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CENTRAL ARIZONA WATER CONTROL STUDY

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CENTRAL ARIZONA WATER CONTROL STUDY FACTBOOK

The Central Arizona Water Control Study (CAWCS) is nearing the end of the second of three stages. The CAWCS is a study under the direction of the U.S. Water and Power Resources Service (formerly the U.S. Bureau of Reclamation) and the U.S. Army Corps of Engineers. The purpose of the study is to identify a preferred plan to reduce flood damages along the Salt and Gila Rivers and provide regulatory storage of water for the Central Arizona area. This Factbook is a summary of the information which is currently available regarding the various alternatives which are being considered. But the planning process is an "interactive" process. As more is known about an alternative, the alternative may be revised to minimize an environmental or social impact, or make it more economically feasible. So the information in this Factbook is more like a progress report. As further studies are completed in Stage III, facts and figures may change. This is the best information currently available.

Because of the complexity and number of alternatives being considered, this Factbook attempts to provide the public with the essential information which will be used in making decisions as to which plans will be considered in the final stage of the study. It is a resource book. It also provides you with the information you will need to participate in the study.

AN INVITATION TO PARTICIPATE

What we need from you--the public--is to know what questions you have about these facts, what additional facts you need to make your own

evaluation of the alternatives, what reactions you have to decisions that have been made, which alternatives you prefer and why. You can respond to these questions in several ways. You may write us (CAWCS, Suite 111A, 234 N. Central, Phoenix, Arizona 85004) or phone (602-271-0915). In addition public meetings will be held during the latter part of November 1980, and at several points during Stage III. We invite you to participate.

November 24 - Tucson, 7:30 P.M.
Tucson Community Center

November 25 - Casa Grande, 7:30 P.M.
Ramada Inn (I-10)

December 1 - Mesa, 7:30 P.M.
Centennial Hall

December 2 - Phoenix, 7:30 P.M.
Carl Hayden High School

In addition an Information Fair featuring exhibits on the CAWCS was held at the Valley Bank Center in Phoenix from November 17-21 with technical experts available on November 21 from 11 A.M. to 2 P.M. at the Valley Bank Center display area.

HISTORY

This study is sometimes referred to as the "Orme Dam Alternatives Study," because the flood control and regulatory functions which this study addressed were originally to be provided by Orme Dam, a dam which was to be built at the confluence of the Salt and Verde Rivers. In 1968 the U.S. Congress authorized the construction of Orme Dam or a suitable alternative as an element of the Central Arizona Project (CAP). A draft

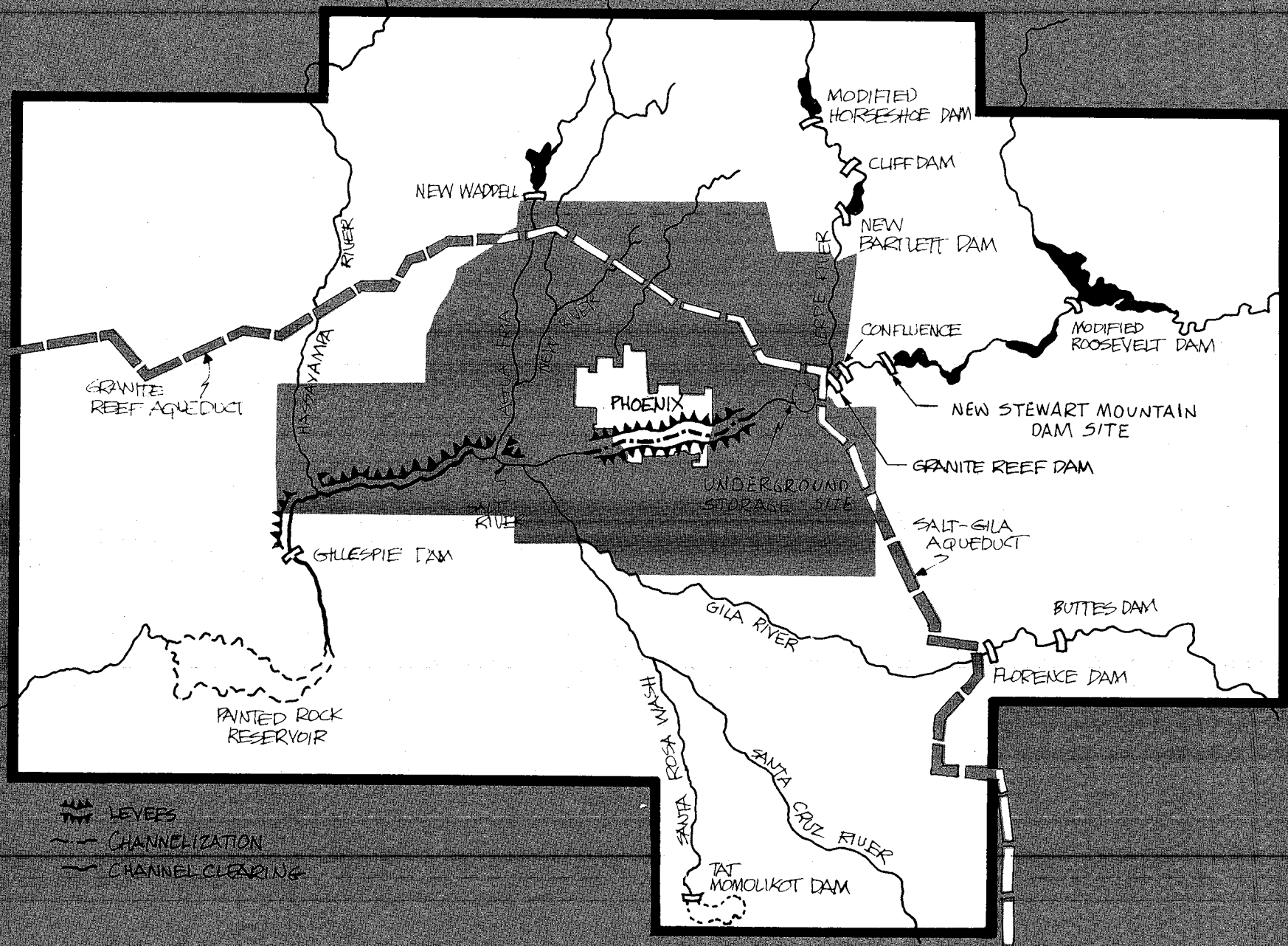
environmental statement was prepared for Orme Dam in 1976. Public response to the statement indicated substantial environmental, economic and social concerns. A large dam built at the confluence would result in inundation of major portions of the Fort McDowell Indian Reservation. It would also inundate riparian habitat unique to the Central Arizona area which supports a wide variety of plant and animal species, including two rare and endangered species. These concerns and others caused the Water and Power Resources Service (Service) to reassess the merits of Orme Dam and delay preparation of a final environmental statement. Then, in April 1977, as part of the Water Projects Review, President Carter recommended that Orme Dam be deleted from the CAP.

Flooding along the Salt River in 1978 resulted in renewed efforts by local agencies and citizens to obtain flood control. The Service began the CAWCS in July 1978. Additional flooding in 1979 and 1980 has reinforced the public interest in seeking successful resolutions to water control issues.

Because of the level of public concern about the confluence site, the Service decided it would not be appropriate simply to resurrect the Orme Dam proposal, but instead the study would consider all alternatives as objectively and thoroughly as possible. The possibility of a dam at the confluence site would be among the alternatives studied, but it would be given no special consideration and would rise or fall on its own merits in comparison with the other alternatives (see map on page 4).

Because of the flood control aspect of the study, the U.S. Army Corps of Engineers (Corps) shares in the management of the study, although the Service has the final responsibility for its completion. The Corps is

SITES UNDER CONSIDERATION



responsible for the flood control planning and analysis. The two agencies are proceeding with a completely coordinated study which efficiently uses the resources of both agencies and has concurrent decision dates.

Numerous contracts have been awarded for technical studies. The Service let a contract to conduct the environmental and social studies, and also has responsibility for public involvement coordination. The Corps has awarded several smaller contracts for recreation, economics, engineering design and cost, and nonstructural studies. Other studies are being completed by either the Service or the Corps staff. For simplicity the total study is called the CAWCS (see Chart 1).

PURPOSES

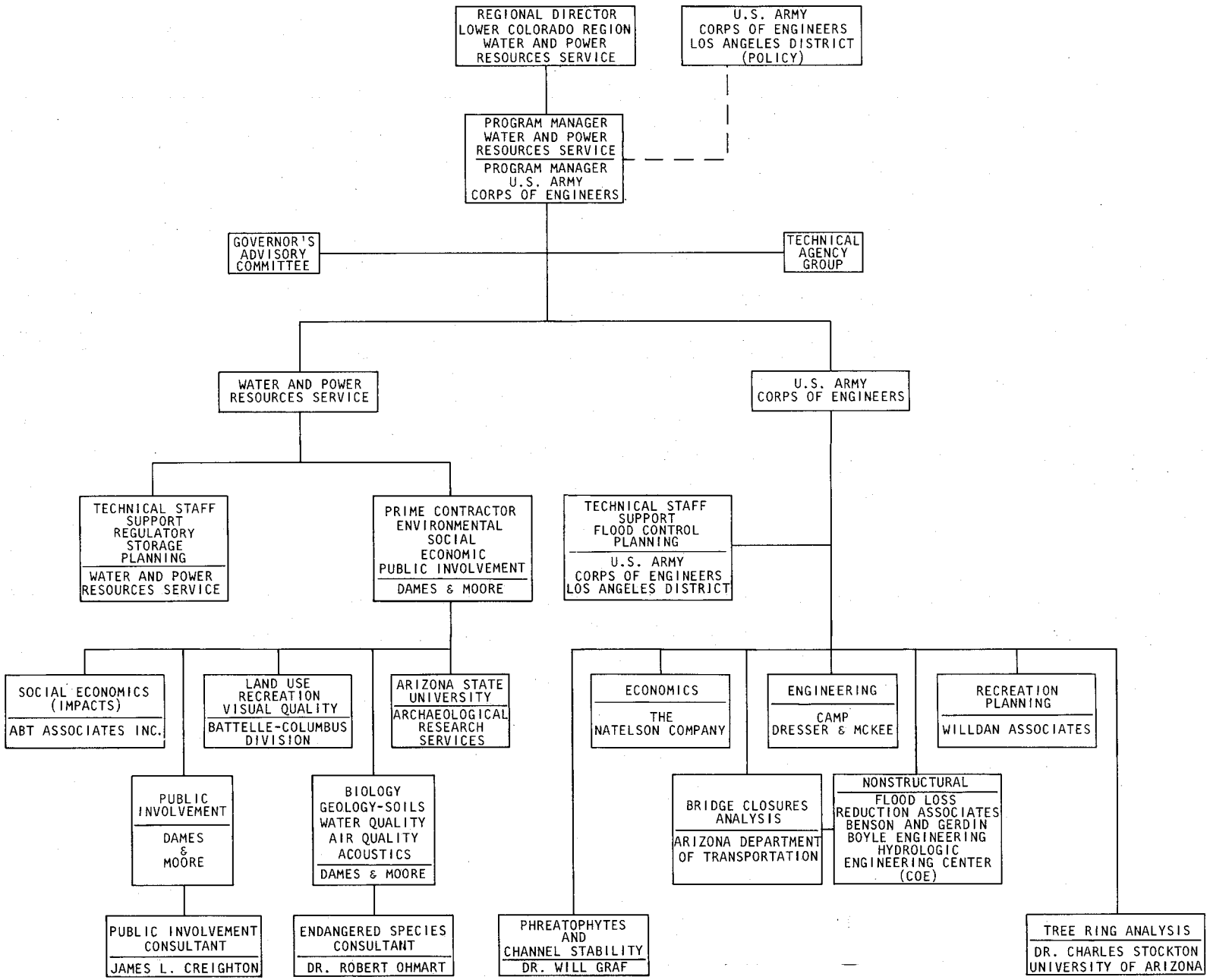
CAWCS has two major purposes: 1) flood control and 2) regulatory storage. Each of these purposes is described below:

Flood Control - Flooding along the Salt and Gila Rivers has been a problem for the Phoenix area since its early settlement. Historical photos of the early 1890's show flooding of the downtown area as far north as Jefferson and Central Avenues. In part this is due to the construction, since that time, of the various dams operated by the Salt River Project. But the problem of flooding is not just the amount of water running down the river, it also has to do with the location and sizing of dams, bridges, etc. In recent years, for example, substantial growth of suburban developments along the Salt River has occurred. Most of the time transportation across the river simply means driving across a dry riverbed. Until recently the

CAWCS ORGANIZATION

CHART 1

CENTRAL ARIZONA WATER CONTROL STUDY
CONTRACTORS/SUBCONTRACTORS



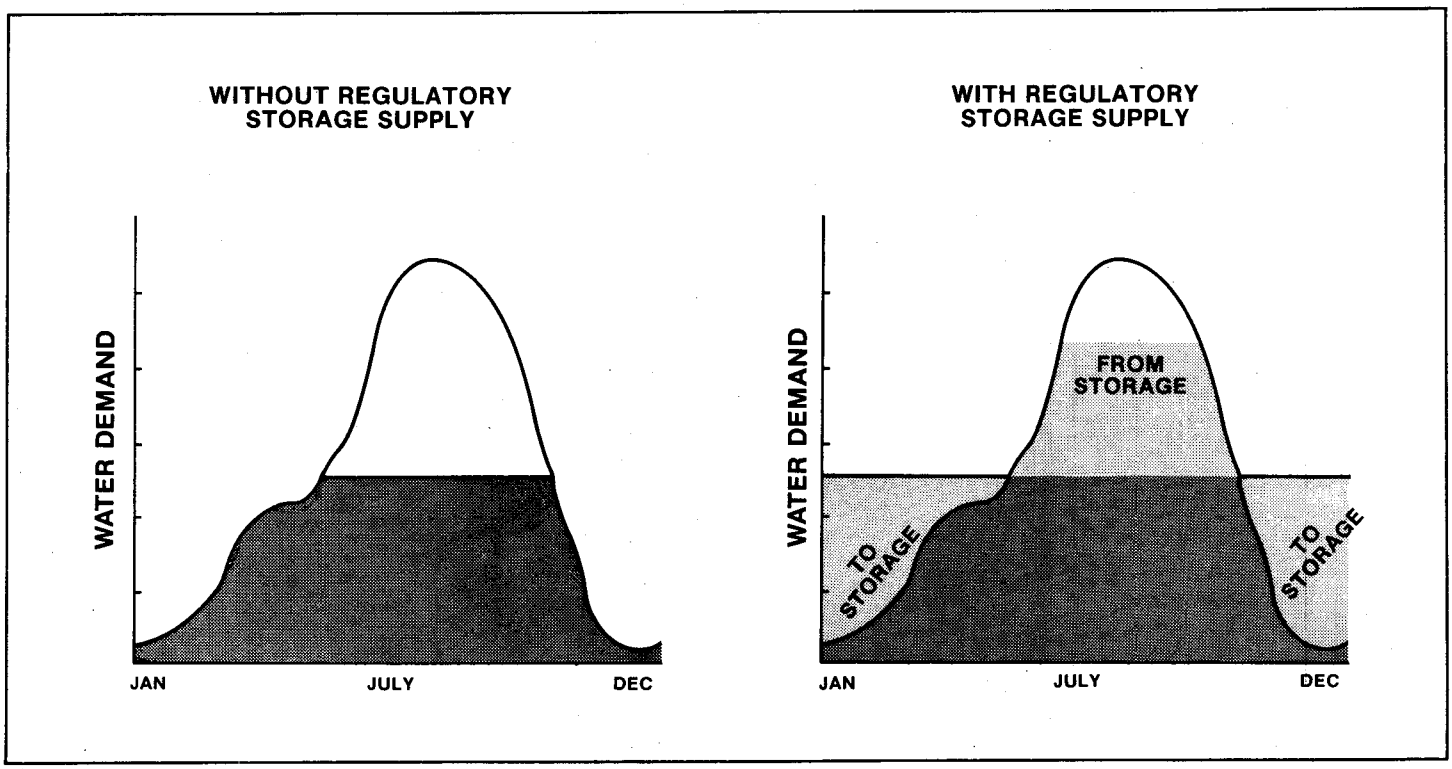
size of bridges was based on a number of dry years, rather than the possibility of flooding, and people and businesses built in the floodplain. The major impact of flooding these past three years has been on transportation, both in terms of physical damage to bridges and river crossings and in major traffic jams on the undamaged bridges.

Another problem is that in the western portion of the study area the Gila River channel has overgrown with saltcedar, causing the channel to move. This change in the channel has resulted in flooding to farmlands and some residential areas as well as contributed toward transportation problems.

Monetary damages along Salt-Gila Rivers were estimated at $31 million from the February-March 1978 floods and $46 million for the December 1978 flood. Flood damage reports for the February 1980 floods have not been published but were estimated to be in the $50-$60 million range.

Regulatory Storage - Regulatory storage is the second of the two major purposes of the CAWCS study. This can be illustrated in the diagram on page 8.

The Central Arizona Project will be bringing water to Phoenix, and eventually to Tucson, via aqueducts from the Colorado River. Since a number of states are dependent on water from the Colorado River, the amount of water which can be taken from the river under normal conditions is strictly prescribed by law. These laws have come to be known as the "Law of the River." However, at times extra water is available during the years when the Colorado River reservoirs, such as Lake Mead and Lake Powell, are essentially full or spilling. During this time of year the CAP would be able to withdraw water to its physical capacity. The problem is that there is not always a



big demand for water throughout the entire year. The demand is higher in the summer. Since the aqueduct needs to be full during those months anyway, the only time when the CAP could import this extra water is in the winter or spring. The idea of regulatory storage is to provide some place, other than in the aqueduct itself, to store the unused water in those months so it can be used during the summer months when the demand is high.

The first purpose of regulatory storage is that it increases the amount of CAP water during the months when it is needed. This water would probably be used by non-Indian farmers since other users, such as Municipal and Industry and Indian agriculture, can probably receive all of their CAP share even without the extra water.

A second major value of regulatory storage is that it provides an element of insurance to CAP water users in the event of some stoppage in the

flow of water in the aqueduct. This might occur if there was some physical damage in the aqueduct upstream of the user. The aqueduct might have to be shut down while repairs were made. With regulatory storage, the supplies held from the wet period could be used to meet those urgent needs until the repairs were completed. Another possibility besides physical damage would be a power outage. The CAP Havasu Pumping Plant, which provides the power to pump the water to the Phoenix area, represents a very large energy load. If a power system emergency were to occur, utilities could cut off the main pumping plant, using the power for critical users such as home, hospitals, etc., but water could still be supplied from regulatory storage supplies.

Regulatory storage also reduces dependence on the use of energy during peak periods. The demand for energy is much higher at certain times of the day. These peaks add to the cost of energy because utilities must build enough power plants to have the capacity to meet the peaks, even though this capacity goes unused the rest of the time. With regulatory storage, CAP water would be pumped into a reservoir during the non-peak energy periods, then delivered by gravity flow during the peak periods. In fact, the water released during the peak periods could be used to generate hydropower, increasing the amount of energy available.

PROCEDURES

The CAWCS remains quite controversial, and many people are keenly interested in the study procedures which will be used, in particular, that environmental and social concerns will be treated on an equal footing with economic and technical concerns. But, procedures for a study like this are

not simply created on the spot but are defined by law and well-established agency policy.

One of the most important requirements is that the study is conducted under "Principles and Standards" established by the U.S. Water Resources Council under Congressional authority. These "Principles and Standards" specifically require that federal and federally-assisted water and land activities must be planned with National Economic Development (NED) and Environmental Quality (EQ) as co-equal national objectives. In the final stages of the study an NED Alternative, the alternative that contributes the most to national economic development, and an EQ Alternative, which is the best alternative from an environmental quality perspective must be designated. Public documents will also display the effects of all alternatives in terms of National Economic Development, Environmental Quality, Regional Development, and Social Well-Being.

The CAWCS must also observe the NEPA Process, a set of procedures established by the U.S. Council on Environmental Quality, based on authorization in the National Environmental Policy Act of 1969. Under the NEPA process, a Draft Environmental Impact Statement, which displays all the environmental and social consequences of all proposed alternatives must be developed. The draft environmental impact statement is then subjected to close scrutiny by the public and other governmental agencies. It is revised as needed, and a Final Environmental Impact Statement is prepared. The Council on Environmental Quality also specifies that opportunities for public involvement and communication with other agencies will occur throughout the entire process.

Three other laws that govern procedures followed in the study are:

1. The Preservation of Historical and Archaeological Data Act of 1974, which established procedures for assessing and protecting historical and archaeological artifacts and data.

2. The Fish & Wildlife Coordination Act of 1958, which provided that wildlife conservation would receive equal consideration with other project purposes, and established coordination procedures with the U.S. Fish and Wildlife Service to ensure that this takes place.

3. The Endangered Species Act of 1973, which required Federal agencies to protect and conserve endangered species, and established procedures for this.

