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Watershed Work Plan

HARQUAHALA VALLEY WATERSHED

Flood Control District of Maricopa County
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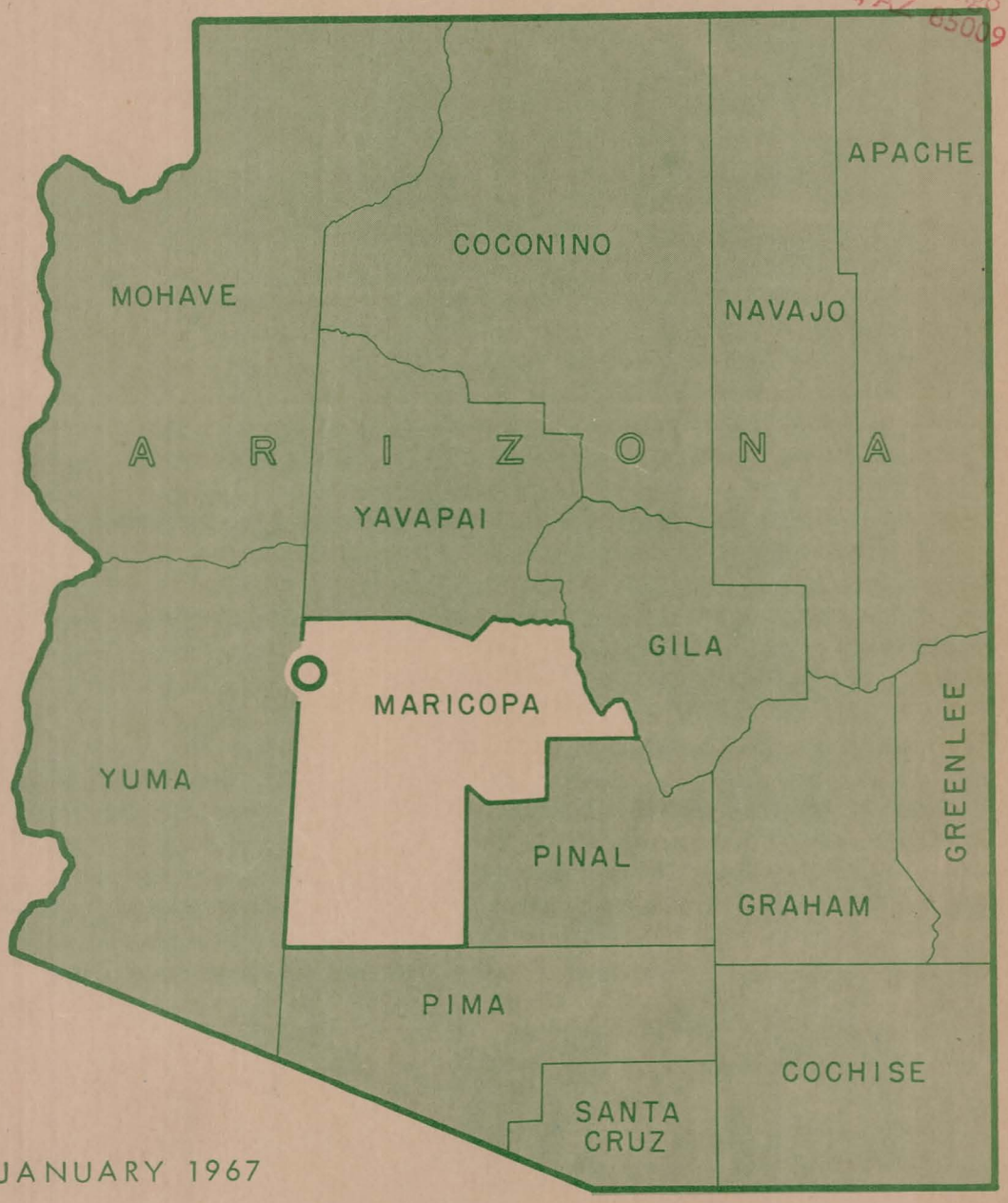

JANUARY 1967

Prepared under the authority of the Watershed Protection & Flood Prevention Act (Public law 566, 83rd. Congress, 68 Stat. 666) as amended.

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Watershed Work Plan
Hassayampa Valley Watershed

Maricopa and Yuma Counties, Arizona

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by: Flood Control District of Maricopa County

Buckeye-Roosevelt Soil Conservation District

Wickenburg Soil Conservation District

With Assistance by:

U. S. Department of Agriculture, Soil Conservation Service

January 1967

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WATERSHED WORK PLAN AGREEMENT

Between the

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

BUCKEYE-ROOSEVELT SOIL CONSERVATION DISTRICT

WICKENBURG SOIL CONSERVATION DISTRICT

(hereinafter referred to as the Sponsoring Local Organization)

State of Arizona

and the

SOIL CONSERVATION SERVICE
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Harquahala Valley Watershed, State of Arizona, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Harquahala Valley Watershed, State of Arizona, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about five years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Flood Control District of Maricopa County will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the works of improvement. (Estimated cost, $1,927,550.)

2. The Flood Control District of Maricopa County will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.

3. The total construction cost of the structural measures will be borne by the Service. (Estimated cost, $2,275,220.)

4. The total cost of installation services will be borne by the Service. (Estimated cost, $682,570.)

5. The Flood Control District of Maricopa County will bear the costs of administering contracts. (Estimated cost, $22,770.)

6. The Buckeye-Roosevelt and Wickenburg Soil Conservation Districts will obtain agreements from owners of not less than 50 percent of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

7. The Buckeye-Roosevelt and Wickenburg Soil Conservation Districts will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Buckeye-Roosevelt and Wickenburg Soil Conservation Districts will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Flood Control District of Maricopa County will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C.F.R. Sec. 15.1-15.13), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any activity receiving Federal financial assistance.

12. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal or local funds. The financial and other assistance to be furnished by the Service and the Sponsoring Local Organization in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose. Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Flood Control District of Maricopa County prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

13. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

14. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

Flood Control District of Maricopa County

By William S. Rudrews

Title Chairman

Date April 10, 1967

The signing of this agreement was authorized by a resolution of the governing body of the Flood Control District of Maricopa County adopted at a meeting held on April 10, 1967

Secretary Thea Woodall

Date

Buckeye-Roosevelt Soil Conservation District

By Wallace Bales

Title Chairman

Date 3-7-67

The signing of this agreement was authorized by a resolution of the governing body of the Buckeye-Roosevelt Soil Conservation District adopted at a meeting held on Feb. 21, 1967.

Secretary John Forres

Act Sec

Date 3-7-67

Wickenburg Soil Conservation District

By Ben F. Matthews

Title Chairman

Date 3/13/67

The signing of this agreement was authorized by a resolution of the governing body of the Wickenburg Soil Conservation District adopted at a meeting held on 1-4-67.

Secretary Donald W Burnelson

Date March 13, 67

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

Watershed Work Plan

Harquahala Valley Watershed

Maricopa and Yuma Counties, Arizona

January 1967

SUMMARY OF PLAN

Size and Location

The watershed is located in northwestern Maricopa County and includes about 3,950 acres in eastern Yuma County, about 75 miles west of Phoenix, Arizona. It includes the southern end of the Harquahala Mountains, the Big Horn Mountains, Burnt Mountain, the west slopes of the Saddleback Mountains, and a broad alluvial plain. The watershed drains into Centennial Wash.

The watershed covers an area of 239,360 acres or 374 square miles. Included in the floodplain area are 19,000 acres of valuable, highly productive farmland which is irrigated by pumping and 1,000 additional acres which are expected to be developed without the project. Located in the watershed are county roads, farm roads, Interstate Highway 10, the El Paso Natural Gas Line, the AT&T Cable, and residential and commercial properties.

Sponsoring Organizations

The work plan was prepared by the Flood Control District of Maricopa County and the Buckeye-Roosevelt and Wickenburg Soil Conservation Districts. Technical assistance was furnished by the Soil Conservation Service of the United States Department of Agriculture. The work plan is endorsed by the Harquahala Valley Association.

Watershed Problems

Several large floods have caused extensive damage in the Harquahala Valley Watershed floodplain even though the farming area is relatively new. Three extremely damaging floods were experienced within an 18 month period. They occurred on September 9, 1963, August 26, 1964, and February 6 and 7, 1965. Damages from the August 26, 1964, event alone amounted to about $833,500.

The floodplain area lies directly below desert mountains to the east and north. Larger mountains lie further north and produce floodwater that enters the floodplain from the northwest and west. Natural, well-defined flood channels are almost non-existent on and adjacent to the floodplain. Therefore, floodwater enters the floodplain primarily

as overland flow. The topography of the floodplain is such that regardless of origin, west, north, or east, the floodwater funnels down through the center of the farmland. The low area is in the center of the floodplain draining southward. Grades are so flat, however, that almost all of the farmland could be inundated by the larger storms.

Farmland is being intensively farmed and is highly productive. All cultivated fields are prepared for irrigation. Most of the irrigation ditches are concrete lined. Farm roads are well maintained. Expensive homesteads have been built on many of the farms. Each farm has a large inventory of expensive equipment that is vulnerable to flooding. Flood damage is extremely high on lettuce and nursery crops. Lettuce is grown on 21 percent of the farmland and is virtually destroyed when flooded. Nursery crops are also heavily damaged, especially by deposition of sediment and the inability to irrigate soon after flooding.

Works of Improvement to be Installed

Works of improvement proposed in this plan are located entirely within Maricopa County and include both land treatment measures and structural measures.

The land treatment measures to be installed are an integral part of the overall watershed protection and flood prevention objectives of the project sponsors. Land treatment measures reduce runoff and erosion, and increase infiltration rates and the water-holding capacity of the soil.

Measures to be installed on the cultivated farmlands include: conservation cropping systems; cover and green manure crops; crop residue use; irrigation ditches and canal lining; irrigation field ditches; irrigation land leveling; irrigation pipelines; irrigation systems, tailwater recovery; irrigation water management; structures for water control; wells and pumping plants.

The Bureau of Land Management will continue its existing conservation program on Federal land which it administers (68 percent of the total watershed area).

A system of two floodwater retarding structures, two floodways, and three diversions will be installed above the cultivated area to reduce floodwater, sediment, and erosion damages. A levee will also be installed along Centennial Wash so that floodwater released from the two floodwater retarding structures will be confined to the Centennial Wash floodplain. One of the diversions is designed to divert runoff from storms expected to occur once in 50 years. The remainder of the structural measures are designed to control floodwater originating from storms expected to occur once in 100 years.

The project will reduce floodwater, sediment, and erosion damages by an estimated 71 percent. The installation period for this project is five years.

The total project cost of $6,844,110 will be borne by P.L. 566 and other funds as shown below:

	Costs (Dollars)		
Item	P.L. 566 Funds	Other Funds	Total
Land Treatment Measures	56,100 1/	1,879,900	1,936,000
Structural Measures-Flood Prevention	2,957,790	1,950,320	4,908,110
TOTAL	3,013,890	3,830,220	6,844,110

1/ Includes technical assistance only.

AVERAGE ANNUAL BENEFITS COMPARED TO AVERAGE ANNUAL COSTS

The total average annual primary and secondary benefits resulting from installation of the structural measures are estimated at $416,650. The average annual cost of proposed structural measures is estimated at $213,730. The ratio of average annual benefits to average annual cost is 1.9 to 1.0.

ARRANGEMENTS FOR INSTALLATION, OPERATION AND MAINTENANCE

Land treatment measures will be applied and maintained by farmers cooperating with the Buckeye-Roosevelt and Wickenburg Soil Conservation Districts and by the Bureau of Land Management on land which it administers.

The Flood Control District of Maricopa County will construct, operate, and maintain the structural works of improvement for flood prevention.

Operation and maintenance agreements will be executed between the responsible agencies and the Soil Conservation Service prior to issuing invitations to bid. Total average annual structural measures cost of maintenance is estimated at $18,440.

DESCRIPTION OF THE WATERSHED

PHYSICAL DATA

LOCATION

Harquahala Valley Watershed is located in northwestern Maricopa and eastern Yuma Counties, Arizona. It includes the southern end of the Harquahala Mountains, the Big Horn Mountains, Burnt Mountain, the west slopes of the Saddleback Mountains, and a broad alluvial plain. The watershed drains into Centennial Wash. Interstate Highway 10, county roads, a major gas line, and an underground cross country telephone cable traverse the watershed.

LAND USE AND STATUS

The watershed area contains 239,360 acres, of which about 19,000 acres are cultivated farmland and the remaining acreage is used for rangeland, roads, farmsteads and other miscellaneous uses. Of the 19,000 acres of cultivated land, 3,360 acres are State owned lands leased by private operators.

There are 49,233 acres of the watershed in private ownership, 26,240 acres are State owned, and 163,887 acres are Federal land administered by the Bureau of Land Management. Most of the State owned land is leased to private interests for agricultural use.

Land Use and Status are shown in Figure 3.

LAND RESOURCE UNITS

Land resource units are geographic areas of land characterized by particular combinations or patterns of topography, soils, climate, water resources, land use and vegetative cover. Two of these, the Mountains Unit and the Plains Unit, exist in this watershed. These are further described under Topography, Soils, and Vegetation in this section of the work plan. The aerial extent of land within these units is as follows:

Resource Unit	Acres	Percent of Area
Mountains	106,240	44.4
Plains	133,120	55.6
Total	239,360	100.0

TOPOGRAPHY

Elevations range from 1,050 feet on Centennial Wash at the southeast corner of the watershed to 5,681 feet in the Harquahala Mountains. The Harquahala Mountains and Big Horn Mountains are north of the agricultural area and the Saddleback Mountains are on the east.

Following is a tabulation of slope variations by resource unit:

Mountains	5% to Vertical
Plains	Less than 1% to 5%

GEOLOGY

Physiographically, the area is part of the Sonoran Desert Section of the Basin and Range province. The portion of the Harquahala Mountains included in the watershed area is composed mainly of Pre-Cambrian granite gneiss and schist; Paleozoic and Mesozoic shale, quartzite, the limestone; and Laramide granite and related crystalline rocks. The portion of the Big Horn Mountains included in the watershed is made up of Cretaceous andesite and andesitic tuff; Pre-Cambrian granite and granite gneiss; and Quaternary basalt with small areas of rhyolite, shale, quartzite, and limestone. The Saddleback Mountains are composed mainly of Pre-Cambrian schist, Cretaceous andesite and andesitic tuff, and Quaternary basalt. Burnt Mountain is composed of Quaternary basalt. Gentle alluvial slopes extend basinward from the mountains. Quaternary-Tertiary sand, gravel, and conglomerate are present near the mountain fronts with Quaternary clay, silt, sand, and gravel occurring at the lower elevations.

SOILS

Soil types and surface conditions vary considerably in the watershed.

Mountains - On the mountains and mountain foot slopes, soils are shallow and very shallow; rocky, cobbly or gravelly. In the steeper areas, as in the Harquahala, Big Horn, Burnt, and Saddleback Mountain ranges, soils are very thin and from 40 to 60 percent of the surface is rock outcrop. In the less sloping areas the soils are from 4 to 14 inches deep, and have a thin, medium or moderately coarse textured gravelly to stony surface soil. The deeper soils have a medium or moderately fine gravelly to stony subsoil. Most of the soils are residual on granite, gneiss, limestone, schist, andesite, basalt, or shale. Smoother slopes generally have a dark desert varnish coating on the gravel surfaces. Local areas of soils have a strongly cemented lime hardpan. Soils in this unit are only slightly erosive. The coarse textures of the soils, gravelly surfaces, and lime hardpans are factors which impede erosion in the area. The soils have a high runoff potential because shallow soils and rock outcrops have a very slow rate of water transmission and very slow infiltration rates when thoroughly wetted.

Plains - Deep or moderately deep soils on alluvial outwash plains constitute most of this unit. Medium or moderately fine surface soils and subsoils are on the smoother slopes near the center of the valley. Coarse or moderately coarse soils are on the upper fans of washes from the granitic mountains. Along the foot of the mountains, there is usually an area of shallow to moderately deep residual soils. These often have a medium textured surface with gravel that is covered with dark desert varnish. They have slightly finer subsoils underlain at 12 to 28 inches by a strongly cemented lime hardpan. Alluvium for the valley fill soils originates in the granite, granite gneiss, schist, limestone, andesite, basalt, and shale rocks of the adjacent mountains. Slightly to moderately erosive soils are present in this unit. Since the land slope is relatively flat and a sheet flow runoff condition prevails, erosion is generally not significant. Erosion is active in some of the channels and diversions constructed in and around the cultivated area where flood flows are concentrated. Generally, the soils have a slow to very slow rate of water transmission and a slow to very slow infiltration rate when thoroughly wetted because of moderately fine to fine texture or a layer that impedes downward movement of water. These soils have a moderately high to high runoff potential.

