LOWER SANTA CRUZ RIVER

Feasibility Analysis

SUMMARY REPORT

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SEPTEMBER 1994

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LOWER SANTA CRUZ RIVER, AZ

SYLLABUS

This report is submitted in partial response to the Flood Control Act of 1938 (Public Law 761, 75th Congress), which authorized flood control studies of the Gila River and its tributaries in Arizona and New Mexico. The study was initiated at the request of Pinal County, AZ, and examined flooding problems along the lower reach of the Santa Cruz River of Arizona. The study was cost shared with the Pinal County Flood Control District. The Feasibility Cost Shared Agreement (FCSA) was signed 8 June 1989.

The Santa Cruz River Basin consists of 8,200 square miles in southern Arizona and 400 square miles in Sonora, Mexico. The study area consisted of the downstream (northern) 1,400 square mile portion of this basin. The study area is located midway between the rapidly growing Phoenix and Tucson metropolitan areas. The area historically has been agricultural, but has increasingly become urbanized. The area is served by two Interstate Highways (I-8 and I-10) and a major transcontinental railroad.

The study area has long been subject to damaging floods. The most recent major event, in October of 1983, caused in excess of $45 million in damages (1994 prices) and inundated approximately 600 square miles. Damages included a broad range of categories, including agricultural, commercial and residential structures, utility lines, and transportation facilities. The frequency of the 1983 flood was estimated have been greater than a 100 year event. Since 1983, the area has developed rapidly and potential damages from future flooding have increased substantially.

Flooding problems along the lower Santa Cruz River have long been studied by Federal, State, and local agencies. No comprehensive solution has ever been implemented. The most recent previous Corps effort, completed just prior to the 1983 event was unable to economically justify an alternative solution.

A wide array of flood protection measures were considered in this current study, including diversion, channelization, detention, use of Central Arizona Project laterals, ring dikes, and non-structural alternatives.

Due to land subsidence and related earth fissuring throughout much of the study area, identified detention solutions, using conventional practices, posed long term risks or required significant project cost increases to mitigate these adverse geotechnical conditions.

The final analysis of this study effort, as in the 1983 Corps study report, focused on diversion to Tat Momolikot Dam. This solution would have required substantial additional study funds to complete necessary technical analyses. By 1993, existing appropriated Federal and local cost shared funds had essentially been exhausted. The Corps and Pinal County decided to terminate the study in the spring of 1994.

The conclusion of this analysis is that the study should be terminated with a finding of no implementable plan.

LOWER SANTA CRUZ RIVER, ARIZONA

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

This Lower Santa Cruz River, AZ, Report presents the results of a feasibility phase study of flooding problems and alternative solutions for the area affected by the Lower Santa Cruz River, AZ. The Report outlines the study purpose and scope, provides a presentation of problems addressed, describes the study area, analyzes the problems and opportunities for action, describes alternative solutions, presents the results of alternative analyses, and identifies potential Federal interest at the time of the study.

CHAPTER II

THE STUDY

2.1. AUTHORITY

This report is submitted in partial response to Public Law 761, Seventy-fifth Congress, known as the Flood Control Act of 1938. That Act reads in part as follows:

* * * * * * * * * * * * * * * * *

SEC. 6. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control including floods aggravated by or due to tidal effect at the following-named localities, and the Secretary of Agriculture is authorized and directed to cause preliminary examinations and surveys for run-off and waterflow retardation and soil-erosion prevention on the watersheds of such localities; ...

* * * * * * * * * * * * * * * * *

Gila River and Tributaries, Arizona and New Mexico

* * * * * * * * * * * * * * * * *

The study area lies within the Gila River and Tributaries Authority area (Fig. 1). This report is an interim response to the overall Gila River Authority.

2.2. PURPOSE AND SCOPE

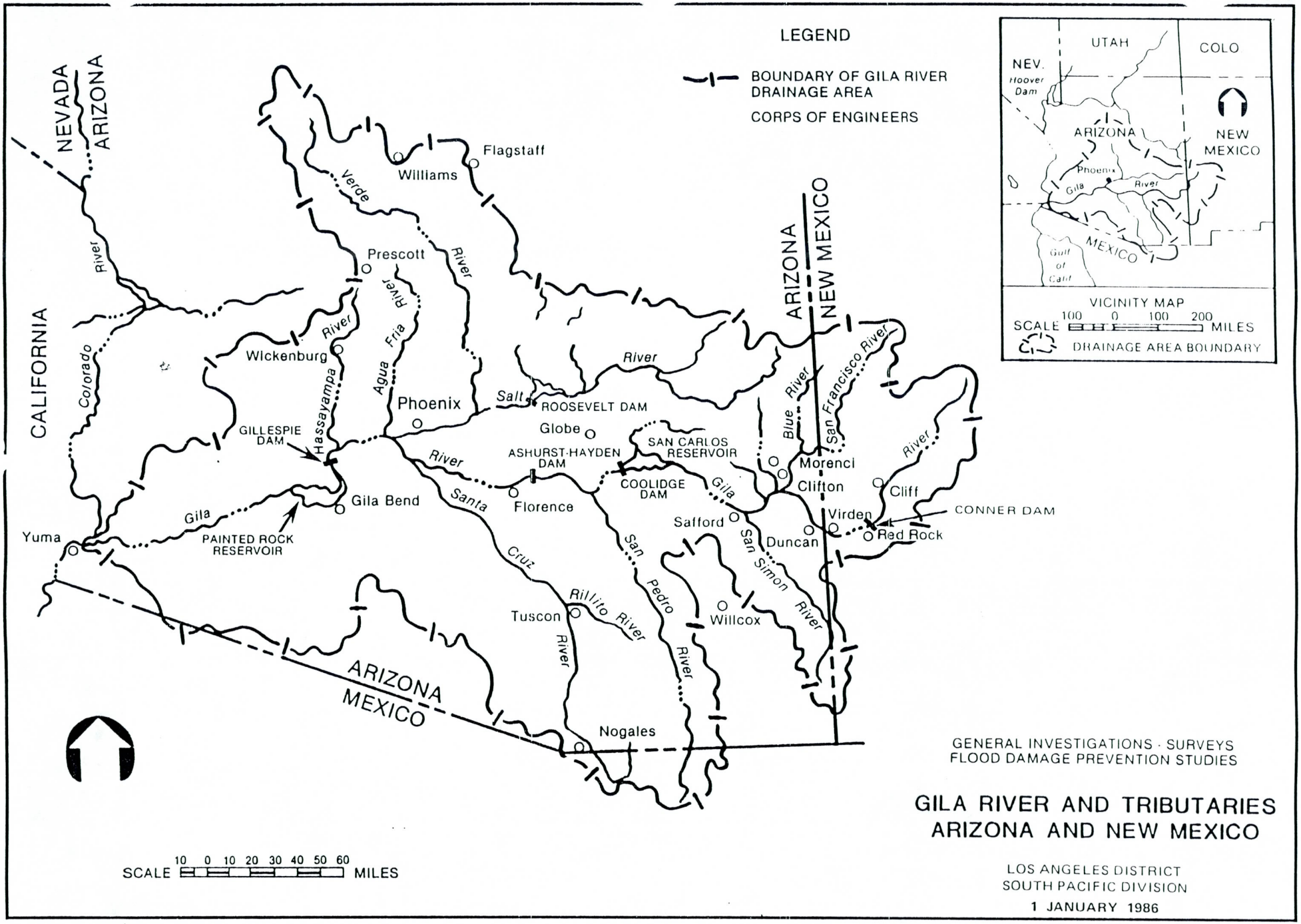
The purpose of the study was to analyze flooding problems within the Lower Santa Cruz River Study area (see paragraph 4.1), and to develop an array of alternatives that would reduce the severity of major flood damages. The objectives of this study were to develop and present information that sufficiently indicate that at least one potential solution met the following criteria:

(1) would have a Federal interest based upon engineering and economic feasibility,

(2) would be in accord with current Federal policies and budgetary priorities,

(3) could be implemented in accordance with environmental laws and statutes, and

(4) would have the support of the local sponsor, Pinal County, AZ.



GENERAL INVESTIGATIONS · SURVEYS
FLOOD DAMAGE PREVENTION STUDIES

GILA RIVER AND TRIBUTARIES ARIZONA AND NEW MEXICO

LOS ANGELES DISTRICT
SOUTH PACIFIC DIVISION
1 JANUARY 1986

FIGURE 1

This report presents and discusses the results of the plan formulation process and subsequent analysis.

CHAPTER III

STUDY HISTORY, PRIOR STUDIES, REPORTS, AND EXISTING WATER RESOURCE PROJECTS

3.1. STUDY HISTORY

In 1976 Congress, under the authority of the Flood Control Act of 1938, funded the Corps to conduct an interim study of the Lower Santa Cruz River from Red Rock to the Gila confluence. The results of that study, released in August 1983, found no economically justified solution. Benefit-to cost ratios ranged from 0.3 to 0.7 for three different diversion plans. All alternatives analyzed were for diversion of floodwaters from the Greene's Canal area to the Tat Momolikot Dam reservoir.

In October 1983 a flood along the Lower Santa Cruz caused over $45 million (1994 $) in damages, and renewed interest in flood control of the river. With local interest, the Corps reevaluated the problem, and it appeared that the diversion alternative might be economically feasible. Pinal County agreed to cost share a feasibility analysis, and a study, upon which this report is based, was started in June 1989.

3.2 EFFORTS BY OTHER AGENCIES

As early as 1937 the Pinal County Board of Supervisors had passed a resolution seeking support for development of a flood control project which would capture major Santa Cruz River floodwaters at the southern end of the county and divert them away from developed areas.

In 1965, the Pinal County Flood Control District constructed local channel improvements along portions of the downstream reach of the Santa Cruz River. Also in 1965, the Stanfield Flood Control District constructed channel improvements along the downstream reach of Santa Rosa Wash, west of the Lower Santa Cruz River, both north and south of Arizona Highway 84.

Major channel improvements north of Highway 84 were constructed in 1967 by a cooperative of local farmers aided by the U.S. Soil Conservation Service. The Greene Reservoir Flood Control District constructed the Greene Wash Diversion in 1967. This diversion is about 3 miles long and connects Greene's Canal with Greene Wash. In 1969 and 1970, the Midway Flood Control District improved existing dikes and constructed new dikes along Greene Wash and its tributaries. The total length of these improvements was about 12 miles. Many of these improvements by local interests have been damaged or destroyed by subsequent floods.