Beyond these laws, both the Service and the Corps have established policies and procedures which guide all studies conducted by them. In addition, a Technical Agency Group has been established representing some 50 federal, state, and county agencies, municipalities, and private organizations in the Valley. This group has a responsibility for "quality control," to insure that the manner in which the study is conducted meets not only agency standards, but the highest professional standards as well. Technical experts from all these various agencies meet periodically with CAWCS technical staff to review all the procedures employed in CAWCS studies, and to insure that all conclusions are justified by the data.

DECISION MAKING PROCESS

The Congress of the United States will be the final decision maker if funds have to be appropriated for construction or if some alternatives being considered have to receive Congressional authorization.

For practical and legal purposes, the Service has ultimate responsibility for this study, and therefore decision-making responsibility. The Corps of Engineers has authority, through a Memorandum of Understanding between the two agencies, for flood control planning and analysis. Since the time the study was initiated, the Corps has also obtained a separate study authority under the Gila River and Tributaries Project, but this involves only a portion of the study area. This means that the Regional Director of the Service in Boulder City, Nevada and the District Engineer in Los Angeles will sign their names to any recommendations which go forward to the Secretary of the Interior and Secretary of the Army, respectively, for review.

In reality, however, numerous decisions are made continually in a planning study of this size, and for this reason, local Program Managers of the study must also be considered decision-makers.

But the political realities should not be overlooked. The chances of any project getting built rest in the preferred plan having a high level of community support. This means that other agencies, political leaders, and the public must generally support the preferred plan and believe that the process followed to arrive at that decision was legitimate.

Governor Bruce Babbitt has appointed a Governor's Advisory Committee representing the major interests in the Valley to advise him of the study's progress. The Arizona Department of Water Resources also oversees the study on behalf of the State, and as mentioned earlier, the Technical Agency Group monitors the technical basis upon which decisions are made. In addition, an extensive public involvement program designed to solicit the ideas and reactions of interest groups and interested citizens throughout the

Valley exists. At each major decision point there will be a series of public meetings or workshops which will allow the public to review the study work to date, react to any suggestions by the agencies, and evaluate the alternatives proposed.

In effect, the decision-making process in interactive. The agencies conduct studies and develop alternatives, then test them against the reaction of the various public, governmental, technical, and interest groups, and individual citizens. Based on these reactions, the alternatives are modified or adjusted, studied further, recommendations developed, then presented to the public again. It's true that in the final analysis the agencies make the decision, but the reality is that the decision represents the product of many peoples' ideas and concerns.

ORGANIZATION

The study is organized in three major stages. Each stage represents a different level of evaluation, ranging from a preliminary evaluation during Stage I which could eliminate only those alternatives that were clearly unsuitable, to a full feasibility study of remaining alternatives in Stage III. At the end of Stages I and II decisions are made to eliminate some alternatives and carry others forward for more detailed study. At the end of Stage III a single preferred plan will be recommended.

In some ways the study is organized like the NCAA Basketball Championship. In the first round a number of competing teams are in each league, and only the best team from each league survives. Then the best teams in a region play each other, and only the best team in each region

survives. This continues through successive rounds until the champion emerges. However, if you've ever watched a tournament like this, you've probably noticed that some outstanding players are on teams that are eliminated. You may even have wondered what would happen if these outstanding players could be added to the winning team from their region, so that by the time of the finals the very best players from the entire country were in the finals.

This is exactly what we are able to do in the CAWCS. At each stage some alternatives are eliminated, but if some feature of one of the eliminated alternatives would strengthen one or more of the remaining alternatives it is also retained. In other words, at each stage the best possible alternatives have been assembled and retained.

During Stage I problems and needs were identified, the objectives of the study were defined, and a large array of possible alternatives were named. These alternatives were called elements, since few of them could solve both the flood control and regulatory storage problems alone. In effect, they were like players that would have to be combined into a team. At the end of Stage I some of the elements were eliminated because they were clearly unsuited geotechnically, were totally unrealistic economically, or simply wouldn't work.

At the beginning of Stage II each element was studied in much more detail so that the costs, engineering characteristics, and environmental and social effects were defined. But still 20 possible elements remained. If all combinations were considered, possibilities would run into the thousands. So instead, a decision was made to "screen" some of the elements. This is a little like picking only the best team from each league. Some of the elements solved the problems in the same way. In effect they were

competitive because only one or the other, never both, would be implemented since they performed the same function. The "best" of these competitive elements was selected through a process of screening. This process is described in detail in a later section of this book.

The remaining elements were then combined into systems, which would solve both the flood control and regulatory problems. An analysis was made of the cost, performance characteristics, and environmental and social effects of each of these systems. Each of these systems will work, but some provide more flood control than others, some more regulatory storage than others, while others have fewer environmental and social impacts. To assist in the decision, these values will have to be "traded." In mid-November the decision makers from each of the agencies held a "Trade-off Meeting." They were presented economic, performance, environmental, and social data, as well as comments received on the alternatives from flood control, water conservation, environmental, and Indian interests. During this meeting the agencies identified several alternatives that they felt should be carried forward into Stage III for detailed analysis. This decision was preliminary, however. Comments received in the public meetings in late November and early December could result in retaining other alternative or eliminating some of the recommended systems. Based on the public review, the local Program Managers from the agencies will develop final recommendations which will be viewed by regional management of the agencies in December-January.

In Stage III the objective is to identify a single preferred plan. The first part of this process will be to conduct a final complete analysis of the technical, economic, and institutional feasibility of each alternative. In addition, a final analysis of the environmental and social effects

of each alternative will be made and documented in a draft environmental impact statement. The choice of the "best" or preferred plan will include a number of public involvement activities in the Fall of 1981. The CAWCS schedule for Stage II is as follows:

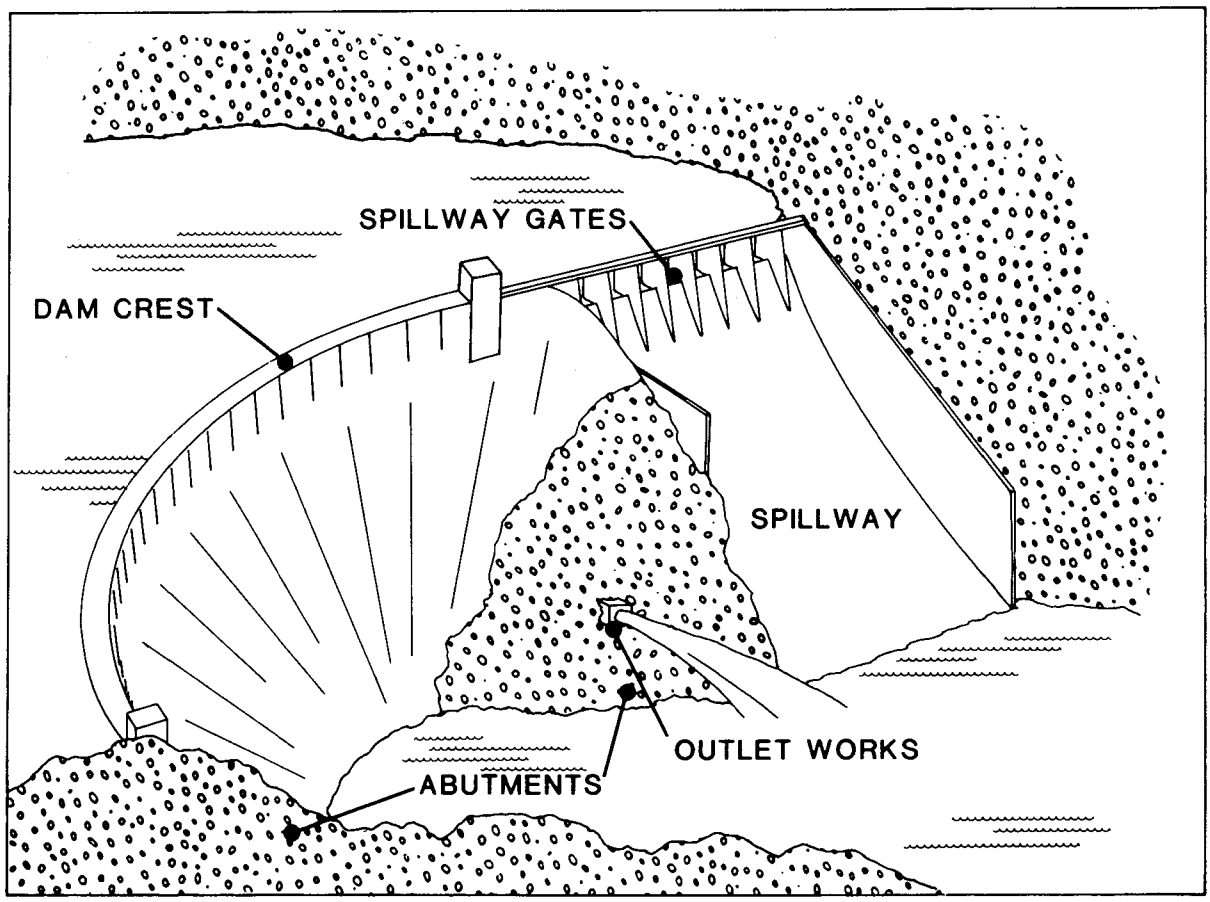
Activities	Completion Date
Stage II Decisions	December 1980
Feasibility Designs & Estimates	August 1981
Public Involvement Meetings	October 1981
Select Preferred Plan	October 1981
File Draft Environmental Impact Statement	Winter 1981
File Final Environmental Impact Statement	Late Summer 1982

SAFETY OF DAMS

During 1980 the issue of dam safety grew in importance and has the potential to substantially influence the CAWCS.

Following the failure of Teton Dam in Idaho and Toccoa Falls Dam in Georgia, the public, Congress, and the President began to show a very active interest in the safety of existing dams. In 1978, Congress passed the Reclamation Safety of Dams Act (Public Law 95-578). The Act authorized the Secretary of Interior to construct, restore, operate, and maintain new or modified features at existing Federal Reclamation dams for safety of dams purposes. While prior to the Act the Service had a regular inspection program of dams for safety, the Act increased the inspection requirements and made it easier to obtain funding for repair of dam safety problems.

To date, Roosevelt, Stewart Mountain, Bartlett, and Horseshoe Dams have received this type of inspection. Horse Mesa, Mormon Flat, and Granite Reef Dams will be inspected in December 1980. While there are some minor problems at Bartlett and Roosevelt, only Stewart Mountain Dam causes much concern. Stewart Mountain Dam is made of large concrete blocks. Because of the interaction between the concrete that was used and our climate, the bonding between the blocks has developed a layer of alkali which creates some possibility of slippage. Concern is warranted when the dam is at its highest capacity, so SRP is now operating the dam at less than full capacity and is exploring alternative ways of solving the problem permanently. Basically the dams on the Salt and Verde River are structurally sound.



In addition to field inspections, the Safety of Dams programs includes a reanalysis of the geology and drawdown capabilities for each dam and calculations for the Maximum Credible Earthquake and the Inflow Design Flood. The recalculations are made because when dealing with dam safety, it is essential to understand that failure of a dam may be catastrophic. While releasing all the water behind a dam as fast as possible would cause downstream flooding, that flooding would be small compared with the devastation that could be caused by the failure of a dam.

Our discussion will be primarily concerned with the Inflow Design Flood. In order to design a safe dam it is necessary to know what the maximum amount of water that could ever flow into the dam. The dam must either be large enough to contain the water, or have a spillway capacity large enough to pass the water along down the river. Keep in mind that where dam safety is threatened it is better to have large quantities of water passing down the river, even if it causes some downstream flooding, than it is to have a dam failure.

An Inflow Design Flood is the standard that is set for the amount of water which the dam can withstand (either by containing it or passing it on downstream). To establish this standard scientists compute the maximum possible runoff, in peak flow, that could ever occur in the watershed under extreme climatological and meteorological conditions. While it is expected that this flood is so large as never to occur, it is essential that dams be designed to withstand this flow without structural failure. In fact there have now been several instances in other parts of the United States where storms have come near to reaching the Inflow Design Flood standard.

Such storms have probably rarely occurred over the Salt and Verde watersheds, so it is unlikely that this storm has been recorded in the hundred or so years that reasonable records have been kept. So instead a model of a storm is created, poor ground conditions (such as heavy snow pack) are assumed, and the runoff rates and volumes are calculated. So the projections are not based on historical records, but on projections of what could happen. Over the years, scientists have developed sophisticated techniques for developing these projections. So while it isn't possible to check the projections out with a rain gauge (come prepared to swim), these projections are based on standard procedures which all agreed upon by the scientific community.

Our knowledge of how to project storms has increased in the past sixty-five years. In addition the recent floods have given scientists new knowledge about the storm potentials in the Central Arizona area. So when the Inflow Design Floods for the Salt and Verde Rivers were recently re-analyzed, the figures changed dramatically. The new Inflow Design Floods that are being considered are nearly triple the old ones, as shown below:

	Salt River Behind Roosevelt Dam	Verde River Behind Horseshoe Dam
Previous Inflow Design Flow	214,000 cfs	237,000 cfs
New Inflow Design Flow	680,000 cfs	760,000 cfs

Again, the reason for this dramatic change is not the result of a change in agency policy, but simply the result of improved scientific procedures and an understanding of the climatology of the Salt and Verde watersheds. In fact, the Service and Corps of Engineers each had a team working

on these projections, and working independently, they came up with approximately the same figure.

The importance of this new standard is that if the Inflow Design Flood were to occur it would overtop the dams along the Salt and Verde by 10-23 feet, as shown in Figure 1. As the dams are now, a safety problem will occur long before the IDF level is reached.

A study is currently underway to determine what actions can and should be taken. Among the options are:

1) New Spillways: The problem is not just the size of the dams, but that fact that the spillways on these dams are relatively small. These dams were designed to store water, not pass it on through in high volume, so the spillways are not large. It should be noted that installing new spillways is usually a major and very expensive proposition.

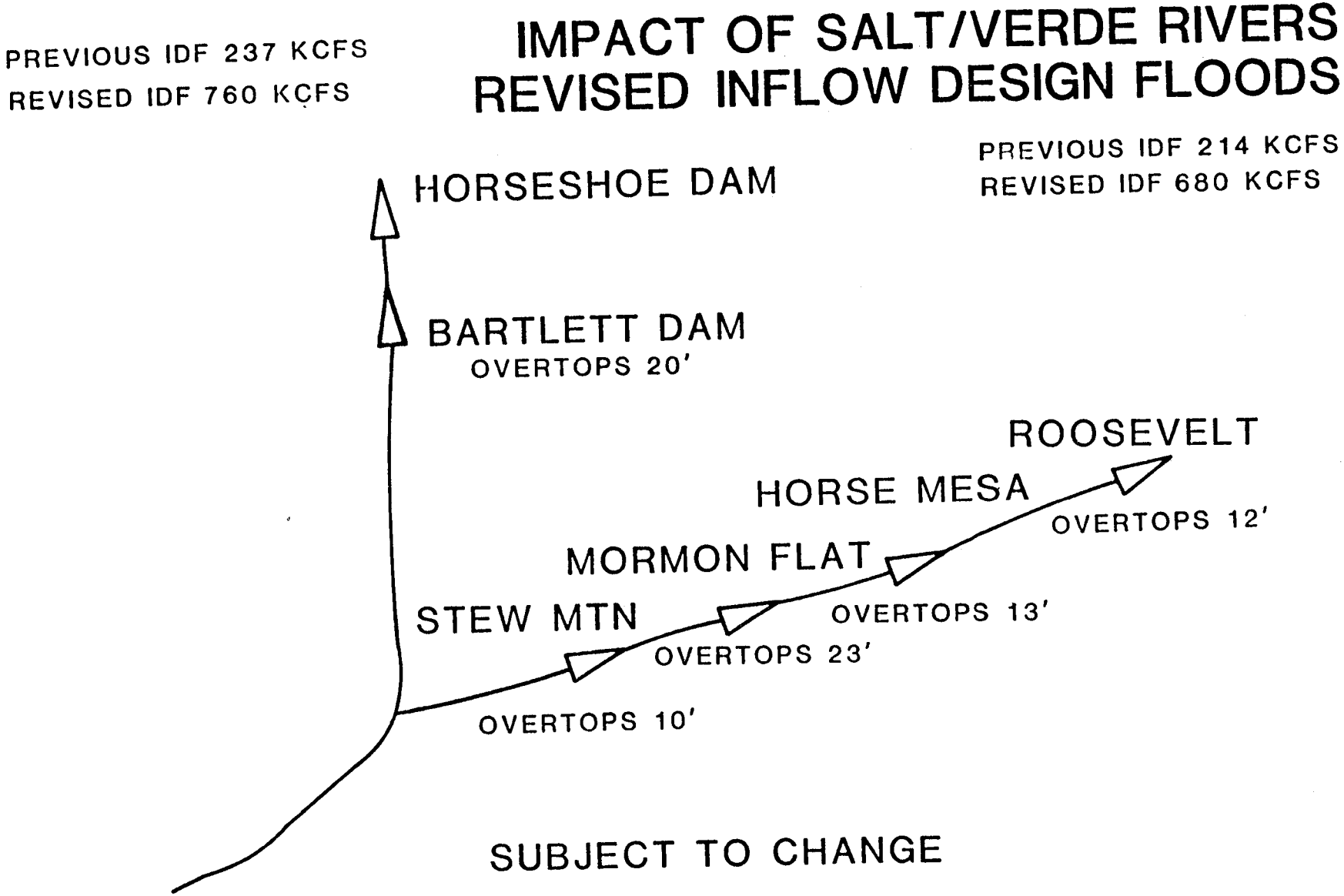
2) Raise Dams: The potential exists to raise both Bartlett and Roosevelt Dams. Again these would not be minor modifications.

3) New Dams: New dams with larger spillways and/or increased capacity could be built at the present sites of Roosevelt, Horseshoe, Bartlett, and Cliff Dams. The raising or building of new dams allows a storage cushion to prevent overtopping.

4) Revised Operating Criteria: The operating criteria could be revised to require that dams not be filled to anywhere near their present capacity, so that storage would be available in the event of the Inflow Design Flood. This would mean a

FIGURE 1

IMPACT OF SALT/VERDE RIVERS REVISED INFLOW DESIGN FLOODS



tremendous loss in the amount of water which could be provided to the Valley by the SRP.

5) No Action: Studies are underway to determine the actual effect of overtopping on these particular dams. Perhaps the concrete dams could be allowed to overtop. Earthen dams, of course, cannot.

Recommendations for action will be available by January 1981.

Some readers may be wondering what the difference is between the Inflow Design Flood, discussed above, and the Standard Project Flood (SPF) which will be referred to frequently in the following pages. The Inflow Design Flood is larger than the Standard Project Flood. The Inflow Design Flood is based on an extreme case model. The Standard Project Flood is based upon historical records. One way to view the difference is that the Inflow Design Flood is a maximum flood given what is known about the watershed. The Standard Project Flood is the largest flood that could reasonably occur at least once during the life of the project. With luck, the SPF might never occur, but the consequences of IDF, if it did occur, would be so devastating that the chance of dam failure can't be risked.

The point of emphasis is different for the two standards also. In the Standard Project Flood the concern is that the reservoir is large enough so that the amount of water passing down the river does not reach flood levels. In the Inflow Design Flood the concern is for the integrity of the dam, even if the amount of water released causes some flooding. This is the problem facing the SRP dams as their release capability is relatively low.

RELATIONSHIP BETWEEN SAFETY OF DAMS AND CAWCS

In one sense the Safety of Dams study and the CAWCS are completely separate studies. But it is also clear that they are closely interrelated since they might potentially involve the same structure. If, for example, Roosevelt Dam had to be raised 40 feet for dam safety, an additional increment up to a total of 60 feet might solve a number of flood control problems. Or to reverse the formula, a new dam on the Verde River for flood control and regulatory storage, could eliminate the safety danger to Bartlett and downstream development.

Unfortunately the two programs are not on the same time schedule. Waiting for the Safety of Dams information could delay the CAWCS three to four months, and as it is, many people are already upset with the length of the CAWCS study. Instead, the possibility of safety of dam solutions has been taken into account in the alternative systems that have been developed in Stage II. In addition, some systems may be carried forward into Stage III which would have been eliminated if only regulatory storage and flood control were factors. Fortunately, the safety of dams recommendations will come soon after the first of the year, and the CAWCS staff is confident that any needed adaptions can be made in Stage III without causing delays.

One thing which no one knows yet is the impact the safety of dams issue may have on the financing of a project. If Roosevelt Dam, for example, were raised 40 feet for dam safety, and then another 20 feet for regulatory storage and flood control, would only the final 20 feet be charged to regulatory storage or flood control? Since no major projects like this have been implemented under the 1978 Act, no one really knows the answer to

this question. These financial issues are among the many which will have to be resolved over the next few months.

