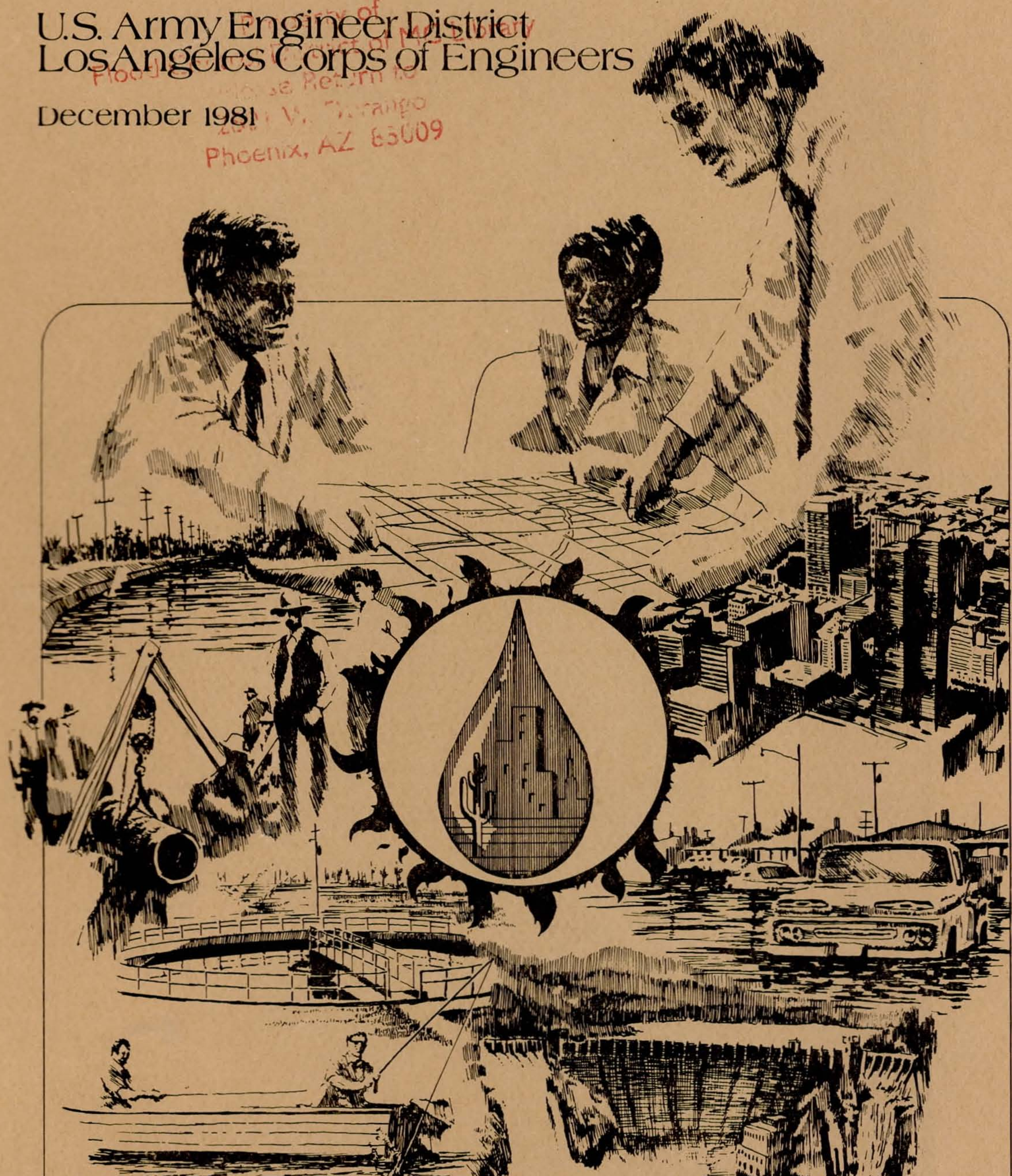
BACKGROUND INFORMATION APPENDIX

Phoenix Urban Study Final Report

U.S. Army Engineer District
Los Angeles Corps of Engineers

December 1981



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PHOENIX URBAN STUDY

FINAL REPORT

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

Water has been the single most important factor contributing to the phenomenal growth of the Phoenix metropolitan area. A century ago planners in the Salt River Valley were laying the groundwork to develop the limited water resources of the area to provide an adequate supply of water. In so doing they provided the most feasible location for development of a large population center in the entire lower Colorado River Basin. The successful development that resulted from the efforts of these pioneers in water resource planning, however, has placed an even greater demand on today's available water resources. In recognition of the need to extend and refine water resource planning, the U. S. Army Corps of Engineers undertook the Phoenix Urban Study in cooperation with local authorities.

THE STUDY

During the course of the Phoenix Urban Study, water resource plans formulated were consistent with other urban programs and flexible to allow accommodation of changing social and economic conditions. Because the study interfaced closely with water resource programs of other agencies, special attention was devoted to insuring the study did not duplicate the efforts of other agencies, but rather served as an extension and coordination of these efforts. The Corps also dovetailed its Urban Study program with other federal, state and local planning efforts to address future and residual water resource problems at the time not under study.

STUDY REPORT

This Background Information Appendix of the Final Report provides a discussion of the existing regional profile and probable future conditions, together with an identification of the specific problems, issues, needs, and concerns to which solutions may be addressed. For a more detailed understanding of the Final Report organization and content, refer to Figure 1.

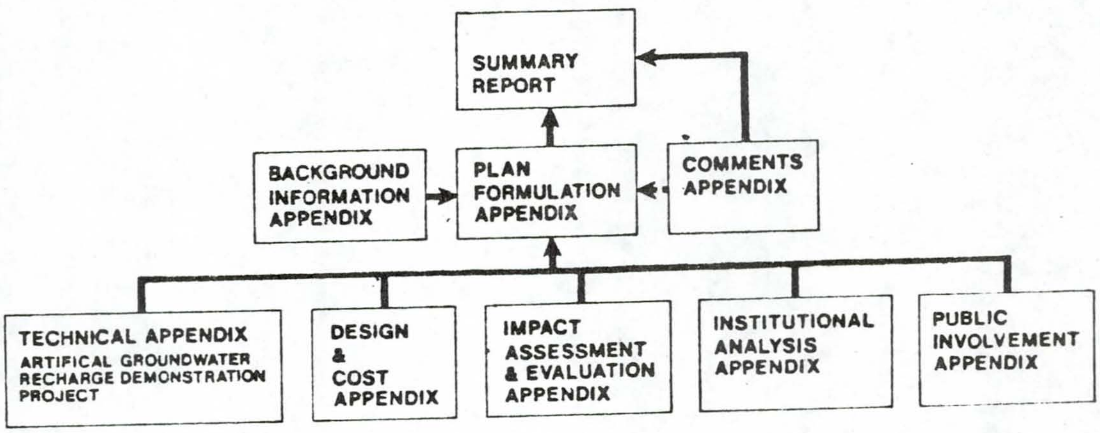


Figure P-1

Study Report Organization & Content

CHAPTER I

THE STUDY AREA

STUDY AREA LOCATION AND BOUNDARIES

The study area of the Phoenix Urban Study is located in the Salt River Valley of south-central Arizona. The boundaries of the study area were selected so as to include those cities and communities that are presently within, or are expected in the next 50 years to be within, the contiguous metropolitan area and whose water resource problems are interrelated. Figure I-1 indicates the geographical limits, principal communities, and major features of the study area.

The northern and western study boundaries were selected on the basis of growth projections developed by individual communities and the Maricopa Association of Governments. These projections generally indicate that urbanization will not exceed the boundary within the temporal scope of the study (year 2020). Existing communities on the northwest which are now or are expected to become part of the contiguous urban area are included within the study boundary. The northeastern study border follows the Tonto National Forest boundary to its intersection with the Maricopa County line. Because of existing land use plans, projected growth trends and planned land sales, it was not deemed necessary to include Forest Service or other county lands within the study area. The Maricopa County line also serves as the southern and southeastern boundary. The study area extends to Palo Verde Road on the west and includes the town of Buckeye. This area is predominantly agricultural, although specific water resource problems exist and affect the urban area, and urban growth is expected to reach into the region.

The area enclosed by the study boundary contains approximately 2300 square miles. The five major cities in the study area are Phoenix, Mesa, Scottsdale, Tempe, and Glendale, which together account for more than 93 percent of Maricopa County's population. The United States censuses of 1960 and 1979 developed the concept of Standard Metropolitan Statistical Areas (SMSAs). SMSAs comprise whole counties with a central city of 50,000 or more population where the entire SMSA is economically or socially integrated. Some rationale existed for adopting the limits of the Phoenix SMSA (which is identical to Maricopa County) as the boundary for the Phoenix Urban Study. Particular attention was given to the possibility of including the towns of Wickenburg and Gila Bend. The Corps of Engineers' Urban Study program, however, is intended to encompass only urban areas. For this reason it was determined that extending the study beyond the geographical limits of the metropolitan area violated the existing authority.

CULTURAL DEVELOPMENT

Regional Cultural History

The Phoenix metropolitan area, a major prehistoric population center, contains abundant archaelogical remains. The Hohokam tradition, which appeared about 350 B.C., was the principal prehistoric cultural complex represented within the study area. Hohokam origins had a basis in earlier cultures, with an important infusion of ideas, objects, and possibly population from Mexico. Sedentery village dwellers, the Hohokam centered in the Salt and Gila River valleys. They practiced irrigation agriculture, and over a period of nearly thirteen centuries developed more than 125 miles of canals. The Hohokam lived in sizeable communities and produced a wide variety of material goods including plain and decorated ceramics and jewelry.

With the disappearance of the Hohokam culture about A.D. 1450, a hiatus of about 300 years appears in the archaeological record of the study area. It is possible that the Pima and Papago Indians who lived in the region at the time of Spanish contact were the cultural descendents of the Hohokam, although their development during this "protohistoric" period is largely unknown.

Historic Indian groups native to the study area include the Pima, Papago, Maricopa, and Yavapai. The first three groups depended on a mixture of irrigated agricultural products and wild food resources, while the Yavapai were dependent on big game and wild foods. An additional Indian group, made up of members of the Yaqui tribe of northwest Mexico immigrated to the study area early in the twentieth century and founded the community Guadalupe.

Historical Development

It is possible that Spanish explorers passed through the Salt River Valley in the 17th and 18th centuries. The earliest permanent non-Indian settlement in the study area, however, did not occur until 1865 when Camp McDowell was established on the west bank of the Verde River a few miles upstream from its confluence with the Salt.

Modern development of the Salt River Valley began in the mid-1860s when Anglo-American settlers diverted water from the Salt River to irrigate farmland. Later in the decade, Phoenix was established. During the 1870s, the town became the commercial center for the region. Over the next two decades, the expansion of irrigated agriculture resulted in the growth of Phoenix and the establishment of a number of suburban and satellite communities.

Destructive floods in 1891 and 1905 and a drought beginning in the 1890s and lasting into the early 20th century, caused farmers and townspeople in the study area to seek a dependable source of water. Their efforts resulted in the construction of Roosevelt Dam, the first multipurpose dam authorized under the National Reclamation Act of 1902. Completed in 1911, this structure provided both irrigation water and hydroelectric power for the Valley. In the 1920s and 1930s, three more dams were built on the Salt River and two were constructed on the Verde River.

During World War II, the Salt River Valley was the site of a number of military airfields and defense plants. After the war, the study area entered into a sustained period of urbanization and industrialization. The development of air conditioning made life in metropolitan Phoenix comfortable the year round. In recent years the study area has undergone a tremendous growth in population as people and businesses continue to be attracted by the dry climate and increasing economic opportunities.

PHYSICAL CHARACTERISTICS

The Phoenix metropolitan area is in central Arizona. It is generally within the Basin and Range physiographic province and typified by geologic block faulting and tilting. This tectonic activity has formed numerous northwest - southeast trending mountain ranges separated by broad alluvial basins. Despite the prevalence of faults throughout the area, the earthquake danger in the study area is not considered severe. While several major earthquakes have occurred in California and northern Mexico, few quakes of consequence have centered in central Arizona. Elevations range from approximately 900 feet above sea level where the Agua Fria River joins the Gila River near Avondale to over 3800 feet in the McDowell Mountains northeast of Phoenix. The dominant mountain ranges within the study area are the South Mountains, the Phoenix Mountains, and the McDowell Mountains. The mountain ranges around the perimeter of the study area include the Sierra Estrella Mountains to the southwest, the White Tank Mountains to the west, the Hieroglyphic and New River Mountains to the north, the Superstition, Goldfield, and Mazatzal Mountains to the east and northeast, and the Santan and Sacaton Mountains to the Southeast. Elevations range from about 3000 feet in the White Tanks to 7000 feet in the Mazatzals. Camelback Mountain, elevation 2704 feet above sea level, is the most prominent Valley landmark.

Principal natural drainages in the study area are the Salt and Agua Fria Rivers which are tributary to the Gila River. Typical desert streams, they have virtually no base flow and carry only floodwaters, reservoir releases or effluent from wastewater treatment plants. The Arizona, Grand, Western, and Highline Canals, which are artificial waterways, collect some stormwater runoff from limited drainage areas, but their primary purpose is water supply transmission from reservoirs in the watershed.

Slopes in the study area are less than 10 percent, except in mountainous areas where grades of 20 percent and greater are encountered. Slopes greater than 20 percent are suitable for neither agriculture nor urban development.

CLIMATE

The climate in the study area varies depending on the occurrence of natural topographic features, terestrial-aquatic patterns, and man-related structures. It is generally a warm, arid desert type climate with low annual rainfall and low relative humidity. Summers are usually long with high temperatures. Winters are mild, with gradual transitions in the spring and fall seasons.

Temperature

Summers in the study area are hot. Normally in July and August temperatures range from the upper 70's at night to 105 to 115 degrees F. during the day. Temperatures in December and January typically vary from near 40 degrees F. in the early morning to the middle 60's during the afternoon.

Precipitation

Rainfall throughout the study area is governed to a great extent by elevation and the season of the year. From November through March, cyclonic storm systems from the Pacific Ocean cross the study area. These winter storms occur frequently and sometimes bring with them heavy rainfall with durations of more than 24 hours. The average annual precipitation for the entire drainage area is 11.4 inches. Phoenix recieves 7.2 inches annually. Rainfall amounts have varied from less than 3 inches in 1953 to almost 20 inches in 1905. Snow rarely falls on the desert floor. When it does, it usually melts upon hitting the ground. A significant amount of the water in the reservoirs to the north and northeast of Phoenix is derived from melting snow from mountains north and northeast of the study area. Spring runoff is derived largely from snow at elevations above 7,000 feet in the upper watershed of the Salt and Verde Rivers.

Summer rainfall begins early in July and usually extends to mid-September. Moisture-bearing winds sweep into the study area from the southeast from the Gulf of Mexico. Summer rains occur in the form of thunder showers generally caused by excessive heating of the ground and the lifting of moisture-laden air along main mountain ranges. The heaviest thunder showers usually fall over or near the mountains. These thunder storms are often accompanied by strong winds and brief periods of blowing dust prior to the onset of rain. Hail occurs infrequently.

Wind Direction and Velocity

Winds from the east through southeast combined occur approximately 42 percent of the time, while winds from the northwest through southwest occur approoximately 32 percent of the time. Wind in the study area usually blows from the east down the Salt River at night and from the west up the river in the afternoon. Southeast winds are quite common in the late morning, during the transition period between downvalley and upvalley winds. Average wind values in the Phoenix area rarely exceed 8.3 miles per hour. Despite the low average wind speeds, a speed of 75 miles per hour was reached during a thunderstorm on the afternoon of September 18, 1950. The highest daytime wind speeds in the study area are reported in the spring. The strongest night winds occur in midsummer.

Humidity

Generally, humidity values in the study area are low, occasionally falling to less than 10 percent in the early summer, and rarely rising above 60 percent in the winter.

The highest humidity occurs in the months December to February and the lowest humidity occurs in the late afternoon during May and June.

