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PLAN OF STUDY

STUDY OF ALTERNATIVES FOR SALT-GILA FLOOD CONTROL

AND

REGULATION OF CENTRAL ARIZONA PROJECT WATERS

prepared by

Arizona Projects Office, Bureau of Reclamation
and
Phoenix Urban Study, U.S. Corps of Engineers

APRIL 1979

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SUPPLEMENT TO

MEMORANDUM OF UNDERSTANDING
BETWEEN

CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

AND

BUREAU OF RECLAMATION
DEPARMENT OF THE INTERIOR

PERTAINING TO A STUDY OF ALTERNATIVES
FOR CONTROL OF FLOODS ALONG THE SALT AND GILA RIVERS
AND REGULATION OF CENTRAL ARIZONA PROJECT WATERS

This Supplement to the Memorandum of Understanding is entered into this day of .

The attached Plan of Study serves to supplement the Memorandum of Understanding dated December 15, 1978, as required by Article IIF, and incorporates the criteria of the Corps of Engineers for a Reconnaissance report.

_____ Dated: _____
District Engineer
Corps of Engineers

_____ Dated: _____
Regional Director
Bureau of Reclamation

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SUMMARY

Executive Summary of the Plan of Study for a Study of Alternatives for Salt-Gila Flood Control and Regulation of Central Arizona Project Waters

In 1968, Congress enacted the Lower Colorado River Basin Act (Public Law 90-537) which authorized the Central Arizona Project (CAP) as a means of reducing water shortages in central Arizona. CAP is a multi-purpose water resource development and management project which will bring water from the Colorado River across Arizona into Maricopa, Pinal, and Pima Counties, utilizing a system of aqueducts, generating stations, pump stations, and reservoirs. Currently under construction by the Bureau of Reclamation, the Project is scheduled to begin water deliveries in 1985.

One of the authorized features of the CAP is a dam located approximately 20 miles east of Phoenix at the confluence of the Salt and Verde Rivers, known as Orme Dam. Orme Dam, or a suitable alternative, was authorized to provide a reservoir for seasonal storage and regulation of CAP water upon its arrival in central Arizona. The existence of regulatory storage capacity would increase CAP efficiency by permitting a relatively constant flow of water through the aqueduct system despite fluctuations in demand. Colorado River diversions could be stored during low water demand periods or aqueduct shutdowns; or transferred to the Salt-Gila Aqueduct during high demand or emergency conditions.

In addition to providing regulatory storage, Orme Dam or a suitable alternative would offer a high degree of flood protection to the Phoenix metropolitan area and provide for conservation of flows from the Salt and Verde Rivers that are currently lost for beneficial use. The Salt and Verde Rivers historically have generated serious floods in Phoenix, the largest metropolitan area in the Colorado River basin. Recent floods in March and December 1978 and January 1979 were so serious that federal disaster proclamations were issued for the area. It is estimated that construction of Orme Dam would prevent flood damages averaging over 4 million dollars annually.

In preparation for the construction of Orme Dam, the Bureau of Reclamation issued, in May 1976, a draft environmental statement for the dam and reservoir (Int. DES 76-17). Response to this document revealed concern among some Arizona agencies and citizens regarding the environmental impacts of the proposed dam. Of particular concern are: inundation

of the Fort McDowell Indian Community and riparian habitat, and impacts upon the habitat of the endangered bald eagle and other species; the safety aspects of the proposed dam; and possible restriction of extensive recreational use of the Salt River. These concerns and others caused the Bureau of Reclamation to reassess the merits of Orme Dam and to delay the preparation of a final environmental statement and initiation of the construction of this CAP feature. In April 1977, President Carter, as a result of the Administration's water project review, recommended that Orme Dam be eliminated from the CAP for environmental and social reasons.

This Study centers on identification of a suitable alternative to Orme Dam and Reservoir that would provide flood control and CAP regulatory storage capacity. This Study report presents the results of a preliminary analysis of alternatives and includes a Plan of Study for the remainder of the Study; it also concludes Stage I of a three-stage Study process. In Stages II and III, a number of alternative plans will be formulated by combining the various flood control and regultory storage components identified during Stage I. All proposed alternatives will be measured against a "No Action Alternative" projecting future conditions that would exist if no federal action is taken to provide either flood control or CAP regulatory storage capacity. Alternatives also will be evaluated in terms of their economic, social, and environmental impacts; their potential to provide opportunities for recreation, hydroelectric power generation, water conservation, and ground-water recharge; and their enhancement of fish and wildlife resources, archeological and historical resources, and extent of open space.

Specifically, to meet the CAP regulatory storage objective, it is proposed that the site at the confluence of the Salt and Verde Rivers continue to be studied, along with a New Waddell Dam site on the Agua Fria River. To meet the flood control objectives, alternatives proposed include modification of Roosevelt and Horseshoe Dams to improve their effectiveness by raising the existing structures, by increasing the outlet size and by implementing and preparing new operating criteria; construction of upstream dams at the Tangle Creek and Cliff sites on the Verde River; and providing local protection through channels and levees and various non-structural measures.

In addition to Stage I Study Results, this report contains a Plan of Study developed by the Bureau of Reclamation and the Corps of Engineers (the Agencies). The Study will follow the guidelines contained in Principles and Standards for Planning Water and Related Land Resources promulgated by the Water Resources Council, a federal executive branch

agency. The PLAN OF STUDY provides for assembling additional information required for evaluation of the alternatives and informing and involving the general public and interested agencies in this Study process. The majority of the field work and engineering will be accomplished during Stage II which concludes with the presentation of intermediate alternative plans for review by the Agencies involved, other interested agencies, and the general public. Based on public response and comprehensive assessment of the intermediate plans, Stage III efforts will concern development of several detailed alternative plans, determination of plans preferred by the Agencies and the public, and publication of required planning documents and environmental impact statements.

The Bureau has primary responsibility for the Study. The Corps of Engineers, having considerable experience in flood control matters, is responsible under the Flood Control Act of 1944 for prescribing regulations for operation of flood control projects constructed by the Bureau of Reclamation. Therefore, the Corps will assist the Bureau by formulating and evaluating plans for flood control. Each Agency's area of responsibility for this Study is specified in a Memorandum of Understanding and the PLAN OF STUDY. The Agencies will follow a common schedule and will avoid duplication of effort by pooling resources in areas of mutual interest, such as environmental assessment and public involvement.

Most of the funding for the Study will be provided through the Bureau of Reclamation to support the efforts of both Agencies. The total estimated cost of the 4-year Study is $7,094,400. with fiscal year costs by Agency as follows:

	FY 78	FY 79	FY 80	FY 81	FY 82	TOTAL
Corps	54,600.	1,306,300.	1,100,900.	395,800.	214,400.	3,072,000.
Bureau	69,500.	1,266,200.	1,435,300.	968,900.	282,500.	4,022,400.
TOTAL	$124,100.	$2,572,500.	$2,536,200.	$1,364,700.	$496,900.	$7,094,400.

The Corps requirement in FY 79 will be met through the use of $350,000 appropriated for the Corps Phoenix Urban Study and the transfer of funds from the Bureau. Corps requirements in fiscal years 1980, 1981, and 1982 may be appropriated to the Corps directly or through the Bureau, whichever Congress determines most appropriate.

Efforts providing support to the needs of both Agencies, such as environmental, economic/demographic and social assessments, and public involvement are included in the cost estimates for the Bureau.

The Study schedule developed by both Agencies indicates that the final report describing the selected alternative plan will be completed in May 1982.

I. INTRODUCTION AND AUTHORITY

I. INTRODUCTION AND AUTHORITY

The Central Arizona Project (CAP) was authorized for construction by Public Law 90-537, approved September 30, 1968. The CAP is a multi-purpose water resource development and management project which will provide supplemental water to central Arizona and western New Mexico. Construction of the water-related features of CAP began in 1973. When completed, the Project will benefit both Arizona and New Mexico in the areas of water conservation, flood control, recreation, and fish and wildlife resources.

In general, the area of principal benefit from the CAP is the basin of the Gila River and its major tributaries from above Painted Rock Dam to the river's upper reaches in southwestern New Mexico. This area includes the metropolitan areas of Phoenix and Tucson and the large agricultural complex located in Maricopa, Pinal, and Pima Counties in central Arizona. Direct delivery of Colorado River water will be made by the CAP into these areas. Also, communities and agricultural areas located in and adjacent to the Gila River watershed will receive additional water through water exchange agreements between the Project and central area water users in Arizona.

The major features of the Central Arizona Project as authorized are shown in Figure 1. Table 1 gives the status of each major CAP feature.

The Study centers on the flood control and regulatory storage functions of the proposed Orme Dam and Reservoir which would be located in Maricopa County, Arizona, approximately 20 miles east of Phoenix, at the confluence of the Salt and Verde Rivers. Orme Dam would be operated in coordination with the existing Salt River Project storage system and with diversions from the Colorado River delivered through the Granite Reef Aqueduct, another CAP feature. Orme Dam or a suitable alternative would provide operational flexibility to the Granite Reef Aqueduct by allowing the storage of Colorado River diversions during low water demand periods or during aqueduct shutdowns. In addition to providing regulatory storage, Orme Dam or a suitable alternative would offer a high degree of flood protection to the Phoenix metropolitan area and provide for conservation of flows from the Salt and Verde Rivers. Regulatory storage also would facilitate diversions to the Salt-Gila Aqueduct when maintenance is scheduled for the Granite Reef Aqueduct, during periods of high water demands or under emergency conditions.

Table 1

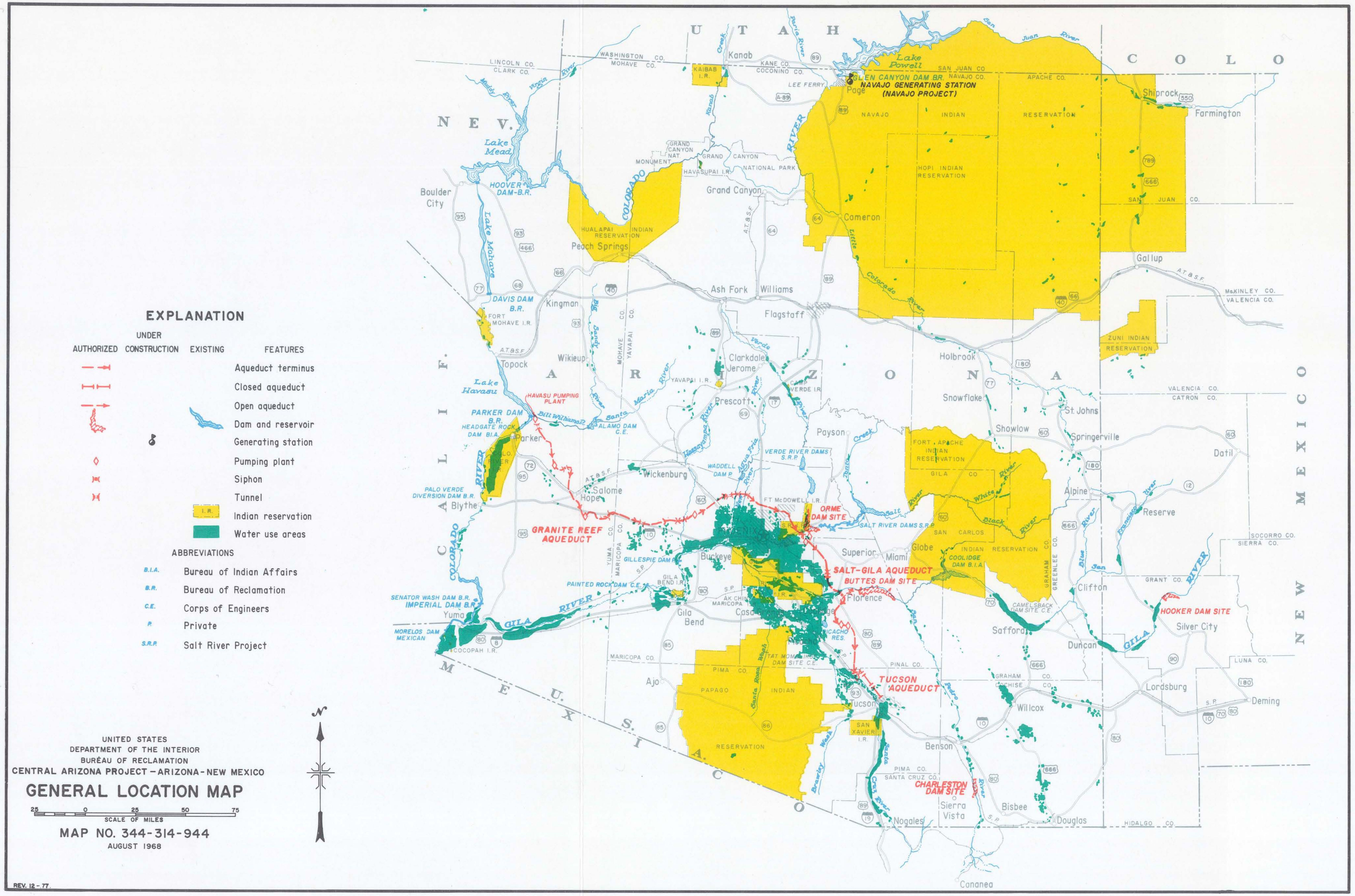
Central Arizona Project Features

Authorized Features	Status
DAMS AND RESERVOIRS	
Orme	*
Buttes	Advance Planning
Charleston	*
Hooker	*
AQUEDUCTS	
Granite Reef	Under Construction
Salt-Gila	Advance Planning
Tucson	Advance Planning
POWER GENERATION	
Navajo Generating Station	Existing

The Project also includes various electrical power transmission lines, communications systems, distribution systems to Indian and non-Indian lands, and drainage facilities.

* Recommended for elimination from the Project by President Carter in his Statement on the Water Project Review, April 1977.

Figure 1



The Central Arizona Project has been modified to eliminate construction of Orme, Hooker and Charleston Dams.

In May 1976, the Bureau of Reclamation published a draft environmental statement for Orme Dam and Reservoir. Public response to this environmental impact statement identified major concerns among some agencies and many residents of Arizona. In particular, concerns regarding the inundation of the Fort McDowell Indian Reservation, inundation of riparian habitat, and inundation of the habitat of the endangered bald eagle were expressed. Also, the safety aspects of the proposed dam, deleterious effects upon regional water quality, destruction of historical and archeological resources, and conversion of recreational use of the Salt River from tubing and picnicking to lake-oriented recreation were questioned. Additionally, the feeling was expressed that more information should be presented on the alternatives to the proposed Orme Dam.

These concerns and others caused the Bureau of Reclamation to reassess the merits of Orme Dam and to delay the preparation of a final environmental statement and initiation of the construction of this feature. In April 1977, President Carter, as a result of the Administration's water project review, recommended that Orme Dam be eliminated from the CAP for environmental and social reasons.

An impasse obviously had been reached. The CAP was under construction and a decision on regulatory storage capacity was needed. The Salt and Gila Rivers frequently flood the Phoenix area causing widespread damage and destruction. Orme Dam, planned and authorized to resolve both problems, had been deemed inappropriate by President Carter. The Bureau of Reclamation renewed its search for an alternative solution and found that other plans may be feasible, although additional information will be required before a final decision can be made.

This PLAN OF STUDY presents a preliminary analysis of alternative plans made since President Carter's decision in April 1977, and also presents a plan for gathering additional information concerning these alternatives upon which the Agencies (Bureau of Reclamation and Corps of Engineers) will base their decision as to which alternative plan should be implemented. The report is divided into two sections. The section immediately following this introduction is titled STAGE I STUDY RESULTS and briefly describes a preliminary analysis of alternatives for regulatory storage and flood control. The final section of this report, PLAN OF STUDY, presents the plan which will be followed to determine the most suitable alternative for implementation.

Authority for the Study is derived from the Lower Colorado River Basin Project Act (Public Law 90-537), signed into law September 30, 1968. This act authorizes construction of Orme Dam and Reservoir, or a suitable alternative, by the Bureau of Reclamation. The study of "suitable alternatives" is precisely the purpose of this Report. The Flood Control Act of 1944 (Public Law 78-534) assigns to the Corps of Engineers responsibility to prescribe regulations for use of storage allocated for flood control at all reservoirs constructed with federal funds. Based on this authority, the Corps of Engineers will assist the Bureau of Reclamation by formulating and evaluating alternative plans for flood control.

A Memorandum of Understanding between the Agencies that defines the respective responsibilities was signed by the Regional Director of the Lower Colorado Region and the Los Angeles District Engineer on December 15, 1978.

MEMORANDUM OF UNDERSTANDING
BETWEEN

CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

AND

BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR

NO. 9-07-30-X0057

PERTAINING TO A STUDY OF ALTERNATIVES
FOR CONTROL OF FLOODS ALONG THE SALT AND GILA RIVERS
AND REGULATION OF CENTRAL ARIZONA PROJECT WATERS

THIS MEMORANDUM OF UNDERSTANDING, entered into this 15th day of December, 1978, between the Corps of Engineers of the Department of the Army, hereinafter referred to as the "Corps," and represented by the District Engineer, Los Angeles District, and the Bureau of Reclamation of the Department of the Interior, hereinafter referred to as the "Bureau," and represented by the Regional Director, Lower Colorado Region together hereinafter termed the "Agencies." This is entered into under the authority of the Act of June 20, 1932, as amended (47 Stat. 382) which is commonly known as the "Economy Act."

WITNESSETH THAT:

WHEREAS, the Central Arizona Project (CAP) was authorized by Public Law 90-537 on September 30, 1968, "for the purpose of furnishing irrigation water and municipal water supplies to the water-deficient areas of Arizona. . . control of floods. . ." and to consist. . ." of the

following principal works: . . . (2) Orme Dam and Reservoir and power-pumping plant or suitable alternative . . . ; and

WHEREAS, the President in his Statement on Water Projects dated April 18, 1977, recommended that the CAP be modified by eliminating Orme Dam which would have provided flood control along the Salt and Gila Rivers and regulation of CAP waters; and

WHEREAS, the Council on Environmental Quality Guidelines for Preparation of Environmental Impact Statements pursuant to the National Environmental Policy Act (NEPA) require the responsible agency to study, develop, and describe all reasonable alternatives, including those not within the existing authority of the responsible agency; and

WHEREAS, the Interagency Task Force on Orme Dam Alternatives was unable to make a recommendation on a suitable alternative to Orme Dam, but concluded in its final report, dated May 5, 1978, that further work needs to be done and it now appears possible to select a realistic number of alternatives for detailed analysis; and

WHEREAS, the Resolution by the United States Senate Committee on Public Works, dated July 31, 1973, directed the Board of Engineers for Rivers and Harbors to conduct the Phoenix Urban Study which addresses, among other things, flood problems on the Salt River; and

WHEREAS, the Agencies agree that a multipurpose plan to accomplish the goals of flood control along the Salt and Gila Rivers in the metropolitan Phoenix area and regulation of CAP waters to be imported from the Colorado River is urgently needed.