DECISIONS MADE DURING STAGE I

Following the planning process described earlier, decisions--such as whether or not to retain an alternative--are made at each stage of the planning process. In Stage I decisions were made to drop some alternatives while retaining others for more study. Maps and descriptions of each of the elements considered in Stage I were included in an earlier document published by CAWCS. ("Special Edition I" - August 1979.) The list of elements that were considered in Stage I, and the decisions made about them, are summarized in Table 1.

TABLE 1

STAGE I ELEMENTS

Element	Decision: Retain	Decision: Eliminate	Reason for Elimination
VERDE RIVER			
Tangle Creek Dam		x	Geotechnical problems including hot springs deep under dam site; unsuitable foundation material for left abutment.
Modified Horseshoe Dam	x		
Cliff Dam	x		
New Bartlett Dam	x		

TABLE 1 (Continued)

Element	Decision: Retain	Decision: Eliminate	Reason for Elimination
SALT RIVER			
Carrizo Creek Dam		x	Too far upstream to provide effective flood control; no regulatory storage capability.
Klondike Buttes Dam		x	Too far upstream to provide effective flood control and no regulatory storage capability; too expensive.
Modified Roosevelt Dam	x		
Coon Bluff Dam		x	Geotechnical problems including seepage; high permeabiity.
Confluence Site (Orme Dam)	x		
Granite Reef Dam	x		
Rio Salado Low Dams		x	Upstream flood control protection required; high permeability.
AGUA FRIA RIVER			
Lake Pleasant Storage	x		
New Waddell Dam	x		
Agua Fria Dam		x	Geotechnical problems including seepage.
Calderwood Butte Dam		x	Geotechnical problems including seepage.
SKUNK CREEK, CAVE CREEK			
Expansion of North Phoenix Flood		x	Topographical conditions at these sites would

TABLE 1 (Continued)

Element	Decision: Retain	Decision: Eliminate	Reason for Elimination
Control Dams (Currently under construction)			preclude larger reservoirs.
GILA RIVER			
Coolidge Dam		x	Prohibitive cost.
Florence Dam	x		
Painted Rock Dam		x	Too far downstream to provide either flood control or regulatory storage.
Buttes Dam	x		
SANTA ROSA WASH			
Tat Momolikot	x		
CHANNELS			
Granite Reef Diversion Dam to Country Club Road		x	Lack of economic justification.
Country Club to 35th Avenue	x		
LEVEES*			
Granite Reef Diversion Dam to Country Club Road		x	Lack of economic justification.
Country Club to 35 Avenue	x		
35th Avenue to Salt-Gila River Confluence		x	Lack of economic justification.
North side of Gila from 91st Avenue to Gillespie Dam	x		

TABLE 1 (Continued)

Element	Decision: Retain	Decision: Eliminate	Reason for Elimination
CHANNEL CLEARING	x		
WATER EXCHANGES	x		
FLOODPLAIN MANAGEMENT MEASURES	x		
GROUNDWATER RECHARGE	x		
Watershed Management		x	Negligible impact**
No Action Alternative	x		Provides a baseline for comparison.

*Local levees for protection of certain areas along the rivers will be considered in Stage III.

**Vegetative management can have a limited impact on flood peaks and flows, but a number of additional factors determine the degree of impact it will have. These factors include the size of the watershed, the intensity and duration of the flow-producing storm, the season of storm occurrence, soil conditions, etc. Vegetative management has been credited for being effective on small watersheds during storms of small or medium intensities, when soil conditions are conducive to a maximumn infiltration and soil-moisture storage. Given unique character, Salt-Gila watersheds, floods might be worse with no vegetative cover, but vegetative cover cannot be depended upon to prevent the occurrence or significantly reduce the magnitude of exceptional floods. It is also not known at this time whether vegetative management would aid in replenishing the groundwater table. Cost figures are not available, but given the apparent insignificant contribution to flood control in this study, further work is not justified (Corps of Engineers Issue Paper dated 9 September 80).

DECISIONS MADE DURING STAGE II

Stage II has been divided into two phases. During the first phase the elements were studied further to determine their feasibility, their cost, and their environmental and social effects.

An extensive series of public workshops were also held to inform the public of study progress and set initial reaction to the alternatives. Specifically the public was asked: 1) Are all the alternatives covered? 2) What factors are important in evaluating alternatives? and 3) What's an acceptable level of flow along the Salt and Verde Rivers? The workshop participants generally indicated that all the major alternatives had been identified. The factors which workshop participants indicated would be most important were: flood damage reduction, protection of Indian communities, environment, project cost and transportation. It was also clear that in the metropolitan area traffic disruption was perceived as the most significant impact of flooding. The acceptable level of water flow on the Salt-Gila Rivers depended upon where people lived. Participants from the Buckeye-Phoenix area, where inundation occurred, preferred a flow of 50,000-100,000 cfs. Participants from Phoenix-Mesa-Scottsdale area preferred 200,000 cfs assuming bridges that could handle those flows.

The Screening Process

As outlined earlier, elements are the pieces which must be combined to produce a system which can solve both the regulatory storage and flood control problems. As mentioned earlier, elements are a little like players

who must be put together to make a team. The analogy does work perfectly, because some of the elements are able to solve both problems, while other-times a "team" of elements is required to solve both problems. However, the very best elements need to be selected. A coach trying to build a basketball team must choose among the best at each position before he can put together a team. He chooses the best Center, the best Guards, etc. They are competing to do the same thing, so he picks the best.

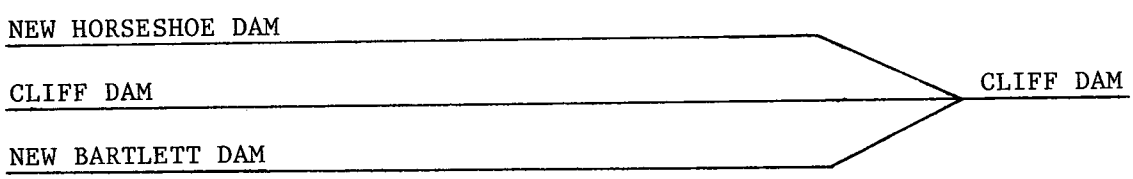
Similarily the CAWCS has "screened" the elements carried over from Stage I, and picked the best of all the competing elements. Only elements that were in competition with a better one were eliminated.

The chart below summarizes the results of the screenings. Explanations for each choice are shown on the following pages.

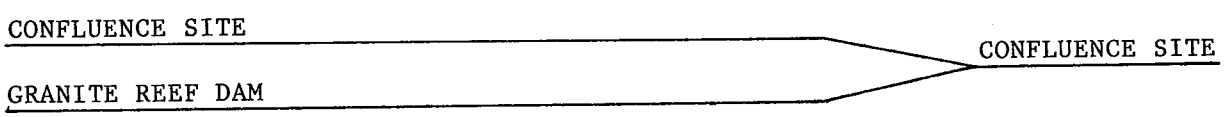
CHART 2

ELEMENT SCREENINGS

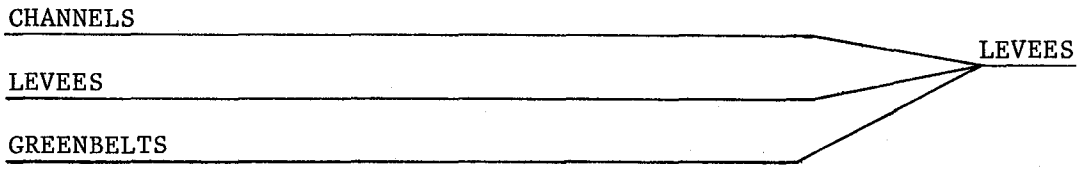
VERDE RIVER ELEMENTS



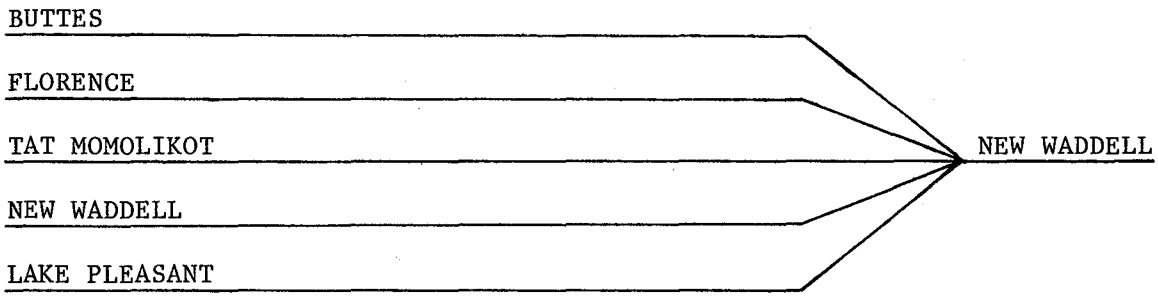
CONFLUENCE SITES



CHANNELIZATION



REGULATORY STORAGE (OFF SALT/VERDE RIVERS)



Verde River Elements - Three elements along the Verde River were investigated in the Central Arizona Water Control Study (CAWCS) for the purpose of providing control of Verde River flood flows: New Horseshoe Dam and Reservoir, Cliff Dam and Reservoir, and New Bartlett Dam and Reservoir.

Studies were performed on the Verde River elements using three sizes. These sizes are expressed in terms of the storage required to reduce the Standard Project Flood (SPF) to a maximum outflow of 10,000 cfs, 20,000 cfs, 50,000 cfs and 100,000 cfs. The smaller the outlet, the larger the reservoir and the more adverse the impact. To gain insight into the relationship between size, cost and environmental effects and for purposes of the comparison of the three elements, the 20,000 cfs size was chosen.

The analysis of the competing elements included engineering, economic, environmental, and social factors.

TABLE 2

COMPARISON OF HORSESHOE/CLIFF/BARTLETT

	Horseshoe	Cliff	Bartlett
TOTAL COST (20,000 cfs)* (million)	$161	$153	$406
ENVIRONMENTAL RANK	3	2	1
SOCIAL RANK	Equal	Equal	Equal

Note: Cliff Dam was considered to be only somewhat more adverse environmentally than Bartlett. Horseshoe was considered to be substantially more adverse than either.

*Preliminary Figures Only.

Cliff, therefore, was the selected element on the Verde River because of moderate cost and environmental impact.

Confluence Sites - A comparative analysis of the Confluence and Granite Reef dam sites was prepared to determine the relative advantage of one versus the other.

Three kinds of project actions were studied for the sites: (1) a regulatory storage (only) dam and reservoir at three sizes (100,000 acre-feet, 300,000 acre-feet, and 500,000 acre-feet of regulatory storage), (2) a flood control (only) dam and reservoir at three sizes (270,000 acre-feet, 560,000 acre-feet, and 970,000 acre-feet of flood storage); and (3) a multipurpose dam and reservoir (with 300,000 acre-feet of regulatory storage, plus 970,000 acre-feet of flood storage). All reservoirs include 47,000 acre-feet of additional inactive storage for a recreation and fish and wildlife pool. The purpose of the size and function variations is to gain insight into the relationship of size versus cost and environmental and social effects.

The factors of geology and cost significantly favor the Confluence location. The Granite Reef site has the disadvantage of a deeper, more extensive buried channel and also a longer crest length. These factors translate into a much higher cost for the dam structure. On the other hand, the Confluence site, being about 20 feet higher in elevation, would inundate a larger portion of the Fort McDowell Indian Community lands. This inundation would lead to relocations of people and homes, the number of which varies with the size of the reservoir.

For the larger reservoir sizes, there is very little difference between the two sites in terms of relocations. However, at small sizes (between 100,000 and 300,000 acre-feet), a Confluence dam and reservoir would cause significantly more relocations than would a Granite Reef dam and reservoir. Despite the apparent difference in the relocation impact for small structures at the two sites, the social assessment team of the CAWCS felt that the overall effect on the Fort McDowell Community would be the same--severe and adverse--no matter how many actual relocations occur. Due to the community's traditions and identification with the land, any permanent relocation of community members would cause serious social disruption. Relocations would mean, in essence, that the community had lost control over their lives and their land.

In the final analysis, the CAWCS staff concluded that--on the basis of geology and cost--the Confluence site was superior to the Granite Reef site. On the basis of social impacts from relocations, the effect on the Fort McDowell Community was evaluated to be equally severe, although the actual number of relocations would be fewer with the Granite Reef site for small-sized dams and reservoirs. The staff recommended that the Confluence

site be used in system building with medium-to-large size dams and reservoirs. In cases where a very small dam and reservoir might be practical, the two sites would be reevaluated to determine whether the Granite Reef site might offer any advantage in terms of reduction in the social impact to the Fort McDowell Community.

TABLE 3

COMPARISON OF CONFLUENCE AND GRANITE REEF SITES

	Confluence	Granite Reef
Can a safe dam be built?	Yes	Yes
Cost* - Large Size (970,000 af) ($ millions)	$481	$512
Cost* - Medium Size (560,000 af) ($ millions)	$355	$426
Cost* - Small Size (270,000 af) ($ millions)	$330	$406
Environmental Ranking		
- Large Size	Equal	Equal
- Medium Size	Equal	Equal
- Small Size	Equal	Equal
Social Ranking		
- Large Size	Equal	Equal
- Medium Size	Equal	Equal
- Small Size	2	1
Geological Ranking	1	2

*Preliminary Figures

Regulatory Storage (off Salt/Verde Rivers) - As a step to the development of alternative systems a comparison of regulatory storage elements not located on either the Salt or Verde Rivers was performed. The elements which fit into this category are:

1. Lake Pleasant Storage
2. New Waddell Dam
3. Florence Dam
4. Buttes Dam
5. Tat Momolikot Dam

These elements are primarily for CAP regulatory storage, although it was recognized that additional purposes could be achieved at all sites. In the cases of the Buttes and Florence Dams a clarification was necessary between regulatory storage functions and the functions which would be accomplished by a dam on the Gila River similar to the authorized Buttes Dam. An incremental analysis was prepared for those two sites to identify performance functions, costs, and impacts attributable to the regulatory storage addition. Since the baseline assumptions for the CAWCS include the construction of Buttes Dam, the question for the screening became, "Which is better from the overall CAP perspective; to construct one large dam and reservoir on the Gila River which includes regulatory storage, or to select a second regulatory storage site located somewhere else?"

Six factors were considered in the comparison of the alternatives: (1) regulatory storage performance, (2) economics, (3) environmental impacts, (4) social impacts, (5) dam safety considerations, and (6) institutional considerations. Data for each of these factors was developed according to

several appropriate categories. This data is displayed in the accompanying table.

TABLE 4

COMPARISON OF OFF-SALT/VERDE REGULATORY STORAGE ELEMENTS

	Florence	Buttes	Tat Momolikot	Lake Pleasant	New Waddell
Total Cost ($millions)	205	177	103	88	219
CAP Yield	70,100	91,000	23,800	50,000	106,600
Environmental Rank	4	5	2	1	3
Social Rank	2	1	5	3	4

Review of the data indicated that the factors of social impacts, dam safety, and institutional considerations were not as critical as the other factors. Based upon the significant impacts and results, the following conclusions were reached:

1. Tat Momolikot could not perform well enough as a regulatory storage element to justify further study in spite of relatively low environmental impacts.

2. While Florence and Buttes could serve well as regulatory storage elements, high costs were required and significant environmental impacts would result.

3. While Lake Pleasant storage was the best alternative from an economic and environmental perspective, it is limited in its ability to perform because of reservoir capacity constraints. The New Waddell site did not have this capacity limitation. The major environmental and social impacts of New Waddell are the result of the loss of the lower lake, which may be mitigatable.

Recommendation: Based upon the comparative results it is recommended that the New Waddell element should be retained for the inclusion in system formulation, and the other sites be eliminated.

Channelization - Competing channelization elements (channels, levees, greenbelt) were screened to select the preferred element. Four critical factors were used in decision making.

1) Flood Control Performance
2) Economics
3) Environmental Impacts
4) Social Impacts

Data for the critical factors were reviewed as follows:

All three elements provide the same level of protection--either SPF (300,000 cfs) or 200,000 cfs protection. Therefore, no element could be selected as "best" for this factor.

Annual damages without the project have been estimated at $25,000,000. With these annual damages, total justified cost of the project would be $340,000,000. This means that none of the downstream elements is economically justified. However, of the three, levees are the least costly, and are therefore the preferred element for this factor.

TABLE 5

COMPARISON OF CHANNELIZATION ELEMENTS

	Channels	Levees	Greenbelt
Cost (millions)	1,000	780	840

Although there are some minor differences among the elements in terms of impact, there is not enough difference to identify the best element for environmental considerations. Therefore, no rankings are provided.

In addition, none of the impacts is of a high magnitude. The biological habitat in the impact area is generally of poor quality, having been subjected to severe disruption in the without-project condition. There are no threatened and endangered species in the impact area, and no preferred habitat for these species.

Water quality impacts are all very minimal. Recreation losses are also minimal. Gains in recreation facilities which would accompany the elements are comparable. The greenbelt would offer more recreation development within the levee alignments, but the opportunity for recreational development is also great with channels, as a large portion of the floodplain would be protected from flooding and would therefore be attractive for such development.

In cultural resources, the sites in the impact area are generally of low quality, having been disturbed by flooding, development, and land modification. Any difference in impact would be in the number of sites affected. This number varies with the different elements, but is not significant.

The social impacts are generally minor, as there are no relocations involved in any of the downstream elements. All the elements would do approximately the same thing in "people" terms--tend to divide South Phoenix from the northern portion of the city.

Based on the review of critical factors, economics was seen to be the major deciding factor, as all other factors were essentially equal. Levees were therefore chosen as the preferred element because they cost less than channels or the greenbelt.

New Elements

Even though the aim was to reduce the number of elements, two elements were added during Stage II: New Roosevelt Dam and New Stewart Mountain Dam. The CAWCS originally examined raising Roosevelt Dam 20 feet

for flood control purposes. However, when dam safety concerns arose, the technical feasibility of enlarging the dam to solve safety problems and still provide flood control came into question. The CAWCS staff therefore analyzed a number of additional sites on the Salt River above the confluence, including some which had been eliminated earlier. Cost, feasibiity, and environmental and social impacts were considered. A New Roosevelt Dam and New Stewart Mountain Dam were added as possible alternatives, should raising the existing Roosevelt Dam prove infeasible. While the two elements appear to be competing, since they are both on the Salt River and could provide the same functions, each site has specific flood control, CAP storage and dam safety attributes which warrant further detailed study in Stage III.

The Remaining Elements: Building Blocks for Systems

After the various screenings and additions the following elements remain. As you can see, some of these elements provide both regulatory storage and flood control, while others provide only one. Even those that perform both functions do so to differing standards, so it is necessary to combine elements into systems which optimize the ability to provide both purposes.

	Flood Control	Regulatory Storage	Dam Safety
Confluence Dam	X	X	X
Cliff Dam	X	X	X
New/Enlarged Roosevelt Dam	X	X	X
New Stewart Mountain Dam	X	X	
Phoenix Levees	X		
Gila Levees	X		
New Waddell Dam		X	
Underground Storage		X	
SRP Reregulation	X		
Nonstructural Options (preparedness planning, relocation, SPF bridges, flood proofing, land acquisition, flood insurance, gravel mining guidelines, and floodplain zoning)	X		
Water Exchange with SRP		X	
No Action			

SYSTEM BUILDING

Again, the reason for building systems is to take advantage of the interaction effect of combining elements (or individual ball players) to get the best system (team) for the job. Good teamwork is the key since each individual element (or player) cannot stand alone and must work well with the team. The systems identified at this stage are not hard and fast but serve as examples to planners and to the public. The elements will continue to be

studied at a finer level of detail during Stage III and have the potential to be recombined for final plans.

The first step in system building was to define generic types of solutions and then build systems which fit into these concepts (see Newsletter 7 "Conceptual Systems Developed," April 1980). Control of the Salt and Verde upstream before the water gets to the Valley is the first concept. Another approach is to protect people and property through Phoenix and further downstream with no structural controls upstream. Third, a combination of some upstream control with downstream protection could be used. Another approach is through the use of existing structures, such as the SRP dams, with little or no new construction. Finally, nonstructural measures that would reduce flood damages without controlling the flow of the river will be considered. Compatible regulatory storage elements were included within each concept.

While "no action" is a possible course for the CAWCS, it is not included as a concept because it does not solve the problems of flood control and regulatory storage. Rather, it will be used as a basis of comparison in evaluating systems.

For convenience these concepts were called: (1) Salt or Verde Control, (2) Salt and Verde Control, (3) Downstream, (4) Upstream/Downstream, (5) Limited Structural, and (6) Nonstructural.

Among the factors considered in developing systems were:

- Flood Control Performance (level of protection)
- Regulatory Storage Performance (increase in CAP yield)
- Dam Safety
- Economics (cost and benefits)

- Environmental Impacts (biological resources, water quality, recreation, archaeological and historical resources)

- Social Impacts

- Institutional Constraints

Before actually describing the systems, additional background material may help you evaluate the system in your own mind:

- Not all systems under study in the CAWCS will offer the same amount of protection from floods. We are looking at various levels of protection to arrive at the "best" solution to the problems of flooding in the Central Arizona area. Consideration was given to cost estimates for each different size, level of protection, increase in CAP yield and dollar benefits provided by each size within a particular system. The size that produced the most benefits for the money was selected.

