split



3.5 Existing Conditions

This section discusses the existing physical roadway and rail conditions in the corridor. This provides useful information during the development of alternatives, especially related to capital costs and infrastructure needs.

3.5.1 I-10 Roadway Conditions

The I-10 freeway was visually field-surveyed by Kimley-Horn personnel on August 27, 1997, to determine the feasibility of additional lanes. Notes were taken on the geometrics of the freeway along with any obstructions or constraints to either side. Table 3-10 summarizes existing roadway conditions on I-10. Figure 3-5 and 3-6 shows typical cross-sections of the freeway. The detailed field survey notes are contained in Appendix C, available as a separate document.

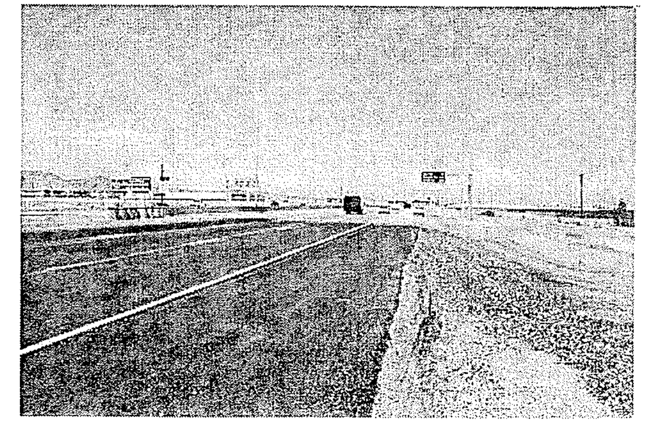
I-10 is primarily an eight-lane interstate, including two HOV lanes, throughout the Phoenix metropolitan area. It narrows to four lanes in the vicinity of Chandler Boulevard and remains in that configuration until Prince Road in Tucson. At that point, I-10 becomes six lanes to Congress Street.

Table 3-10 Existing Roadway Conditions on I-10- Constraints to Widening

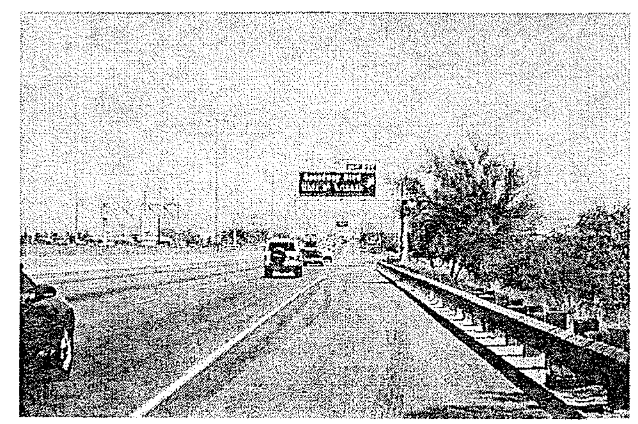
Location on I-10*	Comment
Congress-Broadway	Very tight (little ROW), both eastbound and westbound
St. Mary's	Very tight (little ROW), both eastbound and westbound
Speedway	Very tight (little ROW), both eastbound and westbound
Bridge E. of Ina Rd	Long span bridges over wash
Ina Rd.	Large fill areas
MP 244-242	Large fill area with bridges
Picacho to SR 84-87	Some problems with fill and bridges
Exit 205	Piers too close to edge of pavement
Exit 203	Piers too close to edge of pavement
Casa Grande (SR 84)	Sharp off ramp in westbound direction; long bridge span; large amount of fill
Exit 183 - Exit 184	Rock out crop
Exit 177	Piers too close to edge of pavement
Gila River	Long bridge span
Chandler to Ray Rd	Beginning of urban widening
Guadalupe Rd. to Central Ave.	Out of right-of-way

*Note: Travel began in Tucson on I-10 westbound to Phoenix

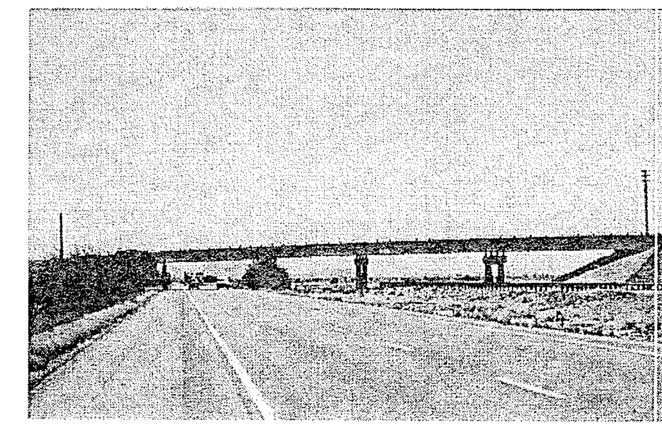
Figure 3-5 Views of I-10



I-10 east at Guadalupe Rd in Phoenix

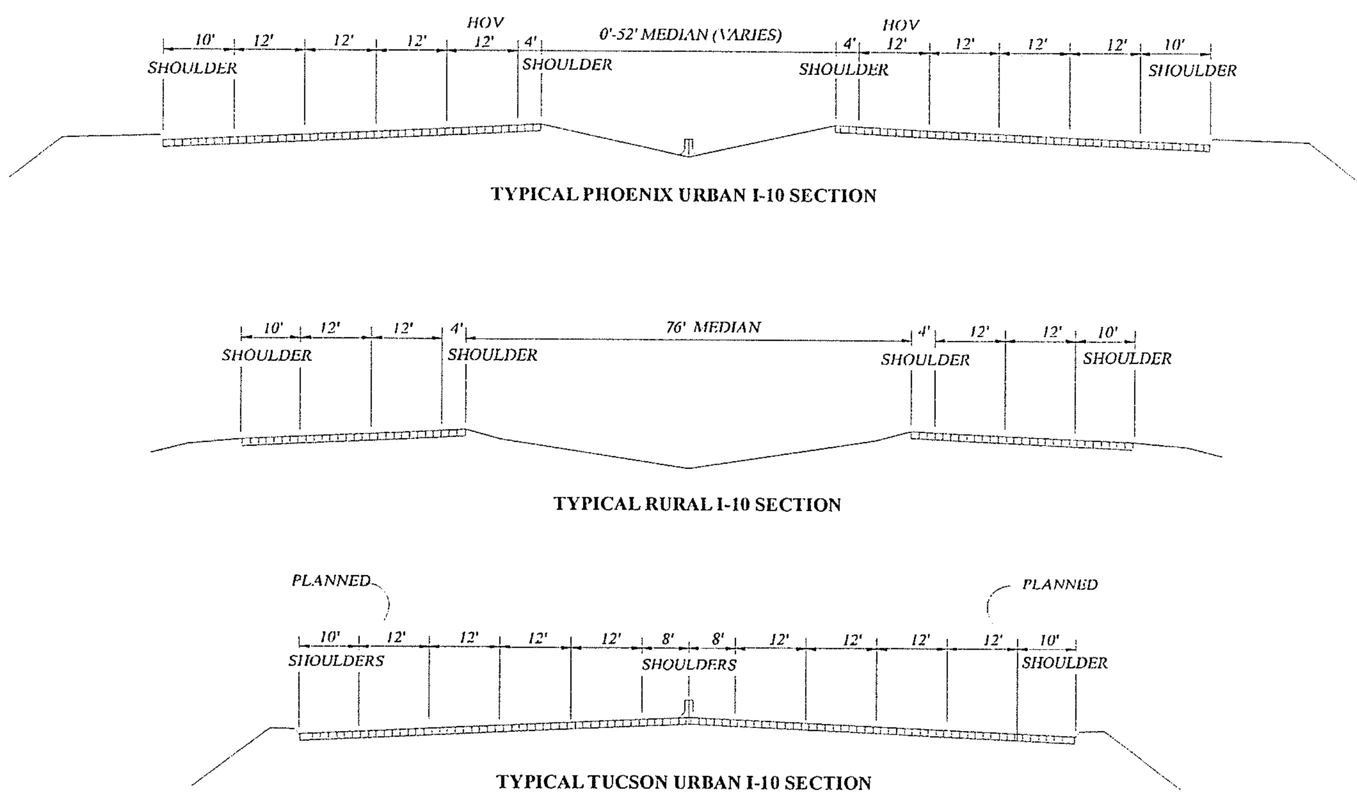


Midpoint on I-10 between Phoenix and Tucson



I-10 at Speedway in Tucson

Figure 3-6 I-10 Typical Sections



3.5.2 *Existing Mainline Railroad Conditions*

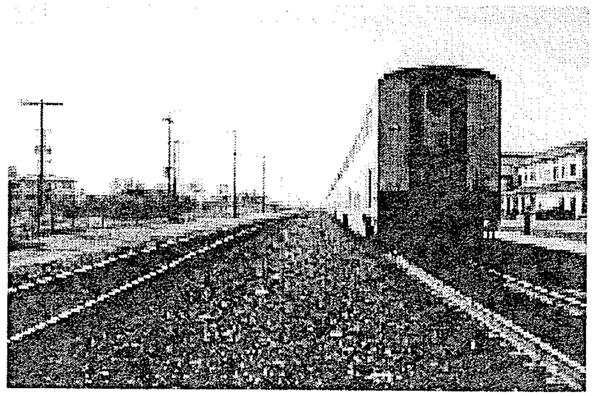
On August 27, 1997, the conditions of the Union Pacific Railroad were field surveyed. As in the roadway survey, the physical conditions, geometrics, and limitations were noted. One of the main concerns with the rail line is the amount of right-of-way available for an additional track from Picacho to Tucson. The main line from Tucson to Picacho is heavily used by freight trains, limiting the possibility of sharing the track. The right-of-way varies through this corridor from 100 feet at the Tucson Station to 400 feet at Red Rock, down to 200 feet at Picacho. The Phoenix subdivision of the line that runs from Picacho to Phoenix is a lesser-used track and the possibility of sharing the track is much greater. The right-of-way for the Picacho to Phoenix segment varies from milepost to milepost, ranging anywhere from 300 feet to 42 feet (at Alma School Road). Table 3-11 summarizes the existing conditions of the rail conditions in the corridor, and Figures 3-7 and 3-8 show typical sections in the Phoenix-Tucson corridor. The detailed field survey notes are contained in Appendices D, E, and F, available as a separate document.

In addition to the UPRR Mainline track, two branch lines were surveyed: the Tempe (Kyrene) branch from Maricopa road to Broadway as it enters the Phoenix subdivision mainline, and the Chandler branch near the junction of SR.347 and SR.87 where it enters the mainline near Baseline Road. Summary of the field analysis can be found in Tables 3-12 and 3-13.

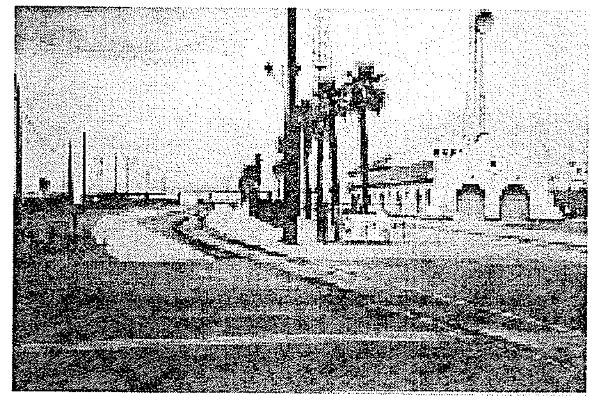
Table 3-11 Summary of Mainline Railroad Survey - Constraints to High Speed Rail Development

Location	Comment
Miracle Mile	Tight underpass
Prince to Ruthrauff Rd	Communication lines and petroleum pipeline on west side; high tension line on east side
Rillito River	5 span steel girder bridge
Orange Grove Rd	Underpass
Canada Grove Rd	Long bridge
Messingale Rd	3 fuel pipelines on west side; canal under track
Cortaro Farms Rd	Large high tension towers on east side
Tangerine Rd	Short distance to I-10 precludes road overpass; gravel/dirt maintenance road on east side of track; pipelines on west side; 4 big billboards; 5 small billboards
MP 963 to MP 962	7 big billboards on west side; canal on west side of frontage road
MP 958	Old road between railroad and frontage road
MP 953.6	3 large billboards
South end of Read Rock	Frontage road is elevated; water tank on east side
Picacho Junction	Cantilever signal bridge; pipelines and MCI on east side
Milligan Rd	MCI on east side
Houser Rd	Wood bridge on south side; MCI on east side
Selma Highway	Next to canal
Steele Rd	Wood bridge south of crossing; MCI on east side
Storey Rd	Industrial recycling and chemicals on west side; wood bridge south of crossing
Kleck Rd	MCI lines on east side
Coolidge Ave	Businesses too close to rails
Central Ave	MCI lines on west side
Florence Ave.	Track on a slight embankment
SH 287	Existing highway over railroad
Gila River	Nine truss span with a wood approach trestle bridge
MP 954	Slight embankment; MCI lines on east side; maintenance road on east side
Hunt Highway	MCI, petroleum and pole lines on east side
MP 942.8	Serves a large dairy feed lot on the west side
Ellsworth Rd	Slight embankment; industry on both sides of ROW
Williams Air Field	Siding and light industry on the west side of the tracks
Ray Rd	North of this location the area is more populated and residential, south of this area is a large distance of virtually undeveloped land.
Greenfield Rd	Crossing is very close to Ray Rd
Warner Rd	SRP irrigation pump station in NW quadrant of the crossing; residential area on the east; golf course on the west
Lindsay Rd	Canal crossing
Elliott Rd	Residential on both sides
Guadalupe Rd	Railroads cross
Dobson Rd	Asphalt crossings in poor condition; small embankment
McClintock Drive	Concrete railroad bridge over roadway
Tempe Junction	Splits to Chandler Branch
Tempe Station	Public restaurant south of crossing; major high tension power lines
Salt River	Major nine span steel truss bridge with wood trestle approach spans
Center Pkwy	Track under highway on embankment
Priest Dr	Major concrete highway over track
36th St	US West and MCI lines on south side; petroleum line on north side
MP907	Major Union Pacific rail yard south of tracks

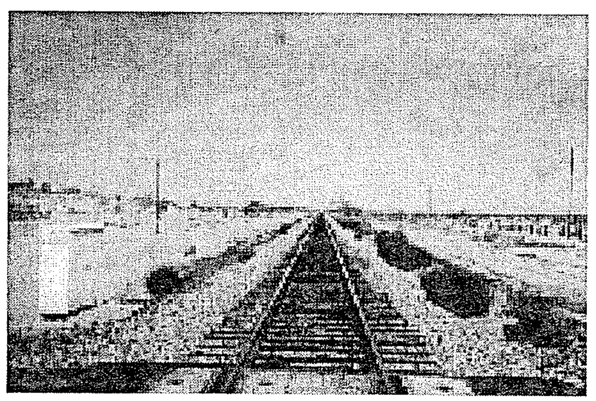
Figure 3-7 Existing Rail Conditions in the Corridor



Tucson Union Station

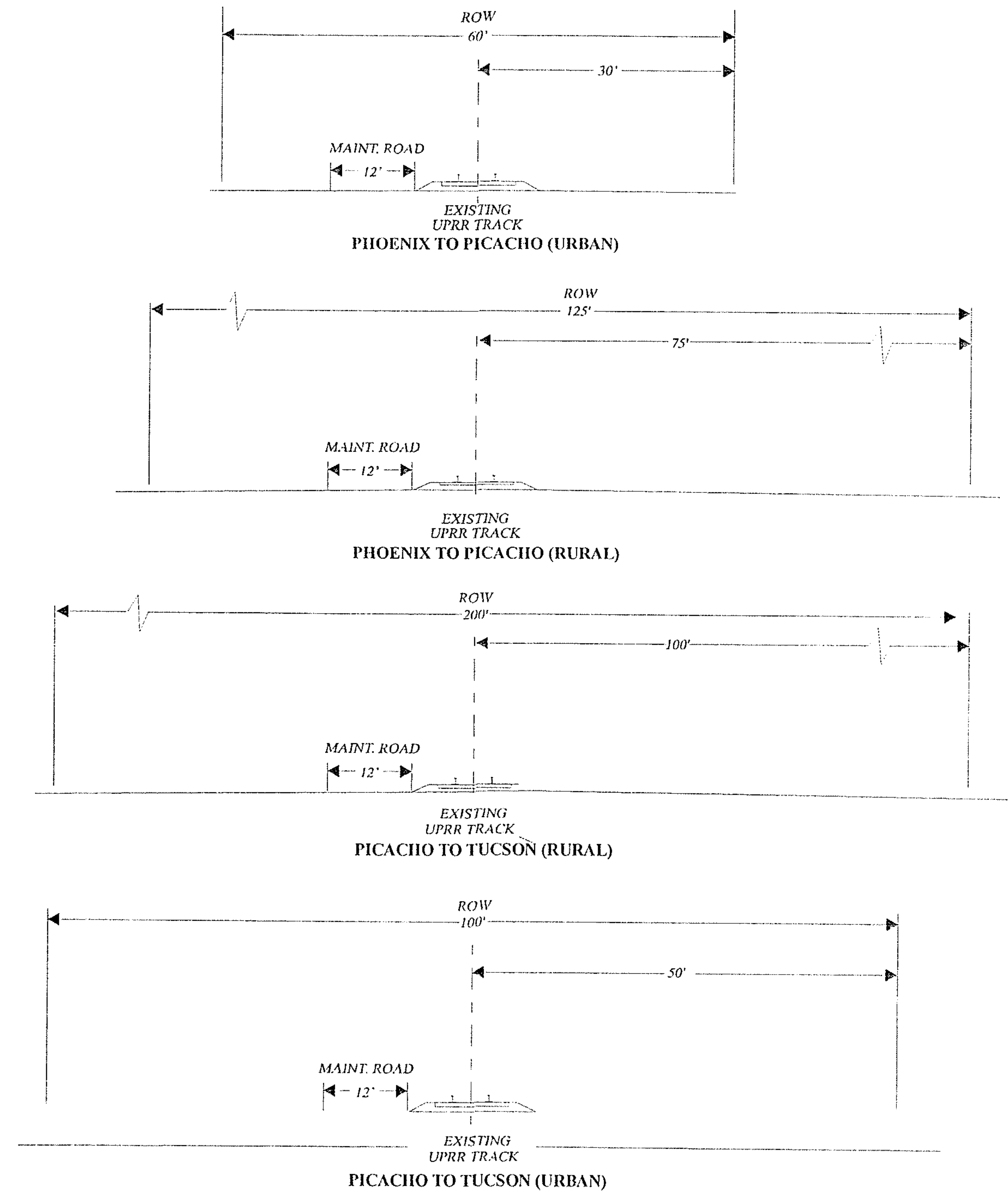


Phoenix Union Station



Area between Tucson and Picacho, Tangerine Road

Figure 3-8 Typical Railroad Sections in Phoenix-Tucson Corridor



3.5.3 Existing Tempe (Kyrene) Branch Conditions

A summary of the conditions found during the September 1997 field survey of the 7.7 mile Tempe branch is provided below. The detailed field survey notes are contained in Appendix G, available as a separate document.

Table 3-12 Summary of Tempe (Kyrene) Branch Survey

Location	Comments
Tempe Junction	Tempe Branch diverges from the main track just south of 13th street.
Broadway to Southern	Right-of-way approximately 100 to 136 feet wide with large power poles alternating to both sides of track. Mixed residential and business along both sides of the right-of-way. Track in poor condition.
SR 60 Underpass	Located about half way between Southern and Baseline. Right-of-way narrows to approximately 30 feet near Baseline Road. Drainage ditch crosses under track and two private access roads cross track north of Baseline Road.
Guadalupe Road to Elliot Road	Mostly industrial with several spur tracks. Right-of-way is wider (estimated to be about 200 feet). Golf courses and Kyrene generating station on east side of track. Diagonal track crossing at intersection of Kyrene and Elliot roads.
Elliot Road to Chandler Blvd.	Width of right-of-way estimated to be 200 feet. Mixed residential and business along both sides of track. Large pole line on both sides of track.
Chandler Blvd. to Allison Road	Right-of-way may be 30 feet wide near 56th Street.
Allison Road to Germann Road	Industrial area on reservation land. Many spur/siding tracks. Track has sharp curves and is in poor condition. Many trucks in area. Branch ends approximately .1 to .2 mile south of Germann Road. Open desert between end of branch and I-10.

Figure 3-9 Typical Urban and Rural Sections of Tempe Branch

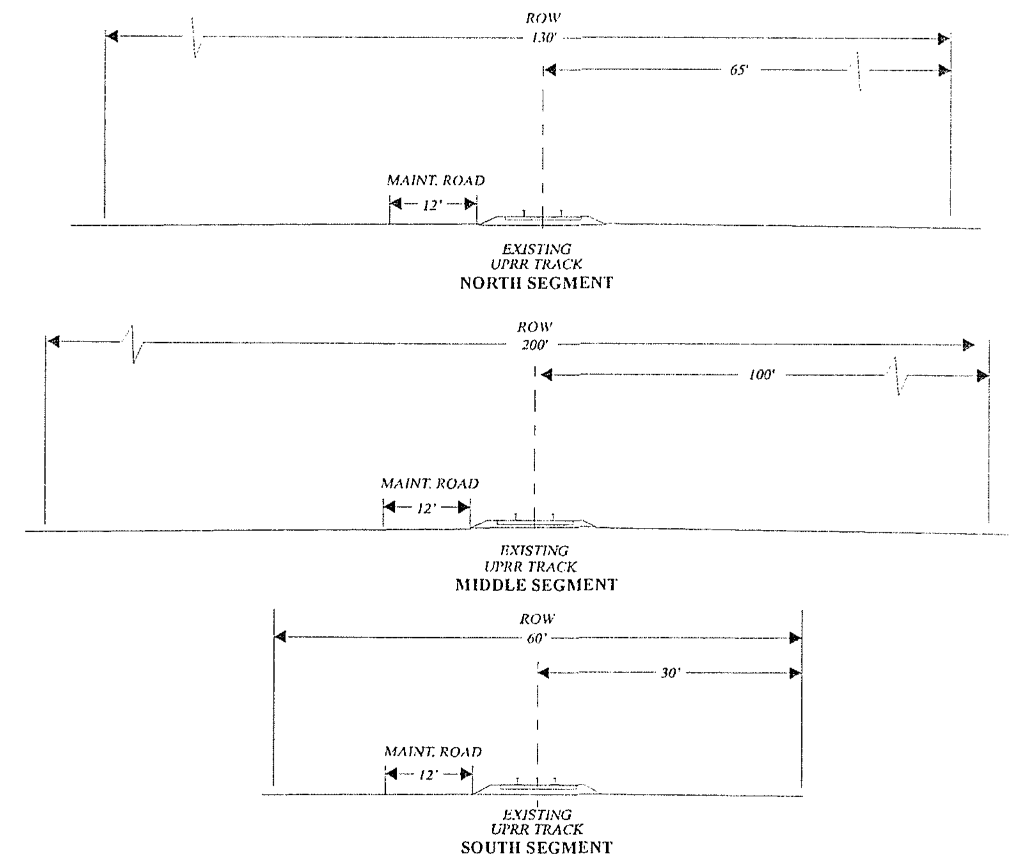
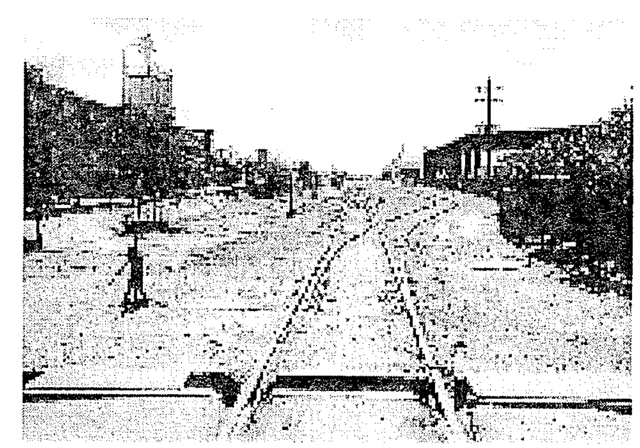
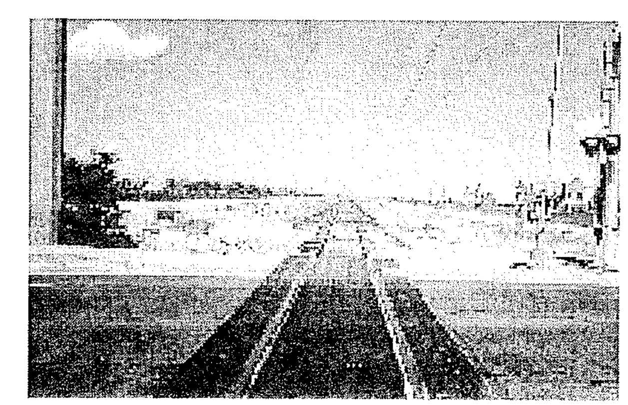


Figure 3-10 Existing Conditions in Tempe (Kyrene) Branch



Tempe branch near junction with mainline, Willis Road, looking west



Tempe branch at Ray Road, looking south

3.5.4 Existing Chandler Branch Conditions

A summary of the conditions found during the September 1997 field survey of the 19.6 mile Chandler branch is provided below. The detailed field survey notes are contained in Appendix G, available as a separate document.

Table 3-13 Summary of Chandler Branch Survey

Location	Comments
Baseline Road	Chandler Branch diverges from Phoenix Line north of Baseline Road.
Guadalupe Road to Elliot Road	Mixed Residential and Industrial area. Golf courses northeast of Guadalupe and east of track south of Guadalupe.
Elliot Road to Ray Road	New large power poles being installed on east side of track. Open fields, industrial, and some residential along right-of-way. Sidings and spur tracks along east side.
Ray Road to Chandler Blvd.	New large pole foundations on east side of track. Right-of-way narrows to about 66 feet near Galveston Street. Old Chandler Station and railroad museum near Erie Street and near Chandler Road. Track is on embankment. Mixed industrial and residential.
Chandler Blvd. to Germann Road	Industrial, open areas, and some residential. Track is on embankment with drainage structures common adjacent to road crossings. New large pole foundations on east side. Several sidings and spur tracks on both sides.
Germann Road to Hunt Highway	Large pole lines on both sides of track. Open fields and industrial. Track is on embankment (5 to 12 feet). Drainage structures common adjacent to road crossings.
Hunt Highway to Southeast	Track curves eastward toward Dock south of Hunt Highway. Open fields or desert on both sides. Desert exists between Hunt Highway and I-10 to south.

Figure 3-11 Typical Urban and Rural Section of Chandler Branch

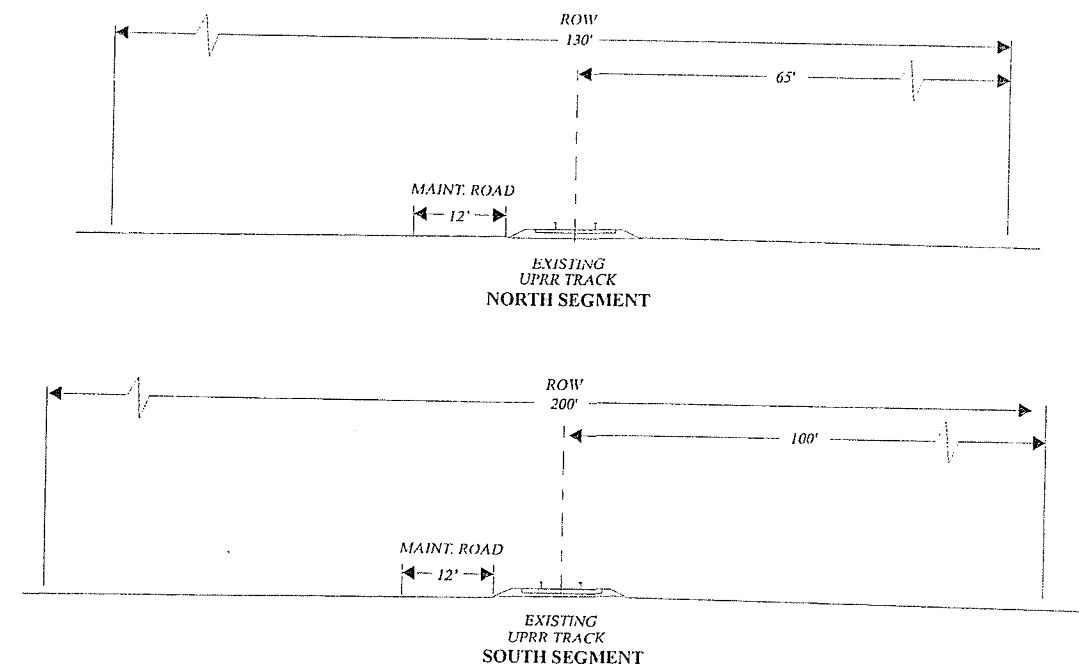
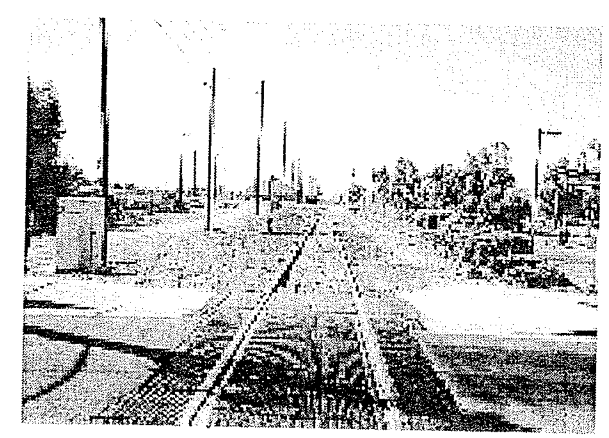
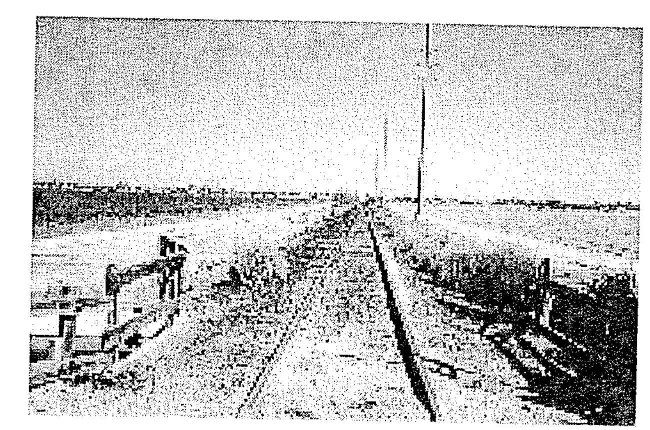


Figure 3-12 Existing Conditions in Chandler Branch



Chandler Branch near junction with mainline at Commenwealth Avenue, looking North



Chandler Branch near Willis Road, looking south

3.6 Purpose and Need

The purpose and need for passenger rail service between Phoenix and Tucson can be summarized as follows:

1. Approximately 75 percent of the State's population lives in the Phoenix and Tucson metropolitan areas. Between now and 2020, the population in the Phoenix and Tucson metropolitan areas is expected to grow by approximately 66 percent and 51 percent, respectively.

2. Approximately 85 percent of the State's employment opportunities are in the Phoenix and Tucson metropolitan areas.

3. The two metropolitan areas house nearly all of the State's major governmental, educational, cultural, medical, recreational, and financial institutions.

4. Approximately 75 percent of the total tourism expenditures in the State are in the Maricopa and Pima Counties.

5. Maintaining convenient and uncongested travel between the two major metropolitan areas of the State is essential for the economy, growth and development of the State.

6. Commercial vehicles constitute approximately 25 percent of the total vehicular traffic between the Phoenix and Tucson metro areas.

7. Other than bus services provided by Arizona Shuttle and Greyhound, no public transit service is available between Phoenix and Tucson metro areas.

8. Travel via commercial air carriers between Phoenix and Tucson exclusively is approximately 35,000 passengers per year, or approximately 100 per day. However, a total of approximately 735,000 passengers per year, or approximately 2,000 passengers per day, travel between Phoenix and Tucson, with final destinations beyond either city.

9. I-10 is the primary facility for transportation of persons and goods between the Phoenix and Tucson metro areas.

10. Portions of I-10 in the Phoenix and Tucson metro areas are either congested or will be congested, necessitating the widening just to accommodate growth within the urban areas. Traffic on I-10 between Phoenix and Tucson is expected to increase by 67 percent by 2020.

11. The rural segments of I-10 will need to be widened to six lanes before 2005 and to eight lanes before the year 2020. While widening to six lanes would not require reconstruction of most structures (Gila River bridge and the Junction with I-10 would need to be widened or replaced), widening to eight lanes would probably necessitate the reconstruction of most of the existing structures. Freeway widening beyond six lanes would most likely result in substantial environmental impacts. Such widening might not be perceived by the public or the Gila River Indian Community as being compatible with the surrounding desert environment.

12. It is necessary to offer alternative means for the transportation of persons in the corridor between Phoenix and Tucson so that reliance on I-10 can be reduced and travel needs beyond the year 2020 can be accommodated.

13. To be effective in attracting riders in this intercity corridor, the transit system must offer travel times better than the automobile.

In summary, as population and employment in the Phoenix-Tucson corridor continue to increase between now and 2020, the transportation infrastructure, with heavy congestion in many areas, will reach capacity unless significant capacity improvements are made. This will result in increased congestion, slower travel speeds, increases in accidents, and a worsening of air quality and the fragile desert-oriented quality of life in the corridor. Without action, travel conditions between Phoenix and Tucson for auto-dependent and transit-dependent (such as mobility-impaired) citizens will continue to worsen. The demographic and transportation conditions forecast for the corridor between now and 2020 suggest the need to develop and evaluate major transportation alternatives to the single-occupant automobile to facilitate the movement of people, goods, and information between the Phoenix and Tucson metropolitan areas.

3.7 Goals and Objectives

The following project goals were developed by the High Speed Rail Task Force at its August 4, 1997, meeting. Several measures for achieving those goals were identified by the Task Force and are listed below. For those goals and measures adopted, it was important to develop thresholds for feasibility in order to assist in determining project feasibility. These goals provided overall guidance to the alternatives as they were developed and evaluated throughout the project.

Goal 1: Passenger rail service must be less in required travel time than conventional automotive travel between Phoenix and Tucson.

Objective 1: Implement a high speed rail system that provides convenient rider access.

Objective 2: Implement a comprehensive and coordinated feeder network to complement the high speed rail system.

Goal 2: Ensure that rail freight and passenger operations are compatible in the corridor.
Objective 1: Implement a high speed rail system that does not conflict with freight traffic operations in the corridor.

Goal 3: Rail service must meet a balance of multiple feasibility criteria.
Objective 1: Ensure that the high speed rail system meets the overall policy and technical aims of the project and its participants.

Goal 4: Project implementation must be supported by the political and public communities.
Objective 1: Ensure that the high speed rail system meets the policy aims of member jurisdictions.
Objective 2: Implement a high speed rail system that is supportive of local ordinances, regulations and policies.

Goal 5: The project must be affordable.
Objective 1: Implement a high speed rail system that is within the region's capital resources.
Objective 2: Implement a high speed rail system that is cost effective from a capital cost per rider perspective.
Objective 3: Implement a high speed rail system that meets national standards for operations cost.
Objective 4: Implement a high speed rail system that maximizes the potential of public/private partnerships.

Goal 6: Ensure that the project be partnered with the railroad company.
Objective 1: Ensure the high speed rail system is compatible with on-going and planned freight operations.

Goal 7: Ensure that sufficient highway trips are diverted to rail to defer the need for highway improvements.
Objective 1: Implement a high speed rail system that results in ridership comparable to, if not exceeding, one new freeway lane capacity in each direction in the corridor.

Goal 8: The project must enhance the travel experience between Phoenix and Tucson.
Objective 1: Ensure the high speed rail system provides convenience and amenities for passengers.
Objective 2: Implement a high speed rail system that provides a wide range of services for riders both in stations and in vehicles.

Goal 9: The rail service must have good interfaces with highway, rail and transit.
Objective 1: Implement a high speed rail system that provides coordinated auto and local transit access.
Objective 2: Improve corridor-wide transit services to efficiently serve the high speed rail system.

Goal 10: Environmental and energy considerations must be enhanced.
Objective 1: Implement a high speed rail system that improves the local environmental by reducing measurable pollutants.
Objective 2: Implement a high speed rail system that results in a net reduction in per capita energy consumption in the corridor.
Objective 3: Implement a high speed rail system that protects and enhances the region's scenic attributes.

Goal 11: Economic development and land use improved.
Objective 1: Implement a high speed rail system that maximizes economic development potential in the corridor and at the station sites.
Objective 2: Implement a high speed rail system that is coordinated with and supports local land use policies.

Goal 12: Maximize rail ridership.
Objective 1: Implement a high speed rail system that increases total transit mode split in the corridor.
Objective 2: Implement ridership incentives and a fare structure to maximize high speed rail ridership.

Goal 13: Maximize private sector involvement.
Objective 1: Implement a high speed rail system that provides as many opportunities as possible for joint development and other private sector participation methods.

Goal 14: Increase tourism.
Objective 1: Implement a high speed rail system that is aimed at serving as many corridor destinations as possible.
Objective 2: Implement a high speed rail system that is a tourist attraction in its own right.

Goal 15: Consider increasing service levels in phases to achieve high speed rail service mission.
Objective 1: Implement a high speed rail system that is flexible enough to meet future economic, demographic, and political needs.

Goal 16: Improve transportation safety.
Objective 1: Implement a high speed rail system that reduces the overall vehicular accident rate in the corridor.
Objective 2: Implement a high speed rail system that is safer than comparable passenger rail systems nationwide.

3.8 Evaluation Measures

This section describes the evaluation measures used to compare and evaluate the alternatives. The measures listed below were developed from the goals and objectives (as well as the feasibility definition). The measures are consistent with the level of analysis detail expected from a study of this nature. The measures are also expected to be readily available from the data collected and forecasting procedures used. Although the numbers reported are expected to be reasonably accurate, the more important value of these measures is to allow reliable *comparisons among* the alternatives, in a relative sense. Unless otherwise stated, the estimates are for the horizon year 2020.

Chapter 5, Evaluation of Alternatives, evaluates and quantifies the measures. Those measures which could not be quantified were dealt with qualitatively.

1. *Number of Users*. This measure is an estimate of the expected number of persons that will use the alternative or the improvement. For the passenger rail alternatives, this measure is equal to the forecasted number of persons boarding the train. For the Highway Widening Alternative, this measure is equal to the forecasted number of persons using the new lanes. Both average weekday and annual estimates were prepared.

2. *Travel Time*. This measure is an estimate of the expected travel time from one end of the project (or improvement) to the other.

3. *Annual Value of Time Saved*. This measure converts the value of the time saved (in comparison to the no-build alternative) to dollars. A value of time equal to 80 percent of the 1997 average Arizona hourly wage rate was used, consistent with Federal Major Investment Study guidance.

4. *Passenger Travel Time Reliability*. This measure is a qualitative comment on the ability of the alternative to provide a reliable travel experience, free from external forces that could cause delays. A rank of "best," "intermediate," and "worst" reliability was used.

5. *Transit Operating Revenues*. This measure is a calculation of the estimated farebox revenues expected from the collection of passenger fares, computed by multiplying the number of boardings by an average fare. Fares are consistent with the level of service provided, as well as experiences in other locations.

6. *I-10 Vehicle-Miles of Travel (VMT)*. This measure is a forecast of the change in VMT (in comparison to the no-build alternative) on I-10 with the various build alternatives in place.

7. *Capital Cost*. This measure is an estimate of the total cost to build the alternative and acquire rolling stock, in 1997 dollars.

8. *Operating and Maintenance (O&M) Cost*. This measure is an estimate of the total cost to annually operate and maintain the alternative, in 1997 dollars.

9. *Cost-effectiveness*. This measure is a calculation of the annualized cost (capital and O&M) per annual user of the alternative. This measure was calculated in a manner generally consistent with Federal MIS guidance.

In addition to the above measures, each alternative was qualitatively (or quantitatively, if possible) assessed in terms of the following measures, using a rank of "best alternative," "intermediate alternative," and "worst alternative":

- Ability to Meet Long-Range Mobility Needs
- Level of Public and Political Support
- Level of UP Railroad Support
- Affordability
- Environmental Benefits
- Economic & Private Sector Development Potential
- Tourism Potential
- Public Safety

Two additional evaluation criteria were considered by the Steering Committee, but were not used. These two items are more relevant to traditional benefit-cost calculations and therefore are not necessary in this phase of the study.

- *Deferred Highway Construction Cost*. This measure is an estimate of the highway construction costs avoided (if any) by implementation of the alternative.
- *Cost per VMT Reduced*. This measure is an indication of how cost-effectively the alternative performs in reducing VMT.

3.9 Feasibility

The definition that follows avoids the pitfalls of using factors that are beyond the scope, resources, and time allocated to this project. Among these factors are detailed environmental considerations, specific line and station locations, ability to finance, levels of potential public subsidies that could be required, and institutional responsibilities for the construction and operation of such a high speed rail passenger service. These important factors and issues required additional time and resources to determine and resolve.

The High Speed Rail Passenger Project connecting Phoenix and Tucson Metro areas was determined to be feasible if the following conditions could be reasonably anticipated:

1. One or more of the project route alternatives identified and evaluated during this study is determined to be technically feasible, ie. able to be constructed in the Phoenix-Tucson transportation corridor, AND
2. The technically possible alternatives meet the project goals and objectives of high speed rail passenger service that is less in required travel time than automotive travel between Phoenix and Tucson, AND
3. The high speed passenger rail service will provide a travel alternative that will attract a sufficient number of passengers to warrant additional studies to refine the location, passenger projections, travel needs, and sources of passenger demand, AND
4. The high speed passenger rail service will meet acceptable environmental standards, AND
5. The high speed passenger rail service can garner enough public support, as determined from extensive public involvement in the study process, to continue project planning and refinement, AND
6. The high speed passenger rail service can be funded, assuming the reasonable availability of existing and projected public and private revenue sources, AND
7. The high speed passenger rail service will be cost-effective and will achieve a favorable balance between benefits and costs.

If at the conclusion of this phase of study, a project is found to be "feasible," as defined above, the project will be recommended for advancement to the next phase of engineering development. A final decision on implementation is subject to much more evaluation than is intended by this initial study.

3.10 Next Steps

The next step in the study defines and develops a set of reasonable corridor mobility alternatives that appear, at least initially, to potentially address the purpose and need, as well as the goals and objectives of this study, as documented herein. Furthermore, as explicitly established by ADOT during the genesis of this study, the alternative improvements evaluated shall focus on specific high speed passenger rail applications and technologies. (Largely for comparison purposes only, a baseline no-build alternative and a highway widening alternative were also included for study).

High speed rail systems have proven to be effective competitors in the travel marketplace. High speed rail travel times can meet and exceed highway and airline travel times. Ridership levels on intercity passenger systems can be similar to multilane freeway usage. Rail passenger systems can be designed in innovative ways to attract riders from other modes, including the automobile. Appendix B, available as a separate document, contains a summary of high speed rail systems around the world.

Key findings of the Committee for the Study of High Speed Surface Transportation in the United States (reference: TRB Special Report 233) that are relevant to this study include the following:

- " Surface transportation technologies are available now that can operate safely at speeds up to 200 MPH.
- The capital costs of high speed ground transportation (HSGT) systems are dominated by the costs of construction of the track or guideway; the cost of the vehicles is a considerably smaller part of the total.
- In certain corridors, speed can be increased and rail service improved without constructing new HSGT systems. Investments in new rail equipment and selective alignment improvements costs less than construction of completely new systems.
- Ridership is the critical factor in determining the feasibility of an HSGT system, regardless of whether it is to be a private or public enterprise.
- The primary potential travel market for HSGT systems in the United States consists of intercity trips in the range of approximately 150 to 500 miles.
- It is unlikely that any new HSGT system in a major U.S. corridor would cover its capital and operating costs from farebox revenues.
- Users would benefit most directly from a new HSGT system and benefits would be reflected by the fares they pay.
- Neither a categorical nor an intermodal fund currently exists at the national level or in most states to fund HSGT implementation.
- European and Japanese HSGT systems have achieved superb operating and safety records.
- For early implementation of an HSGT system in the U.S., the technology must be imported because it is currently available only from foreign suppliers.
- In order to determine the extent of maglev's potential to provide HSGT service, additional research and development is needed."

There are several existing high speed rail systems in operation world-wide that may have applicability in the Phoenix-Tucson corridor. These examples served as prototypes for the alternatives that this study developed and evaluated. It was important that each alternative be distinct and representative of a particular segment of the passenger rail "family" of services. To that end, the rail alternatives range from lower cost options, conventional intercity rail service, to very sophisticated options like magnetic levitation trains. It was expected that the benefits and costs of each option, and its extent in meeting or exceeding the study goals and objectives, vary accordingly. Decision makers had an ample array of options to consider during the course of this study: from minor and major upgrades to the existing UP tracks in the corridor, to separate rights-of-way for electric or maglev high speed rail guideways.

4 *Definition of Alternatives*

The purpose of this Chapter is to develop and define a reasonable set of Phoenix-to-Tucson corridor investments that potentially address the mobility problems between the cities, as well as address the study goals and objectives, as documented in *Chapter 3, Data Collection/Purpose and Need*. Since the overall purpose of this study is to evaluate the feasibility of high-speed rail in the corridor, four of the six alternatives described below are passenger rail options, varying in scope by their performance. Each rail alternative provides a progressively higher technology and speed, with an associated infrastructure cost increase.

There are three candidate continuous rights-of-way in the Phoenix-Tucson corridor that were reviewed for potential intercity passenger rail use including:
1. UP Railroad right-of-way (including the Tempe and Chandler branches);
2. Interstate 10 right-of-way; and
3. Central Arizona Project (canal) right-of-way.

Preliminary surveys of the railroad right-of-way and initial discussions with key UP Railroad staff indicate that this facility is potentially available for intercity passenger rail use if certain conditions are met to protect the existing freight facilities and operations. Preliminary surveys of the right-of-way and initial discussions with key ADOT staff indicate that the I-10 facility is also potentially available for intercity passenger rail use. Preliminary discussions with Central Arizona Project (CAP) staff indicate that this right-of-way is unsuitable for intercity passenger rail use. The CAP is a major aqueduct facility in the corridor, generally paralleling the UP Railroad/I-10 facilities. It is a complicated system of aqueducts, syphons, turnouts, flood control dikes, maintenance roads and utilities. There are also several locations where the aqueduct curves are problematic for passenger rail purposes. In the opinion of CAP staff, construction of an elevated high speed rail line could result in damage to the dikes and/or contamination to the aqueduct. Although these problems could be mitigated, it is the opinion of the consultant that both the UP Railroad and the I-10 rights-of-way are superior candidates for high-speed rail.
In order to minimize costs and environmental impacts, it is therefore recommended that the four rail alternatives use either the existing UP Railroad and/or Interstate 10 rights-of-way in the corridor, to the maximum extent possible. Private right-of-way acquisitions and/or uses will also be minimized.

To allow for a direct comparison to a conventional highway mobility improvement, an alternative that would widen I-10 between Phoenix and Tucson was included for study. A baseline or "do-nothing" alternative that reflects the existing and committed laneages in the corridor was also included for comparison purposes.

The six Phoenix-Tucson corridor alternatives defined in this report are:

Alternative 1	No-Build
Alternative 2	Highway Widening
Alternative 3	Conventional Rail - Minor Upgrade
Alternative 4	Conventional Rail - Major Upgrade
Alternative 5	High Speed Rail - Electric
Alternative 6	High Speed Rail - Maglev

It is important to note that this study is a feasibility study and not an engineering study. Therefore, six alternatives should be viewed as preliminary prototypes that are established only for purposes of study and comparison. Final decisions on specific alignment locations, station locations, equipment selection, operating plans, fares, and the myriad of other decisions that define a project will happen over a period of many years and with the involvement of many more participants in the Arizona community. This study is only the first step, although an important one, in that process.

The following sections describe the six alternatives in more detail. The level of detail and amount of information provided herein is limited to only that which was required to evaluate and make comparisons at a conceptual level.

4.1 Alternative 1: No-Build

This alternative is the baseline option, included mostly for comparison purposes. It is essentially a "do-nothing" option comprised of existing conditions in the corridor, plus any major committed and programmed/funded (but not built) transportation capacity increases, using any mode, as defined by the relevant regional and State transportation plans. I-10 would largely remain in its current configuration as a 4-lane freeway in the rural sections of the corridor. Limited Amtrak passenger rail service would continue along the UP Railroad mainline tracks, through Tucson, with no direct service in Phoenix (Phoenix Amtrak riders would continue to use bus service to access Amtrak in Tucson until a new station is completed in Maricopa).

According to ADOT, MAG, and PAG, the following key I-10 laneages (through-traffic lanes) are included in the No-Build Alternative as "givens,":

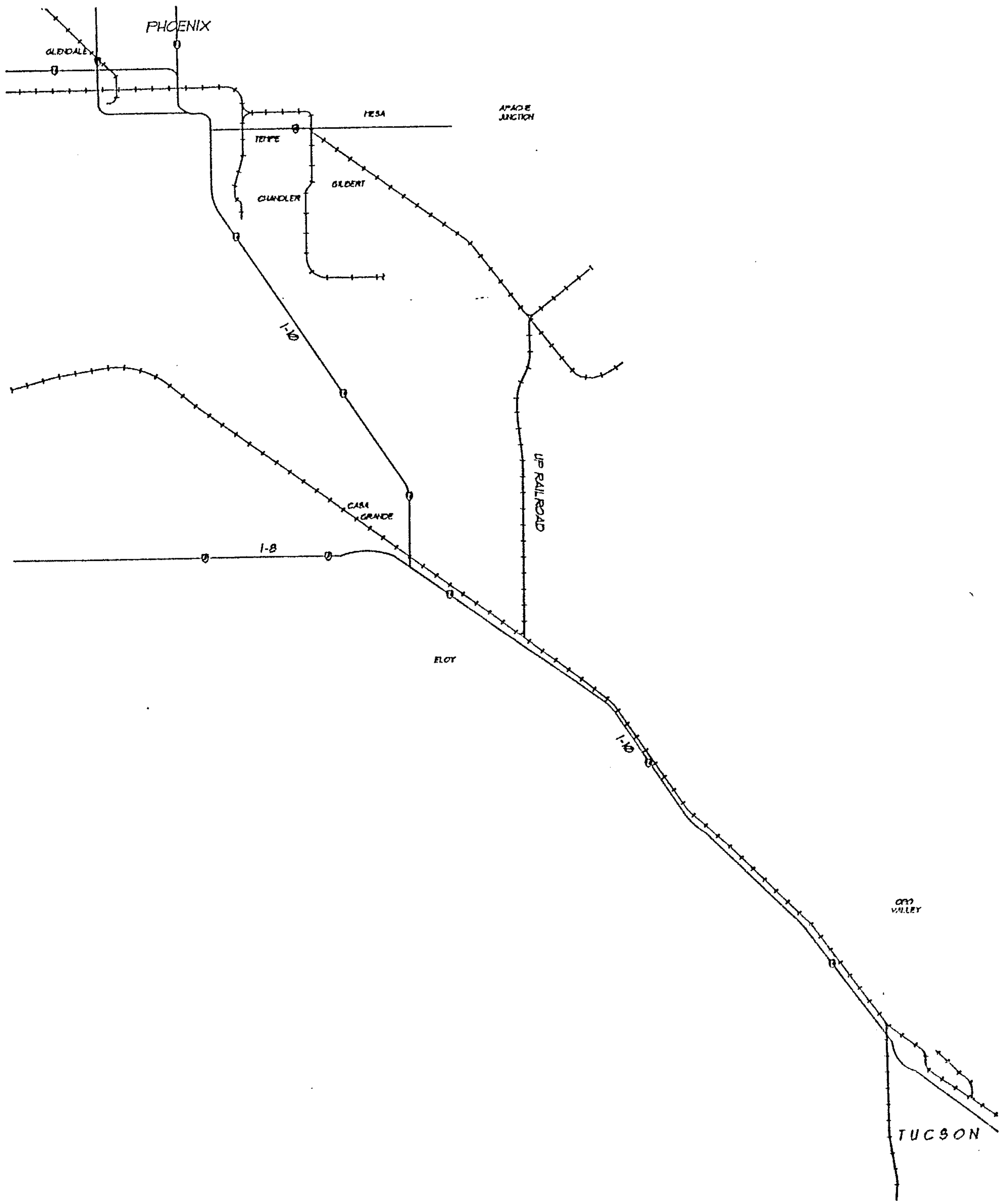
Table 4-1 Existing Plus Committed Lanes in the Phoenix – Tucson Corridor

	Existing Lanes	Existing Plus Committed Lanes
Central Ave. to Broadway in Phoenix	8	8
Broadway to Ray Rd. in Phoenix	8	8
Ray Rd. to Marana Rd. in Pinal County	4	4
Marana Rd. to Ina Rd. in Tucson	4	6
Ina Rd. to Congress St. in Tucson	6	6

Note: for street locations, refer to Appendix H.

Figure 4-1 shows the existing 4-lane freeway and the No-Build Alternative corridor location. Appendix H shows the alternative in more detail.

Figure 4-1 Location of Existing 1-10 and UP Railroad



4.2 Alternative 2: Highway Widening

This alternative assumes that the forecast travel increase in the Phoenix-Tucson corridor will be handled by widening I-10. In order to fairly compare this investment to the passenger rail alternatives, I-10 is assumed to be widened from Downtown Phoenix to Downtown Tucson, which is approximately the same distance as Central Avenue Station in Phoenix to the Tucson Depot by rail. As documented in Chapter 3, traffic trends for the rural portion of I-10 show a need for two additional lanes (six lanes total) sometime before the Year 2005, and another two additional lanes (eight lanes total) sometime before the Year 2020. This alternative is 112 miles long, extending from Central Avenue in Phoenix to Congress Street in Tucson. The table below summarizes the lane assumptions for this alternative.