VEGETATION

Mountains - Desert shrubs dominate the vegetation with lesser amounts of perennial grasses, perennial shrubs, and a few trees. The dominant shrub species are creosote bush and white bursage. Bush muhly and three-awn are the dominant perennial grasses. The sparse vegetative cover of this unit is typical of the southwest desert region. The lack of cover does influence erosion and runoff; however, climatic and soil conditions preclude any significant improvement of the vegetative cover.

Plains - Desert shrubs dominate the vegetation with lesser amounts of perennial grasses, annual grasses, trees, and cacti. Creosote bush is the dominant species of shrub. Tree species are palo verde and ironwood. About 14 percent of this area is irrigated cropland. Lack of vegetative cover has a detrimental effect on erosion and runoff in this unit; however, lack of timely and ample rainfall limits the improvement of this situation.

STREAM CHANNELS

There are no perennial streams within the watershed. Tiger Wash, one of the major tributaries, originates in the Harquahala and Big Horn Mountains and drains the western portion of the alluvial plain. Numerous other washes, all of which are unnamed, head in the Big Horn and Saddleback Mountains and run south and west across the central and eastern part of the alluvial plain. The channels increase in size to maximum width at slopes of about one percent. At lesser slopes, large channels fan out into many smaller channels until they no longer carry a bedload. When slopes approach .005 ft./ft., the channels are poorly

defined and flow as wide shallow streams over much of the area. This is often referred to as sheet flow. It is here that the channels enter the cultivated area. Only a few non-continuous man-made channels have been constructed to provide drainage through the agricultural area to Centennial Wash.

CLIMATE

Climate in the watershed is arid with average annual precipitation ranging from 7.5 to 10 inches. July and August have the highest monthly precipitation and account for about 25 percent of the total. During July, August, and September, high intensity thunderstorms occur and account for most of the runoff for the year. These storms are occasionally associated with moist tropical air from the Gulf of Mexico. The heaviest warm season rains are produced by dissipating tropical disturbances moving north and east from the Gulf of California and Pacific Ocean.

Precipitation and temperature distributions at Salome, 15 miles from the watershed are typical for the watershed. Mean monthly temperatures range from 48.7° F. in January to 88.1° F. in July with a mean annual temperature of 67.1° F. The highest recorded temperature was 118° F. in 1929 and the lowest was 15° F. in 1950. There are an average of 321 days with minimum temperatures above 28° F. Estimated annual mean relative humidities are 46 percent at 6:00 A.M. and 21 percent at 6:00 P.M.

Mean monthly precipitation is as follows:

Month	Mean Precipitation (Inches)
January	.92
February	.92
March	.69
April	.35
May	.06
June	.11
July	1.11
August	1.37
September	.62
October	.50
November	.39
December	.92
TOTAL	7.96

WATER RESOURCES

At the present time water for agricultural use in the watershed is obtained from wells in the cultivated area. This water is drawn from the Harquahala Plains groundwater basin which covers an area of about 350 square miles. The basin has a contributing surface drainage

area of nearly 1,500 square miles. Groundwater movement is toward cones of depression in the groundwater table beneath the cultivated area.

Depth to water in the farming area of the watershed in December 1963 ranged from 200 feet to over 400 feet. Average annual declines in the water table from August 1957 to December 1963 ranged from about 10 to 25 feet.

Many of the irrigation wells in the area are between 1,000 and 2,000 feet deep and yield up to 3,500 gallons of water per minute. The quality of water in the area for agricultural use is generally good.

Recharge to the basin comes mostly from seepage of runoff into the more permeable soils near the mountain fronts. Some recharge also comes from seepage of irrigation water applied to the land.

The cultivated area of the watershed is immediately downstream from the proposed location of the Central Arizona Project Canal. Any water secured from the proposed Central Arizona Project would supplement the water resources now available to the area.

Stock tanks and shallow wells supply water for limited grazing of livestock in the upper watershed.

FISH AND WILDLIFE

There are no live streams in the watershed. A few shallow stock-water ponds are present, but they lack sufficient depth and permanence to sustain fish life. There is no fishing in the watershed.

Wildlife in the watershed include bighorn sheep, mule deer, white-winged doves, mourning doves, Gambel's quail, cottontails, and jackrabbits. Small groups of ducks, principally mallards, pintails and teals, are common on watershed stock ponds and irrigation overflow ponds during fall and winter. The bulk of game populations in the watershed, except for doves, are found in the mountain unit. The irrigated farmlands provide food and water for doves and quail. Hunting in the fall of the year is heavy in the vicinity of grain fields. Lack of natural food and cover in the plains unit, however, precludes significant numbers of other game animals.

E C O N O M I C D A T A

Agriculture within the area is highly developed and relatively new with improvements beginning in the early 1950s. The watershed floodplain contains over 19,000 cultivated acres. An additional 1,000 floodplain acres are expected to be producing crops, without the project, by 1975. All cultivated land is under pump irrigation.

Cropland within the watershed consists of vegetables, 25 percent; alfalfa, 25 percent; small grains, 23 percent; nursery crops, 10

percent; cotton, 8 percent; and miscellaneous, 9 percent. Weighted average annual gross income per acre is estimated at $745.

The soil and climate are excellent for such non-surplus yet high value crops as vegetables and nursery crops which constitute 35 percent of the cropland. Lettuce alone accounts for 21 percent of the cultivated land.

The farming enterprises provide over 2,200 seasonal jobs. The permanent population of the watershed is about 800. Vegetable and nursery crops create a large demand for seasonal labor. The cotton production within and outside the watershed also creates employment for on-farm and cotton gin laborers. The local cotton gin is located on the watershed floodplain. It processes nearly all the locally grown cotton.

There are 22 farms in the watershed being operated as 19 individual units. These farms range in size from 160 acres to 4,080 acres. Over 72 percent of the farms have from 160 to 640 cultivated acres.

Another segment of the agricultural economy is livestock production. Approximately 20,000 sheep are wintered on farmland in the floodplain area. About 900 cattle are pastured on portions of six ranches in the watershed, about four months each year.

The watershed economy is primarily based on agriculture. The large number of acres cultivated, coupled with the high value crops and modernized production methods, have brought industrial and commercial establishments to the watershed. These include two fertilizer companies, service stations, a motel, a laundry, a dry goods and grocery store, a cafe, bars, a trailer court, and cotton gin, all in the floodplain area. Two housing developments are under consideration and one builder has already built three houses. A new elementary school is also in the floodplain.

Paved roads, including Interstate Route 10, provide excellent accessibility to markets. The developed farming area is about 40 miles west of Buckeye and 70 miles west of Phoenix. A paved road also provides access to a main east-west line of the Southern Pacific Railroad. A vegetable packing and loading facility is at the railroad to expedite transportation of perishable crops to market.

WATERSHED PROBLEMS

The principal watershed problems are floodwater and sediment damage resulting from overland flows during high intensity summer storms. Regardless of where a storm may center, sediment laden floodwater flows across the floodplain. Crops are either damaged or destroyed. Concrete lined irrigation ditches are broken and field ditches and furrows are eroded. Floodwater either scours out or deposits sediment on county and farm roads. Floodwater flows through homes damaging structures, contents, and yards. Mechanical parts and interiors of vehicles are damaged. Fences are washed out. Sheep and other livestock have drowned. The quality of stored crops is reduced by flooding. Maximum development of existing land and water resources by the installation of land treatment measures has been greatly hindered by flood flows.

A storm expected to occur once every 100 years, on the average, will inundate 16,400 cultivated acres. Damages estimated at $2,131,000 would result from a storm of this magnitude. The 100-year storm would seriously affect the economy of this watershed for several years.

A storm expected to occur once every other year will inundate 3,500 cultivated acres. Damages estimated at $454,900 would result from a storm of this size.

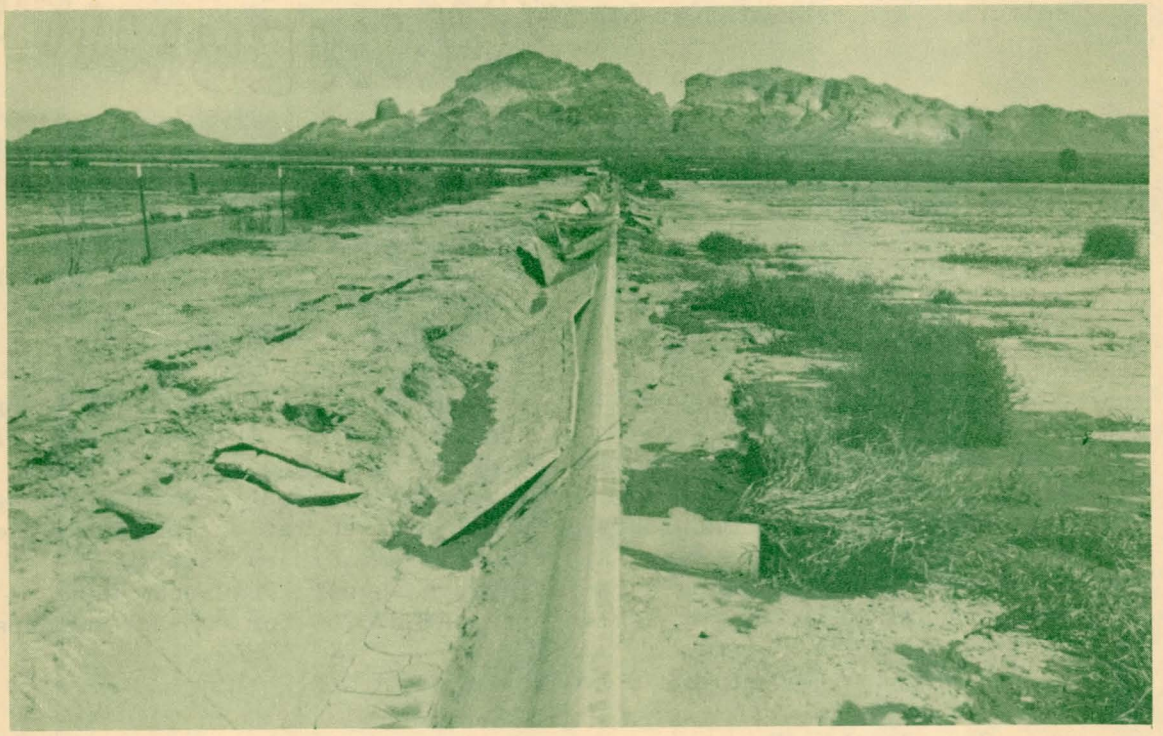
Five damaging floods have occurred since 1963 which have adversely affected the economy of the watershed. These occurred on September 9, 1963, August 26, 1964, September 13, 1964, February 6 & 7, 1965, and August 16, 1965.

An estimated 48 percent of all floods are expected to occur during the months of July, August, and September.

FLOODWATER DAMAGE

Crop damage due to flooding is extremely high in this watershed because of the high value crops grown. Vegetables, especially lettuce, are highly damageable crops. Lettuce is generally totally destroyed when covered by floodwater. Nursery crops also experience great losses due to flooding. During the more severe storms, nursery crops may actually be washed out. This loss is extremely high as these crops require two years or more to develop. Irrigation border and furrow destruction requires immediate repair by hand labor because very frequent nursery crop irrigation is needed in this climate.

Floodwater crossing Courthouse Road at 11:30 A.M. on August 27, 1964. Looking west from the northwest corner of Sec. 6, T1N, R8W. 2-574-6



Section of irrigation canal was washed out. Flood of August 27, 1964, looking east along mid section line, Sec. 7, T1N, R8W. 2-576-9

Even when the plant is not destroyed, quality is generally lowered due to flooding.

Farmers in the floodplain have attempted to protect themselves from some of the more frequent storms. Thousands of dollars have been spent for construction of dikes around the upper sides of fields, and channels have been constructed through farmland to dispose of floodwater. These measures, however, have proven to be ineffective during recent storms.

The August 26, 1964, storm, which inundated 8,400 cultivated acres was the key storm studied. This storm, during which 2.5 inches of rain fell on the south slopes of Burnt Mountain, can be expected to occur on the average of once every seven years. Floodwater, sediment, erosion, and indirect damages from this storm amounted to approximately $833,500. More than forty miles of farm roads were damaged. About ten miles of concrete lined ditch and seventy miles of earth ditch were either destroyed or filled with sediment. Twenty-nine homes and apartments were flooded from 2 to 18 inches deep inside. Values of these homes range from $2,000 to $20,000. Furniture was damaged as were carpets, electrical applicances, and improvements. Several miles of dike were overtopped and broken by this flood. The man-made channels were filled beyond capacity and had to be reworked following the flood, only to be damaged again the following September and again in February. Agricultural damages due to floodwater from the August 1964 storm are estimated at $489,200. Damages, other than agricultural, are estimated at $35,500.

SEDIMENT DAMAGE

As floodwater flows over the floodplain there are many areas where large amounts of sediment are deposited. Irrigation ditches, if not broken, are frequently filled with sediment. Lower ends of fields bordering sumps, high borders, or dikes are areas of heavy sediment deposition. Often entire fields must be releveled to restore proper grade for irrigation. Sediment may cover vegetable, nursery, or alfalfa crops, smothering the plants and destroying production.

Sediment is also deposited inside homes causing extensive damage to carpets, electrical appliances, and furniture. A large amount of time and money is spent in cleaning up sediment and debris. Yards are generally filled with sediment. Sediment laden floodwater damages automobiles and farm machinery. Normal farm operations are disrupted by the necessary dismantling and repair of machinery damaged by sediment. Sediment damages caused by the August 1964 storm were estimated at $293,700 for agriculture and $7,900 for non-agriculture.

EROSION DAMAGE

Considerable land scour occurs with each flood. Scoured areas in cultivated fields must be filled with soil and releveled in order to maintain proper irrigation grades. Land scour during the August 1964

storm caused damages to agriculture estimated at $7,200.

INDIRECT DAMAGE

Indirect flood damages are those which occur without direct contact with floodwater. One example is the lost production time which results from having to make repairs due to flooding. Delay in delivery of irrigation water can cause serious reduction in crop yields and is considered an indirect damage.

Power lines and poles were blown down by intense windstorms occuring during the September 1963 and August 1964 storms. Floodwater delayed restoration of power from a normal six to eight hours to over 30 hours. Crawler type tractors were needed to get trucks and workers through the floodwater into damaged areas. Road traffic was delayed several hours due to excessive floodwater. Interruption of travel to schools, markets and fields is considered an indirect damage.

PROJECTS OF OTHER AGENCIES

Other agencies have no existing projects in the watershed. However, Interstate Highway 10 will traverse the watershed east and west. The location has been definitely set in the field. Construction contracts are scheduled to be let in October 1966 and November 1966.

Also proposed is the Central Arizona Project (Granite Reef) Aqueduct which will traverse the watershed east to west and will be located north of the proposed structural measures. This aqueduct is an integral part of the now proposed Southwest Water Plan.

(For locations of Interstate Highway 10 and the proposed Central Arizona Project (Granite Reef) Aqueduct, see Project Map, figure 4.)

Two large floodwater retarding reservoirs and three water spreading systems, constructed by the Bureau of Land Management, are located on Centennial Wash. The structures are located 11 miles northeast of the town of Wenden and 7 miles southeast of the town of Salome. Although the dams are not located in the watershed, their detention capacity does provide the lower agricultural area of the watershed some protection from Centennial Wash flooding.

BASIS FOR PROJECT FORMULATION

This project represents the combined efforts of the local people:

1. To protect productive irrigated land from floodwater, sediment, and erosion damages.

2. To reduce floodwater, sediment, and erosion damages to on-farm irrigation facilities and buildings.

3. To reduce floodwater, sediment, and erosion damages to county and farm roads.

4. To reduce floodwater, sediment, and erosion damages to commercial establishments, residences, the school, and the cotton gin.

The proposed land treatment program will carry out a portion of the above objectives by reducing runoff and erosion and increasing the infiltration rates and water-holding capacities of the soils. In determing the magnitude of the land treatment program to be applied, emphasis was placed on selecting measures which would meet program objectives and which would fit the needs and agricultural conditions found on the floodplain.

Ninety percent of the farmers in the watershed cooperate with the Buckeye-Roosevelt Soil Conservation District and 46 percent have developed basic farm plans. However, the threat of floods has kept the rate of installation of these conservation measures below that of the remainder of the district. Table 1A summarizes the land treatment practices applied through the Soil Conservation District, and the Bureau of Land Management.

The Bureau of Land Management has been carrying out a program of conservation and improvement on the 163,887 acres of rangeland which it administers. This program consists of stock water development, fencing and grazing management.

The structural works of improvement were determined by considering various alternate plans of structural formulation that would meet the sponsors' objectives and Soil Conservation Service standards and policies. Consideration was given to economic, geologic, topographic and hydrologic factors. Protection from floods originating above the structures from storms of up to the 50-year frequency event in the Saddleback Mountain area, and the 100-year frequency event in the

remainder of the drainage area, was found to give maximum net benefits. With this degree of protection, farmers will be able to make better use of their available resources without fear of seriously damaging floods.