- A system has been designed so that if a Standard Project Flood occurred, flows of water downstream from the dam would be permitted at levels of 50,000, 150,000, or 200,000 cfs. A flow of 100,000 cfs is substantially contained in the present channel and therefore will provide minimum impact except upon dip crossings and riverbed quarry operations. Flows of 150,000-200,000 are comparable or slightly higher than the recent floods. Some of the impacts from flows such as these would be significantly reduced if larger bridges were built which could withstand these flows.

Another analysis will be made of the sizing of the elements during Stage III. For this reason the sizes shown in the descriptions which follow should still be considered preliminary.

- When considering the question of flood protection, there is also a slight problem of comparing apples and oranges. All the proposals which involve dams provide protection by reducing the amount of water flowing through the river. The reregulation of SRP involves essentially the same concept: existing dams are modified and operated in such a way that the downstream flow is reduced.

  Levees involve a different concept. There is no reduction in the amount of water passing through. Instead the water is passed through as quickly as possible but is contained within the levees. Levees must be built to contain a Standard Project Flood, since levees may be washed out if the water overtops.

Nonstructural solutions do not reduce the amount of water flowing through the area either. Instead buildings and facilities are removed or protected from the area where the water might flow, or constructed in such a way that they are unaffected. In effect there is still a "flood" in terms of the amount of water, but people don't suffer as much.

- Depending on the location and economics of sites, systems can accomplish regulatory storage by direct connection to the CAP aqueduct or through water exchange. With direct connection a canal would be constructed from the main aqueduct to the reservoir. Under exchange, Colorado River water would be imported during the late fall, winter, and early spring months in excess of CAP service area demands. The excess water would be used to meet some of all of SRP water demands during this period. Generally, direct connection has the advantage of yielding more CAP water than exchange, but on the other hand exchange is less costly since construction of a connecting canal is not required. To show this difference, some of the systems formed include regulatory storage by exchange, others by direct connection. But it is important to note that either method could be used in any of the Salt/Verde systems.

- Dam safety problems are found at existing dams because of higher Inflow Design Flood flows (as discussed earlier). Some of the systems developed can contribute to solving the problems on the Salt and/or Verde Rivers while some cannot. Generally, the further upstream the structure (e.g., Cliff), the more it can contribute to solving the safety problems of dams downstreams.

- All of the systems developed have varying degrees of environmental and social impacts. These impacts are described in a subsequent section.

THE STAGE II SYSTEMS

Following is a description of each of the systems which have been identified during Stage II. The systems are organized by concepts, as described earlier, e.g., all systems that control both the Salt and Verde, all systems that control either the Salt or Verde and so on. Detailed information including cost, performance characteristics, environmental and social effects is also provided.

Concept I: Salt or Verde Control

Under this concept, one structure provides both flood control and regulatory storage on either the Salt or Verde River. The difference between this concept and others is that construction would be limited to only one site and the flood control and water supply problems could be solved with a minimum number of new dams and reservoirs. However, because only one river is controlled, the systems are limited in the ability to reduce the flow downstream. Three elements, which are systems in themselves, fit this concept:

System IA: Cliff Dam

This structure would control flood flows emanating from the Verde River only and reduce the Standard Project Flood (SPF: 295,000 cfs) to 150,000 cfs at or below the confluence. An additional amount of water conservation space would be provided for CAP regulatory storage. Regulatory storage would be accomplished by means of water exchange with SRP. Cliff Dam could also be designed to solve the general dam safety problem on the Verde caused by higher inflow design flood flows because it is located upstream of Bartlett Dam and would replace Horseshoe Dam.

System IB: Enlarged Roosevelt

This system is similar to IB in providing flood control and regulatory storage by direct connection to the CAP aqueduct. As with Roosevelt, flood control for only the Salt River

would mean that Verde River flows would be uncontrolled. However, because of its location downstream of three structures on the river, only the specific safety problems at the existing dam would be eliminated by replacement of the structure.

System IC: New Stewart Mountain

This system is similar to IB in providing flood control and regulatory storage by direct connection to the CAP aqueduct. As with Roosevelt, flood control for only the Salt River would mean that Verde River flows would be uncontrolled. However, because of its location downstream of three structures on the river, only the specific safety problems at the existing dam would be eliminated by replacement of the structure.

Concept 2: Salt and Verde Control

These systems would control both the Salt and Verde Rivers either through a single structure at the Salt/Verde confluence or a combination of two structures, one on each river. Regulatory storage would be provided at the same structure or at New Waddell Dam on the Agua Fria River. Under this concept, the SPF could be controlled to a much higher degree (50,000 cfs at the confluence) because both the Salt and Verde are controlled. Five elements were combined in various ways to build the systems: Cliff Dam,

Enlarged/ New Roosevelt Dam, Confluence Dam, New Stewart Mountain Dam, and New Waddell Dam. The systems are:

System 2A: Confluence Dam

Under this system, one structure at the confluence of the Salt and Verde Rivers would control runoff from both rivers and provide regulatory storage of CAP water through direct connection to the CAP aqueduct. The dam, however, does not contribute to solving dam safety problems.

System 2B: Cliff Dam +
Enlarged Roosevelt Dam

Under this system both structures would be multi-purpose, including both flood control and regulatory storage. Cliff Dam would control the Verde River flows and Roosevelt would control the Salt River flows. While regulatory storage could be accomplished through exchange or direct connection to the CAP aqueduct, this system shows regulatory storage by exchange. Because both structures are upstream of existing structures, the new sites can be designed to eliminate safety of dams problems for all the SRP dams downstream.

System 2C: Confluence Dam +
Enlarged Roosevelt Dam

This system provides essentially the same flood control plan as 2B, except that a smaller Confluence Dam would control the Verde River. Regulatory storage space would be provided in the Confluence Dam only. Dam safety problems could be solved on the Salt River only.

System 2D: Cliff Dam + New Stewart Mountain Dam
+ New Waddell Dam

Under this system Cliff Dam on the Verde and New Stewart Mountain Dam on the Salt would be primarily flood control dams and regulatory storage would be provided at New Waddell Dam on the Agua Fria. Cliff Dam could solve dam safety problems on the Verde, but only the specific dam safety problem at the existing Stewart Mountain Dam could be solved by replacement of the structure.

Concept 3: Downstream

The downstream system relies entirely on channelization options for flood control. As no upstream reservoir storage is provided, there would be no reduction in peak flows. Rather, the system is designed to pass the flow through the area to be protected. A two-sided levee designed to contain a flow of 295,000 cfs (SPF) would provide flood control on the Salt River through Phoenix from Country Club Drive to 35th Avenue. A one-sided levee from 91st Avenue to Gillespie Dam on the Gila River would provide local westside flood protection. Regulatory storage would be provided at New Waddell Dam.

Concept 4: Upstream/Downstream

For flood control, systems under this concept combine a limited amount of upstream storage on the Salt River with levees on the Salt and Gila

Rivers downstream. These systems reduce peak flows through upstream reservoir storage, but with limited upstream storage, levees are required to handle residual flows through Phoenix. With dams on the Salt River, residual flow is such that levees would be required. Greater control can be obtained on the Verde, so levees are not as necessary. Therefore, Upstream/Downstream systems use sites on the Salt for upstream control. Regulatory storage would be included in the upstream structure. The elements used in system building were: Enlarged Roosevelt Dam, New Stewart Mountain Dam, Phoenix Levees, and Gila Levees. The systems are:

System 4A: Enlarged Roosevelt + Phoenix Levees + Gila Levee

Roosevelt Dam under this system would be multi-purpose, controlling Salt River flood flows and providing regulatory storage to the SRP Salt River system through direct connection to the CAP aqueduct. The Phoenix levees and Gila levee are needed to control flood flows emanating from the Verde River. Under this system the SPF would be reduced to 200,000 cfs.

System 4B: New Stewart Mountain Dam + Phoenix Levees + Gila Levee

This system is basically the same as 4A except that New Stewart Mountain Dam would control the Salt River flows.

Concept 5: Limited Structural

This concept takes advantage of opportunities for flood control and regulatory storage at existing storage facilities, reducing the need for new structures. Systems under this concept have the advantage of generally low construction cost and local implementation since time-consuming major construction would not be involved. However, because the systems are constrained by what exists, they are limited in their function.

Systems developed for this concept rely on SRP Reregulation for flood control and regulatory storage at an underground storage site in the Salt River channel downstream of the Granite Reef Diversion Dam.

Many variations of SRP Reregulation were examined. Two variations of limited structural systems which show differing levels of flood protection were chosen. The first variation does not involve any structural modifications to the SRP dams, while the second would include modifications to Roosevelt and Bartlett Dams.

System 5A: SRP Reregulation (without modifications) + Underground Storage

This system is designed to control the 50-year flood to 150,000 cfs. Under the system, 439,000 acre-feet of existing water storage in the SRP system on the Salt and Verde Rivers would be converted and dedicated to flood control purposes during that time period. There would be no structural changes made to the dams. Use of the dedicated flood control space would also result in a reduction of the SPF (295,000 cfs) to 230,000 cfs.

CAP regulatory storage would be accomplished at an underground storage site in the Salt River bed just downstream of Granite Reef Diversion Dam. CAP water would be pumped out of the Salt-Gila Aqueduct and released into the infiltration basins when the demand is low (fall and winter). It would be stored underground and pumped out in the high-demand spring and summer months. Dedication of existing water conservation space to flood control purposes would result in a loss of surface water resources, which would have to be offset through increased groundwater pumping. It may be possible to store a portion of the flood flows underground rather than spilling them, and pump them out for later use.

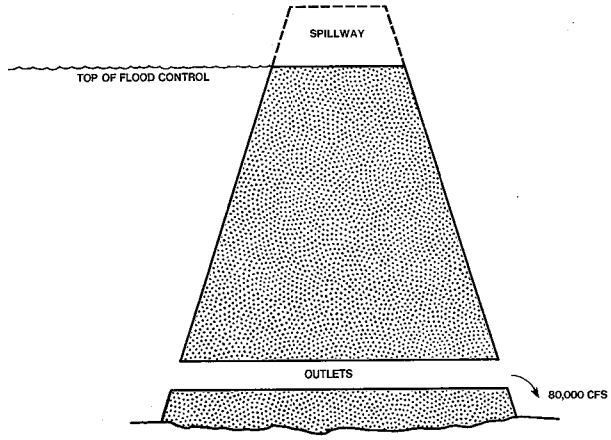
System 5B: SRP Reregulation (with modifications) + Underground Storage

With modifications to existing dams, more water storage can be dedicated to flood control purposes and reduce the peak flow to a greater extent. This system is designed to control the 100-year flood to 100,000 cfs. Under the system, 556,000 acre-feet of existing water storage on the Salt and Verde Rivers would be dedicated to flood control purposes during the flood season. New flood outlet works would be required at Roosevelt and Bartlett Dams. This system also results in a reduction of the SPF to 145,000 cfs. Regulatory storage would be provided through underground storage as described under 5A.

SRP Reregulation

The basic premise of SRP Reregulation is to modify the current operation of SRP dams to provide flood control protection. CAWCS research indicates that this is possible within limits, but that it would result in a loss of available water to the SRP system.

First, it is necessary to understand that the operation and construction of dams is very different for flood control than for water conservation. In flood control, the dam is kept as empty as possible so that the maximum amount of space is available to catch and hold the flood water. Since the priority with flood control is always to have that empty space, as soon as the storm stops or as soon as forecasting will allow, the dam is drained as rapidly as can be done without causing downstream flooding, so that the dam can protect against the next flood. For this reason, flood control dams are designed with large outlets equal to the amount of water that can be released downstream without causing flooding. If, for example, it was determined that 80,000 cfs was the safe level for discharge of water without causing downstream flooding, the outlet would be designed for 80,000 cfs and the dam could be operated so that as storm water flowed into the dam it would be discharged at 80,000 cfs throughout the storm, until the dam was drained to a pre-determined "safe" level in anticipation of the next storm. This is illustrated in the Flood Control Dam design shown in Figure 2.



FLOOD CONTROL DAM

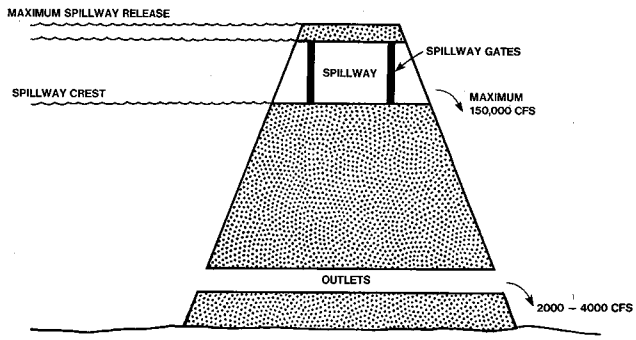
FIGURE 2

The outlet has been designed for 80,000 cfs and is located near the bottom of the dam. The dam doesn't have to be very full before it can discharge water. The size of the dam is sized so that it can contain the maximum reasonable flood (SPF) without exceeding the 80,000 cfs discharge. The spillway primarily provides a safety measure so that if the amount of inflow exceeds the storage capacity of the dam it can be discharged without endangering the integrity of the dam.

The SRP dams are not built for flood control but are built for water conservation. While flood control dams are left nearly empty, the opposite is the case with a water conservation dam. The idea in water conservation is to store water during the rainy season, then release it during the dry season.

A water conservation dam is designed differently than a flood control dam. As indicated in Figure 3, the outlet for a water conservation dam is very small, since it is primarily intended to release small quantities of water for delivery purposes. Large quantities of water can be released

only after the level of the water behind the dam reaches the spillway crest. This means that even if it is known that a storm is coming, and water should be released, only 2,000 to 4,000 cfs can be released until the storm water reaches the spillway crest.



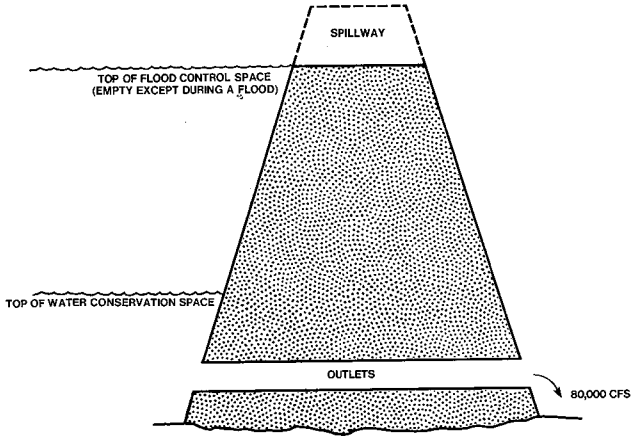
TYPICAL SRP
WATER CONSERVATION DAM

FIGURE 3

It is possible to design a dam that can be operated for flood control and regulatory storage both, as shown in Figure 4. A multi-purpose dam has substantial storage, like a flood control dam, and also has a large outlet. Unlike the flood control dam, a certain amount of water can be stored in the dam for water conservation. As the engineers describe it, a certain amount of storage is "dedicated" or "allocated" to water conservation. The remainder of the storage space is allocated to flood control, and is kept empty except during floods.

This doesn't mean that SRP dams provide no flood control: the February 1980 flood was cut by one third, even with these design limitations. In March 1978 the flood was substantially reduced by the fact that the reservoir at Roosevelt Dam was only partially full.

SRP's first responsibility is to protect the structural integrity of the dams themselves. If this means that water must be released at levels



MULTI-PURPOSE DAM

FIGURE 4

that cause flooding downstream this is unfortunate, but necessary. SRP has indicated that reducing flood damages under storm conditions is its second priority, so long as it does not interfere with the first priority of structural integrity. Its third priority is water conservation, providing drinking water, water for irrigation, and hydropower to the valley. Releases made to reduce flood damages may mean less water during the dry months, if the dams do not fill up to maximum again after the floods.

Underground Storage

Usually when we think of reservoirs, we think of dams. But in fact, by far the largest reservoirs are natural reservoirs called aquifers. Each year as rainfall occurs, some of the water permeates the ground and is contained in aquifers beneath the ground. This water stored in the ground -- "groundwater" -- can then be pumped out for use in the dry season. Arizonans pump considerably more groundwater out than is naturally restored by rainfall each year. This is referred to as "mining" the groundwater. The amount of

water which is "mined" is the amount taken out of the ground in excess of the amount which will be naturally recharged by rainfall.

The recent groundwater law passed by the State Legislature made it a matter of State of Arizona policy to bring the amount of water pumped from the ground into balance with the natural recharge from rainfall. When this is not done, there can be substantial geologic problems when land settles, threatening foundations of buildings, etc. As the level of the groundwater gets lower (referred to as the "groundwater table sinking"), there are also substantially increased energy costs to pump the water.

The idea of underground storage is to use the underground aquifers by permeating more water into the ground during the wet season and pumping it out during the dry season. In effect, underground reservoirs are being used.

This technique is currently in use in California for both water storage and salt water intrusion control. It is also being studied to increase the use of Colorado River water. There are, however, a number of technical problems that still need to be resolved. In particular, one of the principal problems in evaluating underground storage is the lack of existing hydrogeologic data. In other words, we don't know much about how and where groundwater is stored. In most cases, the actual dimensions of the aquifers are not even known. Because of this lack of data and the relatively new technology involved, experts often disagree as to whether the underground storage concept would be feasible in the CAWCS area.

There are also legal/institutional problems. An aquifer may cover many miles underground and is no respector of property lines. Water injected into the ground in one place might increase the water table so substantially as to raise the groundwater table many miles away. In most cases, under Arizona law, whoever owns the land owns the water under the land. Since it costs money to build spreading basins, injection wells, or pumps, there is a cost involved in creating the additional water supply, just as there is in building a dam. If such a project is built with federal funds, the cost of the project must be reimbursed through water sales. But if someone many miles away can pump out the water, and legally "owns" it under state law, what is the mechanism to insure that the water is paid for?

In an effort to identify a feasible underground storage plan from a technical point of view -- ducking the institutional question for the time being -- the CAWCS identified a site in the Salt River channel between the Granite Reef Diversion Dam and Tempe Buttes. Its proximity to the CAP aqueduct makes the site more advantageous as far as providing a delivery mechanism for the water once it is pumped back out.

Concept 6: Nonstructural

Nonstructural flood loss reduction measures are aimed at reducing flood damages due to development in flood-prone areas, rather than changing the flow of water. (See CAWCS Extra, "What Can You Do Besides Build a Dam?," November 1979.) The key factor to these systems is that while floods are generally allowed to occur uncontrolled, economic loss and social disruption are reduced by changing the use of floodplain. However, because flow is not

controlled, the level of protection obtained is often less than with a structural solution. One difficulty with these measures is that they do not alter flood flows, but rather involve changing human behavior. Most nonstructural measures are implemented by local groups and agencies rather than the Federal government.

Floodproofing Existing Homes - This action consists of modifying existing homes and buildings to keep water out of the structure or to reduce the damaging effects of flooding. Frequently this is done through constructing floodwalls. The Corps of Engineers can participate on an 80% federal-20% local funding of such an action. The local sponsor would have to be someone like the City of Phoenix Floodplain Management Department, other city governments, or the Flood Control District of Maricopa County.

Relocation - Relocation usually involves acquiring the land and moving the residents or users to areas outside the floodplain. Typically, the existing structures are then removed from the floodplain, or the floodplain is converted to a use compatible with the potential flooding situation. This action can be federally funded on an 80-20 cost sharing basis, but in order for this to take place, the project must be economically justified and the population must be willing to move.

Gravel Mining Guidelines - CAWCS planners are studying guidelines for gravel and mining operations in the riverbed to ensure that these operations do not result in erosion or deposition of material in the channel which could block or divert the flow of water. These guidelines would not only attempt to improve the flow of the river and minimize any adverse effects on the natural floodway, they would also be designed to prevent erosion which

could damage bridges or adjacent property. While the CAWCS will identify possible guidelines, the authority to establish such guidelines rests solely with local governments. If existing ordinances are enforced and/or new guidelines are imposed, sand and gravel companies may demand compensation for their compliance. It is not clear whether local governments would be willing to compensate them. The possibility exists to use sand and gravel operations positively, by negotiating with sand and gravel operators to channelize certain portions of the floodplain.

Salt River Bridges - Construction of larger bridges over the Salt River can reduce considerably the flood-related traffic impacts suffered by the local population. Responsibility for building these bridges belongs to city governments, the county highway department, and the Arizona Department of Transportation. Some federal assistance might be available from the Federal Highway Administration, but it is not likely to come from the Corps of Engineers.