NOW, THEREFORE, we the undersigned, recognizing the importance of developing a multipurpose plan resulting from a Study of Alternatives for the Control of Floods along the Salt and Gila Rivers and the Regulation of Central Arizona Project Waters, hereinafter referred to as "the Study," hereby agree as follows:

I. Objectives:

A. Development of viable alternative plans for flood control and regulation of CAP waters;

B. Identification of other needs including, but not limited to, water-based recreation, fish and wildlife, hydropower, ground-water recharge, and environmental protection and enhancement;

C. Obtaining of technical, environmental, economic, and social data required for the formulation and evaluation of alternative plans;

D. Fulfillment of the requirements of NEPA regarding the preparation of an environmental impact statement from which the appropriate administrative or legislative action can be taken;

E. Maintenance of a high degree of public and other agency involvement to insure clear and accurate two-way exchange of information on the plans, the decision-making process, and other major study areas of interest.

II. General Provisions:

A. The Agencies shall assign the highest priority to the Study consistent with other responsibilities.

B. The applicable elements of the Principles and Standards for Planning Water and Related Land Resources adopted by the Water Resources Council shall be applied.

C. The applicable elements of President Carter's Water Policy message of June 6, 1978, shall be used in the conduct of the Study.

D. All information developed by the Study or other applicable studies shall be available to each Agency.

E. The Agencies recognize the need to enter into contracts to procure outside services. The Bureau will contract for services involving a public involvement program, and for environmental, social, and economic demographic studies. Other contract services will be procured by either Agency as required; however, procurement of contract services by the Corps will be coordinated with the Bureau.

F. The Agencies will prepare a Plan of Study, describing the specific tasks to be accomplished, responsibilities for the tasks, the schedule, a public involvement program, and other pertinent information. Upon completion and agreement by both Agencies on the Plan of Study, such Plan of Study will become a part of this Memorandum of Understanding.

III. Responsibilities:

The Bureau will have full responsibility for accomplishing the Study. The Corps will provide input as agreed to in the Plan of Study. The Corps input will meet Corps survey report standards for flood control planning.

IV. Program Management:

The Agencies will each name an agency manager to assure continual coordination and adherence to a program schedule. The agency managers shall:

A. Coordinate with their respective agencies to assure adherence to study scope, logic, and schedules, as defined in the Plan of Study.

B. Maintain a study schedule showing tasks to be accomplished by the Agencies, other agencies, and contractors; funding requirements, and personnel needs and services to assure that study objectives are being met.

C. Solicit, as needed, assistance and cooperation from other agencies and the public.

D. Assure adequate public involvement.

E. Prepare periodic progress reports to the Agencies and the public involvement groups.

V. Funds:

Funds for the Study will be those authorized for appropriation by Public Law 90-537 or other applicable law. Should Congress fail to provide the funds required, the Memorandum may be terminated by either Agency.

VI. Modification:

Modification of the Memorandum, consistent with its purpose and within its general scope, may be accomplished by written agreement between the Agencies either by exchange of letters or in the form of an amendment.

VII. Duration:

This Memorandum shall continue in force through September 1982, unless terminated earlier by either of the Agencies by the giving of sixty (60) days notice in writing. It may be extended by written agreement between the Agencies either by exchange of letters or in the form of an amendment.

_____ Dated: _____

District Engineer
Corps of Engineers

_____ Dated: _____

Regional Director
Bureau of Reclamation

II. STAGE I STUDY RESULTS

II. STAGE I STUDY RESULTS

Description of the Study Area

The area under study encompasses portions of the Salt, Verde, Gila, and Agua Fria River drainage basins and is shown in Figure 2. Specifically, the Study area includes:

a. The Salt River drainage basin from Roosevelt Lake to Granite Reef Diversion Dam.

b. The Salt River floodplain from Granite Reef Diversion Dam to its confluence with the Gila River.

c. The Verde River drainage basin from the vicinity of Tangle Creek to its confluence with the Salt River.

d. The Gila River floodplain from the Salt River confluence to Painted Rock Reservoir.

e. The Agua Fria River drainage basin from the vicinity of Waddell Dam to its confluence with the Gila River.

This complex of rivers and floodplains lies mostly within Maricopa County, Arizona, but includes portions of extreme southern Yavapai County and western Gila County. In addition, analyses of flood control and flood frequencies of necessity would have to consider the influence of drainage areas lying upstream of the primary Study area.

The Study area was established after consideration of several factors relating to flood control and CAP regulatory storage. Primary flood damage areas in the Phoenix metropolitan area are included since local protection works, such as channels, will be considered to reduce flood damages. Upstream dams also might reduce these damages, so potential damsites are included. Preliminary analysis indicates that the effectiveness of a flood control dam is greatly reduced if it is located too far upstream of Phoenix. More specifically, a flood control dam such as Klondike Buttes, upstream of the existing Roosevelt Dam on the Salt River, or a flood control dam upstream of Tangle Creek on the Verde River, would be ineffective; therefore, the Study area was limited to these points.

For water conservation purposes, a reservoir site should be reasonably close to the Granite Reef Aqueduct and areas which will receive the water it delivers. A site on the Agua Fria River that meets these

criteria was included, while sites further west on the aqueduct were found to be less effective. While the Florence damsite on the Gila River meets the criteria, it is unacceptable due to geologic limitations resulting in the exclusion of the Gila River insofar as a regulatory storage site is concerned.

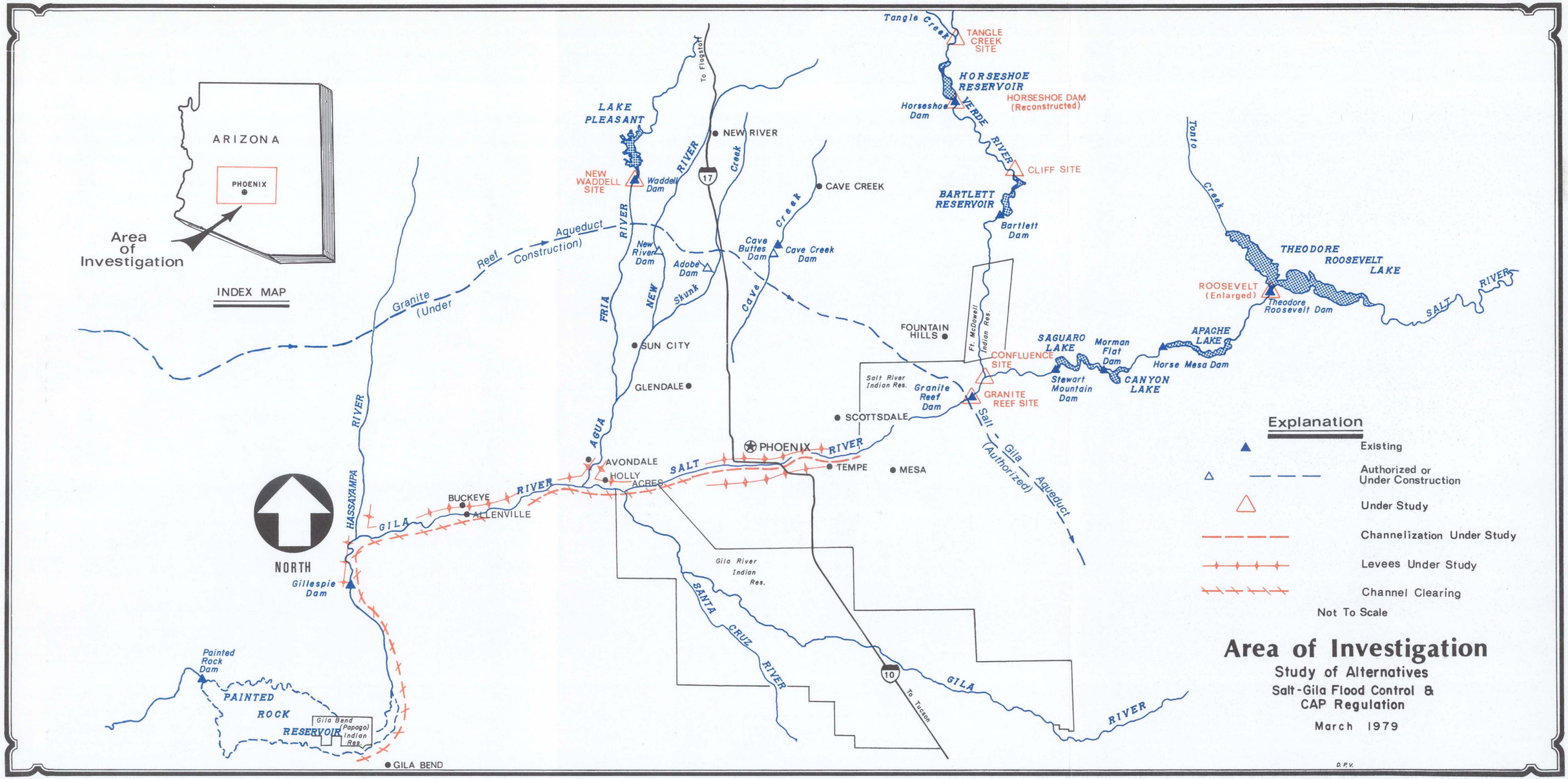
A. Physical Characteristics

Geology. The area is generally within the Basin and Range physiographic province, which is typified by geologic faulting and tilting. This tectonic activity has formed numerous northwest-southwest trending mountain ranges separated by broad alluvial basins. Despite the prevalence of faults throughout the area, the earthquake hazard 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. Elevations in the Study area vary from about 500 feet above sea level at Painted Rock Dam to about 2,150 feet above sea level at Roosevelt Dam. Mountains in the Study area rise to over 7,000 feet above sea level. Elevations in the Salt River watershed upstream of the Study area rise to 11,590 feet above sea level on Baldy Peak in eastern Arizona and 12,670 feet above sea level on Humphrey Peak near Flagstaff. Most of the population of the Study area resides in metropolitan Phoenix. Elevations in metropolitan Phoenix range from 890 feet at Buckeye to 1,380 feet above sea level east of Mesa, with mountains in or near the urban area reaching 4,000 feet above sea level. Slopes in the Study area are, by and large, gentle, although steep gradients (ten percent or greater) occur in the mountains.

Climate. The climate of the Study area is arid and marked by extreme heat and low rainfall. In summertime, daily high temperatures average over 100°, with lows averaging in the 70°. During the winter months, highs average in the upper 60°, with lows about 40°. Temperatures in higher elevations tend to be lower in both summer and winter. Precipitation amounts in the Study area range from less than 6 inches per year in the desert to in excess of 20 inches in the surrounding mountains. Elevations above 3,000 feet experience occasional snowfall. Snow accumulates in substantial amounts in the watersheds above 5,000 feet and is a major factor in the hydrology of rivers in the Study area. Snow rarely occurs in the desert and generally melts upon hitting the ground.

Precipitation in the Study area occurs in two distinct seasons. Winter rains are usually the result of cyclonic disturbances originating over the Pacific Ocean. These storms bring light widespread precipitation. The arrival over Arizona of moist tropical air from the Gulf


ARIZONA
PHOENIX
Area of Investigation
INDEX MAP
NORTH
Tangle Creek
TANGLE CREEK SITE
HORSESHOE RESERVOIR
HORSESHOE DAM (Reconstructed)
Horseshoe Dam
VERDE RIVER
CLIFF SITE
BARTLETT RESERVOIR
Bartlett Dam
Tonto Creek
THEODORE ROOSEVELT LAKE
ROOSEVELT (Enlarged)
Theodore Roosevelt Dam
SALT RIVER
APACHE LAKE
Horse Mesa Dam
CANYON LAKE
Stewart Mountain Dam
Morman Flat Dam
SAGUARO LAKE
CONFLUENCE SITE
GRANITE REEF SITE
Granite Reef Dam
Salt River Indian Res.
Ft. McDowell Indian Res.
FOUNTAIN HILLS
SCOTTSDALE
TEMPE
MESA
PHOENIX
Salt - Gila Aqueduct (Authorized)
Granite Reef Aqueduct (Under Construction)
LAKE PLEASANT
NEW WADDELL SITE
Waddell Dam
NEW RIVER
To Flagstaff
17
CAVE CREEK
Cave Creek
Cave Buttes Dam
Cave Creek Dam
New River Dam
Adobe Dam
Skunk Creek
NEW RIVER
FRIA
SUN CITY
GLENDALE
AGUA FRIA RIVER
AVONDALE
HOLLY ACRES
BUCKEYE
ALLENVILLE
GILA RIVER
HASSAYAMPA RIVER
Gillespie Dam
Gila River Indian Res.
SANTA CRUZ RIVER
10
To Tucson
GILA RIVER
Painted Rock Dam
PAINTED ROCK RESERVOIR
Gila Bend (Papago) Indian Res.
GILA BEND
Explanation
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Authorized or Under Construction
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Channelization Under Study
Levees Under Study
Channel Clearing
Not To Scale
Area of Investigation
Study of Alternatives
Salt-Gila Flood Control & CAP Regulation
March 1979
D.P.V.

344-330-T-716

of California in midsummer signals the start of the "monsoon" or summer rainy season which extends from July to September and occasionally October and is marked by scattered, often heavy thunderstorms. These storms can result in periods of high wind, severe blowing dust, and flashflooding.

B. Biological Characteristics

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 of 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.

C. Socio-Economic Profile

Cultural Background. In prehistoric times, much of the Study area was inhabited by an agricultural people known as the Hohokam. They diverted water from the Salt River and developed an extensive network of irrigation canals. About 1450 AD, the Hohokam deserted their villages and for approximately the next three centuries the area remained largely uninhabited. In historic times the Pima and Papago Indians, possible cultural descendants of the Hohokam, moved into the Salt River Valley.

During the mid-1860's, settlers began diverting water from the Salt River and irrigating farmland. Later in the decade, Phoenix was established and in the 1870's it became the leading commercial center in the Valley. Construction of the Arizona Canal north of the Salt River and other canals to the south, and the arrival of branchline railroads connected to transcontinental routes resulted in expansion of agriculture with the subsequent growth of Phoenix and development of a number of sattelite communities during the 1880's and 1890's.

Destructive floods in 1891 and 1905 together with a drought which began in the 1890's and lasted into the early twentieth century, caused farmers and townspeople in the Study area to seek a dependable source of water. Their efforts resulted in construction of Theodore 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. In the 1920's and 1930's, three more dams were built on the Salt River to conserve water and generate hydroelectric power. Two dams were constructed on the Verde River as well.

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. People and businesses continue to be attracted by the dry climate and increasing economic opportunities.

Population. Almost 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. Portions of Yavapai and Gila Counties are also in the Study area. 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, Buckeye, and Gila Bend. Four Indian reservations are also 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, and the Gila Bend Unit of the Papago Reservation along the Gila River near Painted Rock Dam. For population statistics of the Study area, see Tables 2-4.

Table 2

Population Growth and Racial Distribution, Arizona and Maricopa County

Population

Year		Arizona[1]	Maricopa County[1]
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

Racial Distribution[2]
(July 1, 1977)

Race	Arizona	Maricopa County
White	1,702,600	1,041,500
Spanish Heritage	442,300	190,500
Indian	131,000	15,500
Negro	68,000	44,400
Other	16,800	8,100
Total	2,363,000	1,300,000

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

[2] Valley National Bank, Arizona Statistical Review, 1978.

Table 3

Populations of Study Area Communities (July 1, 1977)[1]

Avondale	6,900
Buckeye	3,525
Cashion	4,280
Chandler	22,800
Fountain Hills	2,000
Gila Bend	2,000
Gilbert	3,975
Goodyear	2,650
Glendale	75,175
Guadalupe	4,400
Litchfield Park	3,100
Luke Air Force Base	7,350
Mesa	115,000
Peoria	11,500
Phoenix	682,200
Scottsdale	82,000
Tempe	103,000
Tolleson	3,750

1 Valley National Bank, Arizona Statistical Review, 1978

Table 4

Populations of Indian Reservations in the Study Area

(July 1, 1977)[1]

Fort McDowell Mohave-Apache Indian Community	348
Salt River Pima-Maricopa Indian Community	2,950
Gila River Indian Community	8,600
Gila Bend-Papago Indian Community	357
Total	12,255

[1] Valley National Bank, Arizona Statistical Review, 1978

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.

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 1977, 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. 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.

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.

Transportation. The Study area is connected to the rest of Arizona and the nation by two interstate highways, two railroads, and ten 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 transcontinental bus lines serve the area. Maricopa County also leads Arizona in motor vehicle registrations, with 646,006 passenger cars, 100,194 commercial vehicles, and 95,893 noncommercial 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 area were 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.

Land Use. The Study area contains one of the fastest growing urban regions in the United States. In recent years rapid population increases have resulted in urbanization of much of the Salt River Valley. Growth is expected to continue, particularly to the west, southwest, northwest, and southeast. A large area of undeveloped land north of Phoenix, presently owned and administered by the State of Arizona, is another potential region for urban expansion. Indian reservations in the southern and eastern portions of Maricopa County may limit urbanization in these directions. For statistics on land ownership and use in Maricopa County, see Tables 5 and 6.

D. Water Resources Profile

The major streams in the Study area are the Salt, Verde, Agua Fria, and Gila Rivers. Their tributaries in the Study area include New River, Skunk Creek, Cave Creek, Indian Bend Wash, and Sycamore Creek, as well as several smaller arroyos and washes. With the exception of the perennial Salt and Verde Rivers above Granite Reef Diversion Dam, these streams are ephemeral. The relatively light winter rainfall usually is insufficient to produce sustained major surface flows along the tributaries, although winter and spring runoff from rainfall and/or melting snow from the watersheds may cause significant flows on the larger streams. Intense summer thunderstorms occasionally result in flooding along tributary streams but not normally along the major water courses.

The Salt and Verde Rivers supply 93 percent of surface water available in the Study area. They are controlled by four dams on the Salt (Stewart Mountain, Mormon Flat, Horse Mesa, and Roosevelt) and two dams (Bartlett and Horseshoe) on the Verde. These structures which, along with the operating agency, are known as the Salt River Project, impound reservoirs which provide irrigation and domestic water for

Table 5

Status of Land Ownership, Maricopa County, Arizona, 1978[1]

U. S. Forest Service	12%
U. S. Bureau of Land Management	31%
Indian Reservation	5%
State of Arizona	10%
Individual or Corporate	27%
Other*	15%

[1] Valley National Bank, Arizona Statistical Review, 1978

* Includes lands administered by the National Park Service, Department of Defense, Bureau of Sport Fisheries and Wildlife, Bureau of Reclamation, and other county, state, and federal agencies.