In November 1976, the U.S. Bureau of Reclamation issued a draft report entitled "San Pedro - Santa Cruz, Arizona; Concluding Report." The Bureau evaluated several different water projects in the Lower Santa Cruz area, including: 1) diversion of Santa Cruz flood flows to Greene's Canal and Wash with storage near the Sawtooth Mountains (Sawtooth Dam and Reservoir); 2) storage at a Sasco site just west of Red Rock,(Sasco Dam and Reservoir); 3) a combination of 1) and 2); and 4) diversion of flood flows to Tat Momolikot Dam. None of the plans was found to be economically justified and the Bureau of Reclamation did not pursue its study further.

As part of the same Bureau of Reclamation study, a water supply structure, referred to as Nogales Dam and Reservoir and to be located on the Santa Cruz River at the border with Sonora, Mexico, was considered. That structure would have been located far upstream from the lower Santa Cruz area, and with limited capacity. It would not have been a major factor in controlling floods in the lower Santa Cruz area. That dam was not built.

After release of the Bureau of Reclamation study, local interest in the diversion to Tat Momolikot Dam concept remained high, and contributed to initiation of the Corps 1983 interim study.

In addition to the above efforts, the U.S. Bureau of Indian Affairs (B.I.A.), local Pinal County Flood Control Districts, and local ranchers have suggested, or proposed, various structural solutions to Lower Santa Cruz flooding. For example, the possibility of a Silver Reef Dam on the Tohono O'odham Reservation, northeast of Tat Momolikot Dam, was considered in a conceptual manner by the B.I.A. No formal study was ever conducted.

Only localized channel improvements and dike or levee protection has resulted from the above efforts. No solution to the major flooding problem from the Lower Santa Cruz River, by the Corps or any other agency, has proceeded beyond the planning phase.

3.3 PRIOR STUDIES AND REPORTS

The studies and reports listed below were conducted by the Corps of Engineers, or other agencies, and were used as references for this study.

(1) Environmental Assessment- Central Arizona Project Reallocation of Non-Indian Agricultural Water, June 1991. (U.S.Bureau of Reclamation)

(2) Flood Insurance Study, Pinal County, Arizona,Unincorporated Areas, Rev. March 1990 (FEMA)

(3) Floods of October 1983 in Southeastern Arizona, March 1989. (U.S. Geological Survey)

(4) Santa Cruz River, Hydrology: Red Rock to Laveen, October 1986. (Corps)

(5) Santa Rosa Canal Division B General Design Memorandum Jan 1985. (Revised - February 1986) (U.S. Bureau of Reclamation)

(6) Central Arizona Project Fish and Wildlife Coordination Act Report on Indian Distribution Division Multiple User Delivery Facilities. April 1984. (U.S. Fish & Wildlife Service)

(7) Interim Feasibility Report on Lower Santa Cruz River Basin and Tributaries, August 1983. (Corps)

(8) Environmental Assessment of the Proposed Irrigation Distribution System Project of Maricopa-Stanfield Irrigation & Drainage District. July 1981. (M-S)

(9) Salt-Gila Aqueduct "Environmental Statement" and Summary description. Nov 1979. (U.S. Bureau of Reclamation)

(10) 6-10 October 1977, Flood Damage Report on Storms and Floods on Santa Cruz, Gila and San Pedro Rivers, Arizona, September 1978. (Corps)

(11) Lower Santa Cruz River, Arizona. Interim Survey Report for Flood Control and Allied Purposes, August 1977. (Corps)

(12) Santa Cruz-San Pedro River Basin Arizona, Resource Inventory, August 1977.(U.S. Bureau of Reclamation)

(13) San Pedro-Santa Cruz Project, Arizona, Concluding Report. November 1976. (U.S. Bureau of Reclamation)

(14) Santa Cruz Floods, 1965 and 1967, Midway Flood Control District. Area between Chui Chu and Stanfield, AZ. (n.d.,n.a.)

(15) Memorandum on Status of Investigation, Santa Cruz River Basin, Arizona, February 1965. (U.S. Bureau of Reclamation)

(16) Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona, Gila River Basin, Arizona and New Mexico, August 1964. (Corps)

(17) Flood-Damage Report on Storm and Flood of 26-30 September 1962. Santa Cruz River and Santa Rosa Wash, Arizona. November 1963. (Corps)

(18) Vaiva Vo Irrigation Project, Papago Indian Reservation, Arizona. Feasibility Report, May 1961. (Bureau of Indian Affairs)

3.4 EXISTING WATER RESOURCE PROJECTS

Other than the localized small flood control improvements, there are no flood control, or other water resource, projects on the lower Santa Cruz River. Tat Momolikot Dam was completed in 1974 on Santa Rosa Wash, a major upstream tributary of the Santa Cruz. The dam is located about 25 miles southwest of Casa Grande on the Tohono O'odham Reservation. The dam was constructed by the Corps for flood control, water conservation, and recreation purposes. Construction of the dam reduced potential flood waters from Santa Rosa Wash that would enter the Santa Cruz River at the downstream end of the drainage area. Use of the reservoir area behind the dam for diverted flood flows from the Santa Cruz River has been advocated by some local interests since the dam was completed.

CHAPTER IV

RESOURCES AND ECONOMY OF THE STUDY AREA

4.1 LOCATION AND BOUNDARIES

The Lower Santa Cruz River study area (Fig. 2) is located in south-central Arizona. The area is bounded on the north at the confluence with the Gila River and the boundary with Maricopa County. The southern study area boundary was initially the Pinal County/Pima County line, but was later extended approximately 20 miles upstream into Pima County. The total study area is approximately 1,400 square miles.

4.2 PHYSICAL CHARACTERISTICS

4.2.1 General Description and Topography

The entire Santa Cruz River Basin comprises about 8,600 square miles of the 58,000 square mile Gila River Basin. About 400 square miles of the Santa Cruz basin is in Sonora, Mexico. The Santa Cruz rises at an elevation of 5,100 feet above mean sea level in southern Arizona, flows southward about 8 miles to the boundary of the United States and Mexico, makes a 35-mile loop into the State of Sonora, and then re-enters Arizona at a point about 6 miles east of Nogales. The river flows northward about 70 miles to Tucson, and then northwestward about 80 miles to the confluence with Greene's Canal in southern Pinal County. Virtually all annual flows, and the larger volume of flood flows, proceed along Greene's Canal.

At the west end of Greene's Canal, the Santa Cruz River, Greene's Wash and Santa Cruz Wash, form a mixed system of channelized, as well as many poorly defined, streams for another 60 miles, ending at the Gila River.

4.2.2 Geology

The study area is part of the Basin and Range Geographic Province of south-central Arizona. The province is characterized by deep basins and low rugged mountains separated by steep normal faults which were active in the late Tertiary period, several million years ago. The project area is essentially aseismic and earthquakes are rare. The basins are filled with a thick accumulation of sedimentary deposits. Subsurface geology in the area is not well known. Local mountain outcroppings, such as the Sawtooth Mountains, are Tertiary volcanos.

4.2.3 Soils and Foundations

The major engineering consideration from a geotechnical standpoint is earth fissuring as related to land subsidence. The magnitude of future subsidence will largely be controlled by the magnitude and pattern of future groundwater extractions, but will likely continue into the next century. The subsidence appears to be caused by dewatering of thick alluvial deposits to the northeast of the Sawtooth Mountains. Subsidence of as much as 15 feet has been documented during the 1950-1989 period. Numerous fissures are located throughout the study area and it is difficult to predict when and where further fissures would appear. Soils in the foundation are subject to compaction, and any embankments would need mitigating measures to preclude future cracking and potential erosion from the pool during storage. Sources of stone and riprap for construction can be found in the general area.

4.3.4 Air Quality

Air quality in the study area is consistently good. The only pollutant that typically exceeds state and Federal standards is concentrations of particulates. This is largely due to wind erosion from idle agricultural land, unpaved roads, and disturbed desert areas.

