DKK

CDM

SALT-GILA INTERIM FLOOD CONTROL WORKS

GILLESPIE DAM TO THE AGUA FRIA RIVER

DRAFT FINAL REPORT

Camp Dresser & McKee

SALT-GILA INTERIM FLOOD CONTROL WORKS

GILLESPIE DAM TO THE AGUA FRIA RIVER

DRAFT FINAL REPORT

For

Flood Control District
of Maricopa County, Arizona

By

Camp Dresser & McKee Inc.
Walnut Creek, CA

June 12, 1981

Effective Date - July 1, 1981

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TASK LISTING

TASK 010 - ADMINISTRATION

Reimbursable work done for Maricopa County and others; general office overhead, staff work and contracts not chargeable to other functions.

Examples: Staff payroll for work done for Planning and Development Department; payroll for administrative services staff, project engineers, hydrologists, drafters, land managers, if not chargeable to other tasks; supervisory time if not chargeable to other tasks; project engineers' time for management of engineering contracts for nonfederal projects.

TASK 020 - PROJECT RIGHTS-OF-WAY

All activities associated with rights-of-way for flood control projects including acquisition, property management and property disposition.

Examples: Staff payroll associated with rights-of-way; surveys to determine rights-of-way requirements; appraisals; legal fees; purchase of properties and relocation assistance for displaced persons and businesses.

TASK 030 - PROJECT RELOCATION COSTS

Relocation of facilities affected by a flood control project; normally a federal project (not relocation assistance for displaced persons).

Examples: Costs of bridges, roads, utilities, irrigation structures, railroads, signs, and payroll for time spent in this category, including payroll for construction management involving relocations.

TASK 040 - PROJECT CONSTRUCTION COSTS

Construction of nonfederal projects managed by the District; construction supervision, inspection and monitoring, regardless of fund source (except for relocations, which are Task 030); studies and engineering for nonfederal projects.

Examples: Payroll, contracts and materials related to the above functions.

TASK 050 - MAINTENANCE

Maintenance of lands and flood control projects.

Examples: Payroll and charges for equipment, materials and contracts related to maintenance.

TASK 080 - COST SHARING

Financial participation in flood control projects managed by other municipalities.

Note: Payroll charges should not be made to this task without first coordinating with the Deputy Chief Engineer.

CDM

8 July '81

1. Rip Rap -10' below invert — based on what CDM did for COE. (Not
2. Bottom width -15'. — for equip.
3. Top of levee paved. — depends if it were over topped

Thickness Rip Rap should be 2'

Paul on vacation ~~24~~ - 4 Aug 81

CDM

environmental engineers, scientists, planners, & management consultants

CAMP DRESSER & McKEE INC.

710 South Broadway, Suite 201
Walnut Creek, California 94596
415 933-2900

June 12, 1981

Mr. Richard G. Perreault
Flood Control District of Maricopa County
3335 West Durango Street
Phoenix, AZ 85009

Dear Dick:

Enclosed are ten copies each of the following reports:

Gillespie Dam to the Agua Fria River
Draft Final Report

Gillespie Dam to the Agua Fria River
Draft Final Report
Appendix

Gillespie Dam to the Agua Fria River
Draft Final Report
Drawings

Holly Acres Area
Draft Addendum and Appendix

Please note that the Holly Acres Area Addendum is not a stand-alone report. It consists of certain pages from the original Holly Acres Area Draft Final Report, with additions corresponding to the bank stabilization alternatives. It should be read with the original report at hand to understand the organization.

After we receive your comments on the Holly Acres Addendum, we will prepare the final report incorporating the addendum materials and making other minor changes to text and tables such that the report will read as a single document. Also, the Addendum Appendix will be incorporated into a final appendix.

We are pleased to submit these reports and look forward to finalizing them as soon as you have conducted your review. If you like, we can schedule a final trip to Phoenix to discuss your review comments or meet with interested parties to explain our findings.

Please call if you have any questions relating to report organization or content.

Respectfully submitted,

CAMP DRESSER & McKEE INC.

Paul R. Giguere

Paul R. Giguere
Senior Engineer

PRG:bw
Enclosure

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

BACKGROUND AND AUTHORIZATION

In February-March 1978, December 1978-January 1979 and again in February of 1980, major flooding occurred along the Salt and Gila Rivers in and around Phoenix in Maricopa County, Arizona. West of Phoenix, the flood damages were mostly related to agricultural lands and irrigation facilities, with residential damages concentrated in the reach from 91st Avenue to the Agua Fria River. This reach is known as the Holly Acres Area.

In April of 1980, the Arizona legislature passed Senate Bill 1163, which appropriated funds to several agencies to study and construct flood control projects throughout the State. The Flood Control District of Maricopa County is the agency responsible for the Salt and Gila Rivers in the Holly Acres Area and the downstream reach shown in Figure 1.

SCOPE OF STUDY

This report presents the preliminary results of a study of interim structural flood control measures for the reach of the Gila River between Gillespie Dam and the Agua Fria River (see Figure 1). The Holly Acres Area was also studied and the results are presented in a separate report. The flood control measures considered are interim measures in that they are limited in the size of flood protected against and the area protected. The projects were formulated considering the possibility that a more comprehensive Federal flood control project may eventually be built and were evaluated assuming a 25-year life.

This study consisted of data collection and review (including site inspections and meetings with affected land owners), quantitative analysis of flood problems, hydrologic and hydraulic analyses, development of alternative measures, benefit/cost analyses and report preparation. The chapters in this report correspond to these major tasks and to the particular sub-reaches for which projects are recommended.

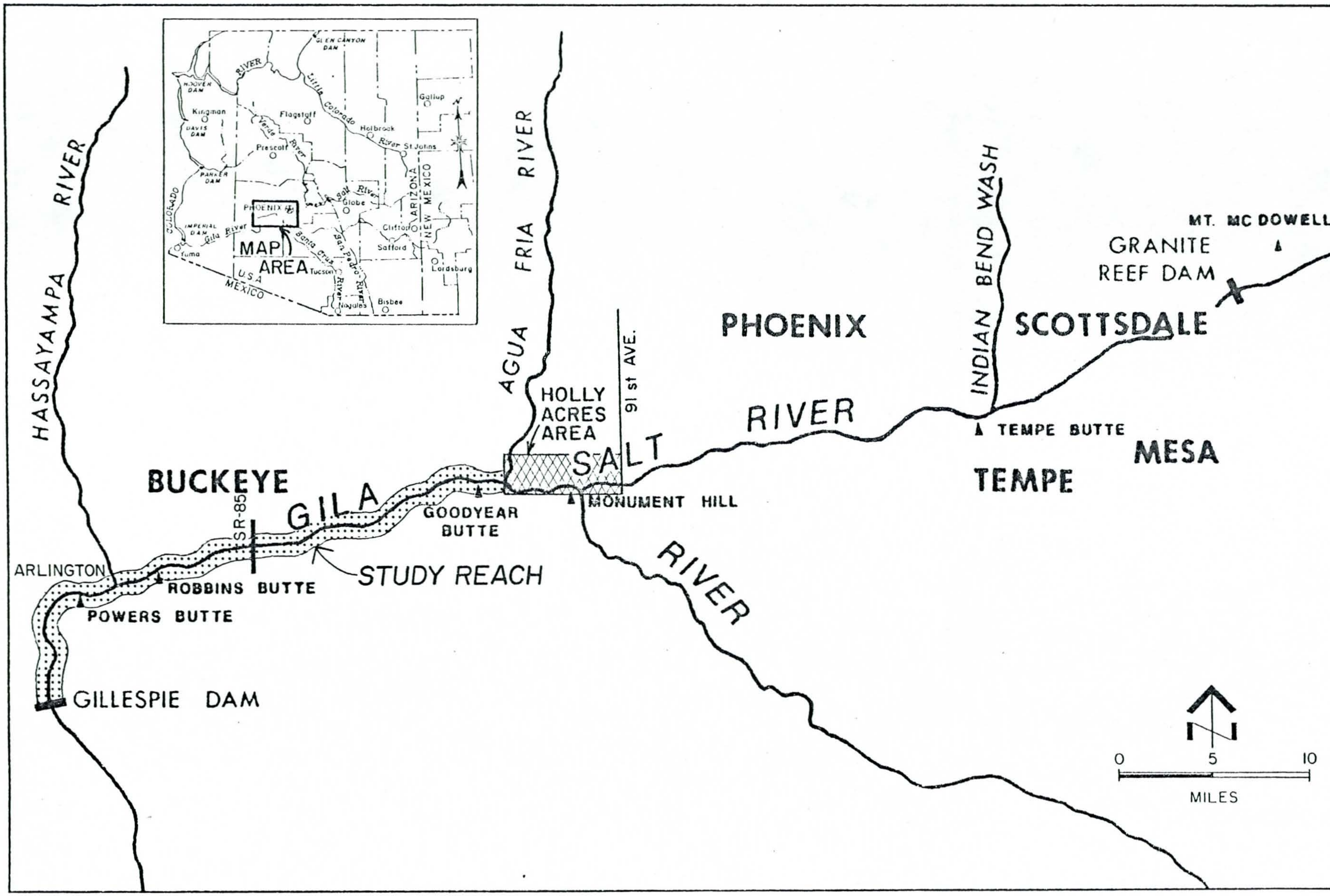

FIGURE 1

SALT-GILA INTERIM FLOOD CONTROL WORKS
STUDY REACH LOCATION MAP

II. DATA COLLECTION AND REVIEW

The following pages list the major data items collected and reviewed in the early stages of the study. The data fall into the categories:

Maps and Photographs
Reports and Documents
Data and Other Information
Contacts Made

These data are listed along with their sources and status. Supplemented by field inspections, these data items provided the basis for most of the analysis in this study.