Table 6

Existing General Land Use, Maricopa County, Arizona, 1973[1]

Land Use	Area in Square Miles	% Total Co. Area
Riparian Habitat	41	0.4
Urban Development	323	3.5
Agricultural	882	9.6
Major Park and Recreation Areas	1,305	14.1
Airports and Military Reservations	1,260	13.7
Mountains and Desert	5,415	58.7
Total County Area	9,226	100.0

[1] Largely taken from Maricopa County Planning Department's, "A Report Upon Future General Land Use for Maricopa County, Arizona, Part Three of the Comprehensive Plan," 1975.

metropolitan Phoenix, 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 Fría River is impounded by Waddell Dam, forming Lake Pleasant. This reservoir supplies water to Maricopa County Municipal Water Conservation District No. 1, although the amount of surface water available from this system is far less and not as reliable as that from the Salt-Verde system.

In the Arizona Water Commission's Phase I - Arizona Water Plan (1975), the average annual consumptive use of water in the Salt River Valley Basin is estimated at 1,563,000 acre-feet, while the average annual supply is only 931,000 acre-feet. The ground-water reserves are being overdrafted at the rate of 632,000 acre-feet per year to supplement the dependable surface supply. Comparable figures for the entire state show that average annual consumptive use in Arizona is 4,800,000 acre-feet while the average annual supply is 2,800,000 acre-feet. The state-wide ground-water overdraft of more than 2,000,000 acre-feet per year is indicated by the difference in these numbers.

Problems and Needs

The settlement, development, and economic growth of central Arizona has been predicated on the location and availability of water resources. Prehistoric and early historic settlers relied on surface flowing streams, springs, and rivers. Since the early 20th century, however, dependence on readily available ground water has increased. Growth has far outstripped the area's renewable water resources, resulting in massive overdrafting of ground-water supplies. Despite this imbalance between water demands and renewable water reserves, the area continues to be plagued by periodic flooding. This section highlights the problems and needs of the Study area and their interrelationship with the Study.

A. Water Supply

The maintenance of an adequate water supply in the 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. While a comprehensive analysis of water supply and demand issues is properly in the State's domain, this Study will address the issues of water conservation, importation of water, and conservation of flood flows as measures which could contribute toward a solution of the water supply problem.

1. 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.

As of 1970, agriculture accounted for 89 percent of water depletions in Arizona. Mining consumed 3 percent, and fish and wildlife interests used a little over 1 percent. Urban uses (municipal and industrial) amounted to less than 7 percent of the depletions. Although urban uses have increased since 1970, agriculture still consumes the largest amount of water. Arizona's farmers and ranchers are generally efficient in their application of water to the land; nevertheless, the potential may exist for irrigation system improvements and improved water management practices. Urban water conservation measures also become increasingly important as more and more cropland is converted to commercial, residential, and industrial uses.

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.

2. Importation of Water

The CAP 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 ground-water 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. The need to provide regulatory storage is one of the primary reasons for this Study.

3. 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.

For instance, 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 Salt River. If flood water were assigned a value equal to the estimated direct annual benefits of CAP irrigation water ($42.91 per acre-foot), it would be valued at $25.7 million. The existence of CAP regulatory storage and flood control storage capacity would increase

the opportunity to store portions of floodflows for later beneficial use either through direct water deliveries or ground-water recharge. Preliminary studies indicate that a dam in the vicinity of the confluence of the Salt and Verde Rivers could conserve a significant amount of water. A number of assumptions made during preliminary studies need to be analyzed, but indications are that on the average, between 68,000 and 256,000 acre-feet per year of surplus runoff could be conserved. The amount of water available for beneficial use would vary greatly from year to year depending on storage capacity, precipitation in the Salt-Verde watershed, and other factors. This same benefit might be derived if the water caught in Painted Rock Reservoir were put to beneficial use.

As a means of providing a partial solution to the Study area's water supply problems, conservation of floodflows needs to be explored and incorporated into the Study's other water resource planning efforts.

B. Flood Control

Flooding along the Salt River has been recorded since the arrival of pioneer settlers in central Arizona in the 1860's. (See Table 7) The most serious of the early floods occurred in February 1891, when an estimated peak flow of 300,000 ft^3/s 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 shifted 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. The peak flow came in November 1905 when over 200,000 ft^3/s was recorded near Phoenix. Warm rains melted a heavy snowpack in the high mountains causing a flow on the Salt River of 120,000 ft^3/s in January and 105,000 ft^3/s in April 1916. This flow was exceeded by the flood of February 1920, which produced a peak flow of 130,000 ft^3/s. Another serious flood on the Salt River occurred in March 1938, producing a peak flow of 95,000 ft^3/s. In 1941, a large storm relieved near-drought conditions and resulted in a flow of 40,000 ft^3/s.

Table 7

Historical Floods on the Salt River*

Date	Flood Peak (ft^3/s)
February 1891	300,000
April 1095	115,000
November 27, 1905	200,000
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 29, 1973	22,000
March 2, 1978	122,000
December 19, 1978	140,000
January 19, 1979	88,000
March 29, 1979	67,800

*. 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 (figures are preliminary and subject to revision).

For the next 24 years there were virtually no flood flows in the Salt River through Phoenix, but several damaging floods have occurred in recent years. The 1965-1966 flood, with a peak discharge of 67,000 ft^3/s 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 17 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 ft^3/s 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.

In March 1978, a flood occurred with an estimated peak flow of 122,000 ft^3/s through the Phoenix area and caused an estimated $33,138,000 in damages (see Table 8). Approximately 95 percent of this damage occurred on the Salt and Verde Rivers. Once again, snowmelt influenced the flow and contributed to the flood.

In December 1978, warm moist air from the Pacific Ocean and the resulting precipitation caused another snowpack to melt. The resultant peak flow of 140,000 ft^3/s on the Salt River was slightly larger than the March flood; however, total damages for the Study area are expected to approximate March 1978 losses. (Damage estimates are not yet available.)

The most severe flood than can reasonably be expected to occur in a region based on its meteorologic 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 $252,000,000 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 ft^3/s.

Table 8

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

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.

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; consequently, there is no dedicated or designated space available in the existing Salt River Project reservoir system for flood control purposes. Some reservoirs were constructed since the large floods of the early twentieth century and would have reduced those flows. Table 9 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 2,063,948 acre-feet storage serves only the Salt River. 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 head works 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 ft^3/s, 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 ft^3/s or less, due to interruption of transportation and aggravation of saline ground-water problems.

Table 9

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	131,427		1946
Bartlett	178,186		1939
Total: Verde System	309,613	15%	
Total: Salt & Verde Systems	2,063,948	100%	

In summary, severe flood hazard conditions on the Salt River have been confirmed by the floods in 1978 and 1979, and a need exists to formulate and implement a plan to reduce flood damages. The Study will address this need as one of its primary objectives.

C. Energy Conservation

In recent years, energy demand and costs have risen dramatically. Substantial efforts are being made by power utilities in the Study area to meet the demand, and in particular, to reduce demand during peak-power periods. The plan developed by the Study will influence and should be influenced by the energy picture in several ways.

If additional reservoir storage space is developed for either regulatory storage or flood control purposes, it may provide additional hydroelectric generating capability. This power might be provided on a continuous basis, thus augmenting base load power capacity, or it could be provided only during periods of peak demand. Peak power generation might involve operation on a pump-back basis in conjunction with existing Salt River Project facilities.

The addition of storage space or more efficient use of existing space might allow the capture and use of water that would otherwise be wasted, and could reduce the amount of water delivered by the Granite Reef Aqueduct from the Colorado River. This would result in obvious savings in the power required for pumping from the ground or the Colorado River.

Finally, if regulatory storage is provided, the CAP would be operated so as to reduce its own peak power demand by pumping whenever possible during low demand periods. This could be done without affecting the ability to meet immediate water demands. Without regulatory storage, however, this method of saving energy would be severely restricted.

Each of these aspects of energy conservation will be taken into consideration in the course of the Study. Particular attention also must be given to close coordination with the Salt River Project.

D. Water Quality

Throughout the nation there is a growing concern for the quality of the country's waters, and this concern has extended into the Study area. The classic differentiation of water into surface and subsurface categories, and of pollutants into point and non-point sources, may aid in the understanding of water quality concerns.

Ground-water quality varies greatly throughout the Study area from low quality with total dissolved solids in excess of 4,000 mg/l to high quality of less than 200 mg/l. Other constituents, such as fluorides, nitrates, chromium, arsenic, sulfates, hardness, lead, and radioactivity cause problems in certain localities. While causes of such pollution are not completely understood, in a number of instances (e.g. fluorides), the problem seems to be caused solely by natural processes. In other instances, man seems to have influenced the problem through generation of pollutants from point sources which percolate into ground-water basins. Non-point sources of pollution also affect water quality, particularly as water management practices come into play. For instance, the continuous application of irrigation water may lead to concentration of salts to the extent that the underlying ground water is no longer useful for most purposes.

Surface water quality also varies in the region. For the most part, pollutants in surface water consist of dissolved salts and are from natural non-point sources. There are few significant point sources of pollution that affect surface water in the Study area.

Man has influenced the concentration of dissolved salts in surface water through management practices. In general, surface water quality improves during periods of high flows and deteriorates as flows decrease. Flood water is of the highest quality in terms of dissolved solids. For instance, flood flows collected in Painted Rock Reservoir after the March 1978 flood contained concentrations of 318 mg/l of total dissolved solids on April 18, 1978, while water delivered through the CAP is expected to contain about 755 mg/l. Under natural conditions, flood water escapes the area quickly, but the construction of the Salt River Project facilities allowed much of this higher quality water to be captured for use, with the net effect of improving water quality. However, long-term surface storage tends to lower water quality as evaporation concentrates the dissolved solids. Since regulatory storage will influence the amount of CAP water delivered, it will also influence the importation of dissolved solids. The location of regulatory storage may influence surface water quality in other respects. Salt River water has an average concentration of 620 mg/l of total dissolved solids below Stewart Mountain Dam, while the Verde River average is 260 mg/l. The average for the Salt-Verde system is 470 mg/l. The regulatory storage site and delivery method will determine the extent to which these waters of various qualities are intermingled. If additional flood water is captured for future use,

it will be of a higher than average quality. If CAP water is stored in ground-water reservoirs, it also will influence water quality there.

In summary, water quality will be influenced in many ways by the plan developed by the Study. The extent of this influence should be estimated, understood, and considered during the Study.

E. Vegetation and Wildlife

All of the structural alternatives to be considered by the Study could impact habitat of significance to birds and mammals of the region. 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. The rapid growth of agriculture and urbanization in large portions of the Study area already 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 River 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 projects.

A dam and reservoir at or upstream of the confluence of the Salt and Verde Rivers could reduce the habitat for local animal population in the area. The mule deer, javelina, gray fox, and coyote would decrease if habitats diminished and recreational uses and development occurred. Bird species nesting in the area could also be affected adversely. The small amount of marsh near the Salt-Verde confluence that constitutes potential habitat for the endangered Yuma Clapper Rail also might be destroyed. Nesting areas for black hawks and the endangered bald eagle could be adversely affected, and eagles in the region would suffer from a reduction of stream feeding habitat. In addition most species of reptiles and amphibians at the confluence site would be impacted.

Not all effects of flood control projects are negative. If ground-water recharge is successfully incorporated into a project, it may improve riparian habitat and thus have a very beneficial impact. Dams, reservoirs, and other alternatives would have similar impacts upon vegetation and wildlife in the immediate area. The consequence of taking no action for regulatory storage and flood control purposes would also have positive and negative impacts on the vegetation and wildlife. These impacts must be addressed during the Study as well as ways of improving habitat and aiding in the recovery and conservation of endangered species.

F. 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 exacerbated further. This produces a cycle of overuse-deterioration-reduced capacity (supply)-overuse, that is difficult to break.

Recreational use of the few watercourses 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 boating and water skiing, and only 15 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 and irreplaceable resource particularly attractive to young people in the

area who could not afford and 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. This need will be addressed as part of the Study.

G. Social Considerations

In the upstream portion of the Study area, major social concerns 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 would affect the Indian people in many ways. It might require extensive relocation of the Fort McDowell residence, 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 Indians. The Study must include extensive coordination with the Fort McDowell and Salt River Indians and must respect their views and values.

Due to the unique recreational use of the Salt River that has developed over the years, destruction of this "tubing" resource would represent a significant social change in the lives of some of the residents of the area. Creation of different forms of recreation would likewise effect social life.

Downstream, in metropolitan Phoenix, the Study faces 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. The social concerns of residents of the Study area south of the Salt River will be taken into consideration by the Study.

Further downstream, very 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.

H. Cultural Resources

Rapid urbanization over the past three decades has placed increasing pressure on the archeological and historical resources and in some cases 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 by flood control and regulatory storage alternatives on the Verde, Salt, Gila, and Agua Fria Rivers.

Historical sites along the major streams also could be impacted by flood control and regulatory storage projects. The remains of old Fort McDowell and the cemetery on the Fort McDowell Indian Reservation might be affected by a dam and reservoir at the confluence site. A sheep bridge spanning the Verde River near its confluence with Tangle Creek which is included on the National Register of Historic Places might be endangered. The modification of Roosevelt Dam on the Salt River also would involve a structure on the National Register of Historic Places.

The Study will take into consideration the value of such cultural artifacts as the prehistoric and historic sites in the Study area, and if possible, will develop plans for their preservation.

I. Water Rights

1. Indian Water Rights

As increasing amounts of western land 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 Winters versus United States; the origin of the term "Winters Doctrine." Through the years, judicial decision has expanded Indian water rights to reservations created by treaty, act of Congress, and executive order. The Arizona versus 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 have more water made available to central Arizona Indians. Since the water supply is so limited, there would undoubtedly be impacts on 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 ground-water 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, and the Federal Government and Salt River Project are both currently involved in negotiations. One of the keys to successful water rights negotiations is the availability of a new source of water to negotiate. CAP water, sewage effluent, and flood water that might be controlled by the plan developed through this Study are examples of additional water sources.

There appears to be no direct role for this Study in the settlement of Indian water rights issues. However, the Study will influence to some extent, the amount of water available. The need for coordination during the Study with those agencies involved in negotiations is also recognized.

2. Ground-water 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 versus 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 ground water.

The depletion of the state's ground-water supplies prompted the Arizona Legislature to adopt the Groundwater Code of 1948. This code provided for the establishment of critical ground-water areas in basins not having sufficient ground water to provide an adequate long-term supply for the irrigation of cultivated lands in the basin 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 ground-water areas have been designated by the State Land Department, one of which is the Salt River Valley.

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

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

The Study needs to recognize the limitations imposed by existing ground-water laws and must monitor the progress of the Groundwater Management Study Commission.

J. Safety of Dams

The construction of a dam anywhere and particularly upstream of a major metropolitan area always involves consideration of the safety of the structure. The recent catastrophic failures in our nation have prompted increased emphasis on dam safety. In the wake of recent interest in dam safety, Congress enacted Public Law 92-367 to assign responsibilities for dam safety.

A review of the safety of existing dams in the Study area has resulted in concern regarding three structures: Bartlett Dam on the Verde River and Stewart Mountain and Roosevelt Dams on the Salt River. Officials of the Bureau of Reclamation and the Salt River Project have frequently pointed to the need for immediate attention to this issue and the need for early corrective action. The Bureau of Reclamation is analyzing the safety aspects of these three structures in its Engineering and Research Center; but that analysis is outside the scope of this Study, except as it applies to Roosevelt Dam which is being considered for modification for flood control purposes. The Study must consider and coordinate the design for modifying the dam for safety purposes along with modifications for flood control.

Safety aspects of future dams must be carefully weighed. The real key to dam safety lies in planning and engineering design. Care must be taken not to allow pressures on the engineers conducting the Study to shortcut, circumvent, or limit in any way, their ability to select the best sites and design the safest structures possible. The flood control problem in the Study area is so acute that constant pressure from community leaders and the general public has been and will be exerted on those conducting the Study to select a plan and implement it quickly. Such pressure could lead to early selection of a damsite before it is conclusively proven adequate. During later stages of design, data may reveal that the site has limitations. The pressure on the engineers would be such that they could not change their minds because it would delay construction.

The Study is certainly intended to be responsive to the various needs of the area as described in this section, and it should be done expeditiously. Extreme care must be taken, however, to consider the safety aspects of existing and proposed structures. The Study must insure that the stage is set to do the most professional job possible and that design engineers are shielded from pressures for premature site selection and hasty designs.

Previous Studies and Current Plans

Several local, state, and federal agencies have studied Salt-Gila flood control, regulatory storage, and related issues. This section identifies these studies by agency and highlights any interrelationship with the current Study.

A. 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 - Federal Interagency Group. A framework is presented for development and management of water and related land resources of the Lower Colorado Region, which includes the area covered in this Study. Many problems considered in the current Study (e.g., water supply, flood control, and water quality) are addressed, but on a regional basis. It also contains much useful background information and will serve as a source document.

Central Arizona Project Studies, 1972-1979.

The implementation of the Colorado River Basin Project Act (Public Law 90-537) has resulted in several studies of the CAP as a whole and of its individual features. A partial listing of published studies will give an idea of their relevance to the scope of the current Study. Of particular interest are the Final Environmental Statement on the entire CAP, which puts the regulatory storage issue in context, and the Draft Environmental Statement on Orme Dam. (See *)

* Final Environmental Statement, Central Arizona Project, Department of the Interior, FES, 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, 1972.

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 Groundwater 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.

Other studies related to the CAP are the Tucson Aqueduct study and the Indian Distribution System study, both of which are scheduled to publish draft environmental statements in 1980. The Buttes Dam and Reservoir Draft Environmental Statement is scheduled for completion in 1981.

Dam Safety Program

The analysis of safety aspects of Bartlett, Stewart Mountain, and Roosevelt Dams is being conducted by the Bureau's Engineering and Research Center in Denver, Colorado, under the authority of the Reclamation Safety of Dams Act of 1978. The analysis of Roosevelt Dam is underway and centers on several areas of common interest to this Study; integrity of abutment geologic formations, spillways and outlet capacity, safety of the highway which crosses the top of the dam, and flood hydrology. This dam safety study and the current Study must be closely coordinated and will share certain technical data. The dam safety study has no firm schedule for completion.

Final Report Interagency Task Force on Orme Dam Alternatives, 1978.