4.3 WATER RESOURCES

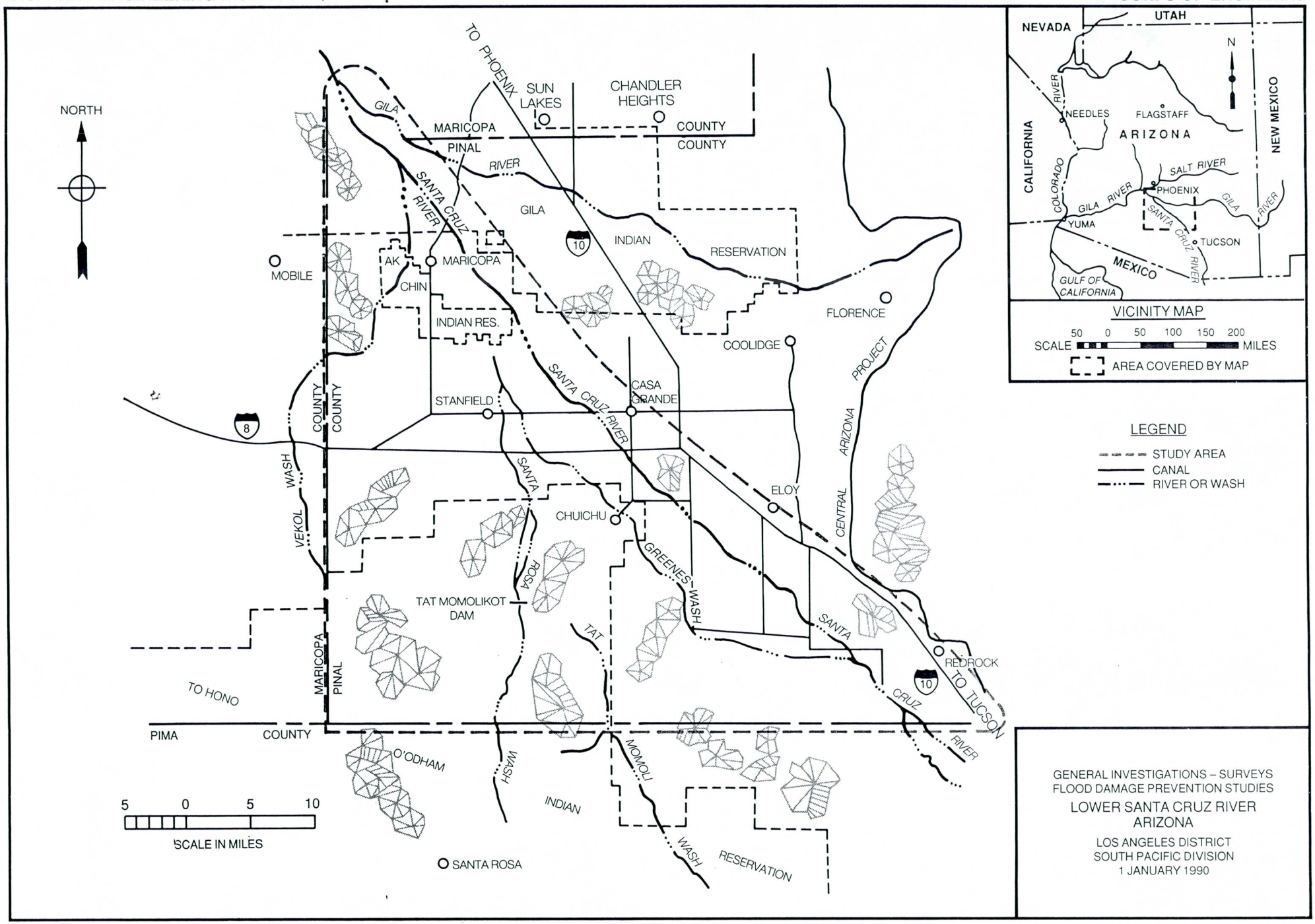
4.3.1 Climate

The study area is located within the Lower Sonoran Life-Zone. The climate is characterized by long, hot summers, short mild winters, sparse rainfall, low relative humidity, and a high percentage of sunny days.

There are two distinct sources of moisture, with precipitation generally occurring in midsummer and midwinter. Winter precipitation is associated with Pacific air moisture moving into the area from the Northwest.

Winter rains may last for several days and usually occur as low intensity showers over a large area. Summer precipitation generally comes from the southeast or southwest, from moist tropical Atlantic or tropical Pacific air masses. Summer thunderstorms, which usually cover only small areas, are intense and of short duration, and produce many of the destructive flash floods well known in the southwest.

Average maximum temperatures in the area range from 103 to 106 degrees F in July to 65 to 67 degrees F in January. Average minimum temperatures range from 72 to 74 F in July to 34 to 36 F in January. Precipitation averages 8-10 inches per year.


NORTH
TO PHOENIX
SUN LAKES
CHANDLER HEIGHTS
MARICOPA COUNTY
PINAL COUNTY
GILA RIVER
SANTA CRUZ RIVER
GILA INDIAN RESERVATION
MOBILE
AK CHIN INDIAN RES.
MARICOPA
FLORENCE
COOLIDGE
CASA GRANDE
STANFIELD
ELOY
CHUICHU
TAT MOMOLIKOT DAM
REDROCK
TO TUCSON
TO HONO
PIMA COUNTY
O'ODHAM INDIAN RESERVATION
SANTA ROSA
VEKOL WASH
ROSA WASH
TAT MOMOLI WASH
GREENES WASH
CENTRAL ARIZONA PROJECT
SCALE IN MILES
5 0 5 10
NEVADA
UTAH
CALIFORNIA
ARIZONA
NEW MEXICO
MEXICO
NEEDLES
FLAGSTAFF
PHOENIX
YUMA
TUCSON
COLORADO RIVER
SALT RIVER
GULF OF CALIFORNIA
VICINITY MAP
SCALE 50 0 50 100 150 200 MILES
AREA COVERED BY MAP
LEGEND
STUDY AREA
CANAL
RIVER OR WASH
GENERAL INVESTIGATIONS – SURVEYS
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LOWER SANTA CRUZ RIVER
ARIZONA
LOS ANGELES DISTRICT
SOUTH PACIFIC DIVISION
1 JANUARY 1990

FIGURE 2

4.3.2. Surface Hydrology

a. Existing Water Courses

The Santa Cruz River basin is characterized by a wide valley broken by several broad, low hills and mountains. The basin area has a maximum length of approximately 175 miles and is about 80 miles wide at its widest point. Stream gradients in the basin range from about 29 feet per mile near Lochiel to 18.5 feet per mile at Tucson to 8 feet per mile at the Gila River confluence.

Major tributaries to the Santa Cruz include: Santa Rosa Wash, Los Robles/Brawley Wash, Rillito Creek, and Canada Del Oro.

The Santa Cruz River and principal tributaries are purely ephemeral, being dry for long periods of time. Flows in the river are a result of direct or upstream precipitation or irrigation tailwater in the basin. For a short distance downstream of Tucson, the river conveys a perennial flow of sewage effluent from a sewage treatment plant.

Analysis of the basin indicates that the Red Rock area marks a change in character of the runoff. Just upstream from Red Rock the Los Robles Wash system enters the Santa Cruz River and is the last major source of uncontrolled runoff from mountainous terrain.

From the headwaters to Red Rock, the Santa Cruz River is a gaining river, meaning discharge generally increases with drainage area. From Red Rock to the confluence with the Gila River, the flood plain flattens and broadens out in the area known as the Santa Cruz Flats and becomes a losing river and flood flows are attenuated as discharge decreases with an increase in drainage area. Local washes, primarily on the western side of the study area, occasionally add large flows of stormwater into the Santa Cruz. These washes include Smith and Vekol Washes.

Flows originating in the upper reaches of the Santa Cruz River rarely reach the Gila River and even then are usually augmented by tributary flows originating in the lower part of the basin. The streambed materials are extremely permeable, especially from Cortaro to Laveen, resulting in high rates of infiltration.

b. Water Quality

Surface water quality data for the study area does not exist in detail. Given the inflow of urban runoff and sewage effluent from Tucson, together with irrigation tailwater, which contains phosphates, nitrates, and pesticides, surface water quality is likely poor, except when well diluted due to storm flows.

4.3.3 Groundwater Hydrology

a. Supply

Groundwater is the principal water source in the study area and accounts for nearly 92% of the total available supply. Since 1945, groundwater mining has resulted in water levels declines of 200 to over 400 feet throughout most of the region. Declining water levels continue and average 3 to 5 feet per year. Addition of irrigation water from the Central Arizona Project (CAP) is intended to reduce local dependance on groundwater, but depletion of the groundwater resource will likely continue for several decades.

b. Quality

The quality of groundwater in the project area is generally suitable for public use without treatment. Dissolved solids values are generally less than 600 mg/1, calcium carbonate values (hardness are generally less than 150 mg/1, and fluoride values are generally less than 1.5 mg/1).

4.4 BIOLOGICAL RESOURCES

4.4.1 Vegetation

Natural vegetation found within the study area is part of the Sonoran Desert Scrub Formation. Three native plant communities occur within the study area: Paloverde-saguaro, creosote-bursage, and desert wash or riparian. The paloverde-saguaro community occupies the upper bajadas and mountain areas. The predominate plant community in the study area is the creosote-bursage association. This community is found on relatively fine-grained non-saline soils of the valley plains and is dominated by creosote bush alone or by creosote bush with white bursage.

Clearing for agricultural development and grazing have eliminated or altered much of this plant community in the study area. The desert wash or riparian community is found along arroyos, washes, major drainage ways and their associated terraces, and in areas where surface water is available, such as irrigation canals, ditches and slight depressions. Stream flow diversion for agriculture and flood control and the declining water table have eliminated or damaged much of the extensive riparian community that historically occurred in the study area. Widely scattered pockets of relatively low quality riparian habitat can be found along the Santa Cruz, Greene's Canal and Greene Wash.

4.4.2 Wildlife

The riparian habitat supports the largest number and greatest diversity of desert wildlife in the study area. This habitat provides essential feeding, nesting, and roosting sites for a number of animals. Birds are the most conspicuous wildlife in the area and include Gambel's quail, white-winged dove, mourning dove, roadrunners, along with various species of songbirds and raptors. Mammals found in the area are mostly small rodents, ground squirrels and rabbits. Coyotes, skunk, fox, javalina, bobcat, and mule deer can also be found. Numerous species of reptiles, especially lizards and snakes are also common.

4.4.3 Special Status Species

Habitat for the Sandborn's long-nosed bat, and a candidate category 1 plant species, Neolloydia Erectocentra var. acunensis, may be found in the project areas. The Tumamoc globeberry, which had been listed as endangered, was delisted in 1992.

Species of Arizona State concern that may be found in the project area include the desert tortoise, kit fox, and Gila monster. Certain cacti and other native plants are protected by Arizona Native Plant Law.

4.5 HUMAN RESOURCES AND CHARACTERISTICS

4.5.1 History and Culture

The Santa Cruz study area has been influenced by four cultures - Native American, Spanish, Mexican, and Anglo-American. Native American culture extends back several thousand years. The ceremonial structure at Casa Grande Ruins National Monument, located just outside the study area, dates to about 1350 AD.

Early Spanish exploration dates to the 16th Century, while Spanish mission construction, farming and ranching dominated the 18th Century. The Mexican period from 1821 to the Gadsden Purchase in 1853 was marked by political and civil unrest and the increasing migration of settlers from the United States. With the establishment of the Arizona Territory in 1863, the railroad land grants, and the Desert Land Act of 1887, Anglo-American migration increasingly dominated the area.

4.5.2 Historic Properties

No known historic properties are located in the study area.

4.5.3 Population

The 1990 population of Arizona was 3,900,000. Pinal County, with 116,345 population had about 3% of the state total. This makes Pinal County the third most populated county in the state, exceeded only by Maricopa (Phoenix) and Pima (Tucson) Counties. Population growth in Pinal County from 1980 to 1990 has been approximately 28% (from 90,900 to 107,000).

The study area is located in the growth corridor between Phoenix and Tucson, and continued steady growth is expected. The flooding problem from the Santa Cruz River will increasingly be of concern as the area develops.

Projected population growth from 1990 through 2010, as forecasted by Arizona Department of Economic Security is 70,000 to a 2010 total of approximately 187,000.

Population data for Pinal County and several communities in or near the study area is presented in Table 1.