Evaporation

Evaporation data taken within the Salt River Valley exhibit a wide variation. The data from University of Arizona Citrus Experiment Station at Tempe show an average annual pan evaporation of 71.75 inches. This value is representative of a citrus grove where the atmosphere locally is more stagnant than in an open area. At the Mesa Experiment Farm, which lies in an open area, the average annual pan evaporation at one location was 82 inches for the 6-year period 1963-1969. A second location recorded an average annual pan evaporation 106 inches for the 5-year period 1969-1973. It is evident that considerable variability exists in the pan evaporation data. Such variability is common. The best that can be done is to utilize the available data in a uniform manner, eliminating from consideration data that are obviously not representative of the area of interest.

Lake evaporation differs from pan evaporation because of the difference in heat budgets between an evaporation pan and a lake. The lake evaporation is obtained by multiplying the pan evaporation by a pan coefficient. According to the data published by the Laboratory of Climatology, Arizona State University, the pan coefficient for the study area is 0.67. This indicates that lake evaporation in the long-term in the study area should generally fall in the range of 62 to 72 inches per year.

VEGETATION AND WILDLIFE

Vegetation in the study area varies considerably and correlates directly with elevation, available moisture, and temperature. The desert plains in the western portion of the study area support only the hardiest plantlife, such as creosote bushes and catclaw. Stands of mesquite, palo verde, and ironwood are found along intermittent creeks, washes, and rivers. Lusher riparian vegetation occurs along flowing streams. Much desert and riparian plantlife, however, has been lost through agricultural development and urbanization of metropolitan Phoenix. In the higher elevations of the study area, up to about 4,000 feet, greater rainfall and rugged terrain support lush desert vegetation marked by large cacti, dense chaparral and, where there is sufficient subterranean water, palo verde, ironwood, and mesquite trees. Stands of oak and pine are found in the well-watered mountains and drainage regions surrounding the study area.

In historic times, non-native crops supported by intense irrigation were introduced into the Salt and Gila River Valleys. Leading agricultural products include seed crops (cotton, milo, barley, sorghum, and alfalfa), vegetables, fruit (citrus and grape), and nut crops.

Wildlife in the study area is typical of that found in desert and foothill regions of the Southwest. For the most part, however, native fauna has disappeared from urban and agricultural portions of the study area and has been replaced by livestock and other domestic animals.

ECONOMY

Overview of the Economy

The study area is a major center for economic activity in the Southwest. Leading factors in the area's economy are manufacturing (principally high technology products), tourism, retail trade and services, and government. Industrial development is centered in metropolitan Phoenix, with agricultural districts extending to the west, southwest, and southeast of the urban area. Within the past 20 years, manufacturing has replaced agriculture as the main source of income in Maricopa County, although the county still leads the state in agricultural production. Agriculture in the study area is expected to continue to decline as the urbanization of metropolitan Phoenix increases.

Population

All of the study area lies within rapidly growing Maricopa County. With over 1,340,000 inhabitants as of 1978, it is the most populous of Arizona's 14 counties. Most of the study area's population resides in the Salt River Valley, leaving much of the region either sparsely settled or uninhabited. Phoenix, with a population of 682,000, is the principal community of the study area. Other prominent towns include Scottsdale, Tempe, Mesa, Glendale, and Buckeye. Three Indian reservations also are included: the Fort McDowell Reservation on the lower Verde River, the northern portion of the Gila River Reservation near the confluence of the Salt and Gila Rivers, the Salt River Reservation north of the Salt River east of Phoenix.

Transportation

The study area is connected to the rest of Arizona and the nation by two interstate highways, two railroads, and twenty commercial air carriers. The major factor in transportation in metropolitan Phoenix, however, is the motor vehicle. Over 100 transcontinental, interstate, and intrastate trucking companies and two bus lines serve Phoenix. The study area leads the state in motor vehicle registrations, with 646,006 passenger cars, 100,914 commercial vehicles, and 95,893 non-commercial trucks registered in 1977. The large number of motor vehicles has increased traffic congestion in Phoenix, but efforts to implement mass transit and car pooling have met with limited success.

Three major freeways are found in the study area. Interstate-17 enters metropolitan Phoenix from the north and connects with Interstate-10, an important east-west link in the Interstate Highway System. The Superstition Freeway (Arizona State Route 360) connects the communities of Tempe and Mesa with Interstate-10. Other freeways proposed in the study are have been halted by citizen opposition to routes and design.

Sky Harbor International Airport is the major air terminal in the study area. It serves in excess of 4,500,000 passengers annually. In addition, there are 22 other civilian airfields and two airbases in Maricopa County which handle an increasing volume of private and military traffic.

Travel and Mobility

The strongest influence on travel patterns in the study area is the location of commercial facilities, particularly, grocery stores.

The Maricopa County Planning Department, in its Comprehensive Plan of 1964, divided shopping centers into three types based on size and types of establishments. These centers are each intended to serve areas of varying size: a 1-mile radius for neighborhood shopping centers, and a 3-mile radius for community shopping centers. In 1964, there were 91 shopping centers and 7 discount stores, making a total of 98 shopping centers in the study area. Many of these centers overlapped their trade areas, resulting in a duplication of service. In 1975, 199 shopping centers were indentified, an increase of 100 percent in the same survey area. In addition, 9 more centers are under construction and some existing centers are planning on expanding. The large number of shopping centers, with their overlapping service areas, would seem to encourage local, nonmobile shopping patterns. With the exception of grocery stores, however, this is not the case.

Phoenix Newspapers, Inc., in their 1978 edition of Inside Phoenix, looked at the shopping patterns of both grocery and retail shoppers. Over half the households bought groceries more than twice a week, and most persons shopped close to home (50 percent within 1 mile). Retail shoppers, however, did not follow this trend. Shoppers travelled to several different locations in order to compare prices and enjoy a wide selection of merchandise. Traffic volume was up over the previous year at nearly every shopping center and area surveyed, an indication of both the mobility and selectivity of the shopper. For example, in a 30-day period, 29 percent of the shoppers in District 4 (northwest Phoenix) shopped in downtown Phoenix, travelling a distance of about 22 miles. Thirty percent shopped in dowtown Glendale, a distance of about 9 miles, in the same period of time.

Based on the service area formula of the Maricopa County Comprehensive Plan, the Phoenix metro area appears to be saturated commercially for retail centers.

Travel patterns indicate that subregional population distribution is relatively independent of employment locations. According to the Maricopa Association of Governments draft working-paper, the average one-way work trip length time in the Phoenix SMSA was 22 minutes or 8 to 10 miles for 1976. By the year 2000, when the expected population level reaches 2.5 million people (up from a population of 1.2 million in 1976), the trip time should increase 23 minutes, even if all currently proposed highways are built. Accessibility to employment was estimated to be high for 20 percent of the working population and low for 20 percent in 1975. This is expected to improve to high accessibility for 40 percent of the population and low accessibility for 10 percent if all proposed highways are completed by the year 2000. Accessibility or ease of transportation will increase as the result of new highway construction. Even with these new highways, travel time nevertheless will increase because of population and traffic increases. During off-peak hours, however, travel time is expected to decrease .

Agriculture

Maricopa County has the highest farm income of any Arizona county, and produces the greatest amount of crops and livestock in the state. It is the fifth highest county in the nation in production of agricultural products according to the most recent census of agriculture.

From 1973 to 1975, crop values increased 31 percent, while the value of livestock production decreased 11 percent. Overall, the increase in cash receipts has only been about 2 percent. Agriculture, however, remains the third leading industry in Maricopa County.

A variety of crops are harvested in Maricopa County. Grains, which lead in acreage in the state, include barley, wheat, corn, sorghum, and hay. Though production of barley, wheat, and hay decreased in 1974, estimates in 1975 showed production increasing for these and the other grains. Cotton is second to grains in amount of acreage. It experienced a significant increase in production in 1974, and a significant decrease in 1975.

Though not charted by yield, citrus acreage in Maricopa County for 1975 was 25,480. There are also small amounts of grapes, nectarines, and peaches grown in Maricopa County. As with crops, livestock is varied.

The majority of land used for agricultural purposes in Maricopa County is public land. Only 1,585 acres, or 27 percent of the agricultural acrease is privately owned. Determination of the value of these privately owned agricultural lands has been difficult and is subject to many influences.

Industry

Industry and manufacturing in 1976 were the leading income producers in the Phoenix area with 49 percent of the total. Industry is the leading nonagricultural employer, with 27 percent of the labor force.

As shown in the section on travel patterns, the location of industry throughout metropolitan Phoenix is varied, resulting in consistent integration of industry with other land use.

Most of the industry in the study area as of 1975 was considered "clean"; there was little polluting industry, such as steel and textile mills. The five leading employers, in order, are electrical machinery, transportation equipment, printing, machinery, and primary metals.

Commerce

In 1975, retail stores recorded sales of $4,140,068,000, 4.5 percent higher than the previous year. Some 57 percent of the consumer dollar is spent at auto dealerships, food stores, and for general merchandise. Most consumers visit more than one area or center when shopping. This is probably due to the high mobility factor in the Phoenix area, and the large number of shopping areas that often overlap in service area. The value of commercial land, like other land in the study area, is extremely valuable but will generally range from $37,000 to $800,000/acre, both developed and undeveloped.

Residential Development

According to Valley National Bank (1976), the number of single family units (including mobile homes) in the Phoenix SMSA increased 43 percent from 252,785 in 1970 to 360,608 in 1975. The number of multifamily units (including townhouses) increased 106 percent from 64,204 in 1970 to 132,203 in 1975.

The value per acre of residential land (like the value of other types of land), has become difficult to obtain. Because there has been so much speculation and sharp increases in the value of land over the last 5 to 10 years, data on land values have been limited. Based on estimates from persons in real estate and government, however, a range of $6,000 to $60,000 per acre for the Phoenix area has been proposed.

DEMOGRAPHY

Growth

Phoenix is a rapidly growing urban area that lies within a designated Standard Metropolitan Statistical Area (SMSA). Maricopa County is coterminous with the boundary of the Phoenix SMSA. Approximately 93 percent of Maricopa County population is within the Phoenix metropolitan area. The county contains much land area, mostly in the western area, which is almost entirely publicly owned and therefore reserved.

Since 1940, the Phoenix metropolitan area has grown from a population of less than 200,000 to over 1.3 million people. Immigration still accounts for a much larger percentage of the growth rate than natural increase, a condition that is expected to continue. Arizona and the Phoenix area offer amenities that will continue to draw population from other areas. Phoenix is one of the few metropolitan areas that has continued to grow rapidly when other metropolitan areas have begun to lose population. Arizona is the fastest growing state in the country. The warm, arid climate, availability of land for expansion, and location for future solar energy development add to the probability that Phoenix will continue to grow.

Racial Composition

As of July 1975, Maricopa County's racial composition was fairly characteristic of the state as a whole. The racial composition of Maricopa County in 1974 was 94.9 percent white, 3.3 percent Blacks, and .64 percent of other ethnic origin according to a report by the Department of Economic Security. The "white" population category also includes at least 14.6 percent Spanish-American, the largest ethnic group in the urban study area. For the most part, Black and Spanish American residents are concentrated in the area south of the Salt River, the Core City, and the Sky Harbor area. These areas also share a lower median income than the urban study average. There are three Indian reservations within Maricopa County whose populations, not included in the county estimates, are as follows: Fort McDowell Indian Community, 340; Gila River Indian Community, 8,330; and Salt River Indian Community, 2,750.

Age

Although the median age of Maricopa County was 26.7 in 1970 and 28.0 in a 1976 consumer survey, these figures do not bring out the great diversity that exists by area. In Sun City (retirement community), the median age is estimated at approximately 65, and in the airport area, the median age is only 18.

The average age of the head of household in Phoenix is given in Table I-1. Sun City, Youngtown, and Peoria have less than 20 percent of the heads of households under 35, South Phoenix and Tempe have 40 percent or more under 35, Glendale and Mesa have 30 to 39 percent under 35. This illustrates that Tempe and South Phoenix are relatively young areas; Mesa and Glendale have a generally older population and are more established areas. Sun City, Youngtown, and Peoria are generally older, which is the result of the retirement community orientation of that area.

Housing

Housing in the study area focuses on the single family structure. A 1977 inventory indicated that 518,000 dwelling units existed in metropolitan Phoenix. Single family houses accounted for 329,400 of these, with apartment units numbering 105,900, and townhouses and mobile homes numbering 83,000. Occupancy rates averaged 97 percent. Over 40 percent of homes in the Phoenix area were less than 10 years old. Housing conditions on the Indian reservations in the study area generally are considered substandard, although improvements have been made in recent years.

TABLE I-1

DISTRIBUTION OF THE AVERAGE AGE
OF THE HOUSEHOLD HEAD IN METRO PHOENIX 1978

HEAD OF HOUSEHOLD	NUMBER OF HOUSEHOLDS	PERCENT
Under 35	150,000	30
35-49	130,000	26
50-64	115,000	23
65 and over	105,000	21

Source: Phoenix Newspapers, Inc., 1978, "Inside Phoenix."

TABLE I-2

INCOME CHARACTERISTICS FOR PHOENIX URBAN AREA

MEDIAN HOUSEHOLD INCOME

Phoenix, Urban Area

Dollars per Household

1970	1971	1972	1973	1974	1975	1976	1978
8,823	9,392	9.813	10,692	11,691	11,956	12,420	14,011

Source: Phoenix Newspapers, Inc., 1978, "Inside Phoenix."

Education

According to 1977 estimates, 21 percent of adults in Phoenix over age 25 had less than a high school education. High school graduates accounted for 35 percent and 13 percent were college graduates. The median educational level for the study area is 12.8 years.

Income

In 1978, the median income for metropolitan Phoenix was estimated at $14,011. Median household incomes were under $10,000 in the inner city, while many families in the north Phoenix, Scottsdale, and Paradise Valley areas earned over $35,000. See Table I-2 for the growth of median household incomes in metropolitan Phoenix. Indian reservations in the study area have family incomes which are quite low. In 1970, the median ranged from $946 on the Gila River Indian Reservation to $4,780 on the Fort McDowell and Salt River Indian Reservations.

LAND USE AND GROWTH

During the next few decades, Phoenix faces the challenge of fabricating a society which not only preserves the delicate balance between the needs of its citizens and their natural resources, but also improves the natural heritage. Proper use of the urban Phoenix land base is paramount in meeting this challenge.

No-Growth vs. Growth

A simplistic approach to land use questions in urban Phoenix imposes a moratorium on growth in the study area, and encourages the development of solutions for mitigating identifiable natural resource degredation. This approach, however, is not feasible. Stemming the increasing tides of emigrants seeking the desirable southwestern lifestyle would require a massive coordination of agencies, almost instant creation and promulgation of growth-restrictive policies, and enforcement procedures nothing short of dictatorial. A more realistic, and not ineffective, approach accommodates the study area's growth along well-defined geographic guidelines, with technological innovation providing essential services to the increasing population in the most environmentally compatible manner.

Development of Population Projections

In the past, a number of organizations, both public and private, have made population projections for Maricopa County.

Valley Area Traffic and Transportation Study (VATTS)

The Maricopa Planning and Zoning Department, in a 1970 report, published population projections for 1980 and 1995. This study was primarily for traffic and transportation analysis, but it did develop the small geographic units referred to as Traffic Analysis Zones (TAZ).

MAG Population Projections

MAG decided in 1972 that the VATTS population projections needed to be updated and projected further into the future. Also the number of Traffic Analysis Zones were increased from the original VATTS 688 to nearly 1000. This large number of TAZs provided a more detailed population analysis and improved the distribution capability.

Department of Economic Security (DES)

The Arizona Department of Economic Security periodically prepares population projections using the Economic Demographic Projections Model (EDPM). This model was originally developed to identify changes in population under varying economic conditions.

Office of Business Economics and Economic Research Service (OBERS)

OBERS (U.S. Department of Commerce, Bureau of Economic Analysis and U.S. Department of Agriculture, Economic Research Service) has made population projections for Maricopa County. These projections are based on the premise that population is a function of employment. (See Table I-4)

Maricopa County

Population projections for Maricopa County, using the component method as defined by the U.S. Bureau of Census, have been prepared by the Maricopa County Planning and Zoning Department (MCPZD).

The varying methodologies used in the population projections, created a wide range of possible projected populations. To assure consistent population estimates and projections throughout the state for planning purposes, Governor Raul Castro signed Executive Order 77-5 on August 3, 1977, designating the Arizona DES as the official population projecting and estimating agency for the State of Arizona. All state agencies must use DES projections for planning purposes. Using an Economic Demographic Projection Model, DES estimates population by county, and these estimates are revised annually.