In 1977 and 1978, the Bureau worked with the Interagency Task Force on Orme Dam Alternatives which addressed issues similar to the ones in this Study. Due to a lack of information on the

alternatives which were considered, the Task Force was unable to reach a conclusion on a preferred alternative. However, the Final Report is an invaluable collection of data on alternative solutions to the problems of interest, and represents a point of departure for the current Study.

B. Corps of Engineers

Interim Report on Survey For Flood Control, Gila and Salt Rivers, Gillespie Dam to McDowell Dam Site, Arizona, 1957.

The Corps studied the Salt-Gila system flood problems in the 1950's, and published this report which resulted in 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 valuable background and technical information and will be used as a resource document.

General Design Memorandum - Phase I, Plan Formulation For Indian Bend Wash, 1973.

This document describes a unique flood control project which incorporates multiple use of the floodplain along with structural and non-structural flood control measures. Conceptually, it is similar to the Rio Salado plan for the Salt River, and will be useful as background information. Indian Bend Wash enters the Salt River in the Study area, making it imperative that hydrological information presented in this report be taken into account.

Gila River, 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.

Painted Rock Dam Operation Study, Information Brochure, 1977.

Painted Rock Dam is located on the Gila River at the western edge of the Study area. The operation of this facility currently is under study and various operational schemes are described. Problems associated with operation of Painted Rock Dam should be taken into account during this Study.

Phoenix Urban Study

The Corps is in the final stages of this study which addresses flood control, water quality, and water conservation; areas of interest common to the current Study. Although the final report will not be published until late 1979, the following interim and draft reports are pertinent.

Groundwater Recharge, February 1977.

This working paper presents a conceptual plan for artificial ground-water recharge of floodwaters in the Salt River. The principles of operation of this plan will be analyzed more carefully in the current Study.

A Plan of Study for a Demonstration Recharge Project in the Salt River Valley, October 1978.

This working paper, prepared for the Corps by the University of Arizona, describes many facets of artificial ground-water recharge and recommends comprehensive study of the concept through a demonstration project. A report has not yet been approved or released by the Corps, but the concepts presented are of interest to the current Study.

Draft Final Plan, 208 Water Quality Management Program, December 1978.

This plan, prepared by the Corps for the Maricopa Association of Governments (MAG), presents an areawide water quality management plan to meet the requirements of Sec. 208, Public Law 92-500. Water quality problems in much of the Study area are described and will be taken into account in the current Study.

Draft Nonpoint Sources of Groundwater Pollution, Water Quality Management Program, November 1978.

This portion of MAG's 208 plan is a comprehensive description of ground-water quality problems and contains a plan to gain better understanding of the causes of the problems. Data contained in the report will assist in the assessment of ground-water quality impacts associated with plans being considered by the current Study.

Draft Environmental Assessment and Impact Statement on Point-Source Metro Phoenix Alternatives, November 1978.

This environmental document addresses water quality in the heart of the Study area. It not only provides water quality management data, but also contains considerable environmental setting information.

Rio Salado, Phase III, 1978.

This report, prepared for the Corps by the Research and Service Foundation, College of Architecture, Arizona State University; describes various flood control channel configurations in the Salt River. The Rio Salado concept envisions multiple use of the natural channel by open space, greenbelts, recreation, commercial operations, and flood control facilities. Rio Salado will be defined further by the Study.

C. Other Federal Agencies

1. U.S. Geological Survey (USGS)

The USGS conducts several programs of particular interest to the Study. Their annual report on water flows and water quality will be used as a basic data source. The USGS has recently undertaken a thorough study of ground-water aquifers which will develop information pertinent to ground-water recharge and storage. The USGS is also involved in the analysis of hydrological data from the recent floods.

2. U.S. Soil Conservation Service (SCS)

The SCS has conducted numerous studies of flood control projects in the Study area, e.g., the Buckhorn-Mesa and White tanks projects. To the extent that these studies affect local hydrology, they will be considered during the Study.

3. 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 directed at management of recreation along the

Salt River will be of interest to the Study. A Draft Environmental Statement, Lower Salt River Recreation Area (R3-78-02) was published in January 1979, discussing this planning. Comments on this document are to be received by the agency by May 1979.

4. U.S. Fish and Wildlife Service

Fish and Wildlife Coordination Act Advance Planning Report for the Central Arizona Project, June 1976.

This report provides an assessment of environmental concerns related to the CAP that should be carefully considered.

D. State Agencies

1. Arizona Water Commission

Phase I - Arizona State Water Plan, Inventory of Resources and Uses, July 1975, and Phase II - Arizona State Water Plan, Alternative Futures, February 1977, are both valuable to the Study for their presentation of data on water supply and uses. Phase III, an evaluation of potential water resource management plans, is under preparation. The Water Commission has primary responsibility to recommend CAP water allocations to the Secretary of the Interior. The amount of water available for allocation (as it is influenced by availability of regulatory storage) will be of interest to the Arizona Water Commission. The Water Commission also is assigned primary responsibility for flood control matters by the Governor.

2. Groundwater Management Study Commission

This agency is involved in preparation of a ground-water management plan for Arizona, to be incorporated into state law in 1981. The staffs of the Agencies have conferred with the Commission in the past and will continue to do so. The eventual plans may affect feasibility of ground-water storage and artificial recharge.

3. Office of Economic Planning and Development (OEPAD)

OEPAD is conducting studies related to secondary economic benefits of channelization as a part of the Rio Salado plan. Preliminary indications are that the benefits are substantial. Inasmuch as an assessment of the primary benefits (i.e., prevention of flood damages and reduction of business losses) has indicated a lack of economic justification for channelization, the OEPAD conclusions will be of great interest.

4. Office of the Governor

Governor Babbit has appointed a 28-member Community Advisory Board to advise him (and the Agencies) on the best plan for Salt-Gila flood control and CAP regulatory storage. This Board will play a key role in the Study, as is described in the next section of this report.

E. Local Agencies

1. Flood Control District of Maricopa County (FCDMC)

The FCDMC acts as the local sponsor for flood control projects in the county. Its interest and input to this Study is obvious, particularly in relation to local cost-sharing requirements. This agency also is conducting a study of the feasibility of channel clearing on the Gila River in the general vicinity of Buckeye, the results of which will be of interest to the Study; however, there is established schedule for completion.

2. Maricopa Association of Governments (MAG)

This voluntary association of cities in Maricopa County and the County itself has been designated as the responsible agency for water quality planning as required by Public Law 92-500. With assistance from the Corps, MAG has prepared the areawide plan required by Section 208 of that law. MAG has published two reports on the Rio Salado Plan (Phase I in 1972 and Phase II in 1974), and maintains continuing interest in that project. MAG has primary

responsibility for transportation planning and will be concerned with eventual flood control plans as they might affect access across the Salt River. MAG also is involved in air quality planning which will be of secondary interest in the Study.

3. 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 storage. This study is scheduled for completion within the year. SRP 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. Its continuous study of methods to improve operating procedures will benefit the Study. The SRP also is involved in the negotiation and litigation of Indian water rights with six tribes in the Salt-Verde watershed. The availability of CAP and flood waters will be of interest to SRP in this regard.

4. City of Phoenix

The City of Phoenix recently initiated a study of the feasibility of channelizing the Salt River in the vicinity of Sky Harbor Airport. The results of this investigation are scheduled to be available in a few months and will be of interest to the Study as will the City's plan for reconstruction of bridges and crossings damaged by recent flooding on the Salt River.

5. 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. Tempe's plan will be considered during the Study.

Stage I Public Involvement

Stage I public involvement has been conducted to insure that public perceptions, concerns, ideas, and preferences are understood so as to structure the Study appropriately. Fortunately, a great deal of information has been accumulated.

A. Public Response

The responses to the Orme Dam Draft Environmental Statement (1976), provide a great deal of insight to public attitudes. The concerns expressed in these responses include:

Alternative means of controlling floods along the Salt and Gila Rivers

Conservation of local floodflows

Regulation of CAP water supplies

Reduction of ground-water overdraft

Archeological and historical impacts

Social impacts

Economic impacts

Endangered species

Vegetation and wildlife habitat

Ground-water recharge

Impacts on Indian communities

Water and air quality

Dam safety

Recreation

Fish and wildlife enhancement

B. Interagency Task Force on Orme Dam Alternatives

Based on the responses to the Orme Dam Draft Environmental Statement, the Bureau reassessed alternatives to Orme Dam. The Interagency Task Force on Orme Dam Alternatives was formed in April 1977 to identify and evaluate single-purpose alternatives for CAP regulation and flood control. The Task Force consisted of individuals with varying viewpoints and backgrounds. A Technical Work Group was organized, which in turn was divided into Flood Control, Regulatory, and Environmental/Socio-economic Subcommittees. The Task Force suspended work following a September 30, 1977 memorandum from the Lower Colorado Regional Director of the Bureau of Reclamation that no further funds be expended on Orme Dam or any confluence structure. Activities were resumed after clarification was received indicating that Congress had not intended to prohibit the study of alternatives at the confluence site. On May 5, 1978, the Task Force submitted a final report which stated that a consensus recommendation could not be made because of the complexity of the issues involved, a shortage of time and resources, and the divergent opinions of the Task Force members. Opinions expressed in response to the final report are valuable to the current Study, and constitute a primary source of information for identification of alternatives to be evaluated further in this Study.

C. The Community Advisory Board

In 1978, Governor Babbit organized the Community Advisory Board, Salt-Gila Flood Control and CAP Regulatory Storage Study, to review and advise on the identification and selection of a viable alternative for flood control and CAP regulatory storage. Composed of community leaders representing a wide range of constituencies and interests, the Board has met four times to discuss its organization and receive information regarding the Study. The response received from this group to date has been limited; however, its interest in expediting the Study has been continually expressed.

D. Public Meetings

A brochure entitled "You and Central Arizona's Water Future" was published by the Agencies in January 1979 to announce a series of public meetings in the Study area. The brochure summarized the alternatives under study and the issues involved and describe the Study process. A map of the Study area showing the alternative sites was included. Three thousand brochures were distributed widely to the public and placed in depositories for reference. A self-addressed postage paid response card was sent with the brochure to give the public an opportunity to comment if they were unable to attend the public meetings. Names of respondents were added to the Study mailing list to receive future material.

News releases were sent to the media along with 20-second public service announcements for radio and television to inform the public of the series of meetings. All meetings were well covered by the media and KCMR radio recorded the meetings in full for later rebroadcast. The proceedings of each meeting were transcribed and are available on request. A description of the public meetings follows.

Three public meetings on the Study of Alternatives For Salt-Gila Flood Control and Regulation of Central Arizona Project Waters were held at: the Buckeye High School Auditorium, January 30, 1979, 7:00 p.m., with 188 persons filling out attendance cards; the Maricopa County Supervisor's Auditorium, Phoenix, January 31, 1979, 10:00 a.m., with 57 persons filling out attendance cards; and the Centennial Building, Mesa, January 31, 1979, 7:00 p.m., with 52 persons filling out attendance cards. The first meeting was chared by John Hawley, Mayor of Buckeye, William A. Lavell, Field Solicitor for the Department of the Interior in Phoenix, chaired the second meeting, and Wayne C. Pomeroy, Mayor of Mesa, moderated at the third meeting. Representing the Bureau of Reclamation at these meetings were Dick Shunick, Projects Manager for the Arizona Projects Office, his assistant Des Chappelear, Stephen Magnussen, Chief of Advance Planning, and Herb Dishlip, Agency Manager for the Study. Present for the Corps of Engineers were Colonel Gwynn Teague, District Engineer, Los Angeles District; Lieutenant Colonel Verne Doyle, Special Assistant to the District Engineer; Joe Dixon, Agency Manager, and Will Worthington, Urban Studies Chief.

Each of these meetings began with slide presentations describing the issues of Salt-Gila flood control and regulation of CAP waters and briefly summarized the alternatives under study by the Bureau and Corps. The Study process and schedule which the Agencies will follow also were discussed. A public information brochure was distributed.

The meetings were then open to public questions and statements. The representatives of the Bureau and Corps made responses to these questions and comments whenever appropriate.

Fourteen persons made comments at the Buckeye meeting. In general, these involved: concern over the length of time of the Study, lack of adequate bridges over the Salt and Gila Rivers from 91st Avenue to Gillespie Dam, impaired access to Rainbow Valley, need for channel clearing or channelization of the Salt and Gila Rivers from 91st Avenue to Gillespie Dam, environmental impacts of upstream structures, channel

clearing or channelization; concern for the Fort McDowell Indians, operation and safety of Painted Rock Dam, linking downstream flood control with CAP regulatory storage operating efficiency of CAP, criticism of Salt River Project during the recent floods, and support and criticism of Orme Dam.

Specifically, it was suggested that:

1. The Agencies recognize there is no alternative to channel clearing or channelization between 91st Avenue and Gillespie Dam.

2. Gates be installed at Gillespie Dam to lower the height of the structure so that a channel through the Arlington area can be made.

3. The Agencies assist in preparing an environmental assessment for channel clearing.

4. The Salt River Project's operations be reoriented to provide greater flood control.

5. The Agencies' priorities be shifted to provide flood protection for downstream areas in advance of any decision on CAP regulatory storage or upstream flood control measures.

At the Phoenix meeting, twelve persons made comments involving the need for clearing the Gila River channel in the Study area, support for and opposition to Orme Dam or any structure at or near the Salt-Verde confluence, danger to riparian habitat and wildlife posed by some alternatives, concern for Fort McDowell Indians, support of non-structural solutions to flood control and CAP regulatory storage needs, adequate bridges over the Salt River, criticism of the Salt River Project's operation during the floods of 1978-1979, and concern over safety of Stewart Mountain and Roosevelt Dams.

Specifically, it was suggested that:

1. Channelization or channel clearing is needed below the 91st Avenue wastewater treatment plant even if Orme Dam or alternative upstream flood control structure is built.

2. Ground-water recharge be thoroughly investigated as an alternative for CAP regulatory storage.

3. Renewed consideration be given to regulatory storage damsites on the Agua Fria and Gila Rivers.

4. San Carlos Lake be investigated for CAP storage.

5. Floodplain regulation be strictly enforced.

6. The Salt River Project's responsibilities should include specific flood control duties.

7. Improved flood warning systems are needed.

Twenty persons made comments at the Mesa meeting. In general, these comments concerned: the length of time of the Study, cost of the Study, costs of Orme Dam and Reservoir and of channelization of the Salt River, operating criteria for any proposed upstream flood control structure, criticism of the Salt River Project's operation during the 1978 floods, the effects of proposed structural alternatives on riparian habitat and eagle nesting areas, the need for non-structural alternatives for both flood control and regulatory storage, the safety of Stewart Mountain and Roosevelt Dams, concern for the Fort McDowell Indians, the need for channels and bridges along the Salt River, and support for and opposition to Orme Dam and Reservoir, as authorized.

Specifically, it was suggested that:

1. The Salt River Project provide increased flood control through modification of existing regulations or restructuring of the Board of Directors.

2. Water exchanges with the Salt River Project be accomplished to provide CAP storage.

3. Bridges, channels, and floodplain regulation be examined as more economical solutions to flood protection.

4. Ground-water recharge be promoted as an alternative for CAP regulatory storage.

5. Improved flood warning systems be developed.

6. The Agencies recognize that construction of any new upstream structure or modification of existing structures may endanger important archeological sites and critical riparian habitat.

Additional comments and suggestions were received in written form from interested citizens and governmental agencies.

E. Public Review and Comment

Numerous comments and suggestions were received by the Agencies in addition to the statements made at the public meetings. Several letters and telephone calls were received in response to the brochure, "You and Central Arizona's Water Future." A number of comments were included on the mailback postcards. Letters containing suggestions and points of view were received as a result of newspaper articles and television coverage of the flood events. Letters written to the newspaper editors often contained information relevant to this Study. Many specific public comments on the PLAN OF STUDY were provided by members of the Technical Agency Group and the Community Advisory Board. These groups were furnished early drafts of this report so that their ideas and comments could be incorporated into the final report.

The Agencies have chosen to reply to these comments through revisions, corrections, and additions in the text rather than by a separate comment/response section. The direct incorporation of public comments into this document is intended to make the public viewpoint an integral part of the Study.

Stage I Reconnaissance Findings

The primary purpose of Stage I of the Study was to develop a broad array of alternative plans for securing CAP regulatory storage and flood control, subject to detailed technical, engineering, economic, social, and environmental assessments in Stage II.

In the course of Stage I activities, a number of structural and non-structural alternatives were identified, but on a single-purpose basis only. The Interagency Task Force evaluated these alternatives and made recommendations as to whether they were worthy of further consideration. During Stage I, the Agencies reviewed the Task Force findings and applied a screening criteria to determine site viability. Since data on environmental and social factors are limited, it would be inappropriate to make judgments on site viability based on those parameters at the present time. Those factors will be used to determine the screening criteria at the end of Stage II as prescribed by the Principles and Standards. It was felt that sufficient engineering and economic data had been developed on which to base acceptability judgments. Generally, the criteria used was that benefits derived should equal or exceed costs. This criteria was not rigidly applied, however, due to the preliminary nature of the cost data. Thus certain alternatives were retained for further consideration if it appeared that a marginal benefit/cost ratio might improve when more detailed data was developed. On the other hand, several damsites were eliminated from further consideration when it became evident that more detailed studies were likely to result in vastly increased costs without improvement in benefits and thus the benefit/cost ratio would drop to an unacceptable level. In most cases, this determination resulted from the discovery of major geologic deficiencies at the damsite which would require considerable cost investment to overcome.

It is important to recognize that the planning process for this Study will involve several iterations where viability judgments must be made. As more data is developed for the broader range of planning objectives, more factors are brought into the decision-making process. Also, as the Study progresses, the staffs of the Agencies and/or the public involvement program may identify still other alternatives, and they too will be given consideration.

Descriptions of alternatives considered in Stage I and recommendations for further study are provided in the following paragraphs. Cost values represented are based on January 1977 prices. Engineering designs leading to these estimates are generally of reconnaissance grade and include only base structural construction costs. External costs, such

as those for recreation, fish and wildlife enhancement, archeological mitigation, are not included due to lack of data. Also, no attempt was made to estimate the additional costs required to overcome geological problems at several of the damsites. These additional costs for such items as reservoir lining and foundation treatment could represent a significant addition to the base costs shown.

Values used for the estimation of benefits are also representative of 1977 prices. Benefits for regulatory storage alternatives were prepared by the Bureau of Reclamation and were limited to those accruing to CAP. Studies indicate that irrigated agriculture would be the major identifiable beneficiary of CAP regulatory storage. Therefore, benefits were based on the estimated value per acre-foot of irrigation water:

Direct annual benefits/acre-foot	$42.91
Indirect annual benefits/acre-foot	55.24
Total Benefit/acre-foot	$98.15

Direct benefits are those which resulted from application of Project water and reflects the gross value of crops produced less farm operating expenses. Indirect benefits are those accruing outside the farm unit, and resulting from increased flow of products, farm machinery and purchases.