Table 1

Lower Santa Cruz River, AZ
Population Data

Location	1990	2000	2005
Pinal Co.	116,345	149,108	187,000
Arizona City	2,100	2,500	2,800
Casa Grande	19,625	25,100	28,300
Maricopa	1,620	2,200	2,560
Stanfield	1,580	2,000	2,280

(Source: AZ Department of Economic Security)

4.5.4 Land Ownership

Land ownership in the study area is a mix of private and public lands. The area includes parts of three Indian Reservations.

4.5.5 Economy

Agriculture predominates in the study area. The area around Casa Grande has increasingly become commercial, with expansion of retail and wholesale business and light industry.

CHAPTER V

PLAN FORMULATION

5.1 HISTORICAL FLOOD DAMAGES

The Lower Santa Cruz River has a long history of flooding throughout Pinal County. Approximately every two years there are localized flood damages, and more widespread damages at least every 5-10 years. At least 40 damaging floods have been recorded and documented since 1887. The frequency of the flood of record, in 1983, exceeded a 100 - year event. Approximate area inundated during that event is shown in the shaded area of Figure 3. Since 1983, construction of the Central Arizona Project lateral canals, and associated irrigation infrastructure, have added additional potential damages from future events. With the addition of the CAP system, activities at the Pinal Air Park, and other commercial developments, current damages from a storm and flood similar to the 1983 event, could easily exceed $100 million.

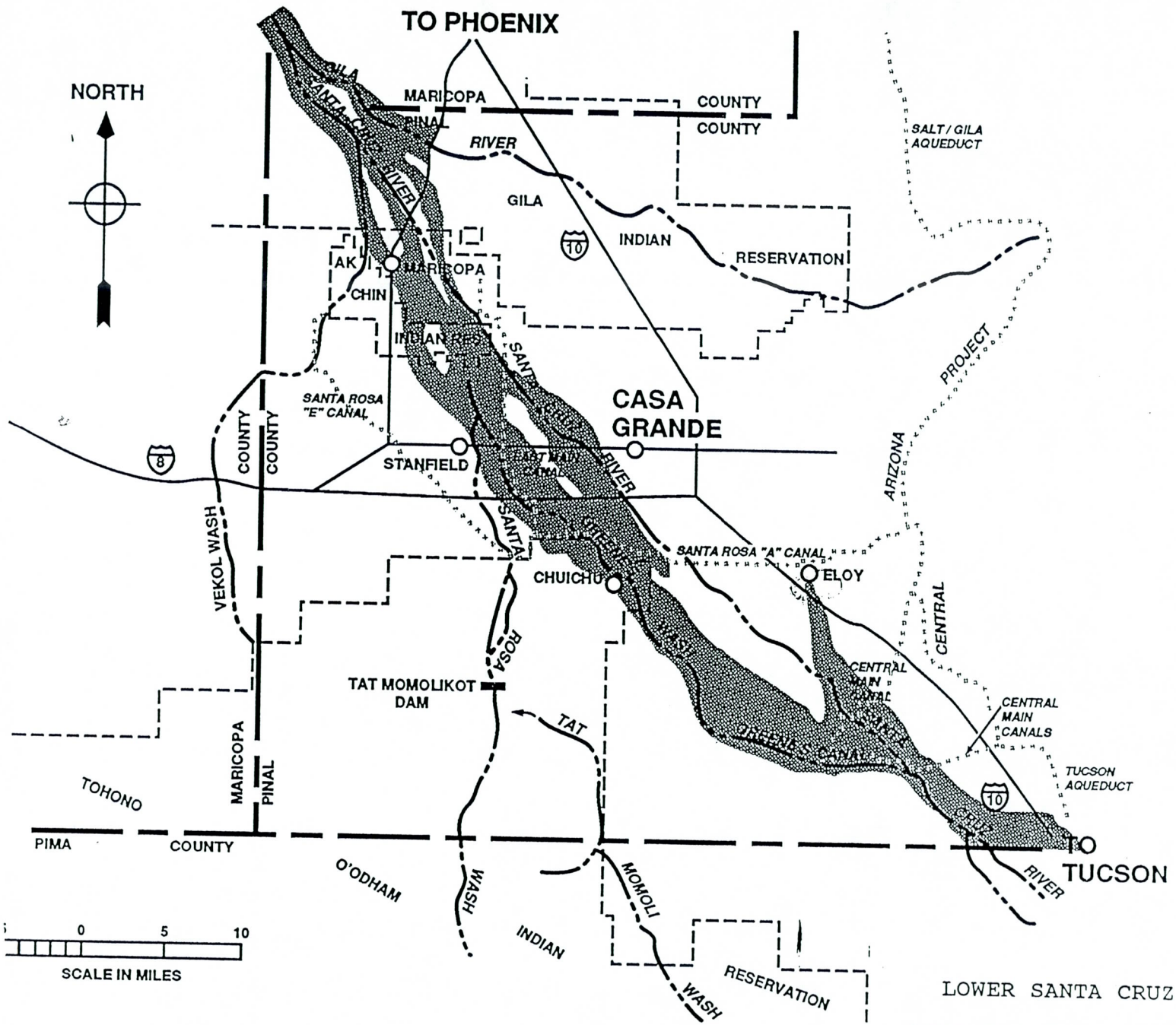
5.2 PROBLEM IDENTIFICATION

Major floods on the Lower Santa Cruz River occur primarily from large storms which impact a large portion of the upstream drainage area. Occasionally late summer and autumn tropical storms and hurricanes off the west coast of Mexico will send large amounts of moisture into Southern Arizona. The resulting heavy rainfall has created major floods, including the 1983 flood of record. In addition to the late summer-early fall storms, the winter season periodically will see large flood events.

Flooding along the river results when flows exceed limited channel capacities and flood waters inundate adjacent areas. Historically, the Santa Cruz River has migrated east and west across a broad flood plain throughout what is now central Pinal County. A map of 1896 shows the channel of the Santa Cruz at that time running generally northward from the Red Rock area, past the present town of Eloy, and joining the Gila River just west of the town of Coolidge.

After construction of Greene's Canal in 1910, flows of the river, particularly during floods, increasingly tended to the west. Most of the flow of the 1983 event flowed along Greene's Canal.

Agricultural development and construction of laterals off of the Central Arizona Project Aqueduct have all contributed to redirection of major floodflows. An additional factor is that several hundred square miles of the Lower Santa Cruz floodplain have been subject to land subsidence over the last 40 to 50 years. This subsidence, and related fissuring, has modified local topography and redirected floodflows.



LOWER SANTA CRUZ RIVER, AZ

AREA FLOODED DURING 1983 FLOOD

FIGURE 3

5.3 FORMULATION OF ALTERNATIVE SOLUTIONS

Upon initiation of this study, Corps staff met with the local sponsor to develop alternatives to solving the flooding problem.

Based upon these discussions with the local sponsor, the scope of the study was focused as follows:

(1) Emphasis was to be placed on solutions within Pinal County. (This was later expanded to include the upstream portion of the Santa Cruz River in Pima County).

(2) Only the mainstem of the Santa Cruz was to be studied, not localized flooding in adjacent communities.

(3) The study effort would concentrate on solutions to major flooding events, i.e. those of a 50- to 100-year frequency or greater.

These meetings with the local sponsor were followed by scoping sessions which included the local sponsor, Federal and state representatives and local interests. Seven general alternative solution groupings were identified:

1. Diversion
2. Channelization
3. Detention
4. CAP Laterals
5. Ring Dikes
6. Non Structural
7. No Action

The above list of alternatives was then incorporated into a public meeting format, and meetings were held in the communities of Casa Grande and Maricopa to receive public input and comments prior to commencement of the technical evaluation effort.

5.4 WITHOUT PROJECT CONDITIONS

Initial plan formulation technical work was focused as follows:

Hydrologic Studies - Feasibility level discharge and volume frequency analysis was conducted for the Santa Cruz River from Red Rock to Laveen. Hydrologic information from the 1983 report was updated to include data from the October 1983 flood. A model of the lower Santa Cruz River from Red Rock to Laveen was constructed for simulation of the effects of the alternatives. These investigations were included in a study report entitled "Santa Cruz River, Hydrologic Documentation for Feasibility Studies, July 1990." Since other agencies had also made estimates of frequency relationships for the Santa Cruz, a meeting was held with representatives from the Corps, Pinal County, Pima County, Maricopa County, U.S. Geological Survey, and the Arizona Department of Water Resources, to discuss hydrologic data for the river. The Corps discharge frequency relationships, which were used to establish without project conditions and to formulate alternatives, were subsequently utilized for this analysis with the knowledge of these agencies. Should future hydrologic analyses result in higher discharge frequency figures, this might potentially increase without project damages and change FEMA mapping. However, higher flows would also require a larger, more expensive structural solution to provide the same level of protection. Additional hydrologic analysis was conducted during evaluation of alternatives (see Ch. 6).

Hydraulic Studies - Hydraulic overflow analysis was conducted for the study area, including modeling of the 1983 flood, as well as preparation of overflows for different frequency events. Mapping was done on 7.5 minute USGS quad sheets. Extensive hydraulic design work was conducted as evaluation of alternatives progressed. (see Ch. 6)

Geotechnical Studies - Since the area is prone to land subsidence and earth fissuring, discussions and meetings were held with the U.S. Geological Survey, U.S. Bureau of Reclamation, Office of the Arizona State Geologist, private engineering firms, and local and private agencies and individuals. Mapping was obtained for known subsidence areas and fissures. It was assumed that fissuring and subsidence would remain, for the forseeable future, a without project condition. Site visits and additional geotechnical analysis are reported in Chapter 6.

Economic Studies - The floodplain was surveyed through site visits and aerial photography. Structure enumeration was accomplished through coordination of ground surveys and an assessor's parcel listing. Specific structures, such as cotton gins and an automobile test track required specific data from owner/operators. Pinal County provided data on roads and bridges.

The Bureau of Reclamation provided data on the Central Arizona Project. Potential agricultural crop damages were estimated with data provided by the Cooperative Extension Service, University of Arizona, the U.S.D.A. Agricultural Stabilization and Conservation Service, and local residents. Economic without project conditions were reported in the study documentation "Lower Santa Cruz River, Arizona, Interim Study, F3 Conference, October 1, 1990." A summary of without project damages is found in Table 2.

Environmental Studies - Environmental analysis included site visits and coordination with Federal, state, and local agencies, including the U.S. Fish and Wildlife Service, the Arizona Game and Fish Department, and State Historic Preservation Office. A Planning Aid Letter was prepared by the Fish and Wildlife Service.