SALT-GILA INTERIM FLOOD CONTROL WORKS
DATA COLLECTED

Data Item	Source	Status
A. MAPS AND PHOTOGRAPHS		
1. Aerial photos, full coverage, stereo pairs, 9" x 9" prints, 1"=1,000' or 1,500'±, taken March 14, 1980.	ADOT/County FCD	Obtained
2. Aerial photos, full coverage, stereo pairs, 9" x 9" prints, 1"=2,000'±, taken February 15, 1979.	ADOT/Arthur Beard Engineers	Obtained
3. Aerial photos, full coverage, 9" x 9" prints, 1"=1,000' or 1,500'±, taken Feburary 16, 1980 (during flood).	ADOT, Landis	Obtained
4. Aerial photos, limited coverage, 9" x 9" prints, 1"=1,000'±, taken prior to 1978 floods.	Kenney, Landis, ADOT	Have lists of available photos, will order later if needed.
5. Base photo mylars, full coverage, 1"=400', enlargements of photos taken March 14, 1980.	ADOT	Obtained
6. Floodplain maps 1"=400' bluelines, showing topo, floodway, floodway fringe and HEC-2 cross-sections. Gila River from Arlington to Salt: 29 sheets. Salt River from Gila to 91st Ave.: 5 sheets.	County FCD	Obtained
7. Topographic maps, 1"=400' bluelines, showing topo and HEC-2 cross-sections. Gila River from Gillespie Dam to Arlington: 2 sheets.	Corps of Engineers, L.A.	Obtained
8. Channel clearing project, 1"=400' bluelines, showing 300' and/or 1,000' wide strips and property lines on 3/14/80 aerial photos. Gillespie Dam to Robbins Butte: 6 sheets Bullard Rd. to 91st Ave.: 3 sheets	County FCD	Obtained

Data Item	Source	Status
A. MAPS AND PHOTOGRAPHS (Continued)		
9. USGS 15'Quads, full coverage, 1"=5,208'.	Arizona Map Shop	Obtained
10. USGS 7.5' Quads, full coverage, 1"=2,000'.	Arizona Map Shop	Obtained
11. Buckeye Irrigation Company system map, showing canals, wells, lands. 1"=4,000'.	Buckeye Irrigation Company	Obtained
12. Overflow maps for existing conditions and with channel clearing for various flows	Corps of Engineers, L.A., Phoenix	Obtained
13. FIA maps, showing zones and water surface elevations, effective July 2, 1979. Index and panels 1215,1455, 1465,1470,1480,1485,1490, 1495,1505,1510, and 1700.	Corps of Engineers, L.A.	Obtained
14. FIA Maps	County FCD	Obtained
15. Plans for new Tuthill Rd. Bridge	County Highway Department	Obtained
16. Plans for new SR 85 Bridge	ADOT	Obtained
17. Plan and Profiles for levee alternative, Structural Flood Control Alternatives, CAWCS: 7 sheets.	CDM	Obtained
B. REPORTS AND DOCUMENTS		
1. Draft Environmental Assessment Report, Benham Blair & Affiliates Inc. Oct. 1980.	County FCD	Obtained
2. Final Report of the Holly Acres Flood Relief Commission, July 1980.	County FCD	Obtained
3. Senate Bill 1163	County FCD	Obtained
4. CAWCS Phreatophyte Study by Graf	Corps of Engineers, Phoenix	Obtained

Data Item	Source	Status
B. REPORTS AND DOCUMENTS (Continued)		
5. Flood Damage Survey Reports-floods of Feb.-March 1978, December 1978 and Feb. 1980.	Corps of Engineers, Phoenix	Obtained
6. State of Arizona economic evaluation criteria and procedures.	Arizona DWR	Obtained
7. SCS Project reports on Hassayampa River and Centennial Wash.	County FCD	Will request only if needed later.
8. FIA report, showing water surface profiles.	County FCD	Obtained
9. Gillespie Dam Modifications Report by John Corollo Engineers.	County FCD	Obtained
10. Study of Flood Damage Reduction for Allenville, Arizona by Corps of Engineers.	County FCD	Obtained
C. DATA AND OTHER INFORMATION		
1. Hydrology Data	Corps of Engineers/ County FCD	Obtained
2. Flood damages incurred by the Buckeye Irrigation Company.	Buckeye Irrigation Company	Obtained
3. HEC-2 data listings and run summaries for analysis of existing and cleared channel conditions.	Corps of Engineers, L.A., Phoenix	Obtained
4. Newspaper clippings and correspondence files	County FCD	Will inspect County files if needed.
5. Bid summaries for recent flood control project in Central Arizona	County FCD	Obtained
6. Economic data used in channel clearing study	Great Western Research	Obtained
7. Economic data used in Central Arizona Water Control Study	Corps of Engineers, L.A.	Obtained

D. CONTACTS MADE

Agency or Group	Individuals Contacted
Flood Control District of Maricopa County	Nick Karan Dick Perreault Lionel Lewis David Johnson Stan Smith
Maricopa County Highway Department	Bill Horne
Arizona Department of Transportation	Ron Brechler Bert Solano Ray Jordan Dan MacDonald Mike Hall (photos)
Arizona Department of Water Resources STEVE JENKINS Bill JENKINS COE	Joe Dixon (Phoenix) Don Gross (Phoenix) Glen Mashburn (L.A.) Frank McDonnell (L.A.)
Maricopa Association of Governments	Arnold Burnham
Holly Acres	Adron Reichert and other homeowners
Buckeye Irrigation Company	Chuck Kupcik Steve Bales Gene Ray
Arlington Irrigation District	Bob Richardson
Great Western Research	Alan Kleinman
Arthur Beard Engineers	Gary Siders
Water Resources Associates	Bill Erikson

III. QUALITATIVE ANALYSIS OF FLOOD PROBLEMS

This chapter presents a general discussion of the factors that influence flooding in the study area. It is based on previous studies of this and other comparable areas, information from locally knowledgeable individuals, and the observations and engineering experience of the authors. It should be noted that some parts of this analysis are ~~are~~ subjective in nature and may be subject to alternative interpretations by others.

The Salt and Gila Rivers are typical of the rivers of the Great Basin geomorphic province of the American Southwest. These rivers are basically dry except during seasonal floods, are marked by high width to depth ratios and are often braided into several channels across their floodplains. The flows in the Salt and Gila Rivers are largely controlled by upstream water conservation dams except during large floods. Therefore, the rivers tend to be nearly dry all year (or for several years) except for those rare flood periods, at which time the flow is very high. The critical flood events in the study area originate on the Salt River, with the Gila River upstream of its confluence with the Salt River contributing only a small additional flow.

When flooding occurs, flow is initially confined to a meandering low-flow channel that is much narrower than the river. This condition is stable to the extent that this confined flow is capable of transporting its sediment load. As the flow rises, it begins to spread out rapidly across the river in various smaller channels. The flow tends to be concentrated in channels since this allows more sediment to be carried. The flow is concentrated in areas of least resistance, and deposition occurs in areas of higher resistance where velocities are lower. Through a process called channel avulsion, sediment deposition in parts of the river cause the flow to seek new routes, leading to substantial changes in the location of the low-flow channel and in the braiding pattern of the river in the course of one or more floods. This process of continual shifting of the low-flow channels in the Salt and Gila Rivers is well documented by historical aerial photographs.

A factor that further increases the instability of the Salt and Gila Rivers in the study area is the presence in the river of phreatophytes (water-loving plants), mostly salt cedar. These plants tend to grow rapidly following a flood and are often concentrated in the low flow channel. The next flood cannot easily flow in the low-flow channel due to the resistance created by the plants. Flow velocities are low, deposition occurs in the low-flow channel, and the flow seeks another location. Areas of phreatophytes may be washed away and new channels scoured out while others are reinforced by deposition at their bases. The instability of the river thus is increased further by the phreatophytes.