WORKS OF IMPROVEMENT TO BE INSTALLED

LAND TREATMENT MEASURES

NON-FEDERAL LAND

Land treatment measures outlined in this plan include measures and practices which will contribute to program objectives. These measures will be installed on privately owned lands as well as land leased from the State of Arizona for agricultural purposes. Almost all of this land is under agreement with the soil conservation districts. The measures will reduce runoff and erosion, increase infiltration rates and water-holding capacities of the soils, and contribute to better agricultural water management. These measures are essential to the successful functioning of the watershed project and are a part of the overall project formulation. The measures provide for use of the land within its capabilities and treatment in accordance with its needs for sustained agricultural production. Combinations of measures, including alternatives, are expected to be applied to achieve essential treatment for the cropland acres shown in Table 1. Alternate practices and alternate combinations of practices including minimum tillage, use of moisture probes to check water penetration, sprinkler systems, and changing the direction of irrigation runs used in conjunction with crop management practices were considered and will aid in achieving these objectives. The practices outlined herein will afford the maximum land treatment benefits to attain project objectives. Table 1 shows the estimated cost of land treatment measures to be installed within the installation period of the project and the number of acres to be treated. The total cost of installing these measures, including the cost of technical assistance, is estimated at $1,936,000. Technical assistance will be provided all land owners and lessees through the soil conservation districts.

The practices included in this work plan are as follows:

Conservation Cropping System

Growing crops in combination with needed cultural and management measures. Cropping systems include the use of rotations that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without the use of such crops.

Cover and Green Manure Crop

A crop of close-growing grasses, legumes, or small grain used

primarily for summer or winter protection and for soil improvement. It usually occupies the land for a period of one year or less, except where there is permanent cover as in orchards.

Crop Residue Use

Utilizing plant residues left in cultivated fields by incorporating them into the soil or leaving them on the surface during that part of the year when critical erosion periods usually occur.

Irrigation Ditch and Canal Lining

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

Irrigation Field Ditch

A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields within the farm distribution system.

Irrigation Land Leveling

Reshaping the surface of land to be irrigated to planned grades.

Irrigation Pipeline

A pipe or other closed conduit installed in an irrigation system.

Irrigation System, Tailwater Recovery

A facility to collect, store, and transport irrigation tailwater for re-use in the farm irrigation distribution system.

Irrigation Water Management

The use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture-holding capacity of the soil and the need of the crop, where the water is applied at a rate and in such a manner that crops can use it efficiently and significant erosion does not occur.

Pumping Plant for Water Control

A facility for pumping water from wells.

Structure for Water Control

A structure in an irrigation or drainage system for water management that conveys water, controls the direction or rate of flow, or maintains a desired water surface elevation in a natural or artificial channel. Also includes any structure for managing water levels for

wildlife or other purposes.

Well

A well constructed to provide water for irrigation.

FEDERAL LAND

The Bureau of Land Management will continue its existing conservation program of Range Proper Use on land which it administers. This program is primarily the control of grazing by licensing the number of livestock and time of use to maintain vegetative cover on the Federal land and protect the multiple use values of the resources.

STRUCTURAL MEASURES

Structural measures to be installed are those needed to reduce damages caused by flooding. Included in this plan are two floodwater retarding structures and one floodway controlling 34 percent of the watershed area, and four diversions controlling 52 percent of the watershed area. A levee is also included in the plan to confine releases from the floodwater retarding structures to the Centennial Wash floodplain. The total estimated cost of installing these measures is $4,908,110. The distribution of this cost is shown on Table 2.

SADDLEBACK DIVERSION

The Saddleback Diversion will be constructed at the extreme east side of the watershed immediately above the cultivated land. The diversion will have a length of 10.5 miles and will discharge the 50-year flood into a drainageway 1.4 miles above its confluence with Centennial Wash. The diversion embankment will have a maximum height of 8.4 feet and will have a maximum discharge capacity of 3,000 c.f.s. (cubic feet per second). A low flow channel will be constructed in conjunction with the diversion embankment and will consist of a wide shallow channel which will accomodate the low flow discharges and prevent the higher velocity flows from concentrating at the toe of the diversion embankment.

The diversion will include a debris basin in the central portion of its length that will accomodate a 50-year sediment accumulation of 215 acre feet. This debris basin will be 1.2 miles long and will divert the 50-year flood through an emergency spillway at the south end.

The estimated installation cost of this diversion is $1,125,360. Additional structural data is shown in Table 3A.

BURNT MOUNTAIN FLOODWATER RETARDING STRUCTURE AND FLOODWAY

The Burnt Mountain Floodwater Retarding Structure will be constructed north of Salome Road at an estimated installation cost of $1,261,100. This structure will provide floodwater protection up to

and including the 100-year flood. An emergency spillway will be located at the east end of the embankment. The dam will be 5.5 miles long and will have a total storage capacity of 4,740 acre feet, 4,390 acre feet for floodwater storage and 350 acre feet for a 50-year accumulation of sediment. The dam will have a maximum height of 24.1 feet and will have a 4½ x 4½ feet reinforced concrete principal spillway with a capacity of 490 c.f.s. that will release floodwater from the 100-year flood in approximately eight days. Additional structural data is shown in Table 3.

A floodway 1.45 miles long will convey floodwater from the principal spillway of Burnt Mountain Floodwater Retarding Structure to the Big Horn Floodwater Retarding Structure. The maximum capacity of this floodway is 936 c.f.s. The floodway will be stabilized with rock riprap throughout its length to the embankment of the Big Horn Floodwater Retarding Structure. The estimated installation cost of this floodway will be $292,050. Additional structural data is shown in Table 3A.

BIG HORN FLOODWATER RETARDING STRUCTURE AND FLOODWAY

The Big Horn Floodwater Retarding Structure will be constructed south of Salome Road and west of Gin Road at an estimated installation cost of $938,560. The structure will provide floodwater protection up to and including the 100-year flood. It will have a total storage capacity of 4,677 acre feet with 4,317 acre feet being allocated to floodwater storage and 360 acre feet to a 50-year accumulation of sediment. The floodwater retarding structure will have an emergency spillway located at the south end of the embankment and will have a length of 3.3 miles. The maximum height will be 18.9 feet. The maximum release rate from the 6½ x 6½ feet reinforced concrete spillway will be 880 c.f.s. and will release floodwater in approximately 9½ days. Additional structural data is shown in Table 3.

A combined floodway and diversion 1.26 miles long will convey floodwater from the principal spillway of the Big Horn Floodwater Retarding Structure combined with the diverted floodwater from the uncontrolled area of Tiger Wash. This floodway will consist of a channel and embankment for the first .15 mile and will have a capacity of 880 c.f.s. The remaining 1.11 miles of floodway will consist of an embankment having a maximum height of 13.4 feet and will divert the 100-year maximum flood discharge of 10,800 c.f.s. to Centennial Wash. The estimated installation cost of this floodway is $285,560. Additional structural data is shown in Table 3A.

CENTENNIAL LEVEE

The Centennial Levee will be constructed along the northern edge of the Centennial Wash floodplain beginning at the end of the Big Horn Floodway and extending southeast for a distance of 4.34 miles. The levee will be constructed for the purpose of preventing project floodwater from reentering the watershed. The levee was terminated at a point where floodwater will be safely confined to a definite

floodplain. The levee will consist of an embankment with a maximum height of 9.6 feet and will have a capacity of 25,000 c.f.s. The estimated installation cost of this levee is $888,780. Additional structural data is shown in Table 3A.

BURNT WELL DIVERSION

A diversion 3,250 feet long will convey floodwater originating adjacent to and above the Burnt Mountain Floodwater Retarding Structure emergency spillway safely into the retarding pool of Burnt Mountain Floodwater Retarding Structure. The diversion will consist of an embankment with a maximum height of 5.8 feet and will have a capacity of 1,340 c.f.s. The estimated installation cost of this diversion is $23,670. Additional structural data is shown in Table 3A.

LITTLE HORN DIVERSION

Little Horn Diversion, consisting of two embankments, one being 2,300 feet long, and the other 2,600 feet long, will convey floodwater originating above the Big Horn Mountains to the Burnt Mountain Floodwater Retarding Structure. The diversion is necessary so that this floodwater will be conveyed to the structure designed to retard this flow. The diversion will consist of two embankments having a maximum height of 12.6 feet and a capacity of 33,800 c.f.s. The estimated installation cost of this diversion is $93,030. Additional structural data is shown in Table 3A.

EXPLANATION OF INSTALLATION COSTS

LAND TREATMENT MEASURES

Costs for the installation of land treatment measures on private and State lands are the estimates of all costs associated with establishing the measures. They include the application cost to be borne by individual owners and operators. Cost-sharing assistance may be provided through the Agricultural Stabilization and Conservation Service. The technical assistance item includes salaries and associated costs of technicians who will assist the owners and operators in applying the measures. No part of the P.L. 566 funds for technical assistance will be used for soil surveys.

The estimates of quantities and costs of establishing the land treatment measures were based on the quantity-unit cost approach. The most recent local prices were used for the operation, services and materials costs involved in each practice. The estimated technical assistance costs for all measures were based on an analysis of the costs for planning and applying similar measures.

STRUCTURAL MEASURES

The total installation cost of structural measures includes:

1. Construction cost.

2. Installation services.

3. Cost of land, easements and rights-of-way.

4. Cost of administering contracts.

Construction costs shown in the engineer's estimate were based on data found in the most recent contract data for flood prevention projects in Arizona. Unit costs were compared with those found in the Arizona Highway Department publication, "A Comparison of Construction Costs, 1965 with 1964, and Quantities and Costs of Materials 1965." This publication was prepared by Division of Contracts and Specifications, January 1966. Contingency costs are based on additional expenses that may occur at the time of construction as a result of detailed studies. Contingency factors range from 10 to 30 percent of the engineer's estimate. These two cost items, engineer's estimate plus contingencies, make up the construction cost for each item as shown in Table 2.

Installation services are those costs required for detailed engineering surveys, intensive geologic investigations, design, contractual items, layout, supervision of construction and other services. Installation services were based on a percentage of the construction cost. Twenty percent was used for the engineering services and ten percent for other services.

Land, easements and rights-of-way cost estimates were furnished by the sponsoring local organizations, and concurred in by the Soil Conservation Service. These costs were estimated to total $1,927,550. This includes provision for the purchase of land or flowage easements on 6,250 acres of land, 2,920 acres of which are within the Centennial Wash floodplain. These latter lands may be subject to the combined flooding from project and Centennial Wash flows. No project benefits are claimed on this acreage. The remainder of land, easements and rights-of-way costs are for two telephone and telegraph crossings, a bridge on the Buckeye-Salome Road, a bridge on Courthouse Road, two bridges on Interstate Highway 10, and a power line relocation.

Contract administration includes administrative, legal and clerical expenses incurred by the contracting local organization. Contract administration was estimated at one percent of the construction cost.

COST SHARING

Total installation cost of the project is estimated at $6,844,110 of which $3,013,890 are from P.L. 566 funds and $3,830,220 are from other funds.

P.L. 566 Funds

The following costs will be borne by P.L. 566 funds:

1. The cost of technical assistance needed to accelerate the application of land treatment measures on non-Federal land. (Estimated cost $56,100.)

2. Construction cost of the structural measures for flood prevention. (Estimated cost $2,275,220.)

3. Cost of installation services for the structural measures. (Estimated cost $682,570.)

Other Funds

The following costs will be borne by other funds:

1. Cost of installing land treatment measures on non-Federal land. (Estimated cost $1,837,860.) Cost sharing assistance that is available under other programs will be utilized.

2. Cost of technical assistance for the existing land treatment program on non-Federal land. (Estimated cost $42,040.)

3. Total cost of land, easements and rights-of-way for the structural measures. Included in this item are AT&T cable crossings, road and highway crossings and a power line relocation made necessary by the construction of the flood prevention measures. (Estimated cost $1,927,550.)

4. The cost of contract administration. (Estimated cost $22,770.)

Installation costs for each fiscal year during the installation period are as follows:

	PL 566		Other		
Fiscal Year	Land Treat. Measures Non-Fed. Land	Structural Measures	Land Treat. Measures Non-Fed. Land	Structural Measures	TOTAL
1st Year	$ 11,220	$ 105,780	$ 375,980	$1,656,800	$2,149,780
2nd Year	11,220	717,450	375,980	276,040	1,380,690
3rd Year	11,220	959,740	375,980	6,790	1,353,730
4th Year	11,220	1,174,820	375,980	10,690	1,572,710
5th Year	11,220		375,980		387,200
TOTAL	$ 56,100	$2,957,790	$1,879,900	$1,950,320	$6,844,110

EFFECTS OF WORKS OF IMPROVEMENT

The proposed land treatment measures and structural works of improvement will substantially reduce floodwater, sediment and erosion damages on 16,400 acres of cultivated land on 22 farms. This area does not include 1,080 acres of cultivated land within Centennial Wash floodplain upon which no benefits from project measures are claimed. The project will directly benefit about 2,300 people, most of whom are employed by these farms and related processing activities. Floodwater, sediment and erosion damages will be reduced by an estimated 71 percent.

A storm expected once in 100 years would inundate approximately 16,400 cultivated acres under present conditions. This will be reduced to 5,900 acres by the works of improvement. The August 26, 1964, flood inundated 8,400 cultivated acres. This event can be expected to occur once in seven years. The proposed project will reduce flooding from this event by 4,800 cultivated acres.

The proposed structural works of improvement will reduce the expected 100-year peak flows from Harquahala Valley Watershed into Centennial Wash from 40,000 c.f.s. to 5,500 c.f.s. With land treatment measures installed, this peak flow will be further reduced from 5,500 c.f.s. to 4,600 c.f.s.

The Centennial Levee will prevent water released from the Bighorn Floodwater Retarding Structure from re-entering the agricultural land of the watershed. Floodwaters originating from a 100-year storm on the Centennial Wash drainage area will also be prevented from entering the project agricultural land by the Centennial Levee.

Floodwater, sediment and erosion damages sustained by crops and irrigated pasture, channels, dikes, irrigation ditches, sumps, farm equipment and livestock will be greatly reduced by the installation of project measures.

Irrigated land releveling due to land scour will no longer be necessary. The need for maintenance of on-farm dikes and channels will be reduced after installation of project measures. Flood induced weed control problems will also be reduced.

Flooding of residential, commercial and industrial establishments will be virtually eliminated. Road damage will be reduced. Threat of loss of life will be greatly reduced. Health problems due to flooding of cesspools will be eliminated. Another benefit, one which cannot be measured in terms of dollars, will be the peace of mind of the residents.

Considerable protection will be afforded Interstate Highway 10 which traverses the watershed. These benefits, however, have not been evaluated.

The project will reduce losses to producers and processors of agricultural goods. Considerable additional transportation, storage, processing and marketing benefits will result from flood damage reduction on vegetable and nursery crops. A portion of the increased net returns realized by the farmers will also benefit local retailers and wholesalers. A more reliable production base will generate increased net income. Nearly all of the cotton produced in the watershed is ginned locally. Also, nearly all the hay and grain produced in the watershed is locally utilized for livestock feeding. Benefits derived by the first processor or user will be substantial.

No changes in land use are anticipated for agricultural lands as a result of this project. The works of improvement proposed will provide for sustained agricultural production and a more stable economy.

Project plans do not provide for permanent impoundment of floodwater. Accordingly, no fish habitat would be provided with the project.

The proposed diversion structures and floodwater retarding structures would be located in wildlife habitat of generally poor quality. Loss of habitat and wildlife resulting from construction of project features would be insignificant.

The installation of the structural measures is expected to prove beneficial to upland game. The temporary storage of water in the structures will improve soil moisture conditions. This will stimulate the establishment and growth of herbaceous and woody vegetation in and adjoining floodwater retarding pools. These areas will provide excellent feeding, roosting and nesting areas for doves, quail and rabbits. It can be expected that populations of these species will increase with the project.

Additionally, the sediment basin in the Saddleback Diversion can be expected to impound frequently some water during the fall and winter months. This will provide opportunity for the growth of pondweeds, wild millet, smartweed and other plants of value as duck food. This food would be heavily utilized by surface feeding ducks. Depending on the amount of runoff available, this pool could provide for upwards of 2,000 duck-days of use annually.

It is estimated that the above influences of project measures on wildlife and waterfowl habitat will result in 300 man-days of upland game and 100 man-days of waterfowl hunting annually. Most of the upland game hunting would be for quail.

PROJECT BENEFITS

Total benefits accruing to project structural measures are estimated at $416,650 annually. Of these, flood damage reduction benefits amount to $327,600, indirect benefits $33,500 and local secondary benefits $55,550. Direct damage reduction benefits to crops, pasture and other agricultural properties are estimated at $312,000. This includes $193,700 for floodwater, $114,000 for sediment and $4,300 for erosion damage reductions. Direct damage reduction benefits to residences, commercial establishments and county roads are estimated to be $15,600 annually, which includes $12,800 for floodwater and $2,800 for sediment.