Preparedness Planning - Enhancement of the existing flood forecasting system and plan for preparedness, and the dissemination of flood warnings to communities in the floodplain, are ways to reduce flood damages and loss of life in the CAWCS area. Implementation of such programs is the responsibility of state and local governments, although the National Weather Service might provide some assistance for the purpose of improving the area's flood warning system.

Floodplain Regulations and Flood Insurance - Individuals may choose to buy flood insurance for their floodplain property under the federally subsidized National Flood Insurance Program. Typically, this insurance is not available unless local governments have passed ordinances which meet certain

minimum standards. It is possible to pass more stringent floodplain regulations, but such decisions are solely up to state and local governments.

During Stage III, a nonstructural plan will be developed using most of the actions described above. As indicated, many of these actions must be implemented by state or local governments, so the CAWCS will simply provide information to these governmental entities regarding the options available. Many of the nonstructural actions could also be incorporated with structural systems.

Water Exchange - Since the nonstructural actions described above respond only to flood control concerns, a water exchange element has been added to this concept as a means of providing regulatory storage. It should be noted that water exchanges may be consistent with several of the structural systems as well. Water exchanges are not possible with either of the SRP Reregulation systems.

The way that water exchanges would work is that Colorado River water, in excess of the demands of the CAP service area, would be brought in during the late fall, winter, and early spring. This water would be supplied to SRP's customers during this period. Normally these demands are met by releases from the SRP system, generally from the Verde River. The water could be considered a part of SRP's CAP allotment, or it could be released back into the aqueduct for delivery to other CAP customers. The water exchange option makes several assumptions, including:

1) SRP will have vacant storage space available when it is needed;

2) SRP will require water within its own service period during the time of year when excess CAP water is available;

3) SRP would agree to hold its planned releases in storage as CAP water, and accept CAP water from the Granite Reef Aqueduct to fulfill its demand requirements.

In reality, the number of SRP exchanges which take place during the required time are quite low, so this serves as a limiting factor in this plan. As noted earlier, SRP water exchanges and SRP reregulation are not compatible. Under the water exchange plan, reservoirs would be maintained at higher levels than under the existing mode of operation. SRP reregulation would require that reservoirs be maintained at lower levels than the existing mode.

Other impacts of the water exchange plan are that hydropower production during the winter months would be reduced due to the decreased releases from the dams. Increased flows would occur during the summer months, but hydropower production would be limited by the size of the existing plants. During the winter months there would be little, if any, water flowing in the rivers under normal conditions, causing a significant impact on the flowing water recreation above Granite Reef Diversion Dam. In the summer, releases from the reservoir would be greater than normal to meet the combined SRP and CAP demands, resulting in increased flows in the rivers which could pose safety problems for tubers and other recreationists.

Implementation of water exchanges would require the construction of a pumping plant and a short aqueduct to transfer CAP water, released from the SRP system, from the Salt River at the Granite Reef Diversion Dam into the Salt-Gila Aqueduct.

Specifically, the following aspects of nonstructural solutions are being investigated:

- o Modifications to Existing Structures
  - Floodproofing to either 1, 2, or 3 feet and to the 20-year, 100*-year, or 500*-year flood levels.
  - Raising structure to either 1, 2-1/2, or 4 feet and to the 20-year, 100*-year, or 500*-year flood levels.
  - Relocation of individuals and relocation of both individuals and structures in the 20-year, 100-year, and 500-year flood levels.
- o Regulation of Future Development
  - Raise structures to the 20-year, 100-year, or 500-year floodplain.
  - No structures allowed at 20-year, 100-year, or 500-year floodplain.
  - Raise residential to 100-year and floodproof commercial and industrial to 100-year.
- o Preparedness Planning, which is a modification to existing plans
  - Additional measures in the event of catastrophic events.
  - Ways to keep the plan active and the public interested when it isn't used (such as during long dry spells).
- o Other
  - Regulation of sand and gravel mining operators so they don't cause damage to existing structures, or so they can help define the channel as mining takes place.
  - SPF bridge(s) which would keep emergency services open.

*If technically feasible.

Some of these measures could be used with all structural solutions; some can stand on their own, and others fit with other nonstructural solutions. No specific combinations have been made as yet. For regulatory storage, the nonstructural system would rely on water exchange with the existing SRP system. Although these measures are shown as a separate concept, many of

them would still be implemented even if a structural solution were selected as the preferred plan.

EVALUATION OF THE SYSTEMS

As you read through the evaluations, keep a few general points in mind.

- As noted earlier, different levels of flood control and regulatory storage are provided by the different systems. Just looking at the price tag is not enough. A cheaper system may not provide the level of protection or amount of storage needed. On the other hand, there is no need to pay for an expensive system if a cheaper one provided adequate protection.
- There are differences in who pays for the different systems. Generally speaking, the federal government would pay for the more expensive systems which would be beyond the capacity of local governments to handle. Sometimes local participation, about 20 percent, is required. That portion of the costs attributable to regulatory storage is reimbursed through the sale of water. Nonstructural solutions are more likely to be paid by local government, although the federal government can participate in relocation, land acquisition, and some forms of floodproofing. "Who pays" will be addressed in Stage III.
- Legal and institutional issues are associated with each system. In some systems these could be major barriers to implementing a

system. During Stage II we have assumed that these institutional problems could be worked out. Again, this will be addressed in detail in Stage III.

- The costs which are shown include not only construction costs, but also the costs of maintenance and operation. Just like a new car, you not only have to consider the sale price, you also have to consider whether maintenance is more expensive.
- Two annual costs are shown for each system. This is because the cost of borrowing money to build the project is included in the annual costs. Projects which Congress judges to be part of the CAP will be charged at an interest rate of 3 1/4 percent per year, since this project was authorized back in 1968 when discount rates were lower. Projects which have to receive a new authorization will be at the rate of 7 3/8 percent, which is the interest rate established by Congress for new projects. Since we don't know in advance whether the preferred alternative will be considered a part of the CAP, both rates are shown. It has to be acknowledged, however, that the fact that some projects might receive the 3 1/4 percent rate and others the 7 3/8 percent rate could affect the economic analysis in Stage III.
- You may be tempted when you see the same names, e.g., Enlarged Roosevelt, in different systems to assume the same element. If you do, the cost figures will seem inaccurate. Different sized versions of the same element are shown in different systems, so before the cost figures seem strange, check the size

of the element. As noted earlier, these sizes are still preliminary, and could be revised in Stage III in reponse to new system. During Stage II we have assumed that these institutechnical, economic or environmental data.

- Costs to meet dam safety requirements are not displayed. These costs are known for any system which is combined with a Cliff site, enlarged Roosevelt, or New Stewart Mountain. For the remaining systems, neither the dam safety solution nor the costs are known.
- Benefit/Cost: Economic justification of any project which may be constructed with federal funds is subjected to a rigorous cost/benefit analysis. Complete figures are not available at the time of this writing but an explanation of the analysis process will be helpful.

Two measures of economic efficiency are used in analyzing each of these alternative systems: benefit-to-cost ratio and net benefits. The benefit-to-cost ratio indicates whether a given proposal would return more in benefits than it would cost and is used to screen proposals for general investment acceptability. Net economic benefits are the difference between annual benefits and annual costs. The alternative system which addresses the planning objectives in a way that maximizes net economic benefits is the NED plan.

Economic benefits of flood control consist primarily of three major categories: inundation reduction, location, and intensification benefits.

Inundation reduction benefits consist of flood damages that would occur with a project compared to damages that would occur without a project. The net difference is the benefit. Flood damages are classified as physical damages or losses to residential, commercial, industrial, public, agricultural, and other unique land uses. Flood damages also include business and income losses, emergency costs, transportation delays, and savings in cost of future floodproffing.

Location benefits are derived by analyzing undeveloped land without a plan as compared with new development with a plan. The difference between aggregate net incomes is the benefit.

Intensification benefits consist of changes within present land uses, so that the land uses with a plan are more productive and efficient than without a plan. The benefit is the increased net income generated by the change.

Some additional indirect benefits will also be considered: bridge costs foregone, dam safety, advanced replacement of bridges and utilities, major rehabilitation costs foregone, water delivery costs saved, reduction of sedimentation, and savings to downstream activities.

- The environmental evaluation includes five different factors, described below:

Biology - The five major factors that are considered in the biology rankings are:

1) Loss of riparian habitat: Riparian habitat is streamside vegetation which supports a greater number of diversity of plants and animals than other forms of habitat. This type of habitat is limited and decreasing in amounts in Central Arizona and is important to the survival of a large number of resident and immigrant species. Loss of any portion of this habitat would cause a severe impact and in many instances damage some of the native species.

2) Total amount of other terrestrial habitat inundated or severely modified: In addition, there are other types of terrestrial habitat each supporting different kinds of plant and animal life. However, the single most important factor to consider with these habitats is the overall acreage which is inundated and therefore no longer available to support plant or animal life.

3) Loss of Perennial Stream: A perennial stream is a stream in which there is running water all year long. This year-round water supply supports plants and animals that otherwise would not be able to survive Central Arizona's long dry spells.

4) Amount of bald eagle and Yuma clapper rail preferred habitat affected: Both the bald eagle and Yuma clapper rail are endangered species, substantially dependent on a particular kind of habitat for survival. This factor considers the amount of preferred habitat of these two species that is adversely affected by each system.

5) The number of bald eagle nest sites in breeding grounds that will be affected: The survival of the bald eagle requires the preservation of nesting and breeding grounds. This factor indicates the number of bald eagle nesting and breeding sites that would be lost or substantially modified.

Water Quality - In water quality, the impacts are measured in terms of the increase or decrease in concentrations of total dissolved solids (TDS) as a result of mixing CAP water from the Colorado River with water from local sources, such as the Salt or Verde River. Impacts would occur both in the local water source and in the CAP delivery system, and would be influenced not only by the changes in concentrations, but also by the volume of water affected and the use of the water. Any water used for municipal and industrial purposes (M&I) would be more valuable than water used for agricultural purposes.

Recreation - Impacts in recreation considers a number of factors, among them loss or gain of flat-water facilities and resources, stream facilities and resources, and land-related facilities and resources. In addition, the number of recreation days attributed to the recreation development associated with the various systems is also important in the analysis.

Archaeological Resources - Impacts to archaeological resources considers the number of sites affected, the quality and complexity of the sites, and the approximate amount of mitigation that might be required.

Historical Resources - In historical resources, the number of sites affected is the primary basis for assessing impacts. The potential for mitigation of impacts is also considered.

Social Effects - An evaluation and ranking is also provided for the social effects provided by each system. Major social factors include relocation of families or businesses, recreation amenities gained or lost, lifestyle satisfaction, and community viability.

PERFORMANCE

Costs and performance capabilities are summarized on the following tables, pages 67-80.

ENVIRONMENTAL EFFECTS

Summaries of impacts for the disciplines of biology, water quality, recreation, archaeological resources, and historical resources are shown in Table 20. Principal investigators ranked each system within concepts (see Table 21) and met as a group to prepare composite rankings. For each system, the environmental information was reviewed and the relative weights of the various disciplines was decided by the investigators. The rankings were decided by consensus of the group.

TABLE 6

SYSTEM IA

CLIFF WITH EXCHANGE

STORAGE ALLOCATION

	Elevation	Increased Storage	Total Storage	Surface Acres
Streambed	1,810	0	0	0
Replacement	1,952	144,000	144,000	2,912
CAP Storage	1,991	150,000	294,000	4,816
Flood Control	2,043	315,000	609,000	7,332
Surcharge	2,085	360,000	969,000	9,849
Crest	2,090			
Increased CAP Yield			46,100 acre-feet	
Flood Release through Phoenix			150,000 cfs	

CONSTRUCTION COST

	7 3/8%	3 1/4%
Structure Cost	$110,920,000	$110,920,000
CAP Facility Cost	16,440,000	16,440,000
Flood Outlet Cost	86,980,000	86,980,000
Subtotal	$213,340,000	$213,340,000
IDC (4 years)	31,470,000	13,870,000
Total	$244,810,000	$227,210,000

ANNUAL COST

Annual Equivalent	$ 18,070,000	$ 7,700,000
OM and R	470,000	470,000
Pumping Energy	320,000	320,000
Energy Sales Foregone	$ 1,180,000	$ 1,180,000
Total	$ 20,040,000	$ 9,670,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $244,810,000 @ 3 1/4 $227,210,000

SYSTEM ANNUAL COST @ 7 3/8 $ 20,040,000 @ 3 1/4 $ 9,670,000

Notes: CAP Facilities Cost = cost of pumping plant at Granite Reef Div. Dam. Cost included to solve dam safety problems on Verde River but additional cost might be necessary for dam safety solution on Salt River.

TABLE 7

CONCEPT IB

MODIFIED ROOSEVELT WITH DIRECT CONNECTION

STORAGE ALLOCATION

	Elevation	Storage	Total Storage	Area
Streambed	1,902	0	0	0
Replacement	2,136	1,381,000	1,381,000	18,890
CAP Storage	2,153	372,000	1,753,000	21,962
Flood Control	2,163	230,000	1,983,000	23,719
Surcharge	2,192	756,000	2,739,000	28,474
Crest	2,196			
Increased CAP Yield			121,000 acre-feet	
Flood Release through Phoenix			200,000 cfs	

CONSTRUCTION COST

	7 3/8	3 1.4
Structure Cost	95,500,000	95,500,000
CAP Facility Cost	309,860,000	309,860,000
Flood Outlet Cost	96,200,000	96,200,000
Subtotal	501,560,000	501,560,000
IDC (3 years)	55,490,000	24,450,000
Total	557,050,000	526,010,000

ANNUAL COST

Annual Equivalent	41,120,000	17,820,000
OM and R	990,000	990,000
Pumping Energy	1,600,000	1,600,000
Energy Sales Foregone	1,720,000	1,720,000
Total	45,430,000	22,130,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $577,050,000 @ 3 1/4 $526,010,000

SYSTEM ANNUAL COST @ 7 3/8 $ 45,430,000 @ 3 1/4 $ 22,130,000

Notes: CAP Facilities Cost = Direct connect canal between CAP aqueduct and Stewart Mountain Dam + 2 relift plants.
Partial Salt River dam safety problem solved by Modified Roosevelt but additional cost could be necessary to solve remaining Salt and Verde River dam safety problems.

TABLE 8

CONCEPT IC

NEW STEWART MOUNTAIN WITH DIRECT CONNECTION

STORAGE ALLOCATION

	Elevation	Storage	Total Storage	Area
Streambed	1,410	0	0	0
Replacement	1,563	128,000	128,000	2,063
CAP Storage	1,620	160,000	288,000	3,580
Flood Control	1,672	230,000	518,000	5,240
Surcharge	1,694	124,000	642,000	6,110
Crest	1,699			
Increased CAP Yield			82,000 acre-feet	
Flood Release through Phoenix			200,000 cfs	

CONSTRUCTION COST

	7 3/8	3 1/4
Structure Cost	161,800,000	161,800,000
CAP Facility Cost	259,400,000	259,400,000
Flood Outlet Cost	135,600,000	135,600,000
Subtotal	556,800,000	556,800,000
IDC (3 years)	102,700,000	45,200,000
Total	659,500,000	602,000,000

ANNUAL COST

Annual Equivalent	48,680,000	20,400,000
OM and R	1,260,000	1,260,000
Pumping Energy	680,000	680,000
Energy Sales Foregone	710,000	710,000
Total	51,330,000	23,050,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $659,500,000 @ 3 1/4 $602,000,000

SYSTEM ANNUAL COST @ 7 3/8 $ 51,330,000 @ 3 1/4 $ 23,050,000

Notes: CAP Facilities Cost = Direction connection canal between CAP aqueduct and new dam.
New Stewart Mountain dam safety problem solved by new dam but additional cost could be nescesary to solve the remaining Salt and Verde River dam safety problems.

TABLE 9

SYSTEM 2A

CONFLUENCE

STORAGE ALLOCATION

	Elevation	Increased Storage	Total Storage	Surface Acres
Streambed	1,320	0	0	0
Replacement	1,374	47,000	47,000	2,300
CAP Storage	1,430	300,000	347,000	8,712
Flood Control	1,498	970,000	1,317,000	20,780
Surcharge	1,504	132,000	1,449,000	21,960
Crest	1,508			
Increased CAP Yield			112,000 acre-feet	
Flood Release through Phoenix			50,000 cfs	

CONSTRUCTION COST

	7 3/8%	3 1/4%
Structure Cost	$410,060,000	$410,060,000
CAP Facility Cost	44,520,000	44,520,000
Flood Outlet Cost	50,520,000	50,520,000
Subtotal	$505,100,000	$505,100,000
IDC (3 years)	93,100,000	41,000,000
Total	$598,200,000	$546,100,000

ANNUAL COST

Annual Equivalent	$ 44,150,000	$ 18,500,000
OM and R	410,000	410,000
Pumping Energy	330,000	330,000
Energy Sales Foregone	1,390,000	1,390,000
Total	$ 46,280,000	$ 20,630,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $598,200,000 @ 3 1/4 $546,100,000

SYSTEM ANNUAL COST @ 7 3/8 $ 46,280,000 @ 3 1/4 $ 20,630,000

Notes: CAP Facilities Cost = Direct connection canal between CAP aqueduct and new dam.
Feature incorporates no dam safety solutions, additional cost might be necessary to solve the Salt and Verde River dam safety problems.

TABLE 10

SYSTEM 2B

SYSTEM	Cliff				Modified Roosevelt With Exchange			
STORAGE ALLOCATION	Elevation	Increased Storage	Total Storage	Surface Acres	Elevation	Increased Storage	Total Storage	Surface Acres
Streambed	1,810	10,000	10,000	0	1,902	0	0	0
Replacement	1,956	144,000	154,000	2,912	2,136	1,381,000	1,381,000	18,890
CAP Storage	1,983	100,000	254,000	4,402	2,143	150,000	1,531,000	20,155
Flood Control	2,062	510,000	764,000	8,473	2,166	510,000	2,041,000	24,211
Surcharge	2,105	419,000	1,183,000	11,029	2,195	756,000	2,797,000	28,802
Crest	2,110				2,199			

Increased CAP Yield	SYSTEM YIELD	56,000 acre-feet
Flood Release through Phoenix	50,000 cfs	50,000 cfs

CONSTRUCTION COST

	7 3/8%	3 1/4%		7 3/8%	3 1/4%
Structure Cost	$118,070,000	$118,070,000		$ 96,000,000	$ 96,000,000
CAP Facility Cost	---- SYSTEM COST ----			18,720,000	18,720,000
Flood Outlet Cost	88,910,000	88,910,000		43,220,000	43,220,000
Subtotal	$206,980,000	$206,980,000		$157,940,000	$157,940,000
IDC (4 years)	30,530,000	13,450,000	(3 years)	17,470,000	7,700,000
Total	$237,510,000	$220,430,000		$175,410,000	$165,640,000

ANNUAL COST

Annual Equivalent	$ 17,530,000	$ 7,470,000	$ 12,950,000	$ 5,610,000
OM and R	210,000	210,000	470,000	470,000
Pumping Energy	---- SYSTEM ENERGY ----		380,000	380,000
Energy Sales Foregone	---- SYSTEM SALES ----		1,240,000	1,240,000
Total	$ 17,740,000	$ 7,680,000	$ 15,040,000	$ 7,750,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $412,920,000 @ 3 1/4 $386,070,000

SYSTEM ANNUAL COST @ 7 3/8 $ 32,780,000 @ 3 1/4 $ 15,430,000

Notes: CAP Facilities Cost = Cost for pumping plant at Granite Reef Diversion Dam.
Dam safety solutions for the Salt and Verde River are incorporated in this system.

TABLE 11

SYSTEM 2C

SYSTEM	Confluence				Modified Roosevelt			
STORAGE ALLOCATION	Elevation	Increased Storage	Total Storage	Surface Acres	Elevation	Increased Storage	Total Storage	Surface Acres
Streambed	1,320	0	0	0	1,902	0	0	0
Replacement	1,374	47,000	47,000	2,300	2,136	1,381,000	1,381,000	18,890
CAP Storage	1,450	500,000	547,000	11,750	NA	NA	NA	NA
Flood Control	1,484	510,000	1,057,000	17,840	2,159	510,000	1,891,000	23,046
Surcharge	1,490	183,000	1,240,000	19,940	2,189	756,000	2,647,000	27,982
Crest	1,494				2,193			
Increased CAP Yield		141,000 acre-feet				_____ acre-feet		
Flood Release through Phoenix		50,000 cfs				50,000 cfs		

CONSTRUCTION COST	7 3/8%	3 1/4%		7 3/8%	3 1/4%
Structure Cost	$385,080,000	$385,080,000		$ 94,500,000	$ 94,500,000
CAP Facility Cost	44,520,000	44,520,000		NA	NA
Flood Outlet Cost	45,100,000	45,100,000		43,200,000	43,200,000
Subtotal	$474,700,000	$474,700,000		$137,720,000	$137,720,000
IDC (5 years)	87,500,000	36,600,000	(3 years)	15,240,000	6,710,000
Total	$562,200,000	$513,300,000		$152,960,000	$144,430,000
ANNUAL COST					
Annual Equivalent	$ 41,500,000	$ 17,390,000		$ 11,290,000	$ 4,890,000
OM and R	410,000	410,000		210,000	210,000
Pumping Energy	340,000	340,000		NA	NA
Energy Sales Foregone	1,630,000	1,630,000		NA	NA
Total	$ 43,880,000	$ 29,770,000		$ 11,500,000	$ 5,110,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $715,160,000 @ 3 1/4 $657,730,000

SYSTEM ANNUAL COST @ 7 3/8 $ 55,380,000 @ 3 1/4 $ 34,880,000

Notes: CAP Facilities Cost = Direct connect canal between CAP aqueduct and new dam.
Dam safety solutions for Salt River incorporated at Modified Roosevelt but additional cost could be necessary to solve Verde River dam safety problems.