In addition to increasing instability, the phreatophytes also have the effect of generally increasing flow resistance. This causes the depth of flow for a given discharge to be higher than it would be in a clean river. This also means that flooding will occur at a lower discharge and more frequently. Once the river banks are topped, flood waters spread out over large areas of the relatively flat floodplain, causing damages to agricultural and residential acreage.

A recently completed study performed by William L. Graf for the Corps of Engineers documents, by aerial photograph interpretation, the presence and extent of phreatophytes in the study area since 1937. There have been fluctuations over the years, due largely to flood events, but phreatophytes have been widespread throughout this period. A second report by Graf shows that the low-flow channel has been historically very unstable. The low-flow channel has occupied several different positions in the river over the years 1868 to 1980.

Figure 2 (A through D) is a series of aerial photographs taken near the time of peak discharge during the February 1980 flood. Based on the measured hydrograph at Gillespie Dam and the estimated travel time in the river, the flow shown in the photographs varies from about 175,000 cfs at the Agua Fria confluence to about 110,000 cfs at Gillespie Dam. (The peak flow at Gillespie dam was 178,000 cfs). Inspection of these photographs can be very useful for identifying flooding problems and their causes. Figure 2A is at the upstream end of the study reach.

On Figure 2A, the Agua Fria River is just off the picture to the right. Goodyear Butte is at the lower right and the site of the new Tuthill Road Bridge is at the left. This reach historically has had very dense phreatophyte growth, but recently has been relatively clean and efficient. As the photos show, the upper stretch of the reach passed high flows with little overbank flooding. The Buckeye Canal headworks and the Canal itself were not exposed to damaging velocities from the Gila River, although the diversion ditch to the headworks is typically destroyed by floods. Some flooding and land erosion occurred at a golf course and in fields on the south side of the river. Just upstream of Cotton lane, flow breaks out to the north and flows across several fields and re-enters the river about a mile downstream. The flow is contained on the south side over this reach.

At this point, the south half of the river is covered by rather dense phreatophytes and the river bends southward. This concentrates the flow against the north bank for about a mile down to Perryville Road. Although no overbank flooding occurred in this stretch, bank erosion resulted in loss of land and buildings and caused a break in the South Extension of the Buckeye Canal, interrupting delivery of irrigation water to some 4,000 acres of farmland until the canal was rebuilt. The current alinement of the low-flow channel and the possibility of the channel shifting and attacking the bank directly continue to pose a threat to the canal, land and buildings along the north bank, and US 80.

SR 85

FIGURE 2A

GILA RIVER FLOODING
FEBRUARY 16, 1980
AGUA FRIA RIVER TO TUTHILL ROAD

Below Perryville Road, the river continues in a southwesterly direction, turning west at Jackrabbit Road. Along the south side, there are hills and no overbank flow occurs. However, a substantial amount of water overflows to the north and crosses a large area of agricultural land. The flow velocities through this overbank area were high in places where flow was concentrated and there were substantial damages to irrigation ditches. The new Tuthill Road Bridge access road will run along Jackrabbit Road and cross at the narrowest point of the river.

This point marks the upstream limit of very dense phreatophyte growth in the river. Figure 2B covers the reach down past Old Allenville and Buckeye. The reach is characterized by a very wide flooded area, braided channel and inundated vacant and farmed land mostly to the north. Much of the flooding in 1980 was backwater, but a substantial amount of flow appears to have left the river near Watson Road and flowed around the north side of Old Allenville. Floodwaters approached the town of Buckeye from the south. Damages in this reach were largely related to sedimentation in canals, drainage ditches and fields.

Figure 2C shows the State Route 85 (SR-85) crossing to the Hassayampa River. This reach is also characterized by widespread overbank flows to the north. The extent of flooding is somewhat lowered, but note the change in scale of these photos (and Figure 2D) and recall that flows at the downstream end were lower when the photos were taken. Just upstream of SR-85, fields on the south bank were severely eroded. Erosion and sedimentation damages occurred on the north bank throughout the reach. The south approach to SR-85 was washed out and the existing bridge will be extended in that direction. (This is discussed in more detail later in this report). The diversion ditch to the Arlington Canal was washed away and rebuilt starting farther downstream. Extremely dense phreatophytes and higher ground on the north side at the confluence with the Hassayampa force the flow into a relatively narrow channel on the south side near Powers Butte.

0 1300 2600
FEET

FIGURE 2B

GILA RIVER FLOODING
FEBRUARY 16, 1980
AIRPORT ROAD TO ROOKS ROAD

FIGURE 2C

GILA RIVER FLOODING
FEBRUARY 16, 1980
SR-85 TO HASSAYAMPA RIVER

Figure 2D shows the bend from west to south of the Gila River at Arlington and the reach down to Gillespie Dam. Again, dense phreatophytes dominate and force floodwaters on either side of the river through farmlands. The floodwaters broke through a small levee at the bend and swung wide to flood Arlington School. A substantial amount of flow continued to run through the fields until just above Gillespie Dam, where the natural topography constricts the river. It is noteworthy that this reach is very flat in slope due to the accumulated wedge of sediment behind Gillespie Dam. The receding floodwaters left a meandering low-flow channel just upstream of the Dam. Arlington Canal runs along the outside perimeter of the valley, but is generally elevated sufficiently to avoid major damage.

These observations of flooding characteristics led to the identification of several alternative flood control measures that will be described in later chapters. First, however, hydrologic and hydraulic analyses were performed to quantify the extent and frequency of flooding.

IV. HYDROLOGIC ANALYSIS

The hydrology of the Salt and Gila Rivers has been analyzed several times over the years by different parties. These studies are based on long-term flow gauging records available at Gillespie Dam and Granite Reef Dam (see Figure 1), among others. However, because flows are controlled by upstream dams except during large floods, the historical gauge records must be corrected for the effects of storage behind several dams.

It is generally accepted that the peak flows in the study reach originate from the Salt River and its largest tributary, the Verde River. The contribution of the Verde River is especially significant since there are no flood control dams on the Verde River, but Roosevelt Dam on the Salt River provides some flood control. The contribution of the Gila River to flood peaks is relatively small compared with that of the Salt River.

Figure 3 shows the flood frequency curves for the Gila River downstream from the Salt River and at Gillespie Dam. The Gila River flows at Gillespie Dam are some 5 to 10 percent lower than those at the Salt River confluence, for those high discharges of interest. The curve marked "FIA" was developed in 1977 for the Federal Insurance Administration and served as a basis for floodplain delineations. The curve marked "Corps" was developed in June, 1980 by the Corps of Engineers for use in the evaluation of flood control alternatives in the Central Arizona Water Control Study. The Corps study incorporated the floods of 1978-1980 and, as expected, predicts more frequent occurrence of any given discharge. The differences between the FIA and Corps studies is especially great for the smaller floods and is probably attributable to different analysis methodology and assumptions as well as the use of recent flood data.