Reduction of indirect losses is estimated to be $33,500 annually. Of this amount, $31,200 is for agricultural and $2,300 for non-agricultural properties. Annual local secondary benefits stemming from the project are estimated to be $32,760 and those induced by the project, $22,790. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation of the project.

In addition, the land treatment measures will provide primary flood damage reduction benefits estimated at $26,700 annually. This includes $15,300 for floodwater, $8,900 for sediment and $2,500 for indirect damage reduction.

COMPARISON OF BENEFITS AND COSTS

The total average annual benefits to accrue as a result of the installation of the proposed structural measures are estimated to be $416,650. Average annual benefits accruing to flood prevention are $361,100 primary, and secondary benefits $55,550. The average annual cost of the proposed structural measures is estimated at $213,730. The ratio of average annual benefits, including secondary benefits, to average annual cost is 1.9 to 1.0. The ratio of average annual benefits, without secondary benefits, to average annual cost is 1.7 to 1.0.

PROJECT INSTALLATION

To facilitate coordination of effort for the installation of structural and land treatment measures the following are the responsibilities required of each non-Federal and Federal interest:

LAND TREATMENT MEASURES

The Buckeye-Roosevelt and Wickenburg Soil Conservation Districts will:

1. Provide technical assistance to landowners and operators in the Districts to assure the application of land treatment measures outlined in this plan.

2. Conduct such information and education programs as required to inform local people of the project.

The Bureau of Land Management will:

1. Continue to exercise control of grazing on Federal land in the watershed by licensing the number of livestock and time of use to insure vegetative cover.

2. As personnel become available, plan for the best use or uses of Federal land in this area under the Multiple Use Act. Land treatment measures on Federal land will be planned and applied as a coordinating conservation effort to be in harmony with the determined land use and provide for overall conservation treatment of the watershed.

3. Maintain close liaison with sponsors, individual range users and Federal agencies involved in the project.

4. Provide technical supervision on any projects in the watershed initiated by the Bureau of Land Management, or other authorized users of the Public domain.

The Bureau of Land Management has reviewed and concurred in the features of this plan relating to land under its jurisdiction.

The Soil Conservation Service will:

Furnish technical assistance through the Buckeye-Roosevelt and Wickenburg Soil Conservation Districts to private landowners for the

application of land treatment measures outlined in this work plan.

The Agricultural Stabilization and Conservation Service will:

Provide Federal cost-sharing assistance in accordance with existing Agricultural Stabilization and Conservation Service policies and procedures to individual farmers and ranchers in applying approved conservation practices on their farms and ranches.

STRUCTURAL MEASURES

The Flood Control District of Maricopa County will:

1. Carry out and assume the responsibility and all liability for the construction, operation and maintenance of structural measures.

2. Acquire or provide assurance that landowners or water users have acquired any necessary water rights as required by State law.

3. Acquire and bear costs for all land, easements and rights-of-way needed in connection with the works of improvement. The power of eminent domain will be exercised if necessary.

4. Act as contracting organization for the construction of all structural measures.

The Soil Conservation Service will:

1. Furnish installation services for engineering surveys, design, construction plans, specifications of structural works of improvement for flood prevention and supervision of construction.

2. Allot construction money in accordance with cost-sharing and the installation schedule outlined in this plan or as may be revised by mutual agreement. Money allocations will be in accordance with National priorities and availability of funds at the time of installation.

3. Maintain liaison with sponsors, State and Federal agencies involved in order that the objectives of this work plan will be accomplished to the benefit of all concerned.

INSTALLATION SCHEDULE

Installation of structural measures will begin as soon as practical after the approval of the work plan and allocation of P.L. 566 funds for participation in the project. A five year installation period is planned for the project. Construction of the structural measures will be completed within the first four years. Land treatment measures will be

applied throughout the five year period.

Works of improvement will be planned, installed and applied as follows:

First Year

Application of land treatment measures will be started. Engineering field surveys, geologic foundation investigation and engineering design will be completed for the Saddleback Diversion construction unit. Work will be started to acquire the necessary land, easements and rights-of-way for the Saddleback Diversion, Big Horn Floodwater Retarding Structure, Big Horn Floodway and Centennial Levee.

Second Year

The application of land treatment measures will be continued. The Saddleback Diversion construction unit will be built under contract after land, easements and rights-of-way have been acquired. Engineering field surveys, geologic foundation investigations and engineering design will be completed for the Big Horn Floodwater Retarding Structure, Big Horn Floodway and Centennial Levee. The necessary land, easements and rights-of-way on Burnt Mountain Floodwater Retarding Structure, Burnt Mountain Floodway, Burnt Well Diversion and Little Horn Diversion will be acquired.

Third Year

The application of land treatment measures will continue. The Big Horn Floodway, Big Horn Floodwater Retarding Structure and Centennial Levee will be built under contract. Engineering field surveys, geologic foundation investigations and engineering design will be completed for the Burnt Mountain Floodwater Retarding Structure, Burnt Mountain Floodway, Burnt Well Diversion and Little Horn Diversion.

Fourth Year

The application of land treatment measures will continue. The Burnt Mountain Floodwater Retarding Structure, Burnt Mountain Floodway, Burnt Well Diversion and Little Horn Diversion will be constructed.

Fifth Year

The application of land treatment measures will be completed.

FINANCING PROJECT INSTALLATION

The Flood Control District of Maricopa County will construct, operate and maintain the structural measures outlined in this plan. The District is a public political taxing subdivision of the State of Arizona and a municipal corporation. It has the power to acquire property by eminent domain or otherwise and issue bonds.

The District has analyzed its financial needs in consideration of the scheduled works of improvement so that funds will be available when needed through cash resources or tax and assessment levies. Taxes are presently being levied for the benefit of the District.

The loan provisions of the Watershed Protection and Flood Prevention Act will not be utilized by the sponsoring local organization. That portion of the local sponsors share of the installation cost referred to as land, easements and rights-of-way will be negotiated for by the local sponsoring organization or acquired by eminent domain.

Federal assistance for carrying out the works of improvement on non-Federal land, as described in the work plan, will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666) as amended. Funds for technical assistance for continuation of the existing program of the Buckeye-Roosevelt and Wickenburg Soil Conservation Districts, in the watershed, will be from regular appropriations provided the Soil Conservation Service under Public Law 46.

Financial and other assistance to be furnished from P.L. 566 funds in carrying out this project is contingent on the appropriation of funds for this purpose.

In the installation of the land treatment measures described in this plan, Federal assistance in cost-sharing will be utilized in conformance with Agricultural Stabilization and Conservation Service policies and procedures.

PROVISIONS FOR OPERATION AND MAINTENANCE

LAND TREATMENT MEASURES

Farmers and ranchers cooperating with the Buckeye-Roosevelt and Wickenburg Soil Conservation Districts will be responsible for operation and maintenance of land treatment measures installed on their farms and ranches.

STRUCTURAL MEASURES

The Flood Control District of Maricopa County will operate and maintain all structural works of improvement after they are installed.

The responsible Soil Conservation Service employee and a sponsor's representative will make a joint inspection annually, after unusually severe floods, and after the occurrence of any other unusual conditions that might adversely affect any of the structural measures. These inspections will continue for three years following installation of each structure. Inspections after the third year will be made annually by the sponsors and a report sent to the Soil Conservation Service employee responsible for operation and maintenance inspections.

Specific operation and maintenance agreements will be entered into between sponsors and the Soil Conservation Service prior to the issuance of invitations to bid.

Total annual operation and maintenance cost of structural measures is estimated to be $18,440.

Those items considered necessary for the proper operation and adequate maintenance of the structural works of improvement are as follows:

OPERATION

1. The structural measures for flood prevention are automatic in their operation. The principal spillways are ungated allowing floodwater to emit into the floodways as soon as the floodwater reaches the reservoir.

2. A gate in the debris basin portion of the Saddleback Diversion will be closed at all times except in the case

when emergency repairs may be required. The gate may be opened to drain the water impounded in the sediment pool.

MAINTENANCE

1. Keep gate on debris basin outlet in operating condition. Debris and sediment need not be kept from accumulating near the trash rack.

2. Remove trash and debris from principal spillway inlets.

3. Regrade faces of earth embankments and maintain riprap on upstream face of debris basin embankment.

4. Repair any damage caused to emergency spillways.

5. Repair damage caused to floodways and stilling basins.

6. Maintain drainage gradient through reservoir basins.

7. Exercise control and removal of weeds and debris in the low flow channels of the diversions.

8. Remove sediment deposits from the low flow channels of the diversions when needed to maintain capacity giving particular attention to areas where defined tributaries intersect the diversion channels.

9. Refill and compact scoured areas along all embankments and excessively scoured areas in the low flow channels of the Saddleback Diversion and Big Horn Floodway. Refilling and compacting of scoured areas of the Burnt Well and Little Horn Diversions will be done upon recommendation of operation and maintenance inspections.

10. Special attention must be given to the bridges and the two AT&T crossings for excessive scour so that immediate repairs or maintenance may be effected. The El Paso Natural Gas Line crosses below the outlet of Saddleback Diversion. It is anticipated that any localized scouring that occurs in this area will be remedied under the existing maintenance program.

11. Maintain a satisfactory outlet at the junction of the Big Horn Floodway and Centennial Wash.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Harquahala Valley Watershed, Arizona

Installation Cost Item	Unit	Number	Estimated Cost (Dollars) 1/ P. L. 566	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	ac.	19,000		1,837,860	1,837,860
Technical Assistance			56,100	42,040	98,140
TOTAL LAND TREATMENT			56,100	1,879,900	1,936,000
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structure	no.	2	1,339,020		1,339,020
Floodways	ft.	14,309	300,460		300,460
Diversions	ft.	61,290	596,980		596,980
Levee	ft.	22,915	38,760		38,760
Sub-total-Construction			2,275,220		2,275,220
Installation Services					
Soil Conservation Service					
Engineering Services			455,030		455,030
Other			227,540		227,540
Sub-total-Installation Services			682,570		682,570
Other Costs					
Land Easements, and R/W				1,927,550	1,927,550
Administration of Contracts				22,770	22,770
Sub-total-Other Costs				1,950,320	1,950,320
TOTAL STRUCTURAL MEASURES			2,957,790	1,950,320	4,908,110
TOTAL PROJECT			3,013,890	3,830,220	6,844,110

1/ Price Base - 1964 prices - Structural Measures
1965 prices - Land Treatment Measures

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(At time of work plan preparation)

Harquahala Valley Watershed, Arizona

Measures	Unit	Applied To Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Non-Federal Land			
Conservation Cropping System	ac.	7,122	7,120
Cover and Green Manure Crop	ac.	1,100	22,000
Crop Residue Use	ac.	4,567	6,850
Dike and Levee	ft.	134,640	403,920
Irrigation Ditch and Canal Lining	ft.	353,299	406,280
Irrigation Field Ditch	ft.	87,518	8,560
Irrigation Land Leveling	ac.	6,857	342,850
Irrigation Pipeline	ft.	71,333	499,330
Irrigation System, Tailwater Recovery	no.	13	195,000
Irrigation Water Management	ac.	254	1,020
Land Smoothing	ac.	12,143	364,290
Structure for Water Control	no.	358	17,900
Wells and Pumps	no.	49	2,548,000
Range Proper Use	ac.	45,473	29,550
Sub-total			4,852,670
Federal Land			
Fencing	mi.	42.7	29,800
Pit Reservoir	no.	5	23,438
Stockwater Reservoir	no.	1	1,000
Wells	no.	9	40,200
Range Proper Use	ac.	163,887	96,050
Sub-total			190,488
TOTAL			5,043,158

1/ Price Base 1965 prices

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Harquahala Valley Watershed, Arizona
(Dollars) 1/

Structure Name	Installation Cost - P.L. 566 Funds				Installation Cost - Other Funds			
		Instal. Services				Other		
	Construction	Engi-neering	Other	Total PL 566	Adm. of Contracts	Ease & R/W	Total Other	Total Instal. Cost
Floodwater Retarding Structures								
Burnt Mountain	824,320	164,860	82,430	1,071,610	8,240	181,250	189,490	1,261,100
Big Horn	514,700	102,940	51,470	669,110	5,150	264,300	269,450	938,560
Floodways								
Burnt Mountain	175,610	35,120	17,560	228,290	1,760	62,000	63,760	292,050
Big Horn	124,850	24,970	12,490	162,310	1,250	122,000	123,250	285,560
Diversions								
Saddleback	528,900	105,780	52,890	687,570	5,290	432,500	437,790	1,125,360
Burnt Well	10,620	2,120	1,070	13,810	110	9,750	9,860	23,670
Little Horn	57,460	11,490	5,750	74,700	580	17,750	18,330	93,030
Levee								
Centennial	38,760	7,750	3,880	50,390	390	838,000	838,390	888,780
GRAND TOTAL	2,275,220	455,030	227,540	2,957,790	22,770	1,927,550 2/	1,950,320	4,908,110

1/ Price Base - 1964 prices
2/ See page 23 for breakdown

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TABLE 3 - STRUCTURE DATA
FLOODWATER RETARDING STRUCTURES AND DEBRIS BASIN
Harquahala Valley Watershed, Arizona

Item	Unit	Burnt Mt. FRS	Big Horn FRS	Debris Basin	Total
Drainage Area	sq.mi.	59.7	67.5	21.6 1/	136.7
Storage Capacity					
Sediment	ac.ft.	350	360	215	925
Floodwater	ac.ft.	4,390	4,317	--	8,707
Total	ac.ft.	4,740	4,677	215	9,632
Surface Area					
Sediment Pool	ac.	35	110	113	258
Floodwater Pool	ac.	475	740	--	1,215
Volume of Fill	cu.yd.	1,170,000	627,800	93,660	1,891,460
Elevation Top of Dam	ft.	1,280.5	1,232	1,197	
Maximum Height of Dam	ft.	24.1	18.9	9.7	
Emergency Spillway					
Crest Elevation	ft.	1,272.3	1,226.8	1,192	
Bottom Width	ft.	500	600	200	
Type		Earth	Earth	Earth	
Chance of Use	p'cent	1	1	All Flows	
Av. Curve No.-Cond.II		93	91	92	
Emergency Spy. Hydrograph					
Storm Rainfall	in.	3.25 2/	3.44 3/	--	
Storm Runoff	in.	2.20	2.42	--	
Velocity of Flow	ft./sec.	4.10	4.85	--	
Discharge Rate	c.f.s.	1,750	4,580	--	
Max. W. S. Elev.	ft.	1,274.85	1,230.1	--	
Freeboard Hydrograph					
Storm Rainfall	in.	6.46 2/	6.70 3/	--	
Storm Runoff	in.	5.44	5.18	--	
Velocity of Flow 4/	ft./sec.	9.30	6.25	--	
Discharge Rate 4/	c.f.s.	15,750	13,100	--	
Max. W.S. Elev.	ft.	1,280.05	1,231.7	--	
Principal Spillway					
Capacity, Crest of Emergency Spillway	c.f.s.	490	880	--	
Time of Release	day	8.2	9.5	--	
Capacity Equivalents					
Sediment Volume	in.	0.11	0.10	0.42	
Detention Volume	in.	1.38	1.20	--	
Spillway Storage	in.	2.59	1.33	2.11	
Class of Structure		b	b	a	

1/ Includes 12.1 square miles diverted by Saddleback Diversion
2/ 6 hours
3/ 9 hours
4/ Maximum during passage of hydrograph

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TABLE 3A - STRUCTURE DATA
CHANNELS AND DIVERSIONS
Harquahala Valley Watershed, Arizona