Benefit values for single-purpose flood control alternatives are based upon the prevention of damages. A preliminary survey of the floodplain area was prepared, and damages expected from various flood flow rates were estimated. The damages evaluated include those to residential property, commercial and industrial property, agricultural lands, and public buildings. The potential damages from various flood discharges are then analyzed to determine an average annual benefit. It should be noted that economic benefits for flood damage reduction were based on estimates made prior to the 1978-1979 floods. Damages measured following the March 1978 event were approximately three times the estimated damages. It follows, therefore, that all flood damage estimates will increase when data from the recent floods are incorporated into the economic analysis.

Public comment on the draft of this report expressed concern that more current cost and benefit values were not used and also that the ratio of benefits to costs is not in conformance with the four-account procedure described in the Principles and Standards. The Agencies recognize that both these statements are true. Current price values were not used due to the difficulty in upgrading benefit values. While Construction Cost

Trends provide indices which can be applied to construction costs, no such indices are available for benefit values. Since benefit values will be upgraded during Stage II investigations, it was decided that it was not worth the time and effort to attempt to estimate those values for Stage I. Costs were not indexed because the Agencies felt a more meaningful benefit/cost analysis would result if both were kept to the same time frame.

A. Structural Alternatives - Dams

A number of damsites were identified and investigated for both CAP regulatory storage and flood control storage. The following discussion of the alternative sites reflects that studies for Stage I have focused on single-purpose functions. At several of the sites, it may be possible to have multipurpose functions served, which would enhance their economic viability.

Public comments identified that utilizing dams for ground-water recharge may be of benefit. This report has not attempted to evaluate the implications of dams built specifically for ground-water recharge. Seepage losses from a reservoir are, at least in part, returned to the underlying ground water and it is true that these losses are not lost from the region's total supply. However, such losses do affect supplies available for delivery and sale from CAP. The logic that CAP is intended to reduce ground-water overdraft, and that some dams should promote seepage, overlooks the economic aspects of the problem. CAP is to be financed, to a significant extent, by water sales revenues. These revenues, as a minimum, must pay for the costs of pumping the water from the Colorado River and other operation, maintenance, and replacement costs. Promoting non-revenue-producing losses of water would be inconsistent with the intent of the Project, the purposes for which Congress authorized its construction, and the President's current water policy which emphasizes water conservation efforts. Therefore, dams which would allow excessive loss of water availability due to uncontrolled seepage generally could not produce enough water supply benefits to exceed construction costs. Additional costs required to reduce or eliminate seepage would be significant and measures to overcome site deficiencies could be extensive.

Excessive seepage was not considered as a critical factor for analysis of flood control dams because it is usually assumed that those structures will be kept vacant or quickly evacuated and their benefits are derived from flood damage prevention, not sale of water. Of course if site conditions are such that water would merely leak around or under the structure so that no flood water retention could take place, then seepage control would become much more vital.

Confluence and Granite Reef Sites. Orme Dam and Reservoir, as authorized, would be constructed at the confluence of the Salt and Verde Rivers about 20 miles northeast of Phoenix. This earthen dam would be about 195 feet high and 5,700 feet long. Storage capacity at the spillway crest would be 1,360,000 acre-feet. The site does not present any serious geologic difficulties; however, it is expected to produce serious environmental impacts on bald eagle and riparian habitat, and flowing stream recreation. Archeological and historical sites also would be impacted. Additionally, a significant portion of the Fort McDowell Indian Reservation and some of the Salt River Indian Reservation would be inundated if the dam were constructed.

Orme Dam and Reservoir has, in addition to its regulatory storage and flood control functions, the potential for development of hydroelectric power generation and recreation, and the enhancement of habitat for some species of fish and wildlife. Orme Dam would reduce a Standard Project Flood inflow of 290,000 ft^3/s to a release of 50,000 ft^3/s. The multipurpose Orme Dam would cost $243,000,000. The benefit/cost ratio for Orme Dam and Reservoir, as authorized, is 1.8:1.0.

Two smaller structures at the Salt-Verde confluence have been studied. Some adverse impacts were reduced with the smaller structures, but at a considerable loss in flood control capacity. Specific advantages of smaller structures include the reduction of riparian habitat inundation, the elimination of water backed up against Stewart Mountain Dam, a more stable water surface elevation for recreational use, and reduced impact on the Fort McDowell Indian Reservation.

Structures of various sizes at the Granite Reef site located a short distance downstream have been investigated. The estimated cost of a dam at the Granite Reef site to provide a regulatory storage reservoir with a capacity of 767,000 acre-feet is $243,000,000. This structure would have a benefit/cost ratio of 1.6.

The continued study of retention structures with a full range of sizes at both the confluence and Granite Reef sites appears warranted.

Coon Bluff. The Coon Bluff alternative is located on the Salt River immediately upstream from its confluence with the Verde River and downstream from Stewart Mountain Dam. It would be an earthen dam, 128 feet in height, 5,000 feet long with a total capacity of 258,000 acre-feet. The Coon Bluff site impacts about half of the archeological and historical sites affected by a dam at the confluence. Adverse environmental impacts, including effects on eagle habitat, riparian habitat, and flowing stream recreation would result from a dam at Coon Bluff.

Serious geologic problems are present at this site.

Abutments and foundation drilling were begun in September 1976, which indicate the foundation is comprised of weakly to noncemented sandy and silty gravel grading to gravelly silt and sand toward the right abutment. This formation extends to depths of at least 356 feet. Material of these types are considered permeable. The increased hydraulic pressures caused by a reservoir, coupled with the easily erodable foundation material, are causes for serious concern. Blanketing of the foundation area to reduce seepage volume and velocity is probably not practical because of local topography. It is considered possible to design a leaky dam at this site, degrading its value as a storage reservoir, but the risk of failure from piping is significant.

The Coon Bluff alternative could be developed for hydroelectric power generation, recreation, and enhancement of some species of fish and wildlife. Little additional downstream flood control would be provided. The total cost of Coon Bluff Dam would be approximately $272,580,000, with a benefit/cost ratio of 0.96:1.0.

This alternative does not warrant further study because of the significant geologic problems associated with the site.

Tangle Creek. This alternative is located on the Verde River near its confluence with Tangle Creek, 7 miles upstream from the present Horseshoe Reservoir. The dam considered for this site would impound a reservoir with a flood control capacity of 393,000 acre-feet. Although further geologic studies are required, preliminary investigations indicate the availability of several suitable sites along the Verde River. A dam and reservoir at Tangle Creek would impact eagle and riparian habitats. It could also affect a sheep bridge which is on the National Register of Historic Places.

As a single-purpose flood control structure, Tangle Creek would provide limited control over Verde River floodflows. Greater flood control could be obtained in combinations with other schemes. The benefit/cost ratio of Tangle Creek for flood control is estimated at 1.4.

This alternative warrants further study.

Cliff Site. This alternative is located on the Verde River, immediately upstream from Bartlett Reservoir. It would serve much the same function as Tangle Creek. Further geologic study is needed to determine feasibility.

The Cliff alternative would impact riparian and eagle habitats. Significant archeological, social, or historical impacts are not yet assessed. The costs and benefits of a dam and reservoir at Cliff have not been estimated.

This alternative warrants further study.

Modified Horseshoe Dam. This alternative involves the modification of the existing Horseshoe Dam for flood control and water conservation. Water exchanges between the CAP and the Salt River Project might also allow this structure to be used in a CAP regulatory role. Geologic investigations of the site have not been completed. A modified Horseshoe Dam would impact eagle habitat and archeological sites.

In addition to its flood control or regulatory storage functions, a modified Horseshoe alternative could possibly be developed for hydroelectric generation. The benefit/cost ratio for flood control would be 0.9 while that for regulatory storage by means of exchange with Salt River Project would be 5.6.

Further study of this alternative for flood control and/or regulatory storage is warranted.

Modified Roosevelt Dam. This alternative calls for the enlargement of Roosevelt Dam for flood control or regulatory storage of CAP waters. The site has no identified geologic problems. Some archeological sites would be impacted, and Roosevelt Dam itself is on the National Register of Historic Places.

Besides flood control or regulatory storage functions, enlargement of Roosevelt Dam could result in increased hydroelectric generation. Benefit/cost ratios are 1.5 for flood control and 10 for regulatory storage by means of exchange with Salt River Project.

This alternative warrants further study.

Carrizo Creek. The Carrizo Creek alternative calls for the construction of a new dam on the Salt River below the confluence of the Black and White Rivers and near Alkali Canyon. The purposes of this dam and reservoir would be to improve the quality of Salt River water and allow for the diversion of water to the Gila River to augment the natural inflow to San Carlos Reservoir. This proposal, however, fails to meet the needs of CAP regulatory storage and would offer very limited flood control for the Phoenix area.

Because of these factors, the Carrizo Creek site is not an acceptable alternative and no further study is warranted.

Klondike Buttes. This alternative is located on the Salt River above Roosevelt Lake. A dam and reservoir at Klondike Buttes would impact riparian vegetation and would encroach upon a proposed Wild and Scenic Rivers area. Geology of the site requires additional investigation. Klondike Buttes is not a suitable site for CAP regulatory storage. It would not control Tonto Creek, a major tributary to Roosevelt Lake, leaving a large uncontrolled area downstream.

Klondike Buttes is an unacceptable alternative for flood control or CAP storage and no further study is warranted.

New Waddell Dam. New Waddell Dam would be located on the Agua Fria River immediately downstream from the existing Waddell Dam. The present structure impounding Lake Pleasant is not suitable for enlargement for CAP regulatory storage. An earthen dam at the New Waddell site could impound a reservoir with a total capacity of 310,000 acre-feet. Currently, geologic investigations are being conducted to determine the most feasible dam axis and spillway locations. Some archeological and environmental impacts could result from a New Waddell Dam. It also would require the relocation of some Maricopa County park facilities and the breach of the existing structure.

New Waddell Dam would be a single-purpose CAP storage facility. It would not provide significant flood control on the Salt or Gila Rivers, although some flood control on the Agua Fria River could be provided. It would have possibilities for recreational development. The structure would have a total cost of $118,892,000 and an annual cost of $4,550,000. Estimated benefits are $8,680,000 annually, giving the plan a benefit/cost ratio for regulatory storage of 1.9.

This alternative warrants further study.

Agua Fria Siphon Site. A dam and reservoir at this site on the Agua Fria River at the Granite Reef Aqueduct would have a total storage capacity of 313,000 acre-feet and a conservation capacity of 217,000 acre-feet. The structure would be constructed of earth, with a height of 200 feet and a length of 11,000 feet. Environmental impacts are minimal, but several archeological sites would be affected.

The dam axis area was core drilled in 1977. The right abutment would be volcanic rock overlain by alluvium. The foundation, left abutment, and reservoir areas are all sited on alluvial materials. Depth of alluvium exceeds 400 feet. Extensive foundation treatment would be necessary to reduce underflow to safe and acceptable limits. Severe seepage losses from the reservoir area to the New River drainage are likely since no bedrock separation between the two channels (Agua Fria and New River) has been found. Cost estimates for this site include remedial measures to treat the foundation, but no reservoir lining costs are included. Local lining materials in the qualities required are unavailable and cost of lining the reservoir would be prohibitive. Without these special measures, seepage could be as much as 96,000 acre-feet annually.

A dam at the Agua Fria Siphon Site would be a single-purpose alternative, and would not provide flood control for the Study area. Total cost has been estimated at $366,728,000, with an annual cost of $12,920,000. Estimated benefits are $4,900,000 annually, giving the site a benefit/cost ratio for regulatory storage of 0.4.

No further study of this alternative is warranted because of associated geologic problems.

Calderwood Butte. This alternative for CAP regulatory storage is located on the Agua Fria River downstream from the Granite Reef Aqueduct. It would be an earthen dam with a height of 165 feet and a length of 5,750 feet. It would impound a reservoir with a total capacity of 115,000 acre-feet and a regulatory capacity of 73,000 acre-feet. No serious environmental impacts have been identified, although the dam would impact several archeological sites.

Similar to the Agua Fria Siphon site, the geologic setting is largely unconfined alluvium. The depth to bedrock in the vicinity of the dam axis is not known but could be too deep to allow suitable foundation design. However, even if foundation conditions were acceptable, the reservoir area would require lining to inhibit large seepage losses to the adjacent drainage basins. Prohibitive costs to line the reservoir are involved.

A dam and reservoir at Calderwood Butte would have few uses other than regulatory storage and recreation. No significant flood control for the Study area would be provided. Total cost has been estimated at $462,908,000, with annual costs and benefits of $16,475,000 and $880,000, respectively, giving a benefit/cost ratio of 0.1.

No further study is warranted.

North Phoenix Flood Control Dams (for CAP regulation). This alternative would use three authorized Corps of Engineers flood control dams north of Phoenix: Cave Buttes Dam on Cave Creek, Adobe Dam on Skunk Creek, and New River Dam on the New River, for CAP regulatory storage. All three sites would have to be redesigned for CAP use. Redesign of Adobe Dam for regulatory storage purposes is not geologically feasible. If converted to regulatory storage purposes, these dams would lose their flood control effectiveness. This alternative would not provide for flood control of the Salt River through the Phoenix area. Conversion of the dams could impact archeological sites and would have few uses other than regulatory storage.

Total cost for the conversion of the North Phoenix Flood Control Dams (with the exception of Adobe Dam) would be $228,302,000, with annual costs of $8,000,000. Benefits from regulatory storage are estimated at $2,560,000 annually, resulting in a benefit/cost ratio of 0.3.

This alternative does not warrant further consideration.

Rio Salado Low Dams (for CAP regulation). The Rio Salado Low Dams alternative relies on three structures on the Salt River between Mesa and Phoenix to provide CAP regulatory storage. The dams would be located near the intersection of Horne and Thomas in Mesa, Mill Avenue in Tempe, and 48th Street in Phoenix. They would be constructed of earth at least 30 feet high. The sites have serious geologic problems and would require reservoir lining to reduce seepage if water were to be detained on the surface. No archeological, environmental, or historical impacts have been identified.

The Rio Salado Low Dams would not provide flood control and would themselves require upstream protection from flooding and silting. Total cost of the dams would be $173,040,000, with annual costs of $5,890,000. Estimated yearly benefits for regulatory storage are $3,530,000, resulting in a benefit/cost ratio of 0.6.

The Rio Salado Low Dams do not appear to warrant further consideration for flood control or surface regulatory storage. Low dams in the Salt River will be further explored as a means of inducing artificial groundwater recharge through the spreading basin technique.

Florence Dam. The Florence Dam site is located on the Gila River about 4 miles below the Ashurst-Hayden Diversion Dam and 6 miles east of the town of Florence. The reservoir impounded by the dam would have a

total capacity of 110,000 acre-feet and a regulatory capacity of 106,000 acre-feet. It would inundate the present Ashurst-Hayden structure and back water up to the proposed Buttes Dam. Should Buttes Dam not be built, a complete redesign of the Florence structure would be required to deal with flooding and sedimentation. Environmental impacts include adverse effects on riparian vegetation and habitat. Four identified prehistoric sites also would be affected.

Site geology studies were conducted during 1966 and the summer of 1977. The foundation would be on volcanic rocks overlying alluvium. Positive cut off through up to 60 feet of overlying channel deposits would be required. The volcanic rock foundation is estimated to be about 250 feet thick near the center of the dam, thinning toward the abutments. Grouting would be used to seal fractures in the volcanic rocks. The reservoir area is largely alluvium underlain in part by volcanic rocks. There is a strong possibility of seepage losses from the storage pool through and around the right abutment. These losses could amount to as much as 30,000 acre-feet annually.

As presently envisioned, a dam and reservoir at the Florence site would provide no downstream flood control on the Gila River. Other potential uses are quite limited. Total cost of the Florence Dam would be $95,061,000. Annual costs and benefits amount to $3,510,000 and $3,030,000 respectively. The benefit/cost ratio for regulatory storage of the Florence structure is 0.9.

This alternative does not warrant further study due to geologic problems.

Painted Rock Dam and Reservoir. Some of the water conservation benefits which might accrue to existing or proposed reservoirs upstream might also be realized if the water that is detained in Painted Rock Reservoir were put to more beneficial use. The definition and feasibility of such use warrants further investigation.

B. Structural Alternatives - Levees

A continuous system of flood control levees was analyzed. For ease of analysis, the Study area was divided into reaches.

Reach 1 (Granite Reef Diversion Dam to Country Club Drive in Mesa - 11.6 miles). This portion of the levee system would have a capacity of 216,000 ft^3/s, although it could be redesigned to handle

290,000 ft^3/s. Total cost is estimated at $55,700,000 with annual costs of $4,117,000. Yearly flood control benefits are expected to be $140,000, giving it a benefit/cost ratio of 0.03.

Reach 2 (Country Club Drive to Pima Road - 3.6 miles). The second reach of levees would have a capacity of 290,000 ft^3/s. Total cost of this portion of the system would be $17,500,000. Annual costs and benefits are estimated at $1,293,000 and $168,000, respectively. The benefit/cost ratio for flood control is estimated at 0.1.

Reach 3 (Pima Road to 48th Street in Phoenix - 4.0 miles). This reach would have a capacity of 290,000 ft^3/s. Total cost is estimated at $23,800,000, with an annual cost of $1,758,000. Yearly flood control benefits would amount to $734,000. The benefit/cost ratio would be 0.4.

Reach 4 (48th Street to Interstate 10 Freeway - 2.7 miles). This reach would have a capacity of 290,000 ft^3/s. It would be constructed at a total cost of $13,100,000. The annual cost would be $968,000. Yearly flood control benefits come to $554,000, giving a benefit/cost ratio of 0.6.

Reach 5 (Interstate 10 Freeway to 35th Avenue - 6.9 miles). This portion of levees would have a capacity of 290,000 ft^3/s. The total cost is estimated at $35,500,000, with yearly costs amounting to $2,475,000. Annual benefits would come to $1,689,000. The total flood control benefit/cost ratio would be 0.7.

Reach 6 (35th Avenue to the Gila River Confluence - 10.7 miles). This reach of the levee system would have a capacity of 290,000 ft^3/s. Its total cost would be $52,000,000, with annual costs of $3,842,000. Yearly flood control benefits would amount to $295,000, giving the feature a benefit/cost ratio of 0.1.

Reach 7 (Salt-Gila Confluence to Gillespie Dam - 35 miles). This reach of the levee system would consist of a single levee along the north side of the river only, with a capacity of 290,000 ft^3/s. Its total cost would be $12,603,000, with annual costs of $1,560,000. Yearly flood control benefits would be approximately $1,140,000, giving the feature a benefit/cost ratio of 0.7. Because of strong local interest in this area, these costs include the assumption that 80 percent of all required flowage easements would be contributed at no cost to the United States or the local sponsor.