Following the signing of Executive Order 77-5 by Governor Castro, the Maricopa Association of Governments adopted the DES figures for use in their water quality, housing, and transportation programs. MAG allocated these adopted population figures to smaller areas, and worked closely with each member jurisdiction to ensure conformance with local zoning plans and objectives. Historic and future population growth of Maricopa County to the year 2000 is shown in Table I-3 and Figure I-2. Providing essential services to the increasing population in the most environmentally compatible manner will be one of the most pressing concerns facing Maricopa County for the remainder of the century.

Planning for Growth

Historically, the study area was devoted to agriculture. Prior to World War II, Phoenix and surrounding communities existed almost solely to support farm activities. Land use within the study area shows the influence of this early history. In 1970, 48 percent of the Phoenix urban area was in agricultural use, with 34 percent vacant and 18 percent urbanized.

In Part Three of its Comprehensive Plan (1975), the Maricopa County Planning and Zoning Department projected that urban land in the county will increase 50 percent, from 323 sq. mi. in 1990, or 48 percent. Consequently, agricultural land will continue to decline from 882 sq. mi. in 1973 to approximately 600 sq. mi. in 1990.

In the West Central Maricopa County Plan, the MCPZD recommended that four land-use policies be adopted and implemented in the Phoenix urban area:

1. Prohibit excessive use of water in the Phoenix region, to allow for stabilization and, if possible, recharge or the ground water.

2. Permit new urban and rural non-farm residential development on lands that are well-suited for those purposes. Urban development aids in stabilizing the water table

3. Reserve the best agricultural lands for agricultural uses, creating greenbelts between urban core areas.

4. Promote outdoor recreation and other open space land uses within and around urban areas.

Implementation of these recommendations will require several factors:

1. Local zoning decisions based upon the specific land-use plans and policies of each Local Planning Area, as stated in the Comprehensive Plans.

2. Specific land use plans for local areas with consideration given to the need by type, for certain kinds of areas and zones (park, commercial, etc.), as well as financial feasibility, and ability to implement and enforce zoning.

3. Current zoning covenants with provisions for addressing the implementation of the plan through such things as:

a) the sale of development rights for the protection of agricultural or open space areas, b) taxing incentives, c) the dedication of park, school, and/or open space areas by large-scale developers, d) land exchanges or leases between the federal government and private developers, e) sale or exchange of land between the state and local governments or private developers, f) leases between the Indian reservations and state and local governments and private developers.

As of 1975, all of the incorporated cities and towns in the county, except Goodyear, had a comprehensive plan for their planning areas, although many of these plans are out of date. In areas that do not have updated reports, more recent data can be obtained from both the county and the 1977 MAG updated general plan.

Because of their geographical location, certain portions of the Salt River, Fort McDowell, and Gila River Indian Reservations are considered suitable for development. Recent federal legislation permitting 99-year leases by private individuals allows a good chance of development. As of 1975, however, only the Salt River and Gila River Indian Reservations had land-use plans.

As of 1972, 68 percent of the land in Maricopa County was publicly owned. Most of this is in large parcels owned by the state and federal governments and surrounds the Phoenix urban area. Since these agencies are generally not interested in disposing of their lands, they act as a boundary around future urban growth by their size and location. The state, however, has claim to 168,600 acres of federal lands granted to it by Congress. It can transfer these to local governments and private owners when deemed necessary. It is possible urban development could expand into these public areas.

At present, there exists no legislation directly restricting or protecting agricultural land use. In its report on West Central Maricopa County, the Maricopa County Planning and Zoning Department has proposed that an agricultural conservation zoning district be established. Such a district would protect agricultural land by excluding other nonrelated uses, and has already been implemented in both California and Hawaii.

A continuation of current development trends is best shown by the MAG Composite Future Land Use Plan. This plan represents the accommodation of up to 2.6 million people at population densities similar to existing densities in the region today. Current population densities average approximately 4,000 persons per square mile in the urbanized area. Future densities for 1995 in the expanded urbanized area range up to an average of 4,600 persons per square mile.

TABLE I-3

Population Growth
Arizona and Maricopa County

YEAR		Population: ARIZONA	Population: MARICOPA COUNTY
1960	(Census)	1,302,160	663,510
1965		1,584,000	852,000
1970	(Census)	1,755,400	971,230
1975		2,212,000	1,209,800
1976		2,270,000	1,260,500
1977		2,364,000	1,292,000
1980	(Projected)	2,610,000	1,431,000
2000	(Projected)	3,939,000	2,181,000

Census year data from the Bureau of the Census. Others from the Arizona Department of Economic Security.

TABLE I-4

OBERS POPULATION, HISTORICAL AND PROJECTED

PHOENIX SMSA*

1929 - 149,038	1970 - 979,151
1940 - 186,095	1971 - 1,009,900
1950 - 334,607	1980 - 1,288,700
1959 - 642,537	1985 - 1,447,200
1962 - 775,000	1990 - 1,625,100
1967 - 890,000	2000 - 1,886,400
1968 - 914,000	2010 - 2,121,400
1969 - 946,000	2020 - 2,346,200

*Standard Metropolitan Statistical Area (encompasses Maricopa County)

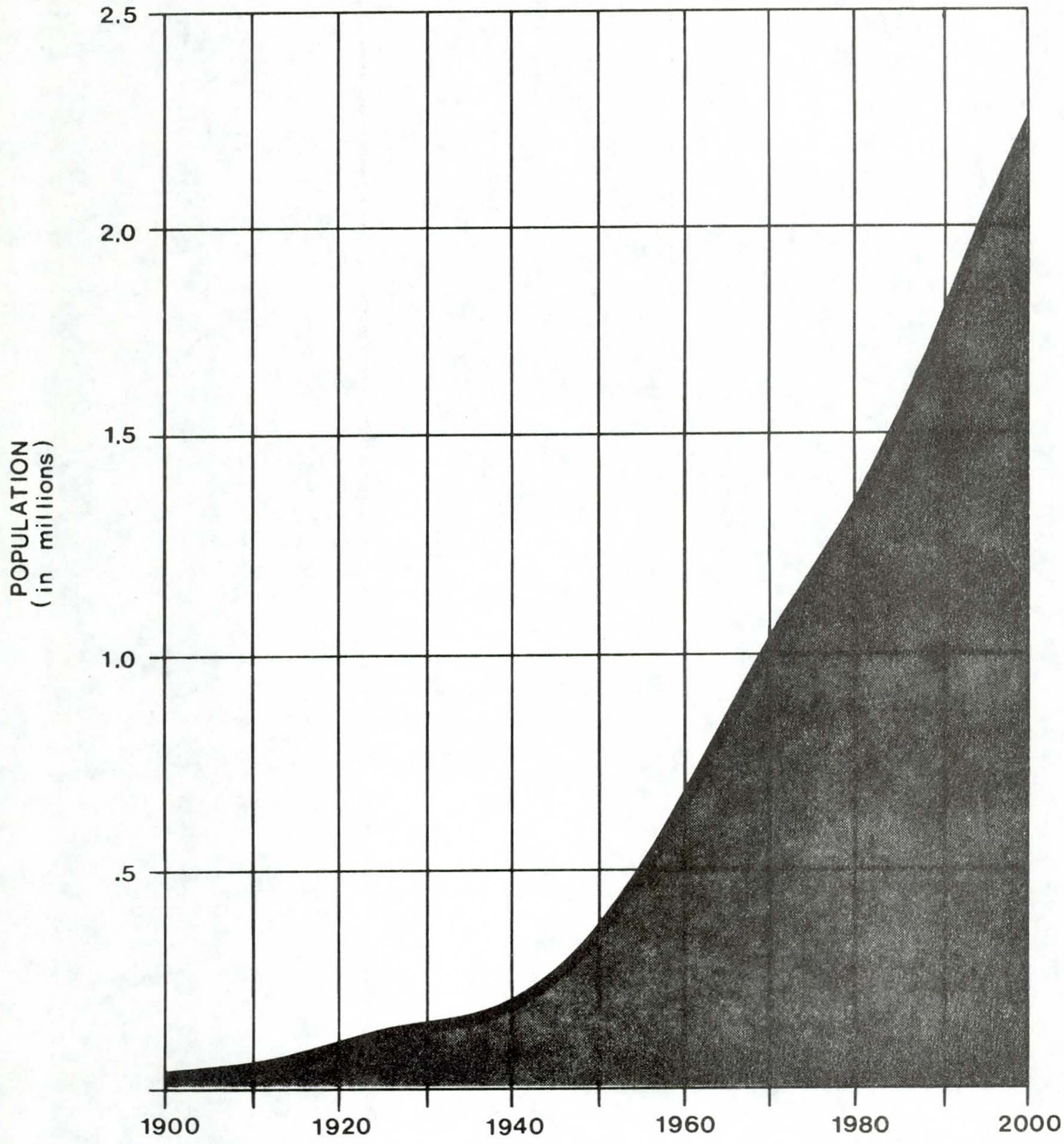


Figure I-2
POPULATION TRENDS

Chapter II
WATER RESOURCES

REGIONAL HYDROLOGY

Suitability for development of any given segment of the water resource depends on quantity, quality, and reliability. The surface water resource varies and is not adequate to meet the total demand for water without augmentation from other sources. Consequently, much of the study area's annual water withdrawal is pumped from the groundwater resource. In some areas, groundwater is being depleted because the rates of withdrawal exceed the rate at which the reservoir is being replenished.

Surface water is Arizona's major renewable water resource. Although the average amount of surface water that can be expected each year is small compared to the amounts of groundwater storage, surface water supplies account for about 40 percent of the renewable or dependable supply. The quality of surface waters varies greatly with time, location, and volume of flow. Surface water, nevertheless, is usually of high quality.

Groundwater is the water occupying all the voids within a volume of rock. Hydrologists define "rock" as both hard, consolidated formations such as limestone, sandstone, or granite; and loose, unconsolidated sediments such as sand and gravel. Aquifers are layers of rocks that contain groundwater and allow its movement in appreciable quantities.

The bulk of the water that flows into aquifers enters the rock units in places known as recharge areas. These areas are locations where water from lakes, rivers, streams, or washes infiltrates into the ground and percolates downward to the water table. The existence of groundwater in an aquifer does not necessarily imply that the aquifer is being recharged. It is believed that in Arizona most of the groundwater entered storage during the extremely long period of time when deposition of sediments was taking place or in water geologic ages.

Recharge to the aquifers throughout most of central Arizona is small. It occurs mainly along mountain fronts and normally dry stream courses. Mountain front recharge occurs when precipitation events of sufficient intensity and duration cause runoff in washes that flow toward the desert floor. The high infiltration rates of these streams rapidly deplete the flow. What water does not evaporate or is not used by plants along the washes, recharges the groundwater, usually in the immediate area of the mountain front. Flows of generally longer duration in stream channels on the floors of the valleys contribute recharge to the younger alluvium. In time, this recharge is distributed to the underlying and adjacent older alluvium.

Recharge incidental to use supplements natural recharge. A significant portion of the large amounts of water that are regularly applied to thousands of acres of crops eventually recharges the underlying groundwater body. Large amounts of water lie in storage beneath many of Arizona's valleys. These amounts have accumulated over many thousands of years and are far greater than current annual recharge.

The present withdrawals of groundwater are causing substantial overdraft in the developed areas of the state. Although Arizona's groundwater resources are large in aggregate, their distribution with respect to potential demand will be a limiting factor on their utilization. Water quality also will restrict development of the resource. Most of the water is stored in separate basins, which although large, are spread from the Mexican border to Lake Mead, and from the Colorado River to New Mexico. The principal source of groundwater in the study area is the Salt River Valley Basin.

Surface Water

The entire study area is within the Gila River Basin drainage area. Streams and rivers that provide drainage for most of the study area include the Agua Fria River, New River, Skunk Creek, Cave Creek, Indian Bend Wash, and the Salt River. All are ephemeral waterways in the study area. A few small pools sparsely scattered along the channels are perennial. These pools result from periodic flooding that accompanies local storms, releases from the mountain reservoirs northeast of the valley, discharge of treated wastewater from treatment plants into the Salt River bed, and excavations that intercept the water table.

The Salt and Verde Rivers have their headwaters in the high mountains to the north and east of the study area, and supply 93 percent of surface water available in metropolitan Phoenix. They are controlled by four dams on the Salt (Stewart Mountain, Mormon Flat, Horse Mesa, and Roosevelt) and two (Bartlett and Horseshoe) along the Verde. The operating agency for these structures is known as the Salt River Project. The dams impound reservoirs which provide irrigation and domestic water for the valley, and were not designed, nor authorized, for flood control even though they provide significant flood damage reduction. At Granite Reef Diversion Dam, waters from the Salt and Verde are channeled into canals which serve the Phoenix area.

The Agua Fria River originates about 7,000 feet above sea level in the mountains of central Arizona and flows southward for about 130 miles before emptying into the Gila River, 15 miles west of downtown Phoenix, at an elevation of 910 feet. The stream channel is nearly equidistant between two parallel mountain ranges, the Black Hill-New River Mountains and the Bradshaw Mountains. These mountains form the eastern and western boundaries of the drainage area. The gradient of the Agua Fria River ranges from about 300 feet per mile in the headwatrers to about 10 feet per mile at the Gila River. One reservoir, Lake Pleasant, impounds the Agua Fria for use by the Maricopa County Municipal Water Conservation District #1.

The New River, the major tributary of the Agua Fria River, has its headwaters in the New River Mountains, roughly 40 miles north of Phoenix. The New River flows generally southward for about 40 miles to its confluence with the Agua Fria River, about 15 miles west of Phoenix. The drainage area of the New River watershed at its mouth is 340 square miles, of which approximately one-third is mountainous. Elevations in the watershed range from a little over 5,000 feet in the New River Mountains to about 1,040 feet at the confluence with the Agua Fria River. The stream gradient ranges from 370 feet per mile in the mountains to 10 feet per mile in the valley.

Skunk Creek, the major tributary of the New River, rises in the New River Mountains about 35 miles north of Phoenix and flows generally southwestward for about 30 miles to its confluence with the New River about 15 miles northwest of Phoenix. The drainage area of Skunk Creek is 110 square miles, of which about 20 percent is mountainous. Stream gradients on Skunk Creek decrease from 650 feet per mile in the mountains to 20 feet per mile near its confluence with the New River. Adobe Dam, currently under construction, will control flows on Skunk Creek.

Cave Creek has its source in the New River Mountains to the north of Phoenix, where elevations rise to as high as 5,000 feet. The stream then descends to an alluvial fan near the community of Cave Creek and flows south for 13 miles to old Cave Creek Dam and Cave Buttes Dam, which now controls the runoff from the 175-square-mile upstream drainage area. Cave Creek then flows across a rapidly urbanizing area between Cave Buttes Dam and the Arizona Canal. The natural channel of Cave Creek below the Arizona Canal has been obliterated by urban development. Floodflows on Cave Creek exceeding the freeboard capacity of the Arizona Canal flow directly through metropolitan Phoenix to the Salt River. The total drainage area of Cave Creek at the Salt River is 311 square miles. The stream gradient ranges from 500 feet per mile in the mountains to 25 feet per mile near the Arizona Canal.

Indian Bend Wash, a tributary of the Salt River, is the principal drainage for Paradise Valley. It can be divided into two reaches: Upper Indian Bend Wash, which lies above the Arizona Canal, and Lower Indian Bend Wash, below the Arizona Canal. The Upper Indian Bend Wash has a drainage area of about 152 square miles. Elevations in the area range from about 4,000 feet above sea level at McDowell Peak to 1,280 feet at the Arizona Canal. The northern portion of Upper Indian Bend Wash is controlled by detention dikes for the Granite Reef Aqueduct of the Central Arizona Project. Lower Indian Bend Wash, extending from the Arizona Canal to the Salt River, a distance of 7 miles, drains an additional 59 square miles.

In addition to rivers and creeks, other important hydrologic features in the study area include reservoirs, detention basins, and canals. Each of the water bodies and their related structures increases the capabilities and flexibility of the local water resources in an area where water is a premium commodity. Reservoirs and detention basins and associated dams and dikes offer localized flood control and/or water conservation capability. The canals provide an important means of water augmentation and distribution. Smaller lakes frequently have interesting or important ecological and recreational water-related features. For these reasons, all water bodies and related structures are considered as sensitive in the study area.