Table 4-2 Lane Assumptions

	Existing Lanes	Existing Plus Committed Lanes	Year 2005	Year 2020
Central Ave. to Broadway in Phoenix	8	8	10	12
Broadway to Ray Rd. in Phoenix	8	8	10	12
Ray Rd. to Marana Rd. in Pinal County	4	4	6	8
Marana Rd. to Ina Rd. in Tucson	4	6	8	10
Ina Rd. to Congress St. in Tucson	6	6	8	10

Note: for street locations, refer to Appendix I.

The median of I-10 is the proposed widening location. It should be noted that there are sections of I-10 where it would not be possible to extend the highway into the median and therefore, the widening would have to take place in the shoulder area, conflicting with existing interchanges and exceeding right-of-way, resulting in the reconstruction of existing over passes and under passes.

Figure 4-2 shows the location of the freeway widening alternative. Appendix I shows this alternative in more detail, identifying all grade separations. Appendix C contains a detailed field survey of the I-10 alignment, and Appendix P lists all I-10 grade crossings.

<u>**Median of I-10, Proposed Widening Location**</u>

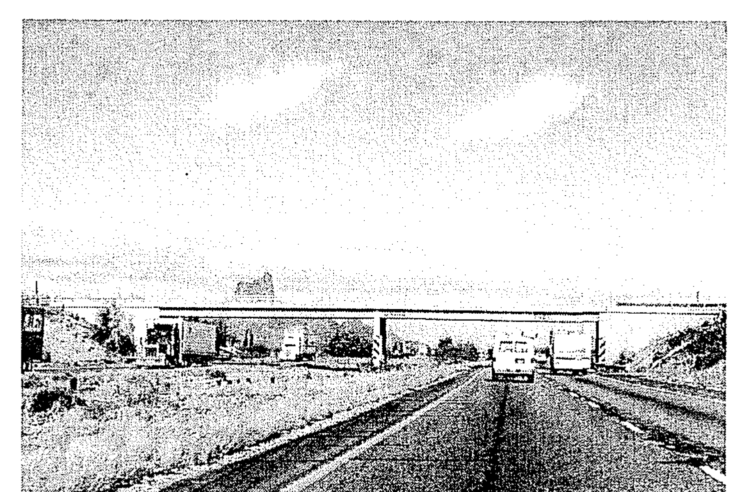
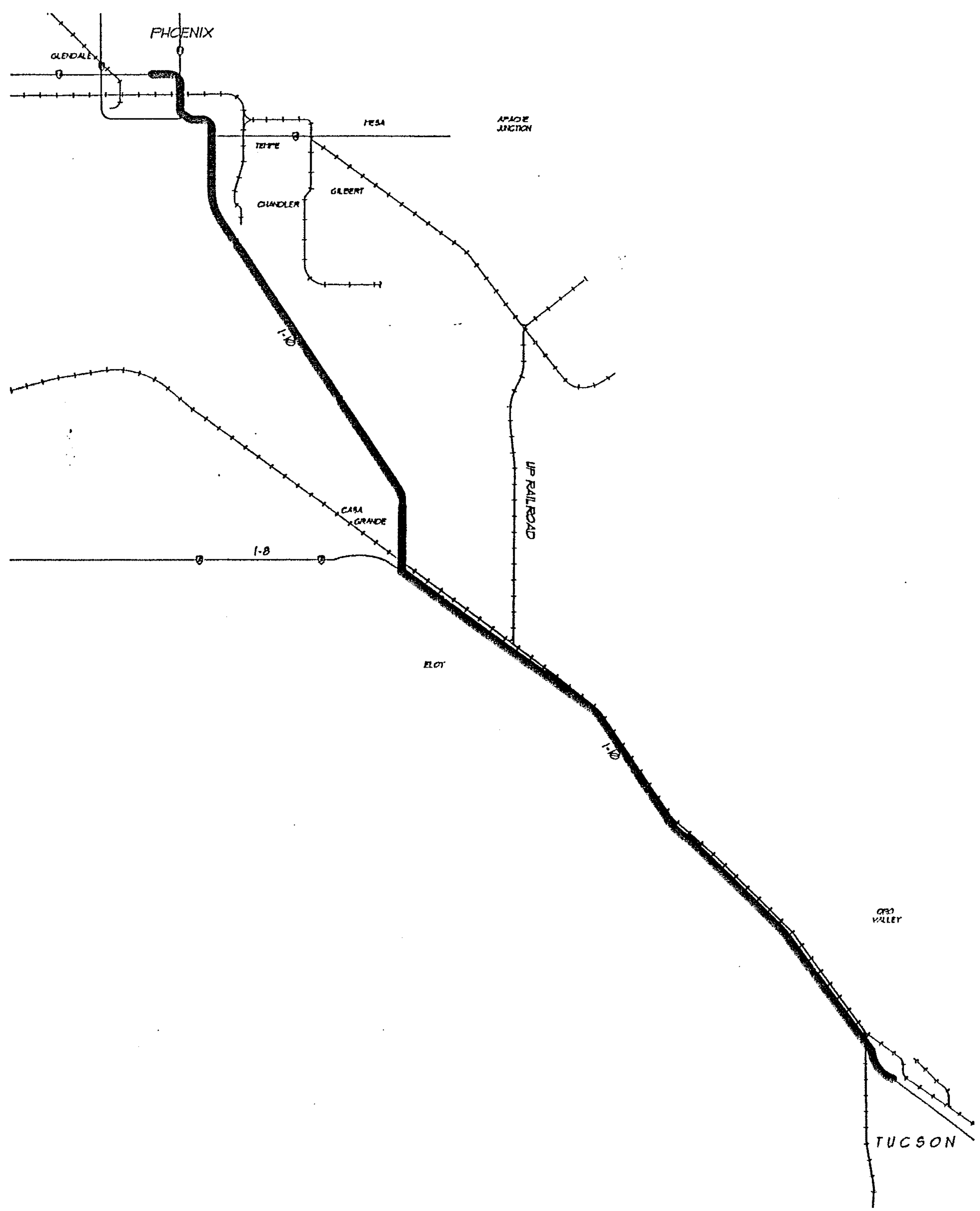


Figure 4-2 Location of Highway Widening Alternative



4.3 Alternative 3: Conventional Rail - Minor Upgrade

This alternative assumes using the existing UP Railroad right-of-way between Phoenix and Tucson, with relatively minor improvements to the track and right-of-way (including grade crossing upgrades) to achieve a top train speed of approximately 80 MPH. Conventional diesel-electric rolling stock is assumed, similar to Amtrak trains. This alternative is essentially the same as the improvements recommended in the 1993-94 ADOT *Rail Passenger Feasibility Study*. This alternative is 121 miles long, extending from a Central Avenue Station in Phoenix to the Tucson Depot. (Note: at an average speed of 62 MPH and a total trip time of approximately two hours, this alternative is not competitive with the automobile).

Most of the railroad improvements for this alternative will occur on the Phoenix Line between the station in Phoenix and Picacho Junction. At Picacho, the Phoenix segment connects with the Union Pacific Sunset Line. The Phoenix segment currently has a maximum operating speed of 60 MPH for passenger trains. The improvements proposed for the minor upgrade include: upgrading the track to allow for higher speeds wherever feasible, extending Centralized Traffic Control (CTC), and modifying the railroad at-grade crossing warning equipment.

Upgrading of the track will occur primarily between Mesa and Picacho where existing track speeds vary from 25 MPH to 60 MPH for passenger trains. Operating speeds in this 56-mile section would be increased to passenger train speeds of 40 MPH to 79 MPH. The existing Automatic Block Signals (ABS) would be upgraded to CTC between Randolph (near Picacho) and Mesa/Gilbert, a distance of approximately 42 miles. Because train speeds will be increased, the at-grade crossing equipment will have to be modified in order to maintain the required warning and gate-down time.

The Sunset Line between Picacho and Tucson is currently single-track with passing and sidings and CTC. The maximum allowable operating speed is 79 MPH for passenger trains. The UP has begun a program to double-track the segment from Picacho Junction to Tucson (Sunset Line). Double-track exists from the Tucson Station to Stockham, a distance of approximately five miles. Track improvements include increasing allowable speed limit from 70 MPH to 79 MPH between Petrie and Jaynes, a distance of approximately four miles.

Any other improvements as may be required by the Union Pacific Railroad (UP) will also be included, such as additional sidings and crossovers, extension of CTC to the Phoenix Station, and/or yard and shop facility improvements for the servicing, storage and maintenance of the passenger train equipment. Additional improvements required by the UP will not be specifically known until the design phase for implementing passenger service. This is a result of the constantly changing railroad environment and the absence of detailed operating plans and engineering drawings at the feasibility study level.

The passenger train locomotives and cars for the minor upgrade alternative will be selected from conventional intercity or commuter rail equipment technology, including tilt train equipment. Examples of these types of equipment, which are currently in service, include the following:

- Amtrak Capital Corridor Service between the San Francisco Bay area and Sacramento in California.
- Amtrak San Diegan Service between Los Angeles and San Diego in California.
- Washington State Talgo Service between Seattle, Washington and Vancouver, British Columbia.
- Commuter rail operations such as CalTrain (San Francisco – Gilroy), Metrolink (Los Angeles area), and Coaster (San Diego – Oceanside).

Below is a typical photograph of this technology. *Figure 4-3 shows the location of this alternative. Appendix J shows this alternative in more detail, and Appendix P lists all UP mainline grade crossings.*

Conventional Amtrak Train

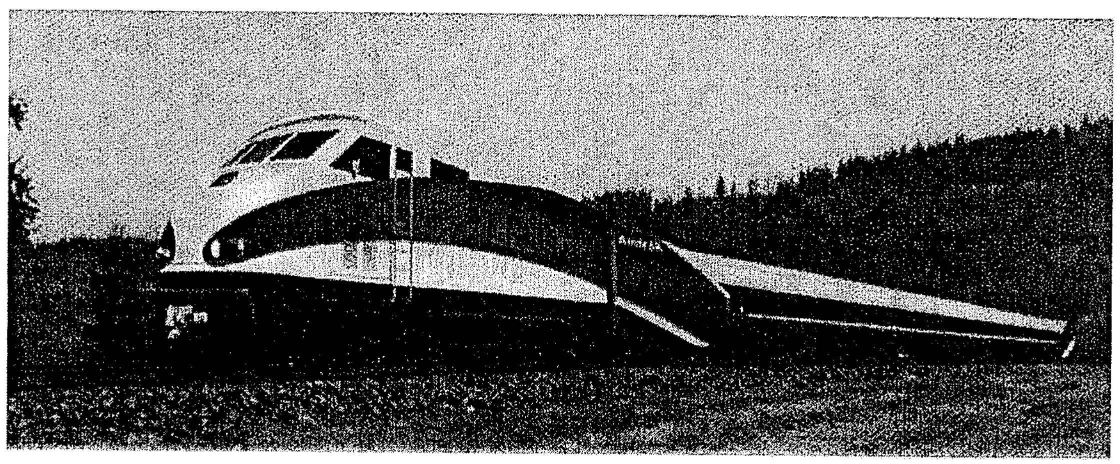
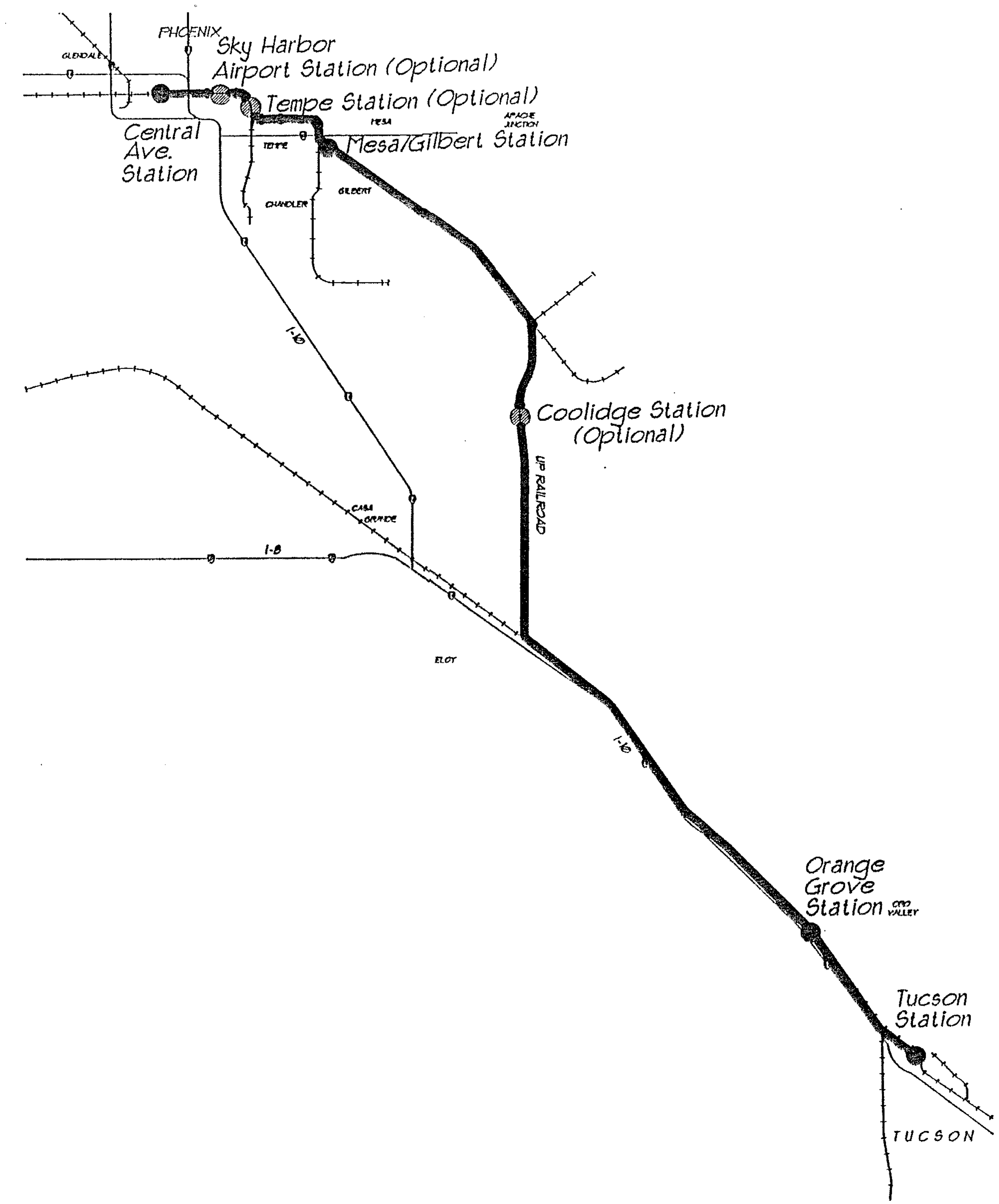


Figure 4-3 Location of Conventional Rail Alternative - Minor Upgrade



4.4 Alternative 4: Conventional Rail - Major Upgrade

This alternative also assumes using the existing UP Railroad right-of-way from Phoenix to Tucson, but with major design and equipment improvements to increase the passenger train speed to a maximum of 125 MPH. Conventional overhead electric rolling stock also is assumed for this alternative. An example of this alternative is the Amtrak Metroliner, currently operating between Boston and Washington, DC. This alternative is 121 miles long, extending from Central Avenue in Phoenix to the Tucson Depot.

This alternative will include the construction of a new, electrified passenger mainline with passing sidings in the existing UP right-of-way over the 121 miles between Phoenix and Tucson. The design of the new track will allow a maximum speed of 125 MPH wherever possible. The maximum speed between the Phoenix and Mesa/Gilbert stations has been restricted due to the level of congestion. The speed restriction was implemented in order to preclude concerns such as trains operating at speeds over 100 mph in congested areas, noise and vibration issues for residences and businesses, and the cost involved in the reconstruction of three curves which would be necessary to increase train speeds.

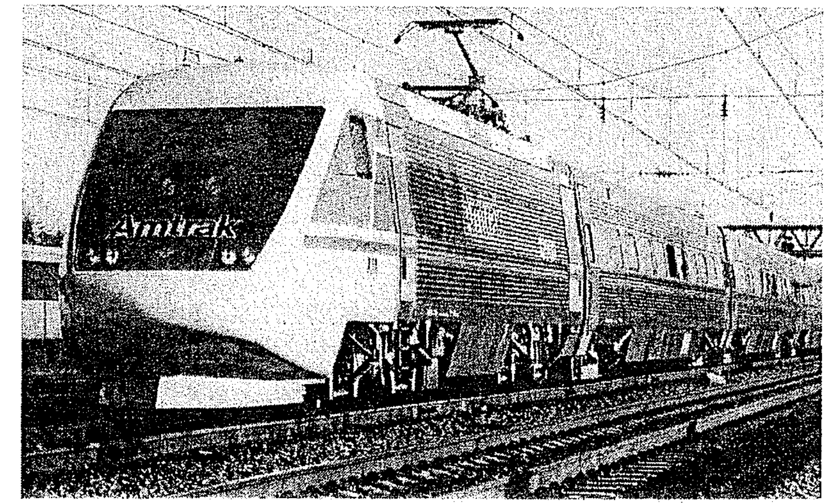
Automatic Train Control with cab signals will provide a positive train control system over the entire line. Railroad at-grade crossing equipment will include the "sealed crossing" protection concept of quad-gates and center roadway barrier markers for all crossings which are currently equipped with gates. Crossings, which currently have only lights and bells or crossbuck signs, will be equipped with full gate warning equipment. This will require modifications to the existing UP Railroad crossing equipment. All new crossing surfaces for roadways will be concrete. The design and construction of the new high speed track will not preclude double-tracking in the future. Passing sidings will be located at each station and at intervals not to exceed ten miles. Each passing siding will be 1,500 feet (at stations) to 2,000 feet (at intermediate locations) in length with # 20 turnouts. A total of 12 to 14 sidings will be required.

The trains for the major upgrade alternative are assumed to be powered by electricity. This decision is based upon the following: 1) the top speed for existing American diesel locomotives is approximately 110 MPH; 2) the only 125 MPH diesel train currently in service is the High Speed Diesel Train (HSDT) of Great Britain, and 3) at 125 MPH, electric propulsion is more cost-efficient in terms of noise mitigation and annual operating and maintenance costs.

It is also envisioned that several existing at-grade crossings will be grade separated and several minor crossings will be eliminated. For the purpose of this study, it is assumed that 12 crossings will be grade separated and six minor crossings will be eliminated. At the feasibility study level, it is not necessary to identify the specific crossings for cost estimating purposes. Local communities and agency planners will need to be involved in grade separation and elimination decisions. While grade separations will involve high traffic roadways, it must be noted that in many locations, other streets and roads, driveways, and other conditions exist which make grade separations difficult without significantly altering existing traffic flow patterns.

The image below is a typical photograph of this technology. *Figure 4-4 shows the location of this alternative. Appendix K shows this alternative in more detail, and Appendix P lists all UP mainline grade crossings.*

Amtrak Metroliner



There are a few examples of 125 MPH systems in the world. Amtrak's Northeast Corridor and Great Britain are two examples. Speeds of 90 MPH to 110 MPH and speeds over 140 MPH are more common due to cost and benefit considerations.

This alternative also extends from Central Avenue in Phoenix to the Tucson Depot, by way of two alignment options including:

a. *UP Railroad Alignment Option* - using the existing UP Railroad right-of-way (121 miles), and
b. *Combined UP Railroad and I-10 Option* - using a combination of the existing UP Railroad and I-10 rights-of-way (117 miles).

4.5.1 UP Railroad Alignment Option

Figure 4-5-1 shows the location of this alternative. Appendix L describes this alternative in more detail, and Appendix P lists all UP mainline grade crossings. This alignment option follows the existing UP track all the way between Phoenix and Tucson, similar to the Minor and Major Upgrade Alternatives discussed above. Note that the cross sections shown in Appendix L are elevated only.

4.5.2 Combined UP Railroad and I-10 Option

Figure 4-5-2 shows the location of this alternative. Appendix M describes this alternative in more detail, and Appendix P lists all UP mainline and Chandler Branch grade crossings. This alignment follows the existing UP track through the Phoenix urban area, transitions to the Chandler Branch of the UP Railroad, traverses a five-mile "cross country" section between the end of the Chandler Branch and I-10, and then follows I-10 and the UP mainline to Tucson. The Tempe Branch of the UP Railroad was also studied as an option to the Chandler Branch but was found to be less desirable than the Chandler Branch due to the following reasons:

- Lack of East Valley penetration and therefore poorer service to that market;
- Narrower right-of-way (power lines on both sides); and
- High residential density.

Originally, several specific alignment locations were identified along the I-10 route. Between Picacho Junction and Tucson, the UP right-of-way is adjacent to I-10, thereby creating a very wide "transportation envelope" for high-speed rail to operate within. New tracks could be built alongside I-10 (north or south side), in the I-10 median, or in the UP right-of-way, which is very wide in this particular segment. Although wide enough, there are several problems with using the median of I-10 for high speed rail (for both High Speed Rail - Electric and Maglev) including:

1. At crossing bridge locations, either (a) the tracks would have to be depressed, (b) the bridges would have to be raised, or (c) both, in order to provide adequate train clearance. Vertical and horizontal separation would have to be sufficient to avoid structural damage to bridges caused by the wind turbulence from the trains.
2. A rail line, which passes beneath a highway overpass, is subject to hitting or being hit by dangling or thrown debris.
3. The freeway horizontal and vertical profile changes too abruptly in several locations for smooth, maximum speed train operation.
4. In sections where there is no median, or the median is very narrow, the highway shoulder adjacent to the inside lanes would be eliminated.
5. Access to the median for construction and maintenance of the rail line is more difficult and disruptive to highway traffic.
6. Access to the median for police and emergency response is significantly reduced.
7. Highway signage would have to be changed at locations where the sign structure support is located in the median.
8. The median itself would have to be physically "walled-off" to prevent wind turbulence caused by the high speed trains. High-profile vehicles on I-10 could be affected by this turbulence.
9. The median of I-10 is currently designed to accommodate drainage for the facility. Special (and costly) design solutions would be necessary in order to build tracks in the same median.
10. If necessary, using the median for rail would preclude the widening of I-10 in this location.
11. Therefore, for purposes of this study, the preferred location for high speed rail tracks is on the north (or east) side of I-10, where the UP Railroad right-of-way could potentially also be available to accommodate special design considerations for the project.

There are also problems with using the I-10 right-of-way on the outside of the facility, including:

1. On and off ramps and approaches would have to be modified;
2. Acquisition of private property in certain areas (ie. area adjacent to Picacho);
3. Realignment of frontage roads in some areas (ie. near Tucson); and
4. In some areas, a barrier or a wall may have to be constructed to prevent wind turbulence caused by the high speed trains. High-profile vehicles on I-10 could be affected by this turbulence.

Figure 4-5-1 Location of High Speed Rail - Electric: UP Railroad Alignment Option

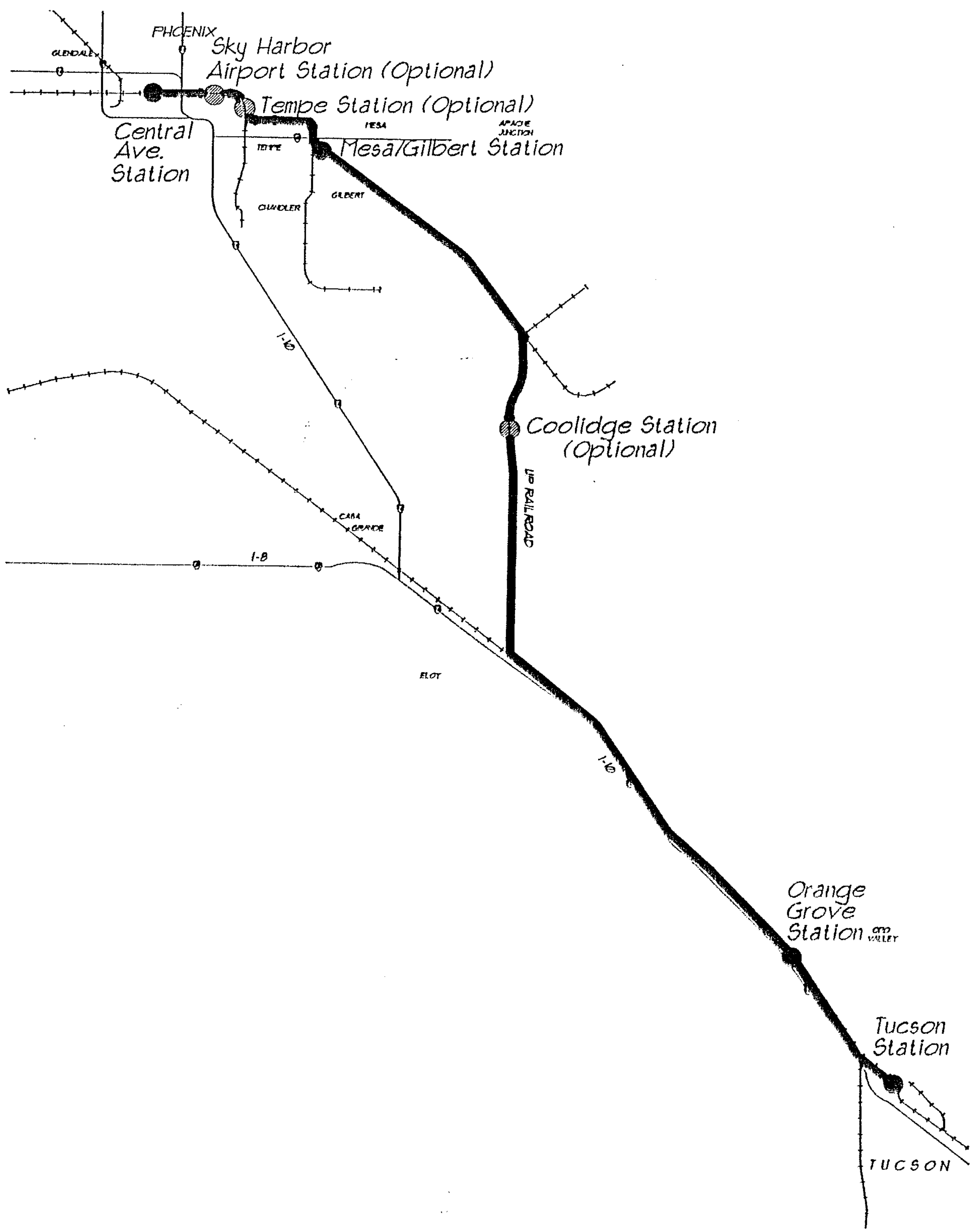
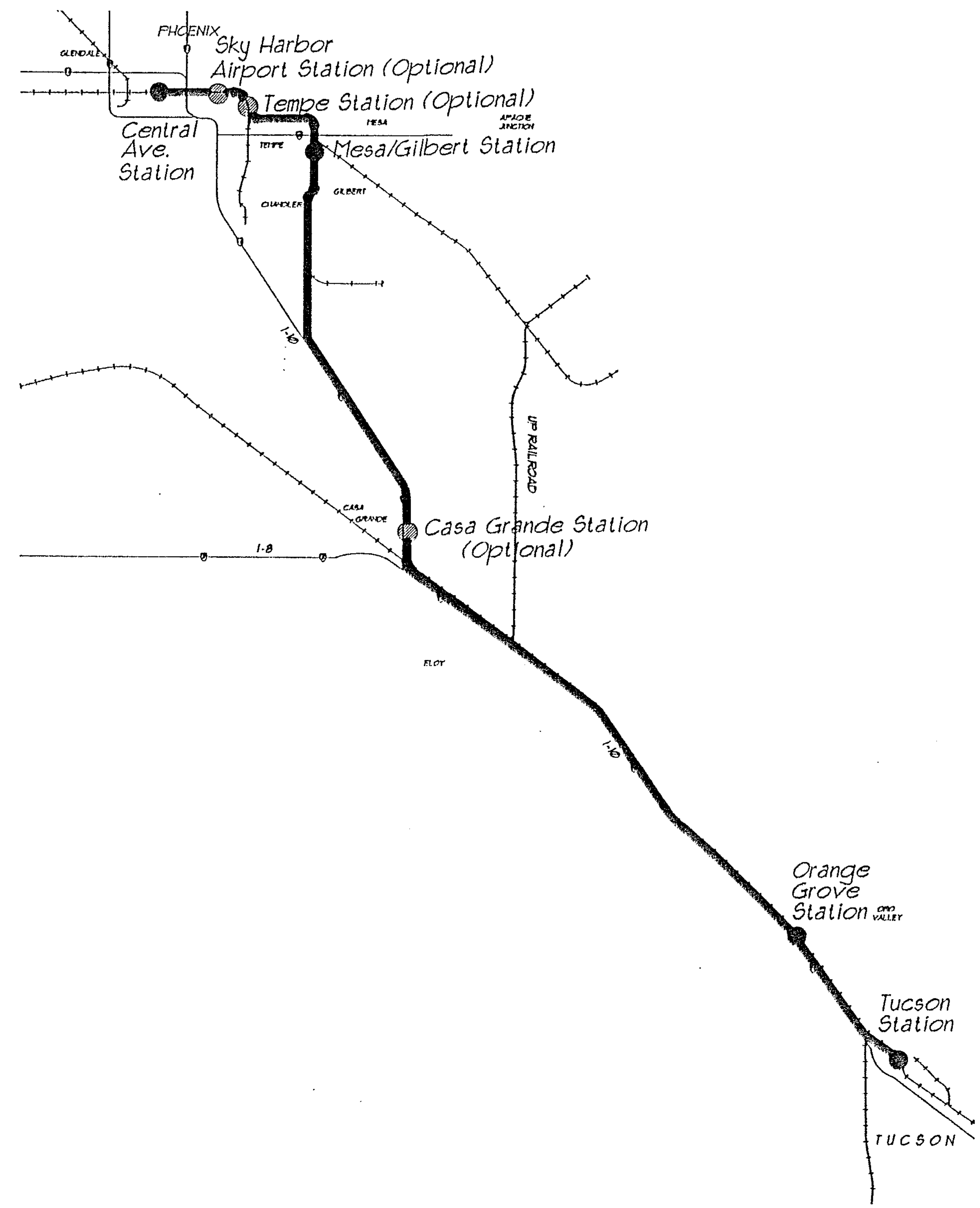


Figure 4-5-2 Location of High Speed Rail - Electric: Combined UP Railroad & I-10 Option



4.6 Alternative 6: High Speed Rail - Maglev

This prototypical alternative encompasses the newly developing magnetic levitation trains that will operate at very high speeds. The German maglev train is proposed to operate at a top speed of 270 MPH and the Japanese version is proposed to operate at a top speed of 320 MPH in revenue service. For purposes of this study, a top speed for this alternative will be assumed to be 250 MPH. As mentioned in the two previous sections on conventional rail - major upgrade and high speed -electric, the maximum speed between the Phoenix and Mesa/Gilbert stations has been restricted due to the level of congestion.

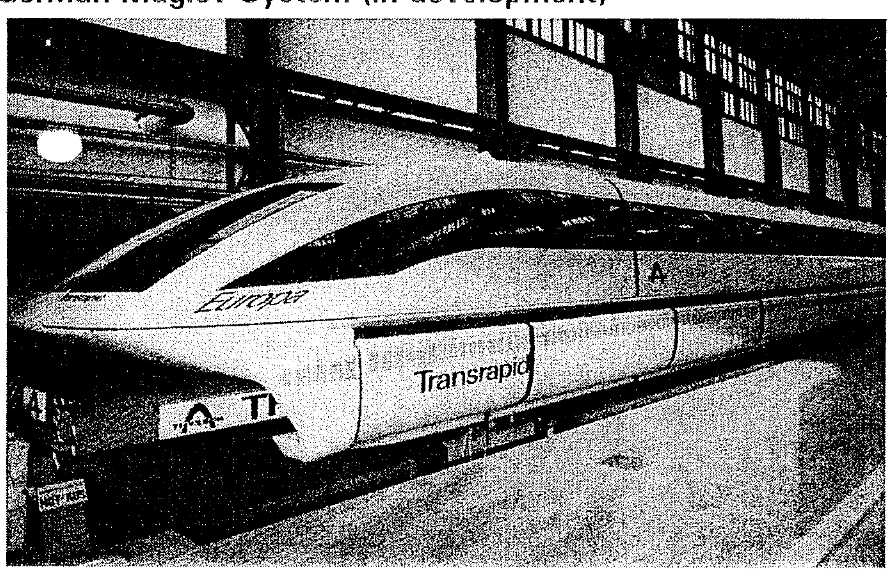
Although not specified in this study, the German approach to magnetic levitation is accomplished by electro-magnets on the railcar, which interact with ferromagnetic elements on the guideway. In the Japanese approach, levitation and propulsion is accomplished by the repulsive force generated between magnets on the railcar and coils along the guideway.

This technology must be elevated because it runs on a guideway and not a rail. This technology is also very sensitive to dirt and debris and therefore cannot be built close to the ground.

This alternative also extends from Central Avenue in Phoenix to the Tucson Depot, by way of two alignment options:

a. *UP Railroad Alignment Option* - using the existing UP Railroad right-of-way (121 miles), and
b. *Combined UP Railroad and I-10 Option* - using a combination of the existing UP Railroad and I-10 rights-of-way (117 miles).

German Maglev System (in development)



4.6.1 UP Railroad Alignment Option

Figure 4-6-1 shows the location of this alternative. Appendix N describes this alternative in more detail, and Appendix P lists all UP mainline grade crossings. This alignment option follows the existing UP track all the way between Phoenix and Tucson, similar to the Minor and Major Upgrade and High Speed Rail Electric Alternatives discussed above.

4.6.2 UP Railroad and I-10 Option

Figure 4-6-2 shows the location of this alternative. Appendix O describes this alternative in more detail, and Appendix P lists all UP mainline and Chandler Branch grade crossings. Similar to the High Speed Rail Electric option, this alternative alignment follows the existing UP track through the Phoenix urban area, transitions to the Chandler Branch, traverses a five-mile "open" section between the end of the Chandler Branch and I-10, and then follows I-10 and the UP mainline to Tucson. The Tempe Branch was also studied but was less desirable than the Chandler Branch, as discussed in section 4.5.2.

Figure 4-6-1 Location of High Speed Rail - Maglev: UP Railroad Alignment Option

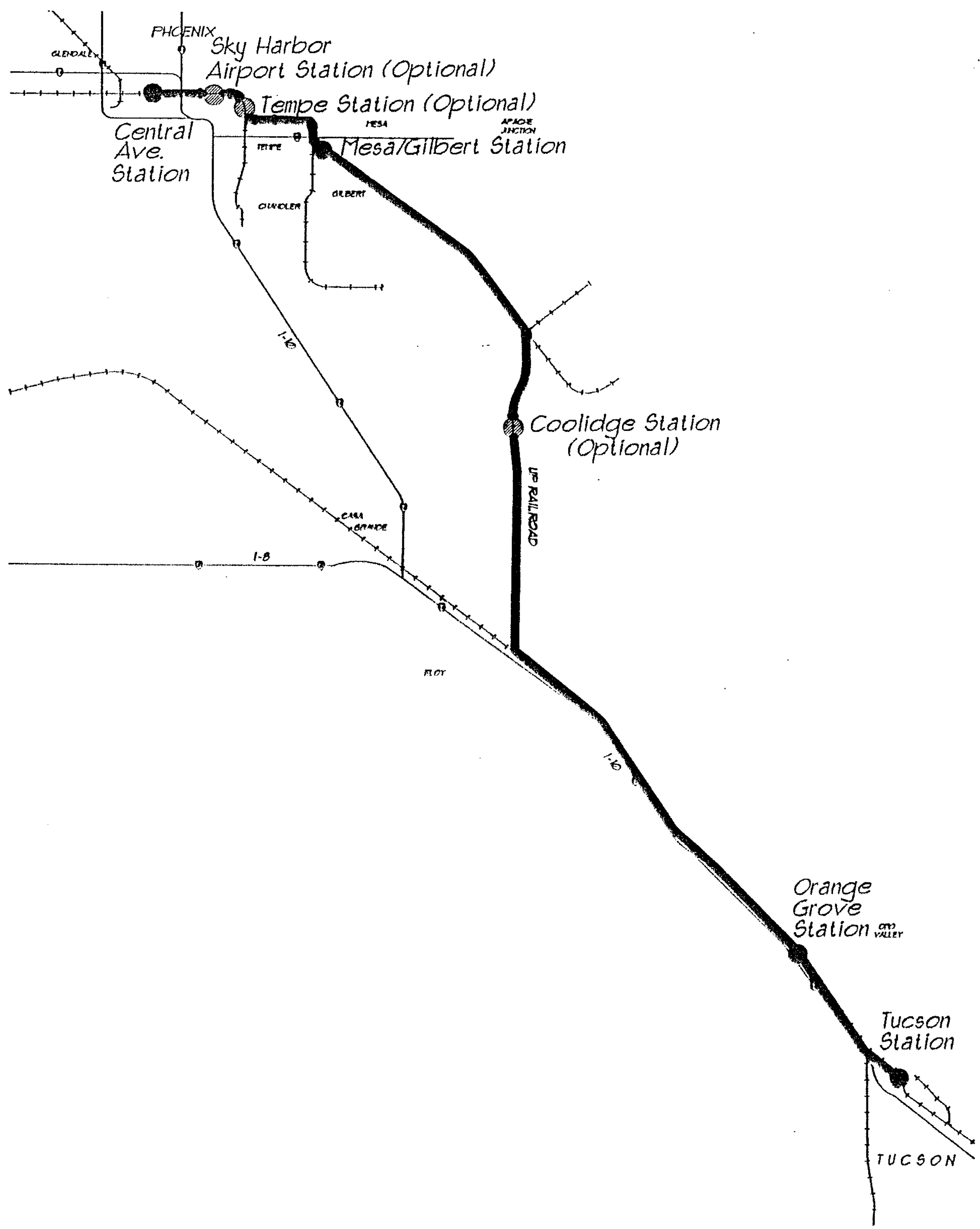
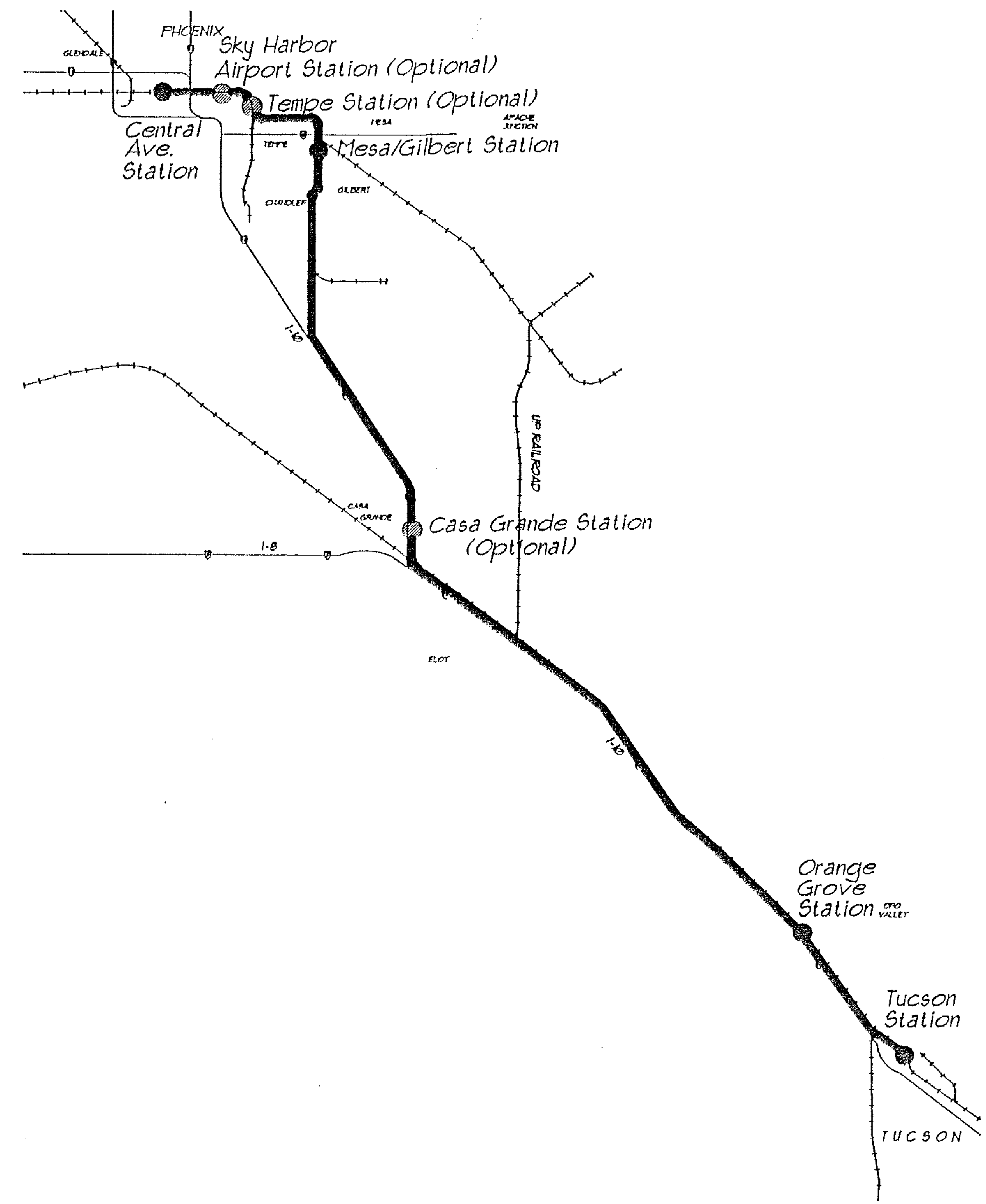


Figure 4-6-2 Location of High Speed - Maglev: Combined UP Railroad & I-10 Option



4.7 Planning and Design Criteria

This section provides key guidance criteria to the civil engineering and operating aspects of the passenger rail alternatives. These criteria were necessary for capital cost estimating of the options, such as trackway, structures, right-of-way, etc.

Table 4-3 Key Civil and Operating Guidance

Alternative	Max. Speed	Min. Radius	Max. Grade	Max. Accel./Decel.
2: Highway Widening	75 mph	812 ft.	4%	--------------
3: CR - Minor Upgrade	80 mph	3,000 ft.	3.5 %	1.0 mph/sec.[2]
4: CR - Major Upgrade	125 mph	7,500 ft.	3.5 %	1.5 mph/sec.[2]
5: HSR - Electric	175 mph	10,000 ft.	3.5 %	1.5 mph/sec.[2]
6: HSR - Maglev	250 mph	13,000 ft.	3.5 %	1.5 mph/sec.[2]

4.8 Typical Station Assumptions

All stations must provide the basic facilities necessary to use the system, including intermodal access facilities, platforms, waiting shelters, ticket sales offices and/or vending machines (TVM's) and validators, information displays, bicycle feeders, and passenger amenities. Wherever possible, opportunities for private station development will be included. Materials used in stations should be attractive, durable, graffiti-resistant, and require only minimal maintenance. Passenger station layouts, facilities for buses (transit centers), automobile passenger drop-off zones and park-ride lots must be tailored to individual line-haul rail requirements.

- **Platforms** at each station must be long enough to sufficiently accommodate the longest trains planned for. Depending on specific site conditions and the number of tracks available, rail platforms may be of either the side or center variety. Platforms may be constructed to accommodate people with disabilities. Platforms may not intrude into the clearance envelopes required by freight equipment.
- **Shelters** should be kept relatively small to minimize platform clutter. Shelters may cover approximately one quarter to one third of the platform length and should be to a standard, simple design to provide an attractive yet cost effective facility. Shelters are generally neither heated nor air-conditioned (though recent innovations in outdoor cooling at bus shelters in Arizona are applicable here).
- **Connections**: provisions for parking feeder buses, auto rentals, airline ticketing and other intermodal services should be provided.

In a few locations, existing facilities may be modified and/or renovated for use by trains. Existing stations include the Tucson UP Depot, Tempe Depot (optional) and Coolidge stop (optional). New intercity rail stations should follow the same general architectural and engineering concepts as previously discussed. Refer to Figures 4-7-1 and 4-7-2 for prototypical surface and elevated intercity passenger rail stations.

Figure 4-7-1 Prototypical Surface Intercity Passenger Rail Station

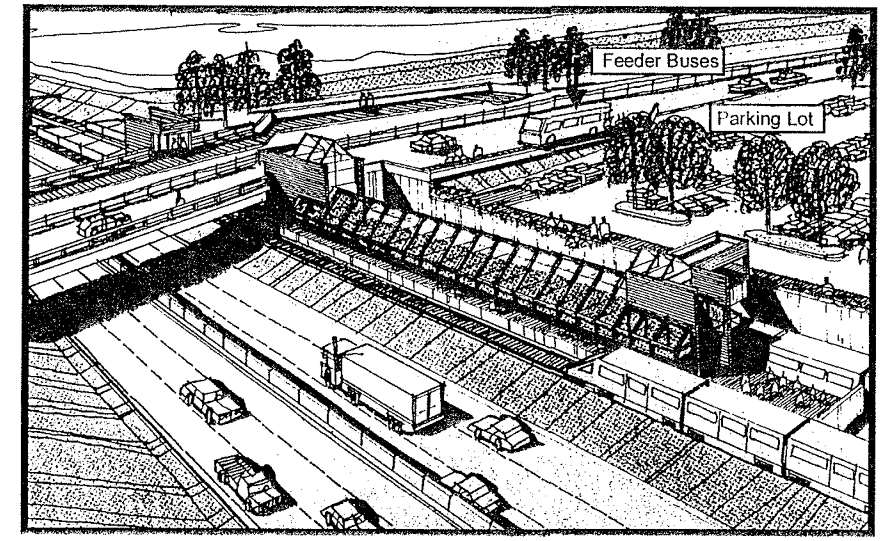
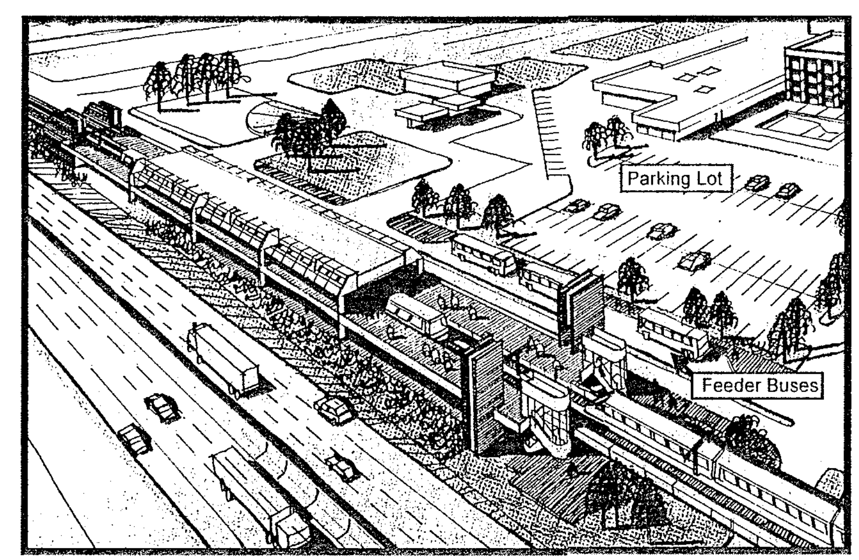


Figure 4-7-2 Prototypical Elevated Intercity Passenger Rail Station



4.9 Rail Operating Plans

This section describes a proposed operating plan for the four passenger rail options. This information was needed for purposes of starting the process of forecasting ridership, estimating fleet costs, and estimating operating and maintenance costs. (The service level and operating schedule for the Conventional Rail – Minor Upgrade Alternative is based on results from *the Arizona Passenger Rail Feasibility Study, 1993*).

Service Level and Operating Schedule Assumptions

Hours of Service for Conventional Rail - Minor Upgrade:
12 hours per day from 6:30 AM to 6:30 PM, 360 days per year. Trains depart Phoenix and Tucson at the following times:

6:30 AM
9:30 AM
12:30 PM
3:30 PM
6:30 PM

Trains consist of one diesel locomotive and four bi-level push-pull cars.

Hours of Service for Conventional Rail - Major Upgrade, High Speed - Electric, and High Speed - Maglev:
18 hours per day from 5 AM to 11 PM, 365 days per year as follows:

Weekday Service Period	Headway
Early (5 AM - 6 AM)	60
AM Peak (6AM - 9 AM)	60
Midday (9 AM - 4 PM)	60
PM Peak (4 PM - 7 PM)	60
Evening (7 PM - 11 PM)	60

Weekend/Holiday Period	Headway
Morning (5 AM - 10 AM)	60
Midday (10 AM - 7 PM)	60
Evening (7 PM - 11 PM)	60

Trains will depart Phoenix every hour on the hour and trains will depart Tucson every hour on the half-hour.

- Conventional Rail - Major Upgrade trains consist of one electric locomotive and five single-level cars.
- High Speed - Electric trains consist of two power units and six single-level cars.
- High Speed - Maglev trains consist of two electric power units.

4.10 Train Operational Data

The following tables summarize important train operational data such as run times, fleet size, and annual unit miles for each alternative. The following station stops include:

UP Mainline Route	**Chandler Branch / I-10 Route**
Central Avenue	Central Avenue
Sky Harbor Airport (Optional)	Sky Harbor Airport (Optional)
Tempe (Optional)	Tempe (Optional)
Mesa/Gilbert	Mesa/Gilbert
Pinal County, Coolidge (Optional)	Pinal County, Casa Grande (Optional)
Orange Grove	Orange Grove
Tucson	Tucson

Hence, the following tables reflect a "four station" and a "seven station" analysis (i.e., with and without the three optional stations).

Table 4-4 Trip Time and Average Speed Comparisons with Four and Seven Stations

#	Alternative	Four Station Option		Seven Station Option		Difference	
	UP Mainline	Trip Time (Min)	Average Speed (MPH)	Trip Time (Min)	Average Speed (MPH)	Savings in Trip Time (Minutes)	Increase in Average Speed (MPH)
3	Conventional - Minor Upgrade	117	62	123	59	6	3
4	Conventional - Major Upgrade	82	88	89	82	7	6
5A	High Speed - Electric	61	120	70	104	9	16
6A	High Speed - Maglev	49	148	60	122	11	26
	Chandler Branch/I-10						
5B	High Speed - Electric	59	119	68	103	9	16
6B	High Speed - Maglev	48	146	59	120	11	26

Note: Three minutes of the savings in trip time accrues from one minute of station dwell time at each station.

Table 4-5 Run Time and Fleet Size for UP Mainline Alignment Alternatives with Four Stations

#	Alternative	Max Speed	Average Speed (MPH) Phoenix Mesa/Gilbert (18 Miles)	Mesa/Gilbert-Picacho (54 Miles)	Picacho – Tucson (49 Miles)	Phoenix – Tucson (121 Miles)
3	Conventional Rail - Minor	80	40	72	66	62
4	Conventional Rail - Major	125	47	111	99	88
5 A	High Speed - Electric	175	68	151	126	120
6 A	High Speed - Maglev	250	76	205	153	148

#	Alternative	Max Speed	One-Way Trip Time Phoenix - Mesa/Gilbert (Minutes)	Mesa/Gilbert-Picacho (Minutes)	Picacho – Tucson (Minutes)	Phoenix – Tucson (Minutes)
3	Conventional Rail - Minor	80	27	45	45	117
4	Conventional Rail - Major	125	23	29	30	82
5 A	High Speed - Electric	175	16	21	23	61
6 A	High Speed - Maglev	250	14	16	19	49

#	Alternative	Total Round Trip Time (Minutes)*	Peak Headway (Minutes)	Peak Trains On-Line	Average Capacity/Unit	Average Capacity/Train
3	Conventional Rail-Minor	255	180	2	130	520
4	Conventional Rail-Major	184	60	3	100	500
5 A	High Speed - Electric	142	60	3	80	480
6 A	High Speed - Maglev	118	60	2	200	400

* Total Round Trip in Minutes = 2 X One-Way Trip Time + 10 Minutes Turnback Time at each terminal.
Trip time includes a 60-second dwell time.
Peak Trains On-Line = Total Round Trip Time / Peak Headway (round up if result contains a fraction of 0.2 or more).

#	Alternative	Powered Units/Train	Trailer Units/Train	Powered Units On-Line	Trailer Units On-Line	Total Powered Units **	Total Trailer Units **
3	Conventional Rail-Minor	1	4	2	8	4	14
4	Conventional Rail-Major	1	5	3	15	5	24
5 A	High Speed - Electric	2	6	6	18	8	30
6 A	High Speed - Maglev	2	0	4	0	8	0

** Total Fleet Size = Peak Units On-Line + One "Ready To Go" Spare Train + 20% Maintenance Spare Units for Conventional Rail and One "Ready To Go" Spare Plus One Maintenance Spare Train for High Speed Electric and Maglev.