Levees along the Salt-Gila Rivers appear to be economically unjustified as a total solution to the flood problem and will not receive further consideration except in Reach 3, Reach 4, Reach 5, Reach 7, and in certain localized damage areas such as Holly Acres and Buckeye/Allenville. Even though the benefit/cost ratio is below 1.0:1.0 in Reaches 3, 4, 5, and 7, it should be noted that damage in the 1978-1979 floods was about three times greater than the estimates used in the preliminary analysis. In addition, releases from upstream reservoirs may require some easement on rights to lands flooded by such releases. Levees should be considered in combination with reservoirs to reduce such requirements. Levees in these reaches warrant further consideration.

C. Structural Alternatives - Channels

Several channel configurations were analyzed for flood control purposes. The most feasible section generally was a trapezoidal shape with rivetted side-slopes and natural bottom. The river was divided into various reaches for analysis, as was done for levee analysis.

It should be noted that different design criteria are used for determining channel capacity than were used for levees. Levees are normally designed to pass the Standard Project Flood safely, whereas channels may be designed to a much smaller capacity. The rationale for this practice is explained in the analysis of the consequences of overtopping. In the case of a levee system, overtopping would probably result in failure with catastrophic results. In the case of a channel, overtopping would not impair the operation of the channel, and it would be expected to reduce flood damages even though the actual flow exceeded its capacity. The channel capacities noted below are preliminary and are intended to approximate the optimum size from a benefit/cost viewpoint. In those reaches where further study is warranted, a full range of capacities up to the Standard Project Flood flow will be investigated.

Reach 1 (Granite Reef Diversion Dam to Country Club Drive in Mesa - 11.6 miles). The first reach of channels would have a capacity of 30,000 ft^3/s. Total cost would be $27,380,000. Annual costs and benefits are $2,023,000 and $116,000, respectively. The benefit/cost ratio for flood control is estimated at 0.06.

Reach 2 (Country Club Drive to Pima Road - 3.6 miles). This portion of channels would have a capacity of 30,000 ft^3/s. The total cost would be $8,497,000, with annual costs of $628,000. Annual flood control benefits would be $81,000, giving this reach a benefit/cost ratio of 0.13.

Reach 3 (Pima Road to 48th Street in Phoenix - 4.9 miles). This section would have a capacity of 30,000 ft^3/s. Its total cost is estimated at $11,567,000. Annual costs and benefits would be $855,000 and $366,000, respectively. The benefit/cost ratio for flood control is 0.43.

Reach 4 (48th Street to Interstate 10 Freeway - 2.7 miles). The fourth reach of channels would have a capacity of 40,000 ft^3/s. The total cost is estimated at $6,888,000. Annual costs are $509,000, and annual benefits from flood control amount to $297,000. The benefit/cost ratio is 0.58.

Reach 5 (Interstate 10 Freeway to 35th Avenue - 6.9 miles). The capacity of this reach of channels would be 50,000 ft^3/s. The total cost is estimated at $19,215,000. Annual costs and benefits would come to $1,420,000 and $1,150,000, respectively. The benefit/cost ratio for flood control is 0.81.

Reach 6 (35th Avenue to the Gila Confluence - 10.7 miles). This reach of channels has a capacity of 30,000 ft^3/s. Total cost would be $25,260,000. Annual costs are projected to be $1,866,000, and annual flood control benefits would be $138,000. The benefit/cost ratio is 0.07.

Reach 7 (Salt-Gila Confluence to Gillespie Dam - 35 miles). The capacity of the channel would be 50,000 ft^3/s. The total cost is estimated at $76,000,000. Annual costs and benefits are estimated at $5,000,000 and $680,000. The benefit/cost ratio would be 0.1. The existing Gillespie Dam would limit the effectiveness and feasibility of channels in this reach. Although many comments were received endorsing a channel in Reach 7, it was subsequently determined that there is no reasonable expectation for the benefit/cost ratio to increase sufficiently to develop a justified project, and that a single levee would provide adequate protection if its feasibility can be demonstrated. Therefore, the channel in Reach 7 was eliminated during Stage I in favor of a single levee and channel clearing.

A continuous system of channels on the Salt-Gila Rivers through all seven reaches for flood control purposes appears not to be justified. Continued study of channels of various configurations in Reaches 3, 4, and 5 does appear to be warranted, again due to experience during 1978-1979 floods when actual damages greatly exceeded previous projections. Also, the possible requirement for flowage easements and the extent to which channels may reduce these easements should be analyzed.

D. Structural Alternatives - Channel Clearing

The authorized flood control project (1957 Survey For Flood Control, Gila and Salt Rivers, Gillespie Dam to McDowell Dam Site, Arizona) includes clearing of phreatophytes from the riverbed to create a 2,000-foot floodway from Gillespie Dam to Granite Reef Dam. This portion of the authorized project has not been implemented because of adverse environmental effects that would be unavoidable. Although the project was justified economically at the time, with a benefit/cost ratio of 1.98, the methods for computing costs and benefits have changed significantly since 1957, and most of the phreatophytes above 23rd Avenue have disappeared. However, reevaluation of the channel clearing project appears warranted.

E. Non-Structural Alternatives

Water Exchanges. The concept of water exchanges envisions storing imported CAP water in existing reservoirs for regulatory purposes. The Salt River Project and Maricopa County Water Conservation District No. 1 have been determined to be the only water supply agencies in central Arizona with the capacity of effecting a water exchange program for regulatory storage with the CAP. Exchanges with the San Carlos Project were not considered in this context because they are already assumed in the operation of the proposed Buttes Dam and Reservoir and will be addressed in planning studies. Proposed exchanges could be related to an enlargement of Roosevelt, Horseshoe, and/or Waddell Dams, or carried out using existing facilities. No geologic problems have been associated with this alternative; however, an evaluation of the existing Waddell Dam will be required to determine if the structure meets Federal standards. Increases in reservoir sizes related to water exchanges could impact eagle nesting areas, riparian habitat, and archeological sites and could cause an alteration in downstream seasonal flows. Flood control problems might also be increased.

The cost of implementing a water exchange program can vary from minor contract expenses up to $40,000,000, depending on extent of the programs and modifications to existing facilities. Regulatory storage benefit/cost ratios, therefore, range from negligible to 10. This alternative warrants further study.

Salt River Flexible Operational Criteria (SRFOC). This is a concept of operating the existing reservoir system on the Salt River so as to optimize water conservation and flood damage reduction. The concept involves flexible operating criteria and may include any or all of the following:

- Sophisticated runoff forecasting capability.

- Improved monitoring of watershed conditions.

- Designation of flood control space which varies according to season and watershed conditions.

- Modification of the water outlets of the existing system.

Use of the SRFOC would decrease downstream releases of water from the system, lessen flood damages and increase utilization of the Salt River floodplain. Impacts on flood control, water conservation, hydropower generation, recreation, and fish and wildlife habitat must be evaluated. This alternative warrants further study.

Floodplain Management Measures. These non-structural alternatives to flood control and mitigation of flood damages involve:

1. Floodproofing - alteration of existing and future development by such means as floodwalls, small levees, temporary closures on openings, raising structures, and removal of structures and/or their contents.

2. Floodplain acquisition - the purchase and removal of existing structures from the floodplain.

3. Floodplain regulation - use of regulations to lessen flood damage.

4. Flood warning - giving advance warning of impending flooding to effect the removal of people and damageable property.

5. Bridge construction - construction of bridges of sufficient capacity to pass flood flows would reduce traffic delay costs experienced during floods.

These measures do not pertain to the regulatory storage question and will not completely solve flood problems, but might be justified in combination with other alternatives. For this reason, further study is warranted.

F. Artificial Ground-water Recharge

This concept incorporates structural measures and operating criteria to increase the amount of surface water that reaches ground-water reservoirs. Preliminary consideration of the spreading basin

method of artificial ground-water recharge during the Corps Phoenix Urban Study and Stage 1 of this Study indicates that further study is warranted. Employment of this technique would allow flood waters or CAP waters to be introduced into ground-water reservoirs.

Physical characteristics of the Study area would limit the recharge rate. The art of ground-water recharge is not highly developed and would require additional study. Aritificial ground-water recharge is not in and of itself a solution to either the flood control problem or the regulatory storage problem. However, it may be incorporated with other measures to arrive at the best solution. This alternative merits further consideration.

G. No Action Alternative.

A "No Action Alternative" will be developed to assess future conditions in the Study area if no action is taken to provide either flood control or regulatory storage. The importance of an accurate assessment of these conditions, based on carefully weighed assumptions, cannot be overemphasized. It is against this scenario, not against present conditions, that all alternatives will be compared and evaluated.

The No Action Alternative will assume operation of the CAP without benefit of regulatory storage. The system then would include only the CAP Aqueduct and Buttes Dam and Reservoir. Since the No Action Alternative assumes no additional federal flood protection for metropolitan Phoenix, the area would be subject to flood damages, loss of life, and disruption of vital services. Future development of the Salt River floodplain also would be limited under the No Action Alternative in accordance with Federal Insurance Adminstration regulations.

In Stage II and III of the Study, a number of plans will be formulated by combining the above list of identified alternative components. In order to achieve Study objectives, these component systems shall be measured against the No Action Alternative; analyzed for economic, social, safety, and environmental impacts; and tested for ability to interface with, facilitate or enhance fish and wildlife resources, recreation opportunities, ground-water recharge, hydroelectric generation, the proposed Rio Salado Project, and water conservation. The following section, PLAN OF STUDY, describes this process.

III. PLAN OF STUDY

III. PLAN OF STUDY

The Stage I Study Results section just concluded described observations made and work accomplished prior to publication of this report. From this point forward, a Plan of Study will be presented which is designed to resolve the stated problems and needs, taking into account previous studies, current plans, desires expressed by the public, and preliminary assessments of the most feasible alternatives.

Planning Objectives

The Bureau of Reclamation and the Corps of Engineers (the Agencies) are guided by Principles and Standards for Planning Water and Related Land Resources, prepared in 1973 by the Water Resources Council under authority of the 1965 Water Resources Planning Act. These guidelines require that federal and federally-assisted water and related land planning have "National Economic Development" and "Environmental Quality" as equal national objectives.

To meet this requirement, therefore, plan formulation will be directed toward meeting current and projected needs and solving problems identified by the public in such a manner that progress can be made toward achieving society's preferences for national economic development and environmental quality. Also, a system of public information accounts will be established that displays beneficial and adverse effects on regional development and social well-being and provides a basis for comparing alternative plans.

The Principles and Standards as applied to this Study require that all monetary, environmental and other costs and benefits of the alternatives will be considered. Planning objectives specific to the Study will be consistent with national objectives so that each alternative can be measured against the same standards.

Initially, twelve planning objectives have been adopted subject to review and modification through the public involvement process. It should be noted that the authority for this Study is derived from Public Law 90-537, which authorizes construction of Orme Dam and Reservoir or a suitable alternative. Therefore, plans developed during this Study must meet the dual purposes of CAP regulation and flood control.

Study Objectives:

A. Increase efficiency of the Central Arizona Project by providing regulatory storage capacity in central Arizona.

B. Decrease flood damages along the Salt and Gila Rivers between Granite Reef Dam and Painted Rock Dam, and the agua Fria River below Waddell Dam.

C. Increase conservation of waters emanating from the Salt-Verde watershed.

D. Minimize power consumption.

E. Take advantage of opportunities for hydroelectric power production.

F. Take advantage of opportunities on the Salt, Verde, and Gila Rivers to enhance the quality of the environment.

G. Take advantage of opportunities to enhance the social well-being of the Fort McDowell Indian Community.

H. Enhance recreational opportunities.

I. Improve water resource management and encourage conservation measures.

J. Take advantage of opportunities to improve the management and protection of open space, and to increase its extent.

K. Improve management and preservation of unique archeological and historical resources.

L. Conserve and enhance fish and wildlife resources.

The Planning Process

In order to conduct the Study efficiently, a three-stage process has been established by the Agencies.

STAGE I PLAN OF STUDY is the phase we are in now. STAGE I efforts include identification of problems and needs in the Study area, establishment of broad planning objectives, delineation of public concerns, and formulation of a management program for conduct of the Study. A wide array of plans is developed. Following a preliminary assessment, decisions are made and unsuitable alternatives are eliminated from further study. The PLAN OF STUDY, published at the conclusion of STAGE I, contains alternatives warranting more detailed evaluation and describes the Plan of Study to be followed, including the estimated Study cost and schedule.

STAGE II DEVELOPMENT OF INTERMEDIATE PLANS includes detailed assessments of geology, hydrology, hydraulics, costs, structural designs, and institutional analyses. More detailed environmental assessments, social and economic studies are also conducted. Non-viable plans are eliminated in STAGE II and a limited number of plans are recommended for further detailed study in STAGE III. STAGE II concludes with a thorough review of findings by the Agency staffs and the general public.

STAGE III DEVELOPMENT OF DETAILED PLANS includes modification of plans and designs based on economic, engineering, environmental, and social concerns disclosed during STAGE II review. Emphasis is placed on a more thorough evaluation of proposed plans and upon implementation arrangements. Near the end of STAGE III, draft planning reports and environmental statements are published and circulated for review and comment. Finally, the Regional Director of the Bureau of Reclamation and the District Engineer of the Corps of Engineers recommend a plan for adoption. Final planning reports and environmental statements are then submitted to the President and Congress.

Laws and Regulations

Numerous public laws (P.L.) and federal regulations guide the Bureau of Reclamation and the Corps of Engineers in project planning. Requirements contained in the documents chronologically listed below will be met when applicable to plans under consideration.

The Reclamation Act of 1902

P.L. 59-209, Antiquities Act of 1906

P.L. 240, Leavitt Act, July 1932

P.L. 74-292, Historic Sites Act of 1935

P.L. 74-738, Flood Control Act of 1936

P.L. 75-761, Flood Control Act of 1938

P.L. 260, Reclamation Project Act of 1939

P.L. 78-534, Flood Control Act of 1944

P.L. 85-624, Fish and Wildlife Coordination, August 1958

P.L. 86-523, Reservoir Salvage Act of 1960

P.L. 89-72, Federal Water Project Recreation Act, 1965

P.L. 89-655 National Historic Preservation Act, 1966

P.L. 90-537, Colorado River Basin Project Act, September 1968

P.L. 91-190, National Environmental Policy Act, January 1970

P.L. 91-611, River and Harbor and Flood Control Act of 1970

Executive Order 11593, Protection and Enhancement of the Cultural Environment, 1971

P.L. 92-500, Federal Water Pollution Control Act Amendments of 1972

P.L. 93-205, Endangered Species Act of 1973 as amended

Council on Environmental Quality Guidelines for Statements on Proposed Federal Actions Affecting the Environment (38 Federal Register 20550), August 1973

Water Resources Council Principles and Standards for Planning Water and Related Land Resources (38 Federal Register 24778), September 1973

P.L. 93-291, Archeological and Historic Conservation Act of 1974

P.L. 93-251, Water Resources Development Act of 1974

P.L. 93-502, Freedom of Information Act of 1974

Executive Order 11514, Protection and Enhancement of Environmental Quality, March 1976

Executive Order 11988, Flood Plain Management, May 1977

P.L. 95-95, Clean Air Act Amendments of 1977

P.L. 95-45, Clean Water Act Amendments of 1977

President Carter's National Water Policy Statement, June 6, 1978

Council on Environmental Quality, National Environmental Policy Act, Implementation of Procedural Provisions; Final Regulations, (43 Federal Register 55978), November 29, 1978

P.L. 95-632, Endangered Species Act, Amendments of, 1978

Study Management

The Study will be accomplished by personnel of the Bureau of Reclamation's Arizona Projects Office and the Corps of Engineers Los Angeles District Office with assistance from contractors, a Technical Agency Group (see Public Involvement section for membership listing), and other Agency staffs such as the Bureau's Engineering and Research Center and the Corps Hydrologic Engineering Center. Information developed by the Study will be presented to the Bureau's Regional Director and the Corps District Engineer for review. The Community Advisory Board will also comment. In the final analysis, however, the Regional Director of the Bureau of Reclamation is accountable to the Executive Branch and Congress for funds made available to the Study. Figure 3 shows these relationships schematically.

The Study involves several levels of management, both internal and external to the two Agencies involved. The Bureau of Reclamation maintains primary responsibility for policy, technical studies, and designs for water conservation components or structures. The Corps of Engineers responsibilities encompass these same factors in relation to flood control measures. Coordination between the Agencies will occur at the local level to assure continuity and adherence to the program schedule.

An Agency Program Manager has been designated by each Agency to control internal processes and effect coordination between local offices.

Responsibilities of the Agency Program Managers are:

A. Prepare work schedules and task assignments; identify deadlines, funding requirements, and personnel needs; and monitor costs.