Groundwater

Groundwater basins in central and southern Arizona are interconnected by thick accumulations of alluvium. Most hydrologic basins, therefore, do not have definite physiographic limits and their boundaries are arbitrarily chosen. The study area is located in the Salt River Valley Basin, which is no exception to the general rule. The Salt River Valley Basin is hydrologically connected with the Lower Santa Cruz Basin to the southeast and the Gila Bend Basin to the southwest. The Central Highlands geomorphic province serves as the headwaters for the valley and defines the basin boundary to the north and northeast.

There are two major groundwater areas in the Salt River Valley: The East Basin (referred to as the Paradise Valley-Chandler-Queen Creek subarea) and the West Basin (referred to as the Phoenix-Buckeye subarea). The basins, consist of unconsolidated water-bearing alluvial deposits, separated by natural rock barriers which restrict groundwater movement between the basins.

Large volumes of water have accumulated in the basin over tens of thousands of years. At the time Anglo settlers came to the Valley, the water table near the Salt River was very close to the surface and no more than 100 feet deep in the central portion of the study area. After the construction of Roosevelt Dam in 1911 irrigated agriculture grew and surface water was applied to more lands. Waterlogging started to become a serious problem. The Arizona Legislature responded by empowering irrigation districts to pump water for drainage purposes. Even after waterlogging was no longer a problem, pumping continued. Agriculture continued to grow during and after World War I, and because all surface water rights had been determined, some irrigation districts were formed which depended totally on groundwater. Since 1900, it is estimated that over 70 million acre-feet of water have been pumped out of the Salt River Valley.

Water-level elevation contour maps for the period prior to heavy pumpage indicate that in the East Basin groundwater moved toward the Salt River, from both the north and south. Groundwater beaneath the Salt River flowed westerly and into the West Basin at Tempe Buttes. In the West Basin, groundwater flowed largely in a southerly direction toward the Salt and Gila Rivers. Groundwater flowed westerly beneath the Gila River upstream of the confluence. Downstream of the confluence, groundwater flowed westerly and left the area west of Buckeye.

Large-scale pumpage has substantially lowered water levels in most of the Salt River Valley. The Arizona Water Commission (1978) summarized water-level declines since 1923 in the Salt River Valley. Near Scottsdale, east of Mesa, and in the Queen Creek area, the average water-level decline was more than 250 feet. The average water-level decline was about 150 feet in the Chandler-Gilbert area and less than 100 feet southwest of Chandler. The average water-level decline in Deer Valley and west of the Agua Fria River and north of the Roosevelt Canal was about 250 feet. The average water-level decline was about 250 feet in the Phoenix-Glendale-Tolleson area and less than 50 feet in the Buckeye area.

The large-scale pumpage has resulted in the development of several large cones of depression. In the East Basin, they are located near Scottsdale, east of Mesa, and in the Queen Creek area. In the West Basin, a large cone of depression is located near Luke Air Force Base and a smaller one in Deer Valley. Groundwater no longer flows from the East Basin to the West Basin, and instead flows toward these major depression cones.

The water level is less than 100 feet below the surface in the Salt and Gila River Basins in the southcentral and southwestern parts of the study area. The shallow depth of the water table in these areas is caused by irrigation return flows, seepage losses from canals, and the fact that groundwater pumpage from the central part of the study area has declined with rapid urban development. Areas where the water table is within 100 feet of the ground surface are considered sensitive areas. These regions are most susceptible to ground water pollution and if possible, should be avoided during considerations of potential waste disposal sites.

The extensive pumping of ground water and resultant lowering of water levels, caused the state to declare the Salt River Valley area a critical ground water basin. A critical ground water basin is one in which no new wells may be drilled for development of agricultural land not already under cultivation when the ban went in effect.

The U. S. Bureau of Reclamation (1977) presented data on the occurrence of three subsurface units in the Salt River Valley: 1) an upper alluvial unit, 2) the middle fine-grained unit, and 3) the lower conglomerate unit. The upper alluvial unit is the major source of groundwater in the Salt River Valley. Deep wells along the edges of the basins tap the lower conglomerate unit, which is another source of groundwater. The middle fine-grained unit is characterized by a fine sand and silty clay upper section, a silt and clay with evaporites middle section, and a lower section composed primarily of evaporites. Examination of groundwater quality data indicates that these subsurface units are of paramount importance in explaining the distribution and time trends of chemical constituents.

In the East Basin the top of the middle fine-grained unit is deepest east of Gilbert. The top of the middle fine-grained unit ranges in depth from less than 700 feet near the edges of the basin to more than 1,100 feet beneath the area east of Gilbert. Work by Dr. Robert Laney of the U. S. Geological Survey, Phoenix subdistrict office, has shown that there is also a substantial lateral variation in the lithology of the alluvial sediments. He has mapped the particle-size distribution for various units in the East Basin. In general, these units become progressively more fine-grained toward the centers of basins. This factor is also very important in interpreting groundwater quality data. Dr. Laney has also mapped the occurrence of a shallow unit known as recent alluvium. The unit is very coarse-grained, unconsolidated, and ranges from a few tens of feet thick to as much as 250 feet thick. In general, this unit is thickest in the East Basin along the floodplain of the Salt River and west of Gilbert along the former channel of the ancestral Salt River. This unit has been largely dewatered except south of Mesa and west of Chandler. South of Mesa, groundwater is perched over large areas, perhaps on the contact between the recent alluvium and the underlying formation, which is not as coarse-grained and is more consolidated. Near the center of the basin, finer-grained deposits predominate. At depths of about 1,600 feet massive evaporite deposits of low permeability apparently are present, forming the base of the productive aquifer.

In the West Basin, the top of the middle fine-grained unit is deepest west of the Agua Fria River. The top of the middle fine-grained unit ranges in depth from less than 500 feet near Black Canyon Highway and Buckeye Road, Glendale, Beardsley, and Goodyear, to about 1,200 feet near Luke Air Force Base. The lower conglomerate unit has been penetrated by wells near the edges of the basin. The top of the lower conglomerate layer is about 500 feet deep beneath downtown Phoenix, and becomes shallower to the northeast toward the Phoenix Mountains. The unit dips toward the center of the West Basin. In Deer Valley, the top of the unit ranges in depth from about 700 feet in the northeast to about 1,400 feet southwest of the Arizona Canal. The top of the unit is about 700 feet deep near Beardsley and more than 1,300 feet deep near Sun City. The top of the unit is about 800 feet deep along the Beardsley Canal, about 500 feet deep at Buckeye and about 700 feet deep at Goodyear.

Mapping of the subsurface materials based on particle-size analyses comparable to that for the East Basin has not been completed in the West Basin. The distribution of recent alluvium, is not known in detail, but it is about 250 feet thick along the Salt River west of Phoenix.

Recharge to the groundwater system is derived from several sources: a) irrigtion and canal seepage; b) streamflow; c) underflow from outside the study area; d) sewage effluent; and e) precipitation. Irrigation and canal seepage are probably the most important sources of recharge. In some areas it has been stated that as much as 35 percent of the water applied to fields may be returned to the aquifers. Although no conclusive data are available to proportion recharge by sources, a large part of the recharge to the groundwater reservoirs of the Salt River Valley is derived from flow in the streams of the region. Releases of water from the Salt and Verde reservoir systems during the period January through May 1973, resulted in the creation of a recharge mound 108 miles long and 6 miles wide along the Salt and Gila Rivers.

The rate of lateral movement of water in the alluvial basins probably ranges from only a few feet per year to several hundreds of feet per year. In the principal cultivated areas, the slope of the water table closely follows that of the land surface except in areas where the gradient has been influenced by pumping.

Between the margins of the cultivated areas and the mountains, the slope of the water table is less than that of the land surface and the depth to the water becomes progressively greater toward the mountains.

WATER SUPPLY

The occurrence, movement, and nature of surface and groundwater affects supply. Surface water occurs with usable frequency in the study area but can provide supplies with long-term dependability only at a rate supported by actual stream flows. Groundwater is distributed fairly uniformly about the study area at variable depths. It can be developed at any rate of pumpage, but will have a definite lifetime determined by the the rate of overdraft and the quality of ground water remaining in storage.

The Phoenix metropolitan area is more fortunate than some parts of the desert southwest. The Salt and Verde Rivers have provided a dependable source of water for centuries. The pre-historic Hohokam Indians developed an elaborate system of canals to utilize the water from the Salt River. Some of these ditches were later re-excavated and used by Anglo-American farmers.

Modern use of the Salt River in the study area began just after the turn of the century with the construction of Roosevelt Dam. The Salt River Project operates a system of canals and laterals throughout much of the metropolitan area. These canals and municipal water systems deliver water to the various users in the area. Without the dams and systems, it is highly unlikely that the metropolitan area and the agricultural lands would have developed.

River water, however, has not been sufficient to supply all the needs of the region. Water is pumped constantly from the ground resulting in a steadily declining water table in most of the region.

Water Supply and Demand

Early in the 1960s, valley residents became concerned about the long-term supply of water. One of the first analyses, completed in 1960 by Samuel F. Turner of Western Business Consultants, Inc., examined an area that is approximately the same as the study area. Mr. Turner concluded:

> "Unless additional water is brought into the area by some method, industry and urban development will have to replace a large part of the area that is at present under irrigation (agriculture)."

Mr. Turner went on to state that salts were becoming more concentrated in some areas resulting in a decline in water quality.

A follow-up study, commissioned by Maricopa County, was completed in 1965 by Dr. Heinrich J. Thiele. His report, entitled Present and Future Water Use and Its Effect on Planning in Maricopa County, Arizona, provided extensive data on ground water quality and quantity. The report concluded:

> "Without augmenting the available water supply, growth and development of Maricopa County, and especially of the Phoenix Metropolitan Area, will be retarded before the year 2000."

Surface water supplies only about 50 percent of the study area's demands, principally from diversions at Granite Reef Dam, the Buckeye Canal, and Lake Pleasant. Water not supplied from surface flows comes from aquifer pumping.

Effluent from the 23rd Avenue wastewater treatment plant currently is discharged into a canal which empties into the Salt River. An undetermined amount is used by a private farming operation, McDonald Farms. The Roosevelt Irrigation District has an option for 20,000 acre-feet/year of 23rd Avenue plant effluent, provided that:

(1) it meets standards for unrestricted agriculture

(2) it can be delivered economically to the existing canal system

(3) it is not required for cooling the Arizona Nuclear Power Project (ANPP)

Effluent from the 91st Avenue plant is committed to:

(1) the Arizona Nuclear Power Project (up to 140,000 acre-feet/year) for use as cooling water for its Palo Verde Nuclear Generating Station

(2) the Buckeye Irrigation Co. (30,000 acre-feet/year) for restricted agricultural use

(3) the Arizona Game and Fish Department (7300 acre-feet/year) for maintenance of a wildlife management area in the Salt River bed near 115th Avenue.

If the amount of effluent from the 91st Avenue plant is insufficient to meet the needs of ANPP, or if ANPP elects to use its full 140,000 acre-feet/year allotment, effluent from the 23rd Avenue plant is to be used. Discharges into the Salt River, except for the Game and Fish Department would be discontinued.

It is estimated that by the year 2000 approximately 195,104 acre-feet/year of wastewater effluent will be available for reuse from the 23rd and 91st Avenue plants.

Central Arizona Project

The following description is taken from the Environmental Impact Statement for the Central Arizona Project (1972). The Central Arizona Project (CAP) is a multi-purpose water resource development and management project that will provide supplemental water to central Arizona and western New Mexico. Construction of the water conveyance facilities and storage facilities within the two states will allow more efficient management of the total water resource. Benefits also will accrue to Arizona in the functional areas of water conservation, flood control, and recreation.

The CAP is generally located within the 50,900-square-mile drainage area of the Gila River and its principal tributaries above the Painted Rock Dam. This includes all of the project area for the Phoenix Urban Study.

The physical facilities of the CAP will extend outside the boundaries of the project area. Primary facilities to convey Colorado River water into Maricopa, Pinal and Pima Counties in central and southcentral Arizona will be the Granite Reef Aqueduct (currently under construction) and the Salt-Gila and Tucson Aqueducts. From the Lake Havasu diversion facilities in Yuma County, the aqueduct system will traverse over 307 miles in a general southeasterly direction through the project area to a point just north of Tucson. Granite Reef Aqueduct will connect Lake Havasu with the Salt-Gila Aqueduct, which will terminate near Marana. The Tucson Aqueduct will then carry water to its terminal point north of Tucson, where it will connect with the existing water system.

WATER USE

The development of Arizona's economy has resulted in increasing demands on the state's water resources. Today, more water is used than nature supplies to the state. The following definitions are used in describing water usage:

> "Withdrawal" is the process of capturing or acquiring water either by diversion from a surface water source or by pumping from the groundwater basin. Water is withdrawn to satisfy some specific purpose such as irrigated agriculture, municipal use, power generation, or preservation or improvement of wildlife areas.
>
> "Depletion" is the measure of the amount of water removed by a use from the water supply cycle. For example, if a water user withdraws 100 acre-feet, uses the water for some purpose and returns 40 acre-feet to a stream or the groundwater basin, then he has depleted the supply by 60 acre-feet.

STATE WIDE WATER USES

Agricultural

Irrigated agriculture is the state's largest water user accounting for 89 percent of total depletions. Agriculture's estimated withdrawal for normalized depletion is 4,294,000 acre-feet. The expansion of agriculture from a reported 665,000 acres harvested during 1940 to a maximum of 1,300,000 acres during 1952 was based on groundwater pumping. Groundwater over-draft resulted and concern over dropping water levels led to the establishment of "critical groundwater basins" in which groundwater development to support any expansion of agricultural acreage was prohibited. The study area lies in a critical groundwater basin.

Electric Power Useage

Historically, the thermal generation of electric power accounted for less than one-half of 1 percent of state water depletions. The normalized 1970 level of water consumption by fossil-fueled steam plants in the state was about 20,000 acre-feet. In addition to the identifiable depletion associated with steam generation, use in the form of evaporation occurs in conjunction with hydroelectric plants and is accounted for as an element of lake evaporation.

Expanding population and increasing per capita consumption of electricity in the study area have caused energy requirements, and in turn water requirements, to increase dramatically in the past two decades. The utilities have been able to acquire water supplies to meet needs as they have arisen and have obtained rights to supplies for future-needs projects currently under development. Examples of such acquisitions are Colorado River water for the Navajo Generating Station at Page and sewage effluent from the City of Phoenix for the Palo Verde nuclear plant west of Phoenix.

Fish and Wildlife

The Arizona Game and Fish Department maintains jurisdiction over approximately 70 facilties in Arizona including lakes, fish hatcheries, wildlife or waterfowl management acres, and administration sites. Some of these facilities are administered jointly with federal fish and game agencies. The U.S. Fish and Wildlife Service maintains nine facilities including three fish hatcheries, two game ranges, three wildlife refuges along the Colorado River, and one water recreation facility.

Actual water consumption at state and federal fish hatcheries is insignificant because the flows required are small and the water usually passes through troughs and concrete lined race-ways with only limited surface areas, thereby minimizing seepage and evaporation losses. In addition to fishing, lakes and reservoirs in the state frequently serve purposes of water supply, flood control, power generation, and many forms of water-based recreation.

The only significant depletions assignable to fish and wildlife use are those uses of mainstream water chargeable to the three national wildlife refuges along the Colorado River in Mohave and Yuma Counties, all lying outside the study area.

Lake Evaporation

Evaporation from the water surfaces of lakes, reservoirs, and stockponds in Arizona is estimated to total 198,200 acre-feet annually. As Arizona does not have large, natural, permanent lakes, almost all evaporation is associated with man-made lakes created for specific purposes. Total evaporation in the state is increasing because of continuing creation of lakes and ponds for recreation, stockwatering, and other purposes.

Recently, there has been considerable public discussion concerning the use of water (evaporation) by subdivision lakes in the urban study area. Loss to evaporation from these lakes appears to be under 3,000 acre-feet annually at 1973 levels of development and does not constitute a major element of total lake evaporation.