Table 4-6 Run Time and Fleet Size for UP Mainline & I-10 Alignment Alternatives (Chandler Branch) with Four Stations

#	Alternative	Max Speed	Average Speed (MPH)			
			Phoenix Mesa/Gilbert (18 Miles)	Mesa/Gilbert I-10 Sacaton (16 Miles)	I-10 Sacaton Tucson (83 Miles)	Phoenix – Tucson (117 Miles)
5 B	High Speed - Electric	175	68	135	138	119
6 B	High Speed - Maglev	250	76	167	177	146

#	Alternative	Max Speed	One-Way Trip Time			
			Phoenix Mesa/Gilbert (Minutes)	Mesa/Gilbert I-10 Sacaton (Minutes)	I-10 Sacaton Tucson (Minutes)	Phoenix – Tucson (Minutes)
5 B	High Speed - Electric	175	16	7	36	59
6 B	High Speed - Maglev	250	14	6	28	48

#	Alternative	Total Round Trip Time (Minutes)*	Peak Headway (Minutes)	Peak Trains On-Line	Average Capacity/Unit	Average Capacity/Train
5 A	High Speed - Electric	138	60	3	80	480
6 A	High Speed - Maglev	116	60	2	200	400

* Total Round Trip in Minutes = 2 X One-Way Trip Time + 10 Minutes Turnback Time at each terminal.
Trip time includes a 60-second dwell time.
Peak Trains On-Line = Total Round Trip Time / Peak Headway (round up if result contains a fraction of 0.2 or more).

#	Alternative	Powered Units/Train	Trailer Units/Train	Powered Units On-Line	Trailer Units On-Line	Total Powered Units **	Total Trailer Units **
5 A	High Speed - Electric	2	6	6	18	10	30
6 A	High Speed - Maglev	2	0	4	0	8	0

** Total Fleet Size = Peak Units On-Line + One "Ready To Go" Spare Train + 20% Maintenance Spare Units for Conventional Rail and One "Ready To Go" Spare Plus One Maintenance Spare Train for High Speed Electric and Maglev.

Table 4-7 Annual Unit Mileage for Conventional - Minor Upgrade UP Mainline Alignment Alternative with Four Stations

ROUTE MILES = 121.0					ROUND TRIP (MINUTES) = 255		
	Service hours	One-Way Trips	Trains On-Line	Units/ Train	Daily Unit Miles	Weekly Unit Miles	Annual Unit Miles
Weekday							
Early	0	0	0	0	0	0	0
Peak	6	2	2	5	2,420	12,100	607,420
Midday	6	3	2	5	3,630	18,150	911,130
Evening	0	0	0	0	0	0	0
Subtotal	12				6050	30,250	1,518,550
Weekend/ Holiday							
Morning	6	2	2	5	2,420	4,840	275,880
Midday	6	3	2	5	3,630	7,260	413,820
Evening	0	0	0	0	0	0	0
Subtotal	12				6,050	12,100	689,700
Total						42,350	2,208,250

Daily Unit Miles = One-way trips X trains on line X units/train X route miles
Annual Unit Miles based upon 251 week days and 114 weekends and holidays per year.

Table 4-8 Annual Unit Mileage for Conventional - Major Upgrade UP Mainline Alignment Alternative with Four Stations

ROUTE MILES = 121.0				ROUND TRIP (MINUTES) = 184			
	Service hours	One-Way Trips	Trains On-Line	Units/ Train	Daily Unit Miles	Weekly Unit Miles	Annual Unit Miles
Weekday							
Early	1	60	3	6	1,452	7,260	364,452
Peak	6	60	3	6	8,712	43,560	2,186,712
Midday	7	60	3	6	10,164	50,820	2,551,164
Evening	4	60	3	6	5,808	29,040	1,457,808
Subtotal	18				26,136	130,680	6,560,136
Weekend/ Holiday							
Morning	5	60	3	6	7,260	14,520	827,640
Midday	9	60	3	6	13,068	26,136	1,489,752
Evening	4	60	3	6	5,808	11,616	662,112
Subtotal	18				26,136	52,272	2,979,504
Total						182,952	9,539,640

Daily Unit Miles = Service hours X trains on line X units/train X route miles
Annual Unit Miles based upon 251 week days and 114 weekends and holidays per year.

Table 4-9 Annual Unit Mileage for High Speed - Electric UP Mainline Alignment Alternative with Four Stations

ROUTE MILES = 121.0					ROUND TRIP (MINUTES) = 130		
	Service hours	One-Way Trips	Trains On-Line	Units/ Train	Daily Unit Miles	Weekly Unit Miles	Annual Unit Miles
Weekday							
Early	1	60	3	8	2,904	14,520	728,904
Peak	6	60	3	8	17,424	87,120	4,373,424
Midday	7	60	3	8	20,328	101,640	5,102,328
Evening	4	60	3	8	11,616	58,080	2,915,616
Subtotal	18				52,272	261,360	13,120,272
Weekend/ Holiday							
Morning	5	60	3	8	14,520	29,040	1,655,280
Midday	9	60	3	8	26,136	52,272	2,979,504
Evening	4	60	3	8	11,616	23,232	1,324,224
Subtotal	18				52,272	104,544	5,959,008
Total						365,904	19,079,280

Daily Unit Miles = Service hours X trains on line X units/train X route miles

Table 4-10 Annual Unit Mileage for High Speed - Maglev
UP Mainline Alignment Alternative with Four Stations

ROUTE MILES = 121.0				ROUND TRIP (MINUTES) = 107			
	Service hours	One-Way Trips	Trains On-Line	Units/ Train	Daily Unit Miles	Weekly Unit Miles	Annual Unit Miles
Weekday							
Early	1	60	2	2	484	2,420	121,484
Peak	6	60	2	2	2,904	14,520	728,904
Midday	7	60	2	2	3,388	16,940	850,388
Evening	4	60	2	2	1,936	9,680	485,936
Subtotal	18				8,712	43,560	2,186,712
Weekend/ Holiday							
Morning	5	60	2	2	2,420	4,840	275,880
Midday	9	60	2	2	4,356	8,712	496,584
Evening	4	60	2	2	1,936	3,872	220,704
Subtotal	18				8,712	17,424	993,168
Total						**60,984**	**3,179,880**

Daily Unit Miles = Service hours X trains on line X units/train X route miles

Table 4-11 Annual Unit Mileage for High Speed - Electric
UP Mainline and I-10 Alignment Alternative with Four Stations

ROUTE MILES = 117.0				ROUND TRIP (MINUTES) = 126			
	Service hours	One-Way Trips	Trains On-Line	Units/ Train	Daily Unit Miles	Weekly Unit Miles	Annual Unit Miles
Weekday							
Early	1	60	2	8	1,872	9,360	469,872
Peak	6	60	2	8	11,232	56,160	2,819,232
Midday	7	60	2	8	13,104	65,520	3,289,104
Evening	4	60	2	8	7,488	37,440	1,879,488
Subtotal	18				33,696	168,480	8,457,696
Weekend/ Holiday							
Morning	5	60	2	8	9,360	18,720	1,067,040
Midday	9	60	2	8	16,848	33,696	1,920,672
Evening	4	60	2	8	7,488	14,976	853,632
Subtotal	18				33,696	67,392	3,841,344
Total						**235,872**	**12,299,040**

Daily Unit Miles = Service hours X trains on line X units/train X route miles

Table 4-12 Annual Unit Mileage for High Speed - Maglev
UP Mainline and I-10 Alignment Alternative with Four Stations

ROUTE MILES = 117.0 ROUND TRIP (MINUTES) = 106

	Service hours	One-Way Trips	Trains On-Line	Units/ Train	Daily Unit Miles	Weekly Unit Miles	Annual Unit Miles
Weekday							
Early	1	60	2	2	468	2,340	117,468
Peak	6	60	2	2	2,808	14,040	704,808
Midday	7	60	2	2	3,276	16,380	822,276
Evening	4	60	2	2	1,872	9,360	469,872
Subtotal	18				8,424	42,120	2,114,424
Weekend/ Holiday							
Morning	5	60	2	2	2,340	4,680	266,760
Midday	9	60	2	2	4,212	8,424	480,168
Evening	4	60	2	2	1,872	3,744	213,408
Subtotal	18				8,424	16,848	960,336
Total						**58,968**	**3,074,760**

Daily Unit Miles = Service hours X trains on line X units/train X route miles

5 Evaluation of Alternatives

5.1 Introduction

The purpose of this Chapter is to evaluate and compare the alternatives defined in the previous *Chapter*. The evaluation methodology employed herein is a conventional *benefits, costs and impacts* analysis. The methodology is generally consistent with Federal USDOT guidelines for transportation projects of this type, at this conceptual level of study. The evaluation criteria or measures relate directly to the stated purpose of the study, as well as the goals and objectives established early in the study process by the study participants. Indeed, the ultimate intent of the evaluation process was to address the questions of "feasibility," as documented in *Chapter No. 3, Data Collection/Purpose and Need.* A typical twenty-year planning horizon was used with evaluation estimates (or forecasts) provided for the year 2020. In some cases, additional specific evaluations are also provided for the year 2040.

This Chapter does not include any specific study recommendations. That is the purpose of *Chapter No. 6, Findings and Conclusions.*

5.1.1 Summary Definition of Alternatives

The six Phoenix-Tucson corridor alternatives are:

Alternative 1 — *No-Build*
This alternative is the baseline option, included mostly for comparison purposes. It is essentially a "do-nothing" option comprised of existing conditions in the corridor, plus any major committed and programmed/funded (but not built) transportation capacity increases.

Alternative 2 — *Highway Widening*
This alternative assumes widening I-10 from Downtown Phoenix to Downtown Tucson, a distance of 112 miles. One additional lane in each direction would be added to the rural section sometime before the year 2005, for a total of six lanes, and two additional lanes would be added to both urban and rural sections by the year 2020, for a total of eight lanes.

Alternative 3 — *Conventional Rail - Minor Upgrade*
This alternative assumes using the existing UP Railroad track and right-of-way between Phoenix and Tucson, a distance of 121 miles, with relatively minor improvements to the track and right-of-way (including grade crossing upgrades) to achieve a top train speed of approximately 80 MPH. Conventional diesel-electric locomotion is assumed.

Alternative 4 — *Conventional Rail - Major Upgrade*
This alternative also assumes using the existing UP Railroad right-of-way from Phoenix to Tucson, a distance of 121 miles. This alternative would require the addition of a new electrified passenger track and major design and equipment improvements to increase the passenger train speed to a maximum of 125 MPH.

Alternative 5 — *High Speed Rail – Electric*
This alternative assumes building an exclusive partially or fully elevated track from Phoenix to Tucson following the existing UP mainline or a combination of the UP mainline and I-10, a distance of 121 and 117 miles respectively, traveling at speeds up to 175 mph.

Alternative 6 — *High Speed Rail – Maglev*
This alternative assumes building an elevated track from Phoenix to Tucson following the existing UP mainline or a combination of the UP mainline and I-10, a distance of 121 and 117 miles respectively, traveling at speeds up to 250 mph.

5.2 Effectiveness Measures of the Alternatives

The term, "effectiveness" is used to measure or describe how well a particular investment alternative performs against the original study goals and objectives. Effectiveness measures either objectively quantify (if possible) or subjectively describe (if not possible to quantify) the expected benefits of the investment alternatives. The effectiveness measures generally conform to the 11 measures described in Chapter 3; however, deferred highway construction cost and cost per VMT reduced were not used.

5.2.1 Number of Users

This measure is an estimate of the expected number of persons that will use the alternative or the improvement. For the passenger rail alternatives, this measure is equal to the forecasted number of persons boarding the train. For the highway widening alternative, this measure is equal to the forecasted number of persons using the new lane to be constructed in each direction, or one-third of the total usage. Both daily and annual users projected for the year 2020 are shown in Table 5-1.

Table 5-1 Number of Users of Improvement (Year 2020)

Alternative	Auto-Diverted Users	Induced Users	Tourist/ Visitor Users	Total Daily Users	Total Annual Users
2: Highway Widening	N/A	N/A	N/A	17,600*	6,424,000
3: Conventional Rail – Minor Upgrade	3,300	150	50	3,500	1,277,500
4: Conventional Rail – Major Upgrade	6,400	300	100	6,800	2,482,000
5: High Speed Rail – Electric	7,300	700	800	8,800	3,212,000
6: High Speed Rail – Maglev	7,800	1,600	2,300	11,700	4,270,500

* equal to the forecasted number of persons using the new lane to be constructed in each direction, or one-third of the total usage.
Note: N/A = not applicable.

For ridership comparison purposes, Caltrain (San Francisco to Gilroy) carried 7.1 million passengers in 1995; LA Metrolink (five lines) carried 4.7 million in 1995; Amtrak NEC Metroliner carried 2.1 million in 1997; and the San Diego Coaster carried more than 500,000 passengers in 1995.

Fare Sensitivity Analysis

Appendix R contains tables that illustrate the relationship between ridership and fare for each alternative.

5.2.2 Travel Time Benefits

The estimated end-to-end one-way travel time for the year 2020 for each alternative is displayed in table 5-2.

Table 5-2 Travel Times (Year 2020)

Alternative	Maximum Speed (mph)	Average Speed (mph)	One-Way Travel Time (Min)
1997 Existing Conditions	*75*	*65*	*103*
1: No-Build	75	55	122
2: Highway Widening	75	65	103
3: Conventional Rail – Minor Upgrade	80	62	117
4: Conventional Rail – Major Upgrade	125	88	82
5A: High Speed Rail – Electric (UP Mainline)	175	120	61
5B: High Speed Rail – Electric (UP & I-10)	175	119	59
6A: High Speed Rail – Maglev (UP Mainline)	250	148	49
6B: High Speed Rail – Maglev (UP & I-10)	250	146	48

Note that the travel time for the Conventional Rail – Minor Upgrade Alternative exceeds the Highway Widening travel time by 14 minutes; however, it is five minutes faster than the No-Build Alternative. All other rail alternatives offer faster travel times compared to both the No-Build and Highway Widening Alternatives. Note too that there is very little difference between the travel times for the UP Mainline alignment and the UP Mainline and I-10 alignment for the High Speed - Electric and Maglev Alternatives.

5.2.3 Operating Revenues

This measure is a calculation of the estimated farebox revenues expected from the collection of passenger fares, computed by multiplying the number of boardings by an average one-way fare. Fares are assumed to be consistent with the level of service provided, competitive with the cost of driving, and experiences in other locations. The average fare collected is assumed to be 80 percent of the published cash fare (non-discounted), in accordance with industry experience for this type of service. Tables 5-3 and 5-4 display these calculations.

Table 5-3 Passenger Rail Transit Fares (Year 2020, 1997 Dollars)

Alternative	Miles	Cash Fare/ Mile	Cash Fare/ Boarding	Average Fare/ Boarding
3: Conventional Rail – Minor Upgrade	121	$0.12	$15	$12
4: Conventional Rail – Major Upgrade	121	$0.30	$35	$28
5: High Speed Rail – Electric	121	$0.33	$40	$32
6: High Speed Rail – Maglev	121	$0.37	$45	$36

Table 5-4 Operating Revenues (Year 2020, 1997 Dollars)

Alternative	Average Fare/ Boarding	Annual Boardings	Annual Revenues
3: Conventional Rail – Minor Upgrade	$12	1,277,500	$15,330,000
4: Conventional Rail – Major Upgrade	$28	2,482,000	$69,496,000
5: High Speed Rail – Electric	$32	3,212,000	$102,784,000
6: High Speed Rail – Maglev	$36	4,270,500	$153,738,000

5.2.4 I-10 Vehicle-Miles of Travel

This measure is a forecast of the change in vehicle miles of travel (VMT), in comparison to the Highway Widening Alternative, on I-10 with the various rail alternatives in place. An average I-10 vehicle trip length of 100 miles is assumed in the study corridor.

Table 5-5 Change in I-10 Vehicle-Miles of Travel (Year 2020)

Alternative	ADT Reduction	Daily VMT Savings	Annual VMT Savings
3: Conventional Rail – Minor Upgrade	2,750	270,000	98,550,000
4: Conventional Rail – Major Upgrade	5,300	530,000	193,450,000
5: High Speed Rail – Electric	6,000	600,000	219,000,000
6: High Speed Rail – Maglev	6,500	650,000	237,250,000

5.2.5 I-10 Level of Service

Another measure of effectiveness is an estimate of the change in level of service (or level of congestion) on I-10 due to the implementation of the various alternatives. Level of service (LOS) is traditionally defined in the *Highway Capacity Manual* as a "grade": from A (best) to F (worst). LOS A is free-flowing traffic and LOS F is stop-and-go traffic. ADOT has an existing policy to provide LOS B on rural-type freeways. Table 5-6 calculates the level of service expected to occur on the rural portion of I-10 with the implementation of each alternative.

Table 5-6 I-10 Level of Service (Year 2020)

Alternative	No. of Lanes	ADT	Daily LOS*
1: No-Build	4	51,000	D
2: Highway Widening	6	51,000	C
3: Conventional Rail – Minor Upgrade	4	47,500	D
4: Conventional Rail – Major Upgrade	4	44,600	C
5: High Speed Rail – Electric	4	43,700	C
6: High Speed Rail – Maglev	4	43,200	C

* LOS includes a factor based upon 25-30% modal split for truck traffic.

5.3 Cost Measures

This section estimates the total costs to both implement and operate and maintain the study alternatives. Brief descriptions of the methodologies and assumptions used are also provided. All methods and assumptions are typical for studies of this nature and this level of detail.

5.3.1 Capital Cost

The purpose of this section is to describe the methodologies used in calculating capital costs for the alternatives. Capital cost is the estimate of the total cost (in 1997 dollars) to design, procure, install, and construct all of the fixed facilities and rolling stock for each alternative. The capital cost estimate is based on quantities derived from schematic design drawings. Cost estimates are based on the quantities of various components measured from the drawings such as lineal feet of track, lineal feet of bridge, square yards of roadway pavement, cubic yards of excavation, number of station crossings, maintenance facilities, etc.

Because this is a feasibility level of study, it is appropriate to use a unit cost approach to estimating. The unit prices developed for the capital costing have been obtained from the following sources: City of Phoenix costing information, the Arizona Department of Transportation Cost Data Book, construction costs for previous high speed electric and maglev railroad studies, and recent bid prices received on similar projects. In addition, significant contingencies were applied to the estimates due to the absence of any engineering design.

The following general procedures were followed in the preparation of the cost estimate:
- Estimate the quantities of the major components required.
- Estimate the unit costs for the components.
- Incorporate into a spreadsheet and multiply the quantities of each component by its unit cost.
- Add in costs for special design features not covered by component categories. These costs are based on actual or estimated costs of comparable facilities elsewhere.
- Sum all component cost totals and apply allowance and contingency factors.

For cost estimating purposes, each alternative was broken down into three categories:
1. urban segment,
2. suburban segment, and
3. rural segment.

This was done to provide for more accurate cost estimates and to be able to compare between the three segments per mile cost. Each urban segment identified in *Chapter No. 4,* was measured and the length was divided into thirds. The two thirds closest to the urban center were identified as urban and the one third bordering the rural segment was identified as suburban.

The following construction costs for each alternative were grouped into eleven capital cost categories:

1. Bridges and Structures
2. Trackwork and Signaling
3. Electrification, Control and Communications
4. At-Grade Crossings
5. Stations and Connections
6. Maintenance Facilities
7. Drainage, Utilities and Environmental
8. Rolling Stock
9. Contingency
10. Add-On Costs (Fees and Other Costs)
11. Right-of-Way

A brief description of each of the capital cost categories is as follows:

1. *Bridges/Structures*
   This cost category includes highway and railroad bridges, elevated railroad structures, elevated maglev guideway structures, culverts, retaining walls, fencing, highways, highway grade separations, earthwork/excavation, removals, and other such structures. The unit costs for this category are based upon ADOT highway costs and estimates, costs from relevant railroad studies and projects, and previous studies for high speed electric and maglev related project elements.

2. *Trackwork/Signaling*
   This category includes railroad track structure and components including mainline track, secondary track, turnouts, crossovers, interlockings, etc., railroad signaling systems, and other such elements necessary for each alternative technology. The unit costs for this category are based upon relevant railroad projects for the conventional rail alternatives and upon previous studies and other published data for the high speed alternatives.

3. *Electrification/Control/Communications*
   This cost category includes traction power system components including substations, distribution cabling, control switchgear, overhead wire or other contact elements, and communications systems such as radio, telephone, cable transmission, supervisory control and data acquisition, public address, and CCTV. The unit costs for this category are based upon relevant railroad projects for the conventional rail alternatives and upon previous studies and other published data for the high speed alternatives.

4. *At-Grade Crossings*
   Included in this category are the components of highway/railroad at-grade crossings which are necessary for the conventional rail alternatives. Federal Railroad Administration regulations do not permit at-grade crossings for systems with a maximum speed of 125 mph or more. Components included in this category include crossing surfaces (concrete, rubber, etc.), warning devices (lights, bells, gates, signs, etc.), and track circuits. The unit costs for this category are based upon relevant railroad projects for the conventional rail alternatives.

5. *Stations/Connections*
   This category consists of two terminal stations and two intermediate stations (four stations) for the rail alternatives. Included in this category are the station structures,

platforms, canopies, lighting, parking lots and structures, access roadways, landscaping, bus bays, and various station amenities. The unit costs for this category are based upon relevant railroad projects for the conventional rail alternatives and upon previous studies and other published data for the high speed alternatives.

6. *Maintenance Facilities*
Maintenance facilities includes train and unit cleaning, servicing, inspection, testing, maintenance, repair, and overhaul facilities; maintenance-of-way servicing, inspection, testing, maintenance, repair, and overhaul facilities; train storage yards, control center facilities, and other facilities as appropriate for each alternative technology. The unit costs for this category are based upon relevant railroad projects for the conventional rail alternatives and upon previous studies and other published data for the high speed alternatives.

7. *Drainage/Utilities/Environmental*
This category includes new construction and relocation of underground water and sewer drains; electric, lighting, gas, water, communications, fuel, and other utility services; and various environmental mitigation measures for issues such as sound walls, water reclamation and treatment, preservation of historical and archeological sites, biological preservation, etc. The capital cost estimates for this category are calculated as a percentage (range of 1% to 5%) of the cost categories listed above and are based upon existing Arizona conditions and requirements.

8. *Rolling Stock*
This category involves the passenger carrying and spare train equipment including locomotives, passenger cars, and powered passenger carrying units as appropriate for each alternative technology. The unit costs for this category are based upon relevant railroad projects for the conventional rail alternatives and upon previous studies and other published data.

9. *Contingency*
For the purpose of this study, a contingency of 25% is applied to the total cost estimated for the construction bid items (all of the capital cost categories listed above). This contingency rate is appropriate for the feasibility level addressed in the study.

10. *Add-On Costs (Fees and Other Costs)*
Add-on costs are allowances for the costs of engineering and construction management services required to implement a project. These costs are computed by adding multipliers to the baseline construction cost estimates. Add-on items are estimated to be 32% of the total project costs as follows:

- Mobilization 3%
- Engineering Design 12%
- Construction Management 15%
- Insurance and Legal 2%

11. *Right-of-Way*
This cost category includes the purchase or lease of railroad and other privately owned right-of-way. The right-of-way costs are estimated on a cost per mile basis.

5.3.2 Operating and Maintenance Cost

The annual operations and maintenance cost (O&M) estimates for the rail options include all labor, service contracts, rental/lease, parts and materials, utilities, and other non-labor expenses required and necessary for the proper operation and maintenance of the rail system. The annual operation and maintenance cost estimates include all labor and non-labor expenses associated with, but not limited to, the following:

Administration and Support:
- System management and administrative personnel
- Purchasing and stores
- Marketing
- Payroll and personnel
- Liability/insurance
- Operating and other agreements

Train Operations:
- Train operations
- Control center operations
- Station operations

Rolling Stock Maintenance:
- Train/unit cleaning and servicing
- Inspection and testing of train units and components
- Preventive maintenance and repair of trains or units
- Modification and overhaul of train units and components

Maintenance-of-Way:
- Inspection, testing, maintenance, repair, and overhaul of:
  - Track/guideway
  - Traction power system
  - Train control/signaling
  - Communications system
  - Fare collection system
  - Buildings, stations, and other structures
  - Landscaping/grounds
  - Environmental/fire protection systems
  - Non-revenue vehicles, equipment, and tools

Safety and Security:
- Trains
- Stations
- Operations facilities
- Maintenance yards and facilities
- Right-of-way
- Cash collection and handling

The annual rail operations and maintenance cost estimates have been developed based on estimated costs per seat mile in 1997 dollars. This method is commonly used in high speed rail studies as more detailed operating cost estimates are not readily available. This is especially true for maglev systems which currently exist only as test track operations. The costs per seat mile which have been used are typical of those used in previous high speed studies and those obtained from other transit industry publications.

Annual O&M costs for the Highway Widening Alternative include only the incremental costs to maintain the added lane in each direction. These estimates are based on national experiences for facilities of this type in this location.

Annual Seat Miles

Annual seat miles are defined as the number of miles that all seats on all trains move in one year. For example, a train with 100 seats travelling 100 miles in one year has the equivalent of 10,000 annual seat miles. The annual seat miles for each rail alternative are shown below.

Table 5-8 Annual Seat Miles

Alternative	Route Miles	Cars Train	Seats/ Car	Seats/ Train	Train Miles/Day	Daily Seat Miles	Annual Seat Miles
3: Conventional Rail – Minor Upgrade	121	4	130	520	1,210	629,200	229,658,000
4: Conventional Rail – Major Upgrade	121	5	100	500	4,356	2,178,000	794,970,000
5A: High Speed Rail – Electric (UP Mainline)	121	6	80	480	4,356	2,090,880	763,171,000
5B: High Speed Rail – Electric (UP & I-10)	117	6	80	480	4,212	2,021,760	737,942,000
6A: High Speed Rail – Maglev (UP Mainline)	121	2	200	400	4,356	1,742,400	635,976,000
6B: High Speed Rail – Maglev (UP & I-10)	117	2	200	400	4,212	1,684,800	614,952,000

Notes:
Data from the levels of service contained in Chapter 4.
Train miles per day for Minor Upgrade = 5 one-way trips/day X 2 directions X route miles.
Train miles per day for other alternatives = 18 one-way trips/day X 2 directions X route miles.
Daily seat miles = seats/train X train miles/day.
Annual seat miles = daily seat miles X 365 days/year.

Annual Operating and Maintenance Costs

The annual O&M costs with and without contingency are calculated below. Because a specific manufacturer was not applied to each rail alternative, and because high speed electric and maglev systems are not currently in operation in the U.S., it was necessary to apply a higher contingency to the O&M cost estimates.

Table 5-9 Annual Operating and Maintenance Costs

Alternative	Max. Speed	O & M Cost/Seat Mile	Annual Seat Miles	Total Est. O&M Cost *without* Contingency	Cont*	Total Est. O & M Cost *with* Contingency
2: Highway Widening	75	N/A	N/A	$2,912,000 **	10%	$3,203,000**
3: Conventional Rail - Minor Upgrade	80	0.07	229,658,000	$16,076,000	10%	$17,684,000
4: Conventional Rail - Major Upgrade	125	0.11	794,970,000	$87,447,000	10%	$96,191,000
5A: High Speed Rail - Electric (UP)	175	0.16	763,171,000	$122,107,000	15%	$140,423,000
5B: High Speed Rail - Electric (UP/I-10)	175	0.16	737,942,000	$118,071,000	15%	$135,781,000
6A: High Speed Rail - Maglev (UP)	250	0.22	635,976,000	$139,915,000	25%	$174,893,000
6B: High Speed Rail - Maglev (UP/I-10)	250	0.22	614,952,000	$135,289,000	25%	$169,112,000

* Contingencies reflect the level of confidence based on 1) the amount and quality of information available, 2) limited operating data on high speed – electric systems and little to no operating data on high speed – maglev systems. These factors represent appropriate margins of error to cover uncertainty. In practice, total O&M costs for these alternatives may prove to be lower.

** Based on O&M cost of $13,070 per lane-mile. Includes **public sector costs** only. Unlike the rail alternatives below, this cost does **not** include private vehicle operating costs. Including private sector vehicle costs, and assuming an average vehicle operating and maintenance cost of 31.5 cents per mile (IRS allowance), an **additional private sector annual cost** of at least $174 million (535 million annual VMT X 31.5 cents) can be attributable to the Highway Widening Alternative.

5.3.3 Farebox Recovery

Farebox recovery measures to what extent the passenger rail alternatives recover their operating and maintenance costs from passenger fares collected. If more revenues are collected from fares than it costs to operate, then the alternative "makes money" (if the capital cost to build the system is ignored.) A farebox recovery ratio greater than 100 percent is extremely rare among existing passenger rail operations. A survey of U.S. passenger rail operations revealed no recovery ratios greater than 100 percent, with typical ratios in the range of 60-80 percent, i.e., annual fare revenues equal to 60-80 percent of annual O&M costs. For comparison purposes, the Amtrak system farebox recovery for 1997 was 80 percent. The revenue shortfall, or subsidy, is typically provided from Federal, State and/or local tax sources.

Table 5-10 Farebox Recovery

Alternative	Annual O & M Cost *	Annual Usage	Average Fare	Annual Revenue	Annual Deficit	Farebox Recovery
Conventional Rail – Minor Upgrade	$17,684,000	1,277,500	$12	$15,330,000	$2,354,000	86%
Conventional Rail – Major Upgrade	$96,191,000	2,482,000	$28	$69,496,000	$26,695,000	72%
High Speed Rail – Electric	$140,423,000	3,212,000	$32	$102,784,000	$43,745,000	73%
High Speed Rail – Maglev	$174,893,000	4,270,500	$36	$153,738,000	$21,155,000	88%

* Includes contingencies.

5.4 Cost-effectiveness Measures

Cost-effectiveness measures, such as a cost-effectiveness index, are ratio-type calculations of costs versus benefits, normalized to common units. Understanding costs alone or benefits alone is important, but neither addresses the "bang for the buck" question. Cost-effectiveness measures are extremely useful because they incorporate both benefits and costs into a single measure, as a rate.

5.4.1 *Cost-effectiveness Index*

A cost-effectiveness index, or CEI, is the cost-effectiveness measure recommended by the USDOT for major transportation investment proposals expecting to receive Federal capital funding assistance. The index is calculated using the following formula:

$$CEI = \frac{\text{Added Costs}}{\text{Added Users}}$$

where,

Added costs is equal to the total annualized cost (capital and O&M) minus the annualized value of time saved for the investment alternative, as compared to the baseline alternative. *Added users* is the forecasted annual usage of the investment alternative, again as compared to the baseline. Capital cost is typically annualized by using a 30-year investment life at a 6 percent discount rate. There are many variations to this particular calculation, but this one serves the purposes of this study.

Table 5-11 Value of Time Saved

Alternative	Time Saved (Min)	Annual Users	Annualized Value of Time Saved
Highway Widening	0	6,424,000	$0
Conventional Rail - Minor Upgrade	-14	1,277,500	-$2,325,000
Conventional Rail - Major Upgrade	21	2,482,000	$6,776,000
High Speed Rail - Electric	42	3,212,000	$17,538,000
High Speed Rail - Maglev	54	4,270,500	$29,979,000

Note: Does not include access and egress travel times.

Table 5-12 below calculates and compares the cost-effectiveness of the study alternatives.

Table 5-12 Cost-effectiveness Index

Alternative	Annualized Capital Cost	Annual O&M Cost	Annualized Value of Time Saved	Total Annualized Cost	Total Annual Users	CEI
2: Highway Widening* (excluding private sector costs)	$102,616,000	$3,203,000	$0	$105,819,000	6,424,000	$16
2: Highway Widening* (including private sector costs)	$102,616,000	$171,833,000*	$0	$274,449,000	6,424,000	$43
3: Conventional Rail-Minor Upgrade	$27,500,000	$17,684,000	-$2,325,000	$47,509,000	1,277,500	$37
4: Conventional Rail-Major Upgrade	$83,853,000	$96,191,000	$6,776,000	$173,268,000	2,482,000	$70
5A: High Speed Rail - Electric (UP) *Partially Elevated*	$278,784,000	$140,423,000	$17,538,000	$401,669,000	3,212,000	$125
5A: High Speed Rail - Electric (UP) *Fully Elevated*	$352,350,000	$140,423,000	$17,538,000	$475,235,000	3,212,000	$148
5B: High Speed Rail - Electric (UP/I-10) *Partially Elevated*	$250,640,000	$135,781,000	$17,538,000	$368,883,000	3,212,000	$115
5B: High Speed Rail - Electric (UP/I-10) *Fully Elevated*	$343,270,000	$135,781,000	$17,538,000	$461,513,000	3,212,000	$144
6A: High Speed Rail - Maglev (UP)	$439,530,000	$174,893,000	$29,979,000	$584,444,000	4,270,500	$137
6B: High Speed Rail - Maglev (UP/I-10)	$428,630,000	$169,112,000	$29,979,000	$567,763,000	4,270,000	$133

* Assuming an average vehicle operating and maintenance cost of 31.5 cents per mile (IRS allowance), an additional private sector annual cost of at least $174 million (535 million annual VMT X 31.5 cents) can be attributable to the Highway Widening Alternative.

5.4.1 Other Evaluation Measures

In addition to the very measurable evaluation criteria described in the previous sections, there were a number of immeasurable (or very difficult to measure) criteria that were nevertheless equally important to the study needs. The intent in this section is to provide a subjective indication of how well the alternatives stack up against each other on a series of these types of measures. In addition to the experience and judgment of the Consultant, significant input was provided by the study participants.

The purpose of the following evaluations is to discriminate between the alternatives. The alternatives are simply ranked using a qualitative scale shown below:

Best Alternative ●
Intermediate Alternative ◐
Worst Alternative ○

5.4.2 *Level of Community Support*

Since no scientific surveys have been conducted, the following evaluation is based on the opinions of a small number of study participants through measures such as public meetings, newsletters, newspapers, radio and television, etc. Using the standard rating system, the best alternative(s), indicated by a solid circle, are those which have the greatest public support.

Table 5-13 Level of Community Support

Alternative	Desire & Support	Will Use	Will Help Finance *
1: No Build	○	○	○
2: Highway Widening	●	●	●
3: Conventional Rail – Minor Upgrade	◐	◐	◐
4: Conventional Rail – Major Upgrade	◐	◐	◐
5A: High Speed Rail – Electric (UP)	◐	●	○
5B: High Speed Rail – Electric (UP/I-10)	◐	●	○
6A: High Speed Rail – Maglev (UP)	◐	●	○
6B: High Speed Rail – Maglev (UP/I-10)	◐	●	○

* Includes taxes, donation of public lands, and other fees the public is willing to support to help finance the project.

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

5.5.2 Level of Railroad Support

The level of railroad support for rail projects is typically provided through cooperation and assistance in areas such as the sale or use of right-of-way (ROW); purchase of trackwork, signaling, and other railroad materials; construction and/or maintenance of track and signals; and operating or cooperating with the operator of the passenger rail service. The following evaluation reflects the opinions of study participants in their informal conversations with the UP Railroad. Using the standard rating system, the best alternative(s), indicated by a solid circle, are those which have the greatest UP Railroad support.

Table 5-14 Level of Railroad Support

Alternative	R-O-W Availability	Trackwork/ Signaling	Construction/ Maintenance	Cooperation with Operator
1: No Build	○	○	○	○
2: Highway Widening	○	○	○	○
3: Conventional Rail – Minor Upgrade	●	●	●	●
4: Conventional Rail – Major Upgrade	●	●	●	●
5A: High Speed Rail – Electric (UP) *Partially Elevated*	●	◐	○	◐
5A: High Speed Rail – Electric (UP) *Fully Elevated*	◐	◐	○	◐
5B: High Speed Rail – Electric (UP/I-10) *Partially Elevated*	●	◐	○	◐
5B: High Speed Rail – Electric (UP/I-10) *Fully Elevated*	◐	◐	○	◐
6A: High Speed Rail – Maglev (UP)	●	○	○	◐
6B: High Speed Rail – Maglev (UP/I-10)	●	○	○	◐

Source: Informal discussions with UP Railroad

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

5.5.3 Affordability

Affordability is a measure of project capital cost and ongoing operating cost in relation to available funding and/or potential funding. The following evaluation is a preliminary subjective evaluation based on the magnitude of capital and operating costs (refer to Tables 5-7 and 5-9). A more detailed analysis is provided in *Chapter 6, Findings and Conclusions.* Using the standard rating system, the best alternative, indicated by a solid circle, is that which is the most affordable.

Table 5-15 Affordability

Alternative	Affordable
1: No Build	●
2: Highway Widening	●
3: Conventional Rail – Minor Upgrade	●
4: Conventional Rail – Major Upgrade	●
5A: High Speed Rail – Electric (UP)	◐
5B: High Speed Rail – Electric (UP/I-10)	◐
6A: High Speed Rail – Maglev (UP)	○
6B: High Speed Rail – Maglev (UP/I-10)	○

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

5.5.4 Negative Environmental Impacts

The level of negative environmental impact associated with each alternative is based on field surveys, available data, and communications with appropriate agencies. Environmental impacts include:

Air Quality
Affected by the reduction in Vehicle Miles Traveled (VMT). The more VMT reduced, the less negative impact on air quality.

Water Quality
All of the alternatives have little to no impact on water quality and therefore have received an intermediate rating.

Capital Energy
The assessment of the amount of energy needed to construct the rail system. If a rail system requires more energy to build than is saved in VMT, the alternative receives a lower rating.

Operating Energy
The assessment of the amount of energy needed to operate the rail system. If a rail system requires more energy to operate than is saved in VMT, the alternative receives a lower rating.

Noise
The level of noise for each alternative depends on the technology, speed, and whether the system is fully grade separated or not.

Land Use
Compatibility with adopted local and State land use plans. Included in this measure is the potential visual impact.

Flora/Fauna
The impact on flora and fauna due to construction and operation.

History
The impact on historical and archeological sites due to construction and operation.
Using the standard rating system, the best alternative(s), indicated by a solid circle, are those which have the least amount of impact on the environment.

Table 5-16 Negative Environmental Impacts

Alternative	Air	Water	Capital Energy	Operating Energy	Noise	Land-Use	Flora/ Fauna	History*
1: No Build	○	◐	●	○	○	◐	◐	◐
2: Highway Widening	○	◐	◐	○	○	○	○	◐
3: Conventional Rail – Minor Upgrade	◐	◐	●	◐	◐	●	●	◐
4: Conventional Rail – Major Upgrade	●	◐	◐	●	◐	●	●	◐
5A: High Speed Rail – Electric (UP) Partially Elevated	●	◐	○	●	◐	◐	◐	◐
5A: High Speed Rail – Electric (UP) Fully Elevated	●	◐	○	●	●	●	◐	◐
5B: High Speed Rail – Electric (UP/I-10) Partially Elevated	●	◐	○	●	◐	◐	◐	◐
5B: High Speed Rail – Electric (UP/I-10) Fully Elevated	●	◐	○	●	●	●	◐	◐
6A: High Speed Rail – Maglev (UP)	●	◐	○	●	●	●	◐	◐
6B: High Speed Rail – Maglev (UP/I-10)	●	◐	○	●	●	●	◐	◐

* Includes historical and archeological sites.

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

5.5.5 Economic & Private Sector Development

Economic and private sector development includes 1) regional development, 2) local development in and around stations and interchanges, and 3) private sector investment opportunities. Using the standard rating system, the best alternative(s), indicated by a solid circle, are those which have the greatest potential for economic and private sector development.

Table 5-17 Economic & Private Sector Development

Alternative	Regional Development	Local Development	Investment Opportunities
1: No Build	○	○	○
2: Highway Widening	◐	◐	○
3: Conventional Rail – Minor Upgrade	◐	◐	◐
4: Conventional Rail – Major Upgrade	◐	◐	◐
5A: High Speed Rail – Electric (UP)	●	●	●
5B: High Speed Rail – Electric (UP/I-10)	●	●	●
6A: High Speed Rail – Maglev (UP)	●	●	●
6B: High Speed Rail – Maglev (UP/I-10)	●	●	●

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

5.5.5 Tourism

Development of the tourist industry is dependent upon access to tourist destinations, convenience, affordability, and the ability to attract tourists as a destination in and of itself. As shown below, all alternatives are rated intermediate, with the exception of the No-Build Alternative which is the worst alternative because it would have an overall negative impact on tourism.

Table 5-18 Tourism

Alternative	Tourism Development
1: No Build	○
2: Highway Widening	◐
3: Conventional Rail – Minor Upgrade	◐
4: Conventional Rail – Major Upgrade	◐
5A: High Speed Rail – Electric (UP)	◐
5B: High Speed Rail – Electric (UP/I-10)	◐
6A: High Speed Rail – Maglev (UP)	●
6B: High Speed Rail – Maglev (UP/I-10)	●

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

5.5.6 Public Safety

The two most significant public safety concerns associated with highway and rail systems are accidents at grade crossings and accidents due to trespassing. Other public safety concerns involve highway accidents, rail accidents and derailments, and truck and rail transport of hazardous materials in corridors of mixed passenger and freight service. Using the standard rating system, the best alternative(s), indicated by a solid circle, are those which are the safest alternatives.

Table 5-19 Public Safety

Alternative	Level of Safety
1: No Build	○
2: Highway Widening	○
3: Conventional Rail – Minor Upgrade	◐
4: Conventional Rail – Major Upgrade	◐
5A: High Speed Rail – Electric (UP) *Partially Elevated*	●
5A: High Speed Rail – Electric (UP) *Fully Elevated*	●
5B: High Speed Rail – Electric (UP/I-10) *Partially Elevated*	●
5B: High Speed Rail – Electric (UP/I-10) *Fully Elevated*	●
6A: High Speed Rail – Maglev (UP)	●
6B: High Speed Rail – Maglev (UP/I-10)	●

KEY: Best Alternative = ● Intermediate Alternative = ◐ Worst Alternative = ○

The following table summarizes the evaluation criteria presented in this chapter.

Table 5-20 Summary Evaluation

	Alternative 1 No-Build	Alternative 2 Highway Widening (Excluding Private Sector Costs)	Alternative 3 Conventional Rail Minor Upgrade	Alternative 4 Conventional Rail Major Upgrade	Alternative 5A High Speed - Electric UP Mainline *Partially Elevated*	Alternative 5A High Speed - Electric UP Mainline *Fully Elevated*	Alternative 5B High Speed - Electric UP Mainline & I-10 *Partially Elevated*	Alternative 5B High Speed - Electric UP Mainline & I-10 *Fully Elevated*	Alternative 6A High Speed - Maglev UP Mainline	Alternative 6B High Speed - Maglev UP Mainline & I-10
Project Length (Miles)	112	112	121	121	121	121	117	117	121	117
Maximum Design Speed (MPH)	75	75	80	125	175	175	175	175	250	250
Average Operating Speed (MPH)	50	65	62	88	120	120	119	119	148	146
Number of Stations	N/A	N/A	7	7	7	7	4	4	7	4
KEY EFFECTIVENESS MEASURES										
Users of Alternative										
Daily	N/A	17,600	3,500	6,800	8,800	8,800	8,800	8,800	11,700	11,700
Annual	N/A	6,424,000	1,277,500	2,482,000	3,212,000	3,212,000	3,212,000	3,212,000	4,270,500	4,270,500
Travel Time Benefits										
Passenger One-Way Travel Time (Minutes)	122	103	117	82	61	61	59	59	49	48
Annual Value of Time Saved (Versus No Build)	N/A	$0	-$2,325,000	$6,776,000	$17,538,000	$17,538,000	$17,538,000	$17,538,000	$29,979,000	$29,979,000
Passenger Travel Time Reliability	Very Low	Low	Medium	High	Very High	Very High	Very High	Very High	Very High	Very High
Transit Operating Revenues										
Average Fare Per Boarding	N/A	N/A	$12	$28	$32	$32	$32	$32	$36	$36
Annual Operating Revenue	N/A	N/A	$15,330,000	$69,496,000	$102,784,000	$102,784,000	$102,784,000	$102,784,000	$153,738,000	$153,738,000
I-10 Vehicle-Miles of Travel (VMT)										
Daily VMT Savings	N/A	N/A	270,000	530,000	600,000	600,000	600,000	600,000	650,000	650,000
Annual VMT Savings	N/A	N/A	98,550,000	193,450,000	219,000,000	219,000,000	219,000,000	219,000,000	237,250,000	237,250,000

Table 5-20 - Continued

	Alternative 1 No-Build	Alternative 2 Highway widening (Excluding Private Sector Costs)	Alternative 3 Minor Upgrade	Alternative 4 Major Upgrade	Alternative 5A High Speed Electric Up Mainline Partially Elevated	Alternative 5A High Speed Electric Up Mainline Fully Elevated	Alternative 5B High Speed Electric Up Mainline & I-10 Partially Elevated	Alternative 5B High Speed Electric Up Mainline & I-10 Fully Elevated	Alternative 6A High Speed Maglev UP Mainline	Alternative 6B High Speed Maglev UP Mainline & I-10
KEY COST MEASURES										
Capital Cost of Alternative										
Cost with Contingency	N/A	$1,412,500,000	$378,500,000	$1,155,000,000	$3,840,000,000	$4,850,000,000	$3,450,000,000	$4,725,000,000	$6,050,000,000	$5,900,000,000
Cost Per Mile	N/A	$12,600,000	$3,130,000	$9,550,000	$31,750,000	$40,000,000	$29,500,000	$40,315,000	$50,000,000	$50,000,000
O&M Cost of Alternative										
Cost with Contingency	N/A	$3,203,000	$17,683,666	$96,191,370	$140,423,000	$140,423,000	$135,781,000	$135,781,000	$174,893,400	$169,111,800
Cost/Seat Mile	N/A	N/A	$0.07	$0.11	$0.16	$0.16	$0.16	$0.16	$0.22	$0.22
Farebox Recovery										
Annual Revenue	N/A	N/A	$15,330,000	$69,496,000	$102,784,000	$102,784,000	$102,784,000	$102,784,000	$153,738,000	$153,738,000
Annual Subsidy	N/A	N/A	$2,354,000	$26,695,000	$43,745,000	$43,745,000	$43,745,000	$43,745,000	$21,155,000	$21,155,000
Farebox recovery	N/A	N/A	86%	72%	73%	73%	73%	73%	88%	88%
KEY COST-EFFECTIVENESS MEASURES										
Cost-Effectiveness Index										
Total Annualized Cost	N/A	$102,616,000	$27,500,000	$83,853,000	$278,784,000	$352,350,000	$250,640,000	$343,270,000	$439,530,000	$428,630,000
Total Annual Users	N/A	6,424,000	1,277,500	2,482,000	3,212,000	3,212,000	3,212,000	3,212,000	4,270,500	4,270,500
CEI	N/A	$16	$37	$70	$125	$148	$115	$144	$137	$133
OTHER EVALUATION MEASURES										
Level of Community Support	○	●	◐	◐	◐	◐	◐	◐	◐	◐
Level of Railroad Support	○	○	●	●	◐	◐	◐	◐	◐	◐
Affordability	●	●	●	●	◐	◐	◐	◐	○	○
Negative Environmental Impacts	◐	○	●	●	◐	◐	◐	◐	◐	◐
Economic & Private Sector Development	○	◐	◐	◐	●	●	●	●	●	●
Tourism Potential	○	◐	◐	◐	◐	◐	◐	◐	●	●
Public Safety	○	○	◐	◐	●	●	●	●	●	●

Key: **Best Alternative ●** **Intermediate Alternative ◐** **Worst Alternative ○**

6 Findings and Conclusions

6.1 Introduction

The purpose of this Chapter is to summarize the key study findings, glean conclusions, and develop recommendations. These findings and conclusions are based upon the benefit, cost and impact comparisons of the alternatives for the year 2020 developed in the previous Chapter. Because this study was conducted at a very conceptual level, these findings and conclusions are intended to help guide decision-making to the next level of study. A final decision on implementation of any major corridor investment will likely take much more study and many more years of development.

However, at least one thing is clear: Travel between Phoenix and Tucson will continue to grow and traffic congestion on I-10 will worsen -- significantly. ADOT, in partnership with all the communities in the corridor—and the private sector, must make significant capital investment plans *now* to solve the problem.

6.2 Achieving Study Goals and Objectives

Early in the study process, the Study Steering Committee and Task Force adopted a set of goals and objectives to help guide and focus the study. The alternatives studied were specifically defined such that they could potentially meet or exceed these goals and objectives. Hence, the following discussion summarizes how well each of the final alternatives addresses the adopted goals and objectives.

Goal 1: Passenger rail service must be less in required travel time than conventional automotive travel between Phoenix and Tucson.

Objective 1: Implement a high speed rail system that provides convenient rider access.

Objective 2: Implement a comprehensive and coordinated feeder intermodal network to complement the high speed rail system.

Findings:

All but one of the passenger rail alternatives studied offers a travel time that is faster than the existing highway travel time between the two cities (103 minutes, based on an average highway speed of 65 MPH). Building a conventional rail line with minor improvements does not improve travel time and actually exceeds travel time by 14 minutes. Building a conventional rail line with major improvements would improve the travel time by 21 minutes. Building a high speed rail line would improve the travel time by 42 minutes using high speed - electric technology and 54 minutes using high speed - maglev technology. ***It is assumed that appropriate feeder networks will be funded and provided by others to serve passengers at all rail stations.***

Goal 2: Ensure that rail freight and passenger operations are compatible in the corridor.

Objective 1: Implement a high speed rail system that does not conflict with freight traffic operations in the corridor.

Comments:

The concepts for all of the passenger rail alternatives were developed to ensure compatibility with rail freight operations in the corridor. Detailed solutions will be resolved in the next phases of project development. Some of the alternatives may benefit freight movements through track upgrades and elimination of at-grade crossings.

Goal 3: Rail service must meet a balance of multiple feasibility criteria.

Objective 1: Ensure that the high speed rail system meets the overall policy and technical aims of the project and its participants.

Findings:

As shown in the Feasibility Summary, Section 6.3, none of the alternatives meet all of the feasibility criteria outlined by the Study Steering Committee and Task Force. However, some of the alternatives meet more of the feasibility criteria compared to others (refer to Feasibility Summary). The High Speed – Electric and Maglev Alternatives meet more of the goals and objectives (approximately 60 percent) compared to the Conventional Rail – Minor Upgrade and Major Upgrade Alternatives (approximately 35 percent) and the Highway Widening and No-Build Alternatives (approximately 30 percent). (Refer to Goals & Objectives Summary).

Goal 4: Project implementation must be supported by the political and public communities.

Objective 1: Ensure that the high speed rail system meets the policy aims of member jurisdictions.

Objective 2: Implement a high speed rail system that is supportive of local ordinances, regulations and policies.

Comments:

It is unclear at this time if the elected officials in the corridor would support one or more of the options. More input from the public and political entities will be needed *in subsequent phases to determine a more representative and accurate level of community support.*

Goal 5: The project must be affordable.

Objective 1: Implement a high speed rail system that is within the region's capital resources.

Objective 2: Implement a high speed rail system that is cost effective from a capital cost per rider perspective.

Objective 3: Implement a high speed rail system that meets national standards for operations cost.

Objective 4: Implement a high speed rail system that maximizes the potential of public/private partnerships.

Comments:
At this level of study, there was not enough information to realistically determine the affordability of the different alternatives. If the communities determine that passenger rail service is a priority, means will be found to fund the program. All options have the potential for public/private partnership. This potential, while mainly focused at station areas, could also include other aspects such as operations. These potentials increase with increased levels of service and ridership. More input from the public and political entities is needed in subsequent phases to determine the priority and affordability of passenger rail service.

Goal 6: Ensure that the project be partnered with the railroad company.

Objective 1: Ensure the high speed rail system is compatible with on-going and planned freight operations.

***Comments**:*
As part of this study, the UP Railroad has been a part of the process and a member of the Study Task Force. They have indicated a willingness to cooperate as long as their facilities and freight operations are not negatively impacted. The railroad company understands the potential benefits to their freight operations as a result of implementing improved passenger services in the Phoenix-Tucson corridor.

Goal 7: Ensure that sufficient highway trips are diverted to rail to defer the need for highway improvements.

Objective 1: Implement a high speed rail system that results in ridership comparable to, if not exceeding, one new freeway lane capacity in each direction in the corridor.

Findings:
All of the passenger rail alternatives studied will divert highway traffic and defer the need for new highway lane construction. The Conventional Rail - Minor and Major Upgrade Alternatives would defer highway widening by three to four years. The High Speed Rail - Electric and Maglev Alternatives would defer highway widening by five to six years. Ridership for the high speed alternatives is comparable to one new freeway lane in each direction.

Goal 8: The project must enhance the travel experience between Phoenix and Tucson.

Objective 1: Ensure the high speed rail system provides convenience and amenities for passengers.

Objective 2: Implement a high speed rail system that provides a wide range of services for riders both in stations and in vehicles.

Findings:
All of the passenger rail options would enhance the travel experience between Phoenix and Tucson. The higher speed options would be more convenient and would provide a more positive experience for the passengers. The Highway Widening Alternative would only marginally enhance the travel experience and only until the traffic levels again reach the capacity of the highway. Widening I-10 from four lanes to six lanes only temporarily improves travel time. Hence, further widening of I-10 (from six lanes to eight lanes) will be required by the year 2020.

Comments:
All of the rail options are planned to include vehicle and station amenities that would attract riders and provide a more comfortable and positive travel experience. These amenities and services would include such items as: food and beverage service, reading material, office support systems, audio and television programs, etc. The rail travel experience would provide a level of freedom from the stress of driving. This level of freedom would allow the passenger to walk around, use restrooms, read, watch TV, etc.

Goal 9: The rail service must have a good interface with highway, rail and transit.

Objective 1: Implement a high speed rail system that provides coordinated auto and local transit access.

Objective 2: Improve corridor-wide intermodal services to efficiently serve the high speed rail system.

Findings:
The higher ridership of the High Speed Rail – Electric and Maglev Alternatives would attract a greater variety and quantity of intermodal interfaces that would

be funded and provided by others. **None of the passenger rail alternatives would be feasible without the presence of adequate intermodal services and interfaces that evolve with the on-going plans in the Phoenix and Tucson areas.** For example: the proposed East Valley LRT line would be an excellent feeder to the intercity line. In addition, local bus routes could be reconfigured to serve rail stations as feeders as shown in Figure 6-1 and 6-2.