TABLE 2

WITHOUT PROJECT DAMAGES
BY
FLOOD EVENT

($1,000)

Category	10-year	20-year	50-year	100-year	200-year	500-year
Upland Cotton						
DPI	295.29	1153.66	2510.40	4036.40	5396.80	7920.00
NI	145.11	565.42	1232.00	1981.20	2651.90	3888.10
Pima Cotton						
DPI	196.99	768.90	1671.70	2694.70	3602.90	5264.10
NI	203.80	795.20	2526.80	2785.90	3725.40	5466.90
Alfalfa						
DPI	0.60	1.02	2.71	3.73	5.03	7.90
NI	14.40	22.60	59.60	83.20	108.80	175.60
Durum Wheat						
DPI	27.14	64.40	118.90	168.10	223.90	313.80
NI	7.75	18.11	33.54	47.49	63.20	88.60
Laser Leveling	4636.20	6623.30	10159.70	13460.00	16092.50	21380.50
Well & Pump	562.37	1145.03	2384.34	4077.01	6432.55	9659.14
Irrigation Systems	534.80	1328.20	3019.80	5392.30	8763.70	13764.40
Farm Cleanup	486.30	633.10	806.40	922.60	954.60	1028.80
Single-Family						
Structure	167.20	225.80	364.50	757.30	1138.60	1569.80
Content	115.00	147.60	244.80	513.30	823.90	1089.70
Multi-Family						
Structure	7.33	7.33	49.72	95.50	157.76	198.08
Content	5.33	5.33	36.14	61.84	111.96	132.45
Mobile Home						
Structure	0.00	0.00	0.00	3.50	255.70	1171.70
Content	0.00	0.00	0.00	0.70	58.00	362.40
Commercial						
Structure	209.20	238.63	318.27	494.41	693.89	881.27
Content	131.55	135.98	215.41	326.85	494.18	695.62
Public						
Structure	0.00	0.00	499.35	907.81	1560.89	1950.11
Content	0.00	0.00	110.60	159.83	322.03	487.93
Farm Property						
Structure	70.00	96.12	263.43	443.97	647.13	839.88
Content	15.89	19.50	51.52	85.67	133.70	195.17
Cotton Gin						
Structure	4.22	4.22	16.51	23.41	97.25	154.79
Content	61.03	61.03	265.88	431.46	1286.39	2167.84
Feedlot	0.00	537.94	722.07	5887.02	8751.15	11981.61
CNTC	1100.00	4435.00	6010.00	7234.00	8138.00	10074.00
LFC Channel	2771.59	3963.19	5391.94	5391.94	5391.94	5391.94
Roads & Bridges	539.41	772.17	1093.60	1433.50	1643.60	2438.43
CAP System	3100.00	5100.00	9100.00	14100.00	32500.00	40100.00
TOTAL	15408.50	28868.78	49279.63	74004.64	112427.40	150840.60

CHAPTER VI

EVALUATION OF ALTERNATIVE SOLUTIONS

6.1 PREVIOUS CORPS INTERIM EFFORT

The 1983 interim survey report identified diversion to Tat Momolikot Dam as an engineeringly feasible solution. The same study, however, found that the diversion solution would not be economically feasible. In light of the extensive flood damage from the October 1983 event a reevaluation effort was conducted by the Corps to update the hydrology, hydraulics, and economics of the 1983 study. The reevaluation effort did not investigate any new alternative solutions. The reevaluation indicated that there may be a federal interest in solving the flooding problems, with a preliminary B/C ratio of 1.03. This reevaluation was a reconnaissance level effort.

6.2 ALTERNATIVE EVALUATION

A summary of all alternative evaluation results is found in Table 3, located at the end of this chapter.

6.2.1 ALTERNATIVE 1: DIVERSION

The basic concept of diversion is to capture floodwaters at an upstream location, and divert them away from high damage areas. All diversion designs included the same basic components: (1) a collector levee, (2) low-flow outlet structure, (3) diversion levee, and (4) end structure. The low-flow outlet structure would allow non-damaging flows to continue down the natural streambed, while diverting floodflows to the diversion levee.

Diversion concepts were evaluated in detail for this current study effort. Four different alignments were evaluated (Fig 4). In addition to differing alignments, analysis included sizing for different capacities, and various materials for construction. Other concepts included construction of a number of spreading basins along the alignment. This spreading basin concept was only conceptual.

Since all alternatives utilized the reservoir behind Tat Momolikot Dam as the outlet for floodwaters, a preliminary analysis was made as to necessary modifications to the Dam. Coordination also took place with representatives of both the Tohono O'odham Nation and Bureau of Indian Affairs, as the Dam lies within the reservation boundary. Site visits were held with technical staff and preliminary overflows developed for spillway flow. Satellite imagery was obtained to assist in determining potential downstream damages.

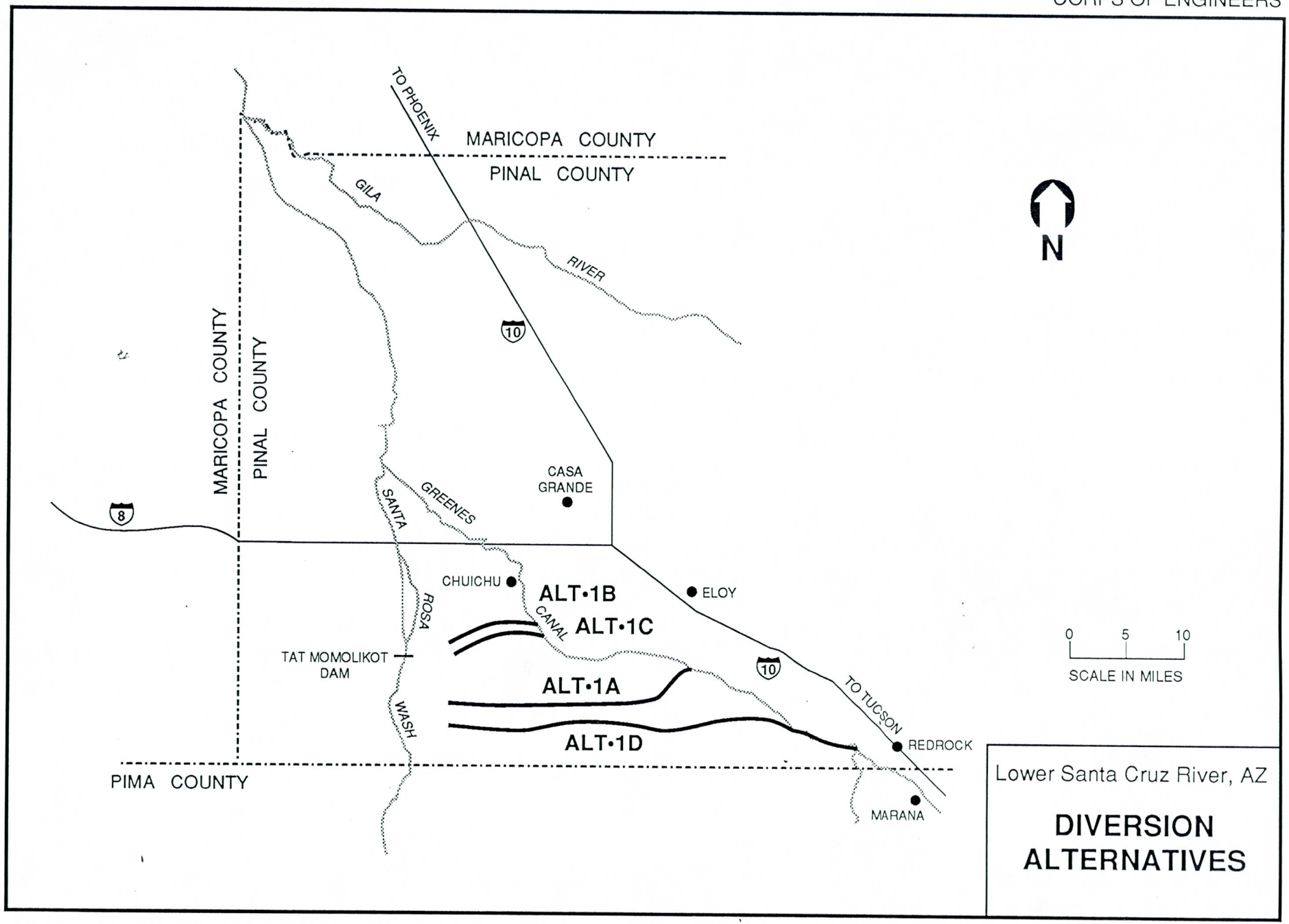

TO PHOENIX
MARICOPA COUNTY
PINAL COUNTY
GILA
RIVER
N
10
MARICOPA COUNTY
PINAL COUNTY
8
SANTA
GREENES
CASA GRANDE
CHUICHU
ALT•1B
ALT•1C
CANAL
ELOY
ROSA
TAT MOMOLIKOT DAM
ALT•1A
WASH
ALT•1D
10
TO TUCSON
REDROCK
MARANA
PIMA COUNTY
0 5 10
SCALE IN MILES
Lower Santa Cruz River, AZ
DIVERSION ALTERNATIVES

FIGURE 4

Potential modifications to Tat Momolikot included an analysis of impacts on the level of protection and safety of the dam from diversion alternatives. Several modifications were considered, including 1) a 2 foot parapet wall on the embankment, 2) a 3 foot parapet wall with spillway modifications to obtain a higher level of protection, and 3) a 5 foot parapet wall with spillway modifications. Preliminary cost estimates of modification of the dam ranged from $3 million to $6 million.

Due to land subsidence and earth fissures in the area, Diversion Alternatives 1A, 1B, and 1C were all found geotechnically infeasible.

Based upon preliminary geotechnical analysis, Alternative 1D appeared to be above the fissure prone area and analysis remained focused on Alternative 1D at the time of study termination. Total cost was estimated at about $65 million in 1993. The estimated B/C ratio for the 1D Alternative was 1.05 at the time of study termination. However, when consideration was given to potential design improvements that might be required to handle cross drainage, sediment transport concerns, and potential geotechnical, or other engineering complications, the B/C ratio may fall below 1.0.