B. Conduct public involvement program.

C. Solicit assistance and cooperation from other agencies.

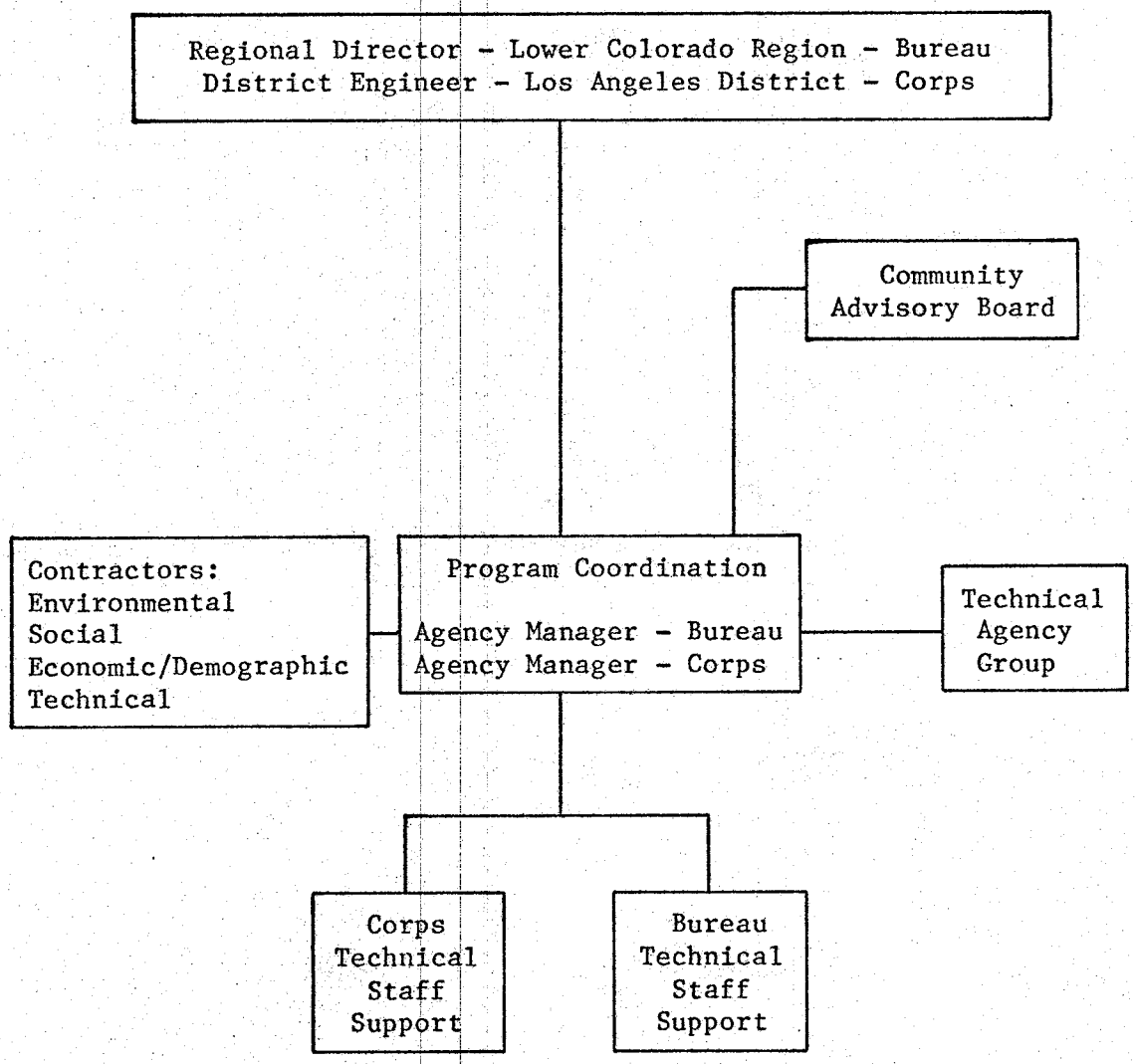
D. Coordinate Agency activities to assure adherence to established schedules.

E. Identify appropriate tasks for outside contractors and insure that work performed under contract is satisfactory.

F. Prepare progress reports for the Bureau, Corps, Technical Agency Group, and Community Advisory Board.

FIGURE 3

STUDY ORGANIZATION CHART



The Los Angeles District, Corps of Engineers, and the Lower Colorado Region, Bureau of Reclamation, will provide policy guidance for conduct of the Study consistent with the Memorandum of Understanding.

In addition to coordination between the Agencies, technical coordination will be required with many other federal, state, and local organizations. A Technical Agency Group (TAG) has been formed for interagency cooperation and coordination. The function and membership of the TAG are discussed under Public Involvement.

Contractors will be retained by either Agency as required. The Contract Officer for each contract will be designated by the originating Agency; contract scopes will be structured to serve the needs of both Agencies where feasible. For example, the Bureau will award a contract for environmental assessments required by both Agencies, and the Corps will award a recreation planning contract to meet the needs of both Agencies.

Study Scope

The Study will follow a three-stage planning process as previously described. The first stage, PLAN OF STUDY, is concluded with the publication of this report. The remainder of the Study consists of STAGE 2 DEVELOPMENT OF INTERMEDIATE PLANS and STAGE 3 DEVELOPMENT OF DETAILED PLANS. The following section briefly describes the various engineering, environmental, socio-economic, and institutional analyses to be undertaken during Stages 2 and 3. Specific features to be studied are listed in Table 10.

A. Technical Studies - Corps of Engineers

1. Hydrologic Studies

Required Tasks:

a. Review and evaluation of previous hydrology studies on the Salt and Gila Rivers and documentation.

b. Determine meteorological and flood runoff characteristics for the Salt River, the Gila River from its confluence with the Salt River to Painted Rock Dam, and major tributaries to the Salt and Gila Rivers in the Study area.

Table 10

SPECIFIC STUDY FEATURES

Features	Functional Purpose	
	Flood Reduction	CAP Regulatory Storage
DAMS		
Confluence Damsite	X	X
Tangle Creek Damsite	X	X
Cliff Damsite	X	X
Modified Horseshoe Dam	X	X
Modified Roosevelt Dam	X	X
New Waddell Dam	X	X
Levees (Pima Road to 35th Avenue, Holly Acres, Salt-Gila Confluence to Gillespie Dam)	X	
Channels (Pima Road to 35th Avenue)	X	
Channel Clearing (23rd Avenue to Painted Rock Reservoir)	X	
Water Exchange (Salt River Project and Lake Pleasant)		X
Salt River Flexible Operational Criteria (SRFOC)	X	
Non-structural Flood Damage Reduction Measures (Floodproofing, Floodplain Acquisition and Regulation, Flood Warning Systems)	X	

NOTE: Artificial ground-water recharge, hydropower generation, recreation, and fish and wildlife habitat enhancement will also be studied in relation to the above features in various combinations.

c. Determine peak discharge, volume frequencies, and estimate of sediment at damsites.

d. Determine Standard Project Flood (SPF) and probable maximum floods at damsites and downstream areas.

e. Determine flood routings under existing conditions and under various alternatives; determine residual flows with various alternatives.

f. Determine water conservation yields for various dam alternatives on the Verde River.

g. Coordination with the Bureau of Reclamation and other agencies.

h. Conduct dendrochronological study to estimate prehistoric hydrograph and prehistoric flood events.

2. Hydraulic Studies

Required Tasks:

a. Analysis of existing channel capacities.

b. Delineation of overflow areas.

c. Hydraulic design of single and multipurpose dams on the Verde River.

d. Hydraulic design of channels, including greenbelts.

e. Hydraulic design of levee systems.

f. Hydraulic design of non-structural alternatives.

g. Hydraulic evaluation of channel clearing.

3. Engineering Design and Cost Studies

Required Tasks:

a. Structural design of flood control features, including dams, channels, levees, and greenbelts.

b. Determine quantity and cost estimate for all flood control features.

c. Engineering design and cost studies for non-structural alternatives.

d. Delineate required rights-of-way.

e. Determine costs of rights-of-way, easements, severence, and damages.

NOTE: Engineering design and cost studies will determine separate costs for all flood control features.

4. Surveying and Mapping

Required Tasks:

a. Limited surveys to obtain overflow data.

b. Limited surveys for reservoir design.

5. Foundation and Materials Investigation

Required Tasks:

a. Provide personnel to oversee and coordinate foundation and materials investigation with the Bureau of Reclamation for damsites under study on the Verde River.

b. Perform geophysical explorations (refractive) of the Verde damsites.

c. Perform foundation and materials investigations for the channel levees and greenbelts.

d. Design of dam embankment sections and levee sections.

6. Economic Studies of Flood Control Alternatives

Required Tasks:

a. Determine existing and proposed land uses.

b. Evaluate existing and projected values of lands subject to flooding.

c. Determine expected damages from future floods over life of the project.

d. Assist in identification of the National Economic Development Plan from alternatives.

e. Compute annual charges from first costs and future costs for alternative plans.

f. Estimate annual benefits accruing to alternative plans. (Anticipated benefits include flood damage reduction, savings in cost of fill, location benefits, employment benefits, recreation benefits, and water conservation benefits.)

g. Compute benefit/cost ratios for alternative plans.

h. Manage socio-economic portion of Bureau's contract.

7. Recreation Studies

Required Tasks:

a. Evaluate characteristics of recreation market areas, including present population and population trends.

b. Determine present and probable future recreational use in the Study area.

c. Preliminary design of recreational facilities for those feasible alternatives that can accommodate recreational development.

d. Determine recreation costs and benefits.

e. Select recreation plans that are consistent with current policy, economically feasible, and desired by local interests.

8. Environmental Studies

Required Tasks:

a. Manage Bureau's environmental contract.

b. Coordination with Bureau.

9. Non-structural Analysis

Required Tasks:

a. Evaluate floodplain regulations.

b. Evaluate floodproofing existing and future structures in the floodplain.

c. Evaluate relocation of structures out of the floodplain.

d. Evaluate current flood insurance programs.

e. Evaluate existing floodwarning systems and possible improvements to these systems.

f. Evaluate modifying existing bridges to handle larger flows or building new bridges.

g. Evaluate flexible operating criteria for the existing reservoir system or for new reservoirs.

h. Evaluate combinations of structural and non-structural measures.

10. Phreatophytic Growth Assessment on Salt and Gila Rivers

Required Tasks:

a. Document the invasion of the phreatophytes into the Study area.

b. Describe methods of control and clearing of phreatophytes.

c. Document the effects phreatophytes have on the rivers' geomorphology.

d. Develop future scenarios of how the phreatophytes will affect or be affected by the No Action Alternative.

B. Technical Studies - Bureau of Reclamation

1. Hydrologic and Hydraulic Studies

Required Tasks:

a. Determine flood runoff characteristics.

b. Determine peak discharge and sediment production.

c. Determine inflow design flood.

d. Review and evaluate existing data.

e. Develop hydraulic design data.

2. Survey and Mapping

Required Tasks:

a. Set control for topographic mapping.

b. Develop topographic maps for all damsites.

3. Geologic Investigation

Required Tasks:

a. Review and evaluate existing data.

b. Location and evaluation of embankment materials.

c. Exploratory boring to determine foundation suitability.

d. Geologic mapping.

e. Seepage evaluation.

4. Economic Studies

Required Tasks:

a. Develop benefit/cost ratio for alternative plans.

b. Update benefit values to current levels.

c. Assist in arraying National Economic Development alternative.

5. Contract Studies

Required Tasks:

a. Environmental studies.

b. Social studies.

c. Economic/demographic studies.

d. Design and aid in conduct of public involvement program.

6. Design and Estimates

Required Tasks:

a. Develop design data package.

b. Preliminary design of features.

c. Preliminary cost of features.

d. Feasibility design of features.

e. Feasibility cost of features.

7. Operation Studies

Required Tasks:

a. CAP operation studies.

b. Water exchange studies.

c. Hydroelectric power generation potential studies.

d. Water conservation studies.

C. Study Management Program - Bureau and Corps

Required Tasks:

Project Management - The management of all Study activities includes scheduling, budgeting, work assignments, coordination, and review so that manpower, money, and time are used in an efficient manner. Reporting

on Study progress and briefing of higher authority are a part of this responsibility.

Coordination and Public Involvement - This includes coordinating Study activity with other interested citizens, groups, and agencies. Preparation for and follow-up on public meetings, workshop meetings, and Study presentations to interested groups is a part of this task.

Impact Evaluation - This will require evaluating all significant economic, social, environmental, and institutional changes associated with each alternative plan. It includes evaluating the National Economic Development and Environmental Quality alternatives for each site.

Preparation of Reports - This includes the preparation of texts, tables, plates, graphics, typing, and reproduction of Study documents, such as this PLAN OF STUDY, Stage II documentation, the draft survey report, draft planning report, draft environmental statement, and the final survey report, planning report, and final environmental statement.

D. Assistance From Other Agencies

In addition to providing consultation and advice, the following two agencies will be asked to provide specific work:

1. Salt River Project

Evaluate hydroelectric power generation potential of each reservoir site.

2. U.S. Fish and Wildlife Service

Review environmental impacts of all plans and recommend appropriate loss prevention, compensation, mitigation, and enhancement measures, and if necessary, provide consultation as required by Section VII of the Endangered Species Act.

E. Unresolved Issues

As technical issues arise during the Study for which the Bureau and Corps have differing criteria, resolution will be at the lowest possible level. For example, the following unresolved issues are discussed below:

Spillway Design. Inflow design floods computed by the Bureau and Corps may vary significantly. The Corps may design a dam and spillway under the CAP authority which eventually may be constructed by the Bureau. A tentative solution is that the Corps design spillways for Verde River dams while the Bureau design Orme, Granite Reef, Roosevelt, and New Waddell Dams.

Discount Rate. The CAP and the Corps Salt River channel improvements are authorized at a discount rate of 3¼ percent, whereas the current rate for plan formulation is 6 7/8 percent. The Study addresses alternatives to both authorized projects, although no decision has been made as to whether the authorized or current rates should be used to evaluate alternatives. It is tentatively planned to display annual costs based on both discount rates.

Authority to Construct. Authorization for the CAP includes Orme Dam or a suitable alternative. The outcome of this Study may propose a plan with features not authorized by the CAP authorizing legislation (P.L. 90-537), such as a dam upstream on the Verde River and channelization of the Salt River. Which Agency would seek funds and authority to implement such a plan remains unclear.

Public Involvement

Public involvement is a term which has many definitions. It is appropriate at this stage in the Study to delineate public involvement objectives and investigate options to implement these objectives.

The major objective of the public involvement program is to provide timely information to the public so that individuals may participate in the planning process. This objective requires that information be generated through the public involvement programs in such a manner that the planning process can be responsive to public needs and preferences.

Due to the previous controversy regarding Orme Dam and recent flood problems, a greater level of public interest exists in this Study than in a typical planning study. The public divides itself naturally into four levels of interest according to the way a project is perceived. Certain sectors of the public will be satisfied with an information-educational program. On the lowest interest level people have a "need to know" attitude but feel in many cases that the project will have little effect on them personally. On the next interest level, individuals have definite opinions, especially on issues which directly affect their lives, but they may not have the time or technical expertise to make

a contribution to the planning process. Beyond this level is a group of about 100-150 individuals who are professional representatives of Federal, state, and local government agencies whose job responsibilities cover subject areas potentially affected by this Study. This group also includes those with a direct stake in the outcome of the Study, such as water users groups, environmental organizations, recreation clubs, Indian tribes, and landowners. Finally, at the highest interest level are the community leaders. These individuals have a special role in a public involvement program because they are able to focus and articulate needs and concerns of their constituencies. These public involvement levels are shown schematically in Figure 4.

The public involvement program should satisfy information needs at all four levels of public interest. It also should facilitate the involvement of individuals in the Study process.

The lowest interest level or passive public should be approached with information program techniques, including a regular newsletter, brochures, newspaper articles, and television coverage. Since these individuals provide little direct feedback to the Study, the effort expended on these activities should be limited. On the other hand, it is important to remember that media coverage is the only means available to reach some sectors of the public.

The more active public desires involvement in the process and has opinions it wants heard. Interaction techniques, such as organized public meetings and workshops, are effective. Meetings should be timed to coincide with critical decisions and not held too frequently. The following schedule of meetings and workshops has been established:

1. Introductory meetings were held in January 1979 to explain Study objectives and encourage participation in the Study process.

2. A series of workshops beginning in June or July 1979 to focus on problems and needs of the Study area and to review preliminary alternatives and solicit public comment.

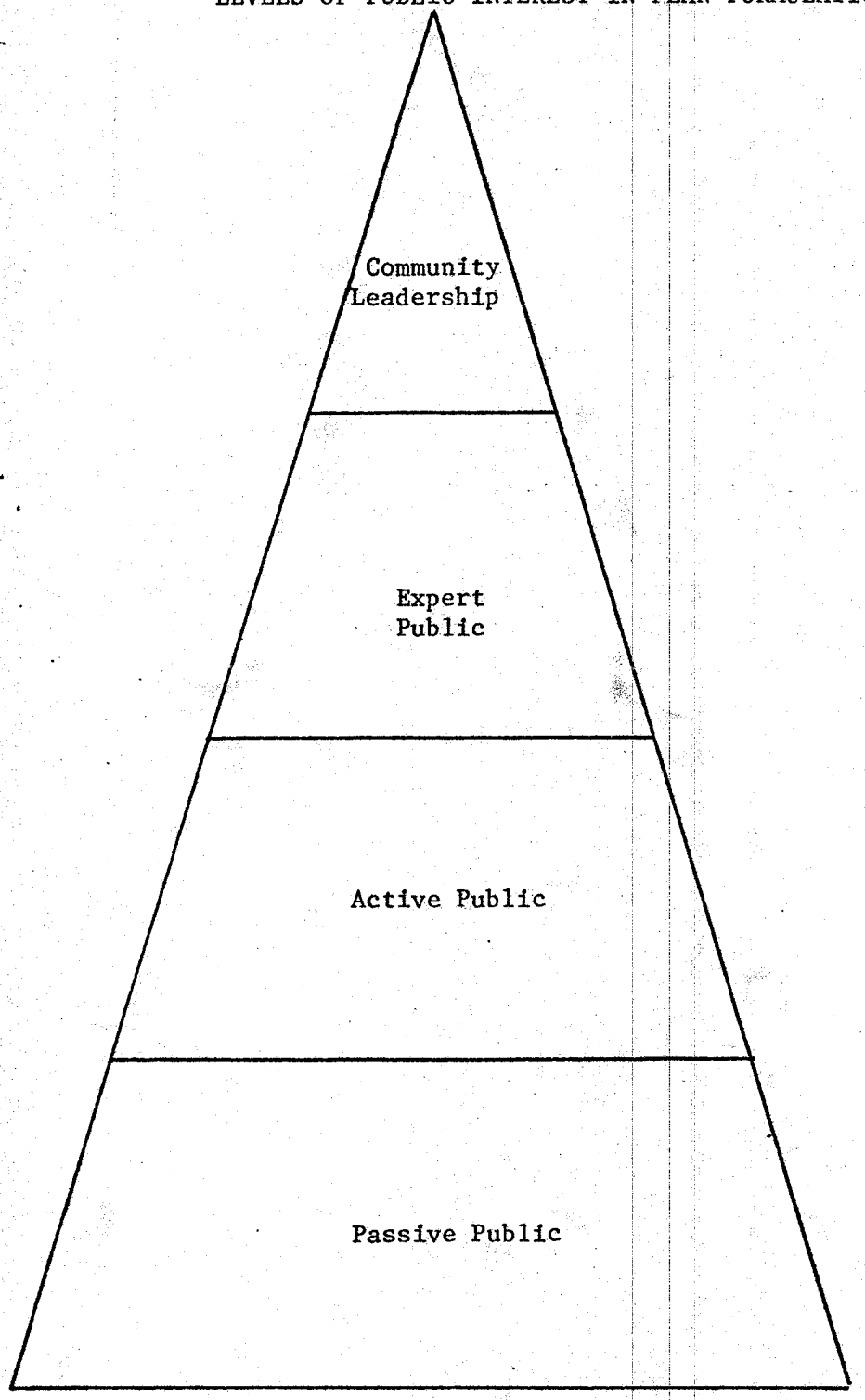
3. A public meeting and workshop session near the end of Stage II to focus on intermediate alternative plans and solicit public comment.

4. A public meeting and series of workshops near the middle of Stage III to discuss the preferred plan and to explain the rationale leading to its recommendation.