Figure 6-1
Before Passenger Rail

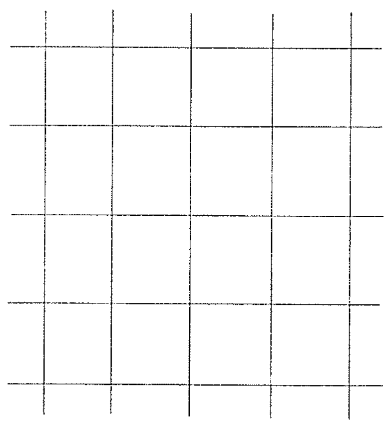
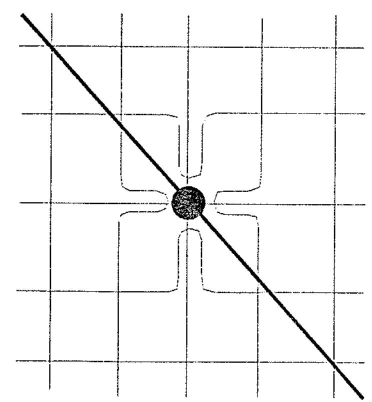


Figure 6-2
After Passenger Rail



Comments:
All of the passenger rail options are planned to include intermodal facilities to accommodate transfers and connections. Depending on the station location and passenger volume, these facilities may include, parking, local feeder buses, private taxi and limo services, rental car services, bicycle facilities, and the potential of other local and regional rail systems such as light rail and commuter rail.

Goal 10: Environmental and energy considerations must be enhanced.
Objective 1: Implement a high speed rail system that improves the local environment by reducing measurable pollutants.
Objective 2: Implement a high speed rail system that results in a net reduction in per capita energy consumption in the corridor.
Objective 3: Implement a high speed rail system that protects and enhances the region's scenic attributes.

Findings:
All of the passenger rail options would reduce vehicle miles traveled, which therefore would reduce pollutants from automobiles. Implementing the Conventional Rail - Minor Upgrade Alternative would reduce 2,137 tons of pollutants annually; the Conventional Rail - Major Upgrade Alternative would reduce 4,196 tons of pollutants annually; the High Speed Rail - Electric Alternative would reduce 4,750 tons of pollutants annually; and the High Speed Rail - Maglev Alternative would reduce 5,146 tons of pollutants annually.

Operational energy consumption, energy consumed to operate a system, would be reduced with the implementation of all rail options, especially the high speed rail systems. However, capital energy, the energy consumed to construct the system, would be the greatest for high speed rail. There are a variety of methodologies used to quantify energy consumption, thus resulting in a wide range of estimates. Therefore, energy consumption was not quantified.

The high speed rail system, either partially or fully elevated, would impact the scenic attributes of the region.

Comments:
The City of Tempe is on record as being concerned about the impacts of passenger rail service on its neighborhoods. This issue also has implications on Goal 11, below.

Goal 11: Economic development and land use improved.
Objective 1: Implement a high speed rail system that maximizes economic development potential in the corridor and at the station sites.
Objective 2: Implement a high speed rail system that is coordinated with and supports local land use policies.

Findings:
All passenger rail options would increase economic development potential in the corridor and at the station sites, especially for the high speed systems. At this level of study, there was not enough information to more accurately determine the level of compatibility with local land use plans and policies.

Goal 12: Maximize rail ridership.
Objective 1: Implement a high speed rail system that increases total transit mode split in the corridor.
Objective 2: Implement ridership incentives and a fare structure to maximize high speed rail ridership.

Findings:
All passenger rail options would help reduce congestion on I-10. Conventional Rail – Minor Upgrade would divert a total of 3,300 daily auto users, Conventional Rail –

Major Upgrade would divert a total of 6,400 daily auto users, High Speed Rail – Electric would divert a total of 7,300 daily auto users, and High Speed Rail – Maglev would divert a total of 7,800 daily auto users.

The fare structure for the passenger rail alternatives creates an incentive to maximize ridership while maintaining reasonable fares. (Refer to Operating Revenues Section in Chapter 5).

Goal 13: Maximize private sector involvement.
Objective 1: Implement a high speed rail system that provides as many opportunities as possible for joint development and other private sector participation methods.

Findings:
All passenger rail options could enable public/private partnerships in the system, in the corridor, and at the station sites. The High Speed Rail – Electric and Maglev Alternatives would provide a greater incentive for public/private partnerships than would conventional rail due to higher ridership.

Goal 14: Increase tourism.
Objective 1: Implement a high speed rail system that is aimed at serving as many corridor destinations as possible.
Objective 2: Implement a high speed rail system that is a tourist attraction in its own right.

Findings:
All passenger rail options would serve tourist destinations. The convenience and positive experience provided by the rail options would "stretch" the impacts of tourism to areas other than original tourist destinations. The rail alternatives would themselves attract tourists, depending upon the specific amenity provided. The high speed alternatives would also attract additional tourists in direct response to the new, advanced technology.

Goal 15: Consider increasing service levels in phases to achieve high speed rail service mission.
Objective 1: Implement a high speed rail system that is flexible enough to meet future economic, demographic, and political needs.

Comments:
*Some passenger rail options are more flexible than others in meeting future economic, demographic, and political needs. Unlike the Conventional Rail - Minor Upgrade Alternative (or some upward derivative of it), **the Major Upgrade Alternative precludes a high speed system in the same corridor because the track for the major upgrade is located where the high speed system would be constructed, and the service provided by the major upgrade system would be discontinued because of construction.***

Goal 16: Improve transportation safety.
Objective 1: Implement a high speed rail system that reduces the overall vehicular accident rate in the corridor.
Objective 2: Implement a high speed rail system that is safer than comparable passenger rail systems nationwide.

Findings:
Rail alternatives are historically safer than highway travel. The High Speed Rail – Electric and Maglev Alternatives would have a zero crossing accident rate due to their grade separated, exclusive right-of-way. All passenger rail systems would reduce the overall vehicular accidents in the corridor due to the diversion of ridership from automobile to rail.

Comments:
Any rail technology would be designed, constructed and operated in accordance with the latest safety and industry regulations and standards in order to provide the safest system possible.

Table 6-1 below illustrates how well the various alternatives meet the study goals.

Table 6-1 Goals & Objectives Summary

Alternative	**Goal 1:** Passenger rail service must be less in required travel time than conventional automotive travel	**Goal 2:** Ensure that rail freight and passenger operations are compatible in the corridor	**Goal 3:** Rail service must meet a balance of multiple feasibility criteria	**Goal 4:** Project must be supported by the political and public communities	**Goal 5:** The project must be affordable	**Goal 6:** Ensure that the project be partnered with the railroad company	**Goal 7:** Ensure that sufficient highway trips are diverted to rail to defer the need for highway widening	**Goal 8:** The project must enhance the travel experience between Phoenix and Tucson	**Goal 9:** The rail service must have good interfaces with highway, rail and transit	**Goal 10:** Environment and energy must be enhanced	**Goal 11:** Economic development and land use improved	**Goal 12:** Maximize rail ridership	**Goal 13:** Maximize private sector involvement	**Goal 14:** Increase Tourism	**Goal 15:** Consider increasing service levels in phases to achieve high speed rail service mission	**Goal 16:** Improve transportation safety
1: No-Build	○	●	◐	○	●	●	○	○	●	◐	○	○	○	○	○	○
2: Highway Widening	○	●	◐	●	●	●	○	○	●	○	◐	○	◐	◐	○	○
3: Conventional Rail-Minor Upgrade	○	◐	●	◐	●	●	●	◐	●	●	◐	◐	◐	◐	●	◐
4: Conventional Rail-Major Upgrade	●	◐	◐	◐	◐	●	●	◐	●	●	◐	◐	◐	◐	○	◐
5A: High Speed Rail-Electric Partially Elev. (UP)	●	●	◐	◐	◐	●	●	●	●	◐	●	●	●	◐	○	●
5A: High Speed Rail-Electric Fully Elev. (UP)	●	●	◐	◐	◐	●	●	●	●	◐	●	●	●	◐	○	●
5B: High Speed Rail-Electric Partially Elev (UP & I-10)	●	●	◐	◐	◐	●	●	●	●	◐	●	●	●	◐	○	●
5B: High Speed Rail-Electric Fully Elev. (UP & I-10)	●	●	◐	◐	◐	●	●	●	●	◐	●	●	●	◐	○	●
6A: High Speed Rail-Maglev (UP)	●	●	◐	◐	○	●	●	●	●	◐	●	●	●	●	○	●
6B: High Speed Rail-Maglev (UP & I-10)	●	●	◐	◐	○	●	●	●	●	◐	●	●	●	●	○	●

Key: Meets Goal ● Partially Meets Goal ◐ Does Not Meet Goal ○

6.3 Determining Feasibility

In addition to the goals and objectives, the Study Steering Committee and Task Force adopted a definition of "feasibility" to further assist in making a determination of whether one or more of the corridor investment options studied herein is worth developing any further. Hence, the following discussion summarizes how well each of the final alternatives addressed the determination of feasibility.

"The High Speed Rail Passenger Project connecting Phoenix and Tucson Metro areas will be determined to be feasible if the following conditions can be reasonably anticipated:

1. One or more of the project route alternatives identified and evaluated during this study is determined to be technically feasible, ie. able to be constructed in the Phoenix-Tucson transportation corridor.

   Finding:
   All of the passenger rail alternatives are technically feasible. The technology for all of the rail alternatives exists and can be constructed in the Phoenix-Tucson corridor. However, since the maglev technology is currently not in revenue service anywhere in the world, implementation of this technology in the corridor might present more problems than the other alternatives.

2. The technically possible alternatives meet the project goals and objectives of high speed rail passenger service that is less in required travel time than automotive travel between Phoenix and Tucson.

   Finding:
   All of the alternatives, with the exception of No-Build, Highway Widening, and Conventional Rail – Minor Upgrade, provide faster travel times than the existing average highway travel time.

3. The high speed passenger rail service will provide a travel alternative that will attract a sufficient number of passengers to warrant additional studies to refine the location, passenger projections, travel needs, and sources of passenger demand.

   Finding:
   All of the high speed passenger rail alternatives will attract a sufficient number of passengers to warrant additional studies.

4. The high speed passenger rail service will meet acceptable environmental standards.

   Finding:
   All of the passenger rail alternatives can be designed to meet acceptable environmental standards. The Conventional Rail - Minor and Major Upgrade Alternatives have less negative impact on the environment because they require less capital energy, there are less construction impacts, there are less impacts from noise and vibration, and they remain within the existing railroad right-of-way.

5. The high speed passenger rail service can garner enough public support, as determined from extensive public involvement in the study process, to continue project planning and refinement.

   Comment:
   More input from the public and political entities is needed in subsequent phases to determine a more representative and accurate level of community support.

6. The high speed passenger rail service can be funded, assuming the reasonable availability of existing and projected public and private revenue sources.

   Comment:
   More input from the public and political entities is needed in subsequent phases to determine the public and private funding sources for passenger rail service.

7. The high speed passenger rail service will be cost-effective and will achieve a favorable balance between benefits and costs."

   Finding:
   The Highway Widening and Conventional Rail - Minor Upgrade Alternatives are the most cost-effective alternatives, generally in accordance with Federal guidelines and therefore are more likely to be implemented. The fully elevated options are not cost-effective.

Table 6-2 below shows how well the various alternatives meet the study feasibility criteria.

Table 6-2 Feasibility Summary

Alternative	1. Technically feasible (able to be constructed)	2. Meet project goals and objectives of high speed rail passenger service that is less in required travel time than the automobile	3. Provide a travel alternative that will attract a sufficient number of passengers to warrant additional studies	4. Meet acceptable environmental standards	5. Garner enough public support, as determined from extensive public involvement in the study process, to continue project planning and refinement	6. Can be funded, assuming the reasonable availability of existing and projected public and private revenue sources	7. Will be cost-effective and will achieve a favorable balance between benefits and costs
1: No-Build	●	○	○	○	More input needed	More input needed	●
2: Highway Widening	●	○	○	◐	More input needed	More input needed	●
3: Conventional Rail-Minor Upgrade	●	○	◐	●	More input needed	More input needed	●
4: Conventional Rail-Major Upgrade	●	●	●	●	More input needed	More input needed	◐
5A: High Speed Rail-Electric Partially Elevated (UP)	●	●	●	◐	More input needed	More input needed	◐
5A: High Speed Rail-Electric Fully Elevated (UP)	●	●	●	◐	More input needed	More input needed	○
5B: High Speed Rail-Electric Partially Elevated (UP & I-10)	●	●	●	◐	More input needed	More input needed	◐
5B: High Speed Rail-Electric Fully Elevated (UP & I-10)	●	●	●	◐	More input needed	More input needed	○
6A: High Speed Rail-Maglev (UP Mainline)	●	●	●	◐	More input needed	More input needed	○
6B: High Speed Rail-Maglev (UP & I-10)	●	●	●	◐	More input needed	More input needed	○

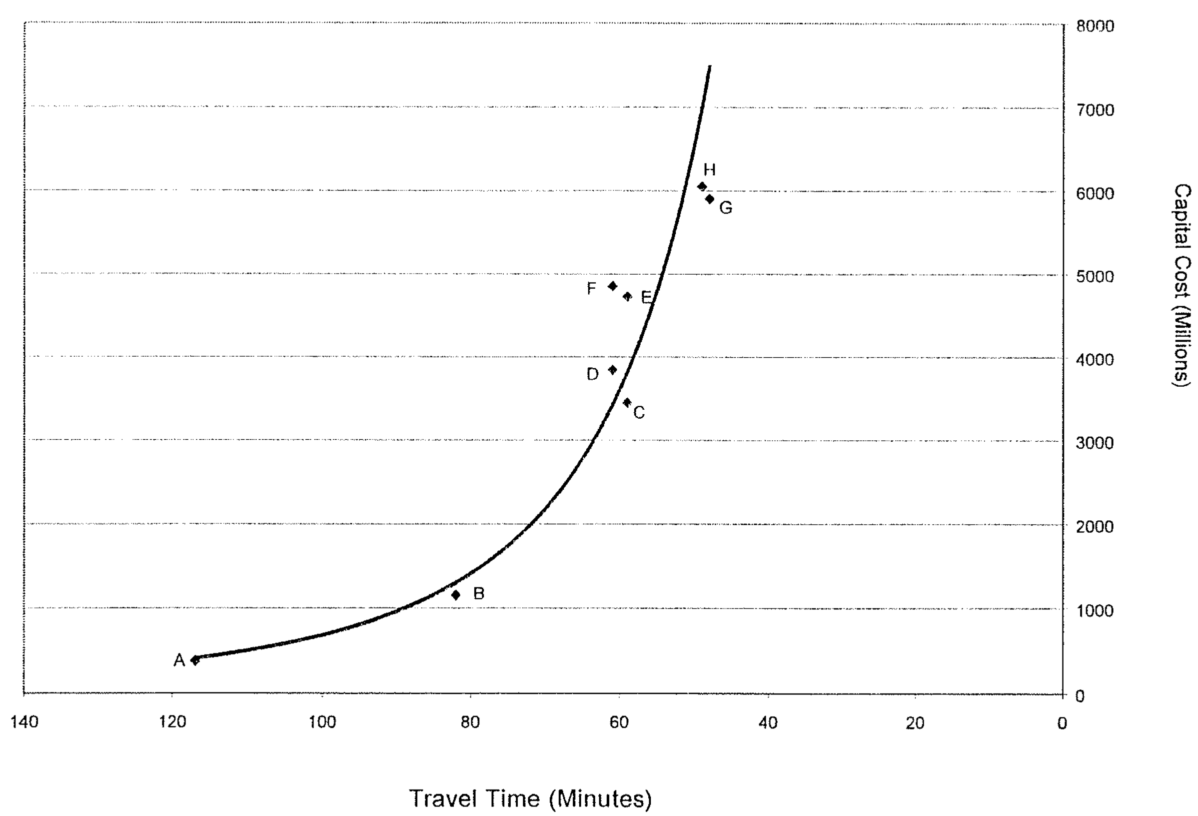
Key: Condition <u>can</u> be reasonably met ● Condition <u>can be partially</u> met ◐ Condition <u>cannot</u> be reasonably met ○

6.4 *Study Conclusions*

This section offers a summary of key study conclusions and a recommended strategy for improving mobility in the Phoenix-Tucson corridor. Widening I-10 from four to six lanes is assumed in the following recommendations and conclusions. Based on the evaluation of study alternatives, the following general conclusions and recommendations are offered:

- Passenger rail implementation would defer the need to further widen I-10 from six to eight lanes for a period of three to six years.
- Improving passenger rail travel time by increasing capital investment in the corridor is an exponential function. Figure 6-3 illustrates the relationship between travel time and capital cost. Note that the point of "diminishing returns" is approximately in the one to three billion dollar range.

Figure 6-3 Travel Time/Capital Cost Relationship for Rail Alternatives

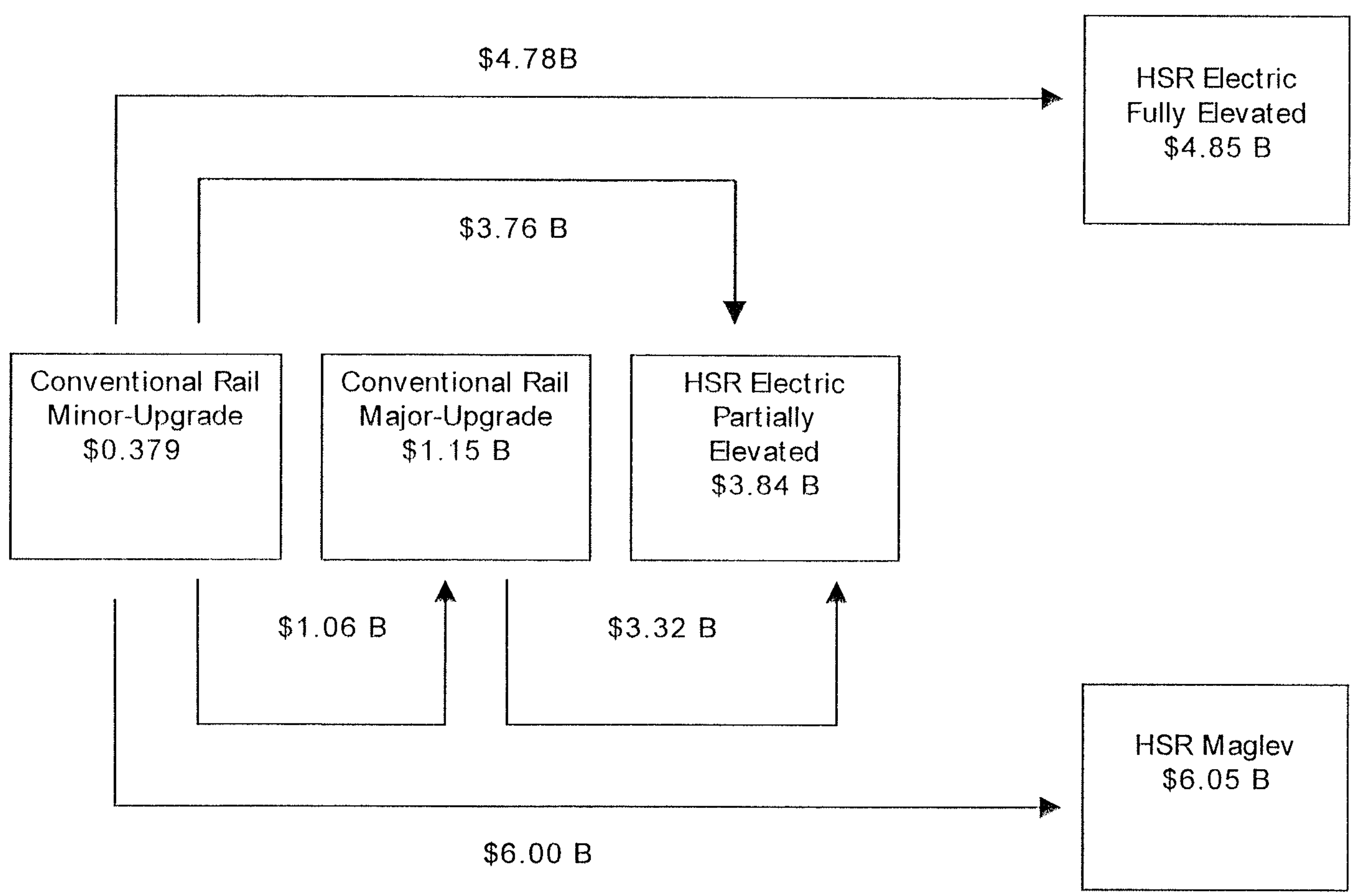


KEY
A = Minor Upgrade
B = Major Upgrade
C = HSR – Electric (I-10/UP, Partially Elevated)
D = HSR – Electric (UP, Partially Elevated)
E = HSR – Electric (I-10/UP, Fully Elevated)
F = HSR – Electric (UP, Fully Elevated)
G = HSR – Maglev (UP/I-10)
H = HSR – Maglev (UP)

- In many cases, a desired project may not be initially affordable or justifiable. A common approach to this dilemma is to stage or phase the implementation of the project. Staging or phasing allows the implementation of an initial project that is more affordable and justifiable. This buys time until resources are available and/or ridership develops to implement the ultimately desired project. The advantages of phasing are: lower initial cost, earlier operation, initial service uses proven and current production technology; and allows time for development and/or actual operating experience to be gained for new technologies.

Figure 6-4 shows the capital cost impacts of selected phasing options. The capital costs shown in the boxes are the "from scratch" estimates. The costs associated with the phasing arrows represent the "incremental" costs to upgrade the project. The incremental capital costs include consideration for previous investments that are not lost when the next phase is implemented.

Figure 6-4 Capital Cost Impacts of Phasing Options
(Costs are in billions of dollars)



Phasing Options Illustrating Total and Unrecovered Costs
(Costs are in billions of dollars)

From Minor Upgrade *($0.379) to Major Upgrade *($1.15);
Total Costs = $1.439
**Unrecovered Lost Costs = $0.289

From Minor Upgrade *($0.379) to Major Upgrade *($1.15) to Elect. Partial Elev. *($3.84);
Total Costs = $4.759
**Unrecovered Lost Costs = $0.919

From Minor Upgrade *($0.379) to Elect. Partial Elev. *($3.84);
Total Costs = $4.139
****Unrecovered Lost Costs = $0.299**

From Minor Upgrade *($0.379) to Elect. Full Elev. *($4.85);
Total Costs = $5.159
**Unrecovered Lost Costs = $0.309

From Minor Upgrade *($0.379) to Maglev *($6.05);
Total Costs = $6.379
**Unrecovered Lost Costs = $0.329

Note: *Cost estimate for "from scratch" construction
**Unrecovered Lost Costs are those that would be lost when next phase is implemented

Recommendation is shown in bold.

Continuing from Section 6.4, the following general conclusions and recommendations are offered:

- The UP Railroad alignment is preferred over the combined UP/I-10 alignment because the UP R-O-W between Phoenix and Picacho will likely have been purchased for implementation of the Minor Upgrade. Therefore, future upgrades would utilize the previously acquired R-O-W.
- Optimum service would be based upon a "four station" scenario. Although additional stations provide further access, studies show that an increase in end-to-end scheduled travel time may result in a net ridership loss. It is important to note that regional systems such as this attract sufficient ridership when part of a matrix of services such as the proposed East Valley LRT, Phoenix area commuter rail, and/or enhanced bus connections.

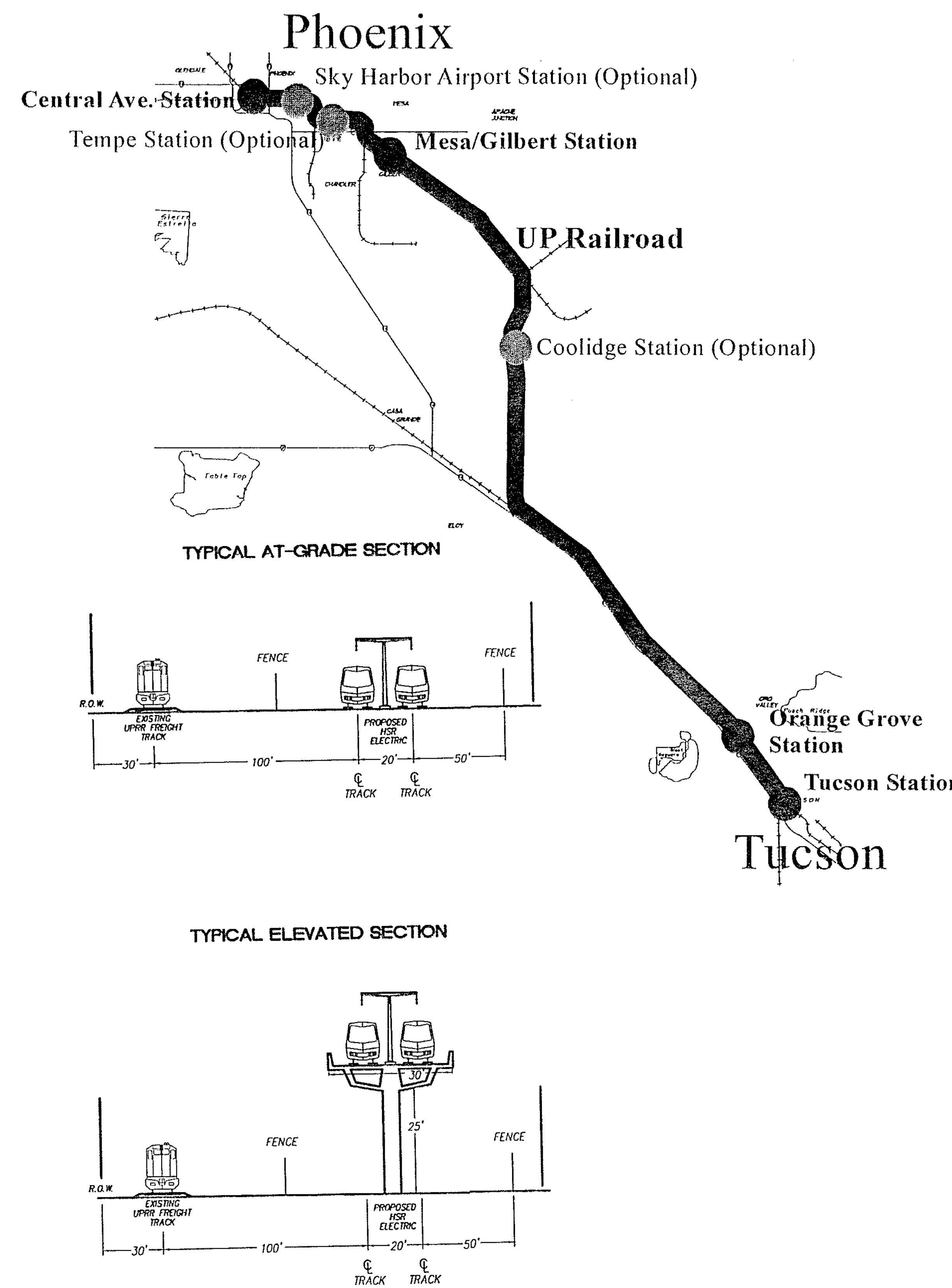
6.5 Preferred Alternative

The description of the preferred alternative includes a general technology, a recommended route, recommended station locations, and a service plan. A summary of estimated costs as well as expected benefits is also provided in this section.

The long-term vision is to implement a partially elevated, yet exclusive R-O-W, high speed rail – electric passenger service utilizing the existing UP Railroad alignment between Phoenix and Tucson. Initially, minor upgrades to the existing UP Railroad using conventional diesel-electric locomotives and push-pull style passenger cars would be implemented. Future upgrades to the passenger rail service, particularly regarding grade separations and higher operating speeds, should then be implemented incrementally, as ridership develops and funding becomes available. Other improvements would also be made to the Minor Upgrade Alternative. These improvements include increasing the maximum operating speed from 79 mph to 100 mph by improving signal system and horizontal track curvature. Over time, an exclusive partially elevated high speed rail – electric line is achieved. At this time, maglev appears to be not cost-effective. However, given the implementation period of this project, technology will evolve and may make advanced systems more feasible.

Figure 6-5 shows the long-term vision alignment and cross sections.

Figure 6-5 Preferred Long Term Alternative



There would be a total of four stations including Central Avenue Station in Phoenix, Mesa/Gilbert, Orange Grove, and Tucson. **The Conventional Rail - Minor Upgrade Alternative would operate five trains per day. The High Speed – Electric Alternative would run 18 hours per day, 365 days per year** as follows:

Weekday Service Period	Headway (minutes)
Early (5 AM - 6 AM)	60
AM Peak (6AM - 9 AM)	60
Midday (9 AM - 4 PM)	60
PM Peak (4 PM - 7 PM)	60
Evening (7 PM - 11 PM)	60

Weekend/Holiday Period	Headway (minutes)
Morning (5 AM - 10 AM)	60
Midday (10 AM - 7 PM)	60
Evening (7 PM - 11 PM)	60

Trains would depart Phoenix every hour on the hour and trains would depart Tucson every hour on the half-hour.

The capital cost of the Conventional Rail – Minor Upgrade is $378 million and the partially elevated High Speed – Electric is $3.84 billion. The annual operating and maintenance cost for the Conventional Rail – Minor Upgrade is $17.6 million and the partially elevated High Speed – Electric is $140 million.

The Conventional Rail – Minor Upgrade Alternative is recommended for initial implementation for the following reasons:

- Most cost-effective rail alternative;
- Earliest to place in operation (rolling stock and fixed plant equipment are readily available);
- Does not preclude Conventional Rail – Major Upgrade or high speed technology in future;
- Can be supplemented to achieve higher operating speed from the beginning;
- Does not preclude local LRT system in Phoenix and Tempe;
- Can be used to generate public interest and support for passenger rail travel;
- Provides a safer alternative to automobile travel; and
- Less environmental impact than the No-Build and Highway Widening Alternatives.

Furthermore, the partially elevated High Speed - Electric Alternative is recommended for incremental implementation for the following reasons:

- More competitive with automobile and airline travel than the Conventional Rail – Major Upgrade Alternative;
- Proven technology;
- Construction does not interfere with on-going operations of the initial Conventional Rail – Minor Upgrade service; and
- Provides travel time that is significantly faster than the legal automobile travel time and which is competitive with airline travel time.

6.5.1 Financing Plan

The construction of the rail system improvements would require a major expenditure of funds and will necessitate that all potential sources of revenue be identified, quantified, and evaluated as the project proceeds through the planning and programming process. For a project of this magnitude, Federal, State, local, and private sources of revenue would need to be pooled to form a package that would:

- be large enough to fund the project,
- meet prudent public fiscal policies, and
- have a reasonable return on private investment.

Based on recent experience and trends, the Federal share for a project of this type would be expected to be in the order of at least 50 percent. The proposed project would need to satisfy Federal criteria on eligibility and cost effectiveness and would need to compete nationally against other transit projects. For the higher cost alternatives, increases in Federal levels of funding would likely be required, since under current levels of Federal funding, the Arizona High Speed Rail Project would take up a very large share of the total available nationally.

At the State and local level, the funding needs for the high speed rail project would be far in excess of any amounts contained in current transportation funding programs. At the State level, there are no sources of funds specifically allocated to public transportation projects. The use for high speed rail of existing transportation funding programs, such as the Highway User Revenue Funds (HURF), Surface Transportation Program (STP), and Lottery Transportation Assistance Fund (LTAF), would necessitate major shifts in emphasis and public policy and legislative actions to permit the use of some of these funds for high speed rail purposes.

To create a new State level funding source, legislative action would be needed. For such Statewide legislative action, appropriate public policy would need to be formulated, and the high speed rail project would need to compete with other Statewide infrastructure needs for other public works projects.

At the local level, existing funding sources would need to be augmented and expanded to create local funds to help fund high speed rail. Any such increase in funding at the local level would require a vote of the public in the affected areas. Very likely, a simultaneous vote in Maricopa, Pima, and Pinal Counties would need to be taken, since unified support for the high speed rail project would be essential for a successful outcome. Approval by the voters in one county, without a commensurate fiscal commitment in the others, would place an unfair burden on one county and may not raise sufficient revenue for the entire project.

Participation by the private sector would be highly desirable in the fiscal package. Opportunities for private participation may come in the form of a design/build consortium that might include the manufacturer of the high speed rail system, land owners/developers in the corridor, landowners/developers in the major metropolitan areas that may be granted land use intensification rights, landowners/developers in station areas, the Union Pacific Railroad, and others.

The development of a successful funding package will necessitate a strong coalition and the consensus of leaders in the public and private sectors. Consensus and public opinion support will be essential in bringing about the necessary legislative actions and the public vote to develop a funding package to implement the high speed rail project.

"Pro Forma"

A "pro forma" is a preliminary assessment of one possible strategy to fund a major capital program, such as this one. Pro forma is Latin for "for form," and is therefore used as a means for discussing the funding options available to decision-makers. It is not necessarily a recommendation for funding. Hence, Table 6-3 (Capital Costs) and 6-4 (Operating and Maintenance Costs) shows how the recommendations could be financed.

Table 6-3 "Pro Forma" Capital Cost Financing Plan for the Recommended Program (1997 Dollars)

Source of Funds	Conventional Rail – Minor Upgrade	Percent	Incremental Cost for HSR – Electric Partially Elevated System	Percent
Federal	$189.5 M	50%	$1.88 B	50%
Non-Federal (local, State, private)	$189.5 M	50%	$1.88 B	50%
Total	**$379 M**	**100%**	**$3.76 B**	**100%**

Table 6-4 "Pro Forma" Annual Operating & Maintenance Cost Financing Plan for the Recommended Program (1997 Dollars)

Source of Funds	Conventional Rail – Minor Upgrade	Percent	Incremental Cost for HSR – Electric Partially Elevated System	Percent
Local	$1.23 M	7%	$18.9 M	13.5%
State	$1.23 M	7%	$18.9 M	13.5%
Federal	$0	0%	$0	0%
Private	$0	0%	$0	0%
Fares	$15.3 M	86%	$103 M	73%
Total	**$17.6 M**	**100%**	**$140 M**	**100%**

6.5.2 Institutional Plan

Construction Strategies

Many options exist to either designate an existing agency or establish a new authority to implement the recommended project. The following existing State-created organizations could act as an overall project administrator:

- Arizona Department of Transportation (ADOT);
- The Regional Public Transportation Authority (RPTA) in Maricopa County, or the Regional Transportation Authority (RTA) in Pima County; or
- A "coalition of counties," created by an inter-local agreement.

These organizations have, or could readily be given, the necessary powers to execute the project.

The State Legislature could also establish a new "State rail passenger authority", "a joint powers authority", or "a public-private consortium" with the ability to collect revenues; design, build and operate the system; acquire real estate; and other political powers necessary for implementing a project. The new authority could be controlled by a board of directors representing all parts of the project area.

Operations Strategies

There are two general approaches to providing actual day to day service: 1) direct operations using public agency employees; or 2) contract operations to a private company. Both approaches are common nationally. It is recommended that the administrating agency initially contract with an experienced passenger rail operator. This would relieve the owner from hiring personnel that are more cost-effectively provided by a service agreement.

6.6 Recommended Next Steps

The following actions are recommended to further develop the recommendations outlined above:

- ADOT should incorporate the results of this study into the I-10 Corridor Profile Study, now underway. Although this study assumes that some of the problems will be solved by widening I-10, other capacity-increasing options should be investigated and compared to a widening program. These options should include a wide variety of Intelligent Transportation System (ITS) measures, addressing both the general traffic as well as the truck traffic congestion.

- ADOT, in cooperation with the local governments in the corridor, should conduct a more detailed study of the passenger rail recommendations outlined herein, including planning for, and study of, connecting feeder systems. The recommendation for further detailed study ought not to begin until ADOT has completed the I-10 corridor profile study referenced above. Depending on Federal funding expectations, this next step would follow one of two processes:
  - If discretionary Federal funding is pursued, a Major Investment Study (MIS) is required. Current Federal law requires that an MIS be conducted in accordance with ISTEA guidance in order for a project of this magnitude to be eligible for Federal financial support; or
  - If Federal funding is not pursued, the project can proceed in a variety of ways. The most logical next step would be to define the project in more detail by preparing an initial level of engineering, often referred to as "conceptual engineering" or "project definition." This phase would include topographic base mapping, schematic design concepts for the trackway and structures, station concepts, more refined cost estimates, more specific right-of-way definition, etc.

  The purpose of either of these efforts (Federal MIS or not) would be to allow decision-makers another milestone in the project development process to re-assess the feasibility of the project.

- The State should establish a Statewide policy regarding acquisition and/or preservation of abandoned railroad right-of-way. The policy should address the public benefits accrued by preserving valuable corridors for long-range transportation purposes. Portions of the Preferred Alternative described in this study should benefit from such a policy.

- The State should actively support and assist local governments in their efforts to implement major local transit initiatives, such as the East Valley LRT proposal and bus system expansions. These local efforts will become essential components of an Arizona High Speed Rail system by collecting and distributing residents and visitors to their final destinations.

In conclusion, this Study was conducted at a very conceptual level. The findings and conclusions are intended to help guide decision-making to the next level of study. Final decisions on specific alignment locations, station locations, equipment selection, operating plans, fares, and the myriad of other decisions that define a project will happen over a period of many years and with the involvement of many more participants in the Arizona community. This Study is only the first step, although an important one, in that process.

Appendix A

Public Involvement Record

(Available as a Separate Document)

Appendix B

Survey of High Speed Rail Systems

(Available as a Separate Document)

Appendix C

Memorandum of I-10 Inspections

(Available as a Separate Document)

Appendix D

Memorandum of Railroad Inspections

(Available as a Separate Document)

Appendix E

Existing Railroad Information and Condition Assessment

(Available as a Separate Document)

Appendix F

Union Pacific Railroad Right-of-Way Width Data

(Available as a Separate Document)

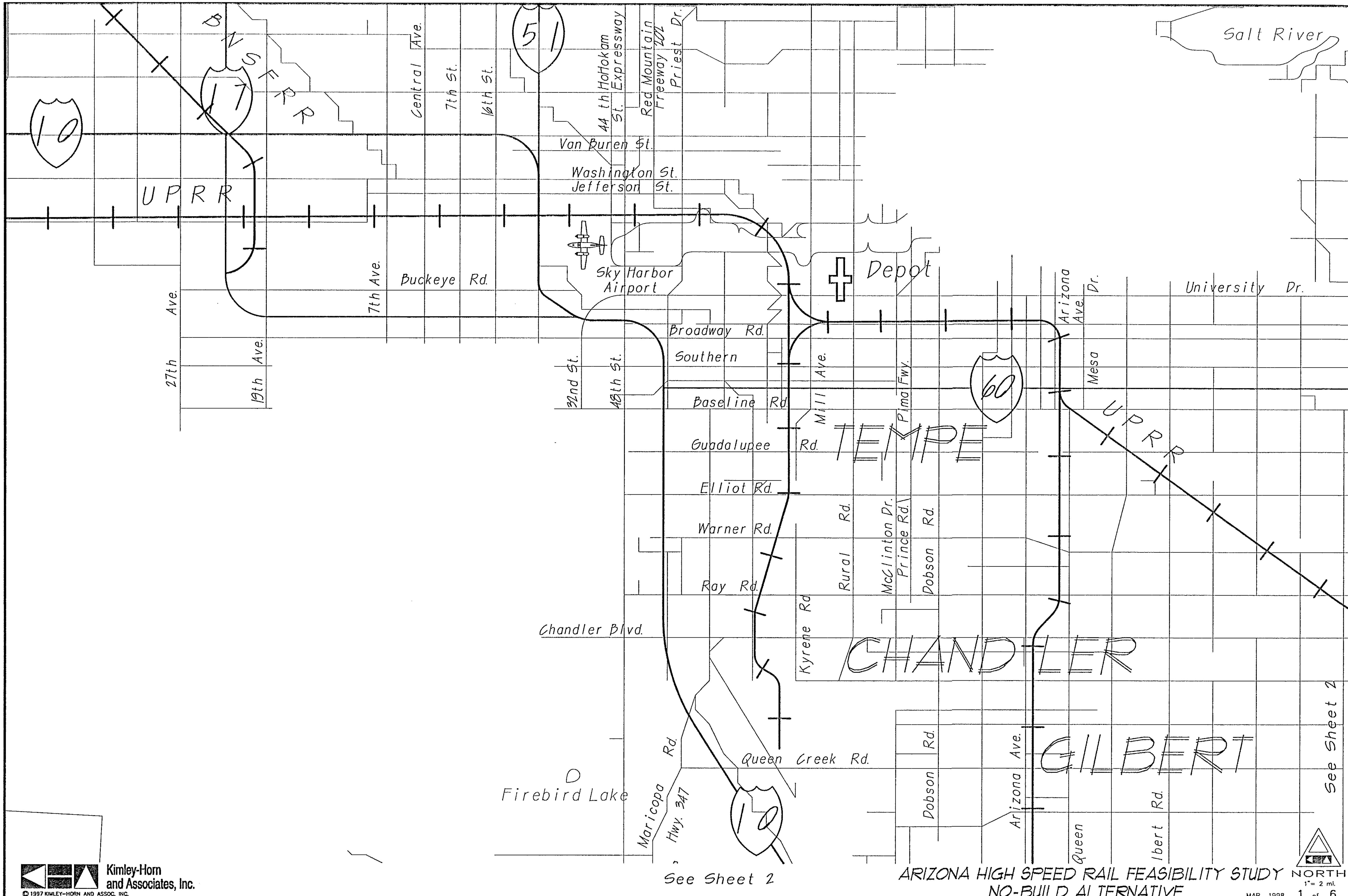
Appendix G

Survey of Tempe (Kyrene) and Chandler Branches

(Available as a Separate Document)

Appendix H

Alternative 1: No-Build



ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
NO-BUILD ALTERNATIVE

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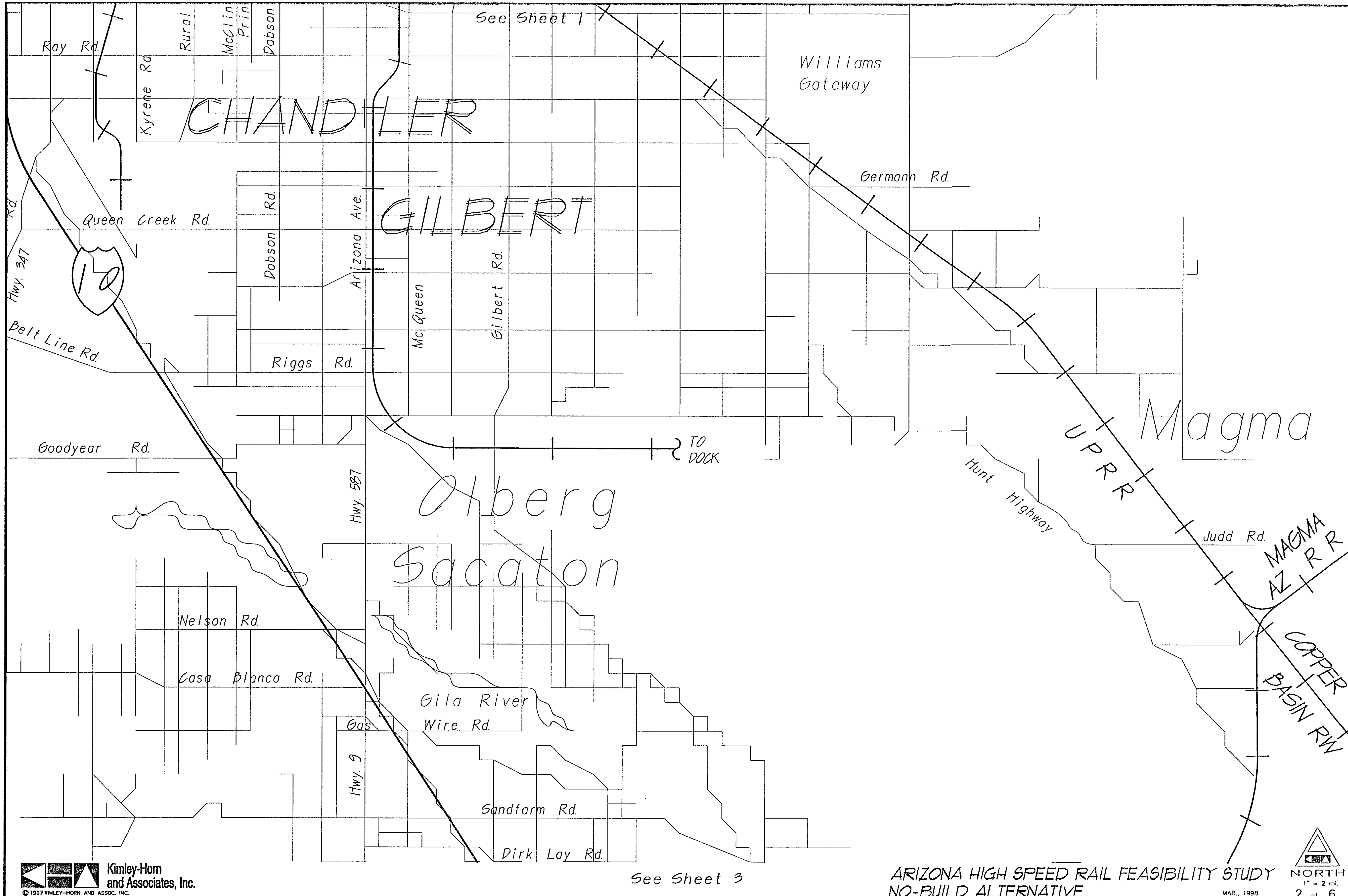

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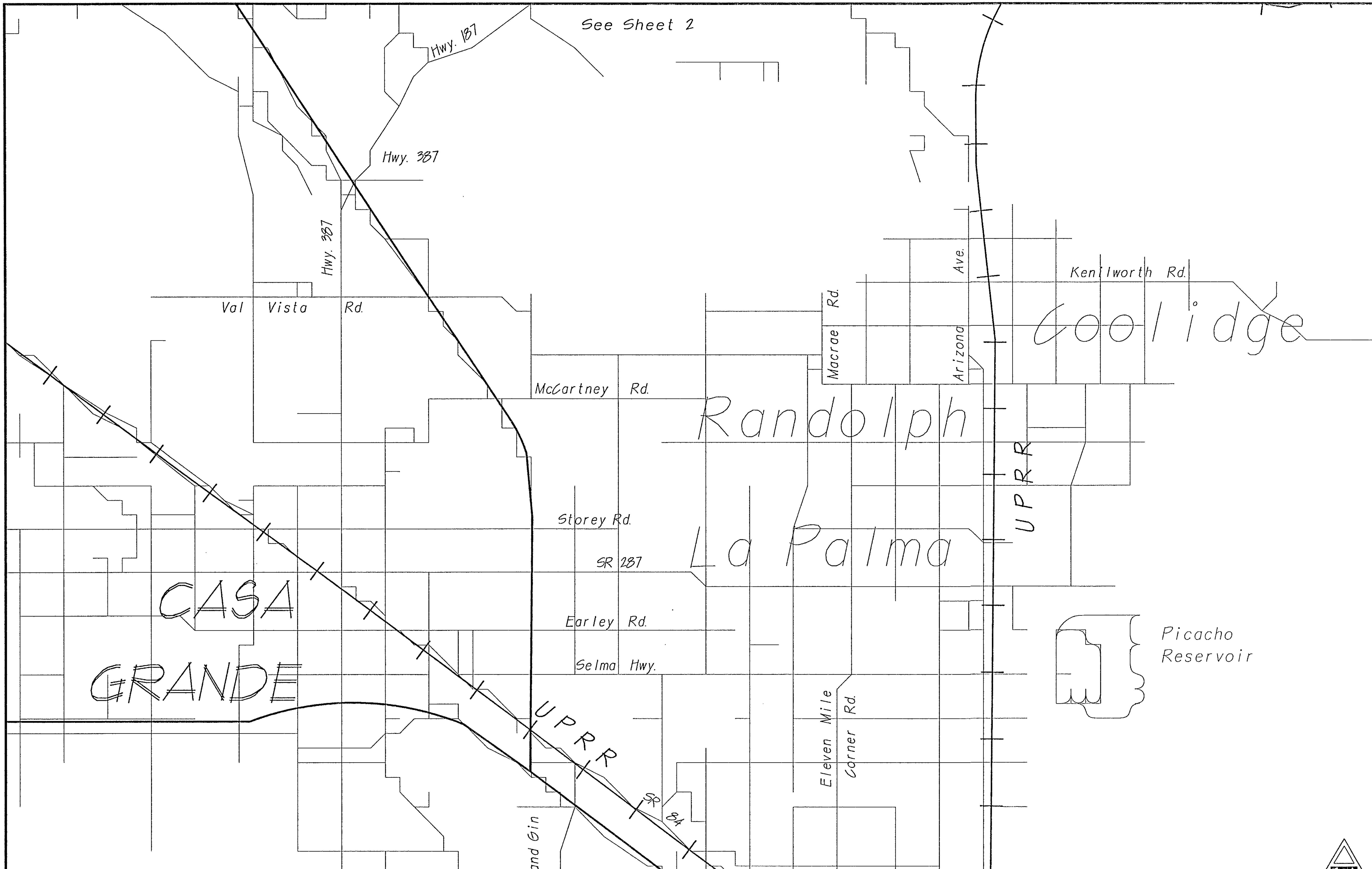

See Sheet 4

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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
NO-BUILD ALTERNATIVE

NORTH 1"= 2 mi.