Channel Designation	Sta. Numbering for Reach Sta. Ft.	Sta. Ft.	Type Channel	Drain. Area Sq. Miles	Average Channel Capacity C.F.S.	Head or Slope Ft/Ft	Avg. Bottom Width Feet	Avg. Design Depth Feet	Avg. Veloc. Ft/Sec	Volume Riprap Cu.Yd.	Volume Excav. Cu.Yd.	Volume Embank. Cu.Yd.	℄ Height Embank. Feet
Burnt Mountain	0+00	= 77+66	℄ Burnt Mountain FRS										
Floodway	0+00	2+26	Riprap Principal Spillway Burnt Mountain FRS										
	2+26	20+00	Riprap	.56	547	.0045	26	3.0	5.05	4,740	27,280		
	20+00	23+00	Interstate Hwy. 10 Bridge 3 8x4 CBC's 429 Cu.Yd. Concrete										
	23+00	40+00	Riprap	.56	742	.0045	40	3.0	5.25	5,780	34,620		
	40+00	50+50	Riprap	.56	888	.0045	48	3.0	5.31	3,340	14,620		
	50+50	=186+96	℄ Big Horn FRS										
	50+50	76+64	Riprap	.56	936	.0045	50	2.4	5.10	5,970	21,650		
	76+64	=160+82	℄ Big Horn FRS										
Big Horn	0+00	= 48+00	℄ Big Horn FRS										
Floodway	0+00	8+00	Earth	--	880	.0000	100	6.6	2.50		5,660	13,110	10.8
	8+00	19+50	Earth	157.90	10,800	.0000	--	10.2	0.90		--	27,490	13.4
	19+50	51+50	Earth	157.90	10,800	.0000	--	9.9	1.00		--	75,000	13.3
	51+50	62+50	Earth	157.90	10,800	.0000	--	8.2	1.40		--	23,170	12.5
	62+50	66+50	Earth	157.90	10,800	.0000	160	6.5	2.20		930	6,430	10.8
Centennial	0+00	= 66+50	Big Horn Floodway										
Levee	0+00	20+00	Earth	246.00	25,000	.0010	320	5.7	2.50		34,000	25,930	9.6
	20+00	50+00	Earth	246.00	25,000	.0027	460	3.9	2.50		31,800	29,700	8.2
	50+00	105+00		246.00	25,000	.0017	--	2.5	2.50		--	18,830	4.3
	105+00	157+50		246.00	25,000	.0032	--	1.8	3.30		--	12,560	3.5
	157+50	203+00		246.00	25,000	.0027	--	2.3	3.10		--	17,350	4.6
	203+00	229+00		246.00	25,000	.0038	--	1.0	3.50		--	4,860	3.0

Side Slopes:
Low Flow Channel: 3 Hor.: 1 Vert.
Embankment: 3:1 Upstream - 3:1 Downstream

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TABLE 3A - STRUCTURE DATA
(Continued)

Channel Designation	Sta. Numbering for Reach Sta. Ft.	Sta. Ft.	Type Channel	Drain. Area Sq. Miles	Average Channel Capacity C.F.S.	Head or Slope Ft/Ft	Low Flow Channel: Avg. Bottom Width Feet	Avg. Design Depth Feet	Avg. Veloc. Ft/Sec	Volume Riprap Cu.Yd.	Volume Excav. Cu.Yd.	Earth Embankment: Volume Embank. Cu.Yd.	Avg. ℄ Height Embank. Feet
Saddleback	0+00	16+00	Earth	.96	880	.00300	60	3.0	4.6		11,500	--	--
Diversion	16+00	20+00	Earth	2.21	1,000	.00300	56	2.7	4.8		3,170	2,130	5.7
	20+00	40+00	Earth	2.21	1,210	.00300	61	2.9	5.0		16,300	16,780	7.3
	40+00	56+00	Earth	3.41	1,500	.00300	71	3.0	5.2		13,830	16,700	8.1
	56+00	59+00	Interstate Highway 10 Bridge 12 8x4 CBC's 660 cu.yd. concrete										
	59+00	60+00	Earth	3.41	1,500	.00300	71	3.0	5.2		2,310	2,780	8.1
	60+00	80+00	Earth	3.41	1,620	.00300	80	2.9	5.2		16,080	11,300	5.9
	80+00	100+00	Earth	3.41	1,620	.00300	84	2.8	5.2		15,480	10,810	5.8
	100+00	117+70	Earth	3.41	1,620	.00300	89	2.7	5.1		13,190	13,250	7.0
	117+70	151+46	Earth	3.41	1,720	.00385	70	3.8	5.6		18,600	9,400	3.8
	151+46	151+94	Salome Road Bridge 50 ft. span 45° skew 288 cu.yd. concrete										
	151+94	160+00	Riprap	12.11	1,900	.00265	108	3.2	6.5	4,030	16,950	760	1.7
	160+00	180+00	Earth	12.11	2,130	.00265	128	3.2	4.5		31,820	4,490	3.4
	180+00	200+00	Earth	12.11	2,460	.00265	98	3.2	5.3		14,660	15,760	7.2
	200+00	226+00	Earth	12.11	2,810	.00265	114	3.2	5.3		5,330	17,130	6.5
	226+00	297+55	Debris Basin - See Table 3										
	297+55	329+36	Earth	24.21	1,780	.00400	125	3.5	4.9		43,580	3,700	2.2
	329+36	329+84	Courthouse Road Bridge - 50 ft. span 45° skew, 288 cu.yd. concrete										
	329+84	335+80	Riprap	24.21	1,780	.00400	64	3.3	7.0	2,950	8,420	600	2.0
	335+80	380+00	Earth	25.06	1,780	.00300	78	3.1	5.4		37,970	24,500	5.9
	380+00	400+00	Earth	25.06	1,780	.00300	80	3.1	5.4		16,900	14,380	6.8
	400+00	420+00	Earth	25.06	1,870	.00300	84	3.1	5.4		17,180	13,330	6.5
	420+00	440+00	Earth	27.26	2,130	.00300	90	3.1	5.4		17,780	10,580	5.7
	440+00	460+00	Earth	27.26	2,410	.00300	88	3.5	5.8		19,120	19,500	8.1
	460+00	520+00	Earth	29.76	2,500	.00300	88	3.6	5.9		60,000	49,770	7.4
	520+00	540+00	Earth	32.99	2,660	.00300	98	3.4	5.8		18,820	17,890	7.8
	540+00	570+00	Earth	35.26	3,000	.00300	100	3.6	6.0		28,890	19,650	6.5

Design Storm Frequency: 2%
Side Slopes:
Low Flow Channel: 3 Hor.: 1 Vert.
Embankment: 3:1 Upstream - 3:1 Downstream

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TABLE 3A - STRUCTURE DATA
(Continued)

Channel Designation	Sta. Numbering for Reach Sta. Ft.	Sta. Ft.	Type Channel	Drain. Area Sq. Miles	Average Channel Capacity C.F.S.	Head or Slope Ft/Ft	Avg. Bottom Width Feet	Avg. Design Depth Feet	Avg. Veloc. Ft/Sec	Volume Riprap Cu.Yd.	Volume Excav. Cu.Yd.	Volume Embank. Cu.Yd.	Avg. ℄ Height Embank. Feet
Burnt Well Diversion	0+00	32+50	Earth	1.36	1,340	.004	--	3.1	3.07			16,400	5.8
Little Horn North	0+00	23+00	Earth	18.90	33,800	.012	--	8.7	10.70			37,700	11.5
Little Horn South	15+00	41+00	Earth	18.90	33,800	.006	--	9.8	8.50			50,700	12.6

TABLE 4 - ANNUAL COST

Harquahala Valley Watershed, Arizona

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost2/	Operation and Maintenance Cost	Total
Diversion, Floodwater Retarding Structures, Floodways and Levee	195,290	18,440	213,730

1/ Price Base: Installation - 1964 prices
Operation and Maintenance - Long-term price levels

2/ Interest Rate: 3 1/8% - Amortized for 50 years

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Harquahala Valley Watershed, Arizona

(Dollars) 1/

Item	Estimated Average Annual Damage Without Project	With Project	Damage Reduction Benefit
Floodwater			
Crops and Pasture	219,600	64,400	155,200
Other Agricultural	75,900	23,000	52,900
Non-Agricultural	19,400	5,700	13,700
Sub-total	314,900	93,100	221,800
Sediment			
Crops and Pasture	123,600	36,200	87,400
Other Agricultural	50,600	15,400	35,200
Non-agricultural	4,300	1,200	3,100
Sub-total	178,500	52,800	125,700
Erosion			
Floodplain	4,300	--	4,300
Indirect	51,000	15,000	36,000
TOTAL	548,700	160,900	387,800

1/ Price Base: Long-term price levels

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Harquahala Valley Watershed, Arizona

(Dollars) 1/

Evaluation Unit	AVERAGE ANNUAL BENEFITS Flood Prevention Damage Reduction	Secondary	Total	Average Annual Cost	Benefit Cost Ratio
Floodwater Retarding Structures, Diversions, Floodways and Levees	361,100	55,550	416,650	213,730	1.9:1.0
TOTAL	361,100 2/	55,550	416,650	213,730	1.9:1.0

1/ Price Base: Benefits - Long-term Price Level
Costs - 1964 Prices

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction primary benefits of $26,700.

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Investigation And Analyses Section

HARQUAHALA VALLEY WATERSHED

Maricopa and Yuma Counties, Arizona

L A N D U S E A N D T R E A T M E N T

H Y D R O L O G I C I N V E S T I G A T I O N S

S E D I M E N T A T I O N I N V E S T I G A T I O N S

G E O L O G I C I N V E S T I G A T I O N S

C H A N N E L S T A B I L I T Y

E N G I N E E R I N G I N V E S T I G A T I O N S

E C O N O M I C I N V E S T I G A T I O N S

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LAND USE AND TREATMENT

Land treatment measures to be applied by farmers cooperating with the Buckeye-Roosevelt and Wickenburg Soil Conservation Districts are an essential part of this watershed work plan. These measures were based on soil surveys, technical guide data, conservation needs inventory, and past accomplishments of the regular going program of the Soil Conservation Districts and the Agricultural Stabilization and Conservation Service.

Cost of technical assistance for installation of the land treatment measures was based on the average work performance time for each of the individual measures to be applied. An average hourly rate was established to fit local conditions using Advisory Notice B&F Arizona-39, dated November 17, 1965, as a guide. The cost of additional technical assistance to be borne by P.L. 566 funds was determined by subtracting the cost of technical assistance available within the watershed under the going program from the total estimated cost of technical assistance.

The unit costs of establishing the land treatment measures outlined in this plan were obtained by checking actual cost records in the area under the going program of the Soil Conservation Districts and the Agricultural Stabilization and Conservation Service program of cost-sharing. These costs were used in computing the unit costs of the accelerated land treatment program in the project. They were also compared to cost data for similar agricultural areas in the state.

Costs of applying the land treatment measures were derived on the basis of the going program with the addition of those measures needed to accomplish the objectives of the local sponsors through accelerated planning. The landowner on whose property these measures are to be applied will bear the cost of application.

HYDROLOGIC INVESTIGATIONS

BASIC DATA

One U. S. Weather Bureau standard rain gage is located in the watershed. There are no stream gages located in the watershed. Precipitation records were analyzed from the following Weather Bureau stations:

Station	Distance from Watershed (miles)	Years of Record
Harquahala Plains	0	12
Tonopah	5	13
Salome	15	52
Aguila	5	28
Litchfield Park	38	23
Buckeye	27	57

Frequency analyses were made of 1, 2, 3, 7, 10, and 30-day precipitation amounts. These frequency curves were compared with U. S. Weather Bureau Technical Paper No. 40 (TP-40) and Technical Paper No. 49 (TP-49) and were found to be slightly higher for short duration rainfall and significantly lower for long durations of 3 to 10 days. Local data were considered to be more representative and were used for all design calculations except spillway design.

Soil and cover reconnaissance surveys were made of the watershed and curve numbers assigned using procedures described in Chapters 7, 8, and 9 of Part I, Section 4, National Engineering Handbook (NEH).

Cross sections were surveyed at 72 locations and velocities were computed. An isovelocity map was drawn of the watershed for computing times of concentration of the sub-watersheds according to the definition given in Chapter 15 of Part I, Section 4. NEH.

TRANSMISSION LOSS

Significant infiltration losses occur from all runoff events due to the large number of sandy bottom washes in the watershed. The procedure used for computing these transmission losses is basically one of evaluating the infiltration of water into channel bottoms over a unit of time. Correlations were made of channel length, channel width, number of channels and drainage area to stream order. Stream order is a geomorphological classification of streams. A first order stream is defined as a small unbranched tributary and the stream

receiving that tributary is labeled second order. Two second order streams join to form a third order, etc. These correlations were based on map and aerial photography studies, field observations and surveys. The correlations compared favorably with results from similar studies on tributaries to the Rio Grande River in New Mexico by L. B. Leopold and J. P. Miller published in U. S. Geological Survey Professional Paper 282-A, "Ephemeral Streams - Hydraulic Factors and their Relation to the Drainage Net."

Infiltration rates were computed from runoff data from the Agricultural Research Service experimental watershed on Walnut Gulch Wash near Tombstone, Arizona. Measurement of transmission losses in channels was accomplished by tandem stream gages and closely spaced precipitation gages. An average infiltration rate in excess of two inches per hour was computed from 17 runoff events.

Loss rates, computed for various stream orders, were plotted against stream order on semi-log paper. First order streams in this watershed are defined as channels with 3-foot average bottom widths because field observations indicated that coarse sands became significant in streams with bottom widths averaging three feet. Loss rate (acre feet per hour) is equal to number of channels x length x width x infiltration rate.

Transmission loss volumes were then computed for sub-watersheds by multiplying loss rate times hydrograph base time. All computed runoff volumes were adjusted for transmission losses.

FLOOD ROUTING

Digital computer facilities available at the Central Technical Unit, Hydrology Branch, Engineering Division, Hyattsville, Maryland, were used in project evaluation and flood routing. Different frequency storms were routed through the watershed with proposed floodwater retarding structures and diversions in place to determine the most economical design.

In order to utilize the computer program described in Technical Release No. 20, curve numbers were modified to reflect transmission losses in the stream channels.

FLOODWATER RETARDING STRUCTURES

The two floodwater retarding structures were designed to retard the 100-year runoff volumes. Volumes of runoff for the emergency spillway and freeboard hydrographs were determined according to procedures outlined in Chapters 10 and 21 of Part I, Section 4, NEH, Technical Release No. 10, and Soil Conservation Service Engineering Memorandum No. 27. Local precipitation data were used.

DIVERSIONS

Peak discharges at various frequencies were computed for the three diversions using procedures outlined in Chapters 10 and 16 Part I, Section 4, NEH. The "Convex" method described in the revised draft of Chapter 17 of Part I, Section 4, NEH was used to floodroute the combined peak discharges from sub-watersheds intersected by Saddleback Diversion. This diversion has a debris basin located approximately in the middle of its length. This debris basin was treated as a dam with sediment and spillway storage. Freeboard on the debris basin was determined from the State Dam Code. The product of storage x height was less than 3,000.

Design capacity of the Big Horn Floodway was determined by adding the maximum release rate from the Big Horn Floodwater Retarding Structure to the peak inflow from Tiger Wash drainage. As a basis for design, it was assumed that one-third of the Centennial Wash flood flows could intermingle with Tiger Wash water. It was also assumed that the peak inflow hydrograph is uniformly distributed over the 6,650 feet of diversion which intersects the Tiger Wash drainage. Flows enter the diversion as sheet flow at a uniform depth throughout this section.

PEAK DISCHARGE-AREA INUNDATION RELATIONSHIP

Peak discharge-frequency curves were computed on a synthetic basis from all sub-watersheds. These peak discharges were added to obtain a combined peak discharge-frequency curve for the watershed. Peak discharges for four events were computed from slope area measurements. Frequencies were assigned on this basis. Peak discharges from the four events were related graphically to the peak discharge-frequency curve. Areas of inundation obtained from field surveys and interviews were correlated with the peak discharge-area inundation curve. Area inundated at the 100-year storm was obtained through projection of areas inundated by known events. Peak discharges were computed on the basis of sub-watershed controlled and for various levels of structure design. Areas inundated were obtained from the peak discharge-area inundation curve.

S E D I M E N T A T I O N I N V E S T I G A T I O N S

SEDIMENT SOURCE AREAS

Investigation shows that the principal source of sediment is from rangeland upstream from the cultivated area. Cover conditions on the rangeland are poor and the principal soil loss is through sheet erosion. Streambank and gully erosion is of minor importance. Other sources of sediment are from erosion of farm and county roads and on-farm diversions and channels.

SEDIMENT STORAGE REQUIREMENTS

Floodwater Retarding Structures

Estimates of sediment storage requirements for the two floodwater regarding structures were based on sedimentation data obtained from surveys of several stock tanks in and near the watershed. Stock tanks surveyed gave information for each of the hydrologic soil groups involved. Sedimentation rates obtained from the surveys were corrected for average rainfall conditions. Adjustments were also made in the rates for trap efficiencies of the tanks. A sediment delivery rate curve was used to determine the on-site erosion rates of the stock tank drainage areas. The appropriate on-site erosion rate was assigned to each hydrologic soil group in the drainage areas of the floodwater retarding structures. Definable individual drainage areas coming into the floodwater retarding structures were delineated, and the average annual volume of material eroded in each drainage area was determined. Delivery rates for each of the delineated drainage areas were obtained from the delivery rate curve and used to determine the average annual volume of eroded materials which would be deposited at the floodwater retarding structure sites.

The estimated average annual sediment storage requirement for the Burnt Mountain Floodwater Retarding Structure is 6.44 acre feet or 0.10 acre foot per square mile of drainage. The 50-year required sediment storage is 322 acre feet. The Big Horn Floodwater Retarding Structure has an estimated average annual sediment storage requirement of 6.66 acre feet or 0.10 acre foot per square mile of drainage. The 50-year sediment storage requirement for this structure is 333 acre feet.