0 1600 3200
FEET

FIGURE 2D

GILA RIVER FLOODING
FEBRUARY 16, 1980
POWERS BUTTE TO GILLESPIE DAM

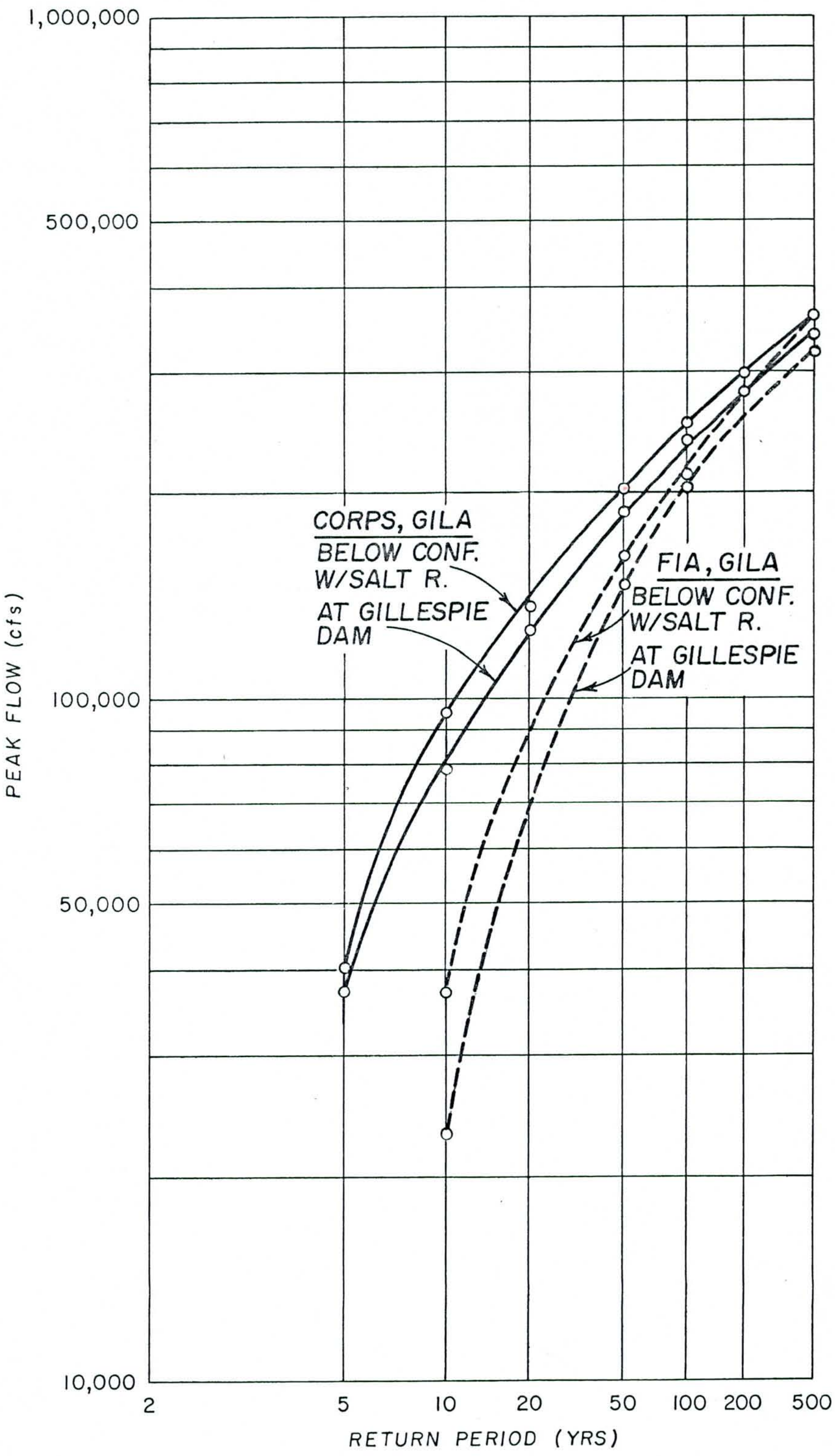

FIGURE 3

FLOOD FREQUENCY CURVES
GILA RIVER BELOW SALT RIVER
AND AT GILLESPIE DAM

For this study the Corps hydrology was used as the basis for determining flood damages with and without flood control measures. The use of the Corps hydrology results in project benefits that are much greater than those calculated using the FIA hydrology.

V. HYDRAULIC ANALYSIS

The hydraulic analysis consisted of computation of water surface profiles through the study reach for flows of 50,000, 100,000 200,000 and 320,000 cfs. The computer program "HEC-2, Water Surface Profiles", developed at the U.S. Army Corps of Engineers Hydrologic Engineering Center, was used to perform the backwater calculations.

The cross-sections utilized to define the river geometry were surveyed in 1976 for use in the Federal Insurance Administration's flood insurance program. It is recognized that the three major floods that have occurred since that survey was made have altered the riverbed substantially. However, as noted earlier in this report, the riverbed of the Salt and Gila Rivers changes substantially after every flood event. Therefore, it was judged that the time and expense required to re-survey the rivers could not be justified for this study.

This is further supported by the fact that the Manning "n" friction factors, as affected by phreatophyte growth and wash-out, is also highly variable. Given the natural variability of the bed configuration and resistance, the condition in 1976 is likely to be as representative of the condition during future floods as is the condition in 1981 unless a long-term trend toward riverbed degradation or aggradation is occurring. Furthermore, the Manning "n" friction factors were recently adjusted or "calibrated" by the Corps of Engineers such that the model roughly matched observed areas of inundation during 1978 and 1980 floods when run for those discharges. These calibrated "n" values were used for the first set of HEC-2 runs.

In certain sub-reaches (Arlington area, SR-85 area), a second set of HEC-2 runs for the same discharges (50,000, 100,000, 200,000 and 320,000 cfs) was made after modifying the Manning "n" values in a 1,000-foot wide strip to simulate the phreatophyte clearing performed by the Flood Control District of Maricopa County. This generally involved utilizing the horizontal variation in Manning "n" option (NH cards) of the HEC-2 program. Manning "n" values outside the 1,000 foot strip were unchanged. In sub-reaches where the recommended project was not particularly sensitive to the water surface elevations (Perryville Road area, Tuthill Road area), the effort required to simulate channel clearing was not warranted.

The computed water surface elevations were used to delineate existing floodplain boundaries. This information was used to estimate flood damages, as discussed later in this report. The flow characteristics vary substantially depending on location and discharge. As an indication, a 200,000 cfs discharge was computed to produce maximum velocities of 5 to 8 ft/sec and maximum depths of 10 to 20 feet.

A few comments are in order on the limitations of the hydraulic analysis. As was previously pointed out, the Salt and Gila Rivers are highly unstable and this instability is compounded by the growth and wash-out of phreatophtes in the rivers. The water surface elevation at any given discharge in the future depends not only on the discharge, but on a number of unpredictable circumstances, including the level of phreatophyte growth, the sequence of preceeding flows and their effectiveness in washing out phreatophytes, and the amount of sediment and debris carried into the reach from upstream. For these reasons, the actual water surface elevations experienced in the future may vary substantially from those computed. Nevertheless, the computed elevations are a reasonable estimate, based on the best data available and observations of recent floods.

VI. FORMULATION AND EVALUATION OF ALTERNATIVES

Areas within the study reach which suffer the greatest flood damages were identified for further study. These areas were selected based on legislative mandate, aerial photograph inspection, discussions with local agencies and residents, flood damages reports and the findings of economic studies of flood damages conducted as part of the Central Arizona Water Control Study and the Flood Control District of Maricopa County Draft Environmental Assessment for channel clearing. The areas identified are covered in detail in subsequent chapters and include the Perryville Road area, the Tuthill Road area, the State Route 85 (SR 85) area and the Arlington-Gillespie Dam area (the Holly Acres area is covered in a separate report).

One or more flood control alternatives were formulated in each of the problem areas. The type of project (levee, bank stabilization, channel excavation, etc.) and design discharge was generally chosen based on the nature of the specific problem and engineering judgment.

Cost estimation consisted of three major tasks: unit costs determination, rough cost estimates and preliminary cost estimates. The rough cost estimates, in conjunction with benefit estimates, served to indicate which alternatives would not be cost-effective and should not be given detailed design or cost-consideration. The preliminary cost estimates are approximate in that the quantities were developed using topography that is not very detailed (1976 topography, 1" = 400, 4' contours) for this type of work. A new survey would be required and the design and costs for a selected project would need to be refined before final plans could be developed.

Unit costs were based on several recent bid summaries for construction projects in the Phoenix area. Among the projects considered were:

- RWCD Floodway-Reach 1, Soil Conservation Service, June 1980
- Saddleback Floodwater Retarding Structure, Soil Conservation Service, August 1980
- Indian Bend Wash Interceptor Channel, U.S. Army Corps of Engineers, October 1980
- Tuthill Road Bridge, Maricopa County Highway Department, July 1980
- Additional information on channel clearing and other local projects, Flood Control District of Maricopa County.

The cost of each alternative was considered. Some of the alternatives were not designed or costed out in detail because they were not considered to be justifiable from an engineering and/or a cost-effectiveness standpoint following initial analysis. The more promising alternatives were studied in greater detail. Annual costs were computed by amortizing the first cost over a 25-year analysis period at 3 percent interest (as per Arizona DWR criteria) and adding estimated annual operation and maintenance costs. The details of the cost estimates are covered in later chapters.

Average annual benefits attributable to each alternative flood control project were estimated in terms of changes occurring to national income due to the project. Only benefits related directly or indirectly to flood control were included. The existing development and land use patterns were assumed in computing the difference in flood damages with and without the projects. However, the without-project condition assumes that the proposed 1000-foot wide channel clearing project has already been implemented and is maintained.

The average annual flood damages in the study reach have been estimated independently within the last year by the Corps of Engineers as part of the Central Arizona Water Control Study and by the Flood Control District of Maricopa County as part of the Draft Environmental Assessment Report for channel clearing. The County study was performed by Great Western Research, a subcontractor to Benham-Blair & Affiliates. The Corps study was generally more detailed and rigorous in approach than the County study, but both studies provided useful information on the extent of flood damages. Information from both studies was used to estimate benefits in this study. In some cases, it was necessary to estimate damages that were not considered by either of the previous studies. Rough estimates were made to screen out some alternatives before more detailed computations were performed. These detailed estimates are preliminary in that they should be re-computed in accordance with State criteria before State funds are requested.

Types of flood damages considered in the benefit calculations included inundation of cropland, irrigation facilities, roads and buildings. Also considered were crop losses, erosion of land and canal breaks. All of the inundation damage categories except residences are relatively insensitive to depth of flooding according to both the County and Corps studies, and so no attempt was made to determine flood depth for each discharge for these categories. Crop losses are also not highly sensitive to depth provided the depth is over about 1 foot, and a constant value was used for crop losses as well. However, depth of flooding was considered in estimating residential damages. The erosive potential of flows over cropland was also considered. Further details of the benefit estimates are covered in later chapters and in the Appendix.