TABLE 12

SYSTEM 2D

SYSTEM	Cliff				New Stewart Mountain				New Waddell			
STORAGE ALLOCATION	Elevation	Increased Storage	Total Storage	Surface Acres	Elevation	Increased Storage	Total Storage	Surface Acres	Elevation	Increased Storage	Total Storage	Surface Area
Streambed	1,810	10,000	10,000	0	1,410	0	0	0	1,420	0	0	0
Replacement	1,956	144,000	154,000	3,063	1,563	128,000	128,000		1,595	157,000	157,000	3,500
CAP Storage	NA	NA	NA	NA	NA	NA	NA	NA	1,669	400,000	557,000	7,556
Flood Control	2,050	510,000	660,000	7,753	1,694	510,000	638,000	4,971	NA	NA	NA	NA
Surcharge	2,092	380,000	1,044,000	10,262	1,716	148,000	786,000	7,046	1,680	93,000	650,000	8,570
Crest	2,997				1,721				1,684			
Increased CAP Yield		NA acre-feet				NA acre-feet					100,000 acre-feet	
Flood Release through Phoenix		50,000 cfs				50,000 cfs					NA cfs	
CONSTRUCTION COST		7 3/8%	3 1/4%			7 3/8%	3 1/4%			7 3/8%	3 1/4%	
Structure Cost		$128,000,000	$128,080,000			$159,800,000	$159,800,000			$147,700,000	$147,700,000	
CAP Facility Cost		NA	NA			NA	NA			53,300,000	53,300,000	
Flood Outlet Cost		68,000,000	68,000,000			75,400,000	75,400,000			NA	NA	
Subtotal		$196,000,000	$196,000,000			$235,200,000	$235,200,000			$201,000,000	$201,000,000	
IDC (4 years)		28,910,000	12,740,000		(3 years)	43,400,000	19,100,000		(5 years)	37,060,000	16,330,000	
Total		$224,910,000	$208,740,000			$278,600,000	$254,300,000			$238,060,000	$217,330,000	
ANNUAL COST												
Annual Equivalent		$ 16,600,000	$ 7,070,000			$ 20,560,000	$ 8,620,000			$ 17,570,000	$ 7,360,000	
OM and R		210,000	210,000			210,000	210,000			690,000	690,000	
Pumping Energy		NA	NA			NA	NA			760,000	760,000	
Energy Sales Foregone		NA	NA			NA	NA			2,020,000	2,020,000	
Total		$ 16,810,000	$ 7,280,000			$ 20,770,000	$ 8,830,000			$ 21,040,000	$ 10,830,000	

SYSTEM CONSTRUCTION COST @ 7 3/8 $741,570,000 @ 3 1/4 $680,370,000

SYSTEM ANNUAL COST @ 7 3/8 $ 58,620,000 @ 3 1/4 $ 26,940,000

Notes: CAP Facilities Cost = Cost of direct connect canal between CAP aqueduct and dam.
Dam safety solutions on Verde and at Stewart Mountain Dam incorporated in Cliff and New Stewart Mountain but additional cost could be necessary for remaining Salt River Dam safety problems.

TABLE 13

SYSTEM 3

SYSTEM	New Waddell				Phoenix Levees		Gila Levee	
STORAGE ALLOCATION								
	Elevation	Increased Storage	Total Storage	Surface Acres				
Streambed	1,420	0	0	0				
Replacement	1,595	157,000	157,000	3,500				
CAP Storage	1,669	400,000	557,000	7,556				
Flood Control	NA	NA	NA	NA				
Surcharge	1,680	93,000	650,000	8,570				
Crest	1,684							
Increased CAP Yield		100,000 acre-feet				acre-feet		acre-feet
Flood Release through Phoenix		NA cfs				300,000 cfs		300,000 cfs
CONSTRUCTION COST								
		7 3/8%	3 1/4%		7 3/8%	3 1/4%	7 3/8%	3 1/4%
Structure Cost		$147,700,000	$147,700,000		$705,500,000	$705,500,000	$467,300,000	$467,300,000
CAP Facility Cost		53,300,000	53,300,000		NA	NA	NA	NA
Flood Outlet Cost		NA	NA		NA	NA	NA	NA
Subtotal		$201,000,000	$201,000,000		$705,500,000	$705,500,000	$467,300,000	$467,300,000
IDC (5 years)		37,060,000	16,330,000		81,600,000	34,400,000	54,000,000	22,800,000
Total		$238,060,000	$217,330,000		$787,100,000	$739,900,000	$521,300,000	$490,100,000
ANNUAL COST								
Annual Equivalent		$ 17,570,000	$ 7,360,000		$ 58,100,000	$ 25,070,000	$ 38,480,000	$ 16,600,000
OM and R		690,000	690,000		19,950,000	19,950,000	16,670,000	16,670,000
Pumping Energy		760,000	760,000		NA	NA	NA	NA
Energy Sales Foregone		2,020,000	2,020,000		NA	NA	NA	NA
Total		$ 21,040,000	$ 10,830,000		$ 78,050,000	$ 45,020,000	$ 55,150,000	$ 33,270,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $1,546,460,000 @ 3 1/4 $1,447,230,000

SYSTEM ANNUAL COST @ 7 3/8 $ 154,240,000 @ 3 1/4 $ 89,120,000

Notes: CAP Facilities Cost = Direct connect canal between CAP aqueduct and new dam.
No dam safety solution incorporate additional cost could be necessary to solve dam safety problems on Salt and Verde Rivers.

TABLE 14

SYSTEM 4A

SYSTEM	Modified Roosevelt with Direct Connect		Phoenix Levees		Gila Levee	
STORAGE ALLOCATION						
	Elevation	Increased Storage	Total Storage	Surface Acres		
Streambed	1,902	0	0	0		
Replacement	2,136	1,381,000	1,381,000	18,890		
CAP Storage	2,153	372,000	1,753,000	21,962		
Flood Control	2,163	230,000	1,983,000	23,719		
Surcharge	2,192	756,000	2,739,000	28,474		
Crest	2,196					
Increased CAP Yield	121,000 acre-feet		_____ acre-feet		_____ acre-feet	
Flood Release through Phoenix	200,000 cfs		200,000 cfs		_____ cfs	
CONSTRUCTION COST						
	7 3/8%	3 1/4%	7 3/8%	3 1/4%	7 3/8%	3 1/4%
Structure Cost	$ 95,500,000	$ 95,500,000	$583,500,000	$583,500,000	$425,100,000	$425,100,000
CAP Facility Cost	309,860,000	309,860,000	NA	NA	NA	NA
Flood Outlet Cost	96,200,000	96,200,000	NA	NA	NA	NA
Subtotal	$501,560,000	$501,560,000	$583,500,000	$583,500,000	$425,100,000	$425,100,000
IDC	55,490,000	24,450,000	67,500,000	37,900,000	49,100,000	27,600,000
Total	$557,050,000	$526,010,000	$651,000,000	$621,400,000	$474,200,000	$452,700,000
ANNUAL COST						
Annual Equivalent	$ 41,120,000	$ 17,820,000	$ 48,050,000	$ 21,050,000	$ 35,000,000	$ 15,340,000
OM and R	990,000	990,000	16,030,000	16,030,000	13,120,000	13,120,000
Pumping Energy	1,600,000	1,600,000	NA	NA	NA	NA
Energy Sales Foregone	1,720,000	1,720,000	NA	NA	NA	NA
Total	$ 45,430,000	$ 22,130,000	$ 64,080,000	$ 37,080,000	$ 38,120,000	$ 28,460,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $1,682,250,000 @ 3 1/4 $1,600,110,000

SYSTEM ANNUAL COST @ 7 3/8 $ 147,630,000 @ 3 1/4 $ 87,670,000

Notes: CAP Facilities Cost = Direct connect canal between CAP aqueduct and New Stewart Mountain dam + 2 relift plants.
Partial Salt River dam safety problem solved by Modified Roosevelt but additional cost could be necessary to solve remaining Salt and Verde River dam safety problems.

TABLE 15

SYSTEM 4B

SYSTEM	New Stewart Mountain with Direct Connect				Phoenix Levees		Gila Levee	
STORAGE ALLOCATION	Elevation	Increased Storage	Total Storage	Surface Acres				
Streambed								
Replacement								
CAP Storage								
Flood Control								
Surcharge								
Crest								
Increased CAP Yield		82,000 acre-feet				acre-feet		acre-feet
Flood Release through Phoenix		200,000 cfs				200,000 cfs		200,000 cfs
CONSTRUCTION COST								
		7 3/8%	3 1/4%		7 3/8%	3 1/4%	7 3/8%	3 1/4%
Structure Cost		$161,800,000	$161,800,000		$583,500,000	$583,500,000	$425,100,000	$425,100,000
CAP Facility Cost		259,400,000	259,400,000		NA	NA	NA	NA
Flood Outlet Cost		135,600,000	135,600,000		NA	NA	NA	NA
Subtotal		$556,800,000	$556,800,000		$583,500,000	$583,500,000	$425,100,000	$425,100,000
IDC		102,700,000	45,200,000		67,500,000	37,900,000	49,100,000	27,600,000
Total		$659,500,000	$602,000,000		$651,000,000	$621,400,000	$474,200,000	$452,700,000
ANNUAL COST								
Annual Equivalent		$ 48,680,000	$ 20,400,000		$ 48,050,000	$ 21,050,000	$ 35,000,000	$ 15,340,000
OM and R		1,260,000	1,260,000		16,030,000	16,030,000	13,120,000	13,120,000
Pumping Energy		680,000	680,000		NA	NA	NA	NA
Energy Sales Foregone		710,000	710,000		NA	NA	NA	NA
Total		$ 51,330,000	$ 23,050,000		$ 64,080,000	$ 37,080,000	$ 38,120,000	$ 28,460,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $1,784,700,000 @ 3 1/4 $1,676,100,000

SYSTEM ANNUAL COST @ 7 3/8 $ 153,530,000 @ 3 1/4 $ 88,590,000

Notes: CAP Facilities Cost = Direction connection canal between CAP aqueduct and new dam.
Stewart Mountain dam safety problem solved by new dam but additional cost could be necessary to solve the remaining Salt and Verde River dam safety problems.

TABLE 16

SYSTEM 5A

SYSTEM	Reregulation		Underground Storage	
STORAGE ALLOCATION				
Water Loss to SRP System 88,000 acre-feet per year @ $45 per acre-foot = $3,960,000				
Hydropower loss to SRP System 41,000 acre-feet per year @ $20 per acre-foot = $ 820,000				
Increased CAP Yield	NA acre-feet		63,000 acre-feet	
Flood Release through Phoenix	230,000 cfs		NA cfs	
CONSTRUCTION COST				
	7 3/8%	3 1/4%	7 3/8%	3 1/4%
Structure Cost			$ NA	$ NA
CAP Facility Cost			101,170,000	101,170,000
Flood Outlet Cost			NA	NA
Subtotal			$101,170,000	$101,170,000
IDC			11,190,000	4,930,000
Total			$112,360,000	$106,100,000
ANNUAL COST				
Annual Equivalent	$ 4,780,000	$ 4,780,000	$ 8,290,000	$ 3,590,000
OM and R	NA	NA	440,000	440,000
Pumping Energy	NA	NA	1,050,000	1,050,000
Energy Sales Foregone	NA	NA	1,340,000	1,340,000
Total	$ 4,780,000	$ 4,780,000	$ 11,120,000	$ 6,420,000
SYSTEM CONSTRUCTION COST	@ 7 3/8 $112,360,000	@ 3 1/4 $106,100,000		
SYSTEM ANNUAL COST	@ 7 3/8 $ 15,900,000	@ 3 1/4 $ 11,200,000		

Notes: CAP Facilities Cost = Recharge and delivery system located in Salt River bed below Granite Reef.
No dam safety solution with this system; additional cost could be necessary to solve the dam safety problem on Salt and Verde Rivers.

TABLE 17

SYSTEM 5B

SYSTEM	Reregulation With Modification		Underground Storage	
STORAGE ALLOCATION				
Water Loss to SRP System 113,000 acre-feet per year @ $45 per acre-foot = $5,085,000				
Hydropower loss to SRP System 42,000 acre-feet per year @ $20 per acre-foot = $ 840,000				
Increased CAP Yield	NA acre-feet		63,000 acre-feet	
Flood Release through Phoenix	145,000 cfs		NA cfs	
CONSTRUCTION COST				
	7 3/8%	3 1/4%	7 3/8%	3 1/4%
Structure Cost	$ NA	$ NA	$ NA	$ NA
CAP Facility Cost	NA	NA	101,170,000	101,170,000
Flood Outlet Cost	79,200,000	79,200,000	NA	NA
Subtotal	$ 79,200,000	$ 79,200,000	$101,170,000	$101,170,000
IDC	8,800,000	3,900,000	11,190,000	4,930,000
Total	$ 88,000,000	$ 73,100,000	$112,360,000	$106,100,000
ANNUAL COST				
Annual Equivalent	$ 12,420,000	$ 8,400,000	$ 8,290,000	$ 3,590,000
OM and R	NA	NA	440,000	440,000
Pumping Energy	NA	NA	1,050,000	1,050,000
Energy Sales Foregone	NA	NA	1,340,000	1,340,000
Total	$ 12,420,000	$ 8,400,000	$ 11,120,000	$ 6,420,000
SYSTEM CONSTRUCTION COST	@ 7 3/8 $200,360,000	@ 3 1/4 $179,200,000		
SYSTEM ANNUAL COST	@ 7 3/8 $ 23,540,000	@ 3 1/4 $ 14,820,000		

Notes: CAP Facilities Cost = Recharge and delivery system located in Salt River bed below Granite Reef.
No dam safety solution with this system; additional cost could be necessary to solve the dam safety problem on Salt and Verde Rivers.

TABLE 18

SYSTEM 6

SRP EXCHANGE

STORAGE ALLOCATION

	Elevation	Increased Storage	Total Storage	Surface Acres
Streambed				
Replacement				
CAP Storage				
Flood Control				
Surcharge				
Crest				
Increased CAP Yield			14,000 acre-feet	
Flood Release through Phoenix			NA cfs	

CONSTRUCTION COST

	7 3/8%	3 1/4%
Structure Cost	$ NA	$ NA
CAP Facility Cost	1,200,000	1,200,000
Flood Outlet Cost	NA	NA
Subtotal	$ 1,200,000	$ 1,200,000
IDC	130,000	60,000
Total	$ 1,330,000	$ 1,260,000

ANNUAL COST

Annual Equivalent	$ 98,000	$ 43,000
OM and R	240,000	240,000
Pumping Energy	210,000	210,000
Energy Sales Foregone	$ 840,000	$ 840,000
Total	$ 1,388,000	$ 1,333,000

SYSTEM CONSTRUCTION COST @ 7 3/8 $1,330,000 @ 3 1/4 $1,260,000

SYSTEM ANNUAL COST @ 7 3/8 $1,388,000 @ 3 1/4 $1,333,000

Notes: CAP Facilities Cost = Pumping plant at Granite Reef Diversion Dam. No dam safety solution with this system; additional cost could be necessary to solve the dam safety problems on Salt and Verde Rivers.

TABLE 19

SYSTEMS PERFORMANCE SUMMARY

SYSTEM	DESCRIPTION	REGULATORY STORAGE AVG. ANNUAL INCREASE IN CAP WATER SUPPLY (acre-ft)	PROJECTED FLOOD CONTROL AT CONFLUENCE (cu ft per sec)	DAM SAFETY		COSTS (million $) rounded to nearest million			
				Problems Solved by the System	Problems Not Solved by the System	Construction		Annual Cost	
						7 3/8%	3 1/4%	7 3/8%	3 1/4%
1A	Cliff + Water Exchange	46,000	150,000	Bartlett, Horseshoe	Roosevelt, Horse Mesa Mormon Flat, Stewart Mt.	245	227	20	10
1B	Enlarged Roosevelt + Direct Connection	121,000 (47,000 w/water exchange instead)	200,000	Roosevelt, Horse Mesa, Mormon Flat, Stewart Mt.	Bartlett, Horseshoe	577	526	45	22
1C	New Stewart Mt. + Direct Connection	82,000 (46,000 w/water exchange instead)	200,000	Stewart Mt.	Horseshoe, Bartlett, Roosevelt, Mormon Flat, Horse Mesa	660	600	51	23
2A	Confluence	112,000	50,000	None	All dams on Salt and Verde	598	546	46	21
2B	Cliff + Enlarged Roosevelt + Water Exchange	56,000	50,000	All dams on Salt and Verde	None	413	386	33	15
2C	Confluence + Enlarged Roosevelt + Direct Connection	141,000	50,000	Roosevelt, Horse Mesa, Mormon Flat, Stewart Mt.	Horseshoe, Bartlett	715	658	55	35
2D	Cliff + New Stewart Mt. + New Waddell	100,000	50,000	Bartlett, Horseshoe,	Roosevelt, Mormon Flat, Horse Mesa	742	680	59	27
3	Levees + New Waddell	100,000	300,000	None	All dams on Salt and Verde	1546	1447	154	89
4A	Enlarged Roosevelt + Levees + Direct Connection	121,000	200,000	Roosevelt, Horse Mesa, Mormon Flat, Stewart Mt.	Horseshoe, Bartlett	1682	1600	148	88
4B	New Stewart Mt. + Levees + Direct Connection	82,000	200,000	Stewart Mt.	Horseshoe, Bartlett, Roosevelt, Mormon Flat, Horse Mesa	1785	1676	154	89
5A	SRP Reregulation (w/o modifications + Underground Storage)	63,000 (reduces SRP water by 88,000 af)	230,000	None	All dams on Salt and Verde	112	106	16	11
5B	SRP Reregulation (w/modifications + Underground Storage)	63,000 (reduces SRP water by 113,000 af)	145,000	None	All dams on Salt and Verde	200	179	24	15
6	Nonstructural + SRP Exchange	14,500	300,000	None	All dams on Salt and Verde	1*	1*	1*	1*

NOTE: Minor modifications required at existing Stewart Mountain even with upstream storage on Salt for dam safety.
* Costs reflect SRP exchange only. Additional costs could be incurred depending on the final plan.

TABLE 20

IMPACTS* SUMMARY: CONCEPT I

SYSTEM	BIOLOGY	WATER QUALITY	RECREATION	ARCHAEOLOGICAL RESOURCES	HISTORICAL RESOURCES
A - Cliff (with Water Exchange)	960 acres riparian habitat inundated; 5,450 total acres of habitat inundated; loss of 10 miles of perennial stream with altered flow in 37 additional miles; loss of 220 acres preferred habitat, 1 bald eagle nest site and possibly adverse effect on 3 breeding sites. ADVERSE FLAG**	Average TDS concentrations decrease 68 mg/l in CAP water, increase 84 mg/l in local surface water.	Exchange affects Verde flows and may inhibit tubing; 364,000 annual recreation days added; 10 stream-miles lost; 4,200 acres of surface water added.	44 sites affected by construction, 278 by inundation; 359 indirectly: total of 681 sites. Sites are important but not unique.	5 sites would be affected, none of which are "problem sites."
B - Raised Roosevelt	1,400 acres riparian habitat inundated; 7,950 total acres of habitat inundated; loss of 4 miles of perennial stream; loss of 130 acres preferred habitat.	Average TDS concentrations decrease 43 mg/l in CAP water, increase 85 mg/l in SRP System.	613,000 annual recreation days added; 4 stream-miles lost in area being studied for designation in Wild and Scenic River System; 6,500 acres of surface water added.	17 sites affected by construction, 219 by inundation; 1,076 indirectly: total of 1,312 sites. Roosevelt sites are unique. ADVERSE FLAG	25 sites would be affected. Problem site is Roosevelt Dam, a National Historic Landmark. ADVERSE FLAG
C - New Stewart Mountain	670 acres riparian habitat inundated; 4,870 total acres of habitat inundated.	Average TDS concentrations decrease 44 mg/l in CAP water, increase 71 mg/l in SRP System.	Saguaro Lake drained during construction; 418,000 annual recreation days added; no stream segments affected; 3,000 acres of surface water added.	21 sites affected by construction, 85 by inundation, 320 indirectly: total of 426 sites. Sites are important but not unique.	13 sites would be affected, none of which are "problem sites."