Saddleback Diversion and Debris Basin

The debris basin is located approximately 4.5 miles downstream from the start of the diversion. This structure must be designed to store the volume of sediment brought into the basin by the diversion as well as the volume of sediment delivered by direct drainages to the basin. Sediment transported through the diversion to the debris basin consists of the sheet erosion sediment yield from the drainage area of the diversion and the volume of material scoured from the low flow channel of the diversion. The sheet erosion sediment volume was determined by the same procedure used for estimating the sediment storage requirements of the floodwater retarding structures. The volume of sediment produced by scour of the diversion low flow channel was determined by estimating the maximum volume of material which could be scoured out before an erosion resistant bed armor would be formed. Reaches were set up along the length of the diversion by material types present. The tractive force method was used along with grain size analyses of materials present and design depths of flow to determine depths of scour necessary for the formation of erosion resistant bed armor in each reach along the diversion channel. Lengths of reaches, depths of scour, and widths of channel were used to compute

the maximum volume of scour.

The estimated average annual sediment storage requirement for the Saddelback Diversion debris basin attributed to sheet erosion is 2.77 acre feet or 0.13 acre foot per square mile of drainage. The 50-year sediment storage requirement from this sediment source is 138.5 acre feet. The estimated 50-year sediment storage requirement for materials scoured from the diversion low flow channel is 76.5 acre feet. The total 50-year sediment storage requirement for the debris basin is 215 acre feet.

Deposition of coarse grained bedload materials at the intersection of incised stream channels with the diversion is expected due to the abrupt changes in channel slopes involved. Additional capacity should be provided in these localized areas for storage of bedload materials which could be deposited during a single storm. This would insure against blockage of flow in the diversion channel until adequate clean-out operations could be accomplished. It was determined that the design storm would produce the greatest volumes of bedload inflow to the diversion channel. Volumes of bedload inflow from the design storm were estimated at one percent of the volume of runoff from each individual defined drainage. The estimate of bedload inflow was made after consideration of sedimentation measurements made at Walnut Gulch Experimental Watershed in Cochise County, Arizona and Judy Wash Dam in Graham County, Arizona, and bedload movement studies made by B. R. Colby in the State of New Mexico.

The courses of incised stream channels at their intersection with the diversion should be turned downstream to provide for more even distribution of inflowing sediments.

A maintenance program for the diversion channel should provide for the removal of bedload deposits which encroach on the design capacity of the structure. Inspections should be made annually and after every major storm to determine maintenance needs of the diversion channel.

Big Horn Floodway

Sediment yield from the drainage area above the floodway was determined by the same procedure as used for the floodwater retarding structures. The floodway will intercept an estimated average annual yield of 3.69 acre feet of sediment. After considering the expected volumes of sediment yield and the design of the floodway with no grade and low velocity flows, it was determined that an aggrading condition would prevail in the floodway area. There are no defined stream channels intercepted by the floodway; however, sediment deposition may be more pronounced in some areas along the floodway than in others. Delineation of these areas of more concentrated deposition is not possible due to the nature of the drainageways involved and because drainageways present now are likely to shift erratically with aggrading conditions.

Extra capacity should be provided along the length of the floodway for deposition of sediment. The channel section of the floodway should be kept open through maintenance.

GEOLOGIC INVESTIGATIONS

Preliminary investigations of the Burnt Mountain and Big Horn Floodwater Retarding Structures, the Saddleback Diversion with debris basin, Big Horn Floodway, and Centennial Levee were made to determine the geologic feasibility and design requirements of the structure sites. Data collected during the investigations include logs of borings and test pits and results of tests conducted on soil samples collected from the sites. Additional information was gained from surface studies of watershed slopes and channel banks.

BURNT MOUNTAIN FLOODWATER RETARDING STRUCTURE

Drilling operations were conducted along the centerline of the dam and in the emergency spillway area. Thirty-one holes were drilled to depths ranging from 8 to 25 feet. Two test pits were also dug to investigate portions of the emergency spillway area. Soil samples were taken of representative materials found at the site for design considerations.

Summary of Findings - Shallow deposits of loose silty to very silty sands and gravels are generally present at the surface along the length of the dam. Coarse grained SP materials were present in localized areas to depths of about 5 feet. Interbedded layers of silty to very silty SM, SM-ML, ML, CL-ML, and GM materials underlie the surface materials. These foundation materials are firm to compact in nature becoming more compact with depth. The gravelly materials become more predominant toward the left abutment section of the dam.

Materials similar to those found along the centerline of the dam were assumed to be present in the borrow area upstream from the dam. Material types available to expected borrow depths will generally range from very silty sands to silty sandy gravels. Silty sandy gravel with some cobbles is present to the proposed grade in the emergency spillway area.

Conclusions and Recommendations: The dam site is geologically feasible. The foundation appears competent to support the loads to be imposed. A shallow key trench through the loose surface materials should be sufficient to provide a suitable bond between the embankment of the dam and foundation materials.

Sufficient quantities of borrow materials are available upstream from the dam for construction of the embankment. Materials excavated from the emergency spillway are suitable for use as embankment fill.

The gravelly materials at the proposed grade in the emergency spillway area are fairly resistant to erosion.

Additional geologic investigations will be necessary prior to preparation of the final design. The detailed investigation should include in-place testing of foundation conditions and additional pits and borings to adequately delineate foundation materials and borrow areas. Additional samples should be taken to provide data for final design.

BIG HORN FLOODWATER RETARDING STRUCTURE

Twenty test holes were drilled along the centerline of the dam ranging in depth from 10 to 22 feet. Soil samples were taken of representative foundation and borrow materials for design considerations.

Summary of Findings - Shallow surface sands are underlain by interbedded slightly to very silty SM, ML, and CL materials. Shallow deposits of non-plastic ML materials and some of the loose SM materials at the right end of the dam may be subject to rapid consolidation upon loading and saturation. The central portion of the dam contains zones of coarse grained slightly silty SM materials at varying depths in the foundation. These materials appear to be highly permeable. CL materials are generally found below the surface sands in the left abutment section of the dam. Compact to very compact SM, ML, and CL materials were found at depth throughout the length of the dam.

Borrow materials were considered similar to those found along the centerline of the dam. These materials include silty sands, sandy clays, and non-plastic sandy silts.

Highly erosive SM and ML materials were found in the emergency spillway area.

Conclusions and Recommendations - The dam site is geologically feasible; however, proper design and construction will be necessary to compensate for site deficiencies. Prewetting of collapsable foundation materials may be necessary so that consolidation of the unstable materials will take place as they are loaded during construction. A cutoff trench should be founded below the highly permeable sands in the center section of the dam where sufficient overburden of less permeable materials is not present to insure against excessive seepage and the possibility of piping. A shallow key trench through the loose surface materials along the remainder of the dam should be sufficient to provide for a suitable bond between the embankment and foundation.

Sufficient quantities of materials are available for borrow. Excavation of borrow materials should not be permitted within 200 feet of the upstream toe of the dam as a further aid in preventing seepage through or into the structure foundation. Materials excavated from the emergency spillway are suitable for use as fill in the embankment.

Additional geologic investigations will be necessary prior to final design. Detailed investigations should include in-place testing of foundation conditions. Additional pits and borings are needed to adequately delineate borrow areas, investigate the emergency spillway, and more closely delineate foundation materials and cutoff trench depths. Samples should be taken to provide more detailed information for final design.

BIG HORN FLOODWAY

A geologic investigation of the floodway was carried out to determine foundation conditions for the floodway embankment and types of materials available for borrow. Hand auger borings were dug and materials logged at six locations in close proximity to the floodway.

Fine grained SM materials were generally found along the floodway, with localized areas of ML materials. The materials were generally loose near the surface becoming firm to slightly compact with depth.

The floodway site appears geologically feasible. Removal of loose surface materials should be sufficient foundation preparation for the site. Materials excavated from the channel section of the floodway should be suitable for use as fill material in the embankment.

A detailed investigation will be necessary prior to final design to more accurately delineate materials present. Samples of borrow materials should be obtained for compaction data.

SADDLEBACK DIVERSION

Test pits were dug at 56 locations along the diversion base line and in the outlet area to determine foundation conditions, materials present to grade in the low flow channel, and types of material available for construction of the embankment. Soil samples of representative materials were taken at the site for design considerations.

Summary of Findings - A cut channel section with no downstream embankment is planned for the first 1,600 foot length of the diversion. Shallow deposits of cobbles and gravel overlie a well cemented caliche conglomerate in this section.

The portion of the diversion between the cut channel section and the debris basin consists of an embankment with a low flow channel. A wide variety of materials were found along this section of the diversion. Surface deposits are generally shallow and range from loose silty sandy gravels to loose very silty sands. GM, SM, and ML materials underlie the loose surface materials. These underlying materials generally become more compact with depth. The gravelly materials are predominant at the upper end of the reach, and the finer grained materials are more common near the lower end of the reach.

In the debris basin section of the diversion, shallow deposits of loose silty sands overlie firm to compact ML and CL materials. Similar materials were considered available for borrow upstream from the debris basin.

The remaining section of the diversion from the debris basin to the diversion outlet consists of an embankment with a low flow channel. Loose silty gravelly sands or silty sandy gravels generally occur in this section over compact silty gravels or caliche conglomerate.

Conclusions and Recommendations - The diversion site is geologically feasible. Foundation materials appear competent to support the loads to be imposed with the possible exception of the loose silty sand deposits found in the surface horizon of the debris basin section. These materials may be subject to rapid consolidation when loaded and saturated. Removal of these materials from the base of the embankment or treatment by prewetting before construction may be desirable. A cutoff trench founded in the CL and ML materials should be provided in the debris basin section. Removal of the loose surface materials should be adequate to provide for a suitable bond between the foundation and embankment along the remaining sections of the diversion. Materials excavated from the diversion channel will generally be suitable for use as fill in the embankment except where caliche conglomerate is encountered. Dozers equipped with rippers will be needed to excavate the caliche materials and blasting may be necessary in some areas. These rocky materials will not be suitable for use as fill in the embankment. Downstream sources of borrow will have to be utilized for construction of the sections of diversion fill where sufficient quantities of suitable materials cannot be obtained from the low flow channel. Riprap should be placed on the upstream face of the debris basin to protect the embankment from erosive wave action. Competent rock for riprap is available in the nearby mountain areas.

Additional geologic investigations will be needed for preparation of the final design. In-place testing of foundation conditions should be carried out in the debris basin section. Additional pits and borings will be needed to delineate borrow areas and foundation materials. Additional pits will be needed to test the competency of the caliche materials to be excavated from the diversion channel and outline the areas of possible "rock excavation" as defined in "Engineering Construction and Material Specifications" SCS-Arizona, Section 4A, Excavation. Additional samples may also be needed to provide data for final design.

CENTENNIAL LEVEE

The levee was investigated by hand auger borings to determine geologic feasibility and types of materials available for use in the embankment. Seventeen hand auger borings were made and materials logged along the levee base line.

Summary of Findings - Fine to medium grained SM materials were generally present along the levee location. Materials ranged from loose to slightly compact, generally becoming more compact with depth.

Conclusions and Recommendations - The levee appears geologically feasible. It may be desirable to remove the loose surface materials from the foundation. Materials present appear suitable for use as borrow for the embankment. Borrow materials should be taken from the downstream side of the embankment so low floods will not impinge on the toe of the levee. The detailed geologic investigation should include sampling of borrow materials for compaction data.

Extra maintenance of the levee may be necessary in areas where concentrated flows are intercepted by the levee.

CHANNEL STABILITY

BURNT MOUNTAIN FLOODWAY

The Burnt Mountain Floodway was investigated to determine types of materials present to proposed grades and the erosion resistance of these materials. Information from four test pits dug along the floodway and data correlated from drill holes along the Big Horn Floodwater Retarding Structure were used in the stability evaluation.

Materials present to grade in the floodway include silty sands, sandy silts and silty sandy clays.

The allowable velocities procedure was used to determine the stability of materials at grade in the floodway. Design velocities range from 5.05 to 5.31 ft./sec. The flows which consist of releases from the Burnt Mountain Floodwater Retarding Structure were considered to be relatively clear water. The design velocities were found to be much greater than the non-scouring velocities of the soil materials, indicating that erosion would occur.

Since the floodway is located downstream from the Burnt Mountain structure and erosion cannot be tolerated, lining of the floodway will be necessary.

BIG HORN FLOODWAY

An investigation was made in conjunction with the geologic investigation to determine the erosion resistance of materials at proposed grades in the channel of the floodway. Silty to very silty, fine grained SM materials were generally found at grade in the channel. Some localized areas of very sandy ML soils were also present. The materials ranged from loose to slightly compact.

The erosion resistance characteristics of these materials are not great, but considering the design of the floodway, with maximum

velocities not exceeding 2.7 feet per second, excessive scour in the channel is not anticipated.

SADDLEBACK DIVERSION

The Saddleback Diversion was investigated to determine the types of materials present in the low flow channel section of the diversion and the erosion resistance of these materials. The field investigation was carried out in conjunction with the geologic site investigation. Material types present are described in the Geologic Investigations section of the work plan. Materials found along the base line location were assumed similar to those present along the centerline of the diversion.

Since the unconsolidated materials along the base line location are generally of the coarse grained, non-cohesive type, the tractive force stability analysis procedure was used. The diversion traverses unimproved rangeland and some deterioration of the low flow channel can be tolerated except at bridge locations. Materials along the diversion were correlated giving consideration to the grain sizes of the materials present. The diversion was divided into reaches based on material types, low flow channel design, and hydrologic factors. Stability determinations were made for each reach. In most cases where unconsolidated soils were involved, coarse grained materials were present in sufficient size and volume for the formation of a relatively stable bed armor in the low flow channel. Depth of scour to formation of the stable bed armor was determined and the volume of scoured material was computed for use in estimating the sediment storage requirements of the debris basin. Caliche conglomerate was considered as erosion resistant and not subject to excessive scour.

Two reaches upstream from the debris basin were determined by the tractive force analysis to be unstable. Excessive erosion is not expected in these sections due to the protection of the soils by inflowing sediment and bedload material.

Channel constrictions at three bridge locations create design velocities which will cause excessive scour. Protection of the bridges and channel sections in these areas of high velocities will be needed.

Scour is expected to occur in the channel section at the outlet of the debris basin. Erosion in this section by any one flow is not critical because channel degrading will increase the capacity of the diversion. However, extra maintenance may be necessary in this section to protect the embankment.

At the outlet of the diversion, flood flows will be released over unimproved rangeland to a drainageway leading to Centennial Wash. The sediment laden flows will not be confined by structural works in this section. Excessive scour is not expected in this section due to the presence of shallow deposits of caliche conglomerate, gravelly

and cobbly materials and very compact silty sands. If limited scour does occur in this section, the diversion will not be endangered. The end of the diversion embankment ties into a basalt hill and is protected by the hill. The low flow channel at the end of the diversion is on caliche conglomerate and is not subject to excessive erosion.

The diversion structure will be essentially stable; however, a continuous maintenance program will be necessary to repair localized areas of scour and for protection of the diversion embankment.

ALTERNATE STUDIES

Channel stability studies were made on the various structural alternates of the Big Horn Floodway in Plan No. II. (See page 61, Alternate Studies, Engineering Investigations.)

In Plan No. II, the Big Horn Floodway would convey the releases from the Big Horn Floodwater Retarding Structure a distance of six miles to Centennial Wash. The floodway would also serve as a diversion for floodwater originating in the Tiger Wash drainage area.

Twenty-eight test pits were dug along the proposed centerline of the floodway. Materials were logged and samples taken of representative material types present. SM, SC, CL, and ML materials were commonly found at proposed grades in the low flow channel.

The tractive force procedure as described in the Review Draft of the Procedural Guide for Planning and Design of Open Channels was used to determine the erosion resistance of materials at the proposed grades in the floodway. The analysis showed that excessive erosion would occur in the low flow channel with design flows. It was also found that the releases from the Big Horn Floodwater Retarding Structure alone would cause excessive erosion. It was concluded that stabilization measures would be necessary if the floodway were constructed at this location.

ENGINEERING INVESTIGATIONS

MAPS

United States Geological Survey 7½ and 15 minute quadrangle maps with contour intervals of 20 and 40 feet were obtained of the watershed area and used as base maps for planning activities.

SURVEYS

Topographic maps with a scale of 1 inch = 400 feet were surveyed of the floodwater retarding structure sites and reservoir areas and the Saddleback Diversion area. Centerline profiles of the floodwater retarding structures were surveyed and used as a basis for computing volumes of embankment. A base line centerline profile of an approximate location for the Saddleback Diversion was surveyed and was used as a basis for determining final diversion location.