Municipal and Industrial Uses

The rapid growth of Arizona's population and economy has resulted in increased use of water for municipal and industrial purposes. From an early 1950's level of depletions of possibly 125 to 150 thousand acre-feet, municipal and industrial depletions rose to a normalized 1970 level of 329,000 acre-feet (excluding mineral and steam electric power uses). Per capita water withdrawal in the study area is estimated to range from 148 to 500 gallons per capita per day. In terms of percentage of total state depletion, this use has grown from approximately 3 percent in the early 1950's to about 7 percent today. These changes make municipal and industrial use the most dynamic element of overall state and study area water use. Serving municipal and industrial demands while maintaining equity for other users within a framework where use already exceeds the renewable supply is the primary concern of state water resource planners and developers.

Mineral Industry

The mineral industry plays a particularly prominent role in the overall economy of Arizona and is overwhelmingly dominant in the economies of several local areas outside the study area. Water depletions associated with the industry amounted to about 131,000 acre-feet for a normalized 1970 level and accounted for about 2.7 percent of total state depletions. Because of the relatively small water requirement associated with high product value, the industry has been able to compete successfully with other users for limited water resources to satisfy its needs. These needs frequently have been met by purchasing agricultural water rights.

STUDY AREA WATER USES

Using 1970 normalized conditions, agriculture accounted for 87 percent of water depletions in the Salt River Valley. Urban (municipal, industrial power, and gravel mining) depletions amounted to 12 percent, and depletions by other interests came to about 1 percent. Although urban needs have increased since 1970, agriculture is still the largest water user in the Salt River Valley.

Agricultural withdrawals for normalized 1970 conditions are estimated at 2,306,000 acre-feet. Municipal and industrial uses (including electric power generation and gravel mining operations) had withdrawals of about 310,000 acre-feet, and withdrawals for other interests (including fish and wildlife enhancement) amounted to approximately 26,310 acre-feet.

WASTEWATER MANAGEMENT

In the early 1960s, treatment plants existed in Mesa, Scottsdale, Tempe, Phoenix (23rd Avenue and 91st Avenue), Tolleson, Gilbert, Chandler, Avondale (including Goodyear), and Buckeye. Glendale and Phoenix discharged their sewage to the jointly-owned 91st Avenue plant which had a capacity of five million gallons per day (mgd). These plants, along with some private systems, served approximately half of the population in the area with the other half on individual septic tanks.

This proliferation of plants, some overloaded, together with individual disposal systems was causing problems--odors, mosquito breeding in ponded sewage effluent, and discomfort for those people living near the plants. Moreover, the system was not planned to meet the growth anticipated in the study area.

To alleviate the situation, the larger communities had a master plan prepared for the area. This plan called for the phaseout of the plants at Scottsdale, Tempe, and Mesa and the development of a regional collection and treatment system under the auspices of the Multicity Agreement. Under such an agreement, communities jointly develop interceptor and plant capacity as needed.

In 1975, the system was still managed under the Multicity Agreement. The 91st Avenue treatment plant had a capacity of 84 mgd and served Phoenix, Scottsdale, Mesa, Tempe, Glendale, Youngtown, Peoria, and Sun City. Peoria and Sun City rented capacity from Glendale's portion of the 91st Avenue plant. The 23rd Avenue plant (31 mgd) served portions of Phoenix and Paradise Valley.

Present wastewater planning calls for expansion of the 91st Avenue plant to a theoretical maximum of 137 mgd and for the effluent to be discharged to the west for irrigation, nuclear power plant cooling water, wildlife enhancement, and groundwater recharge. The problems of small, inefficient treatment plants experienced in the past have been eliminated and the system is proceeding with its planned expansion program.

CHAPTER III

PROBLEMS AND NEEDS

The arid environment and phenomenal population increase in the study area have generated problems of adequate water supply and suitable water quality. These problems in turn affect the quality of life of study area residents. Although at first glance it may seem incongruous, given the arid environment of central Arizona, flooding also poses a serious threat to life and property in the study area. Controlled flood waters and treated wastewaters however, can augment existing water supplies, to some degree. Issues bearing on these additional sources of water include environmental compatibility, influence on existing water quality, and interplay with existing water rights.

GROWTH AND LIFESTYLE

Since 1970, the population of the Phoenix metropolitan area has increased from 971,000 to 1.3 million in 1978. The urbanized area has increased from 230 square miles in 1970 to 320 square miles in 1975. An additional 250 square miles would be required for development if the regional population reaches a projected 2.63 million by 1995. The continuation of current development trends in the region will result in significant conflicts with the goals and objectives which have been expressed in recent years by various local and regional jurisdictions. The conflicts between some of the local and regional objectives and current growth trends are summarized in Table III-1.

In addition to the conflicts between regional objectives and the projected growth trends, there are many areas of conflict among the stated regional objectives. For example, the objective of discouraging urban sprawl and limiting population growth may be directly in conflict with the objectives of maintaining low-density lifestyle dependent on the automobile for mobility. Some of these obvious conflicts are summarized in Table III-2. The agricultural vs. urban issue is expected to remain polarized, with urban avenues of expansion allowed to continue. Loss of agricultural land, however, could be somewhat offset in the next 20 years by agricultural land expansion on the Gila Reservation because of expected CAP water allocation.

WATER SUPPLY

The maintenance of an adequate water supply in the Phoenix Urban Study area for agricultural, municipal, and industrial purposes is a major problem. A satisfactory solution to the water supply problem is being sought by the State of Arizona through the Arizona

Water Commission. Water conservation, importation of water, and conservation of flood flows are measures which could contribute toward a solution of the water supply problem.

Water Conservation

President Carter, in his Water Policy Message of June 6, 1978, placed a new national emphasis on water conservation and directed the Water Resources Council to add conservation as an economic and environmental objective of federal water projects. Because of the long history of water scarcity in central Arizona, this aspect of the President's policy takes on added importance.

Water conservation will continue to be an important facet of central Arizona's overall water picture, and measures to improve water conservation need to be explored. Although conservation alone will not resolve the study area's water problems, it can supplement other measures designed to balance the region's water budget.

Importation of Water

The Central Arizona Project should deliver a long-term average of 1.2 million acre-feet of Colorado River water per year to central Arizona. It is apparent that the amount available will not be sufficient to satisfy the requests for CAP water or to eliminate overdrafting of groundwater reserves. It is equally apparent that the CAP system should be operated at maximum efficiency to allow as much water to be delivered as practicable.

For the CAP to function efficiently, some method of storing and regulating water delivered by the Granite Reef Aqueduct must be considered. Water demand will vary from day to day and season to season while the capacity of the aqueduct is constant. Without regulatory storage, water supplies in excess of the immediate demand could not be delivered to the study area, and releases to the Salt-Gila Aqueduct and downstream facilities could not be regulated efficiently. It is estimated that the ability to deliver Colorado River water into central Arizona through the CAP would be reduced 10-15 percent annually without regulatory storage. Originally, Orme Dam and Reservoir at the confluence of the Salt and Verde Rivers was to be used for regulatory storage. Serious environmental and social concerns voiced after the filing of the draft EIS on Orme, however, caused that feature to be eliminated from CAP. The Bureau of Reclamation and Corps of Engineers currently are engaged in a study of alternative solutions to the regulatory storage question.

TABLE III-1

POSSIBLE CONFLICTS BETWEEN OBJECTIVES

First Set	Second Set
* Discourage urban sprawl and minimize the rate of urban land consumption.	* Continue a low-density lifestyle.
* Protect the quality of the natural and man-made environments (mountains, agricultural lands, open spaces, rivers, air quality, noise, etc.).	* Retain local decision-making process (home rule).
* Develop an effective public transportation system.	* Retain independence in personal decision-making in the choice of residence, employment, and other services.
* Develop a more cost-effective infrastructure system.	* Maintain the freedom of movement provided by the automobile.
* Conserve natural resources and reduce energy consumption.	* Encourage economic growth and employment opportunities wherever market forces dictate.
* Provide a contingency plan in the event of another energy crises.	* Maintain freedom of choice with minimal public restriction.
* Discourages the rate of population growth.	* Minimize public intervention.

Source: Gruen Associates, Growth Management: Urban Form Options for the Phoenix Region, 1975.

TABLE III-2

CONFLICTS BETWEEN OBJECTIVES
AND PROJECTED GROWTH TRENDS

REGIONAL OBJECTIVES	PROJECTED TRENDS
* Discourage new population growth.	* Urbanized area population of Maricopa County could increase from 1.3 million in 1975 to 2.63 million in 1995.
* Discourage future urban sprawl. * Develop an effective public transportation system.	* Overall density would increase by about 15 percent between today and 1995 to about 4,600 persons per square mile in 1995 (assuming) a 2.63 million population.
* Develop a more cost-effective infrastructure system.	* The only feasible transit system, assuming continuing low-density development patterns, would be a grid bus system serving the region.
* Preserve existing open spaces natural amenities.	* An additional 325 miles of arterials would be required to maintain acceptable levels of service. * An additional 250 square miles of open land would be converted for urbanization.
* Retain independence and mobility by the automobile.	* Overall traffic congestion is expected to increase to 180 to 200 percent of capacity by 1995 in the central urbanized area.
* Protect the existing quality of the environment.	* Auto vehicle-miles-traveled (VMT) would increase from 15 to 50 million by 1995. Air

Conservation of Flood Flows

Large quantities of floodwaters flowing through normally dry river channels in the Phoenix area result not only in flood damages, but also in the loss of a portion of these waters for beneficial use. It is interesting to note that the value of the water lost during floods in 1978 roughly approximates the estimate of damages caused by flood waters. Damages sustained on the Salt and Gila Rivers during the March 1978 flood have been estimated at $31.4 million. During that flood, approximately 600,000 acre-feet of water flowed past Phoenix. In the estimated direct annual benefits of CAP irrigation water ($42.91 per acre-foot), the flood water would have been valued at 25.7 million. The existence of flood control storage capacity could increase the opportunity to store portions of floodflows for later beneficial use, either through direct water deliveries or groundwater recharge. Conservation of floodflows and other measures must be examined if the study area is to continue to have an adequate supply of water for municipal and agricultural uses.

FLOOD CONTROL

Salt River

Flooding along the Salt River has been recorded since the arrival of pioneer settlers in central Arizona in the 1860s (See Table III-3). The most serious of the early floods occurred in February 1891, when an estimated peak flow of 300,000 cfs overtopped the Arizona Dam, which at that time diverted water from the Salt River into the Arizona Canal, and washed out other downstream diversion dams and irrigation works. Floodwaters inundated much of downtown Phoenix, reaching the intersection of Jefferson Street and Central Avenue. This event played a major role in shifting the general growth pattern of the city away from the river toward the northern mountains.

Since 1891, a number of less extreme, though significant, floods have occurred in the study area. In 1905 and 1906, several periods of severe flooding again took place on the Salt River. Warm rains melted a heavy snowpack in the high mountains causing a flow on the Salt River of 120,000 cfs in January and 105,000 cfs in April 1916. This flow was exceeded by the flood of February 1920, which produced a peak flow of 130,000 cfs. Another serious flood on the Salt River occurred in March 1938, producing a peak flow of 95,000 cfs. In 1941, a large storm relieved near-drought conditions and resulted in a flow of 40,000 cfs.

For the next 24 years there were virtually no floodflows in the Salt River through Phoenix, but several damaging floods have occurred in recent years. The 1965-66 flood, with a peak discharge of 67,000 cfs at Granite Reef Diversion Dam, caused damages to business and residential properties, feed lots, sand and gravel operations, street crossings, bridges, agricultural acreage, irrigation works, and utilities. Fourteen of seventeen street crossings over the Salt River were washed out. Sky Harbor, the main airport in the study area, sustained considerable damage when 2,600 feet of runway were inundated. Damage to a number of sewage oxidation ponds resulted in the discharge of raw sewage into the Salt and Gila Rivers. Total damages along the Salt River from this flood amounted to about $6,000,000, or about $12,000,000 measured in 1978 dollars.

In 1973, an extensive snowpack in the higher elevations of the Salt-Verde watershed melted, creating a continuous flow through the reservoir system and into Phoenix from February 21 through May 29 (with the exception of 7 days). A maximum flow of 22,000 cfs was experienced along the Salt River. This flow caused damages to sand and gravel operations and forced the closure of several street crossings for an extended period. Monetary losses from this flood, however, were not excessive.

A flood occurred in March 1978 with an estimated peak flow of 138,000 cfs through the Phoenix area and caused an estimated $33,138,000 in damages (see Table III-4). Approximately 95 percent of this damage occurred on the Salt and Gila Rivers. Once again, snowmelt influenced the flow and contributed to the flood.

Warm, moist air from the Pacific Ocean and the resulting precipitation caused another snowpack to melt in December 1978. The resultant peak flow of 140,000 cfs on the Salt River was slightly larger than the March flood; however, total damages for the study area are estimated at approximately $51,700,000.

In February 1980, a third flood occurred. Flows on the Salt River through Phoenix peaked at 180,000 cfs. Damages were estimated at $60,000,000. (See Table III-5)

The most severe flood that can reasonably be expected to occur in a region based on its meteorlogic and geographic characteristics is called a "Standard Project Flood" (SPF). In the case of the study area, this hypothetical flood has been established and, coincidentally, has a peak flow almost identical to the 1891 flood. The Corps of Engineers estimates that property damages in excess of $290,000,000 would result from the SPF on the Salt River. Such an event, with an approximate frequency of once every 200 years, would have a peak flow of 290,000 cfs. Under present conditions, it would inundate portions of downtown Phoenix south of Washington Street, including the Southern Pacific railroad yards at 16th Street. All existing crossings would be closed during a flood of this magnitude.

TABLE III-3

Historical Floods on the Salt River*

DATE	FLOOD PEAK (cfs)
February 1891	300,000
April 1095	115,000
January 19-20, 1916	120,000
January 29-30, 1916	105,000
February 1920	130,000
March 1938	85,000
March 1941	40,000
December 1965 - January 1966	67,000
February 21 - May 1973	22,000
March 2, 1978	138,000
December 19, 1978	140,000
January 19, 1979	88,000
March 29, 1979	67,800
February 1980	180,000

* Data for early floods obtained from the Interim Report on Survey for Flood Control, Gila and Salt Rivers, Gillespie Dam to McDowell Dam Site, Arizona, U.S. Army Corps of Engineers, Los Angeles District, 1957.

Data for recent floods obtained from the U.S. Geological Survey, measured at 48th Street and the Salt River.

TABLE III-4

March 1978 Flood Damage Summary, Maricopa County, Arizona
(1,000's of dollars)

	Physical Damages	Business and Emergency Losses	Total
Agricultural	$3,909	$122	4,031
Residential	2,806	312	3,118
Commercial	686	59	745
Industrial			
Sand and Gravel	2,254	240	2,494
Other Industrial	5,148	188	5,336
Public			
Roads and Bridges	12,508	391	12,899
Other Public	3,412	11	3,423
Other	1,085	7	1,092
Total - All Damages	$31,808	$1,330	$33,138

Source: Flood Damage Report, 28 February - 6 March 1978 On the Storm and Floods in Maricopa County, Arizona

TABLE III-5

February 1980 Flood Damage Summary, Maricopa County, Arizona
(1,000s of dollars)

Residential	-	1890
Commercial	-	3121
Industrial		
Sand and Gravel	-	1795
Other Industrial	-	1012
Public		
Roads and Bridges	-	22001
Other Public	-	13311
Agricultural	-	5005
Business and Income	-	5532
Emergency Costs	-	1614
Transportation Delays	-	8380
		....
TOTAL:		63661

Source: Phoenix Flood Damage Survey, February 1980

The Salt River is regulated by six water conservation reservoirs on the Verde and Salt Rivers. These reservoirs greatly reduce peak flows along the Salt River, although water conservation is their primary objective. Accordingly, the reservoirs are filled to capacity toward the end of the annual runoff season, and as a consequence there is no dedicated or designated space available in the existing Salt River Project reservoir system for flood control purposes. Reservoirs constructed since the large floods of the early twentieth century would have reduced these flows. Table III-5 summarizes the capacities of the Salt River Project reservoirs. The total watershed served by these reservoirs is approximately 13,000 square miles and is nearly equally divided between the Salt and Verde Rivers. The available storage capacity, however, is not so evenly divided, as 85 percent of the 2,072,050 acre-feet storage serves only the Salt River. (See Table III-6). As might be expected with this imbalance, a disproportionate share of the water from recent floods has emanated from the Verde River.