As a final step in the evaluation process, each alternative was evaluated on the basis of its effectiveness, efficiency (as measured by the benefit/cost ratio) and other criteria that may be significant, such as cost, public support and environmental impacts.

In the following chapters, alternatives in each problem area are discussed and evaluated.

VII. PERRYVILLE ROAD AREA

PROBLEM ASSESSMENT

On Figure 2A, it can be seen how the river bends from west to southwest starting about one mile east of Perryville Road, forcing flow against the north bank. Phreatophytes occupy the south half of the river bed and further concentrate flow against the north bank. As a result, erosion of land and a break in the South Extension of the Buckeye Canal occurred during the February 1980 flood. The canal (serving 2,000 acres), several structures, farmland, and a business operation along the north bank are presently in danger of being eroded away by subsequent floods. Note that the bank is high enough to contain the flood of February 1980, which peaked at about 180,000 cfs. The hydraulic analysis indicates that larger discharges would overtop the bank, but the main problem in this reach is bank erosion, not inundation.

FLOOD CONTROL ALTERNATIVES

The proposed channel clearing by the Flood Control District of Maricopa County will tend to reduce the damages by creating more effective flow area in the southern half of the river. However, clearing above alone cannot guarantee that the flow will not continue to erode the north bank.

Two alternative concepts were considered for reducing bank erosion. One concept is to stabilize the bank using rock rip-rap, and the second is to re-direct the flow away from the bank by means of a diversion levee or groin and into an excavated channel in a relocated cleared area. These two plans are shown in Figures 4 and 5 (the water surface profiles shown in these figures do not reflect the cleared channel or the excavated channel). A third possible concept is a high capacity rip-rapped excavated channel. While such a plan could be effective, it's cost would be much higher than bank stabilization and could not be justified. This concept was therefore rejected without detailed development.

The bank stabilization plan (Figure 4) would involve grading the existing bank to a 2 to 1 slope and rip-rapping the face with rock to a depth of ten feet below the river invert. The bank protection would extend a substantial distance upstream from the present location of the bend in the river to better guide the flow around the bend and to help protect the project in the event of substantial shifts in the low-flow channel location. The project's downstream end corresponds to where the danger of bank erosion is minimal. In all, about 2.3 miles of bank would be protected. The project could be reduced in scope to protect only those areas deemed most critical, but changes in the river's course would likely eventually endanger the project and cause damages in unprotected areas. Nevertheless, a benefit/cost evaluation was also performed for a limited project consisting of about 2000 feet of protection at the present critical area, stations 1000+00 to 1020+00 on Figure 4. The short stretch of rip-rap placed following the February 1980 flood to protect the re-built South Extension Canal would need to be inspected to determine its suitability for incorporation into these plans.

The channel excavation plan is shown in Figure 5. The cleared channel alinement differs from the current plans (as shown in Figure 4) to allow the excavated channel to be in the cleared area and to tie-in to the existing low-flow channel. The diversion levee would force most of the flow into the excavated channel, but the channel itself would have a relatively low capacity (approximately 10,000 cfs). At higher discharges, flow could overtop the levee and flow around it, especially from the south. The intent of the excavated channel and the clearing would be to encourage the formation of a major channel in that section of the river. A high capacity, rip-rapped channel would accomplish this directly, but would be much too expensive to be justified. As shown in Figure 5, the plan would not guarantee that the north bank would not be attacked by future flows.

The effectiveness of the channel excavation plan is questionable. The plan was formulated as an alternative to bank stabilization to compare the costs. If the cost was much less than bank stabilization, additional groins could be added to improve the reliability of the measure and keep the costs in line with bank stabilization. As described later, the cost of this measure did not prove favorable.

COST ESTIMATION

Preliminary cost estimats e were developed for both the bank stabilization and channel excavation plans. Tables VII-1 and VII-2 present the cost estimates item by item. The Appendix contains the back-up for those estimates, including design considerations and quantity calculations. The total first cost is $2,466,000 for bank stabilization and $2,469,000 for channel excavation. Because the channel excavation alternative has ~~no~~ little cost advantage and would be less reliable than bank stabilization, it was dropped from further consideration. The annual cost of bank stabilization, amortized over 25 years at 3 percent interest and including a 1 percent O&M allowance, is $166,000 per year. The first cost and annual cost for the limited stabilization project (2000 feet long) are $470,000 and $32,000 per year.

BENEFIT ESTIMATION

The benefits attributable to bank protection are normally not computed, nor are benefit/cost evaluations made. This is largely because of the uncertainty involved in predicting the amount and location of land erosion resulting from a flood. However, an attempt was made to roughly estimate the benefits from the project under one possible scenario to provide a comparison to project cost. The scenario involves the loss of an assumed amount of cropland, buildings and irrigation canal near the existing bank. No benefits related to inundation of land were computed because the project would have no effect on the extent of flooding. The calculations and assumptions are documented in the Appendix. The annual benefit is $32,200 per year for the full plan and $8,600 per year for the limited plan.

Protection of SR85?

20,633 = 0.42

TABLE VII-1

PERRYVILLE ROAD AREA
BANK STABILIZATION
COST ESTIMATE

QUANTITY TAKE-OFF				______ ESTIMATE	
MARICOPA COUNTY FLOOD CONTROL DISTRICT				JOB NO.	
SALT-GILA INTERIM FLOOD CONTROL WORKS	COMPUTED BY			PREPARED BY	
PERRYVILLE ROAD AREA	CHECKED BY			CHECKED BY	
BANK STABILIZATION	DATE			DATE	

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	FIRST COST				
1	Diversion and Control of Water		JOB	L.S.	56,000
2	Clear Site and Remove Obstructions	24	ACRE	300	7,200
3	Excavation				
	A. For Channel	--	CY	1.50	--
	B. For Levee Fill	--	CY	1.50	--
	C. Toe	161,000	CY	2.50	402,500
4	Compacted Fill				
	A. Levees	--	CY	1.00	--
	B. Toe	161,000	CY	1.30	209,300
5	Vegetation Erosion Protection	--	JOB	L.S.	--
6	Filter Material	11,500	CY	18.00	207,000
7	Rock Rip-Rap	46,000	CY	18.00	828,000
8	Flap Gates	--	EA	2000	--
9	Interior Drainage				
	A. Collection	--	JOB	L.S.	--
	B. Pump Station	--	JOB	L.S.	--
10	Road Work				
	A. Excavation and Fill	--	CY	2.50	--
	B. Remove Pavement	--	SF	0.60	--
	C. Aggregate Base	--	CY	18.00	--
	D. Asphalt/Concrete Pavement	--	SF	1.00	--
	Total Construction Costs				1,710,000
	Contingencies, 15%				256,500
	Engineering and Design, 10%				171,000
	Supervision and Administration, 10%				171,000
11	Land Acquisition	20	ACRE	8000 high	160,000
	TOTAL FIRST COST				2,468,500

TABLE VII-2

PERRYVILLE ROAD AREA
CHANNEL EXCAVATION
COST ESTIMATE

QUANTITY TAKE-OFF		______ ESTIMATE
MARICOPA COUNTY FLOOD CONTROL DISTRICT		JOB NO.
SALT-GILA INTERIM FLOOD CONTROL WORKS	COMPUTED BY	PREPARED BY
PERRYVILLE ROAD AREA	CHECKED BY	CHECKED BY
CHANNEL EXCAVATION	DATE	DATE

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	FIRST COST				
1	Diversion and Control of Water		JOB	L.S.	3,700
2	Clear Site and Remove Obstructions	6	ACRE	300	1,800
3	Excavation				
	A. For Channel	930,000	CY	1.50	1,395,000
	B. For Levee Fill	28,600	CY	1.50	42,900
	C. Toe	31,100	CY	2.50	77,800
4	Compacted Fill				
	A. Levees	24,900	CY	1.00	24,900
	B. Toe	31,100	CY	1.30	40,400
5	Vegetation Erosion Protection	--	JOB	L.S.	--
6	Filter Material	1,990	CY	18.00	35,800
7	Rock Rip-Rap	7,960	CY	18.00	143,300
8	Flap Gates	--	EA	2000	--
9	Interior Drainage				
	A. Collection	--	JOB	L.S.	--
	B. Pump Station	--	JOB	L.S.	--
10	Road Work				
	A. Excavation and Fill	--	CY	2.50	--
	B. Remove Pavement	--	SF	0.60	--
	C. Aggregate Base	--	CY	18.00	--
	D. Asphalt/Concrete Pavement on levee (necessary?)	19,200	SF	1.00	-19,200 ?
	Total Construction Costs				1,784,800
	Contingencies, 15%				267,700
	Engineering and Design, 10% .7% .9%				178,500
	Supervision and Administration, 10%				178,500
11	Land Acquisition	7	ACRE	8000	56,000
	TOTAL FIRST COST				2,466,000

No attempt was made to relate flood damage to discharge. It was assumed that any flood over 50,000 cfs could lead to bank erosion and the assumed damage scenario. While larger floods would be expected to result in higher damages, there is no basis for estimating the relative damages. Furthermore, the extent of bank erosion is not as dependent on peak discharge as is overbank flooding. The duration of flow and especially the direction of flow may be more important than the peak discharge alone. For these reasons, the use of a damage vs. discharge relation was not deemed appropriate.