In addition to marginal economic feasibility, a number of technical work items remain unfinished, including: (1) additional hydrologic, hydraulic, and geotechnical analysis, (2) additional evaluation of necessary modifications to Tat Momolikot Dam, (3) preparation of an Environmental Impact Statement, and (4) real estate analysis. Certain institutional concerns, including control of floodwaters diverted from the Santa Cruz River to the reservoir area behind Tat Momolikot Dam, and use of the dam for other than its original purpose, remain to be resolved. All alignments were mapped on 7.5 minute U.S.G.S. quads, and design sketches prepared for each alternative.

6.2.2 ALTERNATIVE 2: CHANNELIZATION

Channelization alternatives were developed to capture flood flows at an upstream location near Red Rock, and to contain these flows in a channel to a point where they could be discharged into the Gila River (Fig 5). Three generalized alignments were identified and preliminary cost estimates prepared. Only conceptual design work was done. Costs were based upon cost per mile for typical Corps levees of a size to handle 100-year Santa Cruz flows. These preliminary costs ranged in excess of $200-$300 million, depending upon alignment, and were so high in comparison with potential benefits, that further analysis was not conducted on this alternative. Comments at public workshops also noted potentially high environmental impacts as well as the social and economic impacts of large real estate acquisitions which would be required.

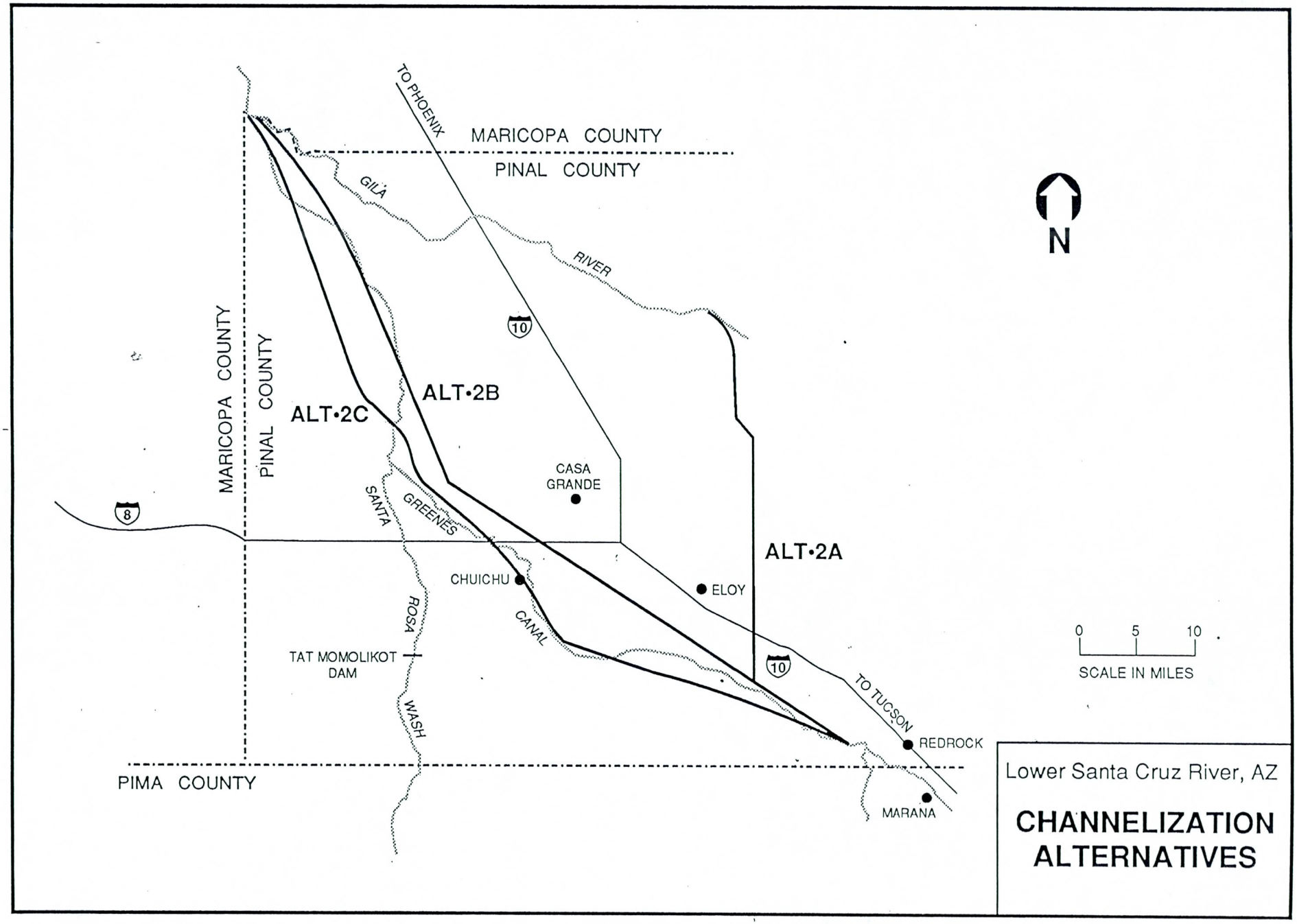

TO PHOENIX
MARICOPA COUNTY
PINAL COUNTY
GILA
RIVER
N
10
MARICOPA COUNTY
PINAL COUNTY
ALT•2C
ALT•2B
CASA GRANDE
8
SANTA
GREENES
ALT•2A
CHUICHU
ELOY
ROSA
CANAL
TAT MOMOLIKOT DAM
WASH
10
TO TUCSON
0 5 10
SCALE IN MILES
REDROCK
PIMA COUNTY
MARANA
Lower Santa Cruz River, AZ
CHANNELIZATION ALTERNATIVES

FIGURE 5

6.2.3 ALTERNATIVE 3: DETENTION

In this group of alternatives the concept of detaining floodwaters and releasing the water at a non-damaging flow rate was evaluated. All detention alternatives were designed with an outlet structure which would allow non-damaging flows to continue down the river channel. Only flows in excess of a pre-determined damaging rate would be detained. Twelve sites were evaluated for possible detention basins (Figures 6 and 7). This evaluation included analysis of different designs, levels of protection, and on- versus off-line concepts.

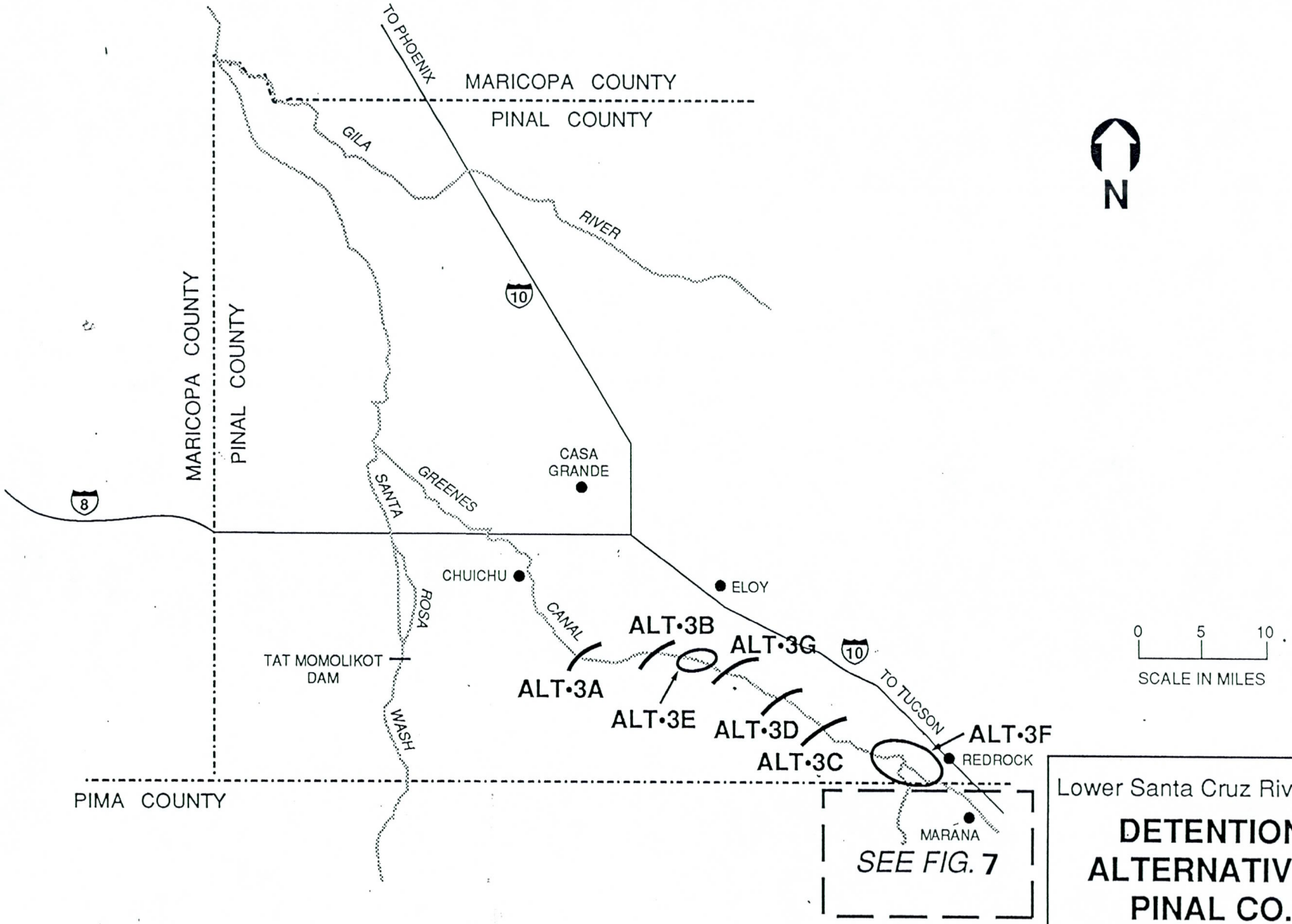
Alternative Site 3A, near the old Greene Reservoir location, initially appeared to be the most promising from an engineering standpoint, as well as having a positive B-C ratio. Subsequent geotechnical consideration, however determined that, not only 3A, but all other detention sites evaluated in Pinal County would not be acceptable due to the potential consequences of earth fissuring in the area. A variety of design features to strengthen the embankments against fissures and subsidence were evaluated, but these features all resulted in costs exceeding benefits. In addition, with the possible exception of complete lining of the reservoir area, no cost effective strengthening technique could guarantee non-failure of a detention embankment in the current subsidence and fissuring conditions which exist in much of Pinal County.