These flood problems interrelate with physical limitations of releases through Gillespie Dam and with the operation of Painted Rock Dam further downstream. Gillespie Dam was constructed to provide headworks for irrigation canals similar to the function of Granite Reef Diversion Dam. It has negligible storage capacity and is filled with sediments accumulated since its construction in 1921. Although river flows pass over the crest of the dam without endangering the structure itself, the dam has a very limited outlet capacity. As a result, water is backed up behind the dam inundating lands upstream, depositing sediments, and stimulating growth of salt cedar and other phreatophytes.

Painted Rock Dam, constructed by the Corps in 1959, provides efficient flood protection for downstream areas. The maximum release from Painted Rock following the floods of 1978 and 1979 has been 3,000 cfs, or 2½ percent of the peak inflow to Painted Rock. The water stored in Painted Rock, however, has very limited use from that point downstream. It represents a liability to the agricultural lands downstream, even at flow rates of 3,000 cfs or less, because of interruption of transportation and aggravation of saline groundwater problems.

Glendale-Maryvale

No defined channels exist in this area. Flooding results from sheet flow and ponding behind obstructions. The Santa Fe railroad, which passes through the area, creates an impediment to the flow of surface waters. The two openings at the trestles and a few drains in the railroad embankment are not of sufficient size to prevent flood waters from ponding against the railroad tracks and flooding adjacent business property in the area. South of the tracks, runoff flows southwestward toward the Grand Canal where ponding occurs, flooding adjacent homes. In the past sufficient floodflows have entered the Grand Canal to cause overtopping of the canal at the upstream sides of weirs and bridges and at low places in the bankfill, resulting in flooding south of the canal.

Glendale has a long history of flooding. The 1963 flood was apparently the most damaging flood of record, and caused ponding along the north side of the railroad tracks to a depth of 2 to 3 feet. Almost all businesses along a six-mile reach were flooded. In Maryvale, water ponded along the Grand Canal resulting in flooding to a depth up to 3 feet in a concentrated residential area. Damages from this flood amounted to $2,900,000 in the Glendale-Maryvale area. This would be equivalent to approximately $4,900,000 in terms of 1978 dollars.

Cave Creek Downstream from the Arizona Canal

The plan formulated for the authorized New River and Phoenix City Streams Project has resulted in authorization of the construction of the Cave Buttes Dam and the Arizona Canal Diversion Channel. These two units will prevent a substantial portion of the flood damages along Cave Creek. Runoff originating below the diversion channel, however, would result in flooding to the business and government center of downtown Phoenix, as well as large residential areas, commercial and shopping centers.

Upper Indian Bend Wash

Flood problems exist along Indian Bend Wash upstream from the Arizona Canal. The lower reach of Indian Bend Wash from the Arizona Canal downstream to the Salt River, has been studied and a flood control project is under construction.

The June 1972 flood, with a peak discharge of 14,500 cfs at the Camelback Country Club in Paradise Valley, caused damages amounting to nearly $500,000 along the upper reach of Indian Bend Wash. The discharge corresponds to a recurrence interval of about 80 years under present conditions. In conjunction with its Granite Reef Aqueduct, the Bureau of Reclamation has under construction a detention dike to protect the structure from floodflows. When completed, this dike will effectively control a great portion of the drainage area, although residual flows downstream of the dike and from the Phoenix Mountains are expected to cause flood problems in the area.

TABLE III-6

Salt River Project Dams

DAM	Reservoir CAPACITY (acre-feet)	Percent of TOTAL	Year COMPLETED
Salt River			
Roosevelt	1,381,580		1911
Horse Mesa	245,138		1927
Mormon Flat	57,852		1925
Stewart Mountain	69,765		1930
Granite Reef	negligible		1908
Total: Salt System	1,754,335	85%	
Verde River			
Horseshoe	139,298		1946
Bartlett	178,477		1939
Total: Verde System	317,715	15%	
Total: Salt & Verde Systems	2,072,050	100%	

South Phoenix

A number of small washes originating in the South Mountains cause flooding problems in the South Phoenix area. These washes are well defined in the upstream reaches but have been obliterated by development below.

No estimates are available on flood frequency in this area, but damages from past floods have been relatively minor. The potential for flooding exists, especially because of urban expansion in this area.

Gila Floodway Area

Portions of the area bounded by the cities of Tempe and Mesa on the north, Interstate 10 on the west, Queen Creek on the east and the Gila River on the south are being rapidly urbanized. The area is poorly drained and poses flooding problems.

Old Cross Cut Canal

Flooding occurs along the Old Cross Cut Canal between the Arizona Canal and the Grand Canal and in the Arcadia neighborhood in Phoenix. The area is urbanized and drainage is poor.

Scatter Wash

Flooding occurs along Scatter Wash, a tributary of Skunk Creek, and endangers an area developed as mobile home parks, schools and residential neighborhoods. Closing of dip crossings in the channel during even minor flood events also creates inconveniences for motorists. The dollar value of all damageable property in the SPF floodplain of Scatter Wash is estimated at $16,000,000.

WATER QUALITY

Surface Water Quality

Relatively comprehensive information on surface water quality is available for sampling locations on: 1) the Salt River below Stewart Mountain Dam, 9.5 miles upstream from its confluence with the Verde River; 2) the Verde River, 1,300 feet below Barlett Dam; and 3) the Gila River, above diversions to irrigation canals 8 miles downstream from the Hassayampa River. Water quality stations on the Verde and Salt Rivers provide data on principal sources of surface water supplies delivered to the study area, while the station on the Gila provides data on the principal source of surface water draining the study area.

Annual maximum and minimum concentrations that were found during the five water-year period from 1972 to 1976 in periodically collected samples at the Salt, Verde, and Gila water quality stations are presented in Table III-7. The constituents selected for inclusion in this Table are those for which the Environmental Protection Agency (EPA) interim Primary Drinking Water Regulation or proposed secondary standards under the Safe Drinking Water Act of 1975 state a "mandatory limit" or "maximum contaminant level". It is emphasized that these analyses are of untreated river water which is not being used for drinking or public water supply without further treatment. All public supply sources must be treated sufficiently to remove harmful constituents prior to distribution to the public.

Water from the Verde River generally has the highest quality. An accepted single indicator of water quality is the concentration of total dissolved solids (TDS) in water. The Verde's concentrations of between 116 and 402 milligrams per liter (mg/l) of TDS are lower than those of the Salt River. Concentrations of between 349 and 788 mg/l, and concentrations in both of these rivers are considerably lower than those in the 202 to 4,740 mg/l range of the Gila River.

Comparing the data shown in Table III-6 with EPA primary and secondary standards indicates contravention of standards for a number of constituents, primarily in the Gila River. Concentrations of TDS in the Salt River exceed the EPA secondary standard of 500 mg/l in four out of the five years for which data are provided. TDS concentrations in the Verde River are well within the standard for all five years. TDS concentrations in the Gila River exceed the standard in all three years for which data are provided.

Verde River waters exceed the standards for only one constituent, and that is lead. In the Salt River, concentrations of lead also exceed the standard. In the Gila River, concentrations of fluoride, nitrate, arsenic, cadmium, lead, mercury, and selenium exceed primary standards; concentrations of sulfate, chloride, and TDS exceed secondary standards.

Groundwater Quality

Groundwater quality varies widely throughout the Salt River Valley, both geographically and vertically.

Salinity has historically been a more severe problem in the southwest portion of the metro area, where irrigation tailwaters collect. In areas near canals, riverbeds or wherever surface water is fairly abundant, TDS levels are lower than the surrounding areas. Generally, salinity in the West Basin increases with groundwater movement to the southwest. In the East Basin salinity increases moving to the southeast. Throughout most of the study area, salinity has remained

TABLE III-7

SALT, VERDE, AND GILA RIVERS, WATER QUALITY COMPARED TO DOMESTIC AND SURFACE WATER STANDARDS

	Primary							Secondary			
	Arsenic[3]	Cadmium[3]	Chromium[3]	Lead[3]	Mercury[3]	Nitrate[1]	Selenium	Fluoride	Chloride	Sulfate	TDS
Domestic Water Supply Standards (mg/l)	0.05	0.01	0.05[2]	0.05	0.002	10.0	0.01	14-2.0	250	250	500
A. SALT RIVER BELOW STEWART MOUNTAIN DAM (highest Protected Use-Domestic Water Source)											
Surface Water Standards (mg/l)	0.05	0.01	0.05	0.05	0.002	NS	0.01	NS	NS	NS	NS
1972	-	-	-	-	-	.02-.59	-	.3-.5	300*-320*	34-74	708*-7
1973	-	-	-	-	-	.00-2.4	-	.2-.5	100-280*	44-75	353-76
1974	.004-.004	0-0	0-0	0.1*	0-0	.00-.00	.001-.002	.2-.4	99-150	41-49	349-44
1975	.003-.004	.01-.01	0-0	-	0-.0001	0-.02	0-0	.3-.5	150-240	43-62	463-64
1976	.003-.004	.01-.01	0-.01	0.1*	0-0	.04-.06	0-0	.2-.4	220-280*	44-77	628*-6
B. VERDE RIVER BELOW BARTLETT DAM (Highest Protected Use-Domestic Water Source)											
Surface Water Standards (mg/l)	.0.05	0.01	0.05	0.05	0.002	NS	0.01	NS	NS	NS	NS
1972	-	-	-	-	-	.0007-.0029	-	0-.5	15-25	40-81	281-40
1973	-	-	-	-	-	.04-3.6	-	.1-.6	3.6-14	11-48	116-31

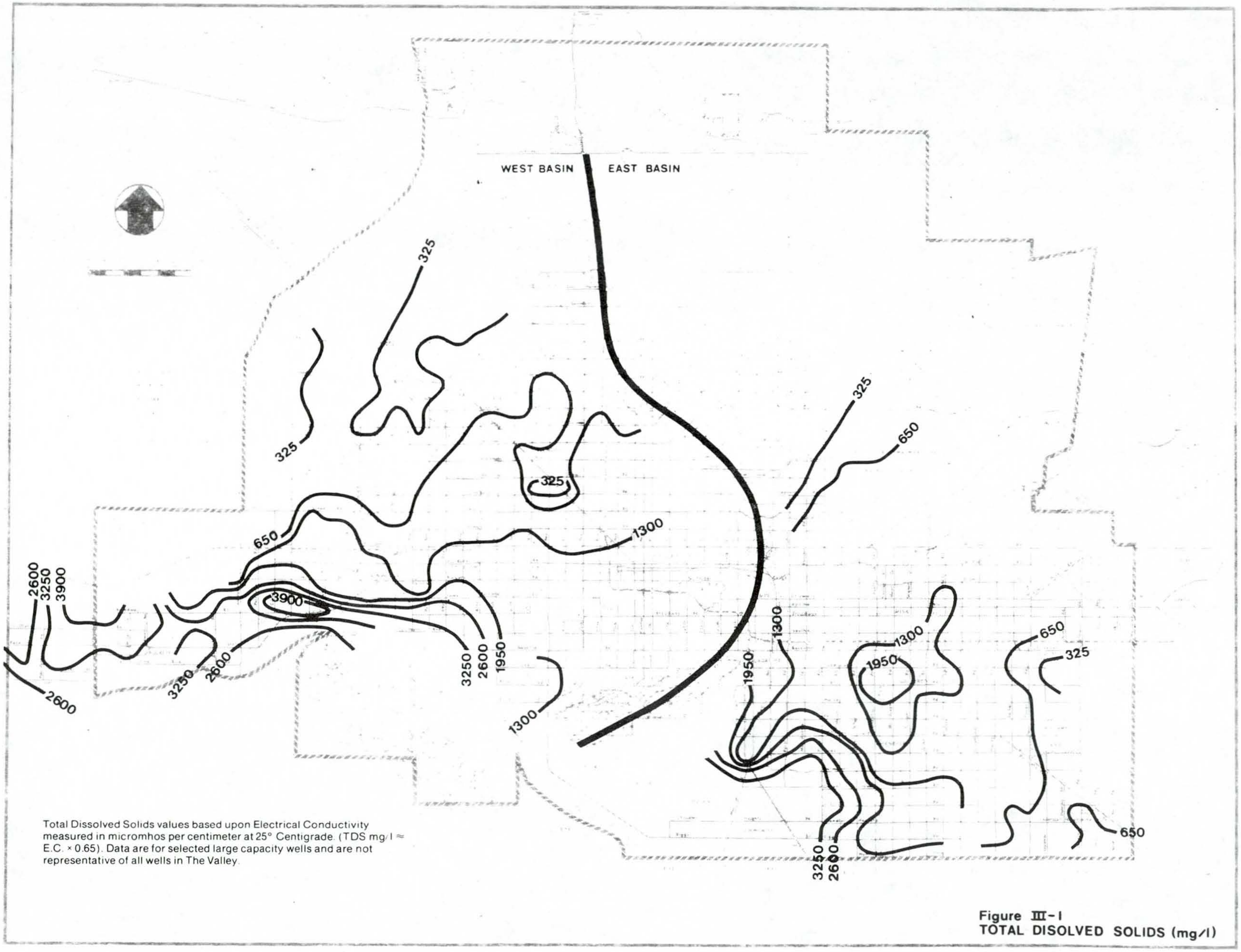
TABLE III-7 (Contd)

SALT, VERDE, AND GILA RIVERS, WATER QUALITY COMPARED TO DOMESTIC AND SURFACE WATER STANDARDS

	Primary							Secondary			
	Arsenic[3]	Cadmium[3]	Chromium[3]	Lead[3]	Mercury[3]	Nitrate[1]	Selenium	Fluoride	Chloride	Sulfate	TDS
1974	0.15-0.21	0-0	.01-.01	0.1*	.0-.0	0-.55	0-.003	.2-.6	14-24	42-65	254-364
1975	.009-.018	.01-.01	0-0	0.1*-0.1*	0-.0001	.02-.31	.001-.110	.2-.5	8.5-30	24-80	191-378
1976	.011-0.18	.01-.01	0-.01	0.1*-0.1*	0-.0002	.01-.29	0-.0001	.2-.3	5.7-26	21-69	155-364
C.	Gila Rivers above Diversions at Gillespie Dam (Highest Protected Use - Riparian Habitat)										
Surface Water Standards (mg/l)	0.05	0.01	0.05	0.05	0.002	NS	0.05	NS	NS	NS	NS
1972	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-
1974	.008-.023	.01-.02*	.01-.03	0.1-0.1*	0-.001	9.7-11*	.007-.009	.4-5.6*	1300*-1600*	750*-1100*	3500* 4740*
1975	.009-.011	.01-.01	0-.02	0.1-0.1	001-.003*	0.3-.28	.003-.010*	.2-2.6*	250-1500*	170* 1100*	384-4310*
1976	0.12*-0.19*	.01-.01	.02-.02	.1*-.2*	0-.0003	6.8-12*	.0001-.109*	-	-	-	-

Source: U. S. Geological Survey Water Resource Data

*Exceeds USPHS (1962) and/or EPA (1975) limits
[1]Several of nitrate concentrations shown include nitrite expressed as N.
[2]Limit of 0.05 is for hexavalent chromium, whereas, analyses are for chromium undifferentiated.
[3]Analyses shown for arsenic, cadmium, chromium, lead, and mercury are for "total" which is generally higher than "dissolved". The standards do not differentiate between "total" and "dissolved".



Total Dissolved Solids values based upon Electrical Conductivity measured in micromhos per centimeter at 25° Centigrade. (TDS mg/l ≈ E.C. × 0.65). Data are for selected large capacity wells and are not representative of all wells in The Valley.