*Impacts were assessed without mitigation.
**ADVERSE FLAG indicates extremely adverse impacts, usually with legal implications.

TABLE 20 (Continued)

IMPACTS* SUMMARY: CONCEPT II

SYSTEM	BIOLOGY	WATER QUALITY	RECREATION	ARCHAEOLOGICAL RESOURCES	HISTORICAL RESOURCES
A - Confluence	4,300 acres riparian habitat affected; 21,340 total acres of habitat inundated; loss of 22 miles of perennial stream; loss of 280 acres preferred habitat, 3 bald eagle nesting sites and 2 breeding sites. ADVERSE FLAG**	Average TDS concentrations decrease 121 mg/l in CAP water, increase 73 mg/l in local surface water. Large volume of Salt/Verde water affected, some is used for M&I.	Loss of 8 stream-miles on Salt River used for tubing; increase in flat-water resources (21,000 acres), 771,000 annual recreation days added. ADVERSE FLAG	16 sites affected by construction, 115 by inundation; 72 indirectly: total of 203 sites. High quality resources at Confluence would be affected.	Loss of 55 sites. Problem sites are the Fort McDowell Military Post and the Fort McDowell Community. ADVERSE FLAG
B - Cliff + Raised Roosevelt	2,370 acres riparian habitat affected; 13,490 total acres of habitat inundated; loss of 14 miles of perennial stream, with potential flow depletion in 37 additional miles; loss of 400 acres of preferred habitat, 1 bald eagle nesting site, possibly adverse effect on 3 breeding sites. ADVERSE FLAG	Average TDS concentrations decrease 68 mg/l in CAP water and increase 84 mg/l in local surface water. Relatively small volume of Verde water affected, some of which is used for M&I.	Variability of Verde flows (potential impact on tubing), increase in flat-water resources (12,400 acres), loss of 14 stream-miles (not used for tubing), 977,000 annual recreation days added.	52 sites affected by construction, 543 by inundation; 1,260 indirectly: total of 1,855 sites. Z High quality resources at Cliff and unique resources at Roosevelt would be affected. ADVERSE FLAG	Loss of 29 sites. Problem site is Roosevelt Dam, a National Historic Landmark. ADVERSE FLAG
C - Confluence + Raised Roosevelt	5,500 acres riparian habitat affected; 24,570 total acres of habitat inundated; loss of 27 miles of perennial stream; loss of 400 acres of preferred habitat, 3 bald eagle nesting sites and 2 breeding sites. ADVERSE FLAG	Average TDS concentrations decrease 119 mg/l in CAP water and increase 104 mg/l in local surface water. Large volume of Salt/Verde water affected, some of which is used for M&I.	Loss of 8 stream-miles on Salt River used for tubing, increase in flat-water resources (24,000 acres). 1,348,000 annual recreation days added. ADVERSE FLAG	24 sites affected by construction, 345 by inundation, 1,008 indirectly: total of 1,377 sites. High quality resources at Confluence and unique resources at Roosevelt would be affected. ADVERSE FLAG	Loss of 75 sites. Problem sites are Roosevelt Dam, Fort McDowell Military Post and Fort McDowell Community. ADVERSE FLAG
D - Cliff + New Stewart Mountain + New Waddell	1,690 acres riparian habitat affected; 18,160 total acres of habitat inundated; loss of 10 miles of perennial stream; loss of 230 acres of preferred habitat and 1 bald eagle nesting site. ADVERSE FLAG	Average TDS concentrations decrease 8 mg/l in CAP water and increase 466 mg/l in local surface water. Small volume of Agua Fria water affected, all of which is used for agriculture.	Loss of 10 stream-miles on the Verde, increase of flat-water resources (12,200 acres), loss of Lower Lake Waddell, Saguaro Lake drained during construction, 1,782,300 days added.	66 sites affected by construction, 375 by inundation, 797 indirectly: total of 1,238 sites. High quality resources at Cliff and New Stewart Mountain and low quality resources at New Waddell affected.	Loss of 27 sites. No problem sites.

*Impacts were assessed without mitigation.
**ADVERSE FLAG indicates extremely adverse impacts, usually with legal implications.

TABLE 20 (Continued)

IMPACTS* SUMMARY: CONCEPTS III AND IV

CONCEPT/SYSTEM	BIOLOGY	WATER QUALITY	RECREATION	ARCHAEOLOGICAL RESOURCES	HISTORICAL RESOURCES
CONCEPT III:					
A - Phoenix Levees + Gila Levee + New Waddell	490 acres riparian habitat and 10,030 acres total habitat affected. No stream-miles, acres of preferred habitat, or threatened/endangered nesting/breeding areas affected.	Average TDS concentrations decrease 8 mg/l in CAP water and increase 446 mg/l in local surface water. Relatively small volume of water affected, all of which is used for agriculture.	Loss of Lower Lake Pleasant, increase in flat-water resources (3,360 acres), 1,000,000 annual recreation days added.	25 sites would be affected by construction, 14 sites by inundation, 155 indirectly: total of 194 sites. Low and medium quality resources would be affected.	Loss of 24 sites. No problem sites.
CONCEPT IV:					
A - Raised Roosevelt + Phoenix Levees + Gila Levee	1,740 acres riparian habitat and 11,750 total acres of habitat affected; loss of 4 stream-miles and 130 acres of preferred habitat. No threatened/endangered nesting/breeding areas affected.	Average TDS concentrations decrease 43 mg/l in CAP water and increase 46 mg/l in local surface water. Relatively large volume of Salt River water affected, some of which is used for M&I.	Loss of 4 stream-miles on Upper Salt (possible Wild and Scenic River designation), increase in flat-water resources (6,100 acres), 613,000 annual recreation days added.	35 sites would be affected by construction, 219 sites by inundation, and 1,157 inundation, and 1,157 indirectly: total of 1,411 sites. Unique resources at Roosevelt would be affected. ADVERSE FLAG**	Loss of 40 sites. Problem site is Roosevelt Dam, a National Historic Landmark. ADVERSE FLAG
B - New Stewart Mountain + Phoenix Levees + Gila Levee	960 acres riparian habitat and 8,980 total acres of habitat affected.	Average TDS concentrations decrease 44 mg/l in CAP water and increase 26 mg/l in local surface water. Smaller volume of Salt River water affected by this system than System A.	Saguaro Lake drained during construction, no flowing stream segments permanently affected, increase in flat-water resources (3,900 acres), 418,300 annual recreation days added.	39 sites would be affected by construction, 85 sites by inundation, and 401 sites indirectly: total of 525 sites. High quality resources in the New Stewart Mountain area and medium quality resources in the Salt River floodplain would be impacted.	Loss of 28 sites. No problem sites.

*Impacts were assessed without mitigation.
**ADVERSE FLAG indicates extremely adverse impacts, usually with legal implications.

TABLE 20 (Continued)

IMPACTS* SUMMARY: CONCEPTS V AND VI

CONCEPT/SYSTEM	BIOLOGY	WATER QUALITY	RECREATION	ARCHAEOLOGICAL RESOURCES	HISTORICAL RESOURCES
CONCEPT V:					
A - SRP Reregulation (without modification) + Underground Storage	70 acres of riparian habitat and 1,450 total acres of habitat affected; potential depletion of 35 miles of perennial stream; adverse impact to 10 acres of preferred habitat and assuming flow depletion possible adverse impact on 2 bald eagle breeding areas. ADVERSE FLAG**	No impacts.	Lowering of reservoirs detracts from recreational use along shorelines; variation in Salt/Verde flows (potential tubing impact); potential of no flow in Verde in dry years.	53 sites affected by construction (underground storage area) and 71 indirectly: total of 124 sites.	Loss of 15 sites. No problem sites.
B - SRP Reregulation (with modification) + Underground Storage	80 acres of riparian habitat and 1,470 total acres of habitat affected; potential depletion of 35 miles of perennial stream; loss of lake fishery at Bartlett Lake; adverse impact to 20 acres of preferred habitat and assuming flow depletion possible adverse impact on 2 bald eagle breeding areas. ADVERSE FLAG	No impacts.	Lowering of reservoirs detracts from recreational use along shorelines; Bartlett Lake drained seasonally; variation in Salt/Verde flows (potential tubing impact); potential of no flow in Verde in dry years.	Same as V-A.	Loss of 15 sites, and potential adverse impacts to 2 additional sites: Bartlett Dam and Roosevelt Dam.
CONCEPT VI:					
A - Nonstructural Flood Control + SRP Water Exchange	20 acres of mixed scrub habitat, 30 total acres affected; potential flow depletion in 37 miles of perennial stream; assuming flow depletion adverse impact to 3 bald eagle breeding areas. ADVERSE FLAG	Average TDS concentration would decrease 68 mg/l in CAP water and increase 84 mg/l in local sources.	Seasonal variability of stream flow could affect tubing.	No impacts.	No impacts.

*Impacts were assessed without mitigation.
**ADVERSE FLAG indicates extremely adverse impacts, usually with legal implications.

TABLE 21

ENVIRONMENTAL RANKINGS OF SYSTEMS

	BIOLOGICAL RESOURCES	WATER QUALITY	RECREATION	ARCHAEOLOGICAL RESOURCES	HISTORICAL RESOURCES	COMPOSITE ENVIRONMENTAL RANKING
CONCEPT I						
A (CLIFF)	3*	2	3	2	1	2
B (RAISED ROOSEVELT)	2	3	1	3*	3*	3
C (NEW STEWART MTN.)	1	1	2	1	2	1
CONCEPT II						
A (CONFLUENCE)	3*	3	4*	2	3*	3
B (CLIFF AND RAISED ROOSEVELT)	2*	2	2	3*	2*	2
C (CONFLUENCE AND RAISED ROOSEVELT)	4*	4	3*	4*	4*	4
D (CLIFF AND NEW STEWART MTN. AND NEW WADDELL)	1*	1	1	1	1	1
CONCEPT IV						
A (RAISED ROOSEVELT AND LEVEES)	2	2	1	2*	2*	2
B (NEW STEWART MTN. AND LEVEES)	1	1	2	1	1	1
CONCEPT V						
A (SRP REREGULATION W/OUT MODIFICATIONS AND UNDERGROUND STORAGE)	1*	X	1	1	1	1
B (SRP REREGULATION WITH MODIFICATION AND UNDERGROUND STORAGE)	2*	X	2	2	2	2

* IMPACTS ARE EXTREMELY ADVERSE ("RED-FLAG").
X SYSTEM IMPACTS EQUAL; NO PREFERRED SYSTEM IN CONCEPT.

Concept I

The Principal Investigators agreed that water quality and recreation impacts were relatively unimportant, and that the rankings should be decided on the basis of biological and cultural resources. Given this assumption, New Stewart Mountain was clearly superior to the other systems, but there was some question as to whether Cliff and Enlarged Roosevelt were tied for second, or whether a differentiation should be made. It was decided that a differentiation could and should be made, and that this involved a trade-off between biological impacts at Cliff and cultural impacts at Enlarged Roosevelt. The biological impacts at Cliff are very adverse for bald eagles, but it was decided that the impacts to cultural resources at Enlarged Roosevelt should be given more weight because of the uniqueness of the historic and prehistoric sites involved. Therefore, Enlarged Roosevelt was judged more adverse than Cliff. However, both were rated as close together and widely separated from the ranking given New Stewart Mountain, which is very favorable from an environmental perspective. The spacing of the ranking is indicated as:

1 - New Stewart Mountain

2 - Cliff
3 - Enlarged Roosevelt

Concept II

It was decided that water quality and recreation were more important than in Concept I but not as important as biological and cultural resources. Cliff + New Stewart Mountain + New Waddell was clearly the best choice in this concept, as it was ranked first in all five disciplines. It was also clear that Confluence + Enlarged Roosevelt was the most adverse system in the concept, and it was therefore ranked fourth. Deciding the second and third ranks was difficult, as Confluence and Cliff + Enlarged Roosevelt were nearly equal in environmental impact. However, Cliff + Enlarged Roosevelt could be given the edge, primarily because this system had been ranked individually as second in four out of five disciplines, while Confluence had been ranked third or fourth in four out of five disciplines. The relative positions of the four systems in this concept are as follows:

1 - Cliff + New Stewart Mountain + New Waddell

2 - Cliff + Enlarged Roosevelt
3 - Confluence

4 - Confluence + Enlarged Roosevelt

Concept III

Only one system is in this concept (Phoenix Levees + Gila Levees + New Waddell), and therefore no comparisons could be made. However, in

general, the environmental impacts of this system are relatively minor, with no "red flags" in any disciplines.

Concept IV

There was consensus that the system with New Stewart Mountain was considerably better than the one with Enlarged Roosevelt. Only recreation impacts were different, and this was because Enlarged Roosevelt offers more recreational benefits (more visitor days) than does New Stewart Mountain. This increased recreation benefit was not great enough to offset the extremely adverse impacts to cultural resources at Enlarged Roosevelt. The relative positions of the two systems in this concept are as follows:

1 - New Stewart Mountain + Levees

2 - Enlarged Roosevelt + Levees

Concept V

Although the impacts of the two systems are nearly the same, the system without modifications was preferred environmentally over the system with modifications primarily because Bartlett Reservoir would be drained nearly dry with this system, resulting in the loss of significant aquatic habitat.

1 - SRP (without mods) + Underground Storage
2 - SRP (with mods) + Underground Storage

Concept VI

There is only one system in Concept VI (Nonstructural Flood Control + Water Exchange with SRP). In general, there are very few environmental impacts with this system, except for impacts to biological resources associated with winter water storage and reduced stream flows.

The following are general recommendations and comments made by the environmental Principal Investigators:

1. Environmentally, New Stewart Mountain is significantly better than other alternatives on the Salt and Verde Rivers. If at all possible, it should be retained for further study because of the opportunity to provide flood control of the Salt River with minimal environmental impact.
2. The Confluence + Enlarged Roosevelt system is so adverse environmentally that it should not be carried forward under any circumstances.
3. The Confluence alternative has major adverse impacts in all environmental disciplines, and is therefore inferior to a number of options.
4. The Cliff element has adverse impacts to biological resources (specifically bald eagles), but mitigations are possible. In general, the smaller the Cliff reservoir, the less adverse the impacts.

5. Water exchanges with SRP using Cliff Reservoir could cause major adverse impacts to bald eagle breeding and feeding areas. However, if there were a guaranteed low flow in the Verde as part of the exchange plan, these impacts could be minimized.
6. With SRP Reregulation there are potentially adverse impacts to biological resources if inflow to reservoirs drained down during the flood season is not great enough to permit releases in ensuing seasons and/or years.
7. The New Waddell element has no major environmental impacts and therefore offers a good opportunity for providing regulatory storage through direct connection with minimal environmental impact.

SOCIAL EFFECTS

Social impacts and effects were also analyzed and rankings were assigned.

Concept I

System C: New Stewart Mountain Dam - With the exception of a temporary loss of recreation facilities, this system would be associated with no adverse effects on social conditions.

System A: Cliff + SRP Water Exchange - This system would adversely affect the personal lifestyle satisfaction of the three people living permanently at Smith (formerly K-A) Ranch because of relocation.

Potential limitations on some low-cost recreation activity, such as summer tubing on the Salt River, because of safety factors, would have some negative implications for social conditions; however, these implications are not highly significant.

System B: Enlarged Roosevelt - Levels of lifestyle satisfaction would be adversely affected for 450 to 500 individuals from communities and ranches in the area because of relocation. Over half of these individuals are retired people who wish to spend the remainder of their lives in their present location and who would have difficulty adjusting to a new environment. Two communities, Roosevelt Lake Estates and Roosevelt Gardens #2 are projected to have viable community structures in the future. These structures would be impacted by significant relocation. Effects on community viability would be adverse.

The spacing of the ranking is indicated as:

1 - New Stewart Mountain
2 - Cliff + SRP Water Exchange

3 - Enlarged Roosevelt

Concept II

System D: New Stewart Mountain + Cliff, plus New Waddell - Relocation impacts individuals at only one ranch; no communities are impacted; there are negative implications for social conditions resulting from recreation changes, but these are not highly significant.

System B: Cliff + Enlarged Roosevelt, + SRP Water Exchange - In terms of lifestyle satisfaction and community viability effects would be less adverse for persons who live at the Cliff and Roosevelt sites than they would be for Fort McDowell Residents. Few residents impacted by System B have historical ties to this location. While many are elderly individuals who would have difficulty adjusting to a new environment, most have greater experience with residential mobility than do the Yavapai elderly. The communities in the area are relatively new, with minimal facilities and activities. Roosevelt Gardens #2 and Roosevelt Lake Estates are projected to have relatively viable community structures in the future, and these would be adversely affected by relocation.

System A: Confluence - The effects of relocation on levels of lifestyle satisfaction and community viability at Fort McDowell Indian Community would be highly adverse. Fort McDowell residents are strongly rooted in the community, with cultural and historic ties to the land, life-long personal relationships and patterns of extended family living. Confidence in community leadership would be eroded by relocation, impacting the working political structure. Community self-image and sense of control would be reduced, and community members would be generally demoralized.

System C: Confluence + Enlarged Roosevelt - This system is ranked last because lifestyle satisfaction would be reduced for over 700 people, and viability of Fort McDowell Indian Community, as well as communities in the Roosevelt area, would be diminished. This system is clearly associated with the most adverse effects on social conditions.

Their relative positions follow:

1 - Cliff + New Stewart Mountain + New Waddell

2 - Cliff + Enlarged Roosevelt + SRP Water Exchange

3 - Confluence

4 - Confluence + Enlarged Roosevelt

Concept III

Phoenix Levees + Gila Levee + New Waddell - No social impacts and effects resulting from relocation are associated with this system. There are implications for social conditions; some of these relate to changes in recreation opportunities while others relate to influences in urban neighborhoods and land acquisition.

Draining Lake Pleasant would mean some loss of low-cost, family-oriented recreation activities such as picnicking and fishing. These are not likely to be replaced at the Upper Lake, which does not duplicate the natural beach environment and which is geared for more costly activities such as boating. It is therefore likely that low to moderate income families and individuals would use these facilities less extensively than they would in the future without the project. Construction of Phoenix levees is expected to reinforce the already existing sense of separation between South Phoenix, which is largely minority, and the northern sector of the city. Construction of both Phoenix and Gila levees would require acquisition of land from a

variety of landholders, including the Gila River Indian Community and the Salt River Pima-Maricopa Indian Community. While further investigation is needed on the implications of these acquisitions for social conditions, preliminary study indicates that the social implications are relatively negative. There is also a possibility that Phoenix levees could impact the sand and gravel operation on the Salt River Pima-Maricopa Indian Community; while this would be an economic impact, it would have adverse implications for social conditions.

Concept IV

System B: New Stewart Mountain + Phoenix Levees, + Gila Levees - There would be no adverse effects on lifestyle satisfaction or community viability associated with relocation.

System A: Enlarged Roosevelt + Phoenix Levees, + Gila Levees - There would be adverse effects on lifestyle satisfaction for 450 to 500 individuals as a result of the relocation associated with the system. Viability for the two communities that are projected to have relatively viable structures in the future (Roosevelt Lake Estates and Roosevelt Gardens #2) would be adversely affected as a result of relocation of residents.

Their relative positions follow:

1 - New Stewart Mountain + Phoenix Levees + Gila Levees

2 - Enlarged Roosevelt + Phoenix Levees + Gila Levees

Concept V

System A: SRP Reregulation With and Without Modification plus Underground Storage - No social impacts and effects resulting from relocation are associated with the system. However, the land acquisition necessary to construct the underground storage system would have implications for social conditions in the Salt River Pima-Maricopa Indian Community (SRPMIC). Given the particular emphasis that is placed on a relationship with the land in traditional Pime and Maricopa culture and the historic conflicts over land between Indian and non-Indian societies, these implications are assessed as negative at this stage of the study.

It also appears that development of the proposed action would impact the sand and gravel operation on the SRPMIC. This is essentially an economic impact, but it is likely to have negative implications for social conditions.

There is no difference between Systems A and B relevant to social conditions.

Concept VI

Nonstructural + SRP Water Exchange - With the exception of SRP exchange, no assessment of impacts and effects associated with this system had been performed at this stage of the study. It is assumed that impacts will occur, and these will be analyzed at a later date. With reference to SRP Water Exchange, implications for social conditions relate to changes in recreation opportunities. Operation of the exchange is likely to produce

occasional rapid flows on the Salt River during summer months, making activities such as tubing unsafe. Necessary limitations on tubing at these times would mean a loss of low-cost recreation, which has negative implications for low income and younger individuals.

STAGE II TRADE-OFF

The staffs of the Water and Power Resources Service and the Corps of Engineers met November 12, 1980, to evaluate systems and make recommendations as to which alternatives would be carried on for further study in Stage III of the CAWCS.