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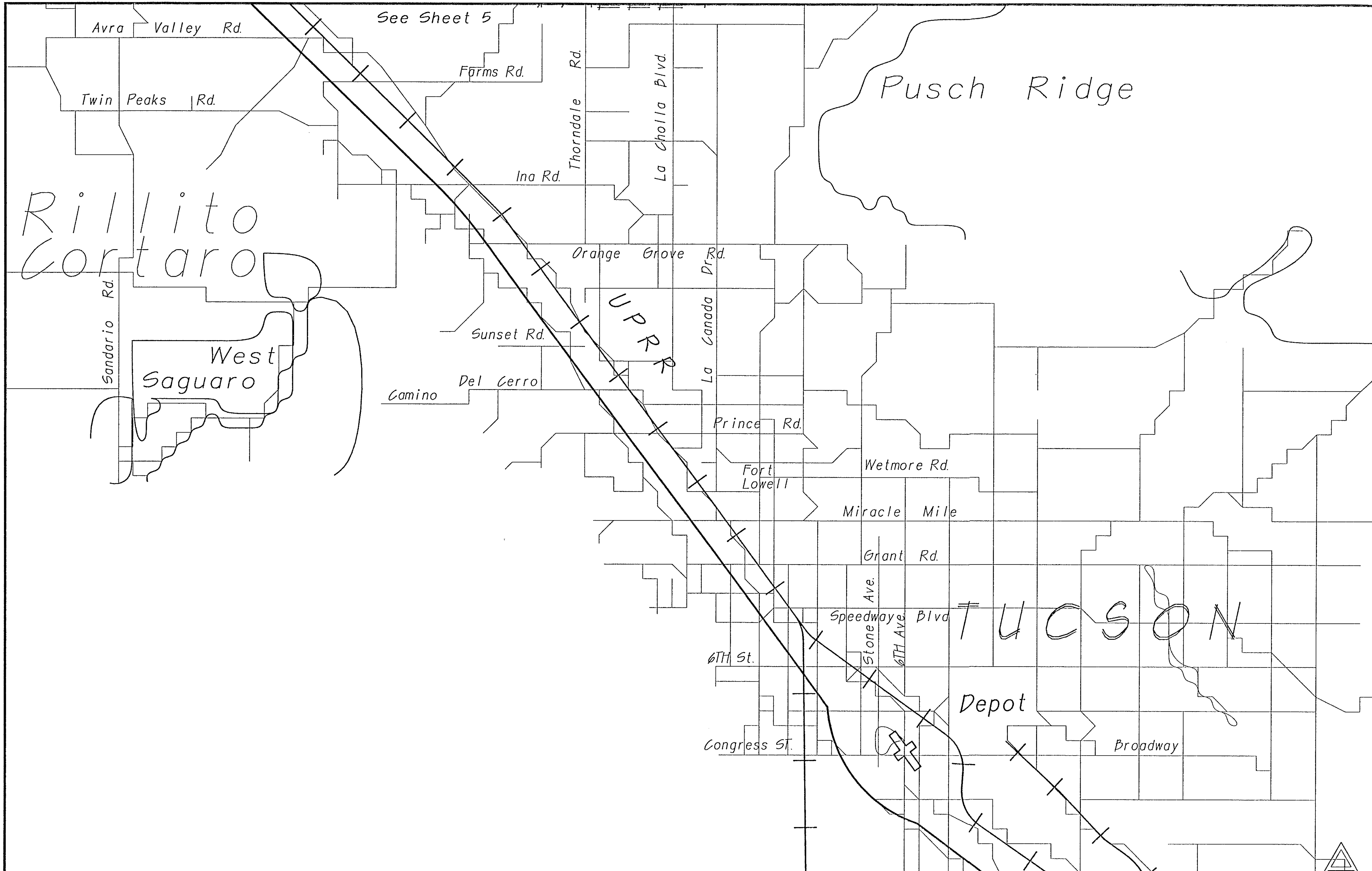

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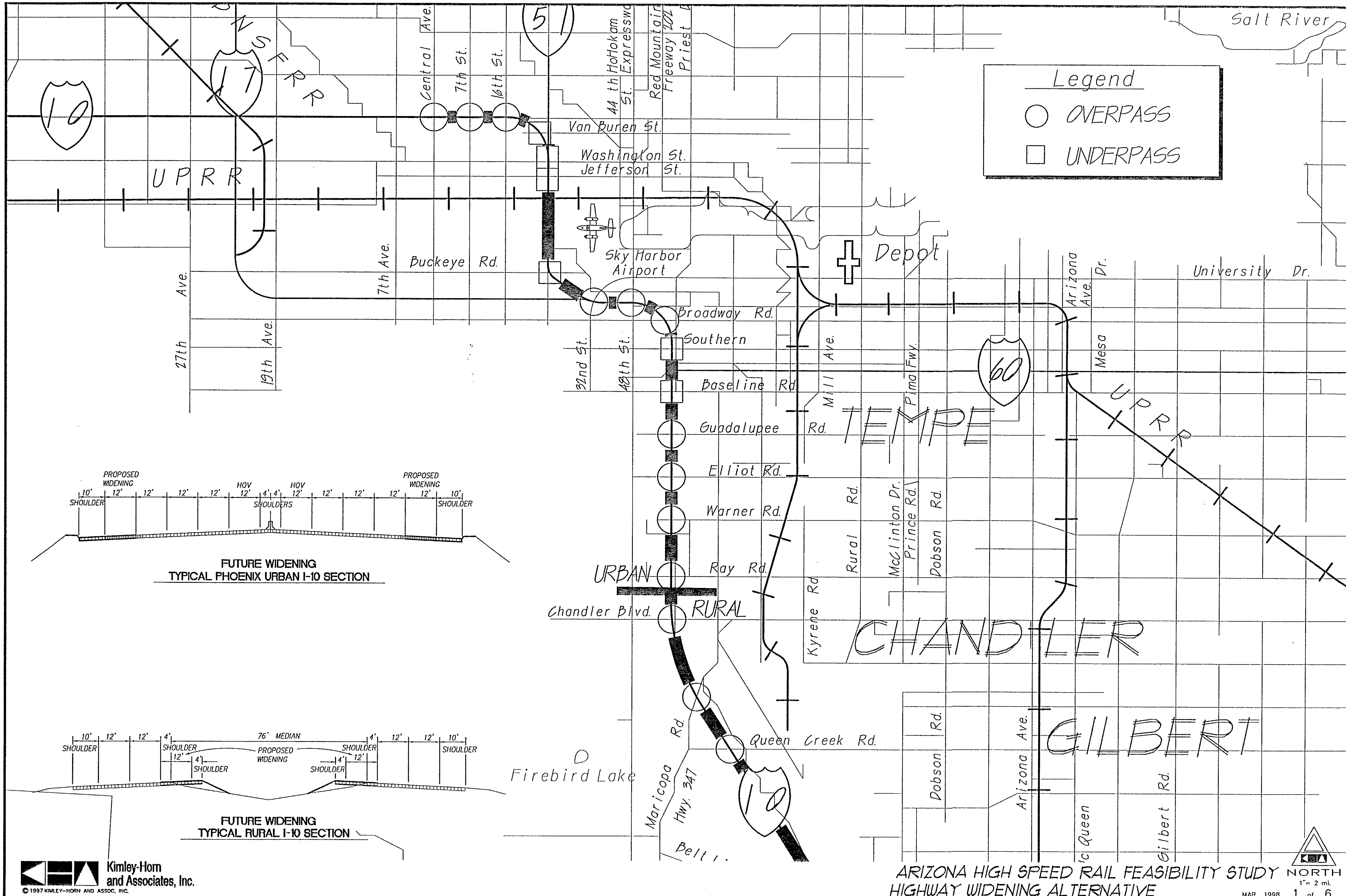
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
NO-BUILD ALTERNATIVE

MAR., 1998 6 of 6

Appendix I

Alternative 2: Highway Widening



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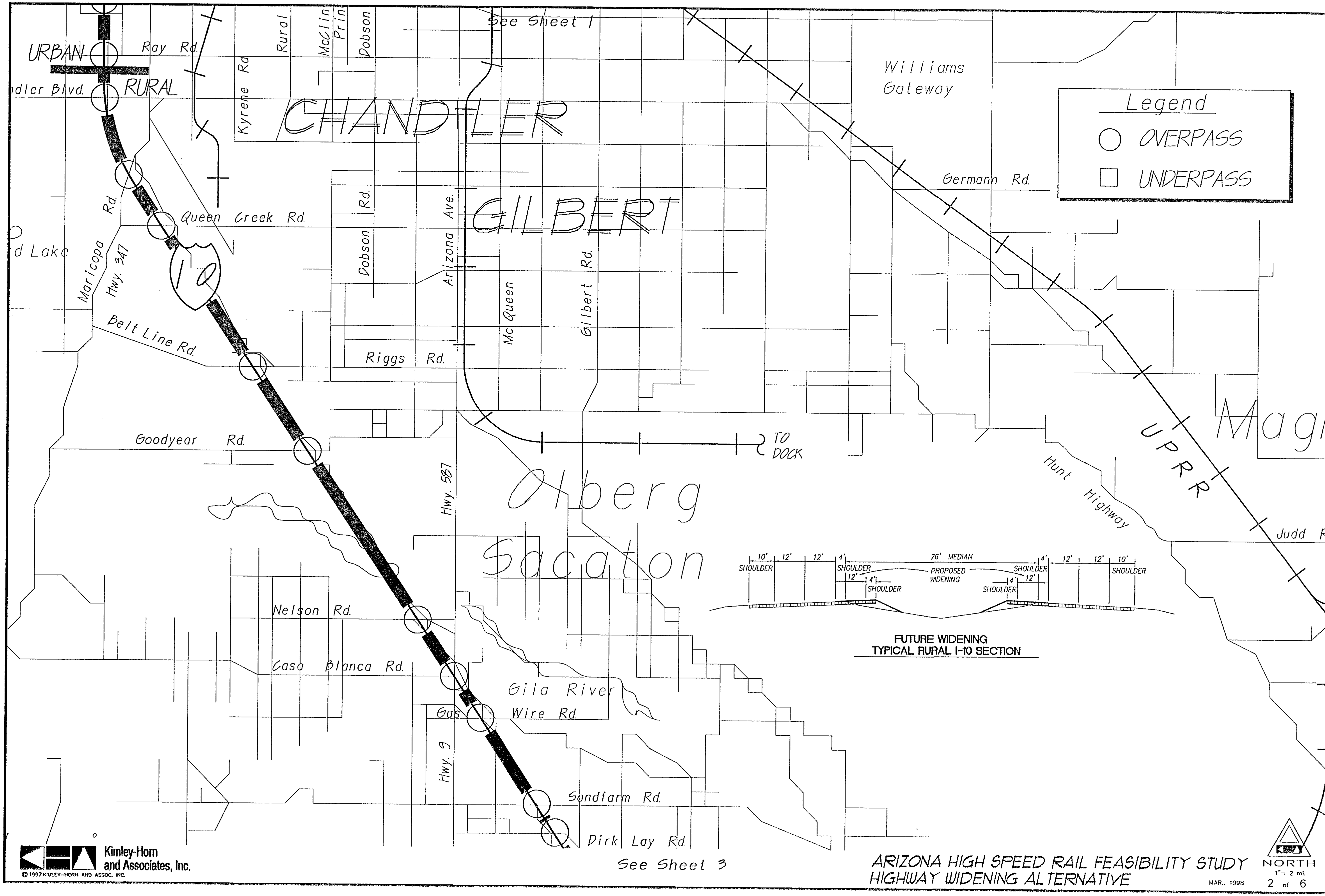

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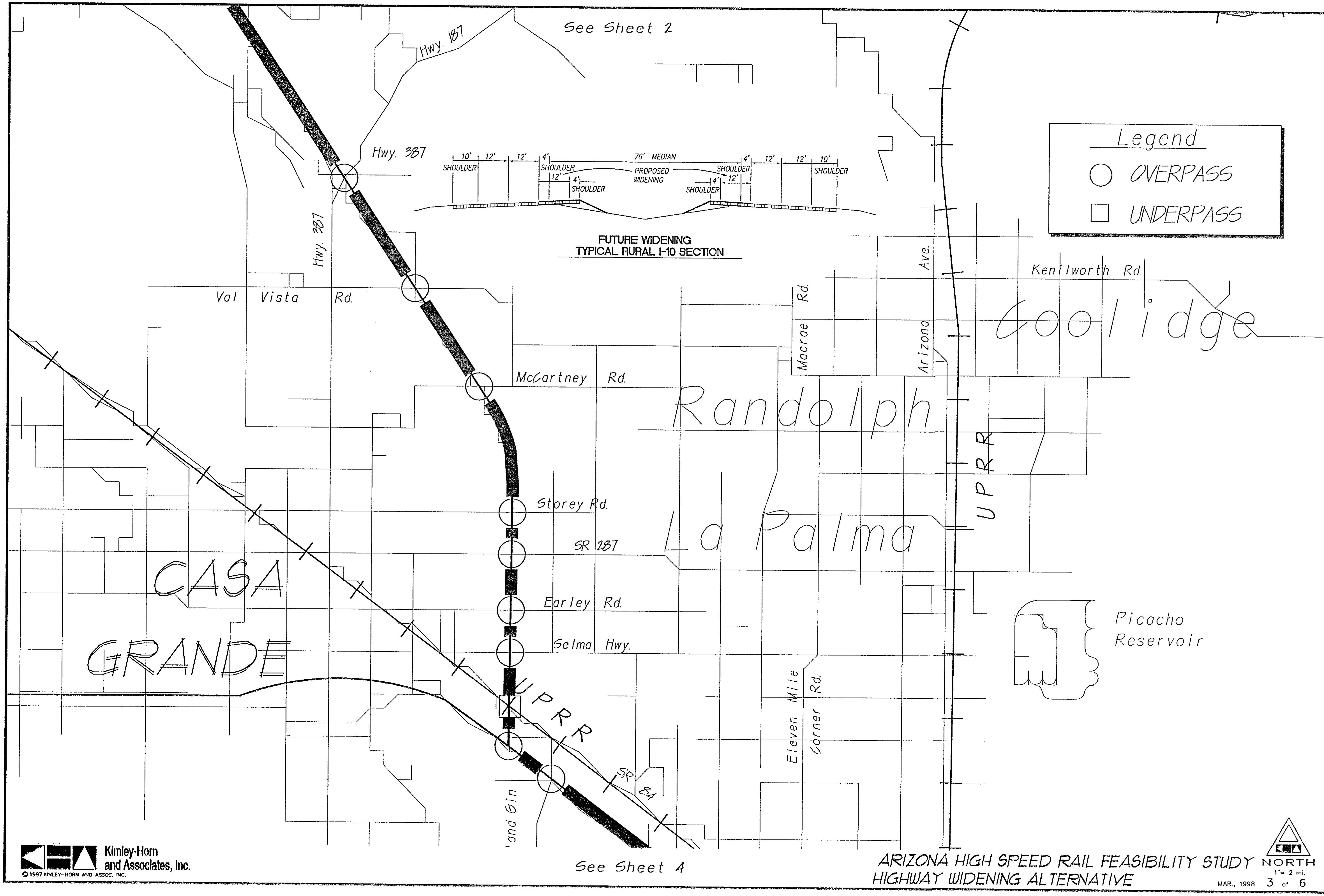

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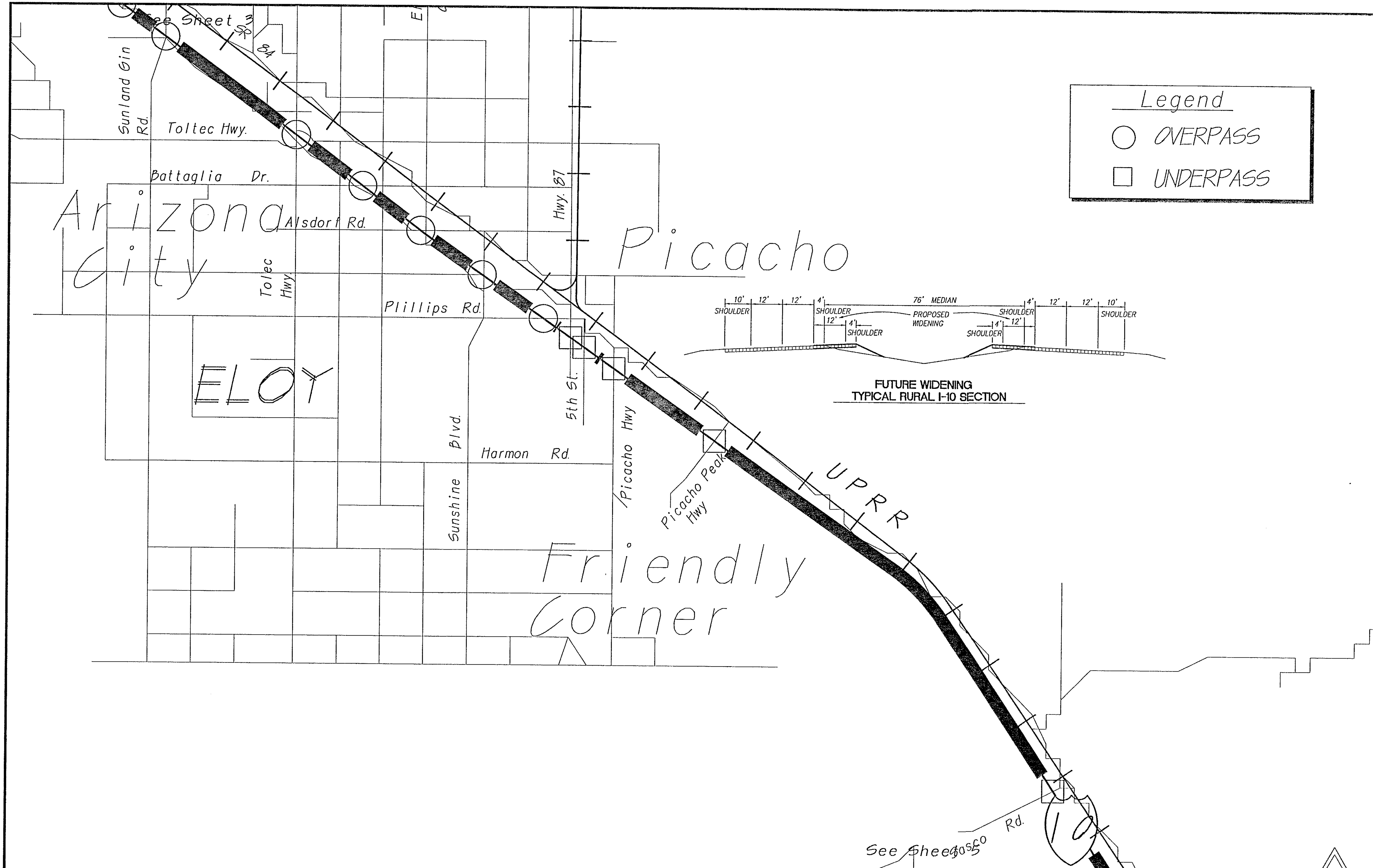

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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGHWAY WIDENING ALTERNTIVE

MAR., 1998

NORTH
1" = 2 mi.

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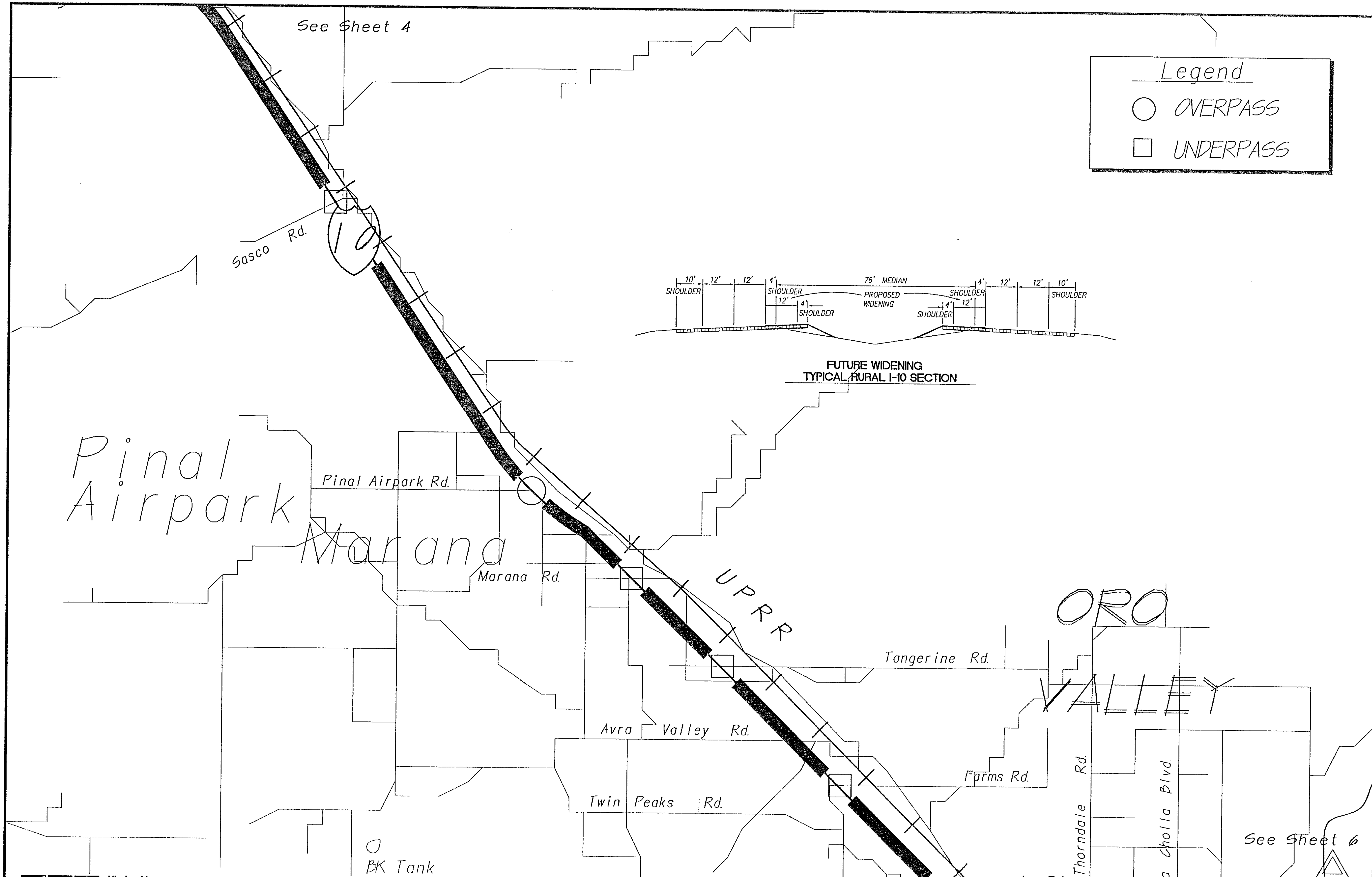

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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGHWAY WIDENING ALTERNATIVE

MAR., 1998

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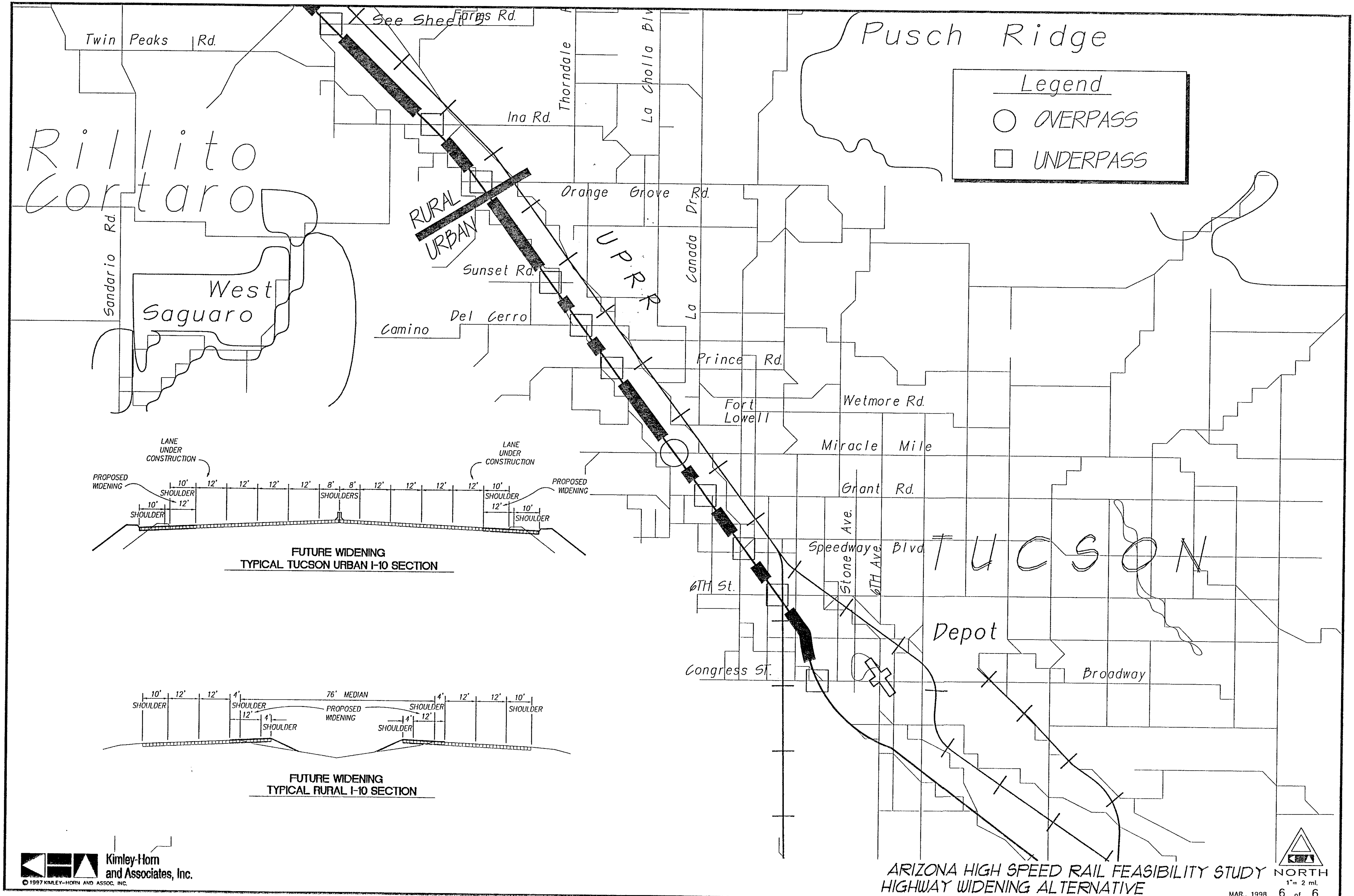

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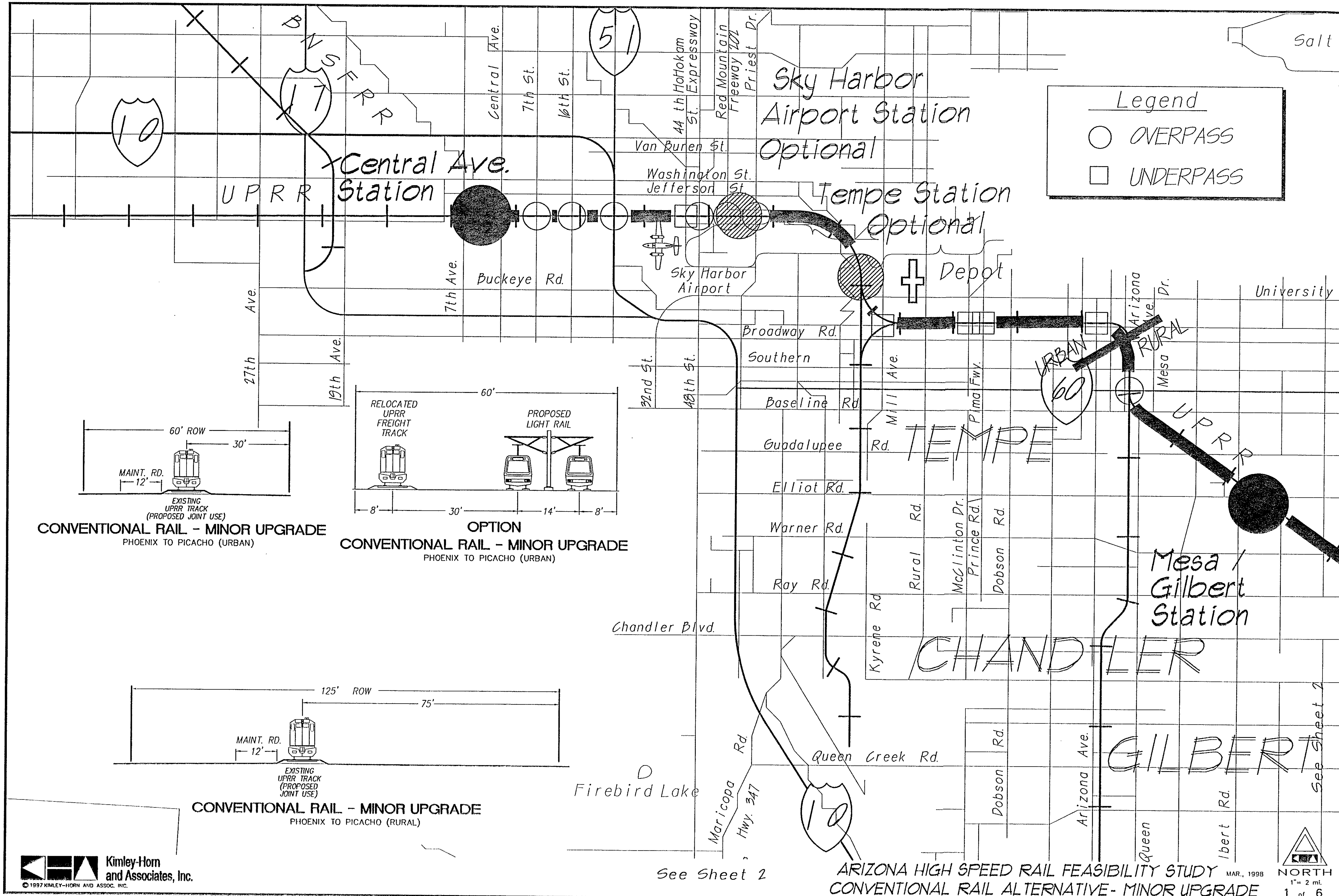
Appendix J

Alternative 3: Conventional Rail - Minor Upgrade



G:\067600.01\DWG\plan-sht\01A3PLN1 Wed Mar 04 13:34:20 1998

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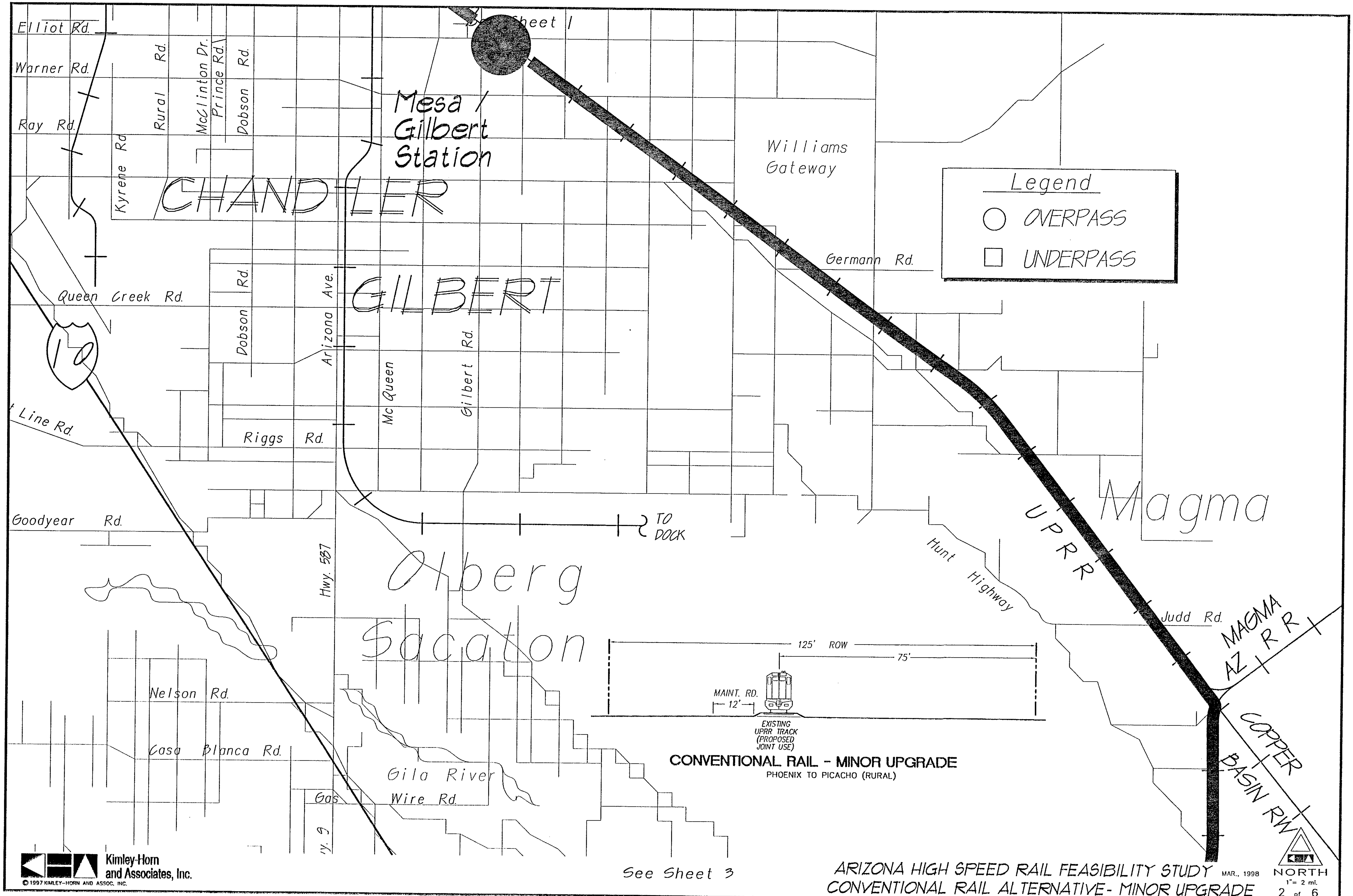

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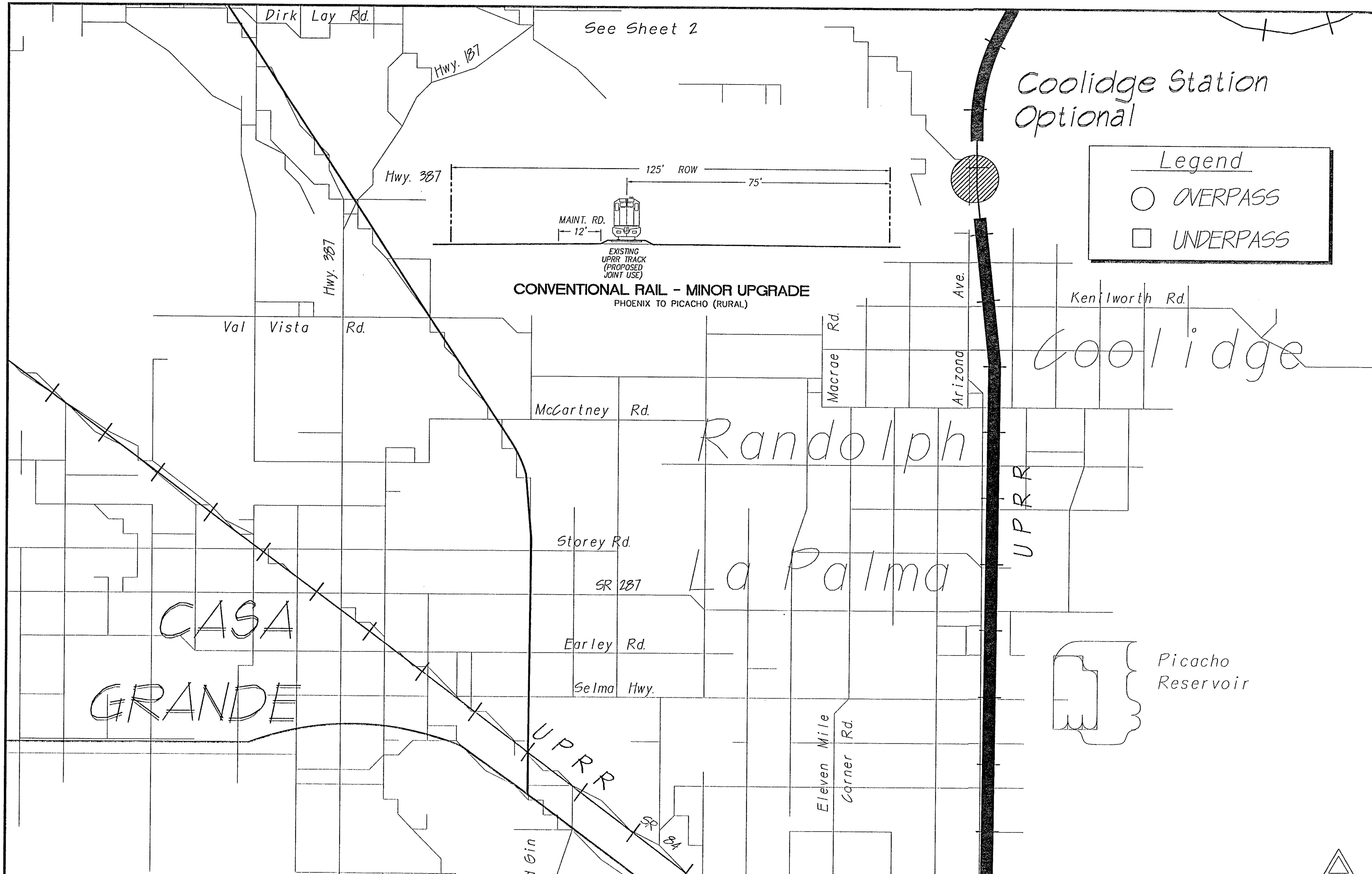
XREF: OD01BASE, OD01ALTS



Kimley-Horn and Associates, Inc.

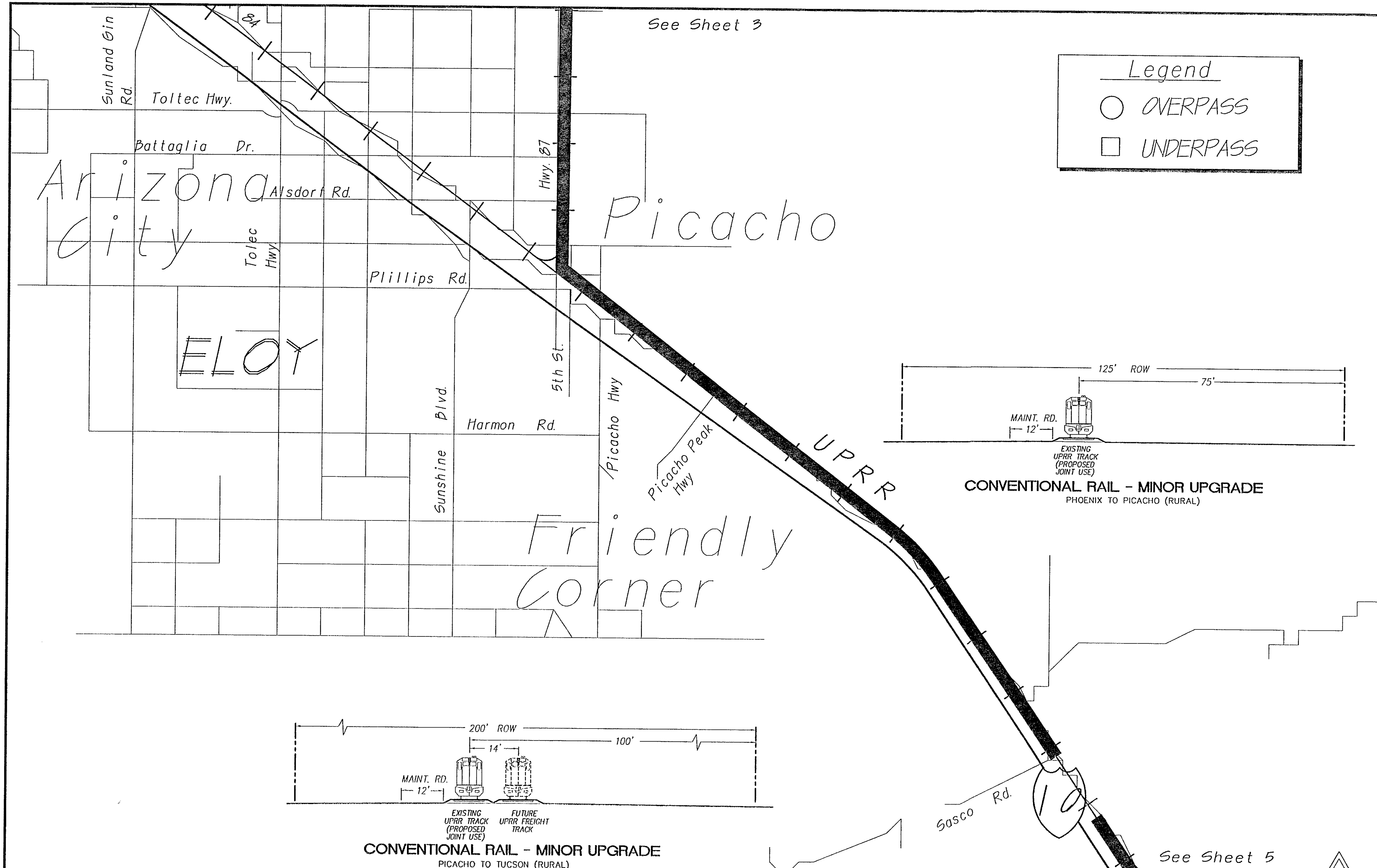
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY MAR., 1998

CONVENTIONAL RAIL ALTERNATIVE- MINOR UPGRADE

NORTH 1"= 2 mi.

G:\067600.01\DWG\plan-sht\01A3PLN3 Wed Mar 04 13:38:07 1998

XREF: 0001BASE, 0001ALTS



Kimley-Horn and Associates, Inc.

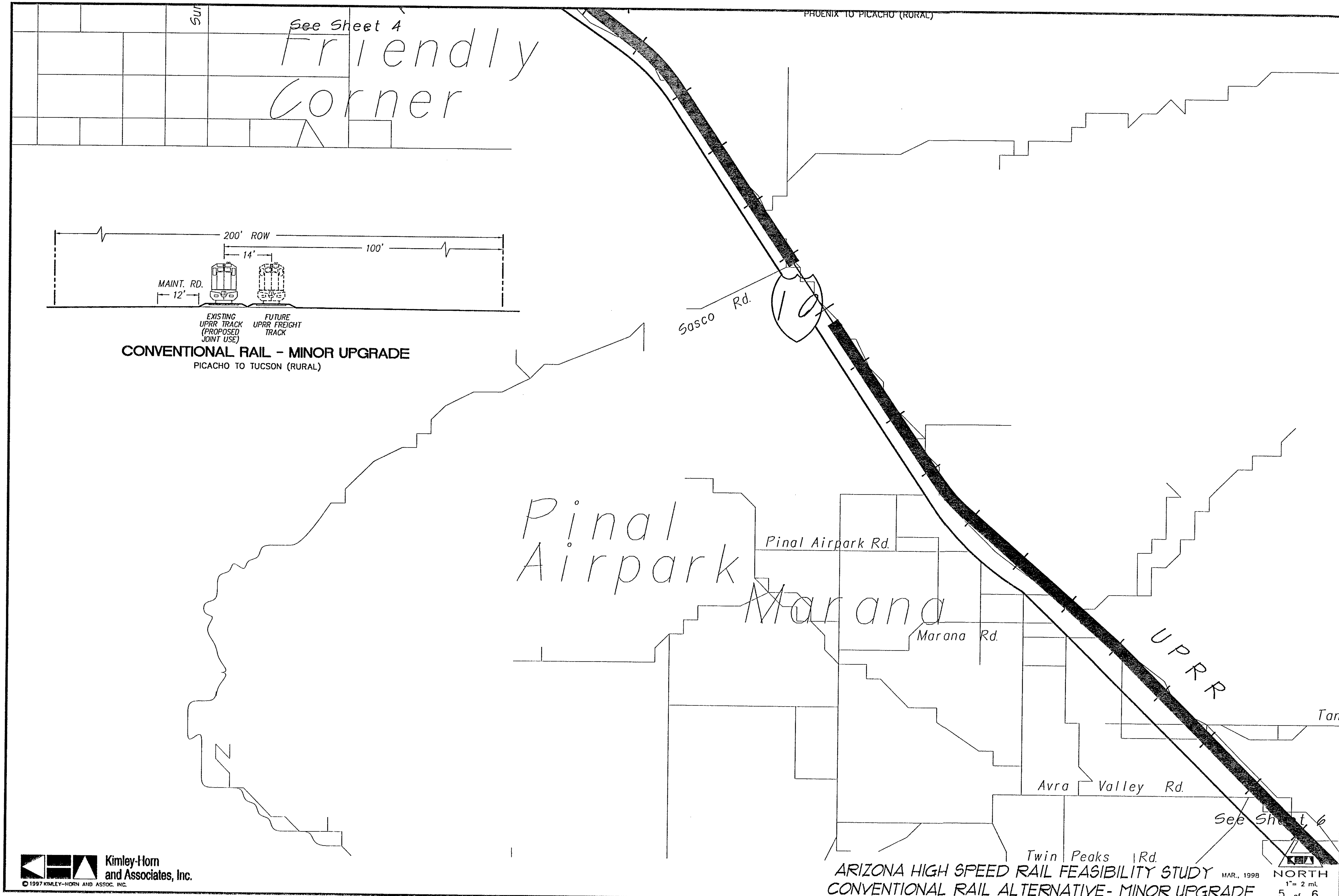
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY MAR., 1998

CONVENTIONAL RAIL ALTERNATIVE- MINOR UPGRADE

NORTH 1"= 2 mi.

G:\067600.01\DWG\plan-sht\01A3PLN4 Wed Mar 04 13:38:57 1998

XREF: 0001BASE, 0001ALTS



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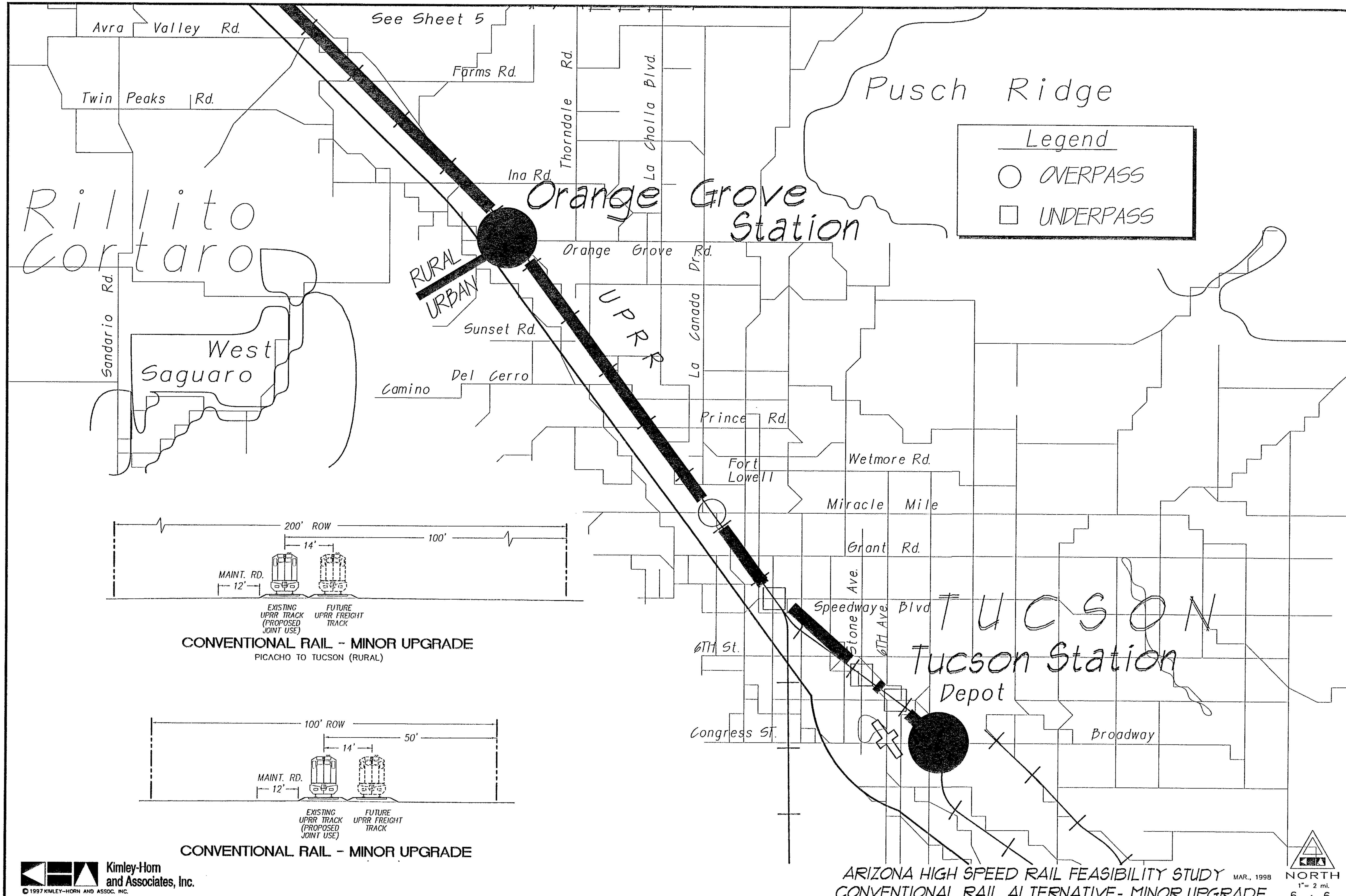
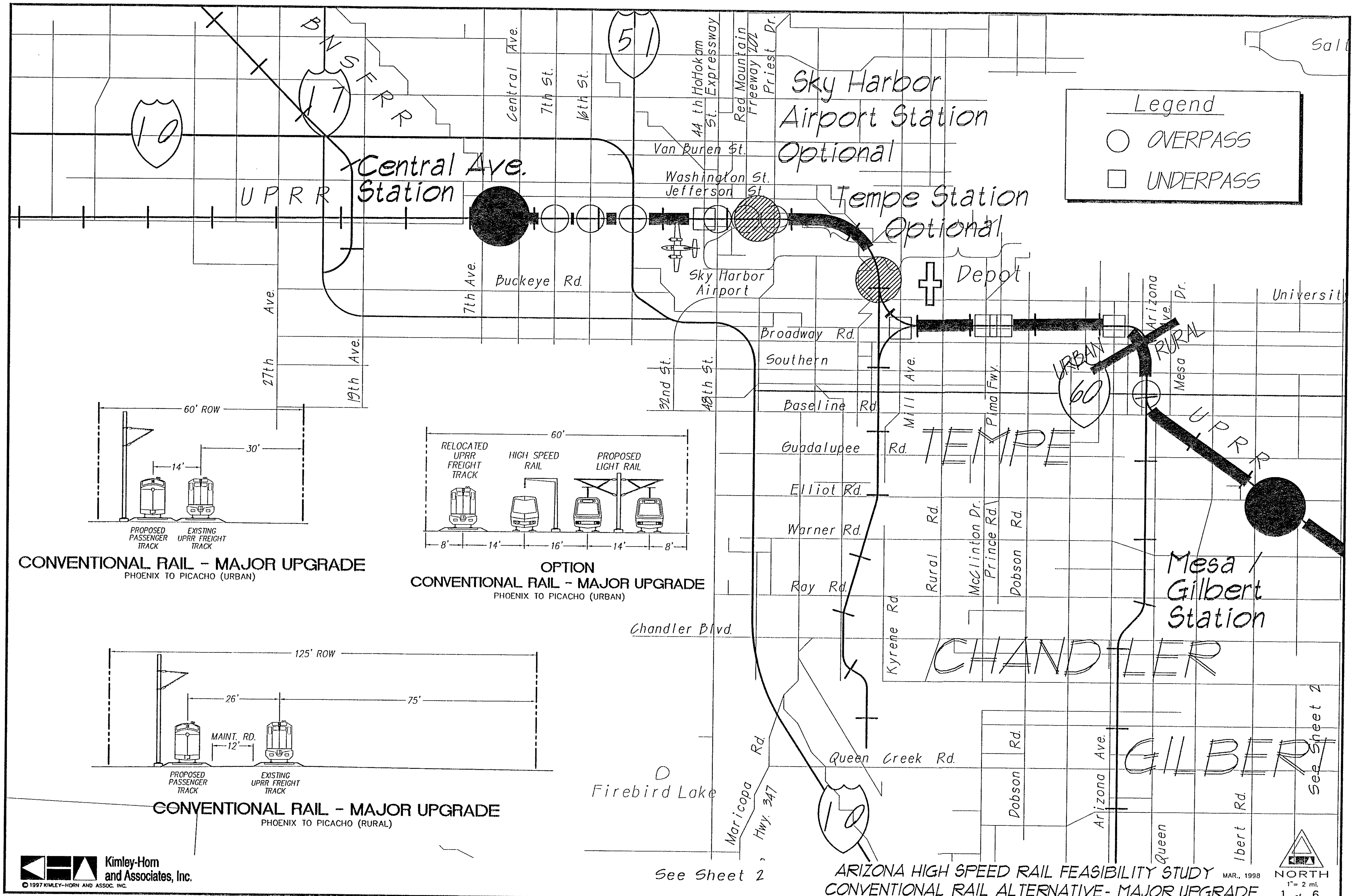


G:\067600.01\DWG\plan-sht\01A3PLN6 Wed Mar 04 13:40:09 1998

XREF: 0001BASE, 0001ALTS

Appendix K

Alternative 4: Conventional Rail - Major Upgrade



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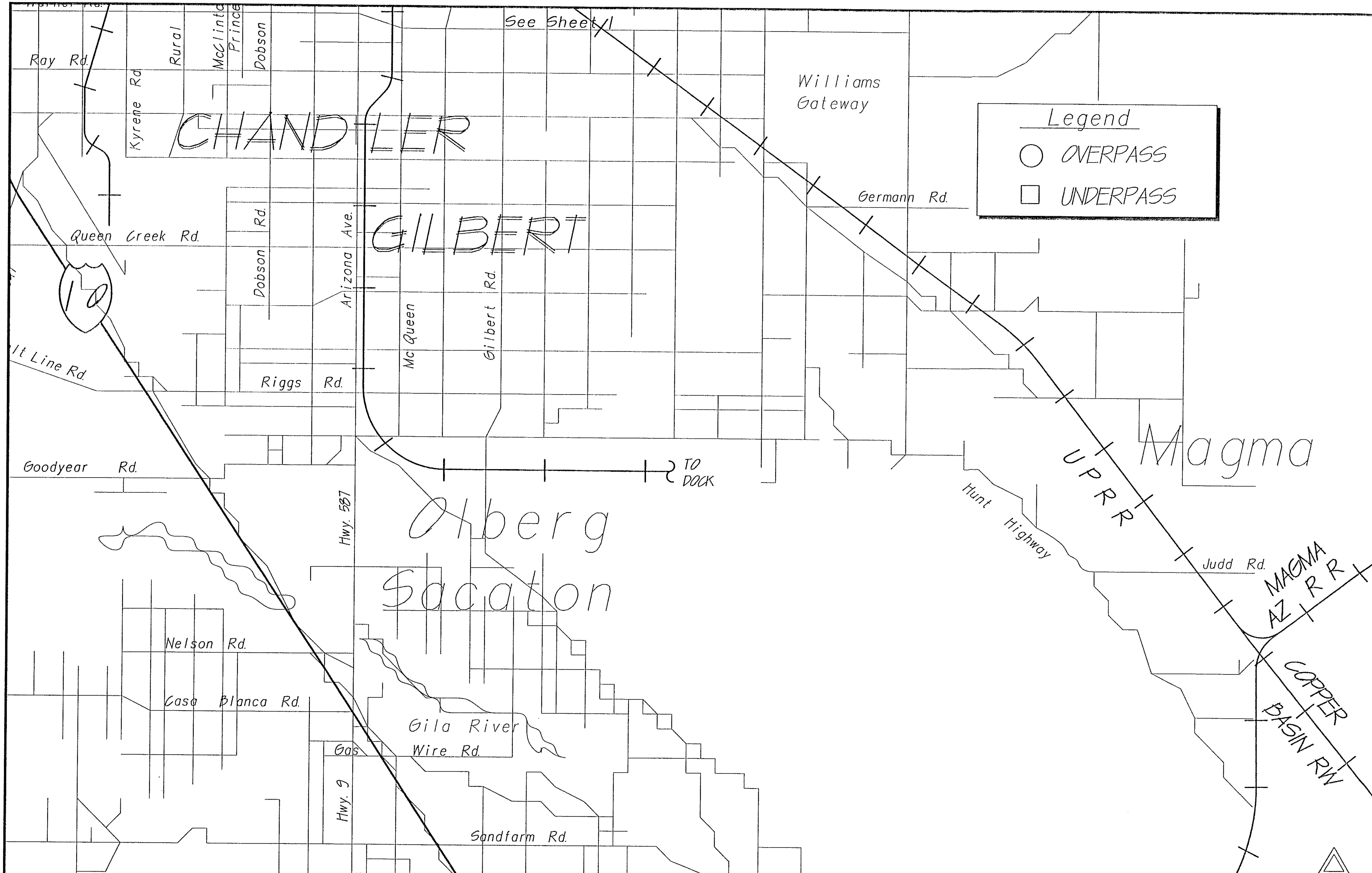
XREF: 0001BASE, 0001ALTS



Kimley-Horn and Associates, Inc.