Figure III-1
TOTAL DISOLVED SOLIDS (mg/l)

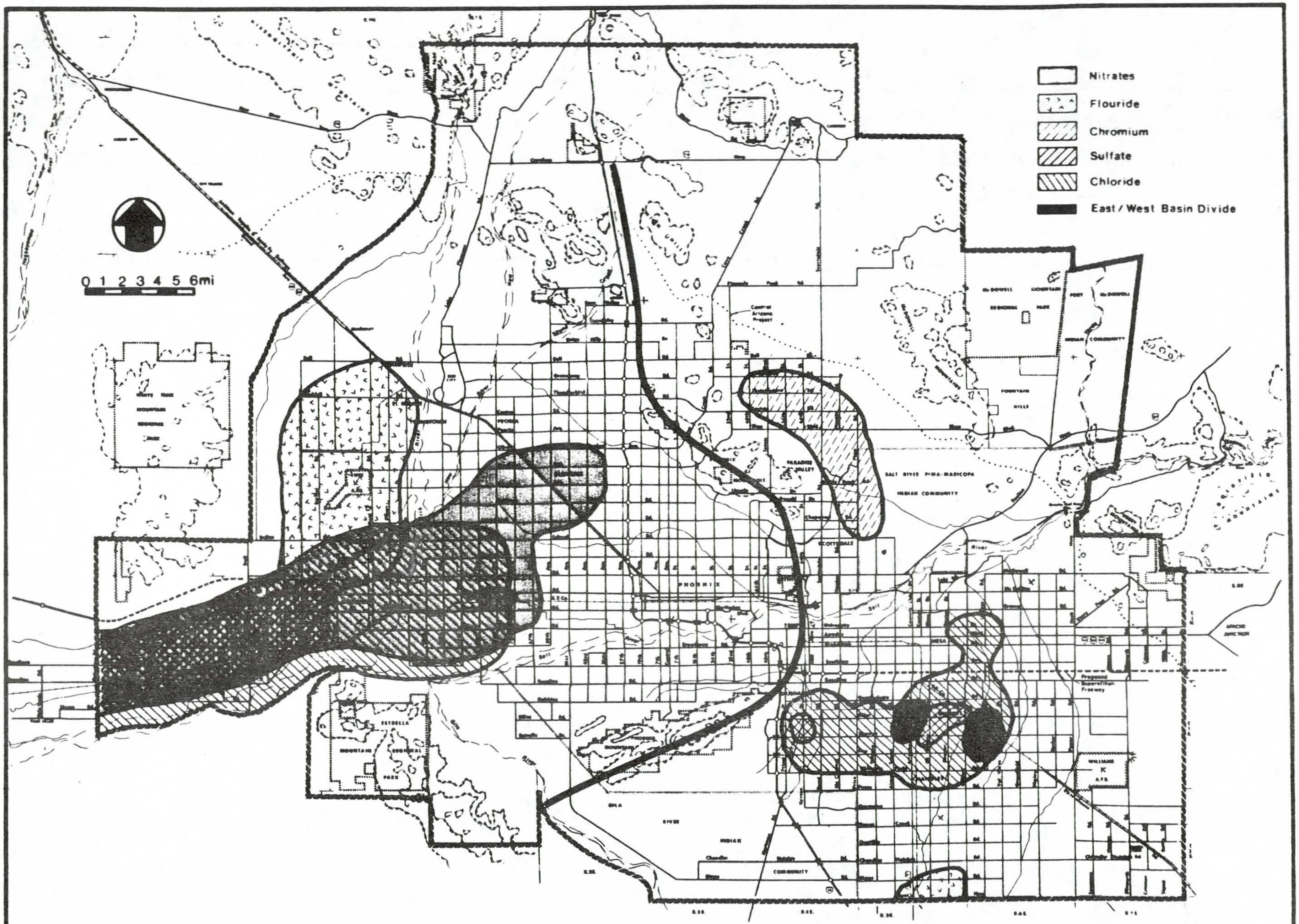


Figure III-2
GROUNDWATER QUALITY PROBLEM
AREAS-SALT RIVER VALLEY

fairly constant since the monitoring began. Levels are significantly on the increasee within the last twenty years near Gilbert (because of irrigation return flow), Chandler (because of changing groundwater movement patterns) and the Goodyear-Liberty area (also because of changing groundwater patterns).

Chlorides are distributed much like salinity and generally exceeded the 250 mg/l secondary standards and reached as high as 1000 mg/l in the Chandler/Gilbert area, and west of Buckeye and the confluence of the Agua Fria and Gila rivers.
Sulfates are not a real concern, exceeding the 200 mg/l secondary standard in three areas: West of Jackrabbit Rd. (500 mg/l); near Gilbert, and South of Guadalupe (250 mg/l).

Nitrates are a more severe problem in the West Basin where the maximum primary contaminant level of 45 mg/l is exceeded in a large area. The area averages eight miles in width and extends southwest from Deer Valley to the Hassayampa River. There are scattered locations throughout the Basins where 25 mg/l are exceeded. Historical well data indicates that generally nitrate levels are decreasing east of the Agua Fria River. Increases west of the river, primarily in the Buckeye Irrigation District area, are attributable to increased use of sewage effluent for irrigation over the last fifteen years.

Fluoride levels exceed safe standards throughout the Basin west of Jackrabbit Rd. and exceeds 3.0 mg/l just west of Buckeye. Sewage effluent has reduced Fluoride levels east of Buckeye. Higher fluoride levels will probably be encountered in the future as deeper wells are drilled into the alluvial deposits.

Chromium (hexavalent) levels are not exceeded in the West Basin, but are often surpassed in the Paradise Valley area. The data suggests these higher levels in Paradise Valley are associated with a NW-SE fault line. Research has shown that higher chromium levels are associated with higher water temperatures. Ths would correspond with the deep wells in the area and the possibility of the NW-SE fault.

Arsenic has a similar distribution to hexalent chromium and fluoride. Arsenic was only sampled in the Paradise Valley area because of historically higher rates.

Lead exceeds the .05 mg/l standard in a one mile wide, ten mile long path south of the Salt River and east of the Gila River confluence.

Most of the contaminants are of natural origin. Salinity, nitrate, chloride, sulfate, chromium, arsenic and fluoride are present in the alluvial deposits which make up the valley.

In summary, at present the major groundwater quality problems in the Salt River Valley are increasing salinity and high contents of chromium, arsenic, nitrate and fluorides, apparently as the result of natural factors. High salinity adversely affects the usefulness of the water for agricultural, municipal and industrial uses. The other factors affect health and may result in expensive treatment, blending with higher quality water, or abandonment of the source for drinking water purposes. In the East Basin high contents of chromium and arsenic are found in Paradise Valley and salinity is increasing near Gilbert (because of irrigation return flow) and near Chandler (because of altered groundwater flow pattern). In the West Basin, there are high nitrate contents in Glendale and west and northwest of Phoenix, high fluoride contents west of the Agua Fria River and increasing salinity in the Goodyear-Liberty area. Increased salinity in this area results from altered groundwater flow. Figure III-2 shows the general locations where nitrate, fluoride, chromium, sulfate and chloride exceed the primary or secondary standards for groundwater being used for domestic purposes.

NATURAL HABITAT

The rapid growth of agriculture and urbanization in large portions of the study area has reduced substantially, the amounts of land and water available for wildlife habitat. Of particular interest to the study are regions of riparian vegetation. Such growths exist in the study area along the lower Verde River, the Salt River above and immediately below Granite Reef Diversion Dam, and the Salt-Gila Rivers from the 23rd Avenue treatment plant in Phoenix to Gillespie Dam. All, or a portion of these stands of riparian vegetation could be impacted by flood control, water conservation, or water quality projects.

Southwestern Desert Riparian Communities are relict and maintained more by local conditions than by the climate. They would be unlikely to recover if subjected to major disturbance. While relatively few animals would die outright as the result of a specific project, the disruption of their habitat would lead to declines in population and possible local extinction of certain species within the study area.

A small parcel of riparian habitat lies in the bed of the Salt River near 91st Avenue. It is being managed as a wetland wildlife habitat in conjunction with the discharged wastewater from the 91st Avenue Sewage Treatment Plant. Projected use of wastewater from the 91st Avenue Plant for Palo Verde Nuclear Generating Station cooling water and irrigation of adjacent lands may preclude its use for wetland wildlife development of this site.

Other stream riparian communities exist along the Verde, Salt, and Gila River drainages, and in scattered isolated disjunct pockets near irrigated cropland. Water supplies to any of these locations would be curtailed with the surrender of strategic agricultural land to urban encroachment.

A major stream riparian community, the Fred J. Weiler Green Belt, extends along the Gila River from the town of Liberty in the southwest portion of the study area nearly 100 miles westward and southwestward to the town of Dateland. Managed by the Bureau of Land Management and named after its director from 1961-1971, it is a major stronghold for whitewing dove, quail, big game, and other wildlife. This area lies outside the urban study limits but is within the hydrologic zone of influence. Groundwater translocation from up-gradient lands could alter the habitat in this area, should major up-gradient land-use converting occur. Such could be the case, for example, if water used for irrigation in the Buckeye vicinity no longer provided tailwater to maintain the shallow groundwater levels in this area. This could result from massive urbanization around Buckeye. Accurate predictive models would be required to quantify the resulting riparian changes.

Aesthetic values are supported by enhancement of biological resources. In what is becoming an increasingly urbanized society, with its attendant technology and labor-saving devices, people require reminders of their connection with nature. Natural areas within or peripheral to metropolitan areas can have therapeutic value in an urban society. These areas can be aesthetically rewarding, physically stimulating, emotionally soothing, and educationally illuminating. The need exists, therefore, to promote the enhancement of natural habitat in the study area through appropriate water resource projects.

RECREATION

Because the desert climate permits year-round enjoyment of outdoor activities, a strong demand exists in the study area for recreational facilities and programs. The population growth experienced by metropolitan Phoenix in the decades after World War II, together with a general increase in income levels and leisure time, has produced an unprecedented demand for recreation of all types. The steadily rising cost of gasoline has, at the same time, caused residents of the study area to orient their activities toward easily accessible facilities.

Local suppliers of recreational programs and facilities, both public and private, have been unable to keep up with the demand. Existing facilities receive heavy, often excessive, use from residents and visitors to the area. The resulting overcrowding not only diminishes the quality of the recreational experience for individual users, but also causes deterioration of the recreation resource itself. Both facilities and settings suffer, thereby reducing the resource's original carrying capacity. The original problem of an insufficient and overtaxed supply is complicated further.

Recreational use of the few water sources in the study area provides an example of this demand/supply problem. During hot summer months, the flowing streams and man-made lakes on the Salt, Verde, and Agua Fria Rivers are used for water-based recreation such as fishing, boating, swimming, water skiing, and floating; while the lakeshores and riverbanks serve as sites for picnicking, hiking, and other activities. The pressure placed on these resources caused so much damage that management policies have been adopted which restrict the number of visitors to some reservoirs and certain reaches of the individual rivers. The U.S. Forest Service is considering additional management plans to facilitate the enjoyment of this resource while, at the same time, protecting it. Arizona's Comprehensive Outdoor Recreation Plan, proposed by the Arizona Outdoor Recreation Coordinating Commission, estimates that by 1985, existing lakes in Maricopa, Pinal, and Gila Counties will be able to supply only 25 percent of the demand for boat ramps. Similar strains are expected for other heavily used facilities such as hiking and riding trails. The flowing streams in the study area represent a unique resource particularly attractive to young people in the area who cannot afford or are not interested in flat-water recreation as compared to tubing down the river. A larger and more diversified stock of land and water-based recreational facilities needs to be developed for the use of Phoenix area residents.

SOCIAL CONSIDERATIONS

Major social concerns in the urban study area involve the quality of life and preservation of the culture of the Indians on the Fort McDowell and Salt River Reservations. At present, the inhabitants of these reservations are faced with such problems as low incomes, inadequate housing, and illiteracy. At the same time, they are a proud people with great respect for their land and environmental issues in general. A dam at the Salt-Verde River confluence which might provide flood protection downstream would affect the Indian people of the Fort McDowell Reservation in many ways. It might require extensive relocation of the Fort McDowell residents, thus placing further strains on their social fabric and jeopardizing the preservation of their culture. A reservoir at this site might improve economic conditions for some because of the recreational use of the lake.

Downstream, metropolitan Phoenix presents a different set of social concerns. Many essential services for the city of Phoenix are located north of the Salt River. Severe floods close most river crossings, isolating South Phoenix from vital agencies and imposing hardships on commuters who must cross the river.

Farther downstream, intensive flooding in the communities of Holly Acres, Allenville, and other areas west of Phoenix, causes social problems to residents. Personal hardship, financial losses, and threat to life caused by the floods are factors that must be considered in water resource planning.

CULTURAL RESOURCES

Rapid urbanization over the past three decades has placed increasing pressure on the archeological and historical resources and in some cases has obliterated many sites of cultural importance.

Because most of the prehistoric inhabitants of the study area practiced irrigated agriculture, the remains of their cultures tend to be located along or near major water courses. As a result, many archeological sites could be impacted adversely by flood control, water quality, and water conservation alternatives. Care must be taken during the planning stages to avoid or mitigate impacts to the area's irreplaceable cultural resources.

CHAPTER IV

WATER RIGHTS ISSUES

ALLOTMENT STRUCTURE

During the territorial period, Arizona courts held that the doctrine of prior appropriation applied to surface water. The principal feature of this doctrine is that he who is first in time has the better right. The senior appropriator in time always prevails over the junior during periods of water shortage. This is the basis of the often quoted, "first in time is first in right".

The First Arizona Territorial Legislature enacted statutes declaring all rivers, creeks, and streams of running water are to be public, and applicable to the purposes of irrigation and mining. All the inhabitants who owned or possessed irrigable lands had the right to construct public or private acequias (canals) and obtain the necessary water from any convenient river, creek, or running stream. Early statutes also prohibited the obstruction of canals.

In 1888, the Arizona Territorial Supreme Court, in the case of Clough vs. Wing, firmly established the doctrine of appropriative rights. Later, the Arizona Constitution declared specifically the common law doctrine of riparian water rights to be void in the state.

The Kent Decree decision, filed in March of 1910, became effective in April of 1910 and established water rights dating from 1869 to 1909 on the Salt and Verde Rivers for about 4,800 irrigators in the Salt River Valley. The original Decree confirmed existing appropriative rights to normal river flows by date of entry to those lands designated Class A, which had been more or less constantly irrigated. Lands designated Class B, while having a history of irrigation mainly from high river flows, had been withdrawn from cultivation prior to 1903. Class B along with Class A had preferred rights to apply for stored waters developed by Roosevelt Dam. Class B lands, however, did not have a right to normal flow. The third class of lands, Class C, had no established surface water rights but was located in the areas served by the canal system. These lands were given the right to apply for a proportionate share of the stored waters from Roosevelt Dam, providing such waters were available after the satisfaction of the senior rights.

In 1893, the 17th Arizona Territorial Legislature enacted the first statutory procedure for posting and filing for a water right. It was not until 1919 that the Arizona State Legislature enacted the State water code governing the procedure to be followed in acquiring a surface water right. The appropriation procedure, outlined in the Arizona Water Code, Arizona Revised Statutes (A.R.S.), Title

45, Chapter 1, has remained substantially the same. An application must be filed with the State Land Department for a permit to appropriate intrastate surface water. If the State Land Commissioner finds the application in order, he issues a permit authorizing construction of the necessary works. After the water is applied to a beneficial use, proof of the fact is presented to the Department and a Certificate of Water Rights is issued to the applicant.

Section 45-101, of the present Arizona Revised Statutes, reads in part:

> "The waters of all sources, flowing in streams, canyons, ravines, or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste or surplus water, and of lakes, ponds, and springs on the surface, belong to the public and are subject to appropriation and beneficial use as provided in this chapter. Beneficial use shall be the basis, measure and limit to the use of water."

In cases involving two or more pending conflicting applications for water from a given water supply, when the capacity of the supply is not sufficient for all applications, A.R.S., Section 45-147 states that preference shall be given to the party according to the relative benefits to the public of the proposed use. The relative benefits to the public for the purposes of this section shall be: 1) domestic and municipal uses (Domestic uses shall include gardens not exceeding one-half acre to each family); 2) irrigation and stock watering; 3) power and mining uses; and 4) recreation and wildlife including fish (as amended, Laws 1962, Ch. 113, Sec. 3).

An Arizona appropriative water right, even though evidenced by court decree or a water right certificate, may be lost or forfeited by either: nonuse for 5 years, or abandonment. Appropriative rights predating June 12, 1919, can be lost only through intentional abandonment. Rights acquired under the statutory procedure can be lost through abandonment and forfeiture.

Abandonment requires an intention to give up one's right to use the water coupled with a cessation of use. There is no requirement that the intention to abandon or the cessation must exist for any particular length of time. There may be either a partial or total abandonment of an appropriation.