Twenty-six cross sections were surveyed on Centennial Wash for use in determining high water marks for rights-of-way purchases. Seven cross sections were surveyed of the main drainageway leading south to Centennial Wash in the center of the cultivated farmland. These cross sections were used primarily in determining rights-of-way required and also for determining measures required to provide a satisfactory outlet from Saddleback Diversion to Centennial Wash.

DESIGN CRITERIA

Floodwater Retarding Structures - The floodwater retarding structures were designed to contain floodwater from the 100-year storm. Additional capacity was provided to contain a 50-year accumulation of sediment. The principal spillways were designed to release the flood volume from the 100-year storm, flood routed through the structure without use of the emergency spillways.

The principal spillways consist of ungated reinforced concrete boxes through the dams with inlet and outlet structures which will release the impounded floodwater into their respective floodways in about ten days for a 100-year storm.

The emergency spillways were designed using Soil Conservation Service standards for floodwater retarding structures in a moderately hazardous situation. The widths of the emergency spillways were determined by routing the design storm hydrographs through the

emergency spillways at a safe velocity. The width of the emergency spillway of the Big Horn Floodwater Retarding Structure was determined by the economics of spillway excavation cost versus embankment fill cost. Depth of freeboard was determined by routing the freeboard design hydrograph through the emergency spillway without overtopping the floodwater retarding structure.

The earth embankment design was based on a study of foundation and fill materials. The nature and characteristics of these materials were determined by preliminary subsurface investigations and laboratory test results of soil samples taken on the centerline of the floodwater retarding structures. Final design will be based on the results of detailed subsurface investigations to be accomplished during early construction planning.

FLOODWAYS

The floodway designs were based on a study of erosion resistant characteristics of channel materials. If velocities were found to be conducive to erosion, some form of stabilization was recommended. Burnt Mountain Floodway will be stabilized by rock riprap throughout its length. Saddleback Diversion will be stabilized by rock riprap at three bridge locations. The thickness and size of the rock riprap to be used was based on Section VI, "Criteria for Rock Riprap Size" in Engineering Design Standards, Far West States, published by the Soil Conservation Service. The Big Horn Floodway will be an earth channel constructed on a level grade to Centennial Wash. Additional embankment height was added to allow for deposition of sediment from Tiger Wash floodwater. If these sediment deposits encroach upon the carrying capacity of the floodway, removal of these sediments is recommended.

DIVERSION EMBANKMENTS AND LEVEE

Embankment designs for the Little Horn Diversion, Burnt Well Diversion, Saddleback Diversion, Big Horn Floodway, and Centennial Levee were based on a study of foundation and fill materials. The nature and characteristics of these materials were determined by preliminary subsurface investigations and laboratory test results of soil samples. The cross section dimensions of the embankment were based on the design criteria as shown for a Class II Dike in SCS National Engineering Handbook, Section 2, Engineering Practice Standards, Part 1; that portion entitled "Dike and Levee."

The Little Horn Diversion is designed to convey the peak discharge from the freeboard hydrograph to Burnt Mountain Floodwater Retarding Structure. The Burnt Well Diversion is designed to convey the peak discharge from the 100-year storm into the reservoir of the Burnt Mountain Floodwater Retarding Structure.

The Big Horn Floodway is designed for the peak discharge from the 100-year storm of the Tiger Wash drainage area combined with the 100-year release from the Big Horn Floodwater Retarding Structure and

one-third of the 100-year peak flow of Centennial Wash. Centennial Levee is designed to confine the peak discharge from the 100-year storm conveyed by the Big Horn Floodway including Centennial Wash flows. Centennial Wash flows were included in this design to prevent levee failure by overtopping.

A study was made to determine the feasibility of a levee designed to convey project floodwaters only. This smaller levee was found to be susceptible to overtopping by a seven year storm event and could not be justified due to the higher incremental costs of operation and maintenance compared to the proposed levee.

Saddleback Diversion is designed to convey the peak discharge expected from a 50-year storm to Centennial Wash. This diversion will consist of an embankment and low flow channel for the major portion of its length. The low flow channel design was based on hydrologic and geologic studies. A channel design was determined by taking into account the (1) balancing of cut and fill quantities, and (2) stability of the channel bottom so that excessive scour or excessive sediment deposition would not occur. At the termination of the low flow channel portion of the diversion, floodwater will be conveyed to a low area which drains southward to Centennial Wash. Additional embankment height was added at specific areas where tributary channels are expected to deposit excessive sediment.

DEBRIS BASIN

Design of the embankment was based on a study of foundation and fill materials. The embankment cross-sections, foundation preparation, and embankment protection was based on criteria for a storage detention dam.

A L T E R N A T E S T U D I E S

Seven alternate proposals were considered during project formulation. Common to all seven proposals are the following structural measures:

1. Saddleback Diversion.
2. Burnt Mountain Floodwater Retarding Structure.
3. Burnt Mountain Floodway.
4. Little Horn and Burnt Well Diversions.

PLAN NO. I

This plan includes the following additional structural measures:

1. Big Horn Floodwater Retarding Structure and Big Horn Floodway.

2. Tiger Wash Floodwater Retarding Structure and Tiger Wash Floodway.

The releases from Burnt Mountain Floodwater Retarding Structure were conveyed into Big Horn Floodwater Retarding Structure and Big Horn Floodway, thence into Centennial Wash. Tiger Wash Floodwater Retarding Structure and Floodway were located above Big Horn Floodwater Retarding Structure and conveyed the floodwater from its controlled area separately to Centennial Wash. This plan was eliminiated for two reasons; one being the possibility that the controlled area of Tiger Wash Floodwater Retarding Structure could not be easily defined requiring some extensive measures for properly channeling flood flows. The second reason was the excessive cost of this plan compared to the plan selected.

PLAN NO. II

This plan includes the following additional structural measure:

1. Big Horn Floodwater Retarding Structure and Floodway.

The releases from Burnt Mountain Floodwater Retarding Structure were conveyed into Big Horn Floodwater Retarding Structure, then a distance of 6 miles to Centennial Wash by the Big Horn Floodway. The Big Horn Floodway would also serve as a diversion for Tiger Wash floodwater and would convey flows to a Centennial Wash location having the carrying capacity necessary to prevent floodwater from reentering the watershed. This plan was rejected due to the high cost of stabilization required for the 6 mile floodway. Various studies of structural alternates involving drop structures and riprap did not significantly change this conclusion.

PLAN NO. III

This plan involved a study of a multi-purpose structure in the debris basin of Saddleback Diversion. Extra storage capacity was added involving a detention pool for fish and wildlife benefits. A study by the Arizona State Game and Fish Department disclosed that the cost for supplemental water to maintain a minimum conservation pool would not warrant cost sharing involved.

PLAN NO. IV

This plan has these additional structural measures:

1. Big Horn Floodwater Retarding Structure and Floodway.

2. Tiger Wash Floodwater Retarding Structure.

3. Centennial Levee.

The floodwater released from Burnt Mountain Floodway would flow into Big Horn Floodwater Retarding Structure and then be conveyed through the Big Horn Floodway to Centennial Wash. A 4.4 mile levee along the north bank of Centennial Wash would convey these releases

along with diverted flows from Tiger Wash and the natural flows of Centennial Wash in a confined channel past the watershed. The Tiger Wash structure would be located in a narrow canyon of Tiger Wash located 14 miles north of Centennial Wash. The floodwater released would find its way to Centennial Wash in natural drainage channels.

This plan was rejected due to a higher cost than the recommended plan.

PLAN NO. V

This is the plan recommended in the work plan and includes the measures shown under Structural Measures.

PLAN NO. VI

This plan is essentially the same as the recommended plan except that a level grade diversion was substituted for the Big Horn Floodway and Big Horn Floodwater Retarding Structure. Plan No. V and this plan have comparable estimated average annual costs; however, due to the inherent advantages of a floodwater retarding structure compared to a diversion, this plan was rejected.

PLAN NO. VII

This plan was investigated because of legislative approval of 12,500 acre feet for floodwater capacity impounded by floodwater retarding structures. This plan is the same as Plan No. V except for the following:

1. Substituted for Big Horn Floodwater Retarding Structure would be a longer structure that would impound the additional floodwater originating from the Tiger Wash drainage area. Two diversions were included in the Tiger Wash drainage area to insure that this floodwater reached the Big Horn Floodwater Retarding Structure.

2. A shorter Big Horn Floodway was substituted for the larger Big Horn Floodway of Plan No. V and would carry only the release rate from Big Horn Floodwater Retarding Structure.

This plan was rejected because of a higher cost of construction than Plan No. V. The savings in rights-of-way costs in the Centennial Wash floodplain for the smaller Centennial Wash flows did not make up for the increased construction cost of the larger floodwater retarding structure.

PLAN NO. VIII

This plan is the same as Plan V except the Centennial Levee was

extended a distance of 34,700 feet to the junction of the drainageway discharging Saddleback Diversion floodwater and Centennial Wash. An analysis was made to determine the feasibility of providing additional protection to about 1,080 acres of cultivated land within the flood-plain of Centennial Wash by the levee extension.

This alternative was found to be not economically feasible.

COST ESTIMATES

The costs of construction items, as shown in the engineer's estimate, have been based on an analysis of costs of previous contracts for flood prevention projects in Arizona. Cost estimates of items not included in flood prevention projects were based on "Arizona Highway Department Construction Cost" prepared by Division of Contracts and Specifications, dated January 1965. Factors considered in estimating quantities and costs are outlined below:

Clearing and Grubbing

The embankment, levee, low flow channel, and floodway channel sites will be cleared of scattered grasses and shrubs. A lump sum price based on 1½ percent of construction cost was used for clearing and grubbing.

Excavation

Total cost of excavation was based on that volume of excavation which was estimated would be wasted and could not be utilized as fill material in the various embankments. The economics of overhaul costs were considered in balancing cut and fill quantities for floodways and emergency spillways. It was assumed that twenty percent of excavation volumes are needed to fulfill the requirements of embankment volumes in balancing cut and fill quantities.

Earth Embankment

Fill materials will be available in borrow areas immediately adjacent to all embankments following clearing and removing of vegetation. Excavation in emergency spillways, core trenches, and floodways will also be utilized where overhaul costs warrant their use. Volume of embankment was computed by the average end area method, based on centerline height. A 5 percent allowance was made for settlement of all embankments.

Rock Riprap

Rock for the stabilized portions of floodways and diversion (including riprap needed for wave protection on the debris basin embankment) is readily available in two locations, one being in the Saddleback Mountains area and the other in the Burnt Mountain area of the watershed.

The Saddleback Mountain area contains large quantities that could be blasted and some quantities of approximately the required size that could be obtained from the adjacent valley floor and easily loaded and sorted. The other source in the Burnt Mountain area contains large quantities of rock in the 12 inch diameter and greater category which can be easily removed. Quantities of this may have to be reduced in size to be usable where needed. Unit costs were estimated on the basis of (1) overhaul, excavation, and loading costs encountered by the Arizona State Highway Department in construction of highways, and (2) placing costs encountered in construction of the Frye Creek-Stockton Wash Watershed project at Safford, Arizona.

Land, Easements and Rights-of-Way

Present land values were used as a basis for computing land rights costs. An estimated cost of $78,300 for utilities and road crossings are included in this item. Also included are land rights costs for that area of Centennial Wash required to pass the flow of project floodwaters, as well as land needed in connection with individual structural measures.

Concrete

All concrete placed in the principal spillways, stilling basins, and bridges will be steel reinforced and will require forming. Unit costs based on volumes of concrete were used to determine total costs of concrete structures. Concrete pipe costs for the debris basin were based on a lineal foot cost as shown by Arizona State Highway Department bid abstracts.

Trash Rack

All steel placed in the trash rack will be prefabricated according to specifications and will require bolting and welding. Unit costs are based on weight following fabrication and installation. Unit costs were used to determine total cost of the trash rack.

Operation and Maintenance

Cost of operation and maintenance of the structural measures were based on estimates as indicated in California Watershed Memorandum No. 6, dated August 15, 1958, and adjusted to meet local conditions.

ECONOMIC INVESTIGATIONS

All of the farm owners and/or operators on the Harquahala Valley Watershed floodplain were interviewed to obtain the magnitude of floodwater and sediment damages. All data collected has been reviewed with farmers and agricultural technicians familiar with the area to assure the accuracy of damage information and frequency of flooding within the watershed.

Crop and pasture damage estimates were based on the data collected for the August 26, 1964, flood. The storms of September 9, 1963, September 13, 1964, and February 6 and 7, 1965, were used to supplement the damage information and firm up damage projections for various magnitudes of flooding. The cost and return estimates developed for each crop with farm owners and operators were used to calculate a damage value by months of the year. These values were weighed by frequency of occurrence for each month to derive a composite acre damage.

Other agricultural damage consisting of flood damage to land, farm roads, irrigation systems, equipment, livestock and other farm property was also collected for the August 26, 1964, flood. A damage value per acre flooded was derived from this data.

The damage for the 1 percent, 5 percent, 10 percent, 20 percent, and 50 percent events was established by relating composite damage per acre to acres flooded. The average annual damage was established by a damage frequency curve.

The exisitng conservation program of range proper use, conducted by the Bureau of Land Management and others, is expected to continue in the arid desert above the proposed structural measures. Limited rainfall prohibits dependable establishment of land treatment measures, such as range seeding, which could change desert runoff characteristics. Land treatment measures to be installed on the irrigated cropland below the proposed structures are dependent on the structures in order to reduce flood flows. Therefore, the first increment of flood damage reduction benefits was the reduction of area flooded estimated for structural measures. The effect of land treatment measures on damage reduction was then calculated. This effect is shown in the footnote in Table 6.

Benefits and costs were computed assuming a project life of 50 years. A study was made of groundwater conditions, crop yields, irrigation efficiencies, production costs, and other pertinent factors. The conclusion was that there would be sufficient water available for economically feasible crop production for at least 50 years after

project completion.

All damage and benefit values were adjusted to long term projected price levels in accordance with projections made by the U. S. Department of Agriculture, Agricultural Research Service and Agricultural Marketing Service, September 1957.

Residential, commercial, and industrial property damages were determined by on-site inspections and by using as a guide the Stanford Research Institute Bulletin, "A Study of Procedures in Estimating Flood Damage to Residential, Commercial, and Industrial Properties in California." Damages to gas lines, telephone cables, electric power lines, and county roads were collected from the various groups concerned. Average annual damages were estimated on a damage-frequency relationship. Benefits to be accrued as a result of the proposed structural works were also based on a damage-frequency analysis.

In project formulation, incremental benefits and incremental costs of various levels of protection were compared for the Saddleback Diversion. This analysis indicated that net benefits would be maximized with a floodwater diversion that would provide protection up to and including the 50-year frequency storm.

Indirect damages to all aspects of the damage picture were obtained in the field along with direct losses. Indirect damages varied from an estimated 10 to 20 percent. The weighted indirect damage to all floodplain facilities is estimated at 10.25 percent of direct.

Secondary benefits have been evaluated following procedures outlined in Attachment 3 of Watershed Memorandum SCS-57, dated October 3, 1962. They include the value of local secondary benefits stemming from and induced by the project. Ten percent of the direct primary benefits were computed to arrive at secondary benefit values stemming from the project.

Secondary benefits induced by the project are considered to be equal to 10 percent of the increased cost that primary producers will incur in connection with increased production (saved from flood damage) and 10 percent of the annual operation and maintenance of the structural measures.

FISH AND WILDLIFE INVESTIGATIONS

Fish and Wildlife investigations were conducted by the Bureau of Sport Fisheries and Wildlife of the United States Department of the Interior in cooperation with the Arizona Game and Fish Department. The statements on pages 8 and 26 of this Work Plan regarding fish and wildlife were taken from the report of the above investigations.

Copies of the complete Fish and Wildlife report may be obtained from the Bureau of Sport Fisheries and Wildlife office at Albuquerque, New Mexico.