In April 1993 the Corps and local sponsor agreed to modify the scope of work for the study to allow for additional analysis which would include evaluation of detention sites upstream into Pima County. This effort evaluated, in a preliminary basis, additional sites as far upstream as the entry point of the Rillito River. Despite the higher potential benefits by protecting additional land and structures such as the Pinal Air Park, none of the Pima detention sites were economically justified. Geotechnical concerns over land subsidence and fissuring also existed in this area of northern Pima County. Detention alternatives were not studied further in the analysis.

6.2.4 ALTERNATIVE 4: CAP LATERALS

Alternative 4 considered the use of the Central Arizona Project (CAP) lateral canals for temporary detention of flood flows (Figure 8). This alternative was evaluated on a preliminary basis and, early in the study was dropped from further consideration for the following reasons:

a. The existing CAP lateral system can only pass a 25 to 50 year event without being overtopped at a number of locations. The existing levels of protection would not be sufficient against major Santa Cruz River events, such as the flood of 1983.



Lower Santa Cruz River, AZ

DETENTION ALTERNATIVES PINAL CO.

FIGURE 6

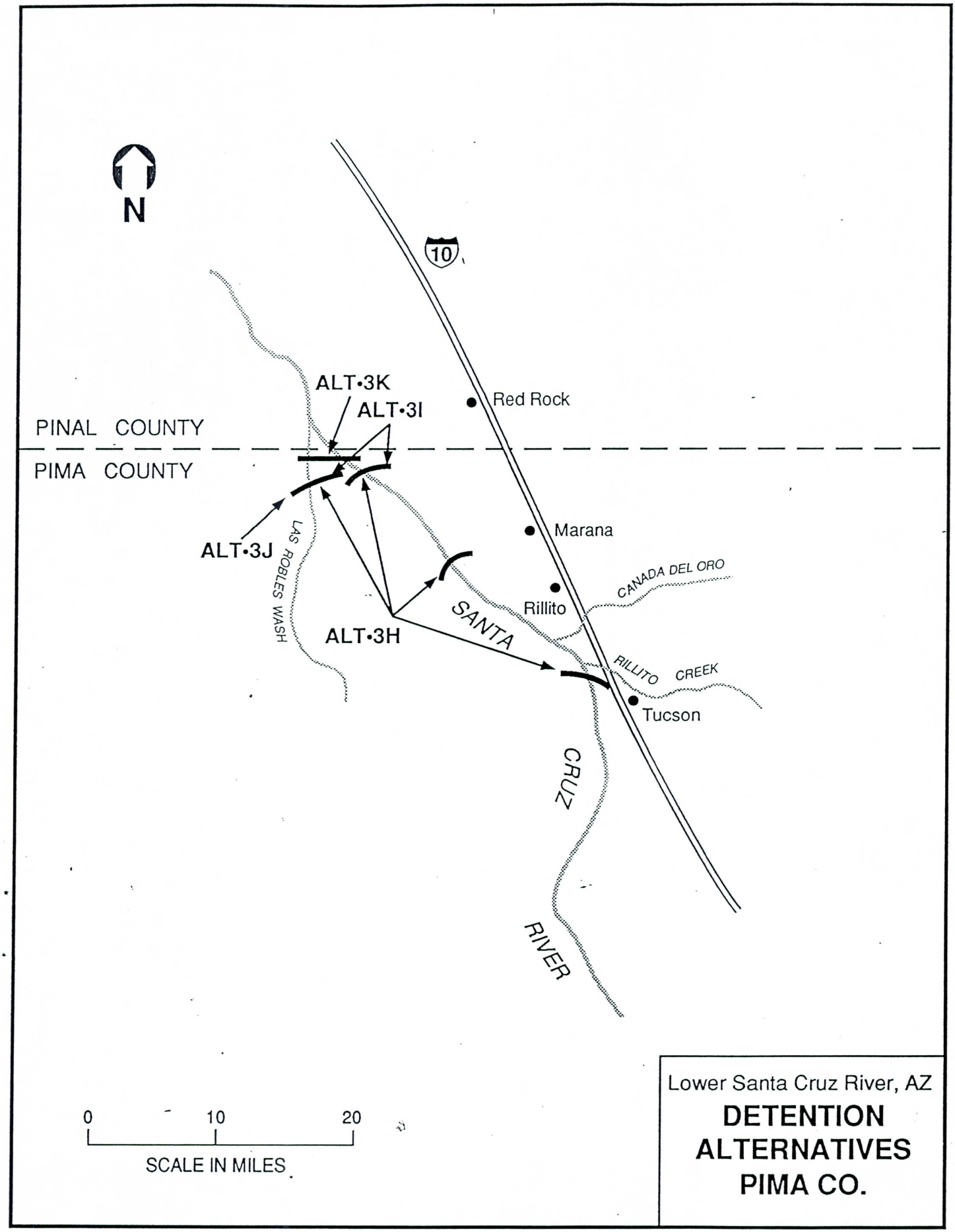

N
10
ALT•3K
ALT•3I
Red Rock
PINAL COUNTY
PIMA COUNTY
ALT•3J
LAS ROBLES WASH
Marana
CANADA DEL ORO
Rillito
SANTA
ALT•3H
RILLITO CREEK
Tucson
CRUZ
RIVER
0 10 20
SCALE IN MILES
Lower Santa Cruz River, AZ
DETENTION ALTERNATIVES PIMA CO.

FIGURE 7

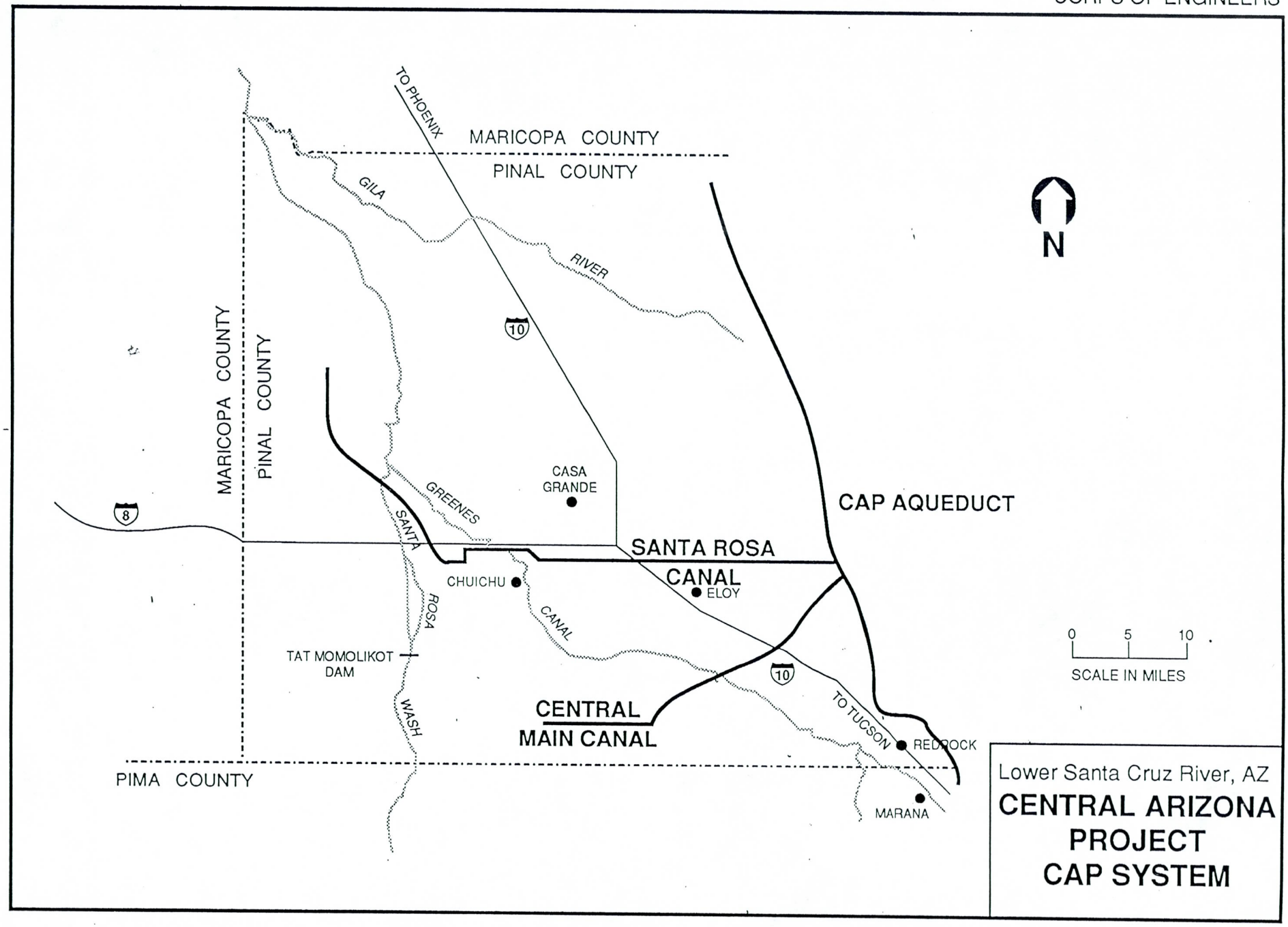

TO PHOENIX
MARICOPA COUNTY
PINAL COUNTY
GILA
RIVER
10
N
MARICOPA COUNTY
PINAL COUNTY
8
CASA GRANDE
GREENES
SANTA
ROSA
WASH
CAP AQUEDUCT
SANTA ROSA
CANAL
ELOY
CHUICHU
CANAL
TAT MOMOLIKOT DAM
10
TO TUCSON
CENTRAL
MAIN CANAL
REDROCK
MARANA
PIMA COUNTY
0 5 10
SCALE IN MILES
Lower Santa Cruz River, AZ
CENTRAL ARIZONA PROJECT
CAP SYSTEM

FIGURE 8

b. This alternative would create ponding, induce flooding in areas upstream of the laterals, and cause internal drainage problems during major flood events.

c. Little public support was expressed for this alternative.

d. Questions of project authorization and purpose of design would need to be resolved as the CAP laterals were constructed for water supply, not flood control purposes.