Nonuse of the water for beneficial purposes for 5 years constitutes a forfeiture of the water right, even though the appropriator does not intend to abandon his right. The forfeiture may be complete or partial depending on the extent of the nonuse. The general practice in the West, however, is that nonuse of the water for a statutory period does not cause a forfeiture if, because of natural causes, there is insufficient water in the stream to supply the appropriation.

GROUNDWATER RIGHTS

Early water law in the Southwest was based on the principle of "first in time, first in right", which mandated a chronological hierarchy among appropriators. Little thought, however, was given to subsurface water rights. It was not until 1904, in the case of Howard vs. Perrin, that the Supreme Court of the Territory of Arizona ruled that underground waters were the property of the landowner, not subject to appropriation, but contingent on beneficial use. The Arizona Legislature, in 1919, adopted a water rights permit system for surface water, but was vague regarding the status of groundwater.

The depletion of the state's groundwater supplies prompted the Arizona Legislature to adopt the Groundwater Code of 1948. This code provided for the establishment of critical groundwater areas in basins not having sufficient groundwater to provide an adequate long-term supply for the irrigation of cultivated lands at the then current rates of withdrawal. Drilling of new wells within the critical area for irrigation of land not in cultivation when the designation was made was prohibited by the code. The code, however, did not control the extent of pumpage of wells already in existence, nor did it prohibit the drilling of new wells for purposes other than irrigation. At present, ten critical groundwater areas have been designated by the State Land Department, one of which is the Salt River Valley.

In May 1977, an emergency groundwater bill was signed into law by the Governor. This act established a 25-member Groundwater Management Study Commission to draft a groundwater management plan which will become law in 1981 if the legislature failed to enact the new groundwater code by that date. The emergency law also put a 4-year injunction to stop transfers of water from already designated areas.

The potential for more extensive conjunctive use of ground and surface waters is frequently mentioned. Groundwater recharge measures and groundwater storage for regulatory purposes have been suggested, yet the existing groundwater law discourages those measures inasmuch as the right to exclusive use of water is lost when it is placed in underground reservoirs.

In 1980, the legislature enacted the Groundwater Management Act which established the groundwater code for Arizona. The Act places the responsibility for administration of the groundwater code with the Department of Water Resources.

INDIAN WATER RIGHTS

As increasing amounts of western lands were reclaimed during the late nineteenth and early twentieth centuries, conflicts arose between Indian and non-Indian water users over water rights. Non-Indian water rights in the West are based on state systems of prior appropriation. Indian water rights are based on judicial precedent. The earliest determination by the courts of Indian water rights was the 1908 Supreme Court decision in Winter vs. United States; the origin of the term "Winters Doctrine". Through the years, judicial decisions have expanded Indian water rights to reservations created by treaty, act of Congress, and executive order. The Arizona vs. California Supreme Court decision of 1964 was a strong reaffirmation of the basic "Winters Doctrine". This doctrine, and in some instances the doctrine of prior appropriation, forms the basis for Indian water claims in central Arizona.

In 1975, representatives of the Fort McDowell and Salt River Indian Reservations were among a group of Arizona Indian tribes presenting water rights claims before the Committee on Interior and Insular Affairs of the United States Senate. They protested the proposed allocation of CAP water as being too low. Several tribes throughout Arizona have filed lawsuits against other water users which in general allege misappropriation of water which rightfully should be available to Indians. A number of bills have been introduced in the Congress which would make more water available to central Arizona Indians. Since the water supply is so limited, these would undoubtedly impact the non-Indian water users.

In this region, settlement of Indian water rights is a pressing matter which would have traumatic impact if a major reapportionment of surface and groundwater rights occurred. It is generally accepted that negotiation of an acceptable solution to Indian water rights is by far preferable to either litigation or legislation. The Federal Government and Salt River Project are currently involved in negotiations.

CHAPTER V

RECENT STUDIES AND CURRENT PLANNING

Several agencies at the federal, state, and local levels have been involved in studying the primary problems addressed by the Phoenix Urban Study: water quality, flood control, water conservation, recreation and enhancement of fish and wildlife. Early in the current project, these studies were identified so that duplication of effort could be avoided. They are presented in this chapter to point out their interrelationships with the Urban Study.

FEDERAL

Corps of Engineers

Interim Report on Survey for Flood Control, Gila and Salt Rivers, Gillespie Dan to McDowell Dam Site, Arizona, 1957: The Corps studied the Salt/Gila system flood problems in the 1950s, and published this report which resulted in the authorization of a project to reduce flood damages. The project was never implemented because of subsequent authorization of the CAP and Orme Dam. The study contains much useful background and technical information and is a valuable resource document.

General Design Memorandum - Phase I, Plan Formulation for Indian Bend Wash, 1973: This document, along with its supporting appendicies and environmental statements, describes a unique flood control project which incorporates multiple use of the flood plain along with structural and non-structural flood control measures. It is identical to the Rio Salado concept for the Salt River, and has been used as background information by the Urban Study. Indian Bend Wash enters the Salt River in the study area, making it imperative that hydrological information presented in this study be taken into account.

Gila River Basin New River and Phoenix City Streams, Design Memorandum -Phase I, Plan Formulation, 1976: This document describes a flood control project in the Phoenix area. The project, which is under construction, affects the area hydrology to some extent by the construction of four dams (Dreamy Draw, Cave Buttes, Adobe, and New River) and a diversion channel.

Detailed Project Report, Study of Flood Damage Reduction for Allenville, Arizona, 1980: This study resulted in the authorization and implementation of a project to relocate the community of Allenville from its flood-prone site in the Gila River south of Buckeye to a flood-free site northwest of that city. This project was completed in November 1981.

In addition to the above, the Corps is developing (or has prepared) Flood Insurance Study reports for the cities of Mesa, Scottsdale, Phoenix and Tempe, and special floodway studies along the following streams: Salt River in the City of Mesa; Agua Fria River from Pinnacle Peak Road to the Salt River; New River from Pinnacle Peak Road to the Agua Fria River; Skunk Creek from Carefree Road to New River; Scatter Wash from the Black Canyon Freeway to Skunk Creek; and Arizona Canal from 67th Avenue to Skunk Creek.

Bureau of Reclamation
Lower Colorado Region Comprehensive Framework Study, 1971:

The Bureau of Reclamation played a major role in this study prepared by the Lower Colorado Region State - Federal Interagency Group. The study presents a framework program for the development and management of the water and related land resources of the Lower Colorado Region, which includes the area covered in the Phoenix Urban Study. It addresses many of the same problems considered in the Urban Study (e.g. water conservation, flood control, and water quality), but on a regional basis. It also contains much useful background information and serves as a source document.

Central Arizona Project Studies, 1971-1979:

The implementation of the Colorado River Basin Project Act (PL90-537) has resulted in several studies of the CAP as a whole and of its individual features. A partial listing of published studies gives an idea of their relevance to the scope of the Phoenix Urban Study. Of particular interest is the Final Environmental Statement on the entire CAP, which puts the regulatory storage issue in context, and the Draft Environmental Statement on Orme Dam.

Final Environmental Statement, Central Arizona Project:

Department of the Interior, FS 72-35, Boulder City, Nevada, 1972.

Final Environmental Statement, Navajo Project:

Department of the Interior, FES 72-1, Boulder City, Nevada, 1972.

Final Environmental Statement, Havasu Intake Channel, Havasu Pumping Plant, and Buckskin Mountains Tunnel:

Department of the Interior, FES 73-2, Boulder City, Nevada, 1973.

Final Environmental Statement, Granite Reef Aqueduct:

Department of the Interior, FES 74-5, Boulder City, Nevada, 1974.

Final Environmental Statement, Granite Reef Aqueduct Transmission System:

Department of the Interior, FES 75-66, Boulder City, Nevada, 1975.

Draft Environmental Statement, Orme Dam and Reservoir:

Department of the Interior, DES 76-17, Boulder City, Nevada, 1976.

CAP Geology and Ground Water Resources Report, Maricopa and Pinal Counties, Arizona:

Phoenix, Arizona, 1976.

Draft Environmental Statement, Salt-Gila Aqueduct:

Department of the Interior, DES 79-1, Boulder City, Nevada, 1979.

Central Arizona Water Control Study: Initiated in 1978 by the Bureau of Reclamation to develop plans for the solution of flood problems along the Salt and Gila Rivers in the Urban Study area and for the regulatory storage of CAP waters. Through the Urban Study, the Corps of Engineers assisted the Bureau in initial work on the flood control aspect of the study. Flood control work was carried on by the Corps to assist the Bureau under authority of the Gila River and Tributaries authorization and the Flood Control Act of 1944 following completion of the Phoenix Urban Study in 1979.

U.S. Soil Conservation Service (SCS)

The SCS has conducted several studies for flood control and watershed projects in the study area, principally the Buckhorn-Mesa, Apache Junction, Gilbert, Williams-Chandler, Guadalupe, Buckeye, White Tanks projects. Some of these have been completed, and to the extent that the projects affect local hydrology, they should be considered during future planning.

Environmental Protection Agency

The Environmental Protection Agency has the responsibility of overseeing the planning efforts necessary to respond to the requirements of Public Law 92-500. To help accomplish this, EPA administers a program of grants that assist the planning and construction of waste management programs and facilities. Grant funds are available to support basin wide planning (Section 303), areawide planning (Section 208), facilities planning and construction (Section 201), and surface water quality monitoring (Section 106) programs.

U.S. Geological Survey (USGS)

The USGS conducts several ongoing programs of particular interest to the Urban Study. Their annual reports on water flows and water quality are used as basic data sources. The USGS also has recently undertaken a thorough study of groundwater aquifers which will develop information pertinent to groundwater recharge and storage.

U. S. Fish & Wildlife Service

The Fish & Wildlife Service has the responsibility of reviewing the environmental impacts of water resource projects and developing appropriate loss prevention, compensation, mitigation, and enhancement measures. If necessary, the agency also provides consultation with water resource planners as required by Section VII of the Endangered Species Act (P.L. 93-205).

U.S. Forest Service

This agency controls much of the land adjacent to the Salt and Verde Rivers. Current planning efforts by the Forest Service are directed at management of recreation along the Salt River.

Bureau of Land Management (BLM)

The Bureau of Land Management is the nation's primary federal land agency and though originally concerned with grazing and minerals on the lands held in trust, is now a "multiple-use" manager of these lands. As a multiple-use manager, the BLM is committed to the best use of lands for the nation's growth and environment. The management duties include: watershed protection, enhancement of water quality, and environmental review and analysis. A state office of the BLM is located in Phoenix with two district offices in the study area. A state advisory board exists and its members are appointed by the State Director upon the Governor's recommendation. This board advises the State Director on land and resource management in the state.

Agriculture Research Service

As part of the U.S. Department of Agriculture, the Agriculture Research Service is involved with ongoing studies dealing with soil arability on agricultural lands in the study area.

Dr. Bouwer of the ARS is currently conducting wastewater studies focusing mainly on monitoring salt transport in areas receiving intensive cultivation. He is also performing research studies on high rate wastewater treatment systems in connection with his Flushing Meadows Project.

STATE

Arizona Water Commission/Department of Water Resources

The Arizona Water Commission was given the authority by the State Legislature to study and plan for the development, conservation, and utilization of all waterways, groundwater, and water resources in Arizona. In carrying out this responsibility, the Commission published Phase I of the State Water Plan, an inventory report of the resources, current uses, and associated problems of the waters of the state, and Phase II, an identification and description of alternative futures.

In 1980, the Arizona State Legislature created the Department of Water Resources, which assumed the duties of the Arizona Water Commission. It has authority over water resource development and conservation, including regulation of dam construction, repair and removal of dams, development of flood control plans, and implementation of groundwater use restrictions. The Arizona Water Commission is continued within the Department of Water Resources

State Legislature

Following the December 1978 floods, a task force of the Arizona Legislature was formed to address flooding problems of the state. In late March 1979, this group presented its recommendations, which included bridge construction and channelization in the study area.

Arizona Department of Health Services

The Arizona Department of Health Services administers both the basinwide planning and the water quality monitoring programs and sets state surface water quality standards. Their 303 basinwide programs currently cover all the State of Arizona, except for Pima and Maricopa Counties. These two counties have been designated as 208 planning areas and will provide both basinwide and areawide planning under the 208 program. In addition to this work, the Department of Health Services reviews and approves areawide (208) and facilities (201) planning for the entire state. In the future, they will administer areawide planning programs for some areas outside of the currently designated 208 areas.

Department of Economic Security

The Arizona Department of Economic Security periodically prepares population projections for the State of Arizona and the counties within the State. The population projections are initially prepared for the state using the cohort survival method of the U.S. Bureau of Census. The county population is then adjusted to agree with the State population projections.

Arizona Game and Fish Department

An ongoing research effort funded by the Arizona Game and Fish Department is the Urban Lakes Program. The program is designed to determine the feasibility/desirability of fisheries within urban areas, however, no data are currently available.

Arizona State Land Department

The Arizona State Land Department has the responsibility to administer laws relating to the waters of the state and to manage state-owned trust lands. Its functions include land use planning, coordination of natural resources conservation, public land acquisition and disposal, and water administration. The agency's involvement in water resources in Arizona centers on its authority to designate critical groundwater areas, registration of water rights, and coordination of the Federal flood plain insurance program.

Arizona Outdoor Recreation Coordinating Commission (AORCC)

The Outdoor Recreation Coordinating Commission has the responsibility of planning, coordinating, and administering an outdoor recreation program for the state. It maintains an inventory of outdoor recreation areas and facilities, and coordinates recreational development of the state's water resources with the Water Commission.

COUNTY

Flood Control District of Maricopa County (FCDMC)

The FCDMC acts as the local sponsor for flood control projects in the county. This agency also conducted a channel clearing project on the Gila River below its confluence with the Salt River.

Maricopa Association of Governments (MAG)

The Maricopa Association of Governments currently serves as the regional planning agency within the county. The membership of MAG includes 19 cities and towns as well as the county.

MAG incorporated the 208 water quality planning into its overall comprehensive regional planning program. The four major elements of this program are: 1) Comprehensive Regional Development Plan; 2) Regional Transportation Plan; 3) Regional Water Resources Plan; and 4) Regional Housing Plan. Each of these elements is being developed simultaneously to fulfill specific planning needs for the region. All four elements will be developed through a unified planning process and will draw on a common data base.

LOCAL

The seventeen incorporated communities within the study area - Avondale, Buckeye, Chandler, El Mirage, Gilbert, Glendale, Goodyear, Guadalupe, Mesa, Paradise Valley, Peoria, Phoenix, Scottsdale, Surprise, Tempe, Tolleson, and Youngtown - are involved in water and water-related programs. In addition, the unincorporated communities of Cave Creek-Carefree, Fountain Hills, Litchfield Park, and Sun City are involved in water and water-related programs administered by others. Luke and Williams Air Force Bases and the Fort McDowell, Gila River, and Salt River Indian Communities are also involved in water and water-related programs.

The community water and water-related programs concern water and wastewater facilities, flood control and drainage, recreation, and solid waste. They are service oriented rather than resource oriented. Communities within the project area do not have all-encompassing water resource management programs, although several of the communities are engaged in the long-term planning for capital improvements.

City of Phoenix

As a result of recent flood events and anticipated expansion of Sky Harbor Airport, the City of Phoenix has conducted studies of channelization of the Salt River around the airport and construction of two new bridges across the river at 16th Street and 19th Avenue.

City of Tempe

The City of Tempe has probably been the most active proponent of the Rio Salado concept. Their planning staff maintains a continuous effort to promote the concept.

Salt River Project (SRP)

The SRP currently is studying a wide range of proposals to provide peak electrical power through a system of pump-back water storage. SRP also is the focal point during periods of flooding on the Salt River inasmuch as it operates extensive snowpack and runoff gaging stations, predicts flood flows, and maintains a system of six storage reservoirs on the Salt and Verde Rivers. It continuously studies methods to improve operating procedures.

Arizona Public Service Co. (APS)

The Arizona Public Service Company has been designated Project Manager and Operating Agent for the Palo Verde Nuclear Generating Station (PVNGS), currently under construction 45 miles west of Phoenix. When completed in 1982, the plant will use treated sewage effluent. The effluent will be purchased under contract from the City of Phoenix and 5 other Phoenix area communities and will be piped to the site from the 91st Avenue sewage treatment facility.