The loss of income associated with reduced crop yields caused by interruption of irrigation supply by breaks in the South Extension of the Buckeye Canal was considered, as well. However, no benefits were assumed for this condition. Past experience has shown that canals that are damaged by floodwaters can be repaired sufficiently quickly to avoid significant impacts to crops, although this may involve a temporary fix before the canal itself is properly repaired or a temporary increase in dependence on alternate sources that are still available, such as wells. This can be done because the flood period of December through April corresponds to a period of low water use. During the peak irrigation months of July and August, an interuption in supply would be very damaging, but the chances of a flood during or within a couple of months before this time is essentially nil. It was therefore assumed that in the event of a canal break, the supply would be restored or obtained from other sources in time to prevent crop losses.

It should be noted that estimation of benefits associated with bank stabilization alternatives requires a considerable amount of subjective evaluation and the resulting benefits should be regarded as rough approximations. A more detailed study could not remove most of the uncertainty and subjectivity in these estimates.

SR85 benefits?

EVALUATION OF ALTERNATIVES

The channel excavation alternative was eliminated from consideration because it was as costly and less reliable than the bank protection alternative. The bank protection alternative that would protect 2.3 miles of bank would have a benefit/cost ratio of 0.19. The benefits, at least according to one scenario, do not justify this project. The limited project that would protect 2000 feet of bank would have a benefit/cost ratio of 0.27, better but still very low. The key reasons for the low benefits are the lack of a substantial number of affected residences, the lack of an overbank flooding problem, and the assumption that any break in an irrigation canal can be repaired before the effects on crop yields would be substantial.

Outside of the poor economic justification, there should be few problems with implementing this measure in terms of environmental impact or public support. Also, the cost of the measures, particularly the limited plan, are not too high to pose serious funding problems.

It is possible that certain circumstances could improve the justification for the project. For example, if rip-rap and labor could be obtained at lower cost than assumed, the project cost could be reduced substantially. If such cost savings are feasible through special arrangements, the bank stabilization alternatives should be re-examined.

VIII. TUTHILL ROAD AREA

PROBLEM ASSESSMENT

About 1 mile downstream from Perryville Road, the Gila River's course bends from southwest to west. Most of the flow is concentrated against the south bank, but high discharges result in substantial overflows north of the river between Jackrabbit Trail and Tuthill Road. This is shown on Figure 2A. Damages occur primarily as a result of erosion and sedimentation in croplands and in irrigation and drainage ditches.

FLOOD CONTROL ALTERNATIVES

The Maricopa County Highway Department has constructed ~~is currently constructing~~ a bridge across the Gila River near Tuthill Road. Figure 6 shows the location of the bridge and the northern approach road from Jackrabbit Trail. Since the design capacity of the new bridge is 200,000 cfs, the approach road is elevated to insure that this discharge is constricted to the bridge opening. The approach road therefore will function as a levee and prevent flows under 200,000 cfs from overflowing upstream from the bridge. The hydraulic analysis performed for this study indicates that the actual effective capacity of the bridge and the approach road may be closer to 300,000 cfs, as shown on the profile in Figure 6. The approach road will therefore essentially prevent flood flows from crossing the north overbank and therefore substantially reduce flood damages in that area. However, some of the area would still be flooded by ponded backwater from downstream.

The Tuthill Road Bridge and approach road were assumed to exist in the without-project condition ~~(the construction is almost complete as of this writing)~~. Additional flood control could be provided by extending a levee along the north bank west of the bridge to Tuthill Road, then continuing the levee north to tie in to higher ground. Such a project would prevent backwater from inundating the area between Tuthill Road and Jackrabbit Trail.

The plan is shown in Figure 6. The feasible level of protection is controlled by the high ground tie-in elevations on Tuthill Road. A discharge of about 150,000 cfs is the highest practical design discharge that can be obtained. Because the levee would not be exposed to direct flow attack, the amount and depth of rip-rap could be reduced from typical values. This cost savings, combined with the approach road, seemed to have potential as a cost-effective solution.

No other alternatives were considered to be applicable to this particular area, since the Tuthill Bridge approach road will reduce the damages in this area to the extent that other more comprehensive alternatives are unwarranted.

COST ESTIMATION

Preliminary cost estimates were developed for the levee plan, although the certain cost items, such as interior drainage, were only roughly approximated. Had the project shown a better benefit/cost ratio, more detailed cost estimates would have been appropriate. Table VIII-1 presents the cost estimate item by item. The Appendix contains the back-up calculations. The total first cost is $1,174,000 and the annual cost for 25 years at 3 percent interest plus 1 percent for O&M is $79,000 per year.

BENEFIT ESTIMATION

Since the Tuthill Road Bridge and approach road were part of the without-project condition, only those additional benefits attributable to the levee downstream from the bridge could be counted. The benefits are restricted to reduction of flood damages to croplands due to backwater flooding in the north overbank. At discharges over 150,000 cfs, the levee would be overtopped and no benefits were assumed for this condition. The benefit calculations and assumptions are documented in the Appendix. The annual benefit was computed to be $17,500 per year.

TABLE VIII-1

TUTHILL ROAD AREA LEVEE

COST ESTIMATE

QUANTITY TAKE-OFF				_____ ESTIMATE	
MARICOPA COUNTY FLOOD CONTROL DISTRICT				JOB NO.	
SALT-GILA INTERIM FLOOD CONTROL WORKS		COMPUTED BY		PREPARED BY	
TUTHILL ROAD AREA LEVEE		CHECKED BY		CHECKED BY	
		DATE		DATE	
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	FIRST COST				
1	Diversion and Control of Water	--	JOB	L.S.	--
2	Clear Site and Remove Obstructions	8	ACRE	300	2,400
3	Excavation				
	A. For Channel	--	CY	1.50	--
	B. For Levee Fill	14,000	CY	1.50	21,000
	C. Toe	68,900	CY	2.50	172,300
4	Compacted Fill				
	A. Levees	12,100	CY	1.00	12,100
	B. Toe	68,900	CY	1.30	89,600
5	Vegetation Erosion Protection		JOB	L.S.	500
6	Filter Material	2,300	CY	18.00	41,400
7	Rock Rip-Rap	9,200	CY	18.00	165,600
8	Flap Gates	1	EA	2000	2,000
9	Interior Drainage				
	A. Collection	--	JOB	L.S.	--
	B. Pump Station		JOB	L.S.	269,000
10	Road Work				
	A. Excavation and Fill	--	CY	2.50	--
	B. Remove Pavement	--	SF	0.60	--
	C. Aggregate Base	--	CY	18.00	--
	D. Asphalt/Concrete Pavement	34,600	SF	1.00	34,600
	Total Construction Costs				810,500
	Contingencies, 15%				121,600
	Engineering and Design, 10%				81,050
	Supervision and Administration, 10%				81,050
11	Land Acquisition	10	ACRE	8000	80,000
	TOTAL FIRST COST				1,174,000

EVALUATION OF ALTERNATIVES

The benefit/cost ratio of the levee would be 0.22. The benefits are low partly because the approach road to the Tuthill Road Bridge has already substantially reduced flood damages in this area and also because the protected area is mostly cropland. The proposed project is also very limited in terms of the number of beneficiaries, which could pose some problems with public support.

PROBLEM ASSESSMENT

State Route 85 (SR-85) crosses the Gila River on a north-south alignment near the town of Buckeye. Most of the crossing consists of a roadway elevated only slightly above the riverbed. A 375 foot long bridge over the low-flow channel was constructed in 1967 and is estimated to have a capacity of about 30,000 cfs. Larger floods do not initially overtop the bridge, but rather flow over the approach road north of the bridge. Dense phreatophyte growth in the river contributes significantly to high flood depths and the resulting flooding of the approaches. The floods of 1978 and 1980, with peak flows of between 120,000 cfs and 180,000 cfs, overtopped the bridge and the approaches and closed the crossing for some time. The 1980 event also eroded a new channel near the south abutment and changed the direction of the low-flow channel from northeast-southwest to east-west (See Figure 2C).

Following the 1980 flood, the Arizona Department of Transportation (ADOT) was instructed by the State Legislature to improve the crossing to provide a capacity of 70,000 cfs. Plans were drawn up to add a new 375 foot long bridge south of the existing 375 foot long bridge. This bridge extension could not by itself appreciably increase the crossing capacity because it would not greatly increase the effective flow area through the bridge and would not address the generally high water surface resulting from the phreatophytes.