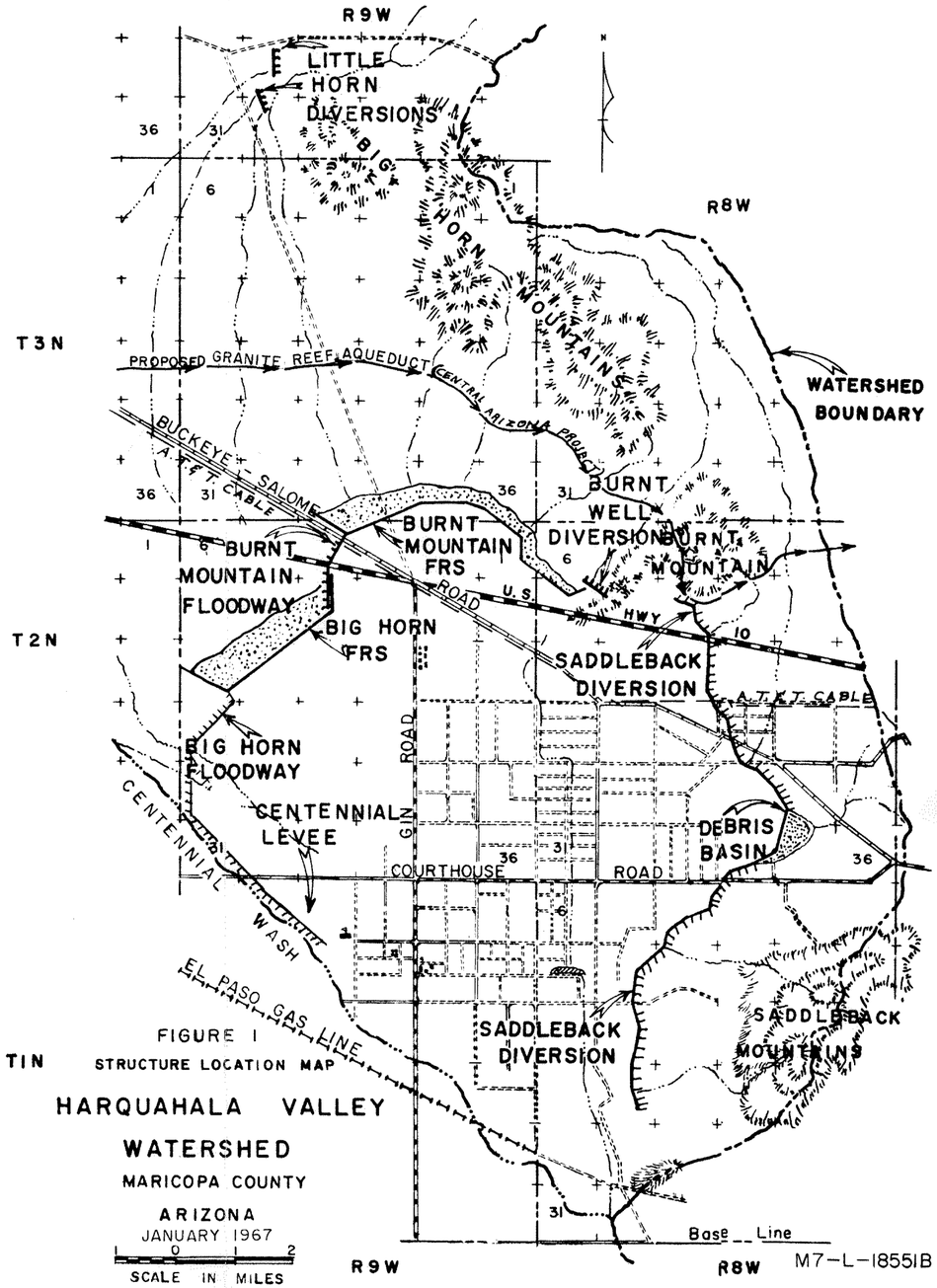


FIGURE I

STRUCTURE LOCATION MAP

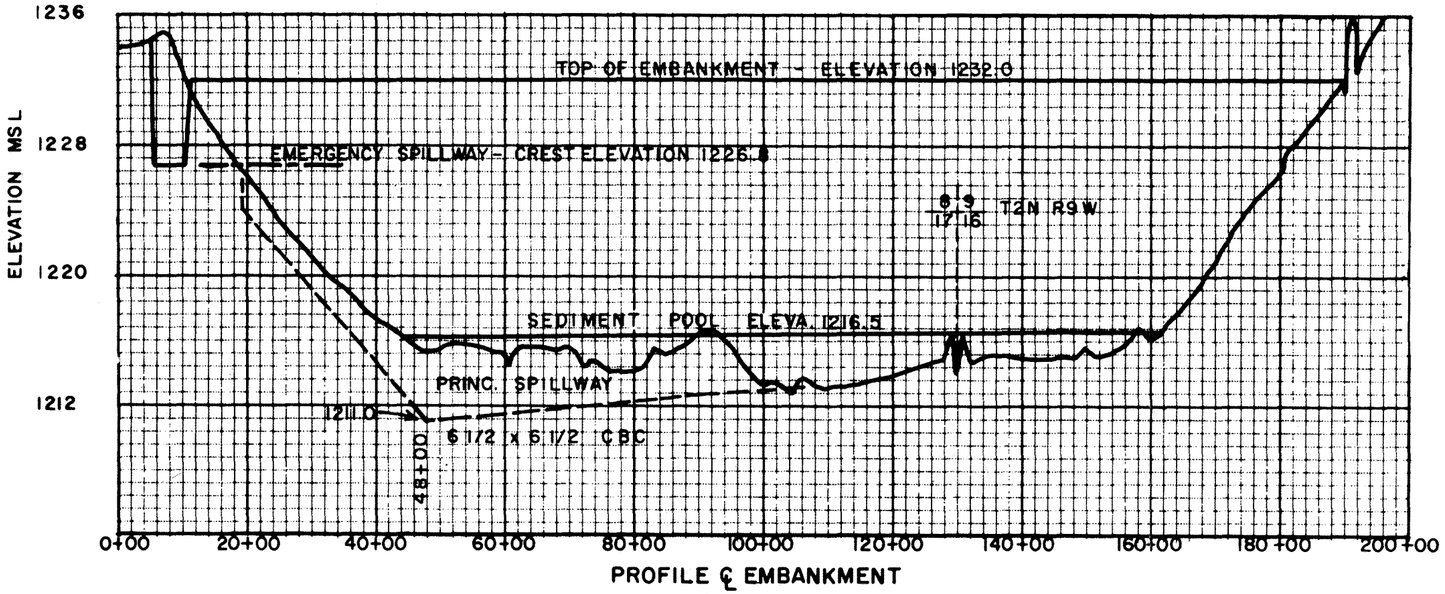
HARQUAHALA VALLEY

WATERSHED

MARICOPA COUNTY

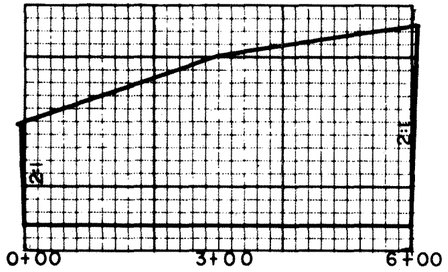
ARIZONA

JANUARY 1967



PROFILE ℄ EMBANKMENT
(Looking upstream)

PROFILE ℄ EMERGENCY SPILLWAY



CROSS SECTION EMERGENCY SPILLWAY

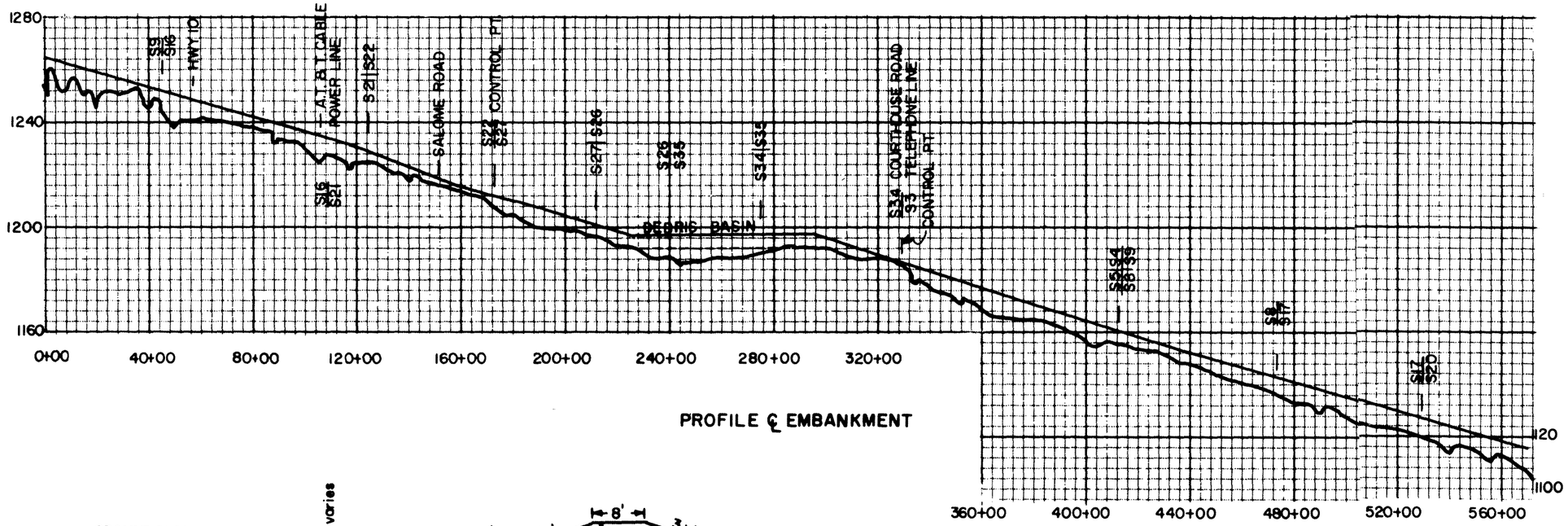
FIGURE 2A
WORK PLAN
BIGHORN FLOODWATER RETARDING STUCTURE
HARQUAHALA VALLEY WATERSHED
MARICOPA COUNTY, ARIZONA

PRELIMINARY PLANS
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

JANUARY 1967

USDA-SCS-PORTLAND, OREG. 1966

M7-N-18551C



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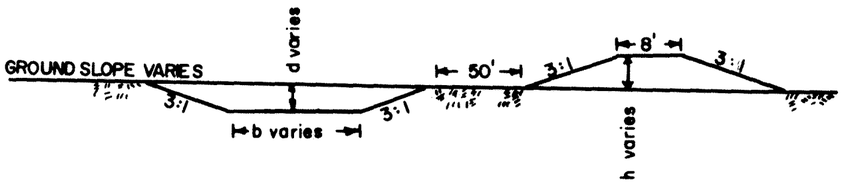


TYPICAL CROSS SECTION

FIGURE 2B
WORK PLAN

SADDLEBACK DIVERSION
HARQUAHALA VALLEY WATERSHED
MARICOPA COUNTY, ARIZONA

PRELIMINARY PLANS
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

JANUARY 1967

USDA-SCS-PORTLAND, OREG. 1966

M7-N-18551D

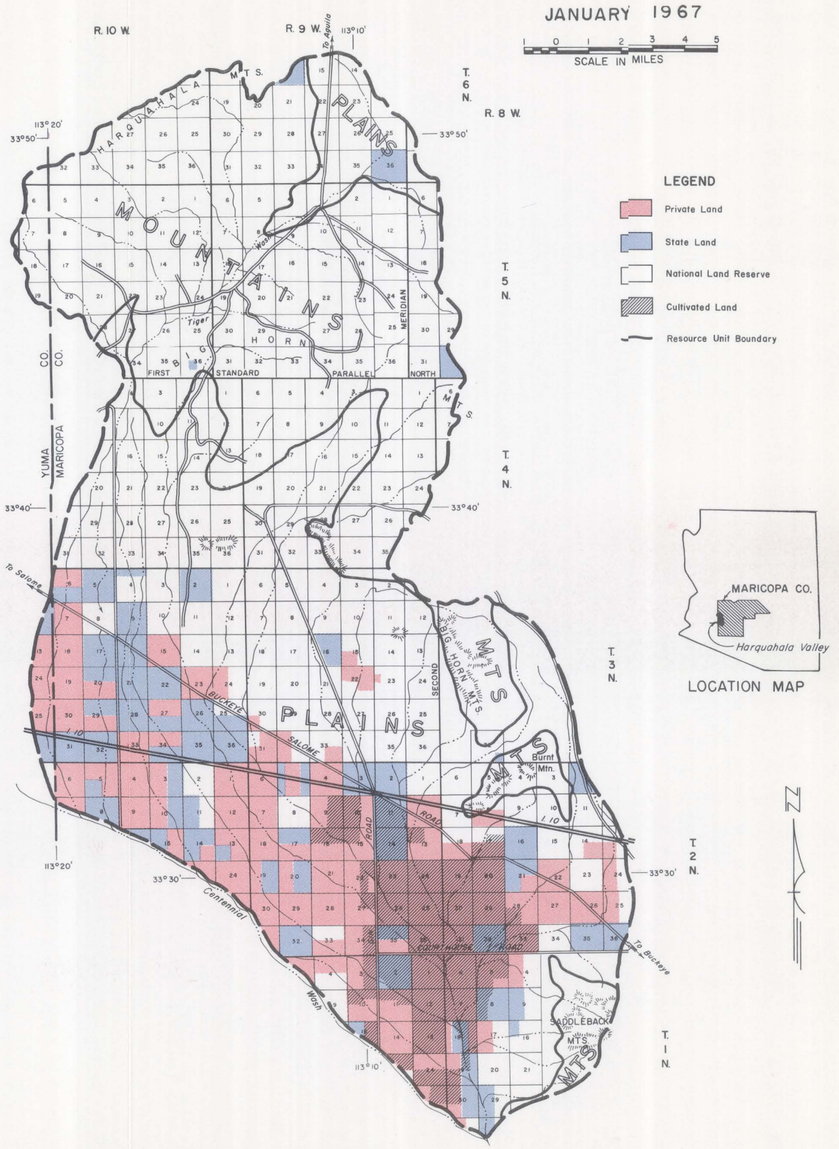
FIGURE 3

LAND STATUS, LAND USE, & RESOURCE UNIT MAP

HARQUAHALA VALLEY WATERSHED

MARICOPA & YUMA COUNTIES, ARIZONA

JANUARY 1967



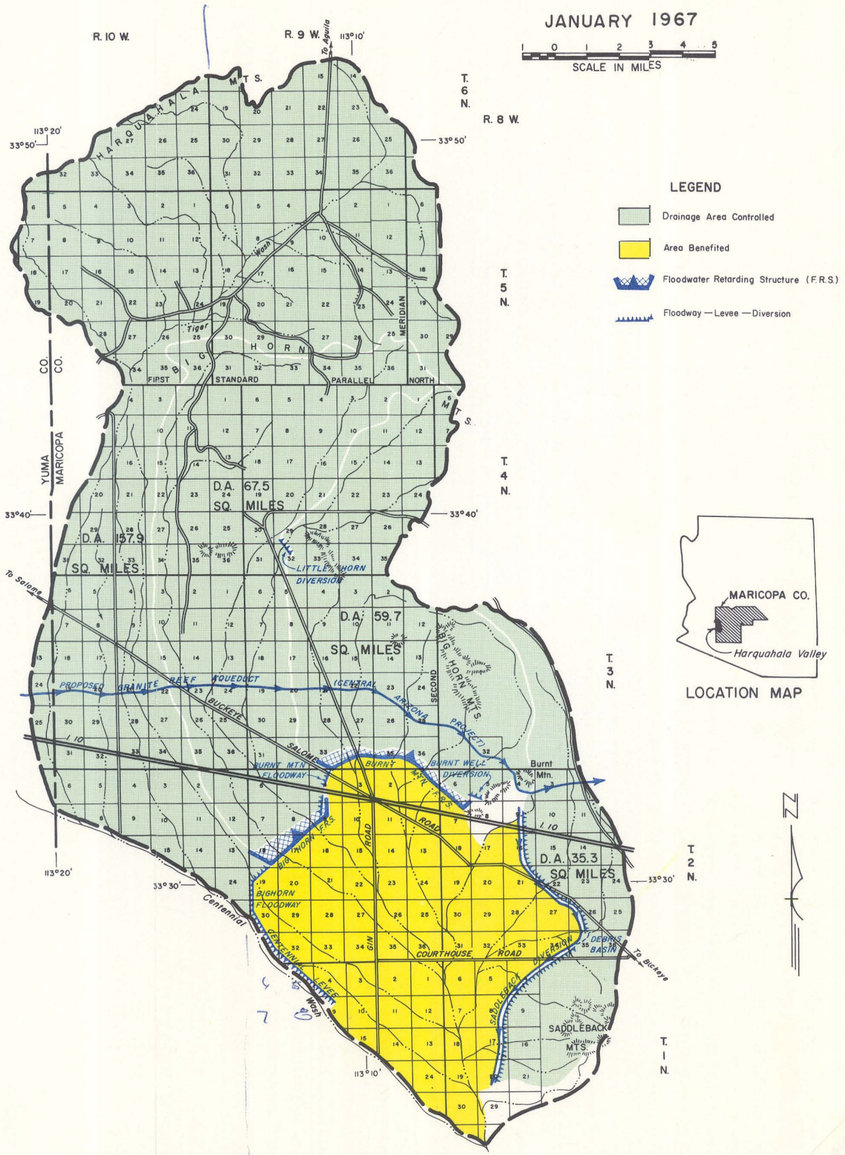
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE USDA-SCS PORTLAND OREG. 1966

M7-0-18551

FIGURE 4

PROJECT MAP

HARQUAHALA VALLEY WATERSHED

MARICOPA & YUMA COUNTIES, ARIZONA

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