6.2.5 ALTERNATIVE 5: RING DIKES

Alternative 5 proposed that ring dikes , or similar protective structures, be constructed to protect communities and other significant structures and/or lands. Specific potential sights were not identified, and no map prepared.This alternative was eliminated early in the plan formulation process for the following reasons:

a. Lack of local sponsor support.

b. Difficulty in designing ring dikes in a situation where rapid growth was taking place.

c. Difficult design problems where large expanses of agricultural lands require protection.

6.2.6 ALTERNATIVE 6: NON STRUCTURAL

Alternative 6 included non structural solutions. Pinal County, with the exception of Indian Reservations, has been mapped by the Federal Emergency Management Agency (FEMA), and participates in the National Flood Insurance program. As part of that program, the County evaluates new construction permits to avoid construction in flood prone areas. The County was provided with materials on flood proofing techniques to share with potentially impacted residents. In addition the Corps intends to continue working with the County with flood plain management services activities. The Corps, Arizona Department of Water Resources, and Pinal County have also discussed flood warning needs and potential assistance.

6.2.7 ALTERNATIVE 7: NO ACTION

Without a project, periodic flood flows will continue to cause damages to lands, structures, and infrastructure throughout the Lower Santa Cruz area. Potential current damages from an event the size of the 1983 flood could easily exceed $100 million.

6.3 SUMMARY OF EVALUATION

At the time of study termination, Diversion Alternative 1D remained the most viable solution. Cost of that alternative is shown in Table 3. However, due to the substantial additional time and cost to complete the necessary feasibility analysis, and the possibility of finding an unfeasible solution at the end of additional work, resulted in a common decision not to proceed further at this time. Additional work items included sediment transport analysis, hydraulic design for the diversion levee, geotechnical analysis, and analysis of control of diverted floodwaters from the end structure to the Tat Momolikot reservoir. Any unforseen impacts or need for additional construction beyond that planned for, would increase costs and bring the B/C ratio below unity.

TABLE 3

DIVERSION ALTERNATIVE 1D

COST ESTIMATE

DESCRIPTION		COST ($1000)
A. STRUCTURE		
	COLLECTION LEVEE	$2,193
	DIVERSION STRUCTURE	$500
	CHANNEL/LEVEE	$25,775
	END STRUCTURE	$1,758
	INVERT STRUCTURE	$350
	SUBTOTAL	$30,576
CONTINGENCY		$6,124
	SUBTOTAL	$36,700
PED-CONSTRUCTION MANAGEMENT		$10,200
	TOTAL	$46,900
B. MODIFY TAT MOMOLIKOT DAM		$3,100
C. REAL ESTATE		$7,000
D. TOTAL (WITH REAL ESTATE)		$57,000
(WITHOUT REAL ESTATE)		$50,000
E. INTEREST DURING CONSTRUCTION		$4,000
GRAND TOTAL		$61,000

TABLE 4

LOWER SANTA CRUZ RIVER,AZ

ALTERNATIVE EVALUATION RESULTS

Alternative 1: **DIVERSION** - Diversion of Santa Cruz floodwaters to a location for natural flow to the reservoir area behind Tat Momolikot Dam. Four alignments studied:

Alt. 1A - Diversion first analyzed in 1983 Survey Report. Updated for current study. Not geotechnically acceptable.

Alt. 1B - Alignment north of Sawtooth Mountains Not geotechnically acceptable.

Alt. 1C - Alternative alignment north of Sawtooths. Not geotechnically acceptable.

Alt. 1D - 24 mile southerly alignment. Remains potentially feasible. Additional analysis required.

Alternative 2: **CHANNELIZATION** - Soft bottom channels to carry floodwaters from southern end of study area to the Gila River. Three alignments studied:

Alt. 2A - 37 mile direct route by Eloy. Preliminary cost estimate exceeded $200 million. Not economically justified.

Alt. 2B - 57 mile route, including straightening of Santa Cruz River. Preliminary cost estimate exceeded $300 million. Not economically justified.

Alt. 2C - 70 mile route following existing Santa Cruz River. Preliminary cost estimate exceeded $350 million. Not economically justified.

Alternative 3: **DETENTION** - Detention structure(s) to detain floodflows and release at nondamaging rate.

Alt. 3A - Detention site near old Greene's Reservoir. Positive benefit-cost ratio, but geotechnically not acceptable.

Alt. 3B - Detention site near Friendly Corners. Geotechnically not acceptable.

Alt. 3C - Detention site near Sasco. Geotechnically not acceptable.

Alt. 3D - Detention site near Picacho Peak. Geotechnically not acceptable.

Alt. 3E - Series of smaller detention structures along Greene's Canal. Geotechnically marginal. Sufficient capacity to only detain a 50 year event.

Alt. 3F - Series of detention structures along Greene's Canal. Not geotechnically acceptable.

Alt. 3G - Site southeast of Picacho Peak on Greene's Canal. Not geotechnically acceptable.

Alt. 3H - Pima County site. Not economically justified.

Alt. 3I - Pima County site. Not economically justified.

Alt. 3J - Pima County site. Not economically justified.

Alt. 3K - Pima County site. Not economically justified.

Alternative 4: **CENTRAL ARIZONA PROJECT LATERALS** - Use of CAP lateral canals for temporary detention. Economically not justified, other technical difficulties.

Alternative 5: **RING DIKES** - Use of ring dikes to protect communities and other significant structures and lands. Alternative dropped due to engineering problems of designing ring dikes in an area with rapidly expanding urban development.

Alternative 6: **NON STRUCTURAL** - Use of non structural techniques such as zoning, floodproofing, flood plain management. This alternative can reduce damages, but is not a comprehensive solution to major flooding events.

Alternative 7: **NO ACTION** - If no action is taken, the serious flooding problem along the lower Santa Cruz River will continue.

CHAPTER VII

PRELIMINARY FINANCIAL ANALYSIS

7.1 PRELIMINARY FINANCIAL ANALYSIS

Since this study concludes with a finding of no implementable plan, financial analysis of a proposed local sponsor was not conducted.

CHAPTER VIII

SUMMARY OF STUDY MANAGEMENT COORDINATION, PUBLIC VIEWS, AND PUBLIC INVOLVEMENT

8.1 COORDINATION

Many agencies and groups at the Federal, State, County, and local level, as well as a number of private firms and Indian communities, participated in, or were the source of information for this study. They included:

FEDERAL

Department Of Agriculture, Soil Conservation Service
Department of Agriculture, Agricultural Stabilization and Conservation Service
Department of the Interior, Bureau of Reclamation
Department of the Interior, Fish and Wildlife Service
Department of the Interior, Geological Survey
Department of the Interior, Bureau of Indian Affairs
Environmental Protection Agency

STATE OF ARIZONA

Department of Water Resources
Department ofEnvironmental Quality
Department of Game and Fish
State Lands Department
Parks Department (State Historic Preservation Office, Recreation)
Department of Transportation

COUNTY

Pinal County, AZ:
- Civil Works
- Flood Control District
- Engineering
- Planning and Zoning
- Cooperative Extension Service

Pima County, AZ:
- Department of Transportation and Flood Control

Maricopa County, AZ, Flood Control District

LOCAL

Maricopa - Stanfield Irrigation and Drainage District
Central Arizona Irrigation and Drainage District
Stanfield Flood Control District
Midway Flood Control District
Greene's Reservoir Flood Control District

NATIVE AMERICAN COMMUNITIES

Gila River Indian Community
Ak Chin Indian Community
Tohono O'odham Nation

OTHER

Santa Fe Pipeline Company
Southern Pacific Transportation Company
El Paso Natural Gas Company
Southwest Gas Company
Southern Pipeline Co.
Western Area Power Administration

Meetings were held with representatives of each of the above agencies and groups who also provided studies, documents and data dealing with water resources analysis and environmental resources.

The U.S. Fish and Wildlife Service prepared a draft Planning Aid Letter analyzing the effects of potential alternatives on the study area environment.

8.2 PUBLIC INVOLVEMENT

This study incorporated a public involvement program consistent with Corps of Engineers guidance and policy. In addition to numerous meetings and study management sessions, Pinal Co. and the Corps conducted formal public meetings and workshops in November 1989 for purposes of obtaining public comment. Workshops were held in Casa Grande on 8 November 1989 and Maricopa on 30 November 1989. In addition to meeting comments, participants were given the opportunity to mail comments directly to the Corps or the Pinal County Flood Control District.

Continuing contact and coordination was maintained with the three Native American Indian communities in the study area. Meetings and presentations at the Tribal Council and/or District level were conducted with officials and members of the Gila River, Ak Chin, and Tohono O'odham communities.

Since Tat Momolikot Dam is located in the Sif Oidak District on the Tohono O'odham Reservation, briefings were held at that District as well as with the Legislative Council.

As specific issues or opportunities developed during the study, contact was made with appropriate public and agency groups. For example, geotechnical concerns were discussed with staff from the Bureau of Reclamation, U.S. Geological Survey, Arizona State Geologist's Office, as well as local Irrigation and Drainage Districts.

As part of this cost shared feasibility study, periodic coordination meetings (Executive Management and Study Management Committee Meetings) were held between the Corps of Engineers and Pinal County staff. Discussion and decisions at these meetings were documented.

CHAPTER IX

CONCLUSIONS

9.1 CONCLUSIONS

The District Engineer, Los Angeles District, U.S. Army Corps of Engineers, has reviewed and evaluated, data, information, and alternatives for water resources development pertaining to the Lower Santa Cruz River, Arizona area. Principal elements considered in the review included engineering feasibility, environmental impacts and effects, and economic factors of regional and national economic development and social wellbeing.

Alternative plans for solving flood problems within the study area were formulated and evaluated. Plans considered in this report were coordinated with interested agencies at the Federal, state and local levels. Public meetings and informational meetings with local officials were held by the local sponsor to solicit public input and preferences used in formulating alternative plans.

No implementable plan was developed with available study funds. The study was terminated with joint concurrence of the Los Angeles District, Corps of Engineers, and the Pinal County, AZ, Flood Control District.

CHAPTER X

RECOMMENDATION

10.1 RECOMMENDATION

It is my recommendation that the Gila River, Lower Santa Cruz River, AZ, feasibility study, be terminated at this time with a finding of no implementable plan.

Jerome J. Dittman
Lieutenant Colonel
Corps of Engineers
Acting District Engineer