As a first step in the analysis of the problem, the HEC-2 model of the SR-85 reach was tested for two historical floods with known high water marks and discharges of about 64,000 cfs and 180,000 cfs. This was done to verify the validity of the model and friction factors. Because the high water marks and peak flows were only approximate and it was not possible to fully reconstruct the situation during those floods, the model verification was highly approximate in nature. The results of the model verification are shown in Figure 7. The high water marks and HEC-2 water surface elevations agreed very closely for the 64,000 cfs discharge and quite closely for the 180,000 cfs discharge. The profiles also demonstrate how the water surface at high discharges is controlled by the flow over the approaches much like a broad-crested weir. At lower discharges, when most of the flow is through the bridge rather than over the approaches, the water surface is controlled by the friction losses in the riverbed and the contraction and expansion losses as the flow funnels into the relatively small bridge opening.

The verification runs suggested that the model was adequate for the analysis of alternatives. However, it must be mentioned that there are limitations on the model. The primary one is that the ground topography is largely based on a 1976 survey. Changes in ground elevations since then have occurred and could have an impact on the crossing's capacity. Aerial photographs before and after the 1980 flood show substantial modifications to the low-flow channel in this area. A re-survey of the reach was not conducted due to study constraints. This limitation is somewhat offset by the verification run for 180,000 cfs (1980 flood) and the fact that the river geometry phreatophyte pattern will continue to change in the future and may be just as likely to resemble 1976 conditions as 1981 conditions, provided there is no long-term trend toward aggradation or degradation of the river in this reach.

With these limitations in mind, the verified model was used to analyze the alternatives described below.

FLOOD CONTROL ALTERNATIVES

Several alternatives to increase the crossing capactiy to 70,000 cfs were developed and analyzed. These included:

1. Channel clearing
2. Channel excavation
3. Raised approach road
4. Levees
5. Combinations of above measures.

All alternatives were based on the extended bridge condition, as proposed by ADOT.

Channel clearing over a 1000 foot wide strip is being planned by the Flood Control District of Maricopa County. This clearing project alone would have a significant effect on the crossing capacity because the phreatophytes have a major impact on water surface elevations here and may not be washed away at discharges under 70,000 cfs. HEC-2 simulations indicate that clearing alone could increase the capacity of the extended bridge from 32,500 cfs to 48,000 cfs. For the purposes of the study, channel clearing was assumed to be completed as part of the without-project condition. Figure 8 shows the predicted water surface profile for 70,000 cfs.

Since channel clearing alone would not increase the capacity to 70,000 cfs, excavation of a channel near the bridge was considered. The simulations indicated that losses just downstream, upstream and through the bridge were significant factors in the cleared channel conditions. These losses could be reduced by excavating the riverbed under the bridge extension to a lower elevation and excavating upstream and downstream a sufficient distance to make the excavated area effective in passing flows. This excavation essentially increases the effective flow area under the bridge extention. A sufficiently large flood would probably wash away much of this material, but excavation insures its removal immediately and may reduce the impacts of sediment deposition downstream.

Figure 8 shows the profile with clearing and excavation. This alternative lowers the bridge water surface elevation to below the minimum top of roadway at the north approach. However, the flow just upstream from the bridge has a velocity head of 1.4 feet. The water surface elevation at the north approach would be somewhat higher than that under the bridge since it is ponded and not flowing. The potential would then exist for the approach to be flooded at a discharge of slightly less than 70,000 cfs. The level of detail of the analysis and the changeable nature of the river do not allow exact predictions of capacities or water surface elevations to within a foot. It is appropriate that some freeboard be provided to insure that the capacity is indeed 70,000 cfs.

Figure 9 shows a plan view of the channel clearing and excavation plan. A break-away levee is proposed for the upstream side of the north approach where the first overflows occur. This two foot high levee would provide some freeboard, but would be overtopped before the water surface could reach the low chord of the bridge. Overtopping would destroy the levee and avoid creating additional backwater at higher discharges. The levee could be initially formed of the excavated material but would need to be replaced following major floods. Figure 9 also shows the recommended alignment for the 1,000 foot wide channel clearing.

Other alternatives such as raising the approach roadway or constructing permanent levees were rejected primarily because they would increase upstream flood problems and be more expensive than the recommended plan.

COST ESTIMATION

The cost of the channel clearing, excavation and break-away levee plan was estimated. However, because channel clearing is assumed to be part of the without-project condition, its cost is not included. The major cost involves excavation in the vicinity of the bridge. ADOT's right-of-way at and downstream from the bridge is sufficient to allow them to perform the excavation and form the break-away levees. Therefore, only excavation upstream from the bridge was considered in the cost estimate for this project.

Table IX-1 presents the itemized cost estimate. The back-up calculations are in the Appendix. The total first cost is $63,400 and the annual cost for 25 years at 3 percent interest is $3,600 per year. O&M was assumed to be part of the channel clearing O & M cost and was not included in the annual cost. Furthermore, engineering and supervision costs for this alternative would be minimal and were not included.

TABLE IX-1

SR-85 AREA
CHANNEL EXCAVATION
COST ESTIMATE

QUANTITY TAKE-OFF				______ ESTIMATE	
MARICOPA COUNTY FLOOD CONTROL DISTRICT				JOB NO.	
SALT-GILA INTERIM FLOOD CONTROL WORKS		COMPUTED BY		PREPARED BY	
S.R. 85 CHANNEL CLEARING AND EXCAVATION		CHECKED BY		CHECKED BY	
		DATE		DATE	
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	FIRST COST				
1	Diversion and Control of Water		JOB	L.S.	5,600
2	Clear Site and Remove Obstructions	5	ACRE	300	1,500
3	Excavation				
	A. For Channel	31,900	CY	1.50	48,000
	B. For Levee Fill		CY	1.50	
	C. Toe		CY	2.50	
4	Compacted Fill				
	A. Levees		CY	1.00	
	B. Toe		CY	1.30	
5	Vegetation Erosion Protection		JOB	L.S.	
6	Filter Material		CY	18.00	
7	Rock Rip-Rap		CY	18.00	
8	Flap Gates		EA	2000	
9	Interior Drainage				
	A. Collection		JOB	L.S.	
	B. Pump Station		JOB	L.S.	
10	Road Work				
	A. Excavation and Fill		CY	2.50	
	B. Remove Pavement		SF	0.60	
	C. Aggregate Base		CY	18.00	
	D. Asphalt/Concrete Pavement		SF	1.00	
	Total Construction Costs				55,100
	Contingencies, 15%				8,300
	Engineering and Design, 10%				--
	Supervision and Administration, 10%				--
11	Land Acquisition		ACRE	8000	--
	TOTAL FIRST COST				63,400

BENEFIT ESTIMATION

The benefits attributable to this project were limited to transportation benefits resulting from continued bridge operation during certain floods. Other benefits that could result from the project are related to reduced damages to the bridge extension and reduced innundated area during large floods. For the purposes of this study, these benefits would be small and very difficult to estimate and were ignored.

The transportation benefits will occur only during floods which peak at discharges between 48,000 cfs and 70,000 cfs. Smaller floods would not result in bridge closure even without the project (assuming channel clearing is completed and maintained). Larger floods will close the bridge even with the project. The annual benefit is therefore equal to the damages resulting from bridge closure multiplied by the probability of the occurance of a peak discharge between 48,000 cfs and 70,000 cfs in any given year.

If the crossing is closed, it was assumed that it would remain closed for 17 days (3 days for flood recession and 14 days for repair or dip construction). During these 17 days, traffic on SR 85 would be diverted onto Old U. S. 80 to the west via Arlington and cross the Gila River near Gillespie Dam. This crossing has a capacity well over 70,000 cfs and has recently withstood flows of up to 180,000 cfs. The alternate route adds 15 extra miles to a typical trip. An average of 7,000 vehicles per day were assumed to cross the bridge. This number is based on MAG projections and includes a correction for reduced traffic flow during floods. An average of 1.4 passengers per car was used, reflecting an increase over normal non-flood levels. Costs associated with the extra mileage and passenger hours were taken from the Central Arizona Water Control Study (11.25 cents per vehicle-mile and $5.89 per passenger-hour).

The detailed assumptions and computations are found in the Appendix. The annual benefit was computed as $18,700 per year.

EVALUATION OF ALTERNATIVES

The channel clearing and excavation alternative was the alternative found to provide the required crossing capacity at a minimum cost and risk. Other possible alternatives would either be more costly, less reliable or would risk inducing more damages upstream. The recommended alternative has a benefit/cost ratio of 5.19. The principal reason for the favorable B/C ratio is that much of the cost was assumed to be sunk and paid for previously. This includes the cost of the bridge itself, excavation within ADOT's right-of-way, and the channel clearing to be performed by the Flood Control District of Maricopa County. These sunk costs are high, yet return relatively small benefits. The proposed excavation is the final requirement to allow the transportation benefits to occur.