See Sheet 3

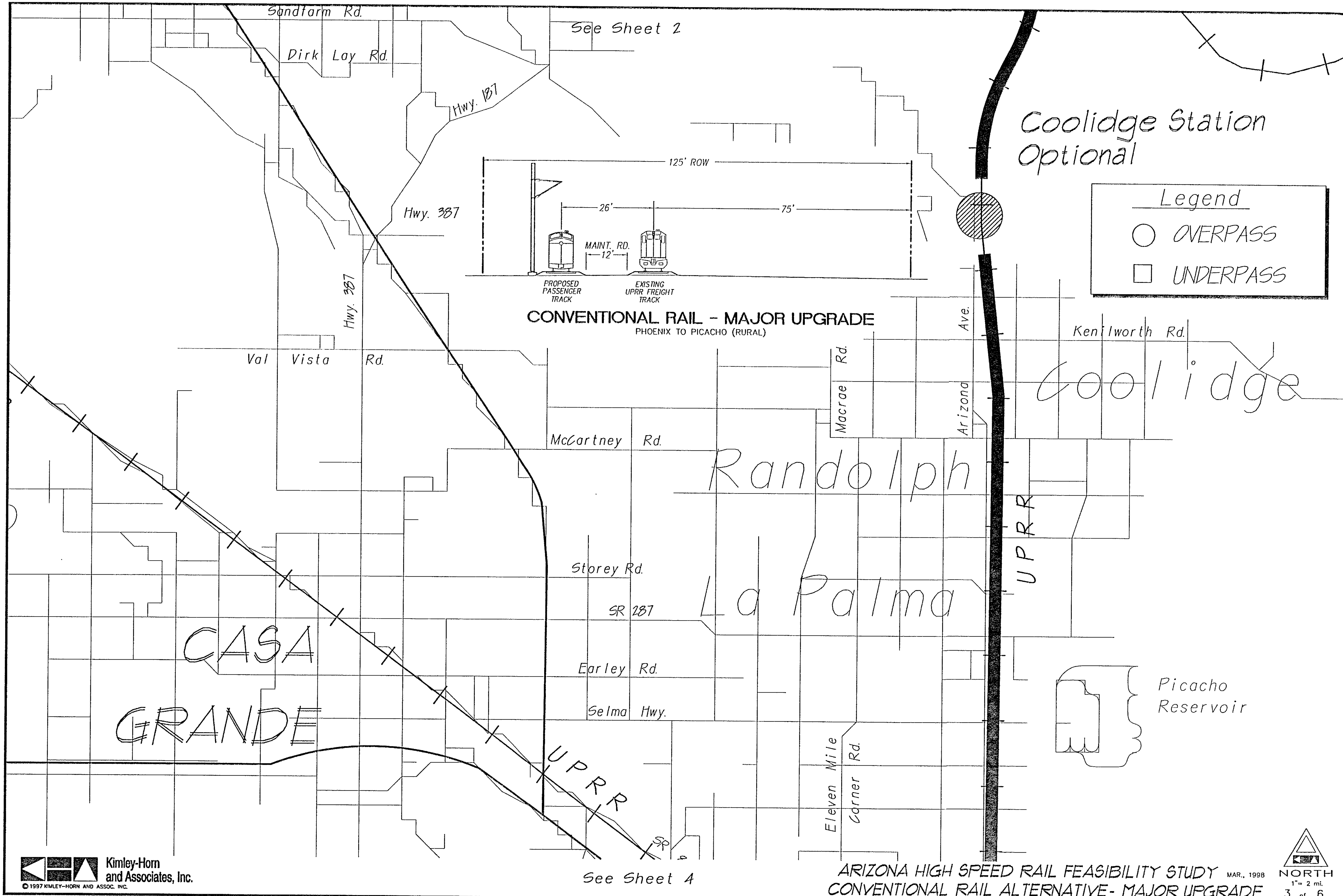
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY MAR., 1998

CONVENTIONAL RAIL ALTERNATIVE- MAJOR UPGRADE

NORTH 1"= 2 mi.

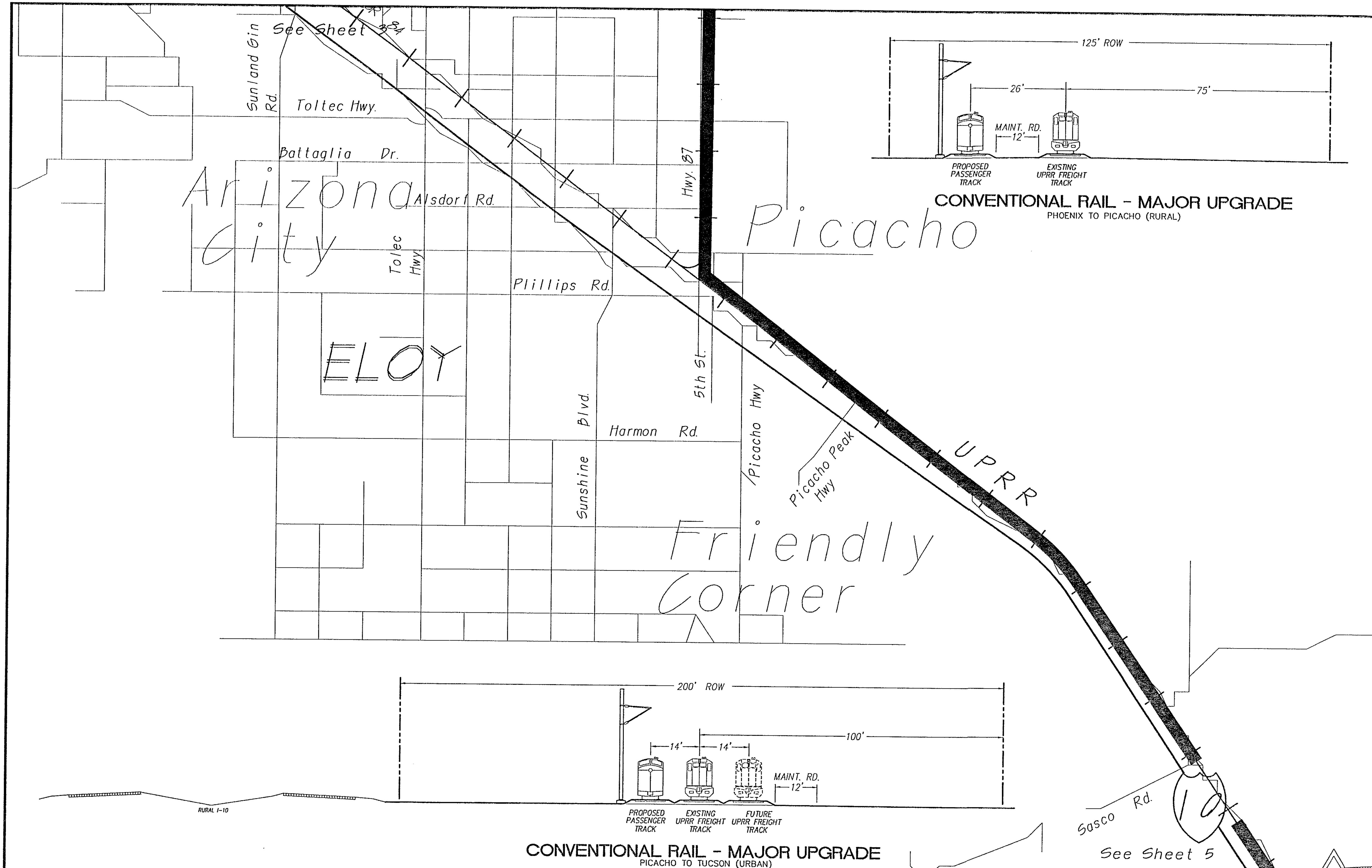
G:\067600.01\DWG\plan-sht\01A4PLN2 Wed Mar 04 13:42:22 1998

XREF: 0001BASE, 0001ALTS



G:\067600.01\DWG\plan-sht\01A4PLN3 Wed Mar 04 13:44:10 1998

XREF: 0001BASE, 0001ALTS



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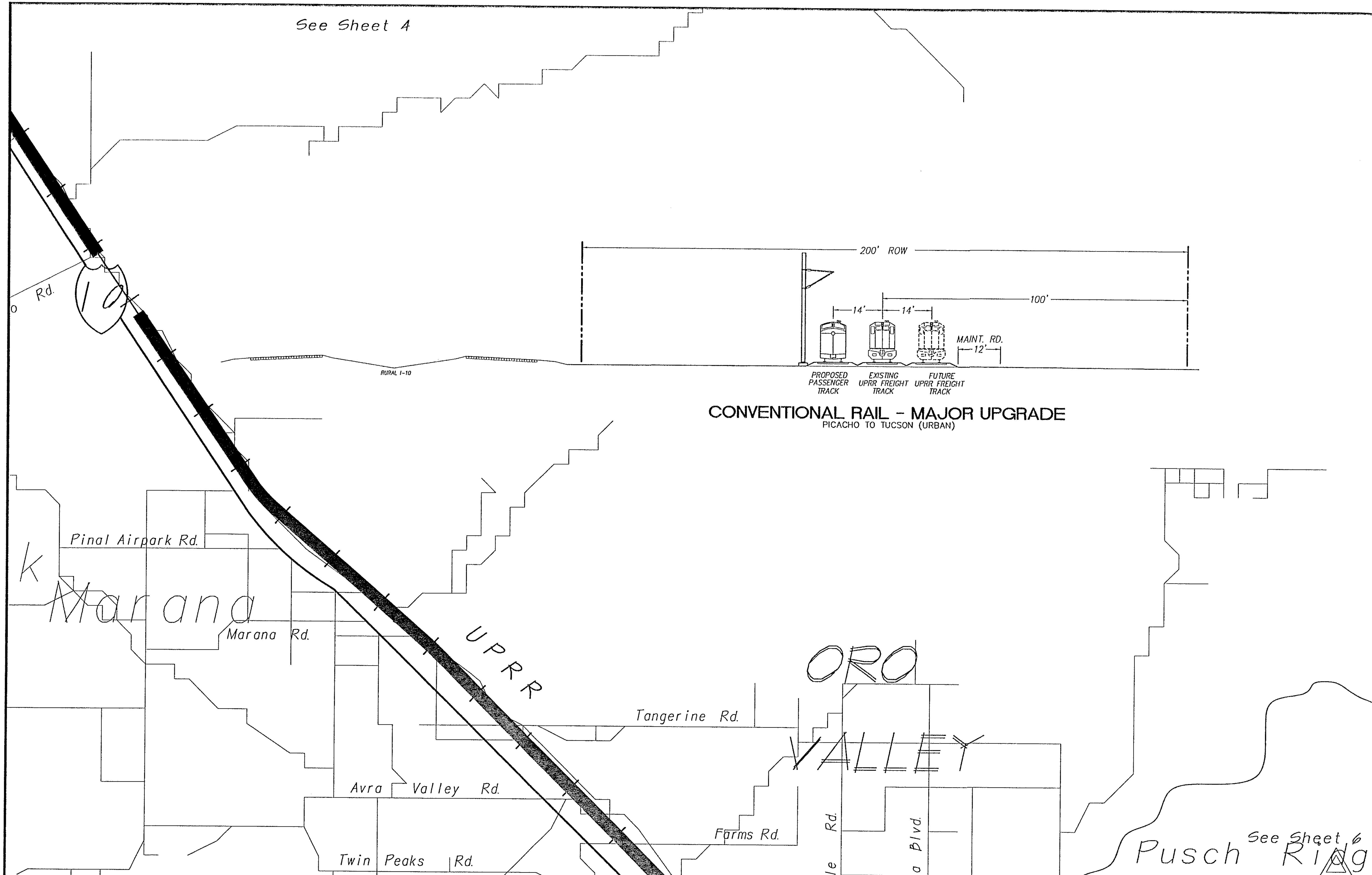
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
CONVENTIONAL RAIL ALTERNATIVE-MAJOR UPGRADE

MAR., 1998

G:\067600.01\DWG\plan-sht\01A4PLN4 Wed Mar 04 13:45:01 1998

XREF: O001BASE, O001ALTS



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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY MAR., 1998
CONVENTIONAL RAIL ALTERNATIVE- MAJOR UPGRADE

G:\067600.01\DWG\plan-sht\01A4PLN5 Wed Mar 04 13:45:40 1998
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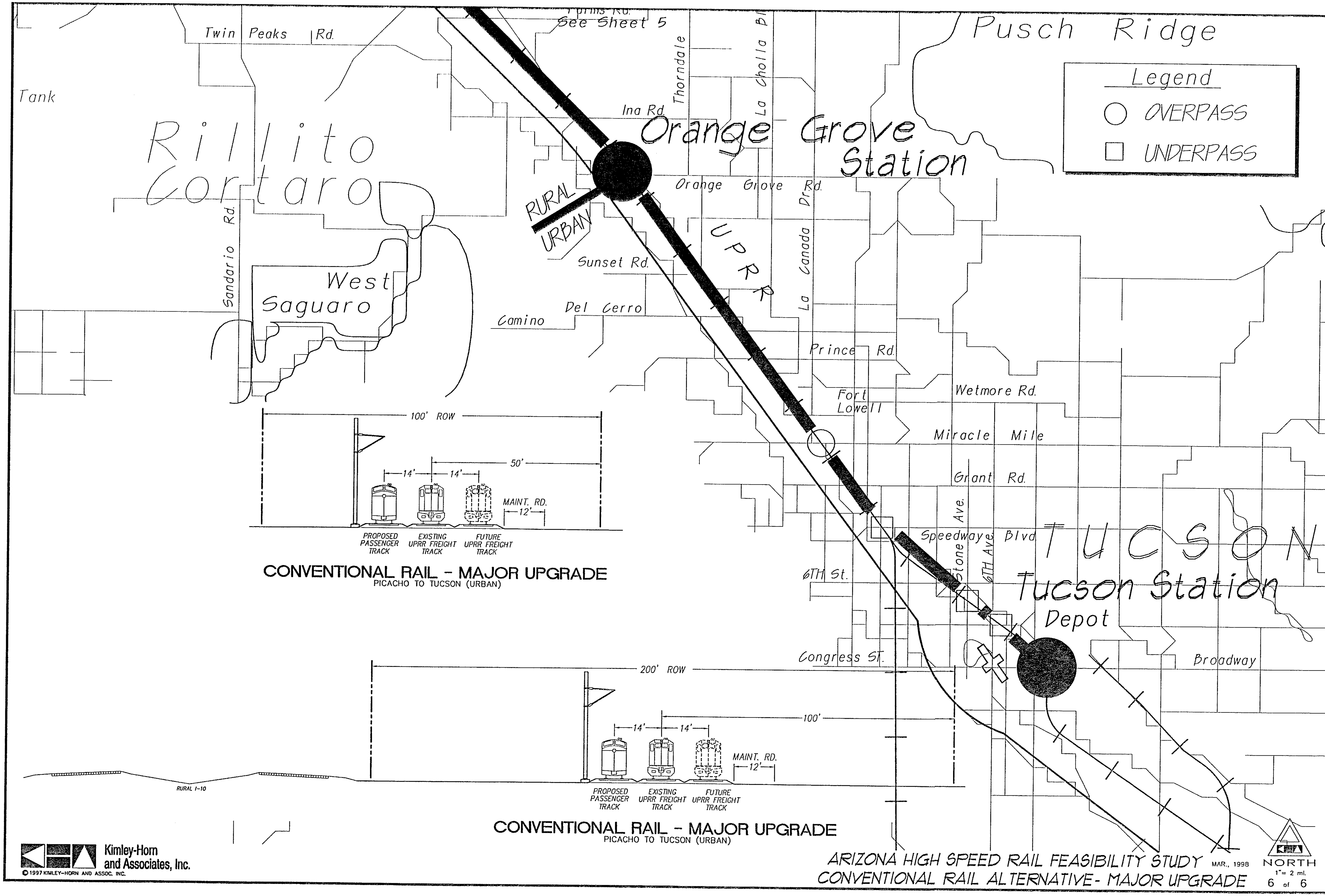
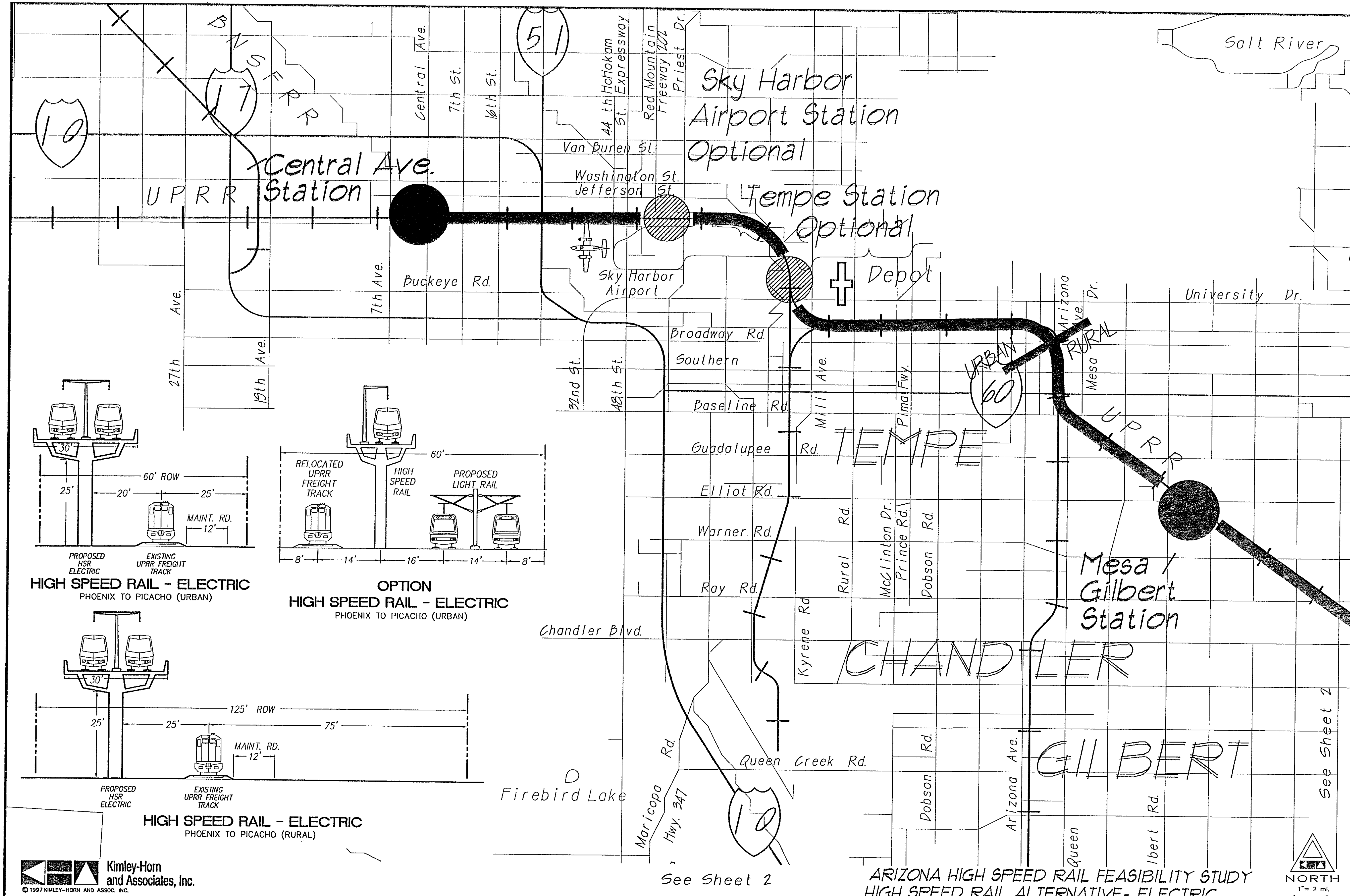


G:\067600.01\DWG\plan-sht\01A4PLN6 Wed Mar 04 13:46:13 1998

XREF: 0001BASE, 0001ALTS



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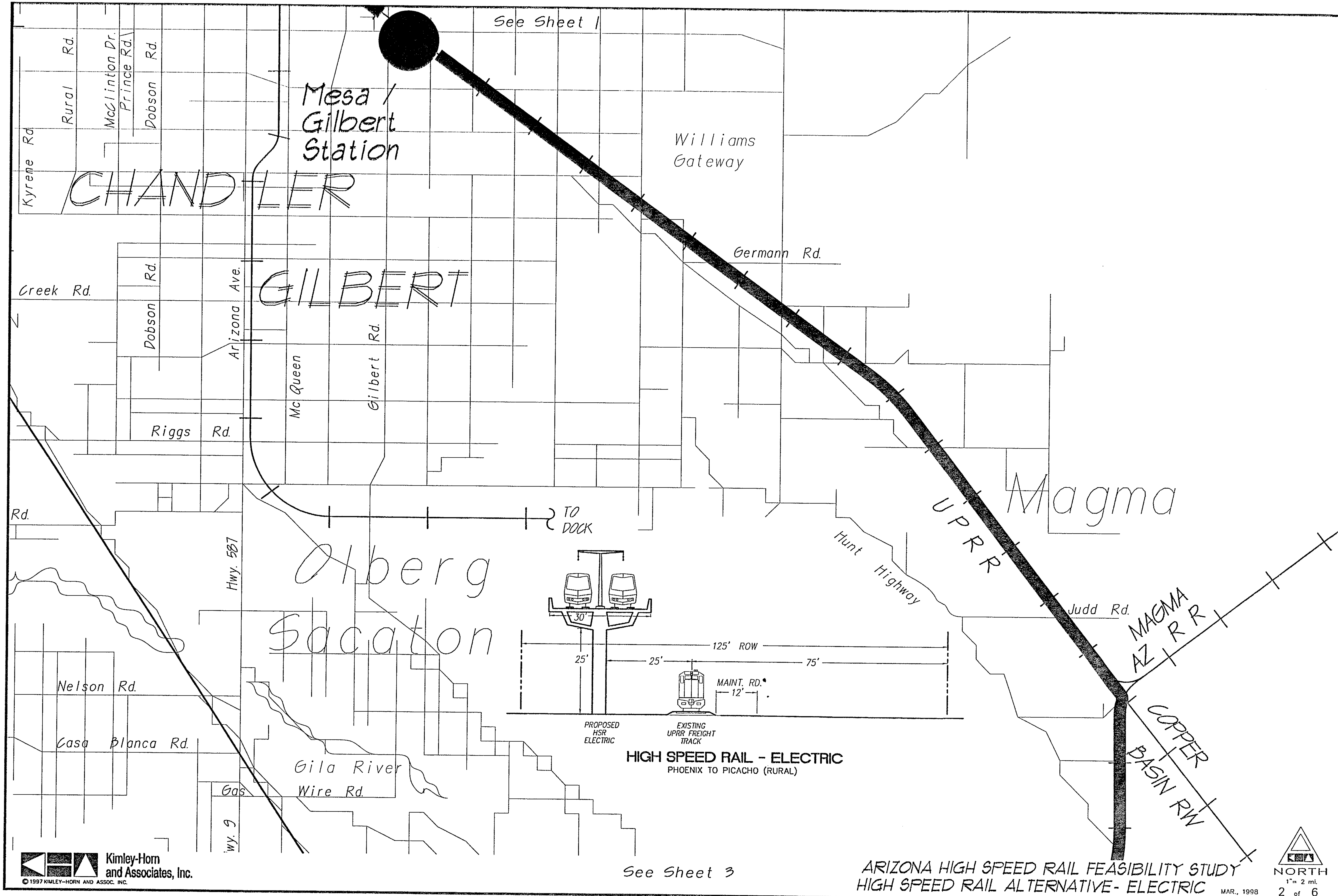
XREF: 0001BASE, 0001ALTS



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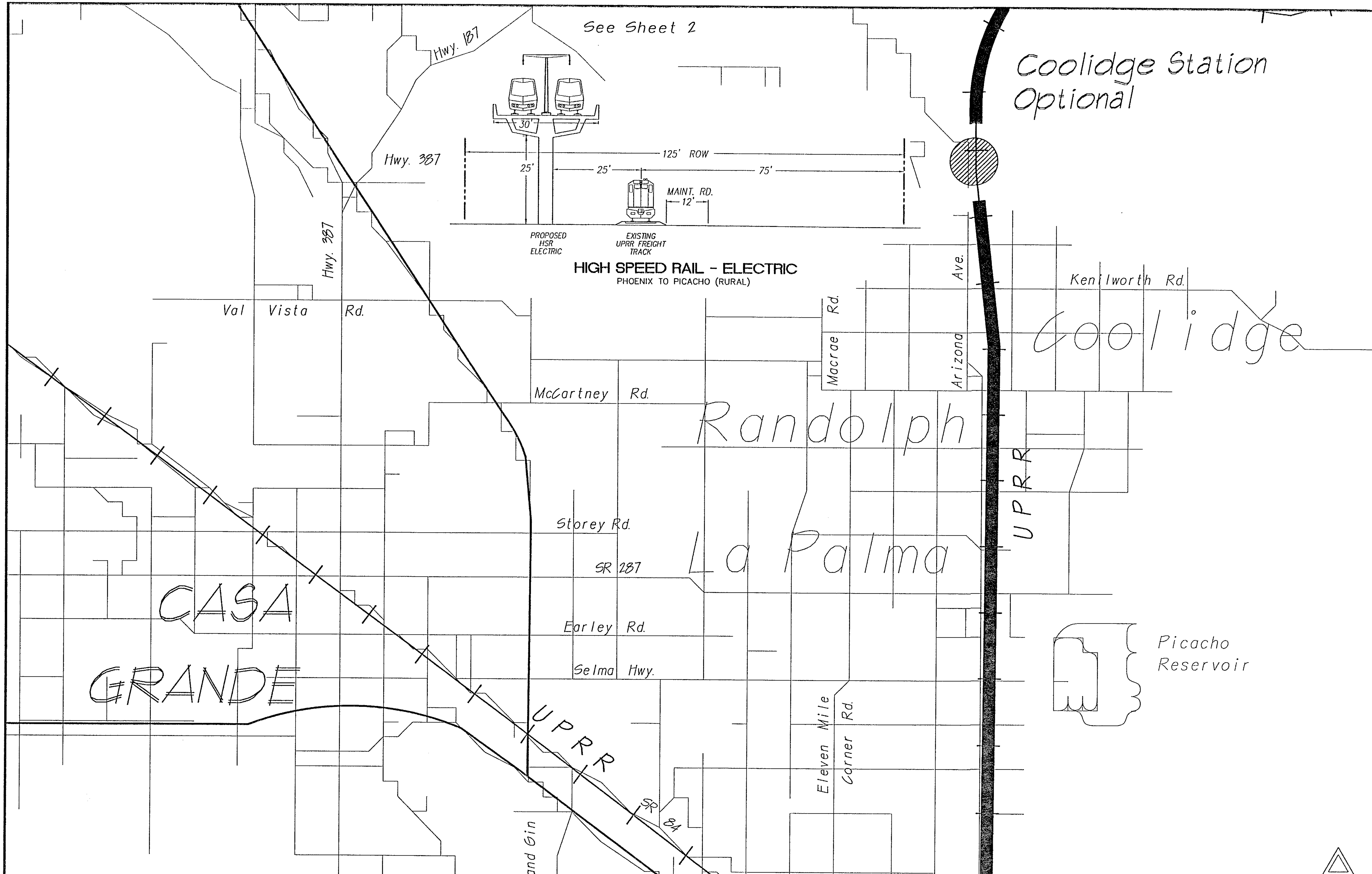

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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNITAVE- ELECTRIC

MAR., 1998

XREF: 0001BASE, 0001ALTS

G:\067600.01\DWG\plan-sht\01A5PLN3 Wed Mar 04 13:49:26 1998

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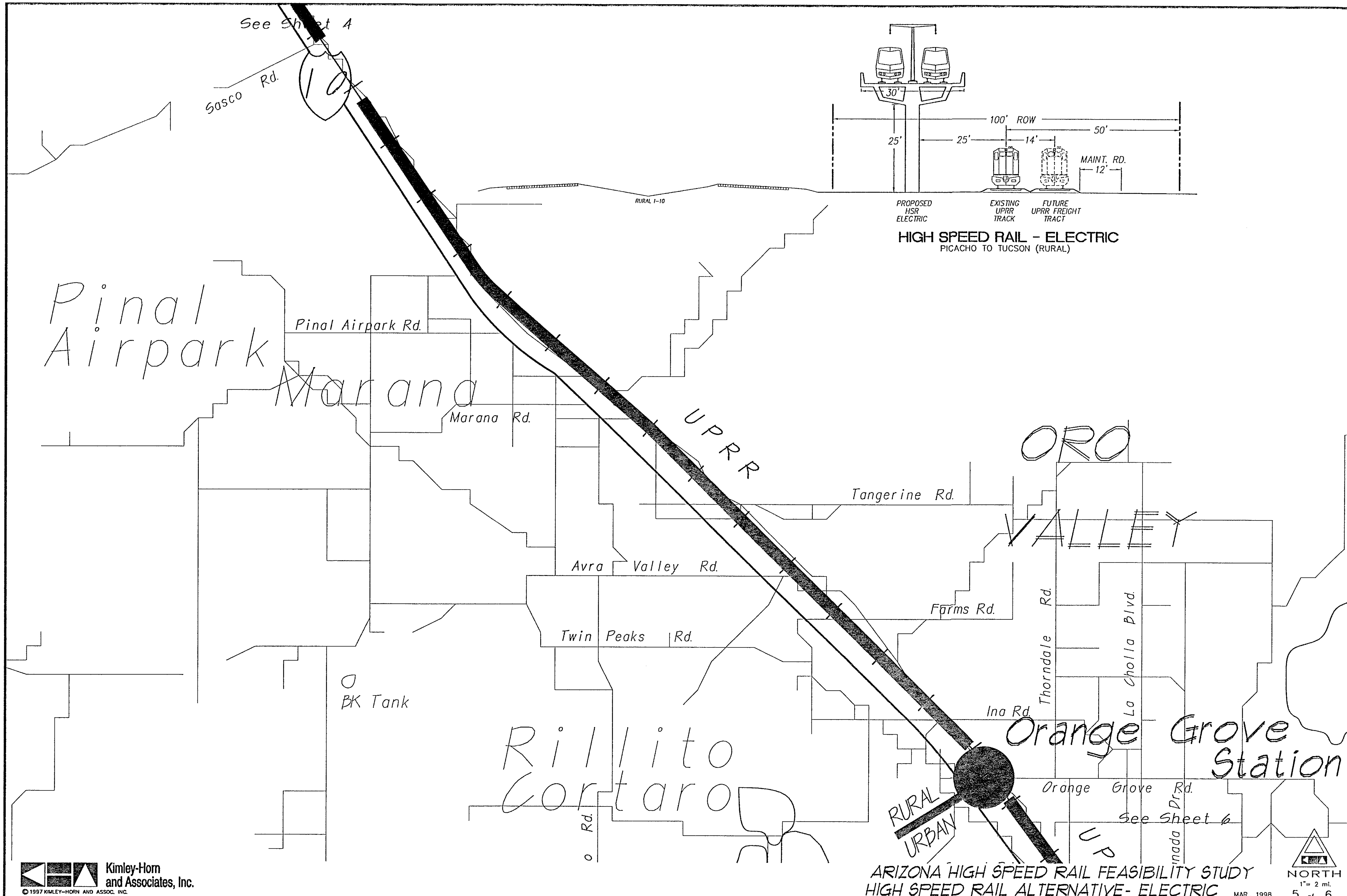
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- ELECTRIC

MAR., 1998

G:\067600.01\DWG\plan-sht\01A5PLN4 Wed Mar 04 13:50:00 1998

XREF: 0001BASE, 0001ALTS



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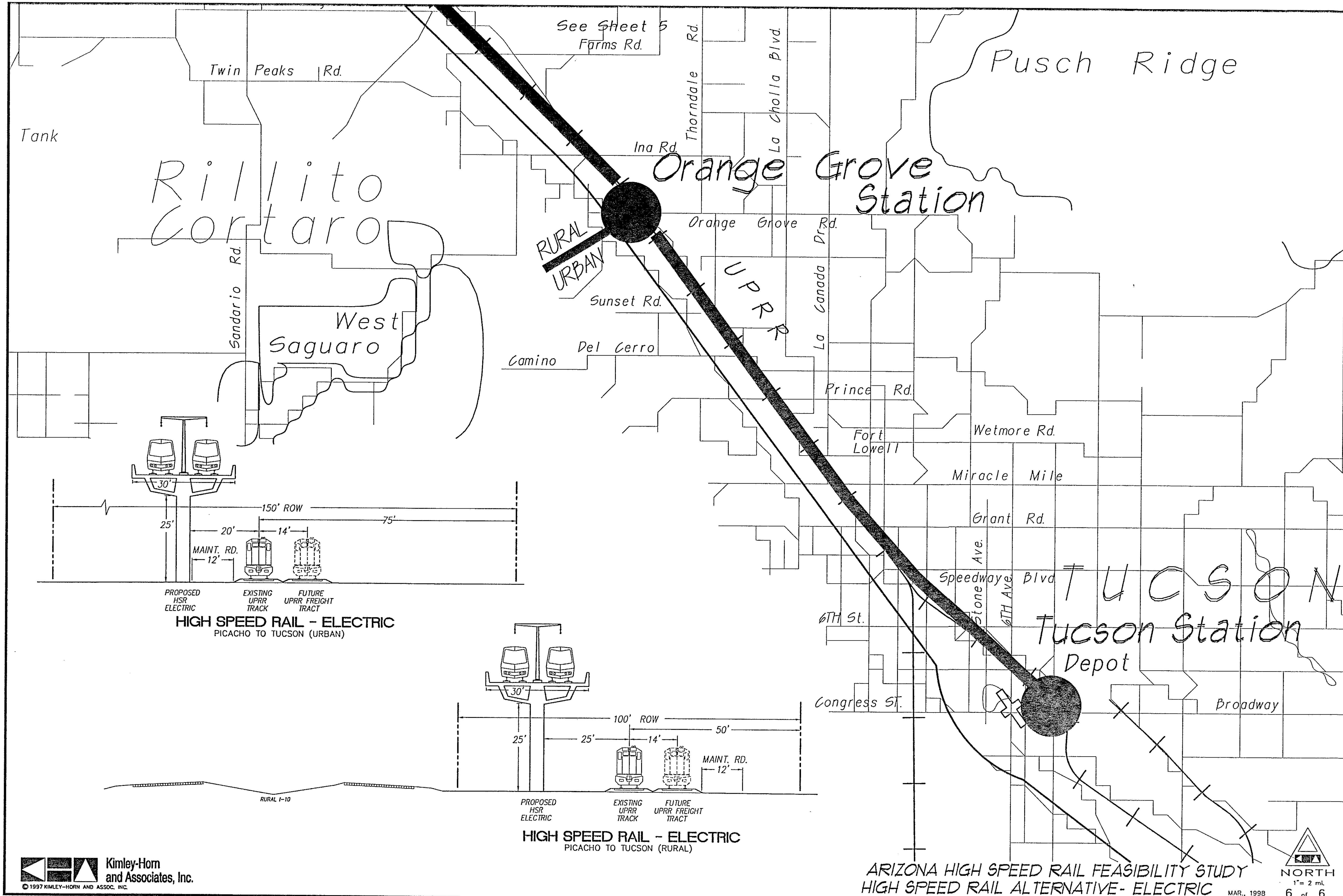
XREF: 0001BASE, 0001ALTS



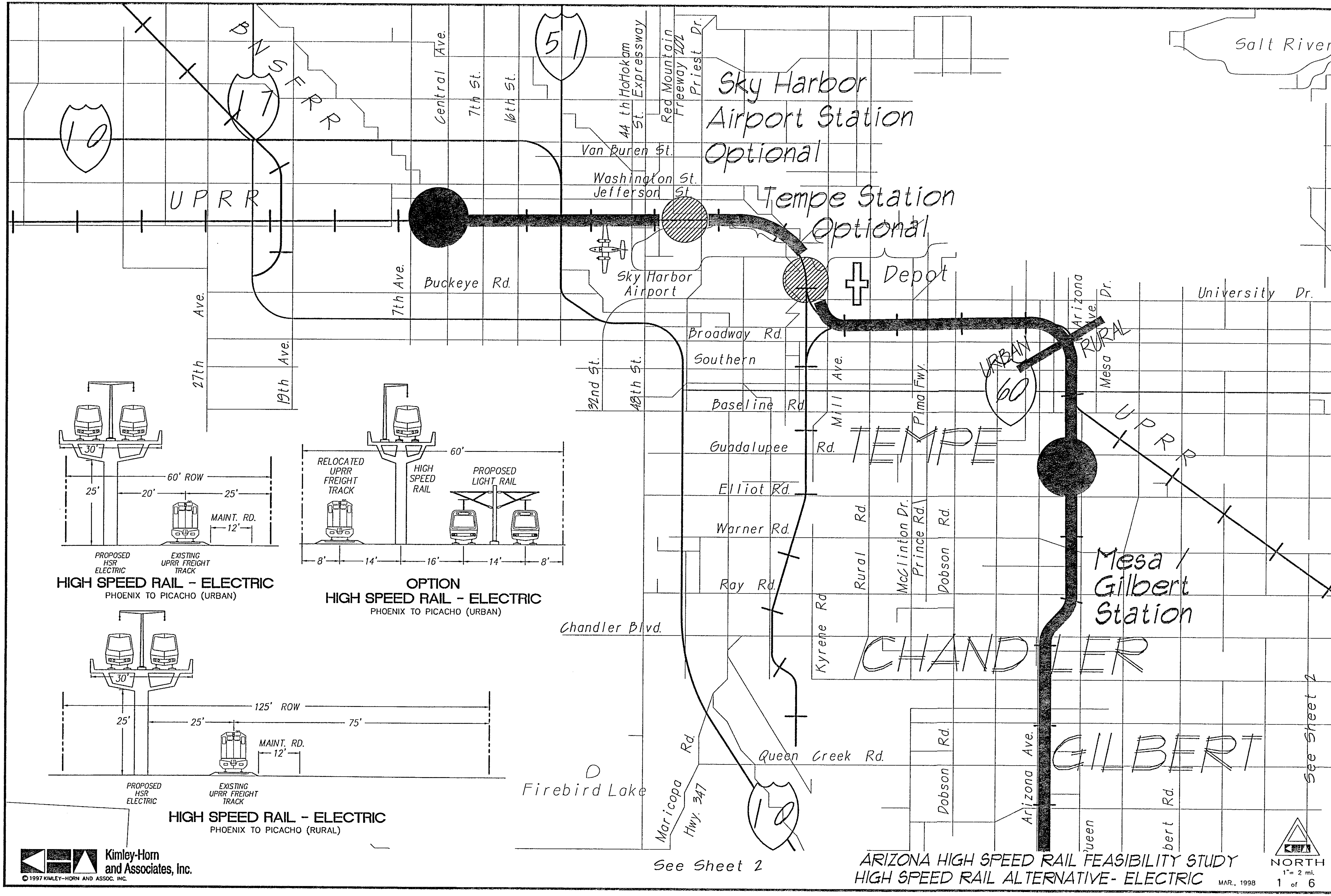
G:\067600.01\DWG\plan-sht\01A5PLN6 Wed Mar 04 13:51:20 1998

XREF: 0001BASE, 0001ALTS

Appendix M

Alternative 5b: High Speed Rail - Electric

Combined UP Railroad and I-10 Option



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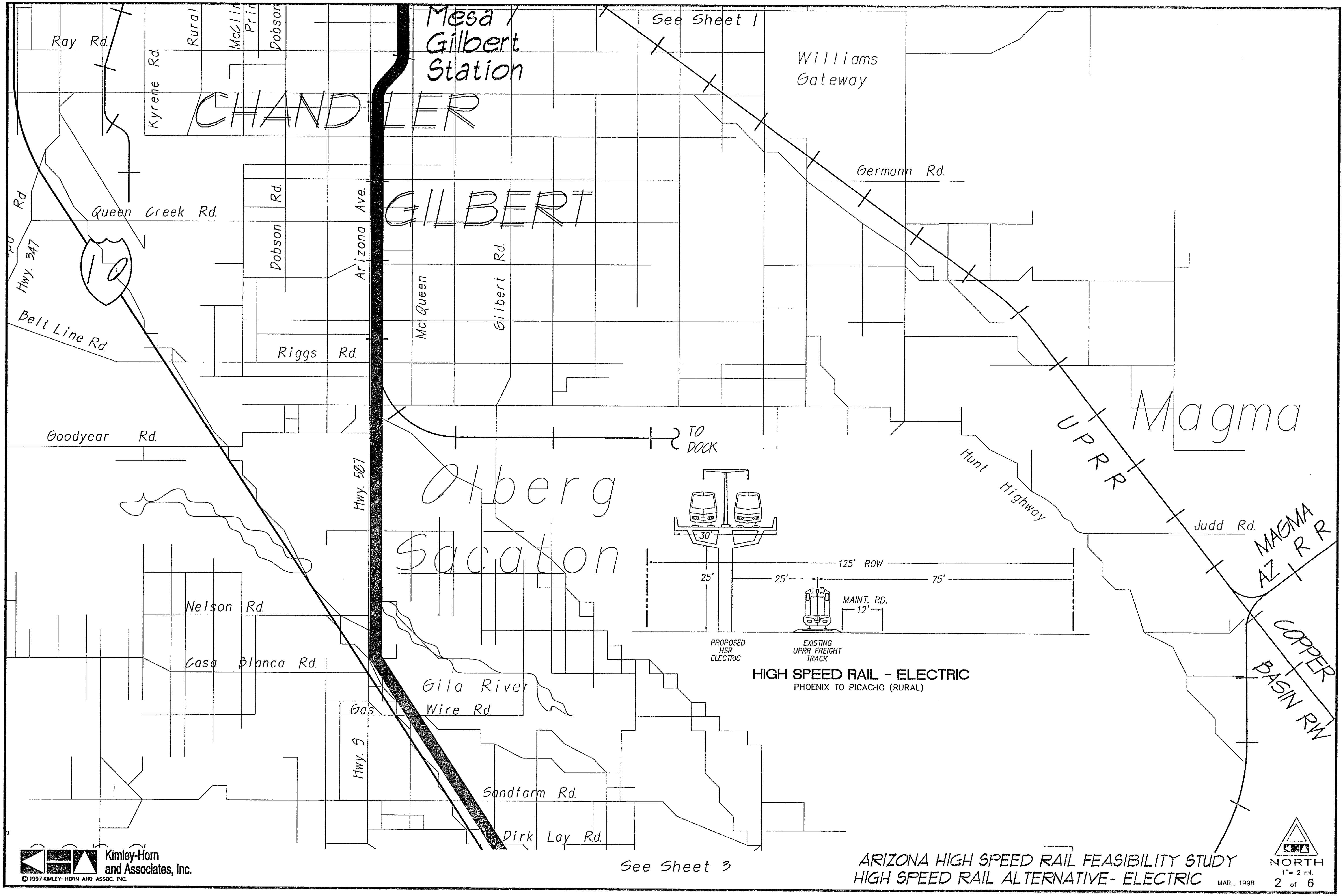

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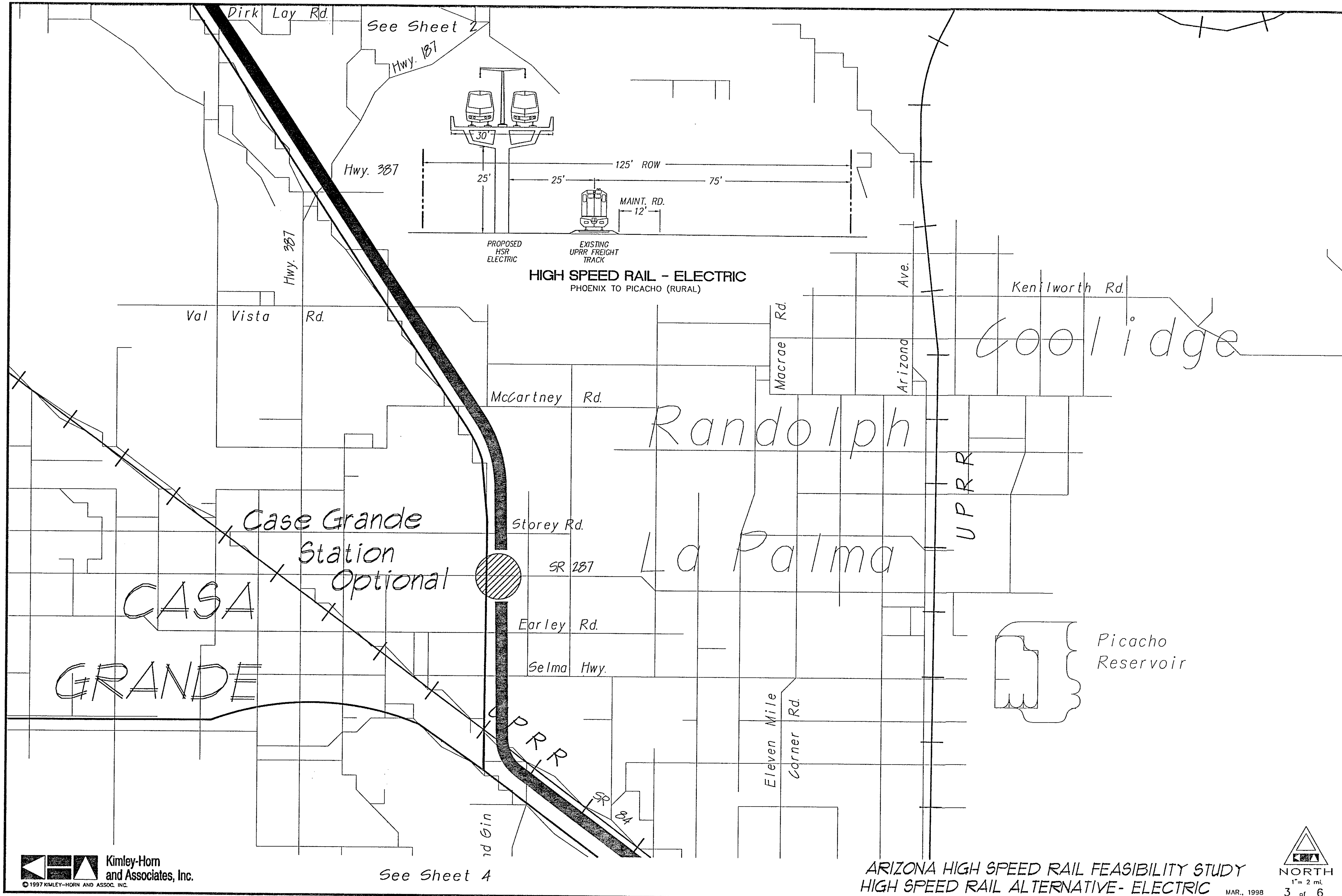

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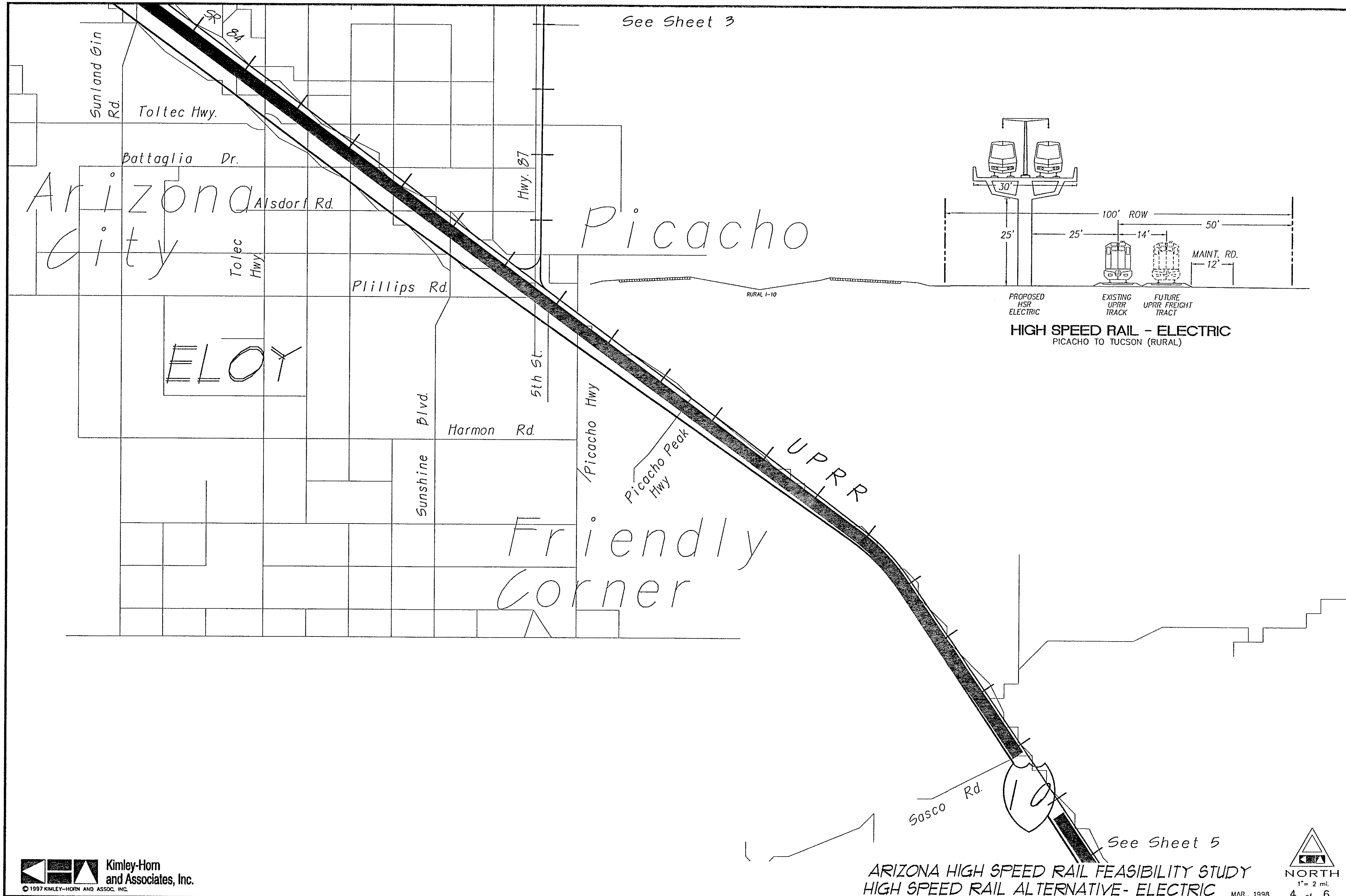

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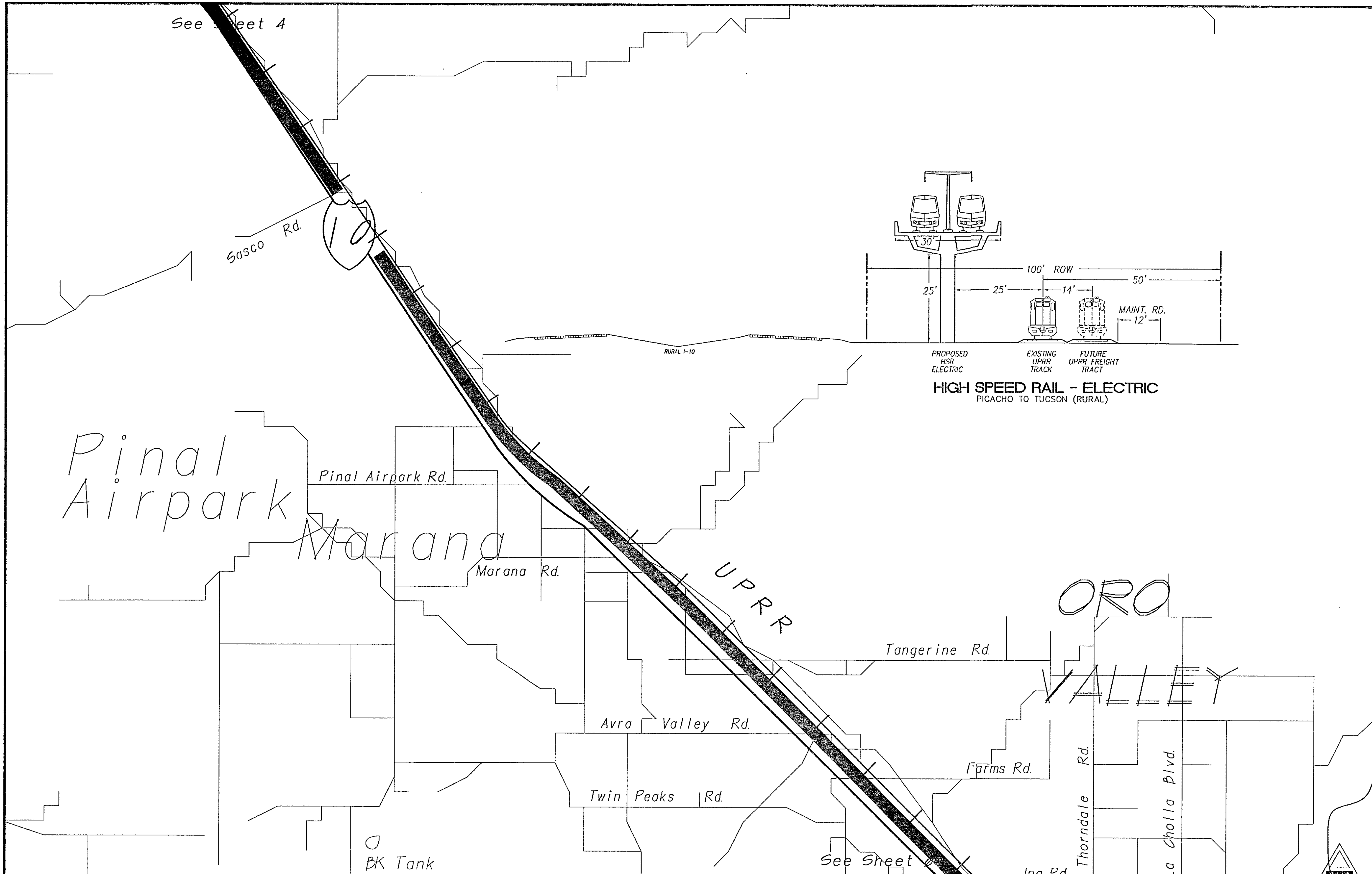