5. A public meeting following release of the draft environmental statement to explain that document and answer questions.

FIGURE 4

LEVELS OF PUBLIC INTEREST IN PLAN FORMULATION



Public Involvement Programs

Community Advisory Board Activities

Technical Activities

Meetings, Workshops, Slide Shows

Newsletters, Television, Press Releases, Newspaper Coverage, Brochures

In addition to meetings and workshops, slide shows will be made available for presentation to interested organizations.

The expert public can provide a great deal of technical information to the Agencies. Governmental bodies and water users groups can produce technical studies useful to the Agencies in areas where they lack expertise or are required by law to coordinate with certain agencies.

The expert public will be organized as the Technical Agency Group (TAG), which will meet periodically during the Study and will interact with the Agencies on a continuous basis. Specifically, the TAG will:

1. Assist in the collection of existing information and develop new data.

2. Review and analyze information.

3. Assist in plan formulation.

4. Participate in public workshops and meetings.

Membership in the TAG will be adjusted by the Agencies during the Study. The TAG may be organized into disciplinary subgroups such as fish and wildlife, recreational and cultural resources, water resources and uses, flood control, and power and engineering. Subgroups could be standing committees or ad hoc, in which case they would organize to perform certain tasks. In general, subgroups would provide data to the TAG as a whole for consideration.

The following individuals and agencies have been requested to participate in the Technical Agency Group:

Federal Agencies

Advisory Council on Historic Preservation
Mr. Walt, Denver, Colorado

Army Corps of Engineers, Los Angeles
District Engineer: Colonel Gwynn A. Teague, Los Angeles, California
Will Worthington, Phoenix, Arizona

Bureau of Indian Affairs
Area Director, Phoenix, Arizona

Bureau of Land Management
State Director, Phoenix, Arizona

Bureau of Mines
Chief of Intermountain Field Operations Center, Denver, Colorado

Department of Agriculture
Soil Conservation Service, Phoenix, Arizona

Department of the Interior
Fish and Wildlife Ecological Service
National Park Service, Southern Arizona Group

Environmental Protection Agency
Arizona Branch Chief: Richard Reavis, San Francisco, California

Federal Highway Administration
Bureau of Public Roads
Division Engineer, Phoenix, Arizona

Interagency Archeological Services
Chief, Heritage Conservation and Recreation Service, San Francisco, Cal.

Tonto National Forest Service
Supervisor, Phoenix, Arizona

U.S. Geological Survey, Water Resources Division
Arizona District Office, Phoenix, Arizona

Indian Reservations

Fort McDowell Mohave-Apache Tribal Council
President: Clinton Pattea
Dan Shaffer

Gila River Indian Community
Water Conservation Board Chairman: Nick Sunn
Governor: Alexander Lewis, Sr.

Salt River Pima-Maricopa Indian Community
Manager: Frank Martley
Planning Director: Roger Evans

State Agencies

Arizona Bureau of Mineral and Geology Technology
Jan Wilt

Arizona Department of Health Services
Bruce Scott

Arizona Department of Transportation
Planning Director

Arizona Outdoor Recreation Coordinating Commission
State Liaison Officer

Arizona State Land Department
Director

Arizona State Parks Board

Arizona Water Commission
Executive Director

County Agencies

Maricopa Association of Governments
Ken Driggs, Director

Maricopa County
Engineer: Bob Estabrook
Health Services: Harry Crohurst
Parks and Recreation: Robert Milne
Planning Department

Maricopa County Flood Control District
General Manager: Herb Donald

Maricopa County Municipal Water Conservation District No. 1
General Manager: H. S. Raymond

Local Entities

Central Arizona Water Conservation District
Executive Director

City of Avondale
Public Works Director: Larry Ramirez

City of Glendale
Manager

City of Mesa
Manager

City of Peoria
Manager: Bill Vaugn

City of Phoenix
Manager: Marvin Andrews

City of Scottsdale
Manager: Lynn Stuart

City of Tempe
Manager

City of Tolleson
Manager: Dave Mansfield

Salt River Project
General Manager: A. J. Pfister

Town of Buckeye
Manager: Steven Thompson

Town of El Mirage
Manager: Margarita Reese

Western Area Power Administration
Phoenix District Manager

The community leadership already has been organized with the formation by Governor Babbitt of the Community Advisory Board to advise him on issues addressed by the Study. An analysis of composition of the Board shows it to be a good cross-section of community leadership, which can speak with authority on most Study issues. Representation on the Advisory Board falls into the following categories:

1. Governmental and political.

2. Environmental and wildlife.

3. Development and business.

4. Indian tribes.

5. Media

6. Labor and citizen groups

While Board members are generally in leadership roles, they will rely on staff personnel to provide technical expertise.

The Community Advisory Board will aid in identification of problems and needs through complaints and comments received from members' constituencies. Their knowledge of other planning issues will help identify ways in which proposed alternatives might affect different projects.

Board members can convey information gained from meetings to their respective organizations to increase the level of communication and input.

The Community Advisory Board may be most helpful to the Study by providing advice on acceptability of alternative plans from political and legal viewpoints. It is anticipated that the Board will offer suggestions concerning compromises and improvements to make alternatives more acceptable. Once the preferred plan is selected, the Board also may aid in demonstrating to the community that all points of view have been considered, resulting in recommendation of the best plan.

While authority for making final decisions on plan formulation and selection rests with the Agencies, advice and recommendations from all four levels of the public will be given serious consideration and will aid the Bureau and Corps in the development of the plan which best serves the public.

Detailed design of the public involvement program described above will be part of a contract to be awarded soon.

Study Schedule

A detailed schedule of Study activities has been established and is available separately. A Summary Study Schedule is presented in Figure 5.

The Milestones established in the Corps Intensive Management Program are listed in Table 11.

Study Cost Estimates

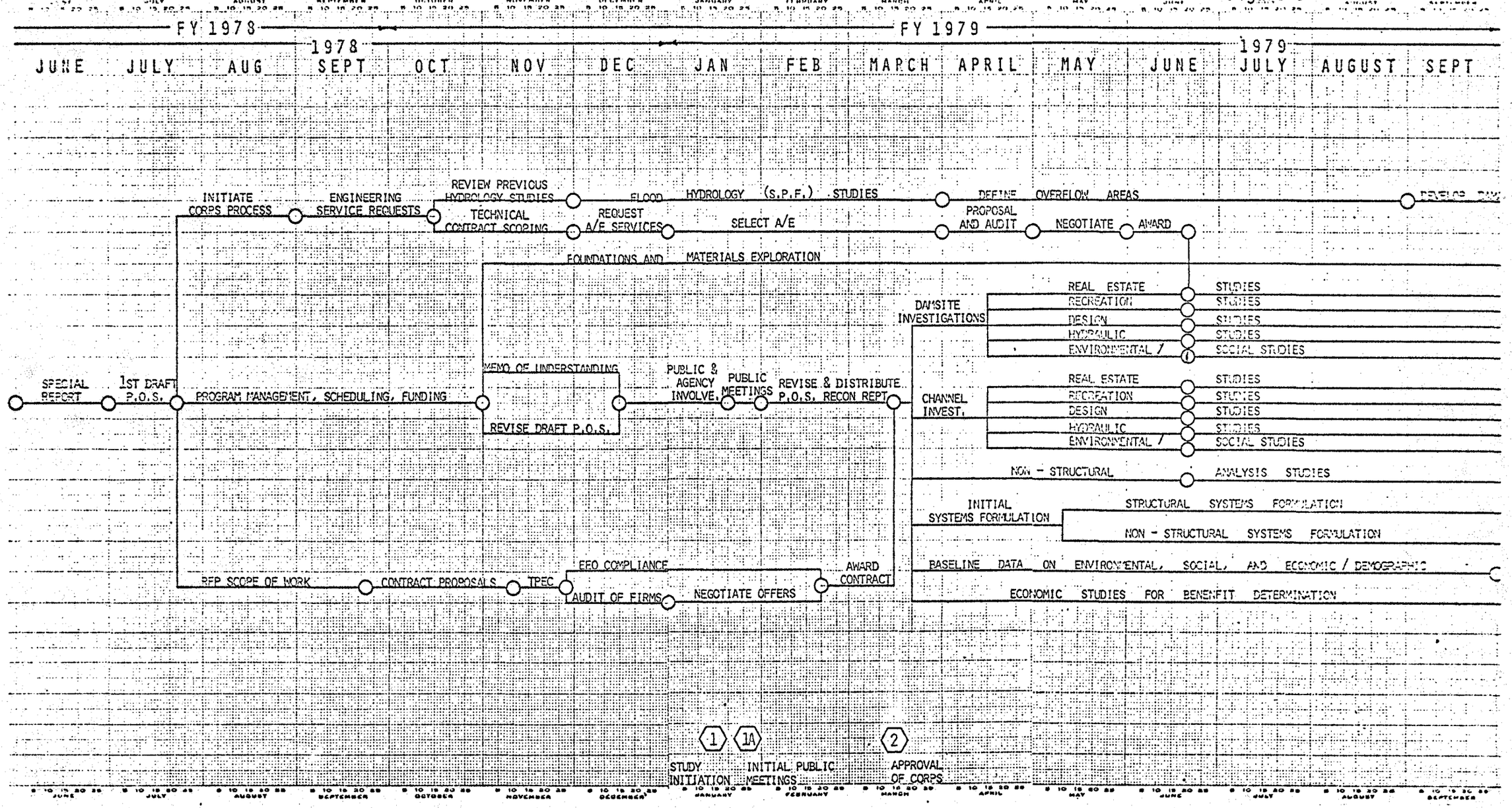
Bureau of Reclamation and Corps of Engineers cost estimates for the Study by fiscal year are as follows:

	FY 78	FY 79	FY 80	FY 81	FY 82	TOTAL
Corps	54,600.	1,306,300.	1,100,900.	395,800.	214,400.	3,072,000.
Bureau	69,500.	1,266,200.	1,435,300.	968,900.	282,500.	4,022,400.
TOTAL	$124,100.	$2,572,500.	$2,536,200.	$1,364,700.	$496,900.	$7,094,400.

The Corps requirement in FY 79 will be met through the use of $350,000 appropriated for the Corps Phoenix Urban Study and the transfer of funds from the Bureau. Corps requirements in fiscal years 1980, 1981, and 1982 may be appropriated to the Corps directly or through the Bureau, whichever Congress determines most appropriate.

SUMMARY STUDY SCHEDULE

Figure 5



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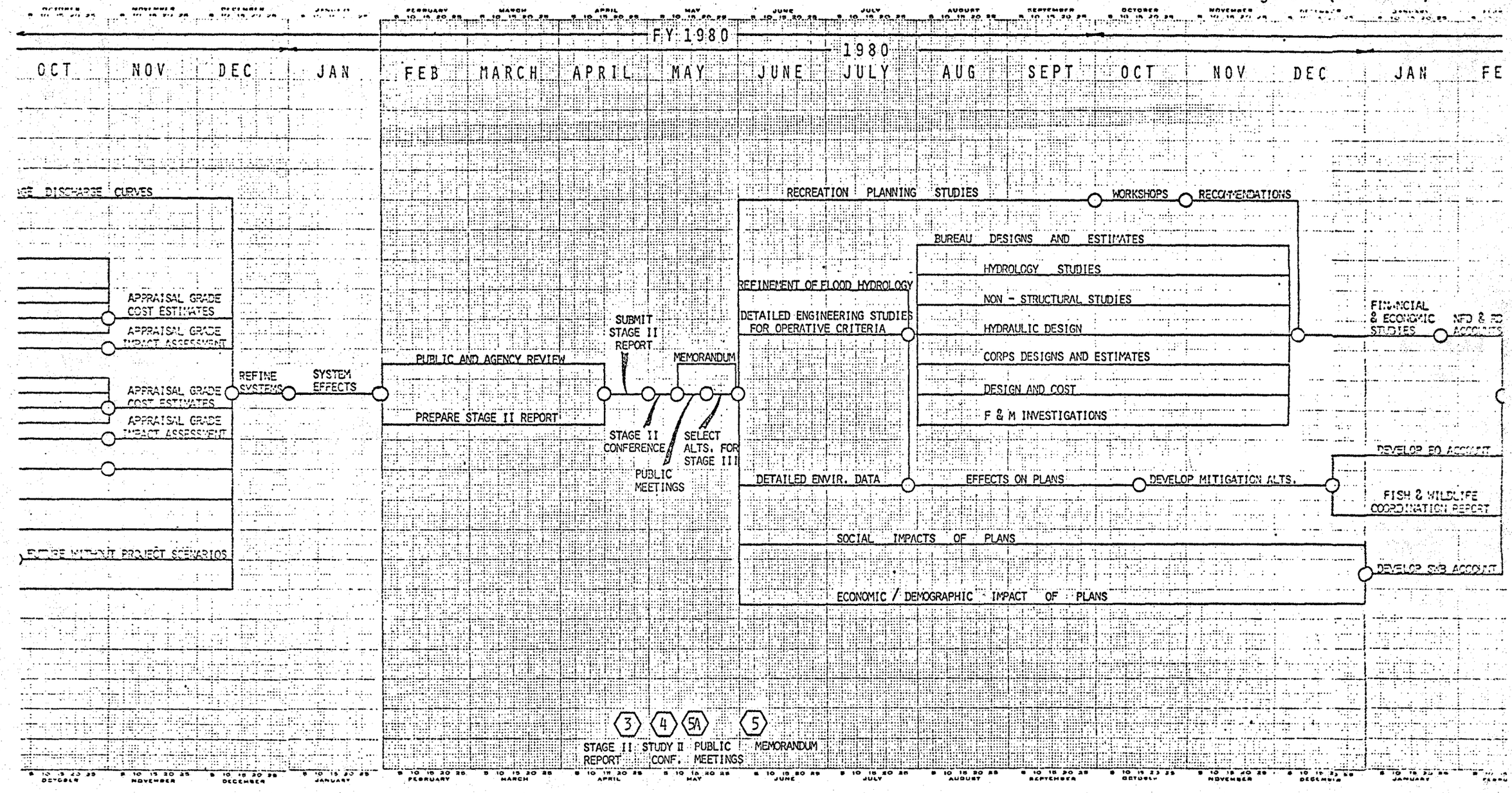

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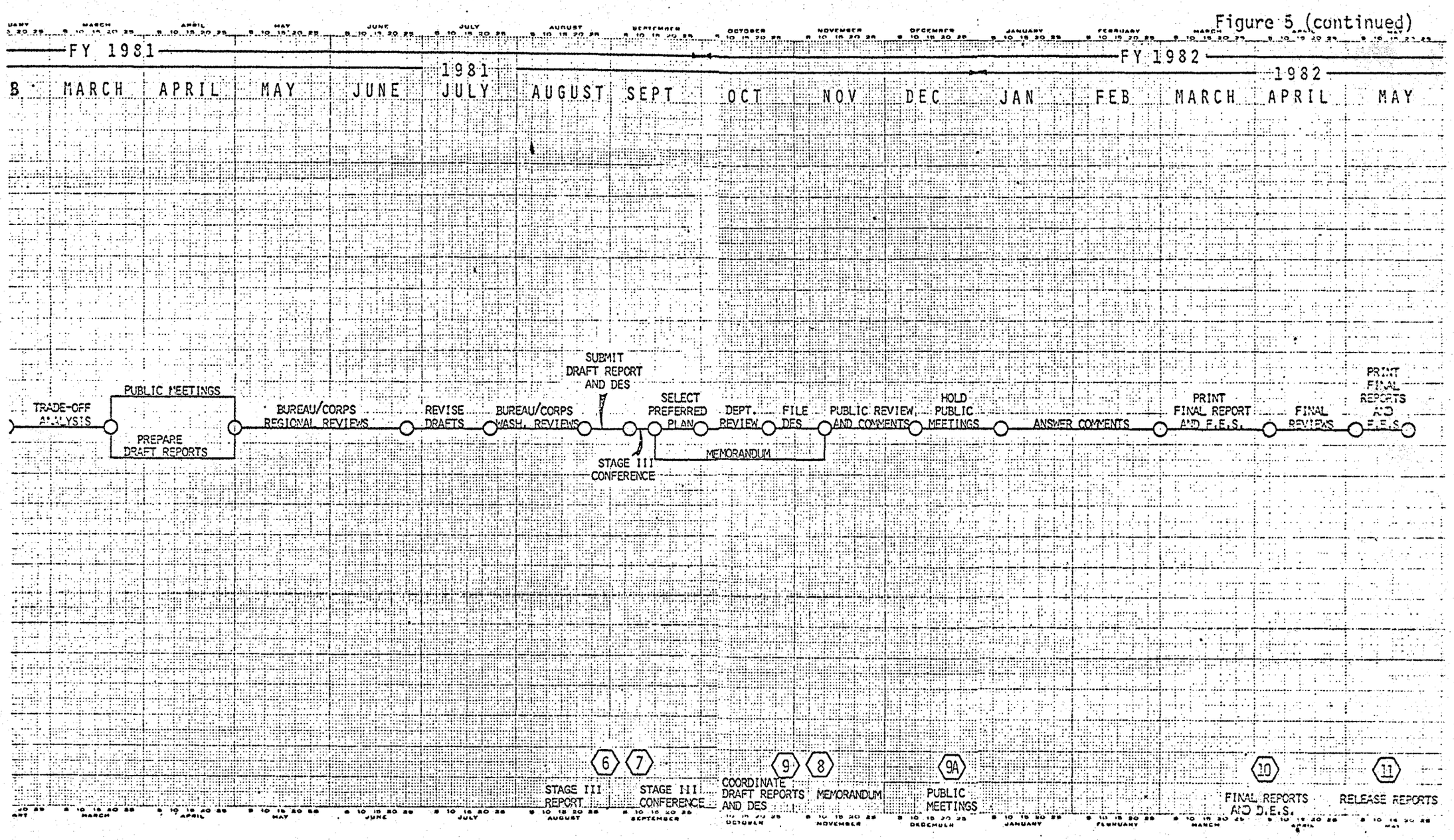

Table 11

Corps of Engineers Milestone Schedule

Milestones	Action	Date
1	Study Initiation Announcement	January 1979
1A	Initial Public Meeting	January 1979
2	Approval of Plan of Study	April 1979
3	Stage II Report	April 1980
4	Stage II Checkpoint Conference	May 1980
5	Action on Memo for Record	June 1980
5A	Public Meeting	May 1980
6	Draft Report and Environmental Statement	August 1981
7	Stage III Checkpoint Conference	September 1981
8	Action on Memo for Record	November 1981
9	Coordinated Draft Report and Environmental Statement	October 1981
10	Final Report and Environmental Statement	April 1982
11	South Pacific Division Release of Report	May 1982