The trade-off meeting involved four basic steps: 1) presentation of comparative information on the systems, 2) comparisons and evaluations of the systems, 3) recommendations, and 4) conclusions. These steps are described more fully as follows.

Comparative information on the systems was presented for the following "critical factors" for decision-making:

- Flood Control Performance
- Regulatory Storage Performance
- Dam Safety
- Economics
- Environmental Impacts
- Social Impacts

This information has been presented in the preceding sections of this Factbook. Within each concept, the systems were compared to determine if any were clearly superior or inferior. In addition, whole concepts were evaluated to see if they were justified. The comparisons are summarized as follows:

Concept I

Three single-element systems are in this concept: Cliff Dam, Enlarged Roosevelt Dam, and New Stewart Mountain Dam.

Flood Control: Cliff would control the Verde River to 150,000 cfs through Phoenix, Enlarged Roosevelt and New Stewart Mountain would control the Salt River to 200,000 cfs.

Regulatory Storage: Cliff would provide an increased yield of 46,000 acre-feet of CAP water per year through an exchange plan with SRP; Enlarged Roosevelt would provide an increased yield of 121,000 acre-feet per year through a direct connection with the CAP aqueduct to Saguaro Lake; and New Stewart Mountain would provide an increased yield of 82,000 acre-feet per year (also through a direct connection).

Dam Safety: Cliff would solve the dam safety problems on the Verde River but not the Salt River; Enlarged Roosevelt would take care of problems on the Salt River, but not the Verde; and New Stewart Mountain would solve the problems at the existing Stewart Mountain Dam, but leave other problems upstream on the Salt and on the Verde.

Economics: Cliff would cost approximately $240 million to construct and would have the benefits of Verde flood control minimal regulatory storage, and a significant contribution to solving dam safety problems. Enlarged Roosevelt would cost approximately $550 million to construct and would have the benefits of flood control of the Salt River, moderate regulatory storage capability, and a partial contribution to solving dam safety problems on the Salt River.

Environmental Impacts: Cliff would significantly affect riparian habitat, flowing stream, and bald eagles; Enlarged Roosevelt has major impacts on archaeological sites and the existing Roosevelt Dam, which is a National Historic Landmark; New Stewart Mountain has relatively minor impacts on the environment. Principal Investigators in the environmental disciplines ranked the three systems best to worst as follows: (1) New Stewart Mountain (best), (2) Cliff, and (3) Enlarged Roosevelt (worst).

Social Impacts: Cliff would result in the relocation of one ranch; Enlarged Roosevelt could result in relocation of up to 500 individuals, and New Stewart Mountain would result in no relocations. The Principal Investigators for the social assessment ranked the three systems best to worst as follows: (1)0 New Stewart Mountain (best), (2) Cliff, and (3) Enlarged Roosevelt (worst).

Summary: Each system in this concept has particular strong points which recommend the system for further study, and no system can be eliminated as clearly inferior.

Concept II

There are four systems in this concept: 1) Confluence, 2) Cliff + Enlarged Roosevelt, 3) Confluence + Enlarged Roosevelt, and 4) Cliff + New Stewart Mountain + New Waddell.

Flood Control: All systems would provide the same flood flow reduction through the Phoenix area: SPF to 50,000 cfs.

Regulatory Storage: The amount of increased yield of CAP water due to regulatory storage with these systems is as follows: Confluence - 112,000 acre-feet per year; Cliff + Enlarged Roosevelt - 56,000 acre-feet per year; Confluence + Enlarged Roosevelt - 242,000 acre-feet per year; and Cliff + New Stewart Mountain + New Waddell - 100,000 acre-feet per year.

Dam Safety: The Confluence would provide no solutions to the dam safety problem. Cliff + Enlarged Roosevelt would take care of dam safety problems on both the Salt and Verde, while Confluence + Enlarged Roosevelt would take care of the Salt River dam safety problems, and Cliff + New Stewart Mountain + New Waddell would take care of the Verde problems.

Economics: The Confluence system would cost approximately $600 million to construct and would provide flood control of both the Salt and Verde Rivers and very good regulatory storage capability, but would not help with the dam safety problems. Cliff + Enlarged Roosevelt would cost approximately $413 million and would provide flood control of both the Salt and Verde Rivers and minimal regulatory storage capability, but would solve both the Salt and Verde River dam safety problems. Confluence + Enlarged Roosevelt would cost $715 million to construct and would provide flood control of the Salt and Verde Rivers and maximum regulatory storage, but would contribute to solving only the Salt River dam safety problem. Cliff + New Stewart Mountain + New Waddell would cost $740 million to construct and would provide flood control of both the Salt and Verde Rivers and good

regulatory storage capability, but would contribute to solving only the Verde River dam safety problem.

Environmental Impact: The Confluence would significantly affect riparian habitat, flowing strema bald eagles and Yuma clapper rails (both endangered species), unique recreation resources (tubing), archaeological resources, and historical resources. Cliff + Enlarged Roosevelt would affect riparian habitat, flowing stream, bald eagles, as well as unique archaeological and historical sites. Confluence + Enlarged Roosevelt would affect riparian habitat, flowing stream, bald eagles and Yuma clapper rails, unique recreation resources (tubing), and unique archaeological and historical resources. Cliff + New Stewart Mountain + New Waddell would affect riparian habitat, flowing stream, and bald eagles. Principal Investigators in the Environmental disciplines ranked these four systems best to worst as follows: (1) Cliff + New Stewart Mountain + New Waddell (best), (2) Cliff + Enlarged Roosevelt, (3) Confluence, (4) Confluence + Enlarged Roosevelt (worst).

Social Impact: The Confluence would result in relocation of 290 individuals from the Fort McDowell Indian Community. Cliff + Enlarged Roosevelt would require relocation of up to 500 individuals near Lake Roosevelt. Confluence + Enlarged Roosevelt would require relocation of more than 700 people from the two impact areas. Cliff + New Stewart Mountain + New Waddell would involve relocation of 3 individuals. The Principal Investigator for the social assessment ranked the four systems best to worst as follows: (1) Cliff + New Stewart Mountain + New Waddell (best), (2) Cliff + Enlarged Roosevelt, (3) Confluence, (4) Confluence + Enlarged Roosevelt (worst).

Summary: No system appears to be clearly superior in this concept but one system has relatively high cost and very adverse environmental and social impacts. This is Confluence + Enlarged Roosevelt. Although performance characteristics of this system are very good, other systems in the concept are comparable and do not have the extremely severe combination of environmental and social impact associated with this one.

Concept III

There is only one system in this concept: Phoenix Levees + Gila Levee + New Waddell.

Flood Control: SPF protection by means of the levees would be provided.

Regulatory Storage: Increased yield of CAP water due to this system would be 100,000 acre-feet per year.

Dam Safety: This system would make no contribution to solving dam safety problems on the Salt and Verde Rivers.

Economics: The system would cost approximately $1.56 billion and provide SPF protection, very good regulatory storage capability, but no contribution toward dam safety.

Environmental Impact: Impacts are minimal with this system.

Social Impacts: There are no social impacts from relocations with this system.

Summary: Although this system does meet the project purposes and has virtually no environmental and social impacts, the cost is so high that it is unlikely that it could ever be implemented.

Concept IV

There are two systems in this concept: 1) Enlarged Roosevelt + Phoenix Levees + Gila Levee, and 2) New Stewart Mountain + Phoenix Levees + Gila Levee.

Flood Control: Both systems would provided upstream control of the SPF to 200,000 cfs and protection through the Phoenix area for this flow.

Regulatory Storage: Enlarged Roosevelt would provide an increased yield of CAP water of 121,000 acre-feet per year, while New Stewart Mountain would provide an increased yield of 82,000 acre-feet per year.

Dam Safety: Enlarged Roosevelt would solve the dam safety on the Salt River, while New Stewart Mountain would solve only the problem at the existing Stewart Mountain Dam.

Economics: Enlarged Roosevelt + Levees would cost $1.7 billion to construct and would provide SPF protection, very good regulatory storage capability, and a significant contribution to solving the dam dafety problem on the Salt River. New Stewart Mountain + Levees would cost $1.8 billion and would provide SPF protection, moderate regulatory storage capability, and a partial solution to the dam safety problem on the Salt River.

Environmental Impact: There are only minor environmental impacts attributable to the levees in this system, but there are significant adverse impacts to archaeological and historical resources at Enlarged Roosevelt. There are only minor impacts at New Stewart Mountain. Principal Investigators in the environmental disciplines ranked the two systems, with 1 being best, as follows: 1 - New Stewart Mountain + Levees, 2 - Enlarged Roosevelt + Levees.

Social Impact: There are no social impacts due to relocation associated with the levees or with New Stewart Mountain. However, Enlarged Roosevelt could require relocation of up to 500 individuals. The Principal Investigator for the social assessment accordingly ranked the two systems as follows, with 1 being best: 1 - New Stewart Mountain + Levees, and 2 - Enlarged Roosevelt + Levees.

Summary: Both systems meet the project purposes and have about equal overall impacts. However, both systems have such extremely high costs that it is unlikely that either could ever be implemented.

Concept V

There are two systems in this concept: 1) SRP Reregulation without modifications) + Underground Storage, and (2) SRP Reregulation (with modifications) + Underground Storage.

Flood Control: Reregulation without modifications would reduce the SPF to 230,000 cfs through the Phoenix area, while reregulation with modifications would reduce the SPF to 145,000 cfs.

Regulatory Storage: Both systems use underground storage, which provide an increased yield of CAP water of 63,000 acre-feet per hear. Both would also result in a loss of SRP water: 88,000 acre-feet per year with the first and 113,000 acre-feet per year with the second.

Dam Safety: Neither option would solve dam safety problems on the Salt and Verde Rivers.

Economics: Reregulation without modifications would cost approximately $112 million to construct and would provide a small amount of flood control, modest regulatory storage capability, and no major contribution to the dam safety problem. The system VB with modifications would cost approximately $200 million and would provide a substantial amount of flood control, modest regulatory storage capability, and no major contribution to solving the dam safety problem.

Environmental Impacts: The major environmental impact of this system has to do with drawing down of reservoirs, particularly Bartlett Reservoir, to provide flood control space and the potential for subsequent flow depletion in the Verde River if inflow is not sufficient to refill reservoirs after the flood season. The drawdown is not as great with the first system with the second and therefore the Principal Investigators in the environmental disciplines ranked the two systems as follows, with 1 being best: 1 - SRP Reregulation (without mnodifications) + Underground Storage, 2 - SRP Reregulation (with modification) + Underground Storage.

Social Impacts: There are no social impacts from relocations associated with either system, but the land acquisition necessary to construct the underground storage system would have implications for social conditions in the Salt River Pimma-Maricopa Indian Community. Since underground storage is in both systems, there is no difference in impact and between the systems and therefore no ranking.

Summary: Both reregulation options in this concept have potential for development in plans, but the underground storage option for regulatory storage appears to have a number of adverse impacts, including high cost for

relatively small yield, institutional and social problems with land acquisition and implementation, and legal problems with recovery of the CAP water from the aquifer.

Concept VI

There is one system in this concept: Flood Damage Reduction Measures + Water Exchange with Existing SRP System.

Flood Control: This system would provide no reduction in peak flow, but reduction in flood damages would occur due to changes in use and occupation of the floodplain. Water exchange with SRP would increase flooding risk.

Regulatory Storage: The CAP water supply would be increased by 15,000 acre-feet per year.

Dam Safety: Exchange would increase risks to dam safety by tending to keep reservoirs more full during the winter flood season. Flood reduction measures would not contribute to dam safety.

Economics: The cost of regulatory storage with the existing SRP system (increased CAP yield of 15,000 acre-feet per year) would be approximately 1 million, which would be for construction of a pumping plant. No costs are available for flood damage reduction measures.

Environmental Impacts: Potential adverse impacts to wildlife and vegetation could occur with SRP exchange as a result of maximizing water storage in the winter and thereby reducing releases and hence stream flows. Depletion of these flows could particularly affect bald eagle

breeding and feeding areas on the Verde River. Impacts of flood damage reduction measures will be asessed when these measures have been developed.

Social Impacts: There are no social impacts from relocations associated with the water exchange plan. Social impacts of flood damage reduction measures will be assessed when these measures are developed.

Summary: Although the flood damage reduction measures have not been fully developed and evaluated at this time, they could be included as an "add on" with many other systems, particularly those flood control systems that do not provide for a great deal of flow reduction. Water exchange with the existing SRP system provides very little in the way of increased CAP yield and could increase flooding and dam safety problems. In addition, there are potentially severe impacts to legally protected wildlife species for the exchange plan.

RECOMMENDATIONS

After analyzing and comparing the data on the various systems, the Service and Corps made the following Stage II recommendations:

1. In Concept I, retain all systems (Cliff, Enlarged Roosevelt, and New Stewart Mountain) for further study with variations and in new combinations.

2. In Concept II, retain all systems with the exception of IIC, Confluence + Enlarged Roosevelt. This system should be eliminated from further analysis on the basis of extremely adverse environmental and social impacts and high cost.

3. Eliminate Concept III (downstream protection only) and Concept IV (combination of upstream control and downstream protection)

because of excessivly high cost. Retain for further study the concept of localized downstream protection, or "limited levees." This localized protection could be added on to a number of systems to provide protection where damages would justify protection.

4. In Concept V, retain SRP Reregulation for further study, but delete underground storage for CAP regulatory storage on the basis of relatively high cost for CAP yield, dependency on energy for water recovery, limited ability to provide reliability for the CAP system, social impacts, and institutional and legal problems with recovery of the water. In Stage III, study groundwater recharge as a mitigation for water losses associated with SRP reregulatrion. Also in Stage III formulate plans with partial reregulation of SRP (Verde or Salt) in combination with other elements.

5. In Concept VI, retain flood damage reduction measures for further study, but delete water exchange with the existing SRP system because of low yield, increased flood risk, and adverse environmental impacts.

CONCLUSIONS

Several conclusions were reached as a result of the analysis and evaluation of the systems:

1. While concepts and systems that were developed for Stage II have been helpful for this phase of the study, they should not necessarily be used in subsequent phases. In the process of evaluating the systems, the agencies identified some elements and some combinations of elements that appear to warrant more study and optimization, and they are not always in the

configurations displayed. Further analysis will concentrate on finding the best alternatives using the reduced set of elements and systems that remain.

2. In eliminating the Confluence + Enlarged Roosevelt system in Concept II a decision was made that a low or medium sized Confluence Dam would not be carried forward for further study. Only the large multipurpose structure at the Confluence will be carried forward. Studies have shown that on the basis of performance, the large dam at the Confluence is superior to low or medium sized dams, and there is no advantage to these smaller dams on the basis of environmental and social impacts.

3. A primarily nonstructural plan will be developed from the various flood damage reduction measures, but also some or all of these measures can be combined with structural solutions. In addition, levees for local protection can be combined with structural and nonstructural plans.

4. With the elimination of underground storage and water exchange with the existing SRP system as regulatory storage elements, there are now four methods provided for regulatory storage: storage at the Confluence; storage at New Waddell; water exchanged with an expanded SRP system; and direct connection from the CAP aqueduct to the SRP system to permit CAP storage in the SRP system. A screening of these four methods could be performed to determine the best regulatory storage alternative to combine with a flood control element.

FREQUENTLY ASKED QUESTIONS

In this section we will attempt to answer some of the questions which are asked of us most frequently:

1. What are the standards by which a project is considered economically justifiable? How is this computed? A comparison is made between the cost of a project and the benefits produced by the project. Benefits include the value of water produced for agricultural, municipal or industrial use; recreation opportunities, and estimated flood control damages which would have occurred if the project were not built. Generally speaking, to receive Congressional authorization the benefits must be at least equal to or exceed the costs. This is usually expressed as a ratio called a "Benefit/Cost Ratio."

The procedures which are used are defined by the agencies and the U.S. Water Resources Council. Generally speaking, the same procedures are used on all agency projects, and all figures generated by CAWCS will receive a thorough review by both agencies, the Water Resources Council, and if the project is recommended by the Secretary of the Interior, a final review by the Office of Management and Budget. It should be noted that under the procedures recently issued by the Water Resources Council the benefits from agricultural irrigation are less than in previous studies.

2. What is the status of Congressional authorization? Does Orme Dam have an advantage because it is already authorized? The CAWCS is being conducted under the CAP authorization which specifies "Orme Dam or suitable alternative." No one knows whether or not this means that a new authorization must be obtained for any project other than Orme Dam. This is

one of the factors that could be considered at the end of the study, but currently this is not included as a factor in evaluating alternatives.

3. What is the relationship between CAWCS and Rio Salado? The Rio Salado concept is a recreational and economic development plan for the Salt River through Phoenix. In order for Rio Salado to be implemented as envisioned by its originators, upstream flood control would have to be provided as would a source of water for the recreational lakes.

The recently enacted State legislation authorizing a Rio Salado Development District specifies that no State general fund monies may be spent on Rio Salado until "Orme Dam or an adequate alternative is constructed and fully operational."

However, with the lack of engineering and economic feasibility data and the uncertainty about the eventual upstream control, if any, to be recommended by CAWCS, the definite relationship between the two remains to be defined.

4. Why is another study being done and why is it taking so long? All previous studies concentrated on Orme Dam, which has serious social and environmental effects. CAWCS is the first study to consider all the alternatives. But because a large number of alternatives are being studied, the time to complete the study is proportionately larger. Also, a number of legal and procedural requirements must be met or there could be legal delays after the study is completed.

5. Why can't SRP control flooding? SRP dams are designed for water conservation not flood control. As described earlier, the design and operation of water conservation dams is very different than flood control dams. SRP is also limited to water conservation and power generation

by its charter. Operating SRP dams for flood control would probably involve a change in its charter. Operating SRP for flood control is possible, but results in a loss of water conservation and hydropower.

6. Why aren't bridges built to last? Local governments may have assumed that Orme Dam would be built, providing flood protection to the 50,000 cfs level.

7. Will underground storage work? Can flood water be saved as well as CAP water stored? There is a description of underground storage and its feasibility earlier in this book. Flood water cannot be saved for underground storage unless there is a reservoir to hold it until the ground has dried out from the rains and the water can be run into spreading basins. Underground storage does not work just by running water out on the ground then pumping it out later.

8. If nothing is done, will we still have the CAP? Yes.

9. Who makes the final decision? Can Congress veto the study decision? See the earlier discussion on decision-making. Congress has the final word on all project authorizations.

10. How will the public input be used in the decision? As the section on decision-making indicates, decisions are made at every stage of the planning process, not just the end. The best way to describe the process is the agency decision makers get ideas from the public, test the ideas for feasibiity, get reactions from the public regarding the alternatives, eliminate or add alternatives based on a combination of public input and technical studies, etc. It is an interactive process. Public comment is not treated like a vote, but it is a major consideration.

11. Does the study team already have an answer? No, the purpose of the CAWCS is to explore all alternatives for flood control and regulatory storage on the Verde, Salt, Agua Fria, and Gila Rivers. The basic underlying assumption that permeates the entire study is one of neutrality. It must be assumed that each alternative has been thoroughly and completely investigated from an unbiased viewpoint.

When interacting with various interest groups and in order to solicit their cooperation, the level of trust must be very high. This can only be achieved through open, honest communication.

12. Who pays? This depends, of course, on which alternative is finally selected. The regulatory storage portion of the costs would be 100% federally funded, and repayment will be accomplished in accordance with a contract between the U.S. Department of Interior and the Central Arizona Water Conservation District. Large flood control projects are federally funded on an 80%-20% local basis. Most of the nonstructural programs require active local assistance, or are completely a local responsibility. The Corps can participate on an 80/20 basis for floodproofing and relocation.

13. Why can't the people in Holly Acres be relocated? Although it is technically feasible to relocate Holly Acres, a relocation project would not be authorized unless the residents of this area were willing to participate. The final report of the Holly Acres Flood Relief Commission (July 1980) indicates that most Holly Acres residents do not wish to participate in a relocation program, therefore implementation of a large-scale relocation project in the Holly Acres area was found to be inappropriate at this time.

The Flood Control District of Maricopa County and Corps of Engineers are currently studying alternative flood control measures on the Gila River, all of which would have some positive flood control effect for Holly Acres.

QUESTION FORM

A question and answer period will be a part of the public forums. To save time we ask that you write down your questions prior to the meeting and hand them in as you arrive. You may also submit additional questions if you think of them during the meeting.

1.

2.

3.

4.

RESPONSE FORM

We would appreciate your comments on the systems described in this Factbook. For mailing: Please fold with address showing; tape or staple edge. No postage required.

CRITERIA USED TO EVALUATE SYSTEMS:

OTHER SYSTEMS THAT SHOULD BE CONSIDERFED:

OTHER INFORMATION YOU NEED:

WHICH SYSTEM DO YOU PREFER (NOT NECESSARILY IN THE COMBINATIONS DESCRIBED):

If you would like your name added to THE CENTRAL ARIZONA WATER CONTROL STUDY mailing list, please complete the following form:

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