Nevertheless, the project as analyzed has very favorable economic justification, low cost, and no significant environmental impact.

X. ARLINGTON-GILLESPIE DAM AREA

PROBLEM ASSESSMENT

Downstream from the Hassayampa River confluence and Powers Butte, the Gila River bends from a westerly course to a southerly course across Arlington Valley. The northwest bank (outside of the bend) is subject to erosion at high flows. During the 1980 flood (see Figure 2D), the floodwaters scoured out a new course outside of the phreatophyte-covered main channel. An unprotected levee could not withstand the erosive forces and failed. The waters travelled across croplands on both sides of the main riverbed before converging at Gillespie Dam.

The problems in this area were aggravated by the construction of the 20-foot high Gillespie Dam for diversion of irrigation water in 1921 and the subsequent filling of the reservoir with sediments. This raised the riverbed about 20 feet at the dam and reduced the slope of the river for several miles upstream. Furthermore, the sediment deposits and high groundwater encourage dense phreatophyte growth. The capacity of the river to convey flows is less than in other reaches and damages to croplands are extensive during floods.

FLOOD CONTROL ALTERNATIVES

Several approaches to flood control in this reach were identified. These include:

1. Channel clearing over a 1,000 foot wide strip. This alternative will be carried out by the Flood Control District of Maricopa County and was assumed to be part of the without-project condition.

2. A comprehensive levee from the Hassayampa River confluence to the Centennial Wash confluence. This alternative was studied recently by the Corps of Engineers as part of the Central Arizona Water Control Study (CAWCS). Plans for the levee are shown in Figures 10A and 10B.

The lands downstream from the Centennial Wash confluence are very low and cannot be effectively protected from both Gila River floods and Centennial Wash floods at a reasonable cost.

3. A limited levee at the northwest bank that would prevent flows from breaking out of the channel at the bend. This alternative is shown in Figure 11. In conjunction with the channel clearing, the levee would work to concentrate flows in the cleared area, encouraging scour and an increase in conveyance in that strip. Tying in to an existing dense stand of phreatophytes should encourage deposition in the phreatophytes and help reduce overbank flooding. By preventing substantial flows from leaving the river at the bend, the intent is to reduce flood damages to those related to ponded water rather than flowing water in the overbank areas.

   The levee would tie in to high ground near the Hassayampa River confluence to insure that no flow could by-pass the levee to the north. The levee would be protected with rip-rap to withstand the high angle of attack of flow around the bend. The height of the levee would be sufficient to contain the 100-year flood at this location of 235,000 cfs with three feet of freeboard. The downstream end of the project would tie into a dense mature stand of phreatophytes that has withstood several large recent floods. No attempt would be made to tie the levee into high ground and prevent all backwater damage as in the comprehensive levee plan. Also, no protection would be afforded to the east side of the river.

4. Any of several possible channelization and levee plans constructed in conjunction with the breaching of Gillespie Dam. A separate study of the dam breaching was recently performed by the Flood Control District of Maricopa County. The concept is to breach the dam over a 500 foot width to allow the river to scour down and lower the flood water surface elevations accordingly. Any breaching plan would need to be accompanied by some channel excavation and levee construction to direct flows into the channel and the breached section of the dam. No channel

or levee plans to accompany a dam breaching alternative were developed in detail because the costs clearly would not be justified by the benefits and there would be serious problems associated with this concept. Some of the problems are discussed later in this chapter.

COST ESTIMATION

1. Channel clearing costs were not considered as part of this study since clearing is part of the without-project condition.

2. Cost estimates for the comprehensive levee plan were based on a costs previously prepared in CAWCS. These costs were adjusted for differences in design and cost criteria and inflation. The cost calculations are in the Appendix. The total first cost is $23,842,000. The annual cost for 100 year ammortization at 3 percent interest including 1 percent for O&M is $992,000 per year. The 100 year amortization is appropriate because this project should be considered a longer term solution than the other alternatives.

3. Preliminary Costs for the limited levee plan were calculated and are documented in the Appendix. Table X-1 presents the itemized cost estimate. The total first cost is $4,565,000. The annual cost for 25-year amortization at 3 percent interest, including 1 percent for O&M is $308,000 per year.

4. The costs for breaching the dam and building a small pilot channel and dike were previously computed by others to be about $7,000,000. The project would not produce any significant benefits without further channelization and levee work. The cost of this additional work was not estimated since the total cost would exceed the cost of the comprehensive levee plan and greatly exceed the potential benefits.

TABLE X-1

ARLINGTON AREA LIMITED LEVEE

COST ESTIMATE

QUANTITY TAKE-OFF				______ ESTIMATE
MARICOPA COUNTY FLOOD CONTROL DISTRICT				JOB NO.
SALT-GILA INTERIM FLOOD CONTROL WORKS	COMPUTED BY			PREPARED BY
ARLINGTON AREA LIMITED LEVEE	CHECKED BY			CHECKED BY
	DATE			DATE

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	FIRST COST				
1	Diversion and Control of Water		JOB	L.S.	--
2	Clear Site and Remove Obstructions	32	ACRE	300	9,600
3	Excavation				
	A. For Channel	--	CY	1.50	--
	B. For Levee Fill	251,700	CY	1.50	377,600
	C. Toe	338,000	CY	2.50	845,000
4	Compacted Fill				
	A. Levees	218,900	CY	1.00	218,900
	B. Toe	338,000	CY	1.30	439,400
5	Vegetation Erosion Protection	8	JOB	L.S.	1,600
6	Filter Material	13,900	CY	18.00	250,200
7	Rock Rip-Rap	55,600	CY	18.00	1,000,800
8	Flap Gates	5	EA	2000	10,000
9	Interior Drainage				
	A. Collection		JOB	L.S.	15,000
	B. Pump Station	--	JOB	L.S.	--
10	Road Work				
	A. Excavation and Fill	--	CY	2.50	--
	B. Remove Pavement	--	SF	0.60	--
	C. Aggregate Base	--	CY	18.00	--
	D. Asphalt/Concrete Pavement	--	SF	1.00	--
	Total Construction Costs				3,168,000
	Contingencies, 15%				475,200
	Engineering and Design, 10%				316,800
	Supervision and Administration, 10%				316,800
11	Land Acquisition	36	ACRE	8000	288,000
	TOTAL FIRST COST				4,565,000

Calculate Costs w/o Land Acquisition

BENEFIT ESTIMATION

1. The benefits for channel clearing were not computed as part of this study since clearing is part of the without-project condition.

2. The benefits for the comprehensive levee plan are basically all the flood damages that would occur in the without-project condition north of Centennial Wash and west of the Gila River. Only damages related to land innundation were considered, but some adjustments were made to account for cases where substantial land erosion may increase damages. The assumptions and calculations are contained in the Appendix. Annual benefit is $228,700 per year.
1.15 × Direct Benefits

3. The benefits associated with the limited levee plan are difficult to estimate because they are related to changes in flow velocity and erosion potential as well as to changes in innundated area. Damage estimates were based on somewhat subjective evaluations and estimates of unit damages. The assumptions and calculations are in the Appendix. The annual benefit is estimated at $94,100 per year. 1.15 × Direct Benefits

4. The benefit from dam breaching and associated channelization and levee work could be comparable to those for the comprehensive levee. However, this benefit would be obtained only after the riverbed is excavated or scours to a new equilibrium level. The benefits from the initial $7,000,000 project would be almost nil, at least in the short term.

EVALUATION OF ALTERNATIVES

The comprehensive levee plan has a benefit/cost ratio of 0.23, even with 100-year amortization. This, combined with the high initial cost of over $20 milion makes this alternative an undesirable one.

The limited levee plan has a benefit/cost ratio of 0.31, somewhat better but not favorable. Although the benefit estimates were highly approximate, it is noteworthy that even if the benefits from the comprehensive levee were taken as an upper limit, the B/C ratio would still be only 0.74. The lack of residential development in this area is the primary reason for the low benefit/cost ratio.

The breaching of Gillespie Dam would require channels and levees to guide the flow into the breach and control the location of upstream channel formation. Without such work, the channel could form to the east or west of the present river and cause damages far worse than the project was built to prevent. The levee, channel or guide bank required would have virtually the same cost as a measure designed to reduce flood damages without the dam breaching. The analysis of the comprehensive levee indicated that such a project is not cost-effective. Adding a dam breaching element would only reduce the B/C ratio. In fact, even the admittedly incomplete breaching and pilot channel project (cost: $7 million) has an annual cost of $472,000, more than twice the annual benefit of the comprehensive levee plan.

In addition to the lack of economic justification for any dam breaching plan, these are serious environmental questions that would need to be studied before such a plan could be implemented. The lowering of the riverbed by up to 20 feet would have great impacts on both man's activities, animals and vegetation for several miles upstream, while the large amounts of scoured sediments that would be deposited downstream could have equally significant consequences.

B/C - 5' below invert =.52