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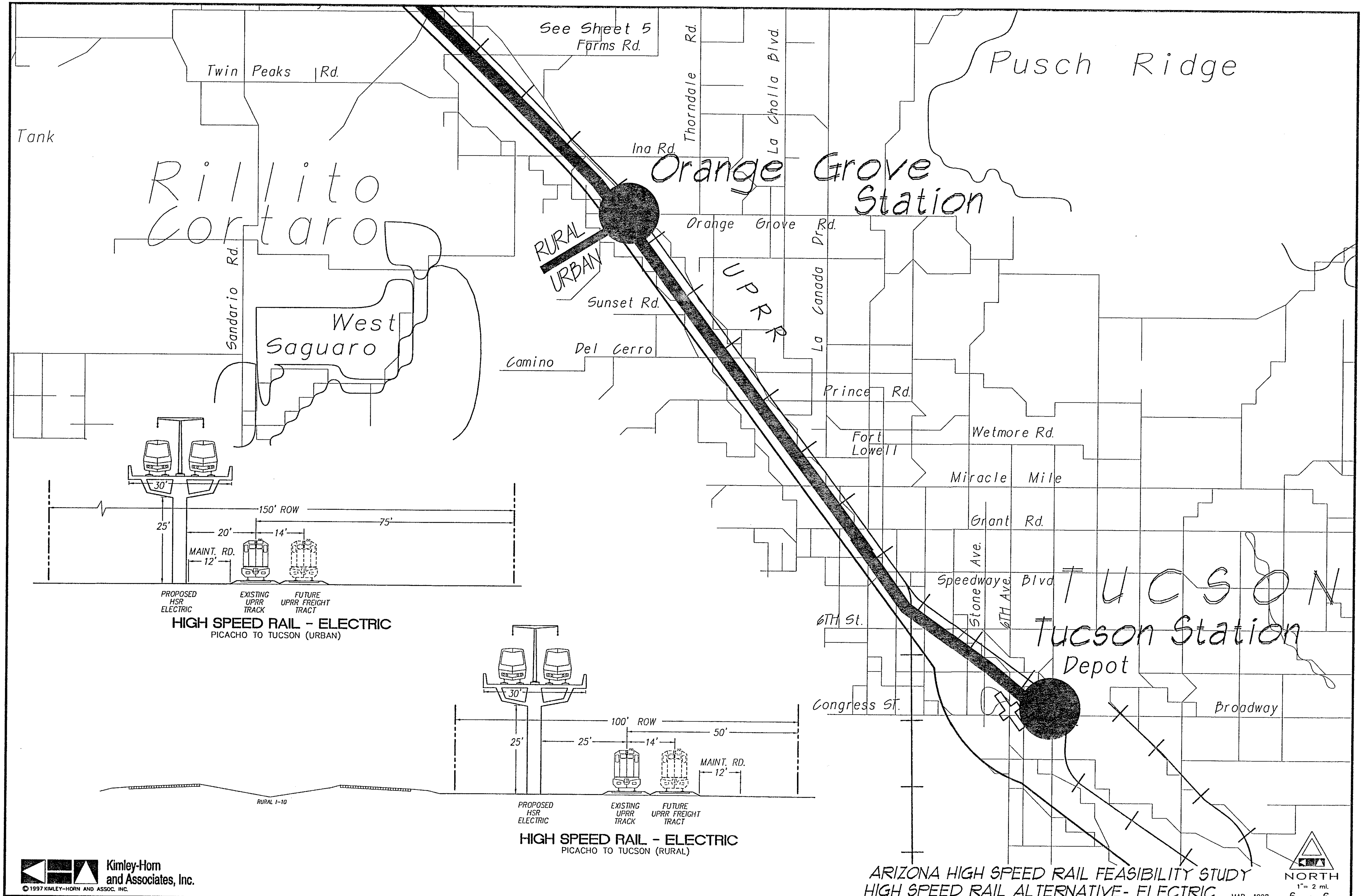
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY

HIGH SPEED RAIL ALTERNATIVE- ELECTRIC

MAR., 1998

G:\067600.01\DWG\plan-sht\015BPLN5 Wed Mar 04 13:27:46 1998

XREF: 0001BASE, 0001ALTS



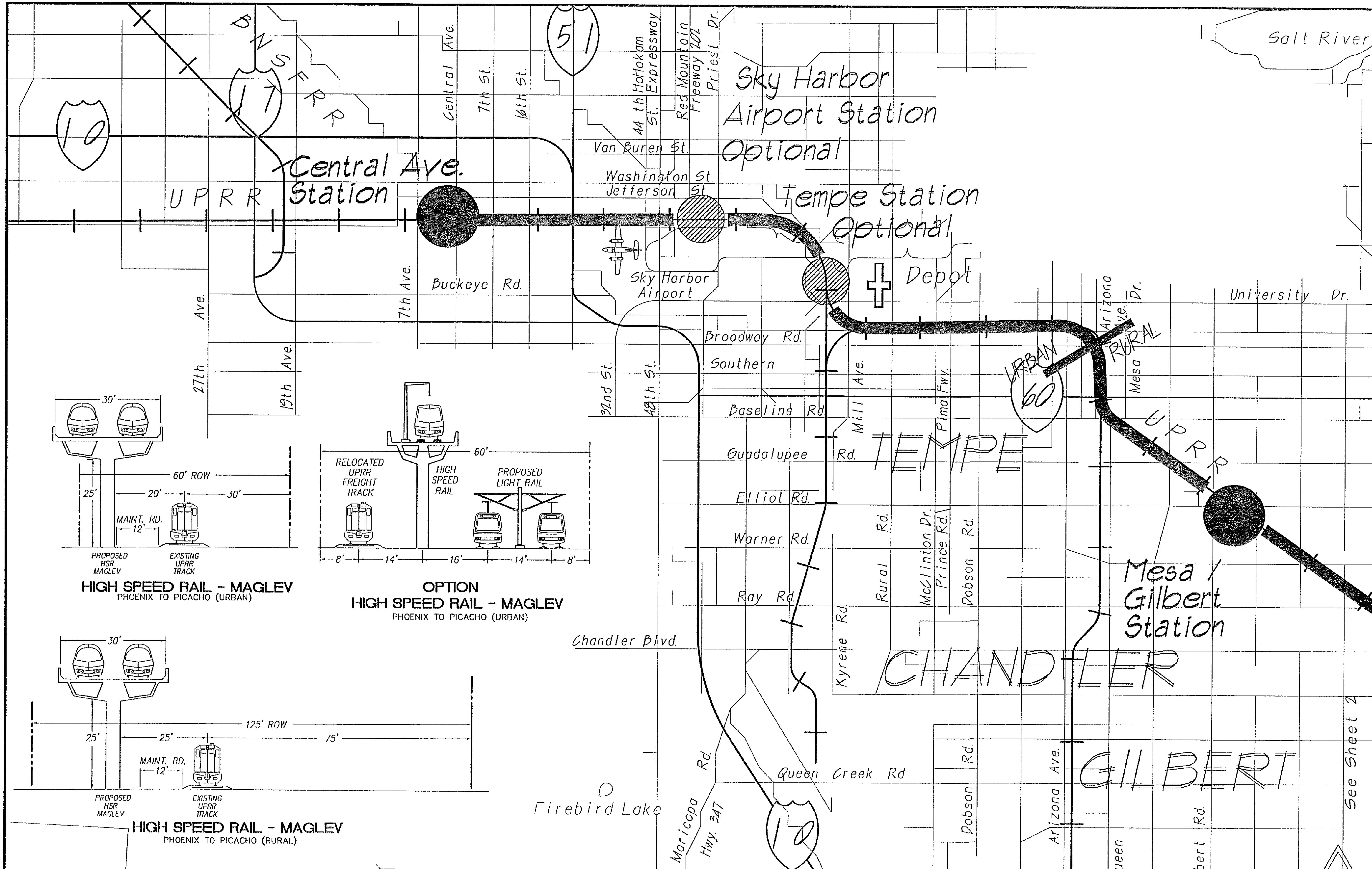
G:\067600.01\DWG\plan-sht\015BPLN6 Wed Mar 04 13:28:22 1998

XREF: 0001BASE, 0001ALTS

Appendix N

Alternative 6a: High Speed Rail - Maglev

UP Railroad Alignment Option



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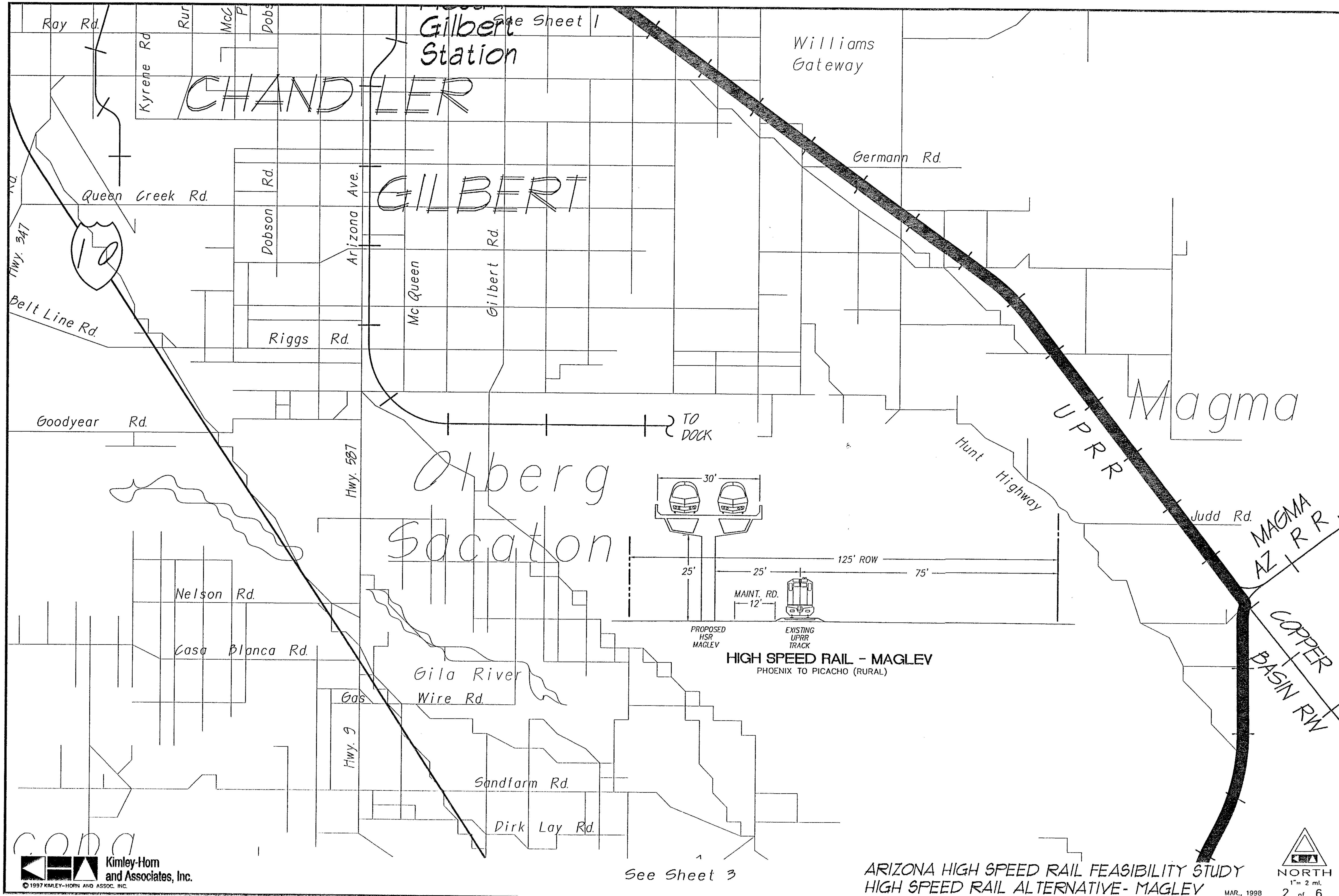
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

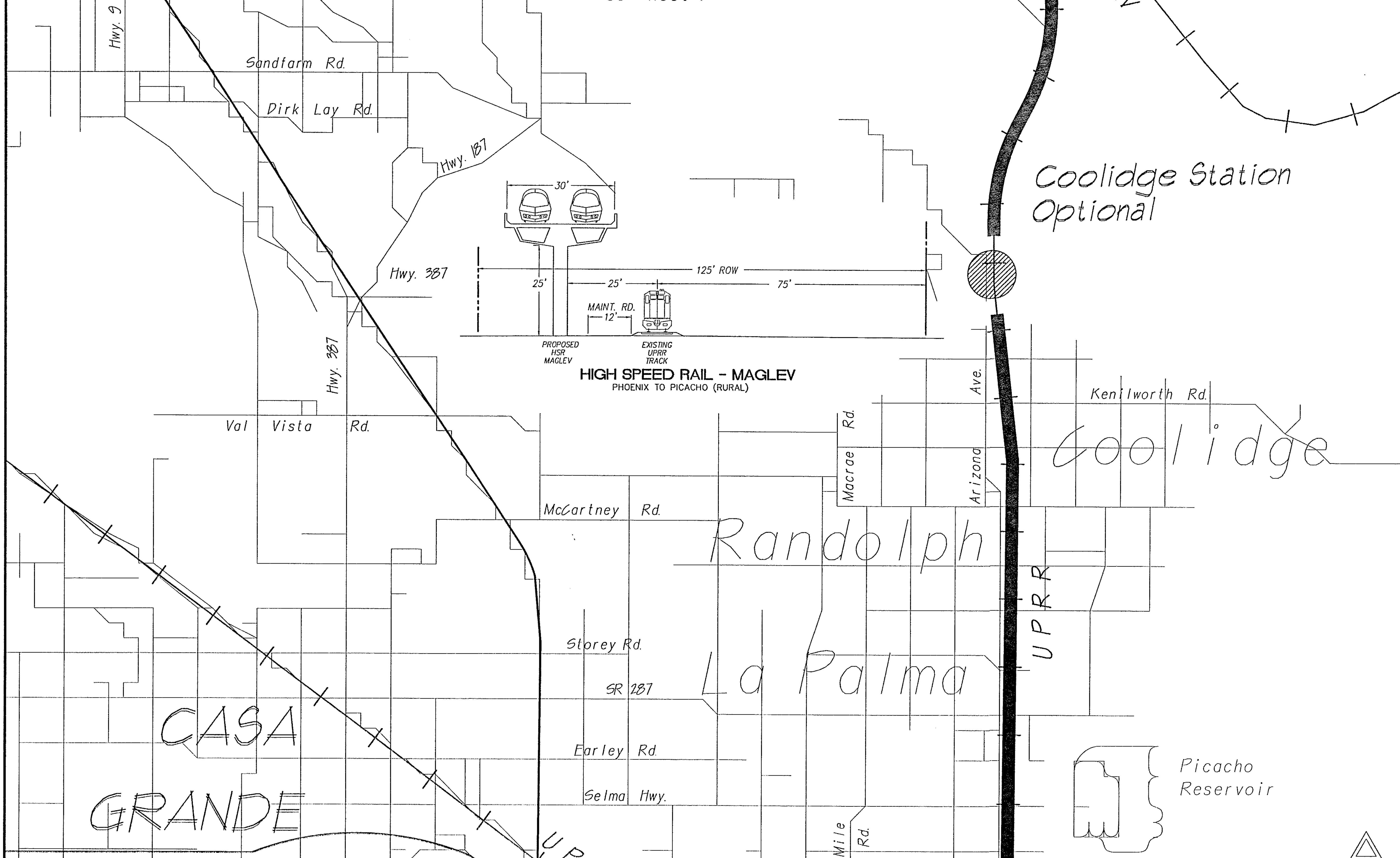
G:\067600.01\DWG\plan-sht\01A6PLN1 Wed Mar 04 13:53:00 1998
XREF: 0001BASE, 0001ALTS



G:\067600.01\DWG\plan-sht\01A6PLN2 Wed Mar 04 13:54:06 1998

XREF: 0001BASE, 0001ALTS

See Sheet 2



See Sheet 4

Kimley-Horn and Associates, Inc.

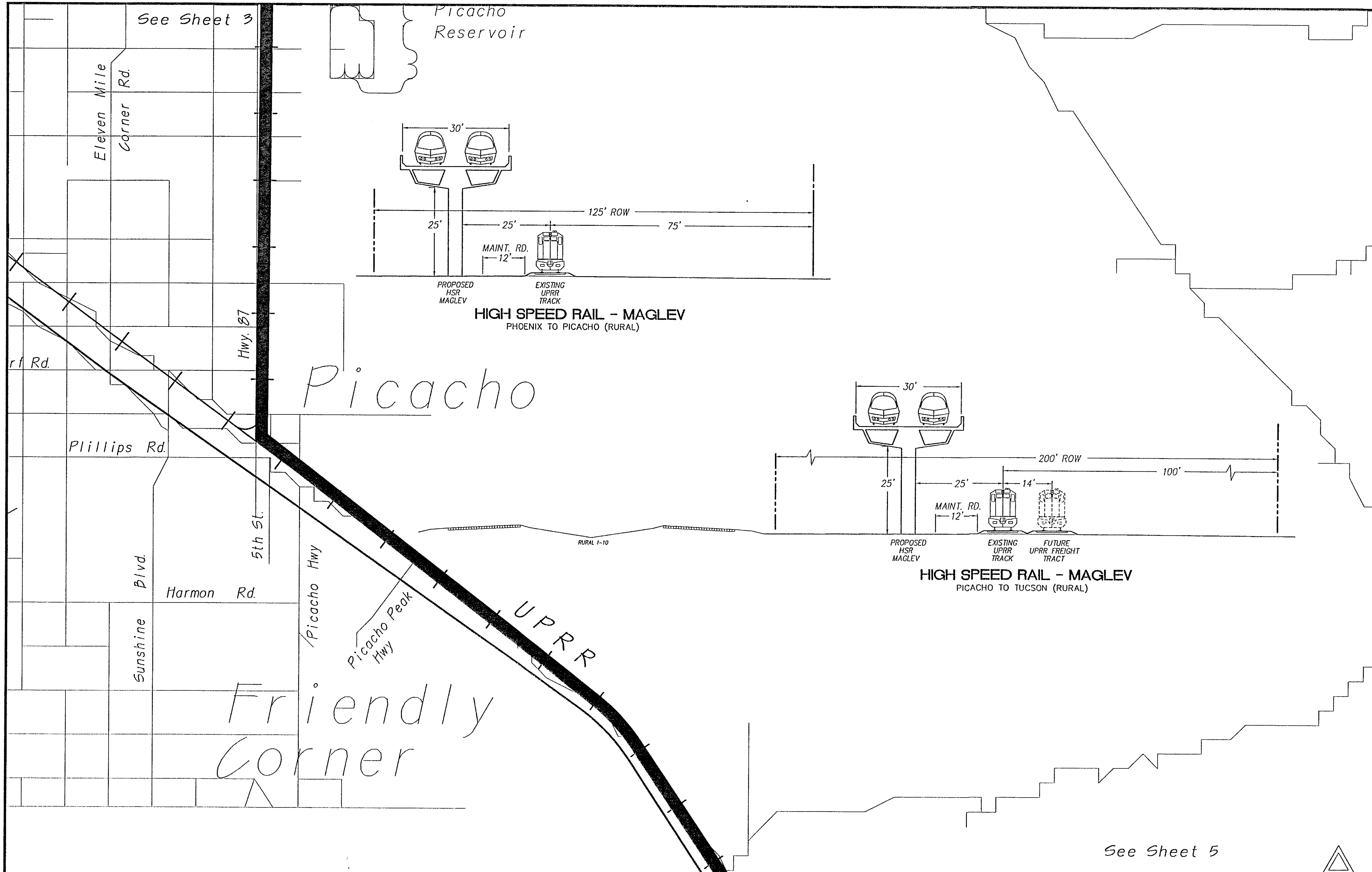
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

NORTH
1" = 2 mi.

G:\067600.01\DWG\plan-sht\01A6PLN3 Wed Mar 04 13:54:39 1998

XREF: 0001BASE, 0001ALTS



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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

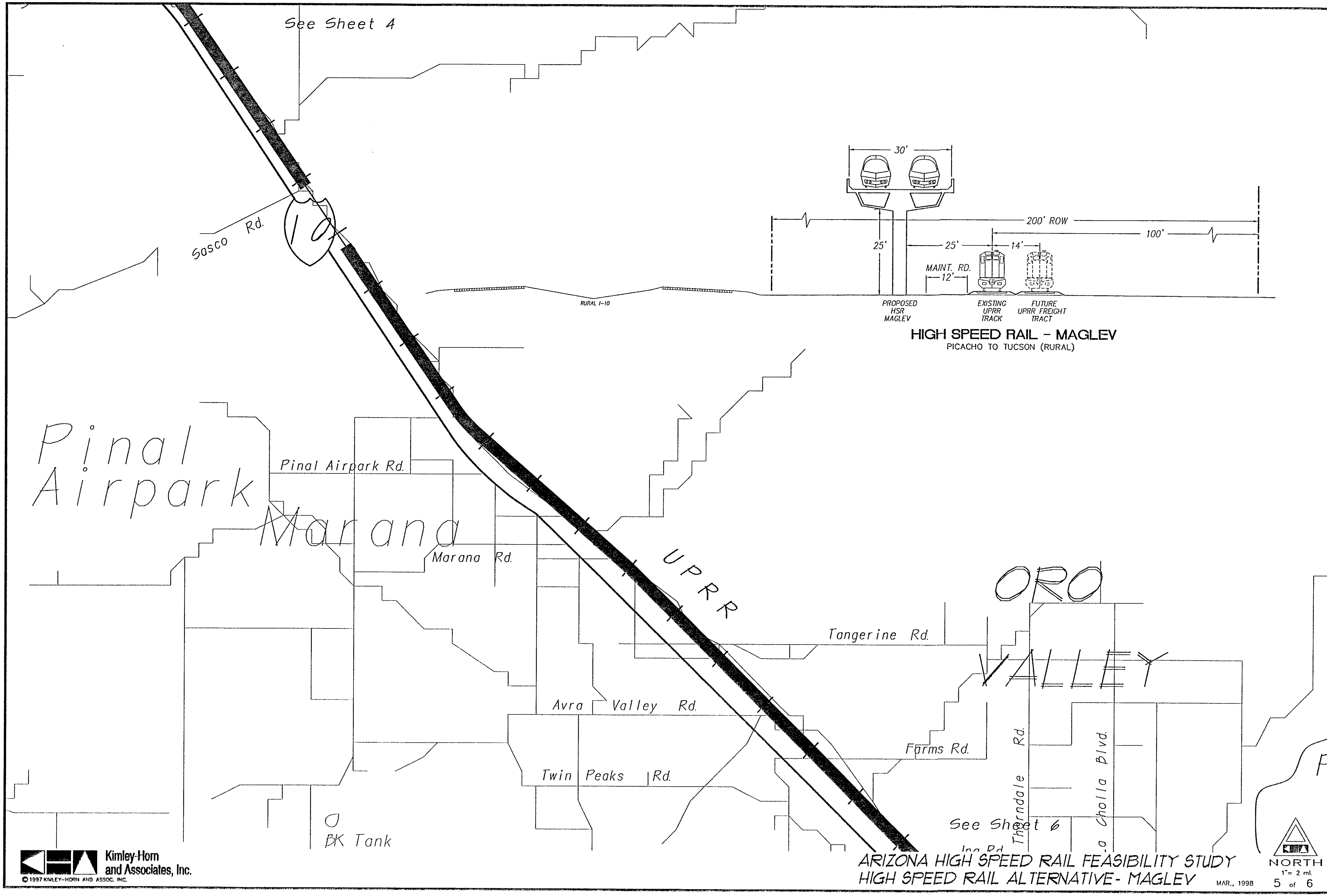
MAR., 1998

NORTH
1"= 2 mi.

4 of 6

G:\067600.01\DWG\plan-sht\01A6PLN4 Wed Mar 04 13:55:13 1998

XREF: 0001BASE, 0001ALTS



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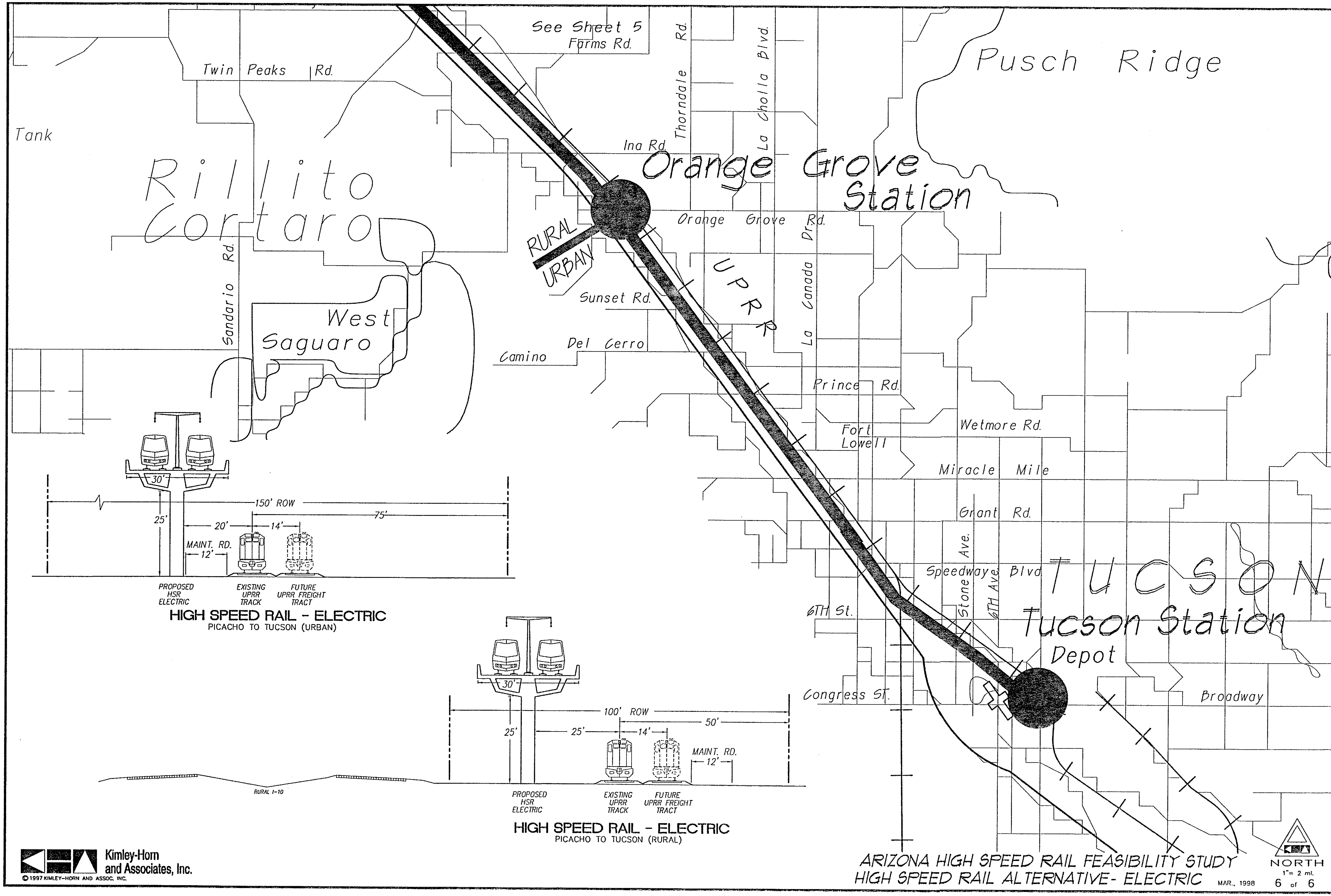


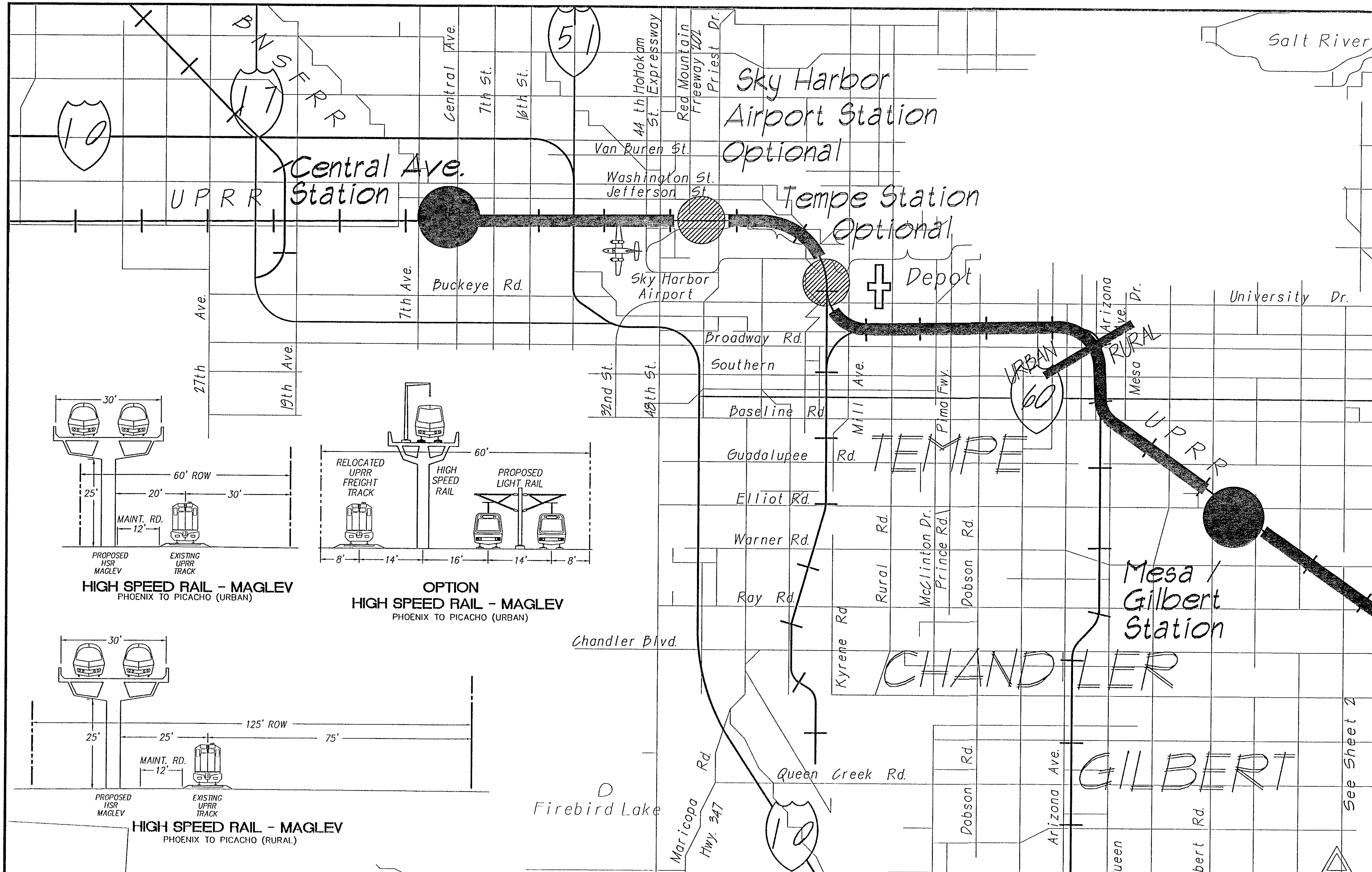
G:\067600.01\DWG\plan-sht\015BPLNG Wed Mar 04 13:28:22 1998

XREF: 0001BASE, 0001ALTS

Appendix N

Alternative 6a: High Speed Rail - Maglev

UP Railroad Alignment Option



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See Sheet 2

ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

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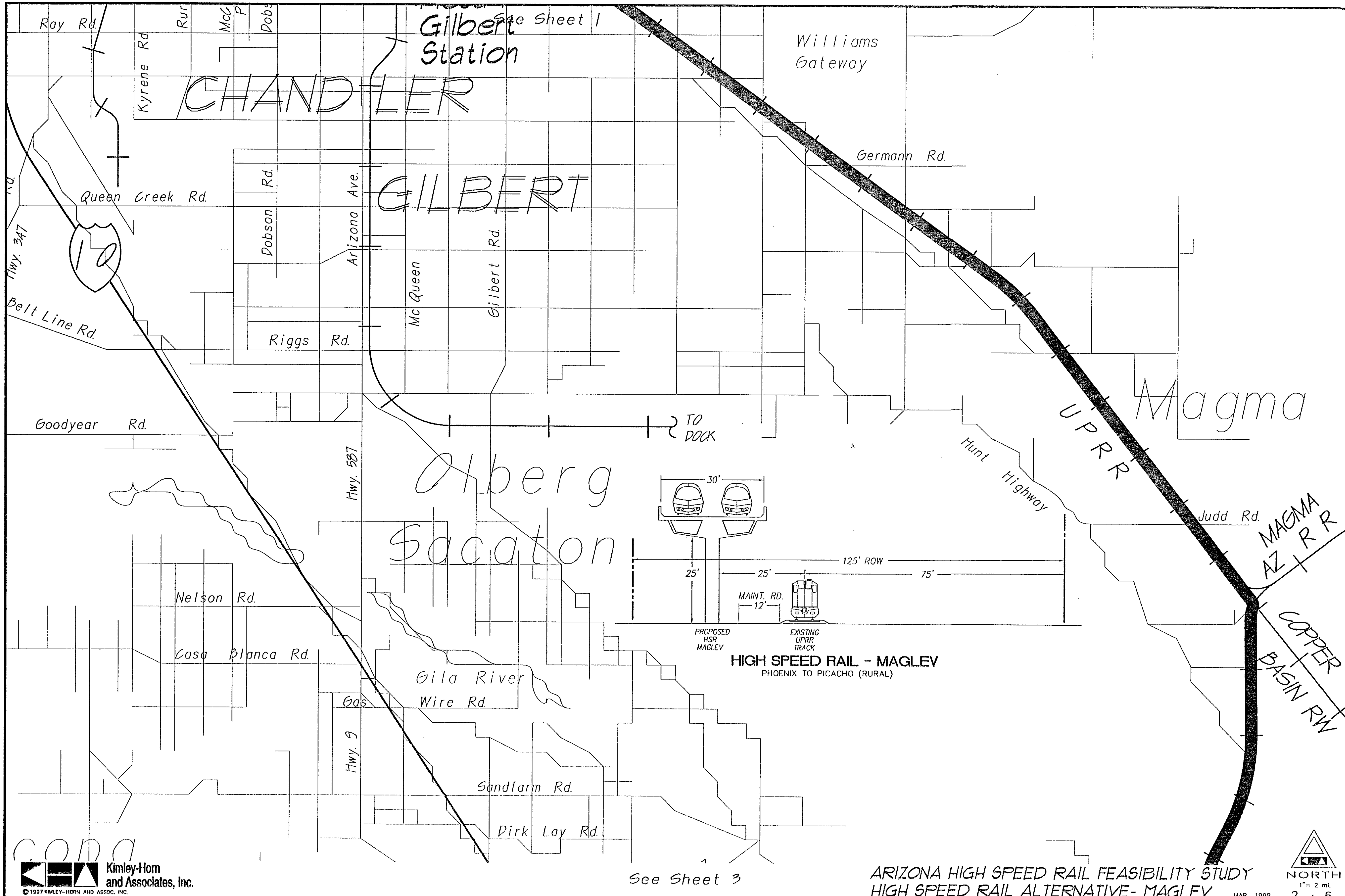
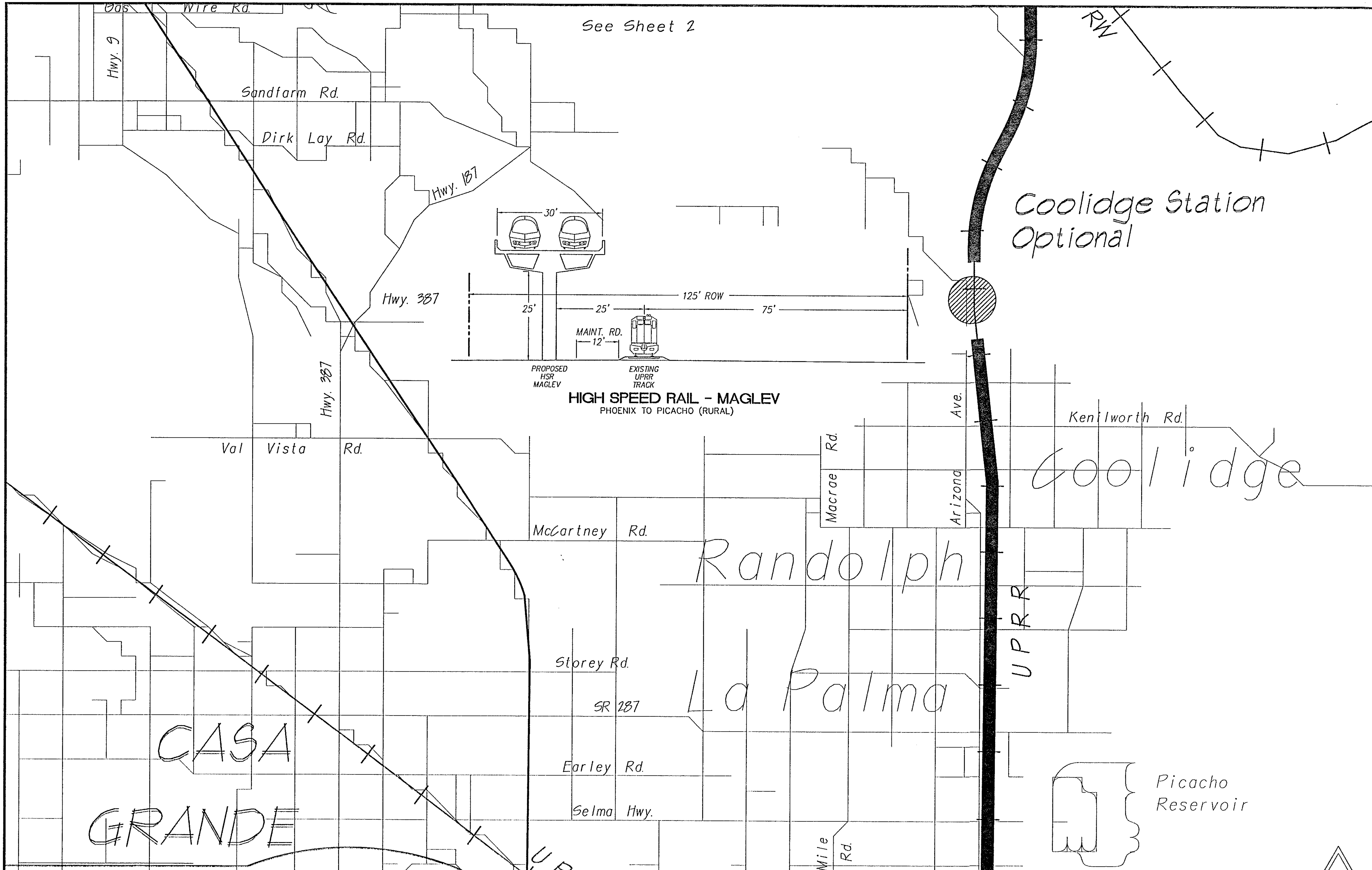


G:\067600.01\DWG\plan-sht\01A6PLN2 Wed Mar 04 13:54:06 1998

See Sheet 2



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See Sheet 4

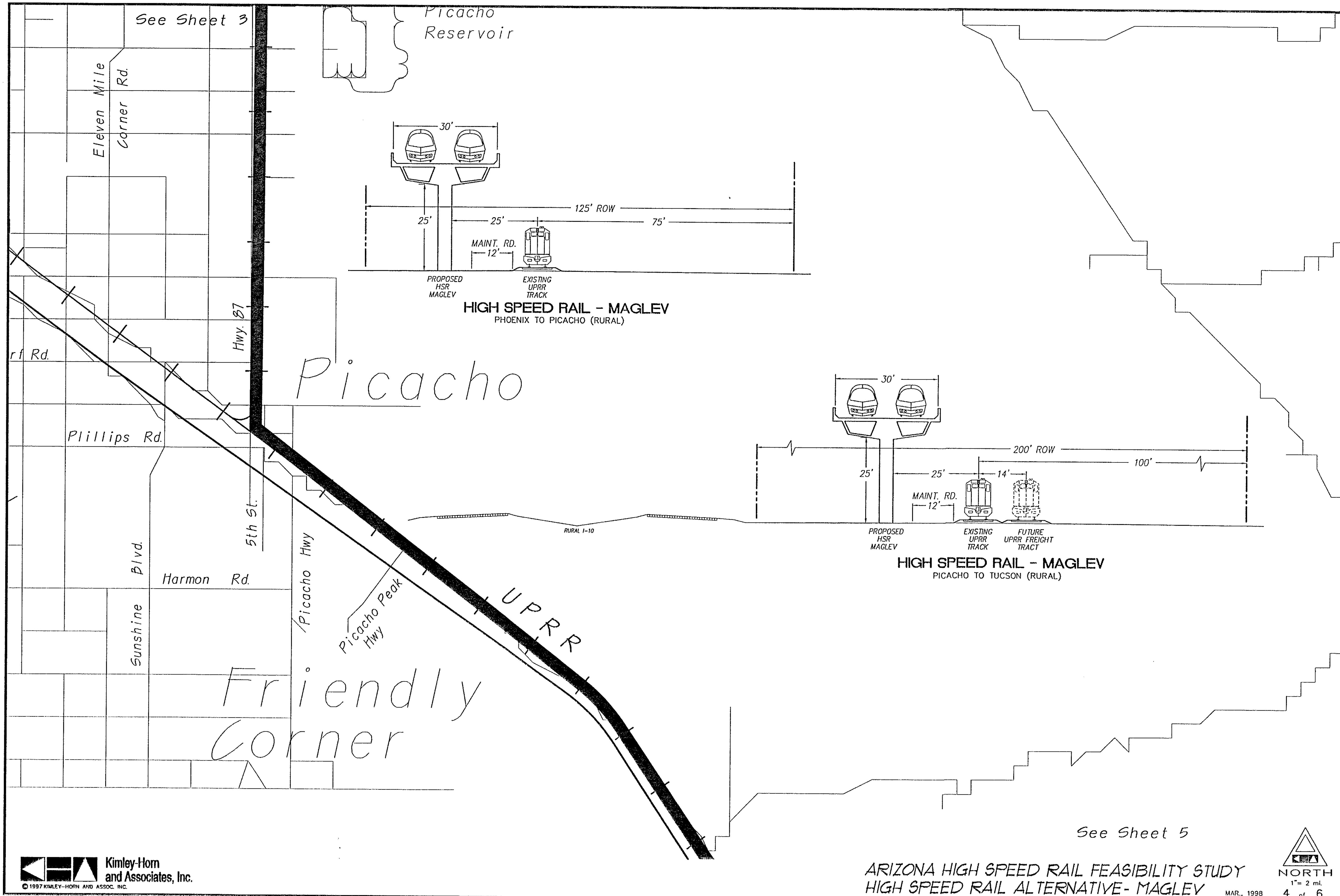
ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

NORTH
1" = 2 mi.

G:\067600.01\DWG\plan-sht\01A6PLN3 Wed Mar 04 13:54:39 1998

XREF: 0001BASE, 0001ALTS



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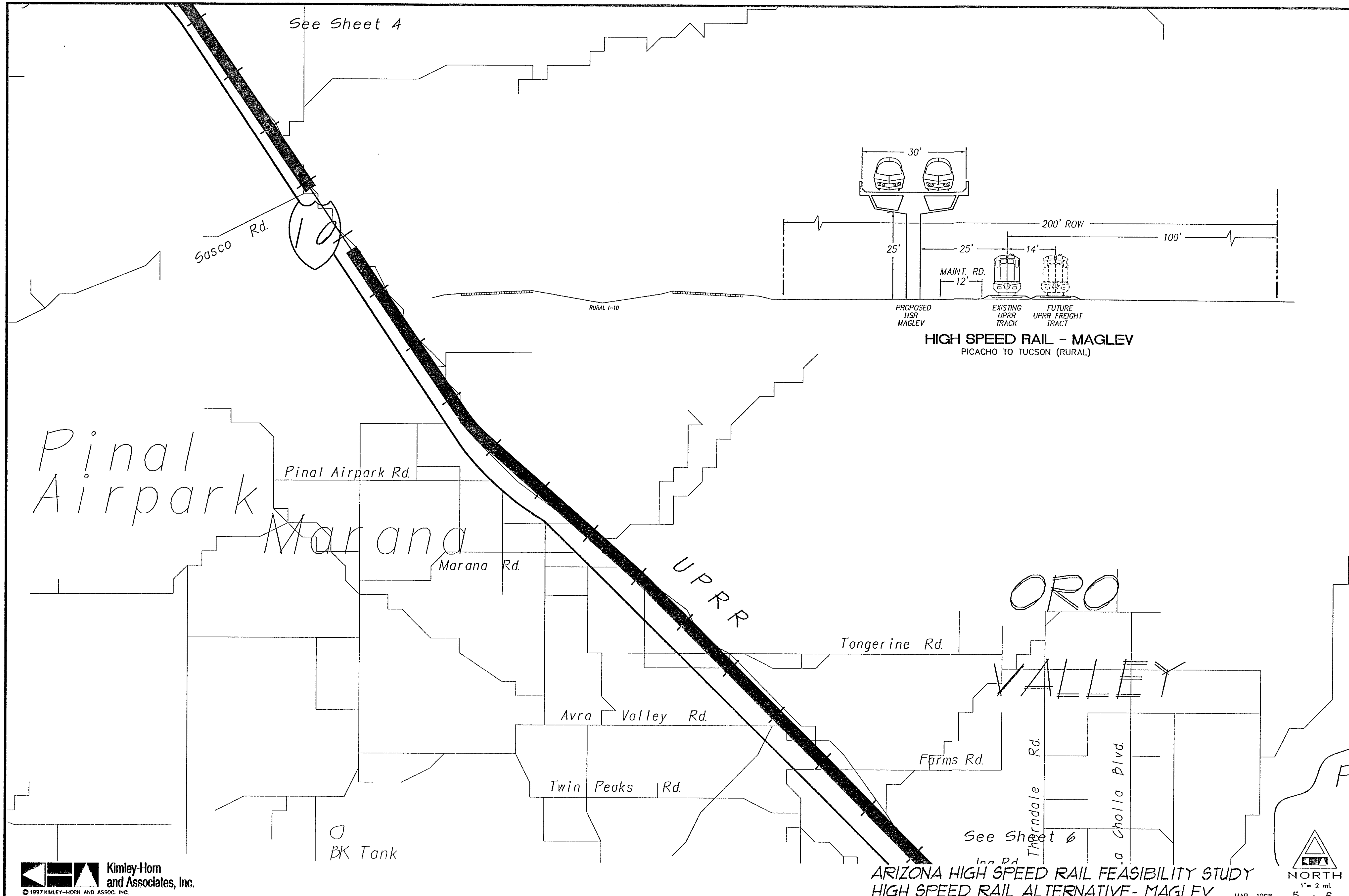
XREF: 0001BASE, 0001ALTS



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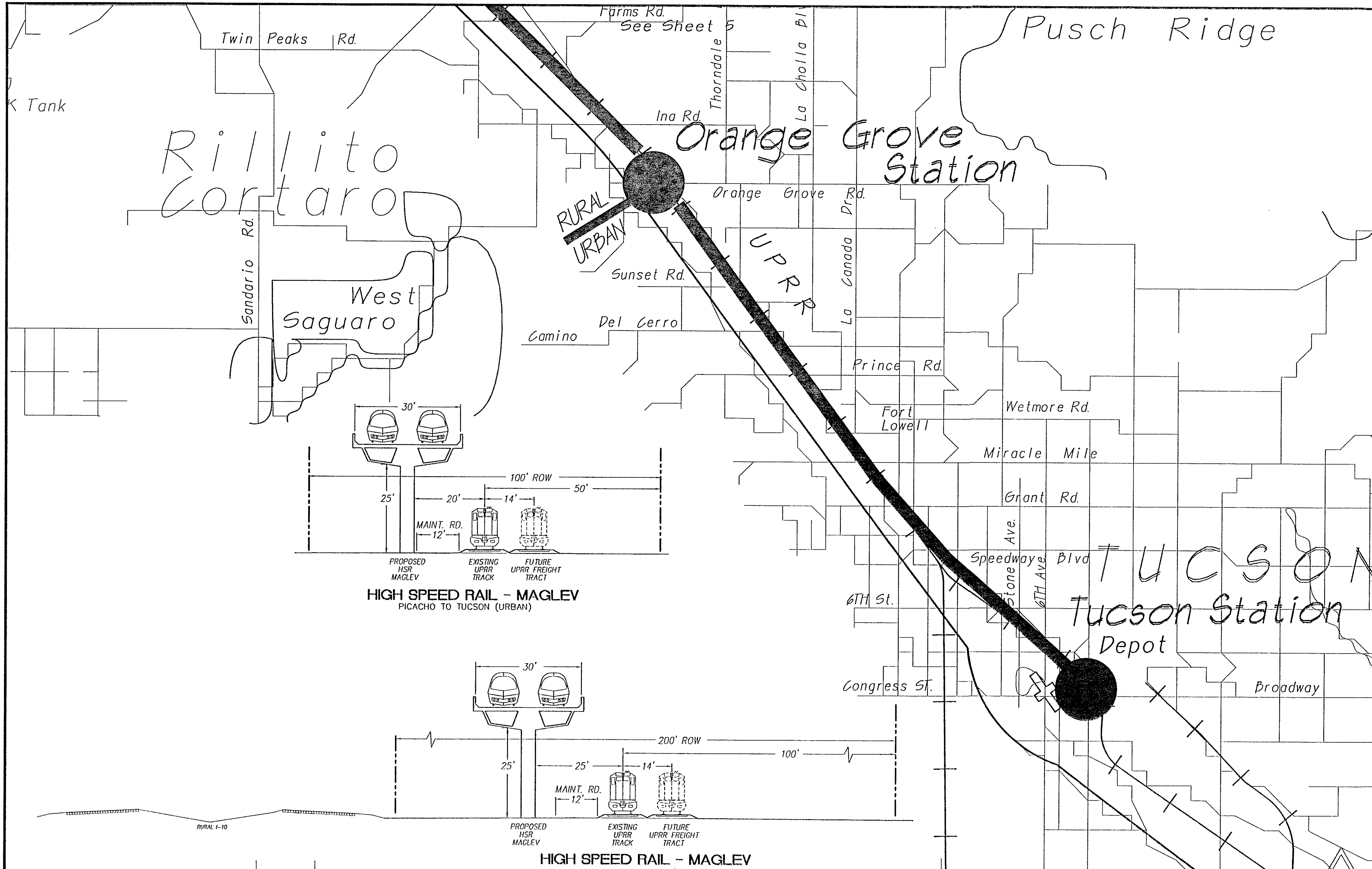
XREF: 0001BASE, 0001ALTS



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ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

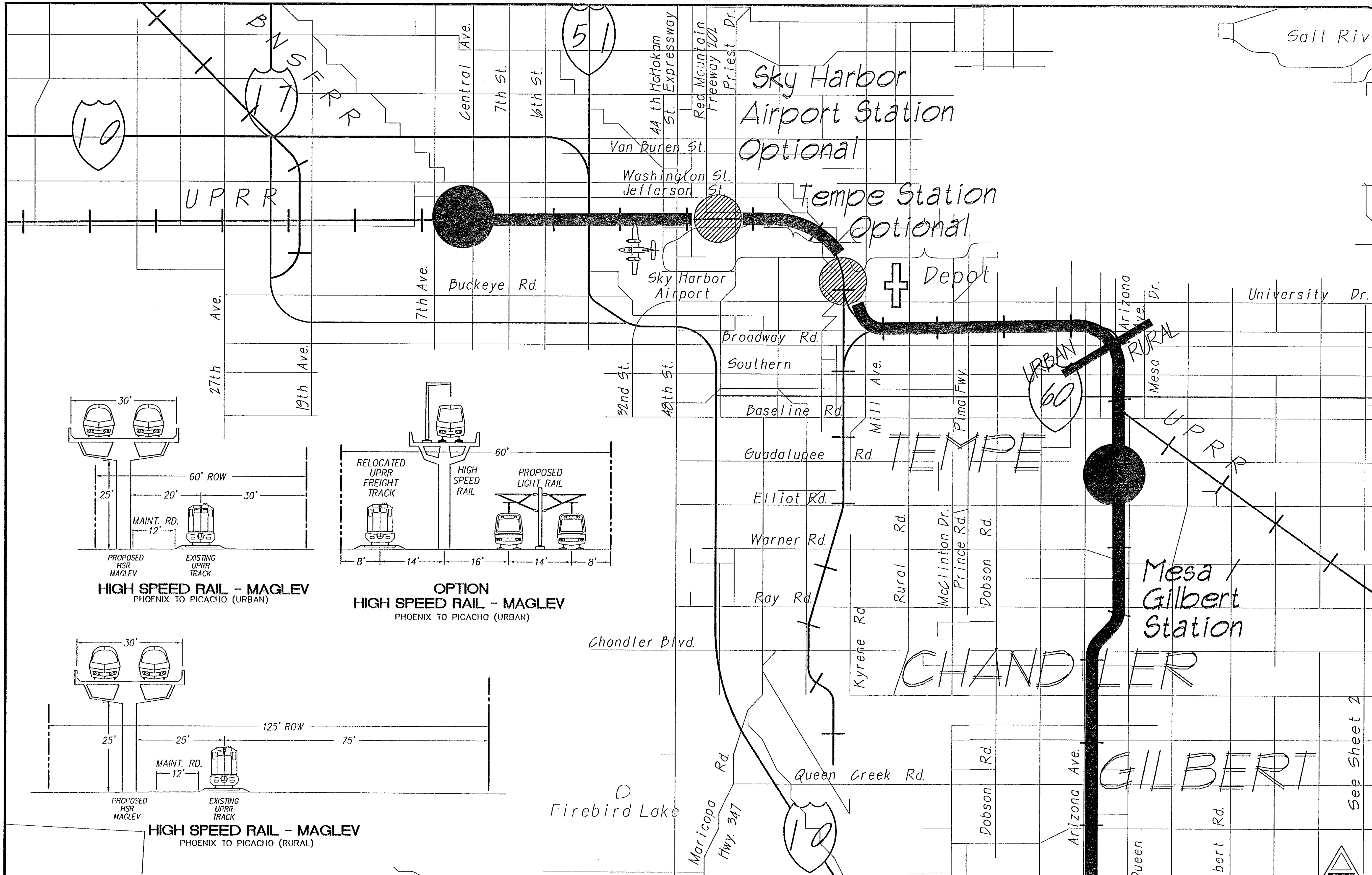
XREF: 0001BASE, 0001ALTS

G:\067600.01\DWG\plan-sht\01A6PLN6 Wed Mar 04 13:56:23 1998

Appendix O

Alternative 6b: High Speed Rail - Maglev

Combined UP Railroad and I-10 Option



Kimley-Horn and Associates, Inc.

ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

XREF: 0001BASE, 0001ALTS

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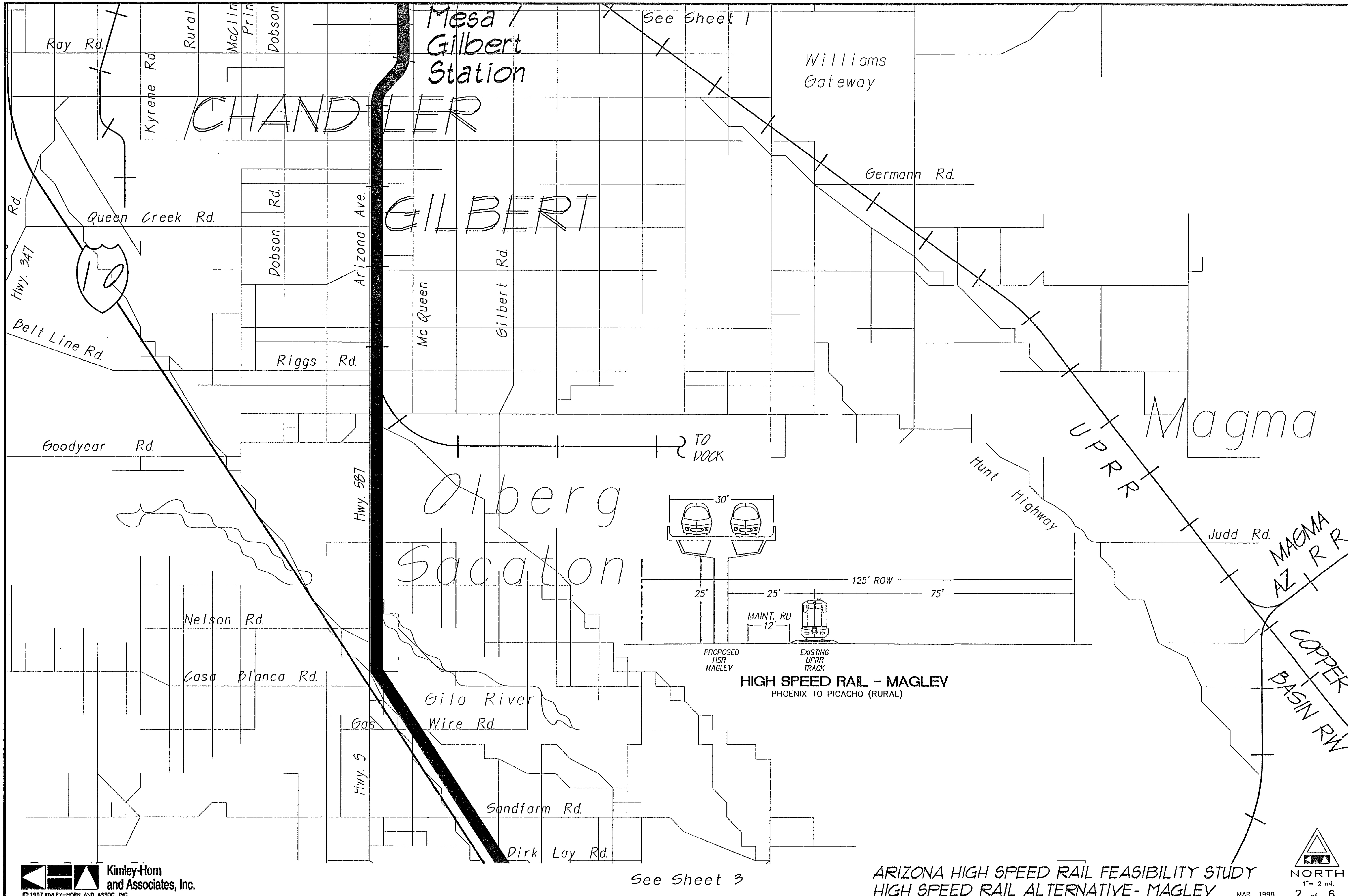

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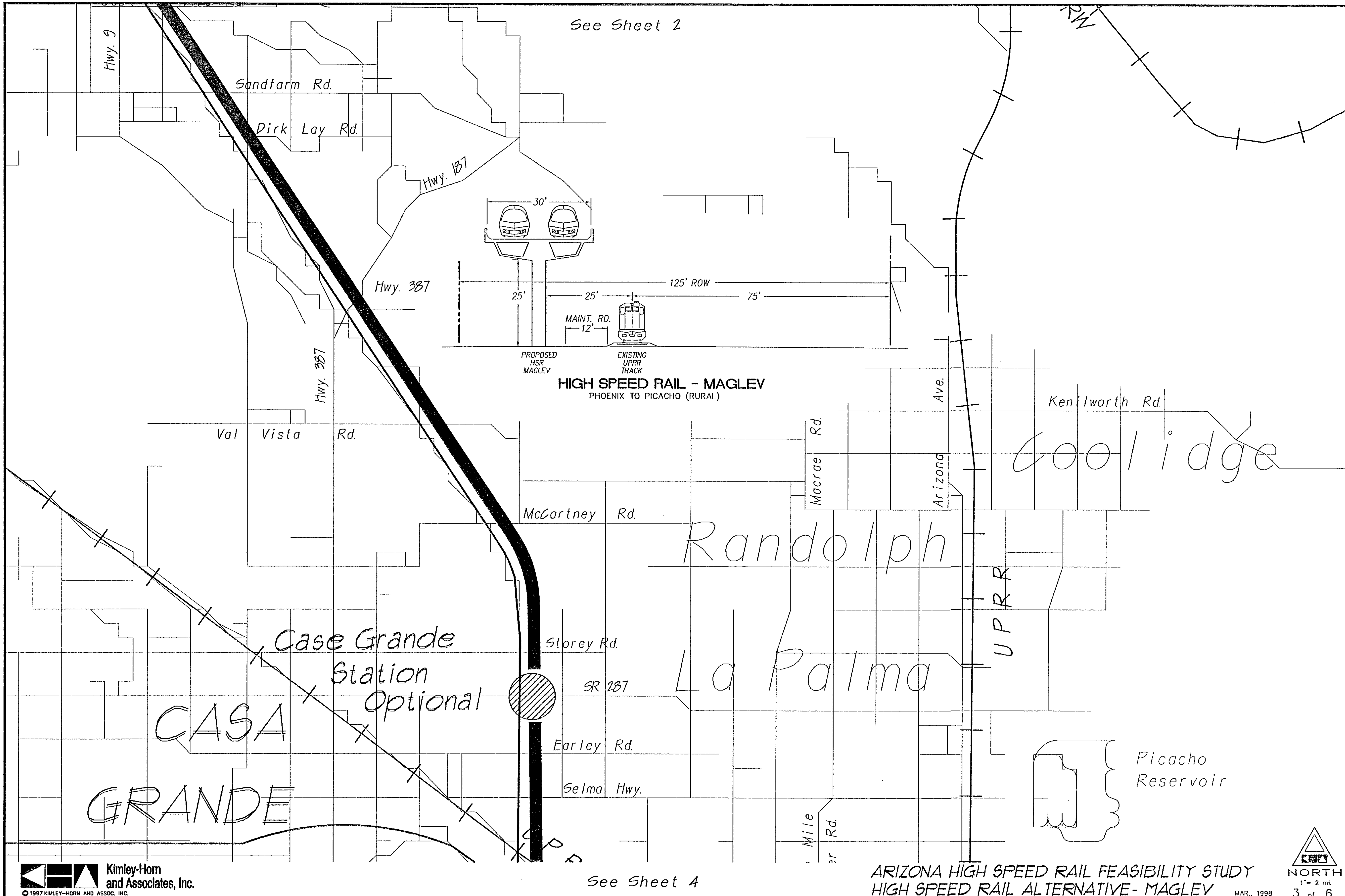

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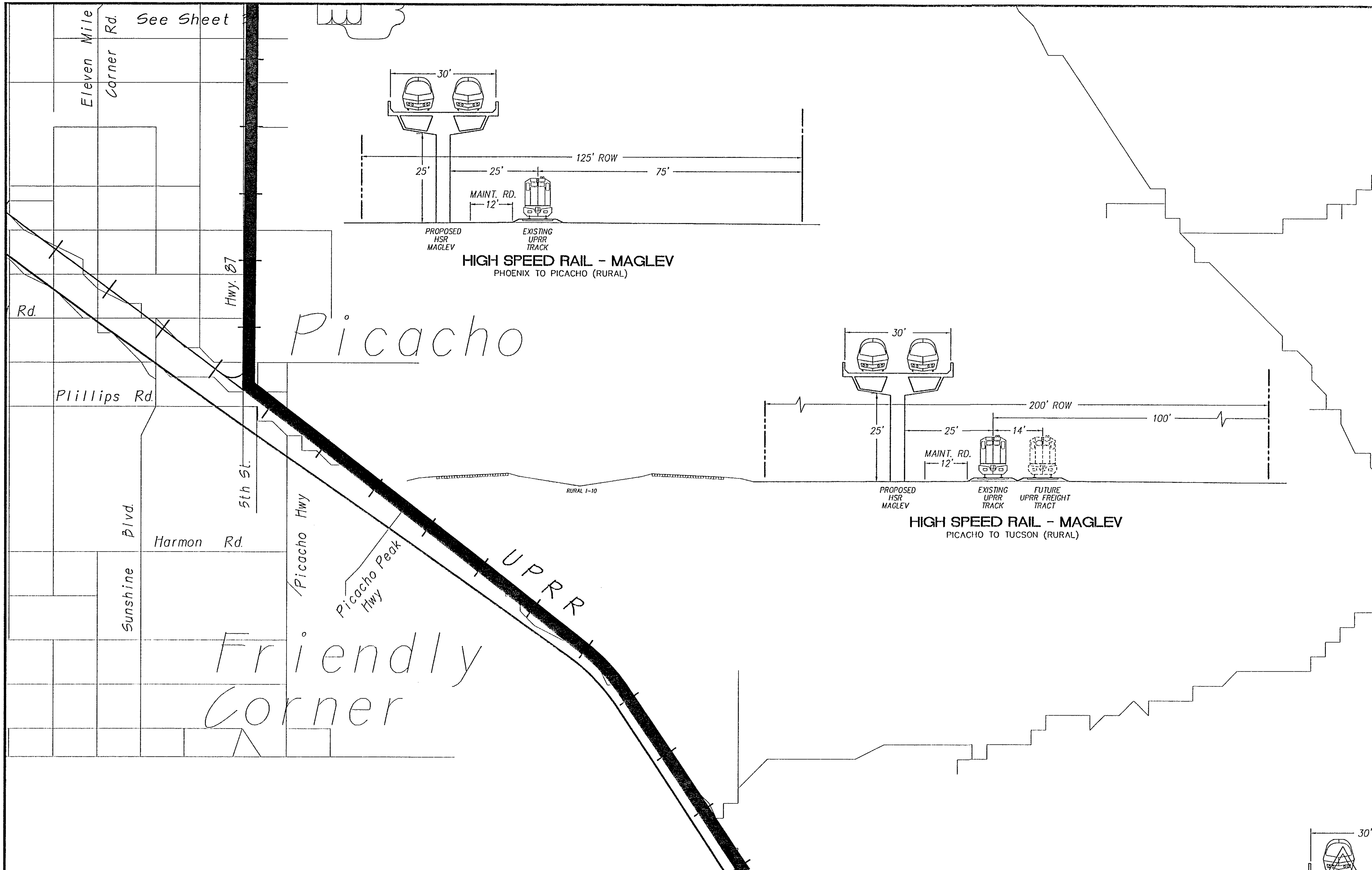


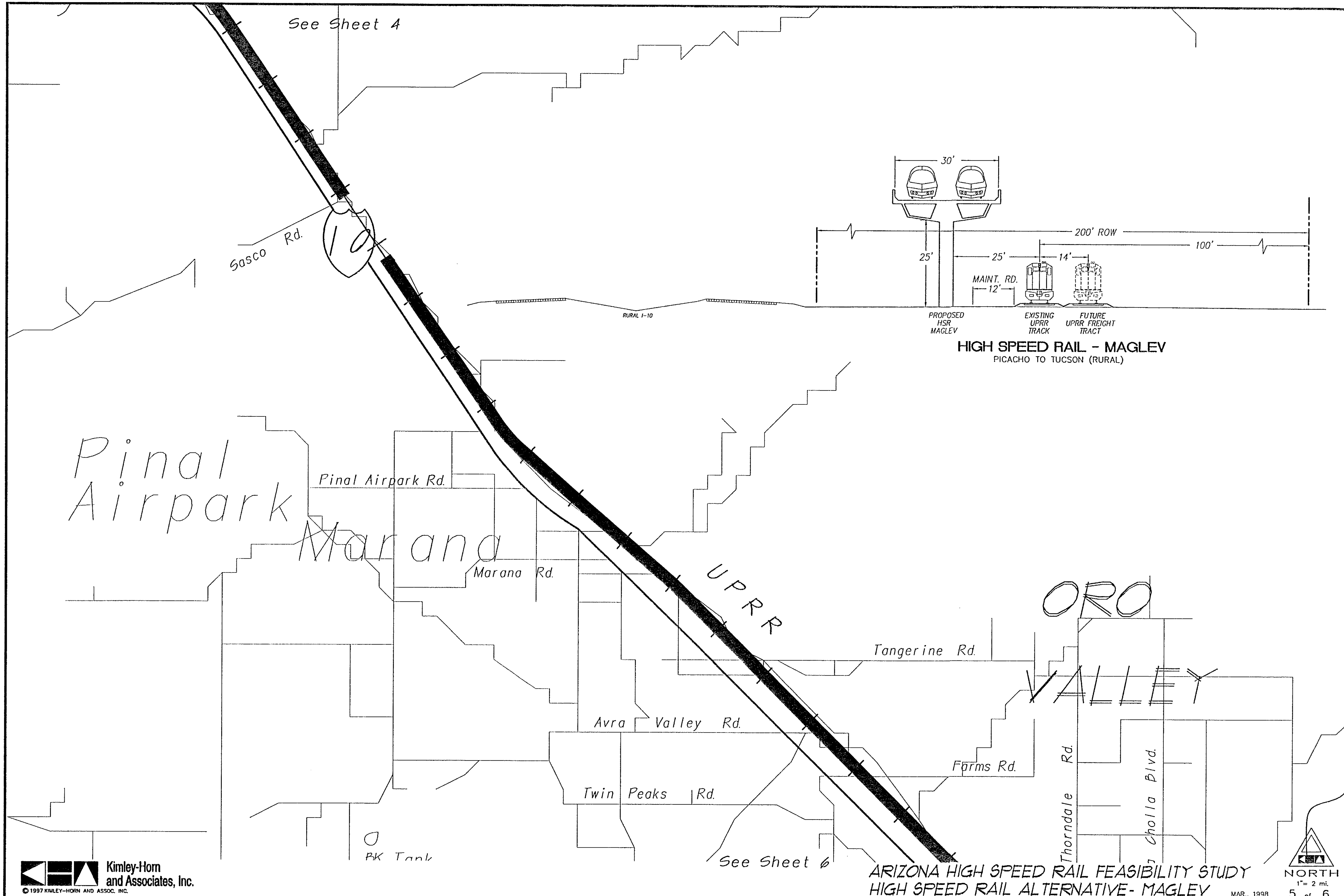
Kimley-Horn and Associates, Inc.

ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY
HIGH SPEED RAIL ALTERNATIVE- MAGLEV

MAR., 1998

G:\067600.01\DWG\plan-sht\016BPLN4 Wed Mar 04 13:32:29 1998

XREF: 0001BASE, 0001ALTS



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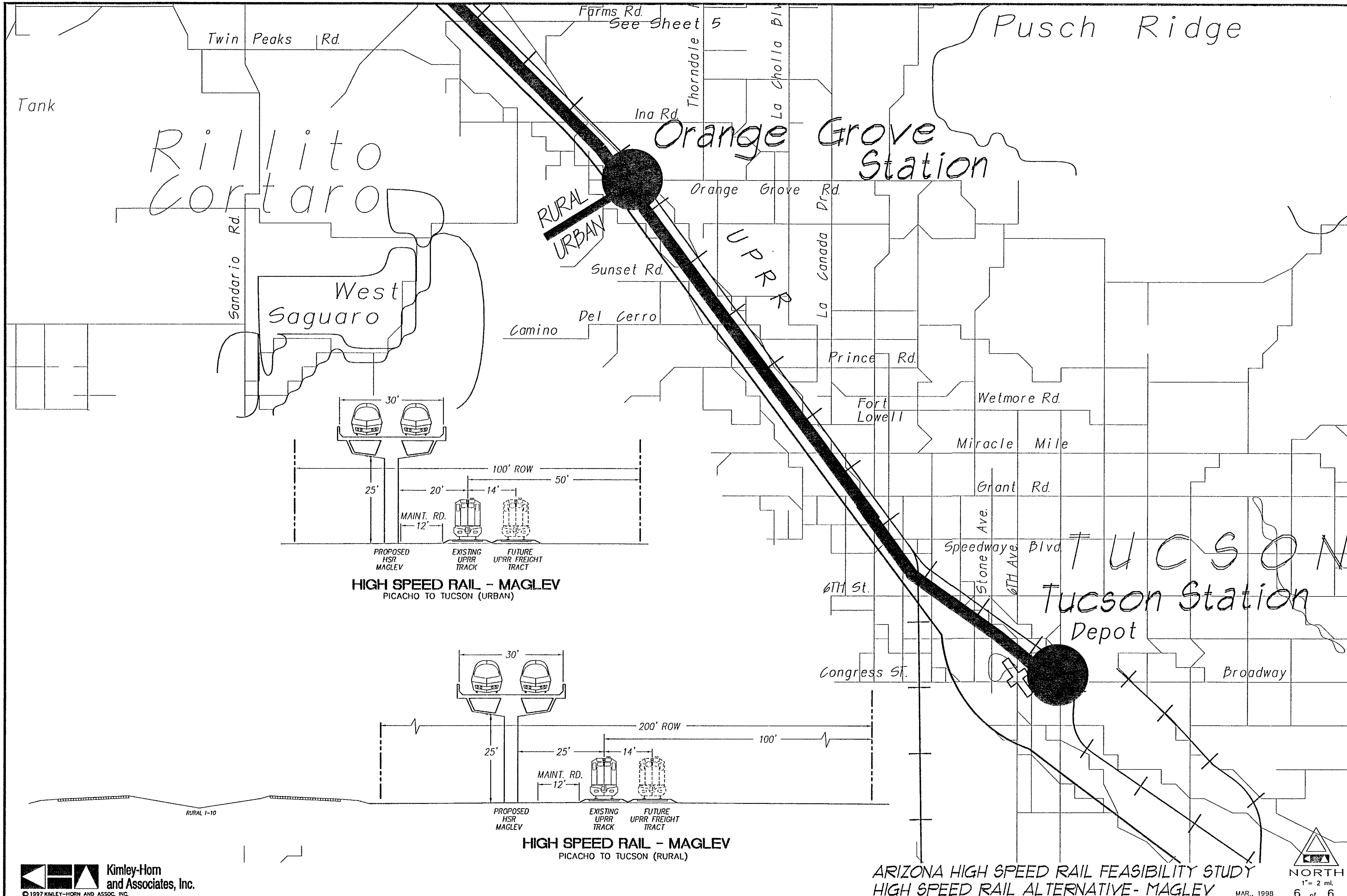

G:\067600.01\DWG\plan-sht\016BPLN6 Wed Mar 04 13:33:39 1998

XREF: 0001BASE, 0001ALTS

Appendix P

Grade Crossing Data

I-10 Grade Crossings

Overpass	Underpass
Central Avenue	Van Buren Street
7th Street	Washington Street
16th Street	Jefferson Street
32nd Street	Buckeye Road
48th Street	Southern
Broadway Road	Baseline Road
Guadalupe Road	SR 84
Elliot Road	SR 87
Warner Road	5th Street
Ray Road	Picacho Hwy
Chandler Blvd	Picacho Peak Hwy
Maricopa Road	Sasco Road
Queen Creek Road	Marana Road
Riggs Road	Tangerine Road
Goodyear Road	Farms Road
Nelson Road	Ina Road
Casa Blanca Road	Orange Grove Road
Gas Wire Road	Sunset Road
Sandfarm Road	Camino del Cerro
Dirk Lay Road	Prince Road
Hwy 387/187	Grant Road
Val ViStreeta Road	Speedway Blvd
McCartney Road	6th Street
Streetorey Road	Congress Street
SR 287	
Earley Road	
Selma Hwy	
SR 8	
Sunland Gin Road	
Toltec Hwy	
Battaglia drive	
Alsdorf Road	
Eloy Sunshine Road	
Phillips Road	
Pinal Airpark Road	
Miracle Mile Road	
Total = 36	**Total = 24**

Chandler Branch Grade Crossings

Overpass	Underpass	At-Grade	Private
		Baseline Road	
		Guadalupe Road	
		Elliott Road	
		Warner Road	
		Knox Road	
		Ray Road	
		Galveston Street	
		Erie Street	
		Detroit Street	
		Chandler Blvd.	
		Commonwealth Avenue	
		Frye Road	
		Pecos Road	
		Willis Road	
		Germann Road	
		Ryan Road	
		Queen Creek Road	
		Appleby Road	
		Ocotillo Road	
		Chandler Heights Road	
		Riggs Road	
		Hunt HWY	
Total = 0	Total = 0	Total = 22	Total = 0

UP Mainline Grade Crossings

Overpass	Underpass	At-Grade	Private
7th Street	44th (153)	1st Street	Between 36th Street and 40th Street
16th Street	Mill Avenue	2nd Street	Between Riggs Road and Magma Junction
I-10/HWY 51 (Papago Freeway)	McClintock Drive	3rd Street	Brooms Turf Farm
48th (143, Hohokam Expressway)	Price Road	4th Street	Between Riggs Road and Magma Junction
Red Mountain Fwy	Pima Hwy	5th Street	Between Arizona Farms Road and Magma Junction
Priest Drive	Country Club Drive	17th Street	Between Hunt HWY and Gila River Bridge
Center Parkway	Speedway Bld	20th Street	Between Hunt HWY and Gila River Bridge
HWY 60 (Superstition FWY)	Stone Avenue	24th Street	Between Hanna Road and Houser Road
HWY 287	6th Avenue	32nd Street	Between Hanna Road and Houser Road
Miracle Mile		36th Street	Between Houser Road and Milligan Road
		40th Street	Between Houser Road and Milligan Road
		48th Street	Walker
		Rio Salado Parkway	Arizona Public Service
		1st Street	Tortolitas Ranch
		5th Street	Between Corenty Road and Tangerine Road
		University Drive	Choate Ranch
		10th Street	
		13th Street	
		College Avenue	
		Rural Road	
		Frontage Road (West)	
		Frontage Road (East)	
		Roosevelt Road	
		Dobson Road	
		Alma School Road	
		Extension Road	
		MacDonald Street	
		Broadway Road	
		8th Avenue	
		Southern Avenue	
		Baseline Road	
		McQueen Road	
		Guadelupe Road	
		Cooper Road	
		Gilbert Road	
		Elliot Road	
		Lindsay Road	
		Warner Road	
		Val Vista Drive	
		Ray Road	
		Greenfield Road	
		Higley Road	
		Williams Field Road	
		Recker Road	
		Power Road	
		Sossaman Road	
		Ellsworth Road	
		Ocotillo Road	
		Riggs Road	
		Arizona Farms Road	
		Hunt HWY	

UP Mainline Grade Crossings - continued

Overpass	Underpass	At-Grade	Private
		HWY 87	
		Florence Avenue	
		Central Avenue	
		Coolidge Avenue	
		Martin Road	
		Bartlett Road	
		Randolph Road	
		Kleck Road	
		Storey Road	
		Steele Road	
		Selma HWY	
		Cornman Road	
		Hanna Road	
		Houser Road	
		Milligan Road	
		Picacho School Road	
		Park Link Drive	
		Missle Base Road	
		Corenty Road	
		Tangerine Road	
		Carrino de Manana	
		Cortaro Farms Road	
		Massingdale Road	
		Ina Road	
		Orange Grove Road	
		Joiner Road	
		Ruthrauff Road	
		Prince Road	
		Grant Road	
		Granada Avenue	
		4th Street	
		5th Street	
		6th Street	
		7th Street	
Total = 10	Total = 9	Total = 85	Total = 16

Appendix Q

Train Operational Data

The following tables are station to station trip times with four stations.

Conventional Rail – Minor Upgrade Alternative

MAXIMUM SPEED = 80 MPH ACCEL/DECEL RATE = 1.0 MPH/S/S
STATION DWELL = 60 SEC

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	45	45	1,485	0	0	337.5	22,275		382.5	6.4	7.7	35.3
SKY HARBOR - TEMPE	3.5	18,480	45	0	0	0	0	280.0	18,480		280.0	4.7	5.6	37.5
TEMPE - MESA/GILBERT	10	52,800	60	0	0	60	2,640	570.0	50,160	60	690.0	11.5	13.8	43.5
SUBTOTAL	18	95,040											27.1	39.9
MESA/GILBERT - PICACHO	54	285,120	80	80	4,693	0	0	2390.1	280,427		2470.1	41.2	45.3	71.5
PICACHO - ORANGE GROVE	40	211,200	80	0	0	80	4,693	1760.1	206,507	60	1900.1	31.7	34.8	68.9
ORANGE GROVE - TUCSON	9	47,520	80	80	4,693	80	4,693	325.0	38,134		485.0	8.1	9.7	55.7
SUBTOTAL	49	258,720											44.5	66.0
TOTALS	121	733,920									6207.8	103.5	116.9	62.1

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

Conventional Rail – Major Upgrade Alternative

MAXIMUM SPEED = 125 MPH ACCEL/DECEL RATE = 1.5 MPH/S/S
STATION DWELL = 60 SEC

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	50	33.3	1,222	0.0	0	307.3	22,538		340.7	5.7	6.8	39.6
SKY HARBOR - TEMPE	3.5	18,480	50	0.0	0	0.0	0	252.0	18,480		252.0	4.2	5.0	41.7
TEMPE - MESA/GILBERT	10	52,800	75	0.0	0	50.0	2,750	455.0	50,050	60	565.0	9.4	11.3	53.1
SUBTOTAL	18	95,040											23.2	46.6
MESA/GILBERT - PICACHO	54	285,120	125	83.3	7,639	0.0	0	1513.6	277,481		1596.9	26.6	29.3	110.7
PICACHO - ORANGE GROVE	40	211,200	125	0.0	0	83.3	7,639	1110.4	203,561	60	1253.7	20.9	23.0	104.4
ORANGE GROVE - TUCSON	9	47,520	125	83.3	7,639	83.3	7,639	175.9	32,243		342.5	5.7	6.9	78.8
SUBTOTAL	49	258,720											29.8	98.5
TOTALS	121	733,920									4350.9	72.5	82.3	88.2

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

High Speed Rail – Electric, UP Railroad Alignment Alternative

MAXIMUM SPEED = 175 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	75	50.0	2,750	0.0	0	191.0	21,010		241.0	4.0	4.4	61.1
SKY HARBOR - TEMPE	3.5	18,480	75	0.0	0	0.0	0	168.0	18,480		168.0	2.8	3.1	68.2
TEMPE - MESA/GILBERT	10	52,800	100	0.0	0	66.7	4,889	326.7	47,911	60	453.3	7.6	8.3	72.2
SUBTOTAL	18	95,040											15.8	68.3
MESA/GILBERT - PICACHO	54	285,120	175	116.7	14,972	0.0	0	1052.6	270,148		1169.2	19.5	21.4	151.1
PICACHO - ORANGE GROVE	40	211,200	175	0.0	0	116.7	14,972	764.6	196,228	60	941.2	15.7	17.3	139.1
ORANGE GROVE - TUCSON	9	47,520	175	116.7	14,972	116.7	14,972	68.5	17,577		301.8	5.0	6.0	89.5
SUBTOTAL	49	258,720											23.3	126.2
TOTALS	121	733,920									3274.7	54.6	60.5	119.9

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

ARIZONA HIGH SPEED RAIL FEASIBILITY STUDY

High Speed Rail – Maglev, UP Railroad Alignment Alternative

MAXIMUM SPEED = 250 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

EEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
X - SKY HARBOR	4.5	23,760	100	66.7	4,889	0.0	0	128.7	18,871		195.3	3.3	3.6	75.4
ARBOR - TEMPE	3.5	18,480	100	0.0	0	0.0	0	126.0	18,480		126.0	2.1	2.3	90.9
- MESA/GILBERT	10	52,800	100	0.0	0	66.7	4,889	326.7	47,911	60	453.3	7.6	8.3	72.2
UBTOTAL	18	95,040											14.2	76.0
ILBERT - PICACHO	54	285,120	250	166.7	30,554	0.0	0	694.3	254,566		861.0	14.3	15.8	205.3
- ORANGE GROVE	40	211,200	250	0.0	0	166.7	30,554	492.7	180,646	60	719.4	12.0	13.2	182.0
GROVE - TUCSON	9	47,520	175	116.7	14,972	116.7	14,972	68.5	17,577		301.8	5.0	6.0	89.5
UBTOTAL	49	258,720											19.2	152.9
TOTALS	121	733,920									2656.8	44.3	49.2	147.5

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONJESTION.

High Speed – Electric, Chandler Branch Alignment Alternative

MAXIMUM SPEED = 175 MPH ACCEL/DECEL RATE = 1.5 MPH/S/S
STATION DWELL = 60 SEC

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	75	50.0	2,750	0.0	0	191.0	21,010		241.0	4.0	4.4	61.1
SKY HARBOR - TEMPE	3.5	18,480	75	0.0	0	0.0	0	168.0	18,480		168.0	2.8	3.1	68.2
TEMPE - MESA/GILBERT	10	52,800	100	0.0	0	66.7	4,889	326.7	47,911	60	453.3	7.6	8.3	72.2
SUBTOTAL	18	95,040											15.8	68.3
MESA/GILBERT - I-10	16	84,480	175	116.7	14,972	0.0	0	270.8	69,508		387.5	6.5	7.1	135.1
I-10 - ORANGE GROVE	74	390,720	175	0.0	0	116.7	14,972	1464.0	375,748	60	1640.7	27.3	30.1	147.6
ORANGE GROVE - TUCSON	9	47,520	175	116.7	14,972	116.7	14,972	68.5	17,577		301.8	5.0	6.0	89.5
SUBTOTAL	83	438,240											36.1	137.9
TOTALS	117	712,800									3192.4	53.2	59.0	118.9

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONJESTION.

The following tables are station to station trip times with seven stations.

Conventional Rail – Minor Upgrade Alternative

MAXIMUM SPEED = 80 MPH
STATION DWELL = 60 SEC
ACCEL/DECEL RATE = 1.0 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	45	45	1,485	45	1,485	315.0	20,790	60	465.0	7.8	9.3	29.0
SKY HARBOR - TEMPE	3.5	18,480	45	45	1,485	45	1,485	235.0	15,510	60	385.0	6.4	7.7	27.3
TEMPE - MESA/GILBERT	10	52,800	60	60	2,640	60	2,640	540.0	47,520	60	720.0	12.0	14.4	41.7
SUBTOTAL	18												31.4	34.4
MESA/GILBERT - COOLIDGE	29	153,120	80	80	4,693	80	4,693	1225.1	143,734		1385.1	23.1	25.4	68.5
COOLIDGE - PICACHO	25	132,000	80	80	4,693	0	0	1085.1	127,307		1165.1	19.4	21.4	70.2
SUBTOTAL	54												46.8	69.3
PICACHO - ORANGE GROVE	40	211,200	80	0	0	80	4,693	1760.1	206,507	60	1900.1	31.7	34.8	68.9
ORANGE GROVE - TUCSON	9	47,520	80	80	4,693	80	4,693	325.0	38,134		485.0	8.1	9.7	55.7
SUBTOTAL	49												44.5	66.0
TOTALS	121	638,880									6505.3	108.4	122.7	59.2

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

Conventional Rail – Major Upgrade Alternative

MAXIMUM SPEED = 125 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	50	33.3	1,222	33.3	1,222	290.7	21,316	60	417.3	7.0	8.3	32.3
SKY HARBOR - TEMPE	3.5	18,480	50	33.3	1,222	33.3	1,222	218.7	16,036	60	345.3	5.8	6.9	30.4
TEMPE - MESA/GILBERT	10	52,800	75	50.0	2,750	50.0	2,750	430.0	47,300	60	590.0	9.8	11.8	50.8
SUBTOTAL	18												27.1	39.9
MESA/GILBERT - COOLIDGE	29	153,120	125	83.3	7,639	83.3	7,639	751.9	137,843	60	978.6	16.3	17.9	97.0
COOLIDGE - PICACHO	25	132,000	125	83.3	7,639	0.0	0	678.4	124,361		761.7	12.7	14.0	107.4
SUBTOTAL	54												31.9	101.6
PICACHO - ORANGE GROVE	40	211,200	125	0.0	0	83.3	7,639	1110.4	203,561	60	1253.7	20.9	23.0	104.4
ORANGE GROVE - TUCSON	9	47,520	125	83.3	7,639	83.3	7,639	175.9	32,243		342.5	5.7	6.9	78.8
SUBTOTAL	49												29.8	98.5
TOTALS	121	638,880									4689.2	78.2	88.8	81.8

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

High Speed Rail – Electric, UP Railroad Alignment Alternative

MAXIMUM SPEED = 175 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	75	50.0	2,750	50.0	2,750	166.0	18,260	60	326.0	5.4	6.5	41.4
SKY HARBOR - TEMPE	3.5	18,480	75	50.0	2,750	50.0	2,750	118.0	12,980	60	278.0	4.6	5.6	37.8
TEMPE - MESA/GILBERT	10	52,800	100	66.7	4,889	66.7	4,889	293.3	43,023	60	486.7	8.1	9.7	61.6
SUBTOTAL	18												21.8	49.5
MESA/GILBERT - COOLIDGE	29	153,120	175	116.7	14,972	116.7	14,972	479.9	123,177	60	773.3	12.9	14.2	122.7
COOLIDGE - PICACHO	25	132,000	175	116.7	14,972	0.0	0	456.0	117,028		572.6	9.5	10.5	142.9
SUBTOTAL	54												24.7	131.3
PICACHO - ORANGE GROVE	40	211,200	175	0.0	0	116.7	14,972	764.6	196,228	60	941.2	15.7	17.3	139.1
ORANGE GROVE - TUCSON	9	47,520	175	116.7	14,972	116.7	14,972	68.5	17,577		301.8	5.0	6.0	89.5
SUBTOTAL	49												23.3	126.2
TOTALS	121	638,880									3679.7	61.3	69.8	104.0

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

High Speed Rail – Maglev, UP Railroad Alignment Alternative

MAXIMUM SPEED = 250 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	100	66.7	4,889	66.7	4,889	95.3	13,983	60	288.7	4.8	5.8	46.8
SKY HARBOR - TEMPE	3.5	18,480	100	66.7	4,889	66.7	4,889	59.3	8,703	60	252.7	4.2	5.1	41.6
TEMPE - MESA/GILBERT	10	52,800	100	66.7	4,889	66.7	4,889	293.3	43,023	60	486.7	8.1	9.7	61.6
SUBTOTAL	18												20.6	52.5
MESA/GILBERT - COOLIDGE	29	153,120	250	166.7	30,554	166.7	30,554	251.0	92,012	60	644.3	10.7	11.8	147.3
COOLIDGE - PICACHO	25	132,000	250	166.7	30,554	0.0	0	276.7	101,446		443.3	7.4	8.1	184.5
SUBTOTAL	54												19.9	162.5
PICACHO - ORANGE GROVE	40	211,200	250	0.0	0	166.7	30,554	492.7	180,646	60	719.4	12.0	13.2	182.0
ORANGE GROVE - TUCSON	9	47,520	215	143.3	22,598	143.3	22,598	7.4	2,324		294.0	4.9	5.9	91.8
SUBTOTAL	49												19.1	154.2
TOTALS	121	638,880									3129.1	52.2	59.6	121.9

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

High Speed Rail – Electric, Chandler Branch Alignment Alternative

MAXIMUM SPEED = 175 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	75	50.0	2,750	50.0	2,750	166.0	18,260	60	326.0	5.4	6.5	41.4
SKY HARBOR - TEMPE	3.5	18,480	75	50.0	2,750	50.0	2,750	118.0	12,980	60	278.0	4.6	5.6	37.8
TEMPE - MESA/GILBERT	10	52,800	100	66.7	4,889	66.7	4,889	293.3	43,023	60	486.7	8.1	9.7	61.6
SUBTOTAL	18												21.8	49.5
MESA/GILBERT - I-10	16	84,480	175	116.7	14,972	0.0	0	270.8	69,508		387.5	6.5	7.1	135.1
I-10 - CASA GRANDE	16	84,480	175	0.0	0	116.7	14,972	270.8	69,508	60	447.5	7.5	8.2	117.0
CASA GND - ORANGE GROVE	58	306,240	175	116.7	14,972	116.7	14,972	1076.5	276,297	60	1369.9	22.8	25.1	138.6
ORANGE GROVE - TUCSON	9	47,520	175	116.7	14,972	116.7	14,972	68.5	17,577		301.8	5.0	6.0	89.5
SUBTOTAL	83												39.4	126.5
TOTALS	117	617,760									3597.4	60.0	68.3	102.8

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

High Speed – Maglev, Chandler Branch Alignment Alternative

MAXIMUM SPEED = 250 MPH
STATION DWELL = 60 SEC

ACCEL/DECEL RATE = 1.5 MPH/S/S

BETWEEN STATIONS:	MILES	FEET	MAX SPEED**	ACCELERATION TIME (S)	ACCELERATION DISTANCE	DECELERATION TIME (S)	DECELERATION DISTANCE	CONSTANT SPEED TIME (S)	CONSTANT SPEED DISTANCE	STATION DWELL TIME (S)	SUBTOTAL TIME (S)	SUBTOTAL TIME (M)	TOTAL * TIME (M)	AVG SPEED
PHOENIX - SKY HARBOR	4.5	23,760	100	66.7	4,889	66.7	4,889	95.3	13,983	60	288.7	4.8	5.8	46.8
SKY HARBOR - TEMPE	3.5	18,480	100	66.7	4,889	66.7	4,889	59.3	8,703	60	252.7	4.2	5.1	41.6
TEMPE - MESA/GILBERT	10	52,800	100	66.7	4,889	66.7	4,889	293.3	43,023	60	486.7	8.1	9.7	61.6
SUBTOTAL	18												20.6	52.5
MESA/GILBERT - I-10	16	84,480	250	166.7	30,554	0.0	0	147.1	53,926		313.7	5.2	5.8	166.9
I-10 - CASA GRANDE	16	84,480	250	0.0	0	166.7	30,554	147.1	53,926	60	373.7	6.2	6.9	140.1
CASA GND - ORANGE GROVE	58	306,240	250	166.7	30,554	166.7	30,554	668.6	245,132	60	1061.9	17.7	19.5	178.8
ORANGE GROVE - TUCSON	9	47,520	215	143.3	22,598	143.3	22,598	7.4	2,324		294.0	4.9	5.9	91.8
SUBTOTAL	83												32.2	154.7
TOTALS	117	617,760									3071.5	51.2	58.5	120.0

* TOTAL TIME INCLUDES 10% TO 20% FACTOR FOR CURVES, DELAYS, AND OTHER SUCH CONSIDERATIONS.

** MAXIMUM ACHIEVABLE SPEED MAY BE LIMITED DUE TO STATION SPACING DISTANCE AND/OR LOCAL CONGESTION.

Appendix R

Fare Sensitivity Data

FARE SENSITIVITY FOR CONVENTIONAL RAIL - MINOR UPGRADE

Fare	Daily Patronage	Annual Patronage	Annual Revenue
$5	4,510	1,646,150	$8,230,750
$6	4,428	1,616,220	$9,697,320
$7	4,346	1,586,290	$11,104,030
$8	4,264	1,556,360	$12,450,880
$9	4,182	1,526,430	$13,737,870
$10	4,100	1,496,500	$14,965,000
$11	3,977	1,451,605	$15,967,655
$12	3,854	1,406,710	$16,880,520
$13	3,731	1,361,815	$17,703,595
$14	3,608	1,316,920	$18,436,880
$15	3,526	1,286,990	$19,304,850
$16	3,301	1,204,683	$19,274,920
$17	3,096	1,129,858	$19,207,578
$18	2,932	1,069,998	$19,259,955
$19	2,747	1,002,655	$19,050,445
$20	2,563	935,313	$18,706,250
$21	2,470	901,641	$18,934,466
$22	2,378	867,970	$19,095,340
$23	2,286	834,299	$19,188,871
$24	2,194	800,628	$19,215,060
$25	2,101	766,956	$19,173,906
$26	2,009	733,285	$19,065,410
$27	1,917	699,614	$18,889,571
$28	1,825	665,943	$18,646,390
$29	1,732	632,271	$18,335,866
$30	1,640	598,600	$17,958,000
$31	1,558	568,670	$17,628,770
$32	1,476	538,740	$17,239,680
$33	1,394	508,810	$16,790,730
$34	1,312	478,880	$16,281,920
$35	1,230	448,950	$15,713,250
$36	1,148	419,020	$15,084,720
$37	1,066	389,090	$14,396,330
$38	984	359,160	$13,648,080
$39	902	329,230	$12,839,970
$40	820	299,300	$11,972,000
$41	779	284,335	$11,657,735
$42	738	269,370	$11,313,540
$43	697	254,405	$10,939,415
$44	656	239,440	$10,535,360
$45	615	224,475	$10,101,375
$46	574	209,510	$9,637,460
$47	533	194,545	$9,143,615
$48	492	179,580	$8,619,840
$49	451	164,615	$8,066,135
$50	410	149,650	$7,482,500
$51	402	146,569	$7,475,018
$52	394	143,708	$7,472,817
$53	385	140,627	$7,453,230
$54	377	137,766	$7,439,366
$55	369	134,685	$7,407,675
$56	361	131,604	$7,369,822
$57	353	128,743	$7,338,352
$58	344	125,662	$7,288,395
$59	336	122,801	$7,245,261
$60	328	119,720	$7,183,200
$61	320	116,639	$7,114,977
$62	312	113,778	$7,054,237
$63	303	110,697	$6,973,910

FARE SENSITIVITY FOR CONVENTIONAL RAIL - MAJOR UPGRADE

Fare	Daily Patronage	Annual Patronage	Annual Revenue
$5	30,600	11,169,000	$55,845,000
$6	26,520	9,679,800	$58,078,800
$7	23,800	8,687,000	$60,809,000
$8	21,080	7,694,200	$61,553,600
$9	19,040	6,949,600	$62,546,400
$10	17,340	6,329,100	$63,291,000
$11	15,980	5,832,700	$64,159,700
$12	14,960	5,460,400	$65,524,800
$13	14,280	5,212,200	$67,758,600
$14	13,600	4,964,000	$69,496,000
$15	12,920	4,715,800	$70,737,000
$16	12,240	4,467,600	$71,481,600
$17	11,560	4,219,400	$71,729,800
$18	10,880	3,971,200	$71,481,600
$19	10,540	3,847,100	$73,094,900
$20	10,200	3,723,000	$74,460,000
$21	9,860	3,598,900	$75,576,900
$22	9,520	3,474,800	$76,445,600
$23	9,384	3,425,160	$78,778,680
$24	9,316	3,400,340	$81,608,160
$25	9,180	3,350,700	$83,767,500
$26	8,840	3,226,600	$83,891,600
$27	8,500	3,102,500	$83,767,500
$28	8,228	3,003,220	$84,090,160
$29	7,956	2,903,940	$84,214,260
$30	7,704	2,812,106	$84,363,180
$31	7,453	2,720,272	$84,328,432
$32	7,222	2,635,884	$84,348,288
$33	7,004	2,556,460	$84,363,180
$34	6,800	2,482,000	$84,388,000
$35	6,596	2,407,540	$84,263,900
$36	6,392	2,333,080	$83,990,880
$37	6,188	2,258,620	$83,568,940
$38	5,984	2,184,160	$82,998,080
$39	5,780	2,109,700	$82,278,300
$40	5,576	2,035,240	$81,409,600
$41	5,440	1,985,600	$81,409,600
$42	5,304	1,935,960	$81,310,320
$43	5,168	1,886,320	$81,111,760
$44	5,046	1,841,644	$81,032,336
$45	4,930	1,799,450	$80,975,250
$46	4,808	1,754,774	$80,719,604
$47	4,706	1,717,544	$80,724,568
$48	4,605	1,680,810	$80,678,899
$49	4,510	1,646,236	$80,665,571
$50	4,420	1,613,300	$80,665,000
$51	4,318	1,576,070	$80,379,570
$52	4,216	1,538,840	$80,019,680
$53	4,114	1,501,610	$79,585,330
$54	4,012	1,464,380	$79,076,520
$55	3,910	1,427,150	$78,493,250
$56	3,808	1,389,920	$77,835,520
$57	3,706	1,352,690	$77,103,330
$58	3,604	1,315,460	$76,296,680
$59	3,502	1,278,230	$75,415,570
$60	3,400	1,241,000	$74,460,000
$61	3,264	1,191,360	$72,672,960
$62	3,128	1,141,720	$70,786,640
$63	3,060	1,116,900	$70,364,700

FARE SENSITIVITY FOR HIGH SPEED - ELECTRIC

Fare	Daily Patronage	Annual Patronage	Annual Revenue
$5	48,400	17,666,000	$88,330,000
$6	42,240	15,417,600	$92,505,600
$7	36,960	13,490,400	$94,432,800
$8	33,176	12,109,240	$96,873,920
$9	29,744	10,856,560	$97,709,040
$10	26,840	9,796,600	$97,966,000
$11	24,640	8,993,600	$98,929,600
$12	22,704	8,286,960	$99,443,520
$13	21,120	7,708,800	$100,214,400
$14	20,240	7,387,600	$103,426,400
$15	19,360	7,066,400	$105,996,000
$16	18,480	6,745,200	$107,923,200
$17	17,600	6,424,000	$109,208,000
$18	16,984	6,199,160	$111,584,880
$19	16,368	5,974,620	$113,512,080
$20	15,752	5,749,480	$114,989,600
$21	15,136	5,524,640	$116,017,440
$22	14,608	5,331,920	$117,302,240
$23	14,080	5,139,200	$118,201,600
$24	13,552	4,946,480	$118,715,520
$25	13,024	4,753,760	$118,844,000
$26	12,584	4,593,460	$119,422,160
$27	12,144	4,432,560	$119,679,120
$28	11,792	4,304,080	$120,514,240
$29	11,440	4,175,600	$121,092,400
$30	11,176	4,079,240	$122,377,200
$31	10,912	3,982,880	$123,469,280
$32	10,648	3,886,520	$124,368,640
$33	10,384	3,790,160	$125,075,280
$34	10,120	3,693,800	$125,589,200
$35	9,856	3,597,440	$125,910,400
$36	9,592	3,501,080	$126,038,880
$37	9,416	3,436,840	$127,163,880
$38	9,240	3,372,600	$128,158,800
$39	9,020	3,292,300	$128,399,700
$40	8,782	3,205,576	$128,223,040
$41	8,562	3,125,276	$128,136,316
$42	8,316	3,035,340	$127,484,280
$43	8,096	2,955,040	$127,066,720
$44	7,894	2,881,164	$126,771,216
$45	7,718	2,816,924	$126,761,580
$46	7,524	2,746,260	$126,327,960
$47	7,348	2,682,020	$126,054,940
$48	7,181	2,620,992	$125,807,616
$49	7,022	2,563,176	$125,595,642
$50	6,864	2,505,360	$125,268,000
$51	6,688	2,441,120	$124,497,120
$52	6,556	2,392,940	$124,432,880
$53	6,424	2,344,760	$124,272,280
$54	6,292	2,296,580	$124,015,320
$55	6,160	2,248,400	$123,662,000
$56	6,028	2,200,220	$123,212,320
$57	5,896	2,152,040	$122,666,280
$58	5,764	2,103,860	$122,023,880
$59	5,632	2,055,680	$121,285,120
$60	5,456	1,991,440	$119,486,400
$61	5,280	1,927,200	$117,559,200
$62	5,104	1,862,960	$115,503,520
$63	4,928	1,798,720	$113,319,360

FARE SENSITIVITY FOR HIGH SPEED - MAGLEV

Fare	Daily Patronage	Annual Patronage	Annual Revenue
$5	64,350	23,487,750	$117,438,750
$6	56,160	20,498,400	$122,990,400
$7	49,140	17,936,100	$125,552,700
$8	44,460	16,227,900	$129,823,200
$9	39,780	14,571,700	$130,677,300
$10	36,270	13,238,550	$132,385,500
$11	33,930	12,384,450	$136,228,950
$12	31,590	11,530,350	$138,364,200
$13	29,250	10,676,250	$138,791,250
$14	27,495	10,035,675	$140,499,450
$15	25,974	9,480,510	$142,207,650
$16	24,687	9,010,755	$144,172,080
$17	23,400	8,541,000	$145,197,000
$18	22,230	8,113,950	$146,051,100
$19	21,411	7,815,015	$148,485,285
$20	20,475	7,473,375	$149,467,500
$21	19,656	7,714,440	$150,663,240
$22	18,996	6,933,584	$152,538,844
$23	18,587	6,784,116	$156,034,675
$24	18,177	6,634,649	$159,231,571
$25	17,768	6,485,181	$162,129,533
$26	17,358	6,335,714	$164,728,559
$27	16,949	6,186,246	$167,028,650
$28	16,539	6,036,779	$169,029,806
$29	16,130	5,887,311	$170,732,028
$30	15,720	5,737,844	$172,135,314
$31	15,369	5,609,729	$173,901,593
$32	15,107	5,514,070	$176,450,227
$33	14,845	5,418,410	$178,807,543
$34	14,583	5,322,751	$180,973,541
$35	14,321	5,227,092	$182,948,220
$36	14,059	5,131,433	$184,731,581
$37	13,797	5,035,774	$186,323,623
$38	13,535	4,940,114	$187,724,347
$39	13,272	4,844,455	$188,933,753
$40	13,010	4,748,796	$189,951,840
$41	12,748	4,653,137	$190,778,609
$42	12,486	4,557,478	$191,414,059
$43	12,224	4,461,818	$191,858,191
$44	11,962	4,366,159	$192,111,005
$45	11,700	4,270,500	$192,172,500
$46	11,431	4,172,279	$191,924,811
$47	11,150	4,069,787	$191,279,966
$48	10,858	3,963,024	$190,225,152
$49	10,589	3,864,803	$189,375,323
$50	10,319	3,766,581	$188,329,050
$51	10,050	3,668,360	$187,086,335
$52	9,781	3,570,138	$185,647,176
$53	9,512	3,471,917	$184,011,575
$54	9,243	3,373,695	$182,179,530
$55	8,974	3,275,474	$180,151,043
$56	8,705	3,177,252	$177,926,112
$57	8,436	3,079,031	$175,504,739
$58	8,167	2,980,809	$172,886,922
$59	7,898	2,882,588	$170,072,663
$60	7,628	2,784,366	$167,061,960
$61	7,359	2,686,145	$163,854,815
$62	7,090	2,587,923	$160,451,226
$63	6,821	2,489,702	$156,851,195

Preface

The consultant team wishes to express its sincere appreciation for the significant contributions made to this study by the Arizona Department of Transportation and the Steering Committee and Task Force members listed below:

Mary Peters, Task Force Chairman *	Arizona Department of Transportation
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*** Also Steering Committee Members**

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